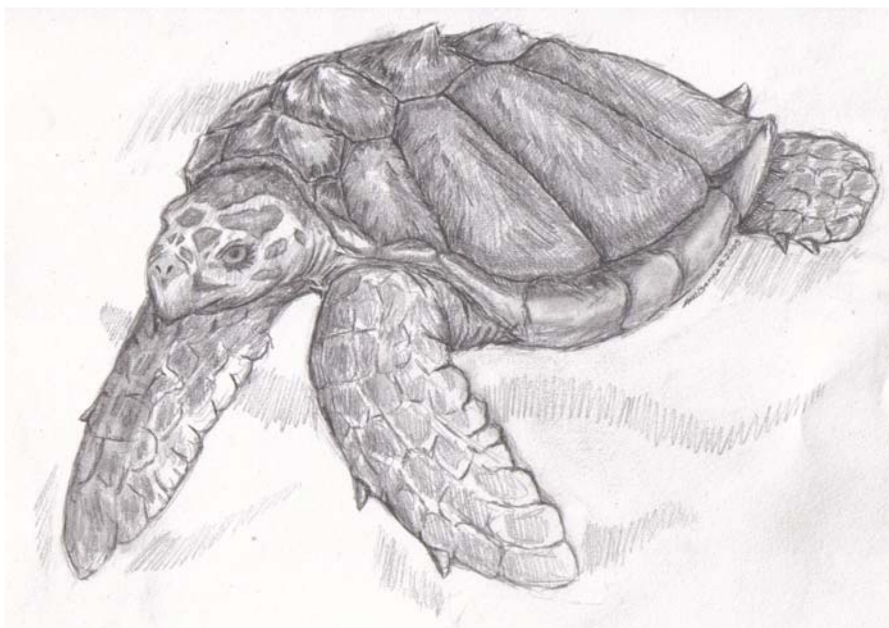
COSEWIC
Assessment and Status Report

on the

Loggerhead Sea Turtle
Caretta caretta

in Canada



ENDANGERED
2010

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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COSEWIC
Assessment Summary

Assessment Summary – April 2010

Common name
Loggerhead Sea Turtle

Scientific name
Caretta caretta

Status
Endangered

Reason for designation
This species is declining globally and there are well documented, ongoing declines in the Northwest Atlantic population from which juveniles routinely enter and forage in Atlantic Canadian waters. The Canadian population is threatened directly by commercial fishing, particularly bycatch in the pelagic longline fleet, and by loss and degradation of nesting beaches in the southeastern USA and the Caribbean. Other threats include bycatch from bottom and midwater trawls, dredging, gillnets, marine debris, chemical pollution and illegal harvest of eggs and nesting females.

Occurrence
Pacific Ocean, Atlantic Ocean

Status history
Designated Endangered in April 2010.

COSEWIC
Executive Summary

Loggerhead Sea Turtle
Caretta caretta

Species information

The Loggerhead Sea Turtle (*Caretta caretta*) is one of six species of hard-shelled marine turtles that comprise the family Cheloniidae in the order Testudines. Although Atlantic and Pacific populations of the turtle are genetically distinct, there are no recognized subspecies.

The Loggerhead Sea Turtle’s head and beak are large in comparison with other sea turtles. Its head and carapace are reddish-brown, and its flippers are chestnut brown, fading to yellow at the edges. The bridge between carapace and plastron, as well as the plastron, underside of the throat, flippers and tail are yellow to creamy white. Sexual dimorphism is usually apparent in animals larger than 67 cm straight-line carapace length. The sexes are most easily distinguished by tail length (longer in males) and claws (one claw is significantly longer and curved in males).

Loggerhead Sea Turtles found in Canadian waters are likely comprised of individuals from the same nesting populations as those turtles found in the northern limits of United States’ waters (Atlantic and Pacific). For the Pacific Ocean, any individuals wandering into Canadian waters would come from nesting assemblages in Japan. Nesting populations from southern Virginia, North and South Carolina, Georgia, Florida, and the Caribbean coast of Mexico contribute to the individuals found in Atlantic Canadian waters.

Distribution

Loggerhead Sea Turtles are widely distributed in the Atlantic, Pacific and Indian Oceans. There are no confirmed records of Loggerhead Sea Turtles in the Canadian Pacific. However, sightings of Loggerhead Sea Turtles in U.S. waters off Washington and Alaska indicate that the turtles may occasionally also occur off British Columbia. Juvenile Loggerhead Sea Turtles are routinely found in Atlantic Canadian waters. They are usually associated with the warmer offshore waters of the Gulf Stream and are most often encountered on the Scotian Shelf, Scotian Slope, Georges Bank and the Grand Banks.

Most loggerheads nest at the western rims of the Atlantic and Indian Oceans, with the largest nesting assemblages in southern Florida, USA and Masirah, Oman. The northern extent of the Atlantic nesting range in North America is in Virginia; the largest nesting colony is in Florida. Loggerhead Sea Turtles in the North Pacific nest almost exclusively in Japan.

Habitat

Although Loggerhead Sea Turtles make use of both terrestrial and marine habitats, they spend the majority of their lives at sea. After hatching from nests laid on sand beaches, Loggerhead Sea Turtle hatchlings move immediately to the marine environment. Male turtles never return to land. Female turtles return only to nest. They do not nest in Canada.

Loggerhead Sea Turtles occupy different marine habitats at different life stages. Hatchling turtles disperse to neritic waters (waters of the Continental Shelf or areas near the shelf where bottom depths are less than 200 m) and then to oceanic waters (deeper than 200 m). Juvenile Loggerhead Sea Turtles make trans-oceanic migrations. They return to neritic zones as they mature, with nesting females homing to their natal beaches. Habitat for mature Loggerhead Sea Turtles and the movements of mature male are still relatively unknown. Current research indicates that Loggerhead Sea Turtles in Canada concentrate in areas where water temperatures are above 22°C.

Biology

Mature female Loggerhead Sea Turtles return to land only to nest. They nest on a 2-3-year interval. During a nesting season, they lay three to four clutches of approximately 112 eggs each. There are approximately 14 days between nesting events. Eggs hatch after 7-13 weeks of incubation depending on the temperature of the nest. The sex of hatchlings is temperature dependent. Incubation temperatures above 29°C produce more or all females, and incubation temperatures below 29°C produce more or all males.

Hatchlings emerge at night, and use ambient light to guide them to the ocean, where they begin a period of frenzied activity, swimming for approximately 20 to 30 hours. They stay in neritic waters (waters over continental shelf) for weeks or months, and then disperse to oceanic waters using ocean currents. Pacific Loggerhead Sea Turtles are known to go to Baja, Mexico, and to use the waters of the Kuroshio Extension Bifurcation Region in the North Pacific. Western Atlantic hatchlings are known to go to the Azores and to Madeira. Recent research suggests that a proportion of the western Atlantic population go north to Canadian waters instead.

Juvenile Loggerhead Sea Turtles recruit back to neritic waters, although this return may not be permanent. Both juvenile and adult Loggerhead Sea Turtles can alternate between neritic and oceanic waters, possibly choosing habitat based on prey availability. Loggerhead Sea Turtles reach sexual maturity at approximately 16-34 years of age, with a generation time of about 46 years. Loggerhead Sea Turtles are carnivorous, feeding on a variety of crustaceans, salps, fish, squid, and jellyfish.

Population sizes and trends

Although Loggerhead Sea Turtles routinely visit waters off Atlantic Canada, little is known about population sizes or trends. In the past, this species was thought to be a vagrant or accidental in Canada’s Atlantic waters, but from 1999-2006 it was estimated that the incidental catch for the Canadian fishery as a whole was 9,592 Loggerhead Sea Turtles (average=1,199 annually). Therefore, the species has a significant presence in Canadian waters. Nesting populations that likely contribute the Loggerhead Sea Turtles found in Canada are declining.

Limiting factors and threats

The primary known threat to Loggerhead Sea Turtles in Canadian waters is bycatch in the pelagic longline fleet. Bycatch of juvenile-stage turtles is particularly significant because changes in survivorship of this life-history stage have the largest impact on population growth. In addition, mixed-stock analyses indicate turtles from a variety of nesting assemblages mix in the oceanic zone. Significant loss of these animals may deplete nesting colonies throughout the region.

Globally, Loggerhead Sea Turtles face threats from fisheries bycatch, non-fisheries resource use (e.g., poaching), construction and development on nesting beaches, other ecosystem alterations, pollution, natural predators, and perhaps from other factors such as climate change.

Special significance of the species

The Loggerhead Sea Turtle is a highly-migratory species, and, therefore, a shared resource among many nations. Canada’s responsibility toward the species is then twofold: first, to protect it as necessary within national boundaries; second, to ensure that the level of protection we afford does not jeopardize conservation activities elsewhere. In addition, this is the only hard-shelled sea turtle to frequent Canadian waters.

Existing protection

Loggerhead Sea Turtles receive some protection from the *Fisheries Act.* The federal government fulfills its constitutional responsibilities for sea coast and inland fisheries through the administration of the *Fisheries Act*. The Act provides Fisheries and Oceans Canada (DFO) with powers, authorities, duties and functions for the conservation and protection of fish and fish habitat (as defined in the *Fisheries Act*) essential to sustaining commercial, recreational and Aboriginal fisheries.

The Loggerhead Sea Turtle receives protection from the United States' *Endangered Species Act*, the Inter-American Convention for the Protection and Conservation of Sea Turtles, the Protocol Concerning Specially Protected Areas and Wildlife, the Convention on International Trade in Endangered Species and the Convention on Migratory Species.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2010)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

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Caretta caretta

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2010

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

SPECIES INFORMATION

Name and classification

The Loggerhead Sea Turtle was described by Linnaeus in 1758 as *Testudo caretta*, and has had more than 35 names since then (Dodd 1988). The species' current and generally accepted scientific name is *Caretta caretta*. In French, the turtle's common name is "tortue caouanne," sometimes spelled "tortue caouane." The Loggerhead Sea Turtle is one of six species of hard-shelled sea turtles that comprise the Family Cheloniidae in the Order Testudines in the Class Sauropsida. Genetic studies indicate that the Atlantic and Indo-Pacific populations are distinct, but there are no recognized subspecies (Dodd 1988; Bowen 2003; Bowen and Karl 2007).

Morphological description

The Loggerhead Sea Turtle derives its common name from its head and beak, which are relatively large when compared with those of other sea turtles. The animal has a short neck and, like other sea turtles, cannot retract its head into its shell. The head is reddish-brown as is the carapace (top shell), and both may be tinged with olive. The scales on the head and the scutes (bony external plates) on the carapace are sometimes bordered in yellow. Its flippers are chestnut brown, fading to yellow at the edges. The bridge between the carapace and plastron (bottom shell) and the plastron itself are yellow to creamy white as are the underside of the throat, flippers and tail. There is some geographic variation in colouring of sub-adults and adults, and significant reported variation in the colouration of hatchlings (even within the same clutch), but no standardized comparison has been published (Dodd 1988; Kamezaki 2003).

The carapace of the adult Loggerhead Sea Turtle is thick and heavily keratinized (covered with a hard, protective protein) (Pritchard 1979; Dodd 1988; Ernst and Lovich 2009). It is elongated, and is often described as heart-shaped. The carapace has five vertebral scutes, usually five pairs of costal scutes, 12 or 13 pairs of marginal scutes (including the supercaudal scute) and a wide nuchal scute that contacts the first costal scute on either side (Figure 1). Kamezaki (2003) warns against using scute formation as the exclusive means of species identification, as there is sufficient variation in Loggerhead Sea Turtle scute formation to render it unreliable.

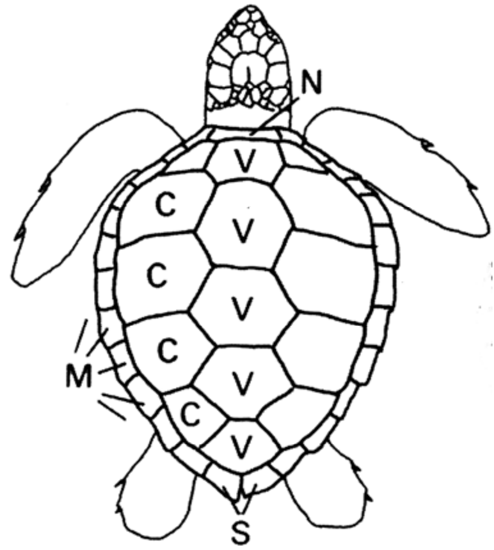

Figure 1. External morphology and scutellation of the Loggerhead Sea Turtle. V: vertebral scute; C: costal scute; M: marginal scute; N: nuchal scute; S: supracaudal scute. From N. Kamezaki 2003.

Scientists generally use a straight carapace length (SCL) to measure Loggerhead Sea Turtles. SCL is measured in one of three ways: minimum SCL, SCL notch to tip, or maximum SCL (Bolten 1999) (Figure 2).

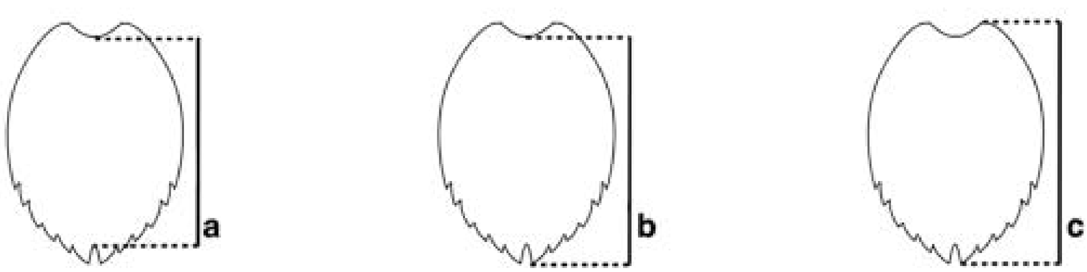

Figure 2. Anatomical points for straight (SCL) and curved (CCL) carapace length measurements. (a) minimum SCL and minimum CCL; (b) SCL notch to tip and CCL notch to tip; (c) maximum SCL. From Bolten 1999.

Dodd (1988) separates size classes of Loggerhead Sea Turtle populations around the world by geographic region. More pertinent to the discussion of Loggerhead Sea Turtles in the Canadian context are the size classes of Atlantic Loggerhead Sea Turtles found in the northern limits of United States' waters. The carapace lengths associated with the five Loggerhead Sea Turtle life stages as described by the Turtle Expert Working Group (TEWG) (2009) are as follows:

- Stage 1—Year One (terrestrial to oceanic, egg to post-hatchling) ranges from hatchling size (average 4.5 cm SCL; Van Buskirk and Crowder 1994) to 15 cm SCL (Bjorndal *et al*. 2000);

- Stage 2—Juvenile (1) (exclusively oceanic) ranges from 15 cm SCL to 63 cm SCL (TEWG 2009);
- Stage 3—Juvenile (2) (oceanic or neritic, small benthic juveniles) ranges from 41 cm SCL to 82 cm SCL, peaking at 63 cm SCL in the Atlantic (TEWG 2009).
- Stage 4—Juvenile (3) (oceanic or neritic, large benthic juveniles) ranges from 63 cm SCL to 100 cm SCL (TEWG 2009);
- Stage 5—Adult (neritic or oceanic) ranges from 82 cm SCL with full recruitment to the adult stage at 100 cm SCL (TEWG 2009).

The overlap in sizes at different life stages reflects the distribution of recruitment sizes at any given stage (TEWG 2009) (Figure 3).

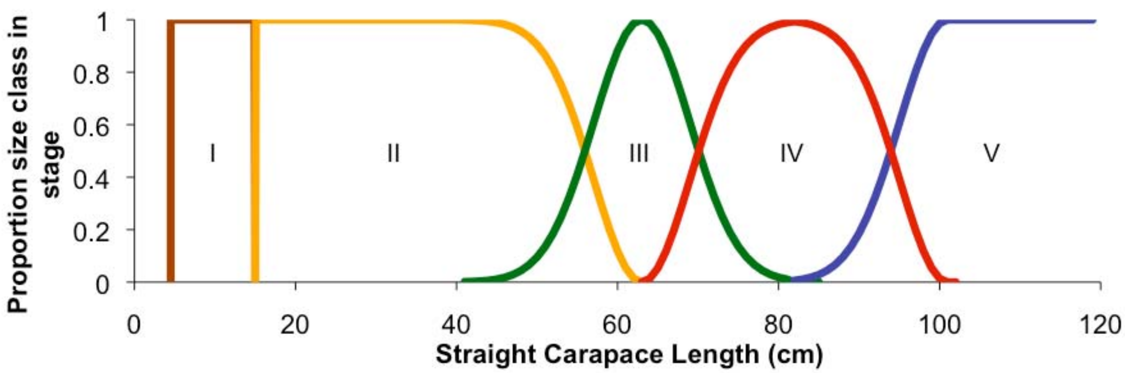

Figure 3. Conceptual model of the size distribution for each life stage of the Loggerhead Sea Turtle. From TEWG 2009.

Measurements of Loggerhead Sea Turtles found in Atlantic Canadian waters suggest they are juvenile animals, as are those found in adjacent U.S. waters (National Marine Fisheries Service NMFS and USFWS 1998; TEWG 2000; Bowen *et al*. 2005; DFO 2006; Bowen and Karl 2007; Ledwell 2007; McAlpine *et al*. 2007; NMFS and USFWS 2007; Brazner and McMillan 2008; NMFS and USFWS 2008). The majority of the Loggerhead Sea Turtles in Atlantic Canadian waters are likely Stage 3 (Watson *et al*. 2005; Brazner and McMillan 2008; TEWG 2009). Loggerhead Sea Turtles captured on pelagic longline fishing gear on the Grand Banks off Newfoundland in the Northeast Distant Statistical Reporting Area (NED) (n=93) ranged in size from 32.4 cm to 68 cm SCL, averaging 56.8 cm (Watson *et al*. 2005). Brazner and McMillan (2008) reported measurement data from 28 Loggerhead Sea Turtles incidentally captured in Canadian waters. The sample ranged in size from 42 cm to 87 cm SCL (mean= 53.9 cm); the majority of turtles (85%) were less than 60 cm SCL and only two individuals were over 80 cm (Brazner and McMillan 2008). Three additional coastal records substantiate this size distribution. One found (live) in Connaigra Bay on the south coast of Newfoundland measured 76 cm curved carapace length (CCL) (Ledwell 2007), one captured off Devil's Island, Nova Scotia, measured 30.5 cm carapace length (neither CCL or SCL was specified), and one captured off Chebucto Head, Nova Scotia, in 1964 measured 74.9 cm CCL (McAlpine *et al.* 2007).

Recorded carapace lengths for Loggerhead Sea Turtles have exceeded 210 cm and masses above 450 kg (Ernst *et al*. 1994). The average mean carapace length of nesting Loggerhead Sea Turtles in the Atlantic is 94 cm, and the mean body mass of female Loggerhead Sea Turtles in the Atlantic is 116 kg (derived from Dodd 1988).

There is less specific information available on the size-class distribution of Pacific Loggerhead Sea Turtles. However, growth rates of juvenile north Pacific Loggerhead Sea Turtles is equivalent to, or slower than, those of Atlantic Loggerhead Sea Turtles (Zug *et al.* 1995; Bjorndal *et al*. 2000). Pacific Loggerhead Sea Turtles do not disperse to neritic zones until they are larger than around 60 cm SCL (Conant *et al*. 2009). Loggerhead Sea Turtles nesting in Japan, nesting stock for North Pacific Loggerhead Sea Turtles (Hatase *et al.* 2002*a*), average 89.0 SCL and 96.8 kg (Uchida and Nishiwaki 1982).

Sexual dimorphism is usually apparent in Loggerhead Sea Turtles of more than 67 cm SCL (Dodd 1988). The most easily identifiable differences are tail length and claws (Wibbles 1999). As with other sea turtles, male Loggerhead Sea Turtles have a longer, thicker and more muscular tail than do females (Dodd 1988; Ernst *et al*. 1994; Wibbles 1999; Kamezaki 2003). The male turtle’s tail extends well beyond the carapace, while the tail of the female turtle barely extends beyond it (Wibbles 1999). Although both male and female Loggerhead Sea Turtles have claws on their front flippers, males have a claw on each flipper that is conspicuously larger and more strongly curved than the rest (Dodd 1988; Ernst *et al*. 1994; Kamezaki 2003).

Genetic description

The Family Cheloniidae has three deep lineages that fossil evidence suggests differentiated more than 24 million years ago (Bowen 2003). Together, the Loggerhead Sea Turtle, the Olive Ridley Sea Turtle (*Lepidochelys olivacea*), the Kemp’s Ridley Sea Turtle (*L. kempii*) and the Hawksbill Sea Turtle (*Eretmochelys imbricata*) comprise the Chelonini tribe (Bowen 2003). The Loggerhead Sea Turtle, based on mtDNA sequences, diverged from the Ridley and Hawksbill Sea Turtles approximately 10 million years ago, and is now a monotypic genus (Dodd 1988; Bowen 2003).

Loggerhead Sea Turtles have two lineages, which diverged approximately 3 million years ago: one in the Indian and Pacific Ocean basins, and the other in the Atlantic Ocean and Mediterranean Sea (Bowen 2003). There have been two effective transfers of matrilines between the groups, likely through the waters around South Africa (Bowen 2003). One occurred approximately 250,000 years ago and one more recently, likely less than 12,000 years ago (Bowen 2003; Bowen and Karl 2007). These rare events have been sufficient to prevent the two lineages from developing into separate species (Bowen 2003; Bowen and Karl 2007).

Genetic sequencing confirms that female Loggerhead Sea Turtles demonstrate "natal homing," which means they return to the vicinity of their natal beaches for mating and nesting (Bowen and Karl 2007). Consequently, each nesting population can be distinguished by its unique ratio of haplotypes (Bowen *et al*. 2005; Bowen and Karl 2007). Studies of the mtDNA in nesting assemblages have confirmed a strong population structure among nesting colonies (Bowen and Karl 2007).

No genetic studies have been specifically conducted on the Canadian Loggerhead Sea Turtle population. In the Atlantic, however, work in the NED suggests that the Grand Banks off Newfoundland are foraging grounds for Loggerhead Sea Turtles from all Atlantic nesting beaches (Bowen *et al*. 2005; LaCasella *et al*. 2006; Bowen and Karl 2007). Contributions to the pelagic juvenile group are approximately proportional to the size of the source nesting populations (LaCasella *et al*. 2006) (Figure 4). Approximately 80% of all nesting in the Atlantic Ocean occurs in Peninsular Florida (Figures 4 and 5), which also produces approximately 90% of all hatchlings (NMFS and USFWS 2008; TEWG 2009).

Loggerhead Sea Turtles found in the North Pacific Ocean nest almost exclusively in Japan (Bowen *et al*. 1995; Hatase *et al*. 2002*a*; Bowen 2003; Kamezaki *et al*. 2003; NMFS and USFWS 2007; LeRoux *et al*. 2008), with low-level nesting in the Xisha Archipelago in the South China Sea (Chan *et al*. 2007) (Figure 5).

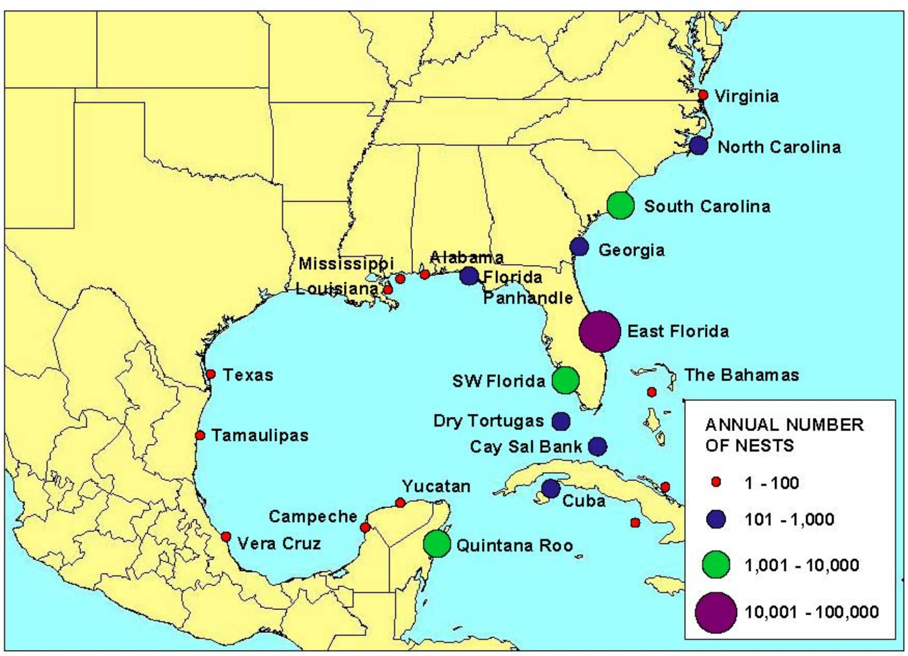

Figure 4. Estimated number and distribution of Loggerhead Sea Turtle nests in the southeastern United States, the Bahamas, Cuba and Mexico from 2001-2008. From NMFS and USFWS 2008.

Designatable Units

Pacific and Atlantic populations of Loggerhead Sea Turtles are both geographically and genetically distinct (Bowen 2003). The United States government, through the National Marine Fisheries Service and the U.S. Fish and Wildlife Service, convened a Biological Review Team (BRT) in February 2008 to determine whether or not Distinct Population Segments (DPS) exist for the Loggerhead Sea Turtle. Similar to the COSEWIC policy on Designatable Units, the U.S. DPS policy applies if a population is both discrete and significant relative to its taxon (U.S. Dept. of the Interior and U.S. Dept. of Commerce 1996).

The BRT unanimously concluded that there were nine Loggerhead Sea Turtle DPS globally, each representing a large portion of the species' range and a unique ecosystem influenced by local ecological and physical factors (Conant *et al*. 2009). Each of the population segments is genetically unique (Conant *et al*. 2009). In the opinion of the BRT, the loss of any of them would represent both a significant gap in the Loggerhead Sea Turtle's range and a significant loss in Loggerhead Sea Turtle genetic diversity (Conant *et al*. 2009). The global Loggerhead Sea Turtle DPSs as defined by the BRT are:

- North Pacific Ocean DPS
- South Pacific Ocean DPS
- North Indian Ocean DPS
- Southeast Indo-Pacific Ocean DPS
- Southwest Indian Ocean DPS
- Northwest Atlantic Ocean DPS
- Northeast Atlantic Ocean DPS
- Mediterranean Sea DPS
- South Atlantic Ocean DPS (Conant *et al*. 2009)

The DPSs most relevant to a consideration of the Loggerhead Sea Turtle in Canada are the Northwest Atlantic Ocean DPS and the North Pacific Ocean DPS. These would correspond to two separate DUs, the Pacific Ocean DU and the North-West Atlantic Ocean DU. However, no Loggerhead Sea Turtle has ever been reported from Pacific Canadian waters, and it seems likely that these waters are only used by accidental vagrants if any loggerheads occur there at all. Therefore, in this report, all Loggerhead Sea Turtles in Canada are considered as a single Designatable Unit.

DISTRIBUTION

Global range

Loggerhead Sea Turtles inhabit the temperate and tropical regions of the Atlantic, Pacific and Indian Oceans. In its Red List assessment of the Loggerhead Sea Turtle, the IUCN (1996) recognized it as native to 54 countries (not including Canada) with uncertain presence in an additional five. The Loggerhead Sea Turtle is found in all FAO (Food and Agriculture Organization of UN) major fishing areas, except for those in the Arctic and Antarctic (IUCN 1996; FAO 2009).

Loggerhead Sea Turtle use of the marine habitat includes both oceanic and neritic zones. Bolten (2003) defines the oceanic zone as the open ocean environment where minimum depths are greater than 200 m. The neritic zone corresponds to the Continental Shelf, or to areas where maximum depths are less than 200 m (Bolten 2003).

In the oceanic zone, Loggerhead Sea Turtles spend 75% of their time in the top 5 m of the water column (Bolten 2003). Of their dives, 80% are less than 5 m deep, and the remainder of dives are distributed throughout the top 100 m of the water column, with occasional dives greater than 200 m (Bolten 2003). Research by McCarthy *et al*. (2004) suggests that Loggerhead Sea Turtles concentrate near oceanographic fronts, possibly because of the associated prey density.

In the neritic zone, Loggerhead Sea Turtles are most commonly found in waters 22 to 49 m deep (Shoop and Kenney 1992; Hopkins-Murphy *et al*. 2003; Schroeder *et al*. 2003). Genetic research suggests that a proportion of juvenile Loggerhead Sea Turtles recruit to the vicinity of the beaches where they hatched, and that mature females, and possibly males, have high site fidelity to their breeding and nesting habitat (Schroeder *et al*. 2003; Bowen *et al.* 2005). There is also evidence that juvenile Loggerhead Sea Turtles exhibit site fidelity to feeding grounds (Avens *et al*. 2003, Avens and Lohmann 2004).

However, current research suggests that Loggerhead Sea Turtles move between oceanic and neritic zones (Hatase *et al*. 2002*a*; Bolten 2003; Ehrhart *et al*. 2003; Schroeder *et al*. 2003; Bass *et al*. 2004; Hawkes *et al*. 2006; McClellan and Read 2007; Casale *et al*. 2008; Mansfield *et al*. 2009; Reich *et al*. 2010). The specific factors responsible for variation in habitat choice are not yet clear. Some studies suggest that the size of the Loggerhead Sea Turtle may be a factor (Hatase *et al*. 2002*a*; Hawkes *et al*. 2006; Reich *et al*. 2010). However, size was not a factor in plasticity in McClellan's (2007) study. McClellan (2007) also suggests that variations in age, sex, condition or nesting beach origin are unlikely explanations. It is possible that temporary or permanent fidelity to specific oceanic or neritic zones may vary among individuals or populations depending on oceanographic features and the availability of food in foraging or migratory areas (Polovina *et al*. 2000; Witherington 2002; Casale *et al*. 2008; Kobayashi *et al*. 2008).

The majority of Loggerhead Sea Turtle nesting takes place at the western rims of the Atlantic and Indian Oceans. The largest nesting assemblages are in southern Florida, USA, and in Masirah, Oman, a country just east of Saudi Arabia that borders the Indian Ocean (Baldwin *et al*. 2003; Ehrhart *et al*. 2003, Kamezaki *et al.* 2003; Limpus and Limpus 2003; Margaritoulis *et al*. 2003). Key nesting grounds in the Pacific Ocean are Japan (Hatase *et al*. 2002*a*; Bowen 2003; Kamezaki *et al*. 2003; NMFS and USFWS 2007; LeRoux *et al*. 2008), eastern Australia and New Caledonia (Limpus and Limpus 2003) (Figure 5).

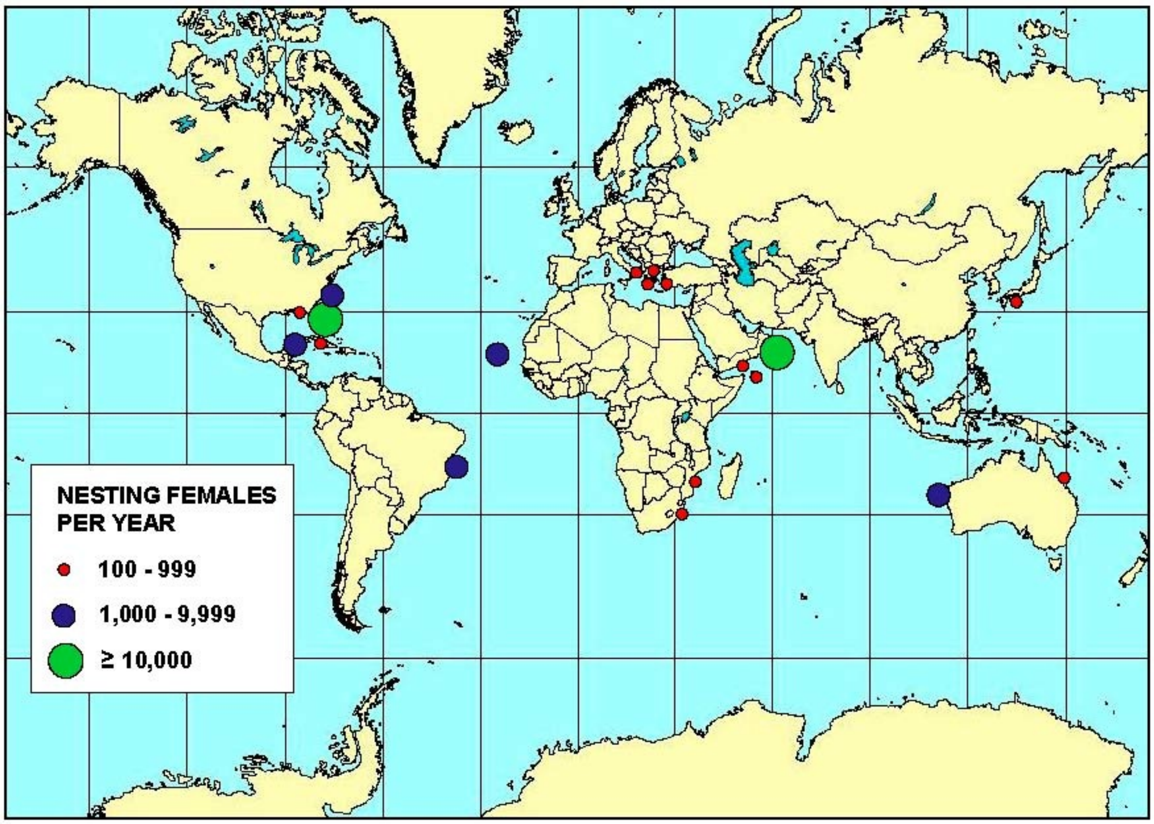

Figure 5. Global distribution of Loggerhead Sea Turtle nesting assemblages. From NMFS and USFWS 2008.

Canadian range

Atlantic Ocean

Loggerhead Sea Turtles are found routinely in Atlantic Canadian waters (Bleakney 1965; Ladzell 1980; Witzell 1999; Javitech 2002; Javitech 2003; Ledwell 2007; McAlpine *et al*. 2007; Brazner and McMillan 2008; James pers. comm. 2009; Lawson pers. comm. 2009). They occur on the Scotian Shelf, Scotian Slope, Georges Bank, the Grand Banks, and waters further offshore (Witzell 1999; Javitech 2002; Javitech 2003; McAlpine *et al*. 2007; Brazner and McMillan 2008; Canadian Sea Turtle Sightings

Database 2009, Lawson, pers. comm. 2009) (Figures 6 and 7). Existing research suggests Loggerhead Sea Turtles are present in Canadian waters in greatest numbers during the spring, summer and fall (Witzell 1999; Brazner and McMillan 2008; Canadian Sea Turtle Sightings Database 2009). These data are linked to fishing effort.

Loggerhead Sea Turtles reported incidentally captured by the Canadian Atlantic pelagic longline fleet (n=701) from 1999-2006 within Canada's Exclusive Economic Zone concentrated in offshore areas along the Western Scotian Shelf and Georges Bank off Nova Scotia, and near the Grand Banks off Newfoundland (Figure 6). No Loggerhead Sea Turtles were observed in inshore areas of southeast Nova Scotia or northeast of the Grand Banks despite considerable observer coverage in these areas. The Loggerhead Sea Turtles were encountered along 20 to 25°C contours despite fishing effort across a range of temperatures (Brazner and McMillan 2008). None of these animals was captured when water temperatures at the sets were less than 15ºC (Brazner and McMillan 2008). The bycatch of turtles was concentrated in water temperatures above 22°C (Brazner and McMillan 2008). Hawkes *et al*. (2007) suggests that Loggerhead Sea Turtles may winter where the Gulf Stream maintains temperatures above 14°C.

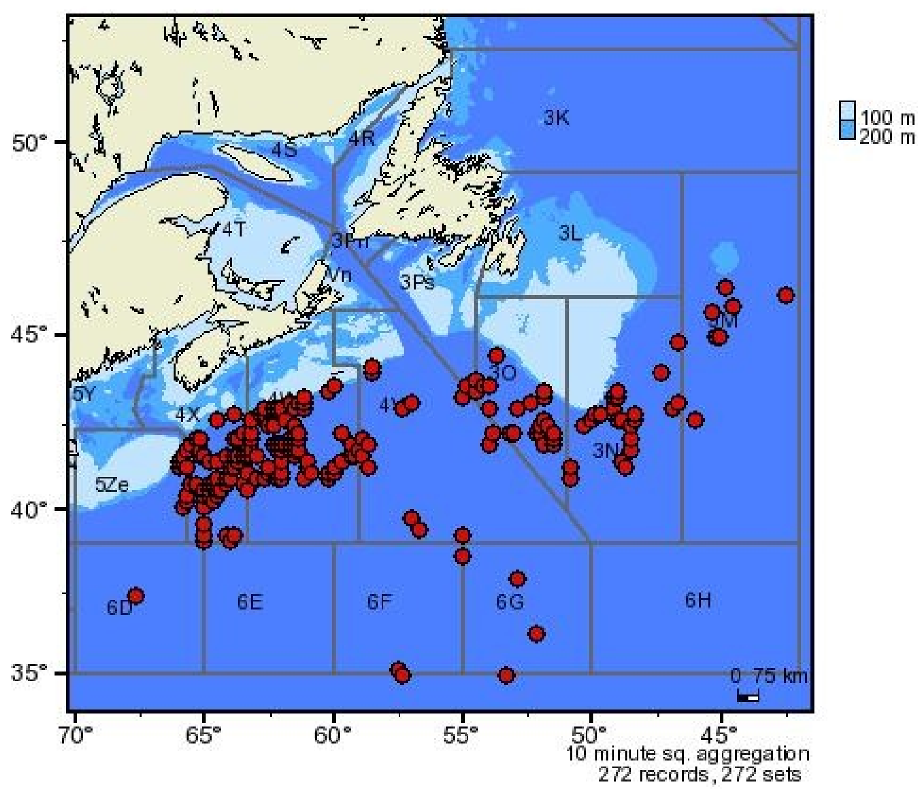

Figure 6. Locations of Loggerhead Sea Turtle captures recorded by at-sea observers on Canadian pelagic longline fishing trips, 1999-2008. Each point does not represent a single turtle. Dots represent locations where one or more Loggerhead Sea Turtles may have been caught. (Department of Fisheries and Oceans 2009).

There are a few inshore records of Loggerhead Sea Turtles in Atlantic Canadian waters (Bleakney 1965; Ledwell 2007; McAlpine *et al*. 2007, Lawson pers. comm. 2009), including a hybrid Loggerhead-Green Sea Turtle (James *et al*. 2004). However, Loggerhead Sea Turtles in the region are generally associated with the warmer offshore waters of the Gulf Stream (Shoop 1980; Shoop and Kenny 1992; Witzell 1999; Hawkes *et al*. 2007; McAlpine *et al*. 2007; Brazner and McMillan 2008; James pers. comm. 2009) (Figure 7). The water temperature inshore in Atlantic Canada is usually too low for the thermal tolerance levels of this animal (Hopkins-Murphy *et al*. 2003; Hawkes *et al*. 2007; James pers. comm. 2009). Loggerhead Sea Turtles become lethargic in water temperatures of approximately 13°C, and adopt a stunned, floating posture in water of approximately 10°C (Mrosovsky 1980). Loggerhead Sea Turtles found inshore are rare, and are likely the result of warm core rings that have broken off from the Gulf Stream (McAlpine *et al*. 2007; James pers. comm. 2009). The Canadian Sea Turtle Network (CSTN) monitoring program, which distributes information on Loggerhead and Leatherback Sea Turtles in coastal communities, has recorded significant numbers of inshore sightings of Leatherback Sea Turtles (Martin and James 2005*a*). There are also numerous offshore reports (n=81) of Loggerhead Sea Turtles (Martin and James 2005*a*; James *et al*. 2006; McAlpine *et al*. 2007; Canadian Sea Turtle Sightings Database 2009). It has not had similar numbers of reports of Loggerhead Sea Turtles inshore; this indicates that Loggerhead Sea Turtles are not regularly found inshore.

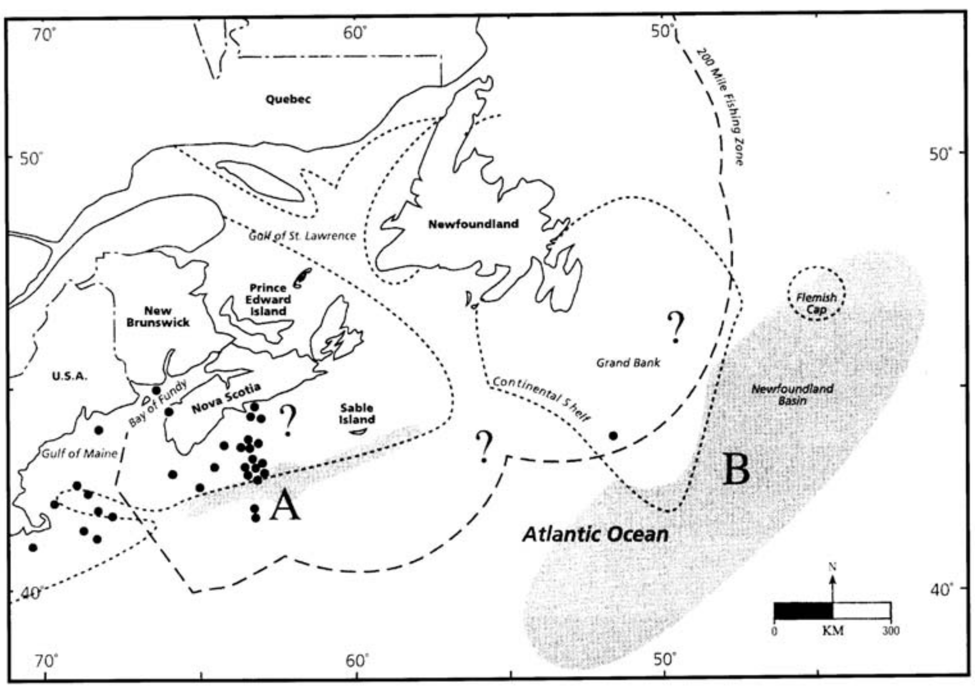

Figure 7. Occurrences of Loggerhead Sea Turtles off eastern Canada. Dots represent single occurrences and are based on published literature as well as unpublished sightings (n=17) collected during U.S. National Marine Fisheries Service aerial surveys conducted between 10-26 August 1999. Shaded areas show the approximate location of concentrations of observations of turtles believed to be Loggerhead Sea Turtles (a) collected by the participants of the Nova Scotia Leatherback Turtle Working Group, or (b) records from the pelagic longline bycatch plotted by Witzell (1999). Question marks indicate areas in need of further study. From McAlpine *et al*. 2007.

Pacific Ocean

There are no reports of Loggerhead Sea Turtles recorded in the Pacific Ocean off British Columbia (McAlpine *et al*. 2007, Spaven pers. comm. 2009). However, sightings of Loggerhead Sea Turtles off the coasts of Washington and Alaska suggest that they may occur in British Columbia occasionally (Hodge 1982; Bane 1992; Hodge 1992; Hodge and Wing 2000; McAlpine *et al*. 2007). The British Columbia Cetacean Sightings Network, which also maintains sightings of marine turtles, has records of 31 unidentified sea turtles (Spaven pers. comm. 2009; Wild Whales 2010). It is possible that some of these are Loggerhead Sea Turtles. However, current understanding of oceanic and neritic habitat for North Pacific Loggerhead Sea Turtles indicates the species only occurs south of Canadian waters. In oceanic zones, Loggerhead Sea Turtles are found south of 44ºN latitude (Kobayashi *et al*. 2008). In neritic zones off Pacific North America, they are found along the coast of Baja California Sur, Mexico (Bowen *et al*. 1995; Koch *et al*. 2006; Peckham and Nichols 2003; Peckham *et al*. 2007).

HABITAT

Habitat requirements

Loggerhead Sea Turtles use both terrestrial (nesting) and marine habitat.

Nesting habitat

Loggerhead Sea Turtles nest on ocean beaches and, infrequently, on estuarine shorelines. Nests are usually laid between the high-tide line and the dune front (Routa 1968; Witherington 1986; Hailman and Elowson 1992). Sea turtle eggs require beaches with high-humidity substrate that allows for sufficient gas exchange as well as temperatures conducive to egg development (Miller 1997; Miller *et al*. 2003). Loggerhead Sea Turtles do not nest in Canada (Figure 5). It is likely that Loggerhead Sea Turtles found in Canadian waters come from similar nesting stock as those Loggerhead Sea Turtles found in adjacent U.S. waters (NMFS and USFWS 1998; TEWG 2000; Bowen *et al*. 2005; DFO 2006; LaCasella *et al*. 2006; Bowen and Karl 2007; McAlpine *et al*. 2007; NMFS and USFWS 2007; Brazner and McMillan 2008; NMFS and USFWS 2008).

Nesting sites for Loggerhead Sea Turtles found in the northwest Atlantic are southern areas of Virginia, as well as in North Carolina, South Carolina, Georgia and Florida. There are also nesting sites found from the Caribbean coast of Mexico through French Guiana, the Bahamas, the Lesser Antilles and the Greater Antilles (Pearce 2001; Bowen 2003; Bowen and Karl 2007; NMFS and USFWS 2008, Conant *et al.* 2009; TEWG 2009). Approximately 80% of all nesting in the Atlantic Ocean occurs in Peninsular Florida (Figures 4 and 5), which also produces approximately 90% of all hatchlings (NMFS and USFWS 2008; TEWG 2009).

Loggerhead Sea Turtles found in the North Pacific nest almost exclusively in Japan (Bowen *et al*. 1995; Hatase *et al*. 2002*a*; Bowen 2003; Kamezaki *et al*. 2003; NMFS and USFWS 2007; LeRoux *et al*. 2008), with one report of low-level nesting in the Xisha Archipelago in the South China Sea (Chan *et al*. 2007). In Japan, nesting beaches are widely distributed from 24º N to 37º N latitude (Hatase *et al*. 2002*a*; Kamezaki *et al*. 2003). The three major nesting sites are Yakushima Island, and Miyazaki and Minabe beaches on the mainland (Kamezaki 2003) (Figure 5).

Marine habitat

Loggerhead Sea Turtles inhabit the temperate and tropical regions of the Atlantic, Pacific and Indian Oceans, and their use of the marine habitat includes both oceanic and neritic zones. Until recently, it was assumed that the species' choice of habitat was governed by discrete developmental shifts: Loggerhead Sea Turtles move from the oceanic zone they inhabit as juveniles to the neritic zone, where they remain permanently, making seasonal, latitudinal migrations between neritic feeding and breeding grounds (Carr 1987; Bjorndal *et al*. 2000; Snover 2002; Bolten 2003). However, recent research indicates that the shifts between habitats are not permanent (Hatase *et al*. 2002*a*; Bolten 2003; Ehrhart *et al*. 2003; Schroeder *et al*. 2003; Bass *et al*. 2004; Hawkes *et al*. 2006; McClellan and Read 2007; Casale *et al*. 2008; Kobayashi *et al*. 2008; Mansfield *et al*. 2009; Reich *et al*. 2010). Casale *et al*. (2008) suggest describing Loggerhead Sea Turtle life history not as a series of ontogenetic shifts and stages associated with oceanographic zones, but by the habitat individual animals frequent for feeding: epipelagic, benthic or both (Figure 8).

If Loggerhead Sea Turtles' habitat use is guided by oceanographic features and food availability (Polovina *et al*. 2000; Witherington 2002; Casale *et al*. 2008; Kobayashi *et al*. 2008), their use of the marine habitat may fluctuate as a result of climate change and associated increased sea surface temperatures (Chaloupka *et al*. 2008). The level to which Loggerhead Sea Turtles and their prey respond to thermal shifts in the marine environment is still poorly understood. However, some studies have documented a shift in nesting behaviour (earlier onset nesting and fewer clutches) occasioned by increased sea surface temperature (Chaloupka *et al*. 2008; Mazaris *et al*. 2008; Mazaris *et al*. 2009).

Atlantic Ocean

Post-hatchling Loggerhead Sea Turtles in the northwest Atlantic migrate offshore and become associated with convergence zones, such as *Sargassum* habitats and driftlines (Carr 1986; Witherington 2002). Loggerhead Sea Turtles use the North Atlantic gyre, and enter the northeast Atlantic and the Mediterranean Sea, including the waters around the Azores and Madeira (Carr 1987; Bolten 2003; Carreras *et al*. 2006; Eckert *et al*. 2008). Oceanic juveniles are also found in Canadian waters and in offshore waters adjacent to Canadian jurisdiction (Bleakney 1965; Ladzell 1980; Witzell 1999; Javitech 2002; Javitech 2003; Bowen *et al*. 2005; LaCasella *et al*. 2006; Ledwell 2007; McAlpine *et al*. 2007; Brazner and McMillan 2008; James pers. comm. 2009; Lawson pers. comm. 2009).

Juvenile Loggerhead Sea Turtles in neritic zones are found from Cape Cod Bay, Massachusetts south through the Gulf of Mexico. Estuarine waters in the United States comprise important inshore habitat (e.g., Long Island Sound, Chesapeake Bay, Pamlico and Core Sounds, Mosquito and Indian River Lagoons, Biscayne Bay, Florida Bay, and embayments fringing the Gulf of Mexico) (Conant *et al*. 2009).

Relatively enclosed, shallow water estuarine habitats with limited ocean access are less frequently used by non-nesting adult Loggerhead Sea Turtles in the neritic zone (Conant *et al*. 2009). Estuarine areas with more open ocean access (e.g., Chesapeake Bay) are used by both juveniles and adults (Conant *et al*. 2009). Shallow water habitat with large expanses of open ocean habitat (e.g., Florida Bay), provide important, year-round resident foraging areas for male and female adult Loggerhead Sea Turtles (Conant *et al*. 2009). Adult Loggerhead Sea Turtles primarily inhabit the continental shelf waters from New York south through the Gulf of Mexico in the offshore (Conant *et al*. 2009). There is also some evidence of seasonal use of mid-Atlantic shelf waters (Hawkes *et al*. 2007), and possibly also of Canadian waters (n=2) (Brazner and McMillan 2008).

Pacific Ocean

Important foraging areas for juvenile Pacific Loggerhead Sea Turtles include the waters of the central North Pacific, including the Kuroshio Extension Bifurcation Region (Polovina *et al*. 2004, 2006) and coastal waters of Baja California Sur, Mexico (Bowen *et al*. 1995; Pitman 1990; Nichols *et al*. 2000; Peckham and Nichols 2003; Peckham *et al*. 2007). The East China Sea is important habitat for post-nesting adult female Loggerhead Sea Turtles, who make seasonal breeding migrations between the feeding grounds and nesting beaches (Iwamoto *et al*. 1985; Kamezaki *et al*. 1997; Conant *et al*. 2009).

A 10-yr satellite-telemetry study of Loggerhead Sea Turtles (n=186) conducted in the North Pacific demonstrated that the animals occurred between 150ºE-130ºW longitude and 27ºN-44ºN latitude (Kobayashi *et al*. 2008). Loggerheads were found in water temperatures ranging from 14.45ºC to 19.95ºC and where surface chlorophyll *a* is between 0.11 mg/m^3 to 0.31 mg/m^3 (Kobayashi *et al*. 2008). Chlorophyll *a* preferences suggest that the Transition Zone Chlorophyll Front (TZCF) is an important Loggerhead Sea Turtle foraging habitat (Kobayashi *et al*. 2008). The TZCF is thought to be a zone of surface convergence that would concentrate the buoyant surface prey of Loggerhead Sea Turtles (Polovina *et al*. 2001; Parker *et al*. 2005; Kobayashi *et al*. 2008).

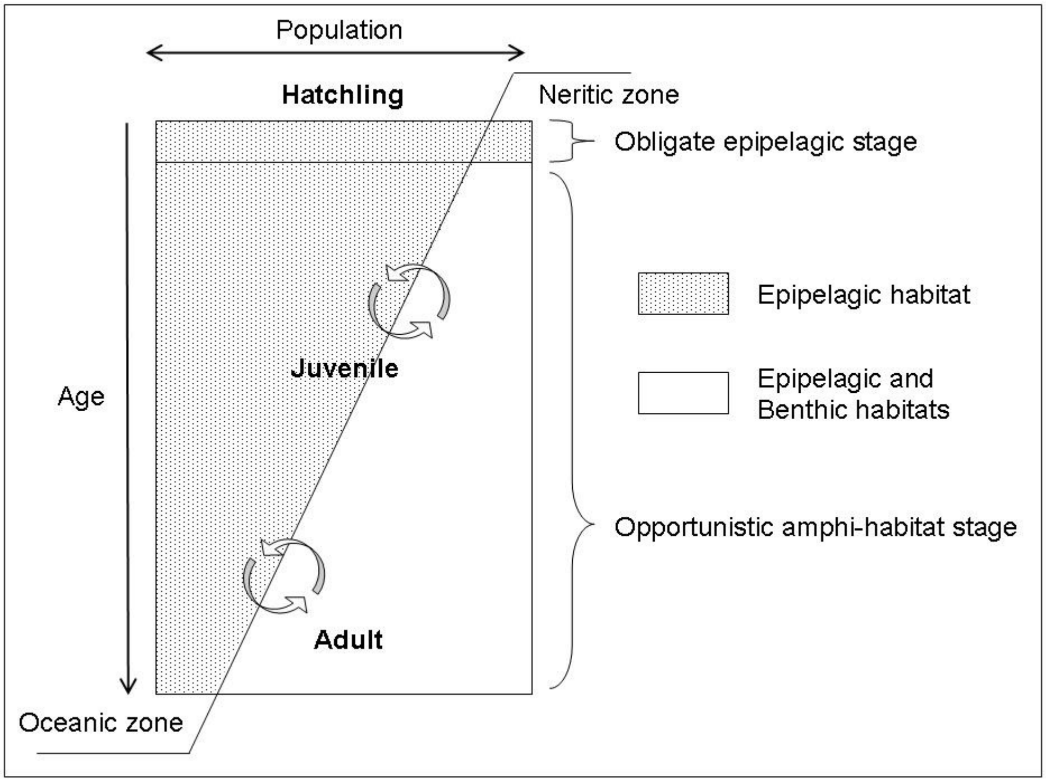

Figure 8. Loggerhead Sea Turtles: Developmental stages (juveniles vs. adults); ecological stages (obligatory epipelagic vs. opportunistic amphi-habitat); habitats (epipelagic vs. benthic); and oceanographic zones (oceanic vs. neritic). Rectangle width represents the total of the population at a given age. From Casale *et al*. 2008.

Habitat trends

The data required to determine habitat trends over the last three generations (>100 years) are not available. The following is a consideration of those factors that currently affect, or are likely to affect in the future, the loss of habitat area or quality. The factors affect both the North Atlantic and North Pacific populations of Loggerhead Sea Turtles. Although Loggerhead Sea Turtles do not nest in Canada, a discussion of the nesting habitat is relevant; Loggerhead Sea Turtles found in Canadian waters hatch and reproduce on nesting beaches.

Nesting habitat

The main factors affecting Loggerhead Sea Turtle nesting habitat are:

- Coastal development and construction, such as the construction of roads, buildings, harbours and breakwaters, alter nesting habitat to some degree, usually making it less suitable for nesting females, egg incubation and/or hatchling emergence (Mrosovsky *et al*. 1995; NMFS and USFWS 2008; Conant *et al*. 2009).
- Beachfront "armouring" (rigid structures placed parallel to the shoreline, such as seawalls, bulkheads, soil retaining walls, and sandbags) negatively impact nesting and hatchling success for Loggerhead Sea Turtles. Fewer Loggerhead Sea Turtles make nesting attempts on armoured beaches than on non-armoured beaches (Mosier 1998). Armoured structures can block a Loggerhead Sea Turtle's access to the upper areas of beach, causing them to nest at lower elevations than they would normally. This puts the nests at greater risk of repeated tidal inundation and erosion, which can alter thermal regimes and, thus, sex ratios (Mrosovsky and Provancha 1992; Mrosovsky 1994; Ackerman 1997; NMFS and USFWS 2008; Conant *et al*. 2009)
- Beachfront lighting associated with coastal development disorients hatchling Loggerhead Sea Turtles and disrupts their movement from their nests to the ocean (Witherington 1997). This increases mortality from dehydration, exhaustion, predation, and anthropomorphic causes such as vehicle strikes (Ehrhart and Witherington 1987; Witherington and Martin 1996).
- Coastal development can increase the number of people and vehicles on nesting beaches, causing sand compaction and nest trampling (Hosier *et al*. 1981; Cox *et al*. 1994; Hughes and Caine 1994; Kudo *et al*. 2003). Changes to the nesting environment from recreational beach equipment and debris affect where females can excavate nests as well as hatchlings' progress from nest to ocean (Hosier *et al*. 1981; Sobel 2002; Margaritoulis *et al*. 2007).
- Beach nourishment affects nesting success and the incubation environment. Although artificial beaches may provide more nesting habitat, their quality may be less suitable than natural beaches (Ackerman 1997; Milton *et al*. 1997; Ernest and Martin 1999; Conant *et al*. 2009). Increased sand compaction, formation of escarpments, and changes of beach profile can result from beach nourishment and have all been attributed to reduced nesting success in Loggerhead Sea Turtles (Nelson *et al*. 1987; Crain *et al*. 1995; Lutcavage *et al*. 1997; Steinitz *et al*. 1998; Ernest and Martin 1999; Rumbold *et al*. 2001).
- Removal of native vegetation through coastal development can cause beach erosion; native dune vegetation enhances beach stability and is an integral buffer between land and sea (NMFS and USFWS 2008; Conant *et al*. 2009).

- The planting or invasion of non-native vegetation that does not stabilize the beach environment can lead to increased erosion and the degradation of suitable nesting habitat (Schmelz and Mezich 1988). Taller plants can increase shading and alter natural sex ratios of hatchlings (Mrosovsky *et al*. 1995). Non-native plants may also form root mats that are so dense they prevent females from excavating nests properly and/or may trap hatchlings trying to emerge from nests (NMFS and USFWS 2008; Conant *et al*. 2009).
- Climate change will increase the erosion rate along nesting beaches as a result of factors such as rising sea levels, and the increase of storm frequency and/or changes in prevailing currents (Antonelis *et al*. 2006; Baker *et al*. 2006). In low-lying nesting areas, erosion will cause the sea to inundate nesting sites and decrease available nesting habitat (Daniels *et al*. 1993; Fish *et al*. 2005; Baker *et al*. 2006). In addition, climate change may also affect Loggerhead Sea Turtle sex ratios because the species exhibits temperature-dependent sex determination. Increasing global temperatures may result in warmer incubation temperatures and, therefore, highly female-biased sex ratios (Mrosovsky and Provancha 1992; Davenport 1997; Glen and Mrosovsky 2004; Hawkes *et al*. 2009).

<u>Marine habitat</u>

Factors that affect the quality of the Loggerhead Sea Turtle marine habitat include:

- Direct alteration of bottom habitat from activities such as bottom trawl and dredge fishing, channel dredging and sand extraction (Conant *et al*. 2009). The effects of trawling and dredging on the marine environment have been likened to the effects of clear cutting forests on the terrestrial environment (Watling and Norse 1998). There is evidence that mobile fishing gear results in short- and long-term changes to the composition of benthic communities, including species groups on which Loggerhead Sea Turtles forage (Gordon *et al*. 1998).
- Where foraging areas coincide with fishing zones, the incidental capture of Loggerhead Sea Turtles and/or the harvest of fish populations (affecting predator-prey interaction) change the ecosystem. Bycatch of Loggerhead Sea Turtles is the major threat to the species survival (see **Limiting Factors and Threats**). There is evidence that alterations in prey availability affect the Loggerhead Sea Turtle diet (Seney and Musick 2007).
- Indirect alteration of habitat by marine pollution, including contamination from herbicides, pesticides, chemical spills, oil spills, and tar balls, as well as direct sewage discharge (Vargo *et al*. 1986; Lutz and Lutcavage 1989; Lutcavage *et al*. 1995; Tomás *et al*. 2002; Conant *et al*. 2009).
- In all life stages, Loggerhead Sea Turtles ingest pieces of marine debris, such as plastic or Styrofoam (Lutcavage *et al*. 1997). Loggerhead Sea Turtles likely ingest these materials because they mistake them for prey items. The effect of ingesting marine debris can be lethal or non-lethal, and cause side effects that may increase the probability of death (Balazs 1985; Carr 1987; McCauley and Bjorndal 1999; Witherington 2002; Mrosovsky *et al*. 2009).

- Climate change and the associated rise in sea surface temperatures may result in trophic level alterations that could affect the abundance and/or distribution of Loggerhead Sea Turtle prey (Conant *et al*. 2009).

Habitat protection/ownership

The Loggerhead Sea Turtles' habitat in Canada receives some protection from the *Fisheries Act*. The federal government fulfills its constitutional responsibilities for sea coast and inland fisheries through the administration of the *Fisheries Act*. The Act provides Fisheries and Oceans Canada (DFO) with powers, authorities, duties and functions for the conservation and protection of fish and fish habitat (as defined in the *Fisheries Act*) essential to sustaining commercial, recreational and Aboriginal fisheries.

Loggerhead Sea Turtle habitat also receives some protection from the *Oceans Act*. The *Oceans Act* provides for DFO to establish Marine Protected Areas (MPAs) to protect and conserve important fish and marine mammal habitats, including some Loggerhead Sea Turtle habitat. The Gully Marine Protected Area, approximately 200 km off Nova Scotia (Department of Justice Canada 2004) includes some loggerhead habitat.

BIOLOGY

Life cycle and reproduction

Nesting

Loggerhead Sea Turtles nest on ocean beaches and occasionally estuarine shorelines. They seem to prefer relatively narrow, steeply-sloped, coarse-grained beaches, although nearshore contours may also influence nesting beach site selection (Provancha and Ehrhart 1987). Nesting takes place at night. Females exhibit strong fidelity for the nesting area where they hatched called "natal homing" (Bowen *et al*. 2005; Bowen and Karl 2007). They nest on a 2-3-year interval. During nesting years, they lay three to four clutches of approximately 112 eggs each with intervals of approximately 14 days between nesting events (Miller 1997). Nests are usually laid between the high-tide line and the dune front (Routa 1968; Witherington 1986; Hailman and Elowson 1992).

Stage 1: Egg to post-hatchling

Loggerhead Sea Turtle eggs hatch after 7-13 weeks of incubation depending on the temperature of the nest (Miller 1997), with a change of 1°C adding or subtracting approximately 5 days to the incubation period (Mrosovsky 1980). The warmer the sand surrounding the egg chamber, the faster embryos develop (Mrosovsky and Yntema 1980). Incubation period, hatchling success and size are influenced by the moisture conditions within the nest (McGehee 1990; Carthy *et al*. 2003).

The sex of hatchlings is dependent on the temperature of the nest; incubation temperatures above 29°C produce more or all females, and incubation temperatures below 29°C produce more or all males (Limpus *et al*. 1983, Mrosovsky *et al*. 1984; Mrosovsky 1988; Marcovaldi *et al*. 1997; Mrosovsky *et al*. 2002; Wibbels 2003). Other environmental factors (such as rainfall, moisture conditions, and shade) may directly or indirectly influence sex ratios (Mrosovsky *et al*. 1995; Godfrey 1997).

Hatchlings pip and escape from their eggs over a 1-3-day interval, and move upward and out of the nest over a 2-4-day interval (Christens 1990). The time from pipping to emergence ranges from 4-7 days (average=4.1 days) (Godfrey and Mrosovsky 1997). Hatchlings emerge at night, and use ambient light from the night sky to guide them to the ocean from their nest (Daniel and Smith 1947; Limpus 1971; Salmon *et al*. 1992; Witherington 1997; Witherington and Martin 1996; Stewart and Wyneken 2004). Immediately upon emergence, hatchlings begin a period of frenzied activity during which they move from their nest to the surf, swim, and are swept through the surf zone (Carr and Ogren 1960; Carr 1962; Carr 1982; Wyneken and Salmon 1992; Witherington 1995). Post-hatchlings spend their time in neritic waters, where they may stay for a period lasting from weeks to months (Witherington 2002; Bolten 2003). In contrast to hatchlings in the swim-frenzy stage, post-hatchling Loggerhead Sea Turtles are largely inactive, exhibiting only infrequent low-energy swimming, and they feed on a wide variety of floating items, such as the hydroids and copepods commonly associated with *Sargassum* (Witherington 2002).

Stage 2: Juvenile (1), exclusively oceanic

This oceanic juvenile stage begins when Loggerhead Sea Turtles first enter the oceanic zone, where they move with predominant ocean gyres for several years before returning to neritic foraging and nesting habitats (Pitman 1990; Bowen *et al*. 1995; Zug *et al*. 1995; Musick and Limpus 1997; Bolten 2003). Their movements in the oceanic stage are both active and passive relative to surface and subsurface oceanic currents and winds, and turtles may use bathymetric features for orientation (Bolten 2003). They feed primarily on sea jellies and other invertebrates (Bjorndal 1997; Witherington 2002; Frick *et al*. 2009).

The duration of the oceanic juvenile stage is variable, with individuals leaving the oceanic zone over a wide size range (15 cm-63 cm SCL, TEWG 2009) (Figure 3). Bjorndal *et al*. (2000) suggest that in the North Atlantic, recruitment out of the oceanic stage begins at 42 cm SCL. Estimates for the duration of the stage range from 7 to 11.5 years (Bjorndal *et al*. 2000; 2003) to 9 to 24 years (average=14.8 years) (Snover 2002). In the North Pacific, juveniles do not move to neritic habitats until they are larger than 60 cm SCL (Conant *et al*. 2009).

Stages 3 and 4: Juvenile (2,3), oceanic or neritic benthic juveniles

In neritic waters, Loggerhead Sea Turtles switch to a diet comprised mainly of hard-shelled, benthic invertebrates (Bjorndal 1997; Seney and Musick 2007). Genetic studies indicate that juvenile Loggerhead Sea Turtles recruit to habitat near their natal beaches, creating a modest population structure (Bowen *et al.* 2005). Small benthic juveniles (2) range from 41-82 cm SCL, and large benthic juveniles (3) range from 63-100 cm SCL (TEWG 2009) (Figure 3). Estimates for the duration of Stages 3 and 4 vary (for a summary, see Heppell *et al*. 2003*b*). Bjorndal *et al*. (2000) estimate the duration from recruitment to 87 cm curved carapace length is 13 to 20 years; Heppell *et al*. (2003a) estimate 14 to 24 years for growth from 45 to 92 cm SCL.

The shift to neritic waters is not unidirectional; some juveniles in neritic habitats may return to oceanic habitats, and some may never leave oceanic habitats except to reproduce (Eckert and Martins 1989; Hatase *et al*. 2002*a*; Bolten 2003; Ehrhart *et al*. 2003; Schroeder *et al*. 2003; Bass *et al*. 2004; Hawkes *et al*. 2006; McClellan and Read 2007; Casale *et al*. 2008; Kobayashi *et al*. 2008; Mansfield *et al*. 2009; Reich *et al*. 2010). Casale *et al*. (2008) describe Stages 3 and 4, as well as the adult life stage, as “opportunistic amphi-habitat stages” during which Loggerhead Sea Turtles choose habitat based on foraging opportunities (Figure 8).

Stage 5: Adult, neritic or oceanic

Recruitment to the adult stage ranges from 82 cm SCL, with full recruitment at 100 cm SCL (TEWG 2009) (Figure 3). Loggerhead Sea Turtles reach sexual maturity between 16 and 34 years of age, depending on the estimate as there is not consensus on this number (Crowder *et al*. 1994; Heppell *et al*. 1996; Parham and Zug 1997; Musick 1999; Dalhen *et al*. 2000; NMFS and SWFSC 2008), and their lifespan can be longer than 57 years (Dalhen *et al.* 2000; NMFS and SWFSC 2008). To estimate generation time, age at maturity is estimated by taking the mean of some published estimates. These estimates range from ~16-35 years. The mean of these is 25 years (but see Ernst and Lovich 2009, who state the range of estimates is 22-35 years). Similarly, natural mortality rate is not known, as most studies use estimates that include anthropogenic mortality sources and these are the main causes of adult mortality (e.g., fisheries bycatch). Therefore mortality rates of freshwater turtles are used as a proxy. These tend to be around 5% annually, and are often even lower (Ernst and Lovich 2009). Based on these estimates, generation time is calculated as: Gen Time = age at maturity + (1 + 1/annual rate of mortality) = 25 + (1 +1/0.05) = 25 +1 + 20 = 46 years. Another estimate using the TEWG 2009 estimate of 34 years age at maturity plus 12.5 (half of a reproductive lifespan estimated at 25 years, Pianka 1974; Dahlen *et al*. 2000), gives a generation time of 46.5 years (NMFS and USFWS 2008).

Neritic waters provide important foraging, inter-nesting and migratory habitat for adult Loggerhead Sea Turtles. However, adult Loggerhead Sea Turtles use both neritic and oceanic habitats (Hatatse 2002*a*; Hawkes *et al*. 2006; Reich *et al*. 2010) (Figure 8). In all three studies, females that foraged in oceanic habitats were smaller than those foraging in neritic habitats, although there was overlap (n=2) in body size in females from Japanese nesting colonies (Hatatse 2002*a*).

Male Loggerhead Sea Turtles never return to land after they hatch, so knowledge of their life history is hampered by access (Bowen and Karl 2007). Studies of nDNA indicate that Loggerhead Sea Turtles have a complex population structure, with male-mediated gene flow (Bowen and Karl 2007). This could be the result of male turtles not homing to their natal beach, or of mating occurring where populations overlap in feeding areas or migratory corridors (Bowen and Karl 2007). However, Bowen and Karl (2007) hypothesize that natal homing occurs in male Loggerhead Sea Turtles because it occurs in Green Sea Turtles (*Chelonia mydas*).

The sex ratios of juvenile and adult Loggerhead Sea Turtles are relatively poorly understood. Few rookeries have been rigorously studied over multiple years, methodologies are not standardized, and there are many variables at play (Mrosovsky 1994; Wibbels 2003; Conant *et al.* 2009). Conant *et al*. (2009) summarize available sex ratio data for North Atlantic Loggerhead Sea Turtles from all stages.

Physiology

Loggerhead Sea Turtles are ectothermic reptiles. As such, their thermal tolerances affect their distribution and behaviour. Their body temperatures only exceed ambient water temperature by a few degrees (3.8º) Celsius (Spotila and Standora 1985). Preferred temperatures for Loggerhead Sea Turtles range from 13.3ºC to 28ºC (Hopkins-Murphy *et al*. 2003). Kobayashi *et al*.'s (2008) study of Loggerhead Sea Turtles in the North Pacific notes their occurrence in water temperatures ranging from 14.45ºC to 19.95ºC.

Prolonged exposure to temperatures below 8 to 10ºC may cause cold stunning in Loggerhead Sea Turtles, a phenomenon in which disruption in the animal's metabolic pathways results in a loss of buoyancy and an inability to dive or swim (Witherington and Ehrhart 1989; Morreale *et al*. 1992; Spotila *et al*. 1997). Milton and Lutz (2003) suggest that it is the rate of cooling, rather than just the water temperature itself, that precipitates cold stunning. Cold stunning can be lethal.

One additional point of interest from Hawkes *et al*.'s (2007) satellite tracking study of Loggerhead Sea Turtles is that females made long resting dives of up to 7 h and 24 min, effectively hibernating during colder months. This behaviour was recorded from two animals, and suggests that large numbers of adult Loggerhead Sea Turtles "sit out" cold periods in the winter while exploiting the productive waters in higher latitudes.

Dispersal/migration

Hatchlings in the frenzy stage orient relative to the direction of the waves and the earth's magnetic field (Lohmann and Lohmann 2003). In the post-hatchling neritic stage, when turtles begin to feed, they are passive relative to the currents and winds (Bolten 2003). Turtles moving into the oceanic zone use both active and passive movements relative to surface and subsurface oceanic currents, winds, and bathymetric features (Bolten 2003). Juvenile turtles are capable of assessing their position in relation to a goal using local cues, and are, therefore, capable of map-based navigation (Avens and Lohmann 2004). General homing during the juvenile neritic stage (Bowen *et al*. 2005) and natal homing of adult nesting females, as well as data suggesting that post-nesting females make directed migrations (Schroeder *et al*. 2003), indicate that Loggerhead Sea Turtles in these stages are actively dispersing. Post-nesting females will also swim against prevailing currents and correct their course if they are displaced due to ocean currents (Schroeder *et al*. 2003).

Interspecific interactions

Bjorndal (2003) notes that there is little quantitative information on the interaction of Loggerhead Sea Turtles with their environment or with other species.

Hybridization

Molecular genetics have confirmed hybridization between the Loggerhead Sea Turtle and Kemp's Ridley Sea Turtle (*Lepidochelys kempii*) (Karl *et al.* 1995; Barber *et al.* 2003), the Loggerhead Sea Turtle and Hawksbill Sea Turtle (*Eretmochelys imbricata*) (Karl *et al.* 1995; Witzell and Schmid 2003), and the Loggerhead Sea Turtle and Green Sea Turtle (Karl *et al*. 1995; James *et al*. 2004).

Diet

The diet of oceanic stage Loggerhead Sea Turtles is poorly studied. The most comprehensive review is Bjorndal (1997), who considers the stomach contents of oceanic juveniles found in the Azores and Madeira. These contained salps (including *Pyrosoma atlanticum*), jellyfish (including *Pelagia noctiluca*), amphipods that associate with jellyfish (*Hyperia medusarum*), pteropods (*Hyalaea tridentata*), the crab *Nautilograpsus (=Planes) minutus*, the barnacle *Lepas anatifera*, sygnathid fish *Entelurus aequoreus*, squid, gastropods (including *Janthina* spp. and *Pterotrachea* spp.), and other pelagic coelenterates (primarily siphonophores). In the north Pacific, pelagic Loggerhead Sea Turtles primarily feed on gastropods (*Janthina* spp.) and *Velella velella*.

Natural predators

Predation of eggs and hatchlings occurs on almost all nesting beaches. The most common predators at the primary nesting beaches in the United States are Ghost Crabs (*Ocypode quadrata*), Raccoons (*Procyon lotor*), feral hogs (*Sus scrofa*), foxes (*Urocyon cinereoargenteus* and *Vulpes vulpes*), Coyotes (*Canis latrans*), Nine-banded Armadillos (*Dasypus novemcinctus*), and Red Fire Ants (*Solenopsis invicta*) (Stancyk 1982; Dodd 1988).

During the juvenile oceanic stage, Loggerhead Sea Turtles are depredated by large carnivorous fish or mammals found in that environment (Bjorndal 2003). Neritic juveniles and oceanic stage juveniles and adults are depredated by large sharks, including Tiger Sharks (*Galeocerdo cuvieri*), Bull Sharks (*Carcharhinus leucas*) and Great White Sharks (*Carcharodon carcharias*), and Killer Whales (*Orcinus orca*) (Compagno 1984; Witzell 1987; Fergusson *et al*. 2000; Simpfendorfer *et al*. 2001; Bjorndal 2003).

Neritic Loggerhead Sea Turtles in the Northwest Atlantic are also harmed by algal blooms such as a red tide. The species that causes most red tides is *Karenia brevis*. Although Loggerhead Sea Turtles that wash ashore alive during red tide events can recover from symptoms of acute brevitoxicosis (uncoordinated and lethargic despite an otherwise robust appearance), red tides (n=4) along the west coast of Florida have been the cause of Loggerhead Sea Turtle mortality (Redlow *et al*. 2003).

Adaptability

The lineage of the Loggerhead Sea Turtle stretches back more than 24 million years (Bowen 2003). This longevity is an indication of its ability to adapt to natural changes in both the marine and terrestrial environments it inhabits. However, the ability of Loggerhead Sea Turtles to survive anthropogenic threats is in doubt. The species is in decline worldwide and, given available information about anthropogenic threats to juveniles and adults in neritic and oceanic waters, it has the potential to continue to decline (Conant *et al*. 2009). Conant *et al*. (2009) determined that the Loggerhead Sea Turtles found in the northwest Atlantic Ocean and the North Pacific Ocean have a high likelihood of quasi-extinction. Quasi-extinction is a threshold at which the persistence of the species is in question, and in this case was determined using a risk index called “susceptibility to quasi-extinction” (Snover and Heppell 2009). (See **Fluctuations and Trends** and **Limiting Factors and Threats.)**

POPULATION SIZES AND TRENDS

Search effort

There is currently no direct stock assessment of Loggerhead Sea Turtles in Canadian waters. Data for abundance in Canadian waters have been compiled from: McAlpine *et al*. (2007); Ledwell (2007); Brazner and McMillan (2008); the Canadian Sea Turtle Sightings Database (2009); Lawson (pers. comm. 2009); and Spaven (pers. comm. 2009). The population and nesting trend status of nesting stocks contributing to, or most likely to contribute to, the Loggerhead Sea Turtles found in Canadian waters comes from three recent analyses conducted in the United States: Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (NMFS and USFWS 1998); An Assessment of the Loggerhead Turtle Population in the Western North Atlantic Ocean (TEWG 1999) and the Loggerhead Sea Turtle 2009 Status Review Under the Endangered Species Act (Conant *et al*. 2009). Their data were derived as follows:

<u>Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (NMFS and USFWS 1998)</u>

Although numbers of nests and nesting females have high annual variability, nesting beach surveys can provide a valuable assessment of changes in the adult Loggerhead Sea Turtle female population because individuals exhibit strong nest site fidelity (Bowen *et al*. 2005). The value of the assessment depends upon surveys conducted over a sufficiently long time and using standardized effort and methods (Meylan 1982; Gerrodette and Brandon 2000; Reina *et al*. 2002). Within a nesting season, the number of females is directly related to the number of nests deposited. Clutch frequency for Loggerhead Sea Turtles has been reported as 3 to 5.5 nests per female per season. The conversion from number of nests to number of nesting females is a simple division of nests divided by clutch frequency, calculated over the number of years of available data. Subpopulations are identified as Recovery Units defined as subunits of the species that are geographically or otherwise identifiable and essential to the recovery of the species. There are five Recovery Units for the northwestern Atlantic population of Loggerhead Sea Turtles (Figure 9):

1. Northern Recovery Unit (Florida/Georgia border through southern Virginia)
2. Peninsular Florida Recovery Unit (Florida/Georgia border through Pinellas County, Florida)
3. Dry Tortugas Recovery Unit (islands located west of Key West, Florida)
4. Northern Gulf of Mexico Recovery Unit (Franklin County, Florida, through Texas)
5. Greater Caribbean Recovery Unit (Mexico through French Guiana, The Bahamas, Lesser Antilles, and Greater Antilles)

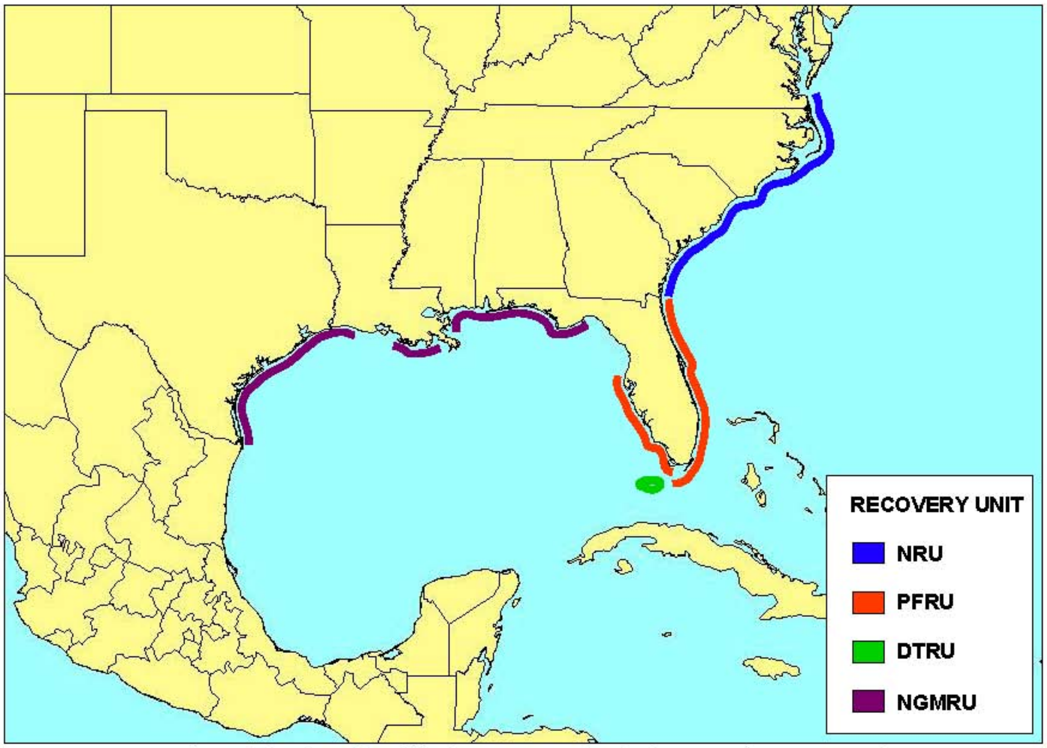

Figure 9. Location of the four identified Loggerhead Sea Turtle recovery units in the United States. NRU: Northern Recovery Unit; PFRU: Peninsular Florida Recovery Unit; DTRU: Dry Tortugas Recovery Unit; NGMRU: Northern Gulf of Mexico Recovery Unit. From NMFS and USFWS 2008.

<u>An Assessment of the Loggerhead Turtle Population in the Western North Atlantic Ocean (TEWG 1999)</u>

Population trends were estimated for Loggerhead Sea Turtles found in the Western North Atlantic based on nest census data that included only those beaches that were most consistently surveyed; these beaches tended to represent a majority of all nesting activity for each subpopulation. Subpopulations were defined as the five Recovery Units identified in NMFS and SWFSC (2008). Trends were estimated using both simple linear regression and Bayesian state-space modelling approaches.

Status Review Under the Endangered Species Act (Conant *et al*. 2009)

Populations for each Loggerhead Sea Turtle DPS (see "Designatable Units") were assessed using two independent analyses.

1. Risk of quasi-extinction. Quasi-extinction is a threshold at which the persistence of the species is in question, and in this case was determined using a risk index called "susceptibility to quasi-extinction" (Snover and Heppell 2009). The approach is based on stochastic projections of observed trends and variability in the numbers of mature females at various nesting beaches. The analysis is based on the available time-series data on the numbers of nests at nesting beaches.
2. Threat matrix analysis. This is a deterministic stage-based population model focused on determining the effects of known anthropogenic mortalities on each DPS with respect to the vital rates of the species. Anthropogenic mortalities were added to natural mortalities, and possible ranges of population growth rates were computed as another metric of population health. This analysis is based on the known biology of the species and anthropogenic mortalities independent of observed nesting beach data.

Data from Atlantic Canadian waters

McAlpine *et al*. (2007) summarized historical reports of Loggerhead Sea Turtles in Canadian waters, and introduced the first data on Loggerhead Sea Turtles from the Canadian Sea Turtle Network, which included Loggerhead Sea Turtle sightings from 1998-2000. This sighting information has been updated for this report (n=81) (CSTSD 2009). Sightings information in the CSTSD was obtained through a voluntary sea turtle reporting program targeting commercial fishers in Atlantic Canada (Martin and James 2005*a*). The data are limited not only to those who were aware of the program, but to those who were willing to call in what is a reluctant reporting climate (Martin and James 2005*b*). In addition the Loggerhead Sea Turtle was listed as a secondary species of interest to the program, with the majority of effort directed to raising awareness about the Leatherback Sea Turtle. The sightings themselves are limited by fishing effort.

Brazner and McMillan (2008) reviewed data recorded by the International Observer Program (IOP) about the Canadian Atlantic pelagic longline fleet from 1999-2006 (which includes information from Javitech 2002 and Javitech 2003) within Canada's Exclusive Economic Zone. Observer data from before 1999 were not reviewed because turtles were recorded only as "unspecified sea turtle," not by species. Observations from 1999-2000 were considered underestimates because only those turtles brought on board the boat were recorded when most of the turtles were released by line cutting over the side of the boat. Observer coverage (~10.6%) was estimated as the proportion of total commercial landings that were observed in a given year, season and region. Catch of Loggerhead Sea Turtles per unit of effort was estimated using the total landings from the fishery and the percentage of observer coverage. Difficulties in matching data from the IOP and total landings databases (e.g., estimated vs. actual weights, missing values) introduced bias into estimates of Loggerhead Sea Turtle bycatch; hence, bycatch estimates should be considered minimum numbers, with actual bycatch potentially considerably higher.

Data from Pacific Canadian waters

The British Columbia Cetacean Sightings Network, which also maintains sightings of marine turtles, has records of 31 unidentified sea turtles (Spaven pers. comm. 2009; Wild Whales 2010) some of which may be Loggerhead Sea Turtles. The British Columbia Cetacean Sightings Network is a network of over 1,800 observers across British Columbia, including whale watching operators, lighthouse keepers, charter boat operators, tugboat captains, BC Ferries personnel, researchers, government employees, recreational boaters and coastal residents (Wild Whales 2010). Observers report their sightings via the project website, toll-free line and logbook program (Wild Whales 2010).

Abundance

Northwest Atlantic Nesting Populations

The following estimates of numbers of nesting females (NF) at each Recovery Unit was calculated from the mean number of nests (NN) derived over a stated timeframe (NMFS and SWFSC 2008). Numbers of NF are approximate and are based on 4.1 nests per female.

Northern Recovery Unit: NF=1,272; NN=5,215 (1989-2008)
Peninsular Florida Recovery Unit: NF=15,735; NN=64,513 (1989-2007)
Dry Tortugas Recovery Unit: NF=60; NN=246 (1995-2004, excluding 2002)
Northern Gulf of Mexico Recovery Unit: NF=221; NN=906 (1995-2007)
Greater Caribbean Recovery Unit: Statistically valid analyses of long-term nesting trends are not available for this unit.

Atlantic Canadian Population

There has been no formal scientific study of the abundance of Loggerhead Sea Turtles in Canadian waters.

Loggerhead Sea Turtles (n=701) in Canadian waters were reported by the International Observer Program. Those animals were incidentally captured by the Canadian Atlantic pelagic longline fleet from 1999-2006 within the Canadian Exclusive Economic Zone, and were found concentrated in offshore areas along the Western Scotian Shelf and Georges Bank off Nova Scotia, and near the Grand Banks off Newfoundland (Brazner and McMillan 2008). Given the degree of IOP coverage (~10.6%), Brazner and McMillan (2008) estimate the incidental catch for the fishery as a whole during that time period was 9,592 Loggerhead Sea Turtles (average=1,199 annually).

The CSTSD has 81 records of Loggerhead Sea Turtles from 1997-2009. The structure of data collection in this instance does not allow for extrapolation to the total number of Loggerhead Sea Turtles in Canada, though it does support the seasonal presence of the species in Canadian waters (Martin and James 2005a; James *et al*. 2006).

Sightings and observer data collected to date suggest a seasonal population of juvenile Loggerhead Sea Turtles in Atlantic Canada, as does the presence of Loggerhead Sea Turtles in contiguous American waters (Ladzell 1980; Witzell 1999; Javitech 2002; Bolten 2003; Ehrhart *et al*. 2003; Javitech 2003; Ledwell 2007; McAlpine *et al*. 2007; Brazner and McMillan 2008; CSTSD 2009; James pers. comm. 2009; Lawson pers. comm. 2009). Although COSEWIC criteria usually focus on the number of mature adults in a population, it is important not to underestimate the importance of the juvenile life stage in Loggerhead Sea Turtles to the species' survival. Mixed-stock analyses of juvenile Loggerhead Sea Turtles indicate that individuals from genetically distinct nesting assemblages mix extensively in oceanic habitats (Bowen *et al*. 2005; Bowen and Karl 2007). Therefore, impacts on this population reverberate throughout the nesting habitat (Bowen *et al*. 2005; Bowen and Karl 2007; Brazner and McMillan 2008; Alfaro Shigueto *et al*. 2008; Mansfield *et al*. 2009). Using a stage-based matrix model, Crouse *et al*. (1987) noted that improving survivorship of the large juvenile and adult stages appeared far more effective in ensuring population maintenance and growth than did increases in egg survivorship or fecundity. Following on this study, Crowder *et al*. (1994) calculated stage-specific reproductive values:

- Transition from eggs/hatchlings to small juveniles = 40% increase in reproductive value
- Transition from small juveniles to large juveniles increases reproductive value 4.4x

- Transition from large juveniles to sub-adults increases reproductive value more than 14.3x
- Transition from sub-adult to adult increases reproductive value an additional 2.8x

North Pacific Nesting Population

Nesting beaches in Japan, which are the primary contributors to the North Pacific Loggerhead Sea Turtle population, host approximately 2,000 mature females annually (Conant *et al*. 2009).

Pacific Canadian Population

Abundance of Loggerhead Sea Turtles in Pacific Canada is low; there are no confirmed sightings of Loggerhead Sea Turtles in Pacific Canada (McAlpine *et al*. 2007, Spaven pers. comm. 2009). However, sightings of Loggerhead Sea Turtles off the coasts of Washington and Alaska suggest that they may occur in British Columbia occasionally (Hodge 1982; Bane 1992; Hodge 1992; Hodge and Wing 2000; McAlpine *et al*. 2007). Sightings of unidentified sea turtles (n=31) by the British Columbia Cetacean Sightings Network may include Loggerhead Sea Turtles (Spaven pers. comm. 2009; Wild Whales 2010). However, current understanding of oceanic and neritic habitat for North Pacific Loggerhead Sea Turtles indicates the animals occur south of Canadian waters. In oceanic zones, they are found south of 44ºN latitude (Bowen *et al*. 1995; Koch *et al*. 2006; Peckham and Nichols 2003; Peckham *et al*. 2007; Kobayashi *et al*. 2008).

Fluctuations and trends

Current data on Loggerhead Sea Turtles in the Canadian context are insufficient to determine fluctuations and trends in the population. It is relevant to use trends from nesting beaches known to, or most likely to, contribute to the Loggerhead Sea Turtles found in Canadian waters as proxies. Generation time for Loggerhead Sea Turtles is estimated at 46 years (50 years according to NMFS and USFWS 2008). Trends for both the northwest Atlantic and north Pacific populations of Loggerhead Sea Turtles are declining (NMFS and USFWS 2008; Conant *et al*. 2009; TEWG 2009).

Northwest Atlantic

Results from both the Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (NMFS and USFWS 1998), and An Assessment of the Loggerhead Turtle Population in the Western North Atlantic Ocean (TEWG 1999) are included. Numbers represent annual decline rates.

1. Northern Recovery Unit:

   - 1.3% (1989-2008) (NMFS and USFWS 2008)
   - 1.4% - 1.7% (1983-2005) (TEWG 2009)

2. Peninsular Florida Recovery Unit:

   - 1.6% (1989-2008); this represents a decrease of 26% and a 41% decline since 1998 (NMFS and USFWS 2008)
   - 1.4% - 2.6% (1989-2007); if only the last 10 years of data (1998-2008) are considered, the data suggest a more rapid decline of 6.4% - 9.1 % (TEWG 2009)
   - Note: Approximately 80% of all nesting in the Atlantic Ocean occurs in Peninsular Florida (Figures 4 and 5), which also produces approximately 90% of all hatchlings (NMFS and USFWS 2008; TEWG 2009). Table 1 shows Loggerhead Sea Turtle nesting totals (1989-2009) collected from index beaches in Florida as part of the Fish and Wildlife Research Institute’s Index Nesting Beach Survey (Florida FWC 2010).

Table 1. Loggerhead Sea Turtle nesting totals (1989-2009) collected from index beaches in Florida as part of the Fish and Wildlife Research Institute's Index Nesting Beach Survey (INBS) (Florida FWC 2010). The INBS program uses standardized data-collection criteria to measure seasonal nesting, and to allow accurate comparisons between beaches and years. The Florida Fish and Wildlife Conservation Commission (FWC) coordinates INBS data collection through a network of permit holders consisting of federal, state, and local park personnel, other government agency personnel, members of conservation organizations, university researchers, and private citizens. Fish and Wildlife Research Institute (FWRI) staff members coordinate data collection, provide training, and compile annual survey data for publication and dissemination. INBS nest counts represent approximately 69% of known Loggerhead Sea Turtle nesting in Florida. Under the core INBS program, 320 km of nesting beach are divided into zones (average = 0.8 km long). Each year (from 1989 to 2009) the index zones are monitored daily during the 109-day sea turtle index-nesting season (May 15 to August 31). On all index beaches, researchers record nests and nesting attempts by species, nest location and date.

Year	Total Nests
1989	39,083
1990	51,412
1991	53,899
1992	48,873
1993	42,691
1994	52,281
1995	59,381
1996	54,559
1997	44,686
1998	61,298
1999	58,273
2000	57,901
2001	47,681
2002	39,651
2003	41,509
2004	30,680
2005	35,202
2006	32,274
2007	29,044
2008	39,788
2009	33,773

3. Dry Tortugas Recovery Unit:

- There are 9 years of data for this recovery unit, but there is no trend in nesting numbers at this stage (NMFS and USFWS 2008).
- Trend analyses indicated a high likelihood of a declining annual number of nests (TEWG 2009).

4. Northern Gulf of Mexico Recovery Unit

- Evaluation of long-term trends are difficult because of changed and expanded beach coverage. A log-linear regression showed a significant annual decline of 4.7% (1997-2008) (NMFS and USFWS 2008).

- Trend analyses indicated a likely decline in numbers of nests per year at the index beaches from 1997-2007; however, these index beaches represented only 17% of overall Loggerhead Sea Turtle nesting in this area, and may not be a true indicator of a trend. However, the annual numbers of Loggerhead Sea Turtle nests for the entire Florida Panhandle during the period of 1997-2006 indicated a similar decline (TEWG 2009).

5. Greater Caribbean Recovery Unit:

- Statistically valid analyses of long-term nesting in this region are not available (NMFS and USFWS 2008; TEWG 2009).

Conant *et al*. (2009) calculated a declining trend for the Northwest Atlantic DPS among the Recovery Units for which it had sufficient data (Northern Recovery Unit; Peninsular Florida Recovery Unit; Northern Gulf of Mexico Recovery Unit, and Greater Caribbean Recovery Unit). On Mar 10, 2010, The National Marine Fisheries Service and the U.S. Fish and Wildlife Service issued a proposed rule to change the status of North Pacific and Northwest Atlantic Loggerhead Sea Turtles from “threatened” to “endangered” under the *Endangered Species Act*. The NMFS and USFWS also proposed listing loggerheads around the globe as nine separate populations, each with its own threatened or endangered status.

<u>North Pacific</u>

Data exist for some Japanese nesting beaches back to the 1950s and clearly indicate a significant population decline (Kamezaki *et al*. 2003). Data from the 1970s suggest a period of population stability for nesting females. In the 1980s, there were increases in nesting numbers. The 1990s, however, was a period of consistent decline in annual nesting, dropping numbers below those from the early 1980s. Two beaches in particular suffered major declines: Hiwasa (89% decline) and Minabe (74% decline). The lowest nesting numbers recorded for most beaches were during 1997-1999. (All data on Pacific nesting from Kamezaki *et al*. 2003.) Snover (2008) recently confirmed a general downward nesting trend in Japanese nesting beaches from 1989 (between 6,000-7,000 nests) and 2007 (between 3,000-4,000 nests).

Conant *et al*. (2009) calculated a high susceptibility to quasi-extinction (SQE) for both the North-west Atlantic and the North Pacific Ocean DPS. SQE for Loggerhead Sea Turtles was given a value of 0.3. The North Pacific DPS reached SQE = 0.3 at approximately 3% of the current female abundance. In each DPS, the threshold of SQE = 0.3 was reached at QET < 0.3, indicating high likelihood of quasi-extinction over a wide range of QET values (Conant *et al*. 2009).

Rescue effect

Loggerhead Sea Turtle populations worldwide are in decline and have the potential to decline in the future. As noted above, Conant *et al*. (2009) argue that the northwest Atlantic and north Pacific populations have reached the quasi-extinction threshold.

The highly-migratory behaviour of Loggerhead Sea Turtles makes them a shared resource among many countries. Therefore, international conservation efforts are interdependent (NMFS and USFWS 2008). The loss of any of the world's discrete population segments (n=9) would result in a significant gap in the range of the taxon (Hatase 2002*b*; Conant *et al*. 2009).

In the Atlantic Ocean, Canada hosts a juvenile population of Loggerhead Sea Turtles (Ladzell 1980; Witzell 1999; Javitech 2002; Bolten 2003; Ehrhart *et al*. 2003; Javitech 2003; Ledwell 2007; McAlpine *et al*. 2007; Brazner and McMillan 2008; CSTSD 2009; James pers. comm. 2009; Lawson pers. comm. 2009). Mixed-stock analyses of juvenile Loggerhead Sea Turtles indicate that individuals from genetically distinct nesting assemblages mix extensively in oceanic habitats (Bowen *et al*. 2005; Bowen and Karl 2007). Juvenile Loggerhead Sea Turtles have the highest reproductive value to the species (Crowder *et al*. 1994). Mansfield *et al*. (2009) note that "localized sources of mortality affecting juvenile loggerheads will ultimately translate to population impacts among all USA loggerhead subpopulations." Crowder (2000) and Lewison *et al*. (2004) discuss the responsibility of nations whose pelagic longline fisheries, like Canada's, take Loggerhead Sea Turtles as bycatch; they state, "the basin-wide distributions of both pelagic longline effort and sea turtles…suggest that effective protection for loggerheads and leatherbacks will require coordinated international action." The importance of conserving the population of Loggerhead Sea Turtles found in Atlantic Canadian waters should not be underestimated.

LIMITING FACTORS AND THREATS

The life history of the Loggerhead Sea Turtle requires any threat analysis to consider not only each of its life stages, but also the various habitats it uses, regardless of the many political boundaries it crosses. For example, Loggerhead Sea Turtles do not come onto land in Canada; however, threats to their survival in the terrestrial environment in other countries directly affect individuals for which Canadian waters provide marine habitat. Also, a major limit for this species is its slow rate of recruitment as it has a late age of maturity, nests only once every 2-3 years, has a high rate of egg and hatchling mortality and demonstrates a high sensitivity by adult and late stage juveniles to even small, chronic changes in survivorship (Crouse *et al*. 1987; Crowder *et al*. 1994; Heppell *et al*. 1996, 2003a, 2003b).

Northwest Atlantic Population

The authors of the Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (NMFS and USFWS 2008) undertook an exhaustive analysis of threats facing the turtles in each life stage. The threats were divided into seven major categories: fisheries bycatch, resource use (non-fisheries), construction and development, ecosystem alterations, pollution, species interactions, and other factors (such as climate change). Each of these was broken into a detailed list of threats (n=59; Table 2) and then adjusted for the annual mortality in number of adult females. Table 3 is the key used to assign annual mortality to each threat category, and Tables 4 and 5 are the summaries of this analysis (NMFS and USFWS 2008). Appendix 1 includes the complete set of threat tables created by NMFS and USFWS (2008). Threats that affect Loggerhead Sea Turtle habitat are also discussed in detail in the "**Habitat Trends**" section of this report.

Table 2. Detailed list of threats facing Loggerhead Sea Turtles in the northwest Atlantic as compiled by NMFS and USFWS (2008).

Category	Threat	Description
Fisheries Bycatch	Bottom trawl	Includes bottom trawl fisheries for blue crab, flounder, general finfish, scallop, shrimp, whelk, and the North Carolina flynet fishery for weakfish
	Top/midwater trawl	Includes trawls for sargassum and cannonball jellyfish
	Dredge	Includes dredge fisheries for scallops and whelk
	Pelagic longline	Includes longline fisheries for shark, swordfish, tuna and wahoo
	Demersal longline	Includes longline fisheries for black scabbard and shark
	Demersal, large mesh gillnet	Includes gillnet fisheries for black drum, dogfish, monkfish, shark, and southern flounder
	Demersal, small mesh gillnet	Includes gillnet fisheries for general finfish
	Drift gillnet	Includes drift gillnet fisheries for shark, swordfish, and tuna
	Pound nets and weirs	
	Pot/trap fisheries	Includes pot fisheries for blue crab, lobster, stone crab, and whelk
	Haul seine	
	Channel net	
	Purse seine	Includes purse seines for menhaden and tuna
	Other hook and line (recreational)	
	Other hook and line (commercial)	Includes commercial hook and line fisheries for snapper/grouper, Gulf reef fish, king and Spanish mackerel and sharks
Resource Use (non-fisheries)	Legal harvest	
	Illegal harvest	
	Oil and gas activities	

Category	Threat	Description
	Vessel strikes	
	Beach cleaning	
	Human presence	
	Recreational beach equipment	
	Beach vehicular driving	
	Power generating activities	
	Conservation/research activities	Includes harassment of nesting females and hatchlings, handling of eggs, etc.
	Military activities	
	Salvage operations	
Construction and Development	Beach sand placement	Includes beach nourishment, beach restoration, and inlet sand bypassing
	Beach armouring	Includes bulkheads, seawalls, soil retaining walls, rock revetments, sandbags, and geotextile tubes
	Other shoreline stabilizations	Includes groins, jetties, mesh groins (nets), and offshore breakwaters
	Sand fences	
	Dredging	
	Storm-water outfalls	
	Coastal construction	Refers to buildings on the coast
	Channel blasting	
	Bridge blasting	
Ecosystem Alterations	Trophic changes from fishing activities	E.g., bottom trawling
	Trophic changes from benthic habitat alteration	
	Beach erosion (washouts) and accretion	
	Aquaculture	
	Eutrophication	
Pollution	Marine debris ingestion	
	Marine debris entanglement in derelict fishing gear	
	Marine debris entanglement in non-fishing gear	
	Beach debris	Includes large items that can impede or trap hatchlings and/or nesting females
	Oil pollution	
	Light pollution	
	Noise pollution	
	Thermal pollution	Including from power plants
	Chemical pollution	
Species Interactions	Predation	
	Disease and parasites	
	Harmful algal blooms	
	Predation by exotic species	
	Exotic dune and beach vegetation	
Other Factors	Climate change	
	Natural catastrophes	
	Cold water	
	Other (egg stage only)	Includes root damage, disease events, infertile eggs, relocation mortality, and inundation

Table 3. Key used to assign estimated annual mortality to each threat category (Table 2). Taken from NMFS and USFWS (2008).

KEY		
Estimated Annual Mortality	**Color Code**	**Value**
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)	(stippled)	
> 0 Mortality has been documented or is likely to occur; however, data are insufficient to estimate mortality	(gray)	1
1-10	(yellow)	3
11-100	(light orange)	30
101-1000	(orange)	300
1001-10,000	(red)	3,000
10,001-100,000	(dark red)	30,000
100,001-1,000,000	(black)	300,000

Table 4. Annual mortality for each life stage and ecosystem for each threat category (Table 2) adjusted by relative reproductive equivalents. This table does not include sub-lethal effects. Estimates are based on the colour-coded scale (Table 3). Taken from NMFS and USFWS (2008).

LIFE STAGE	ECOSYSTEM	FISHERIES BYCATCH	RESOURCE USE (NON-FISHERIES)	CONSTRUCTION AND DEVELOPMENT	ECOSYSTEM ALTERATIONS	POLLUTION	SPECIES INTERACTIONS	OTHER FACTORS
Nesting female	Terrestrial Zone							
Egg	Terrestrial Zone							
Hatchling stage	Terrestrial Zone							
Swim frenzy, transitional stage	Neritic Zone							
Juvenile stage	Oceanic Zone							
Adult stage	Oceanic Zone							
Juvenile stage	Neritic Zone							
Adult stage	Neritic Zone							

Table 5. Annual mortality for each threat within a threat category (Table 2) summed for all life stages and ecosystems, and adjusted for relative reproductive values for each. This table does not include sub-lethal effects. Estimates are based on the colour-coded scale (Table 3). Taken from NMFS and USFWS (2008).

THREAT CATEGORY	SPECIFIC THREAT WITHIN A THREAT CATEGORY														
Other Factors	Climate change	Natural catastrophes	Cold water	Other (egg stage only)											
Species Interactions	Predation by native species	Disease and parasites	Harmful algal blooms	Predation by exotic species	Exotic dune and beach vegetation										
Ecosystem Alterations	Trophic changes from fishery harvest	Trophic changes from benthic habitat alteration	Beach erosion [illegible] and accretion	Aquaculture	Eutrophication										
Pollution	Marine debris ingestion	Marine debris entanglement in derelict fishing gear	Marine debris entanglement in non-fishing gear	Beach debris	Oil pollution	Light pollution	Noise pollution	Thermal pollution	Chemical pollution						
Construction and Development	Beach sand placement	Beach armoring	Other shoreline stabilizations	Sand fences	Dredging	Stormwater outfalls	Coastal construction	Channel blasting	Bridge blasting						
Resource Use (non-fisheries)	Legal harvest	Illegal harvest	Oil and gas activities	Vessel strikes	Beach cleaning	Human presence	Recreational beach equipment	Beach vehicular driving	Power plant entrainment	Conservation/ research activities	Military activities	Salvage operations			
Fisheries Bycatch	Trawl (bottom)	Trawl (top/ midwater)	Dredge fisheries	Longline (pelagic)	Longline (demersal)	Gillnet (demersal, lg. mesh)	Gillnet (demersal, sm. mesh)	Gillnet (drift)	Pound nets and weirs	Pot/trap fisheries	Haul seines	Channel net	Purse seine	Other hook & line (recreational)	Other hook & line (commercial)

Northwest Atlantic Population: Threats in Canadian waters

Bycatch

The primary documented threat to Loggerhead Sea Turtles in Canadian waters is the pelagic longline fishery (DFO 2006; McAlpine *et al*. 2007; Brazner and McMillan 2008; CSTSD 2009). Given our current understanding of the distribution of Loggerhead Sea Turtles in Canadian waters, this is likely the only fishery that poses a threat at this time (DFO 2005; James pers. comm. 2009). However, bottom trawl, gillnet, dredge, pot, trap or seining fisheries would pose a threat if they were to operate in waters where Loggerhead Sea Turtles are present (NMFS and USFWS 2008).

Loggerhead Sea Turtles (n=701) were reported by the International Observer Program (IOP) as incidentally captured by the Canadian Atlantic pelagic longline fleet from 1999-2006 within the Canadian Exclusive Economic Zone. The turtles were found concentrated in offshore areas along the Western Scotian Shelf and Georges Bank off Nova Scotia, and near the Grand Banks off Newfoundland (Brazner and McMillan 2008). As noted earlier (**Abundance**), the incidental catch for the fishery as a whole during that period averaged 1,199 annually, a substantial number given the estimate of total adult females nesting annually in the Northwest Atlantic was only ~17,000 (NMFS and SWFSC 2008).

A direct comparison between bycatch of Canadian Loggerhead Sea Turtles in the Atlantic pelagic longline fishery and the bycatch in the American pelagic longline fishery is not published. However, the most recent data on Loggerhead Sea Turtle takes from the observed U.S. pelagic longline fishery (observer coverage ~8%) are: 2004 (n=734) (Garrison 2005); 2005 (n=274) (Fairfield-Walsh and Garrison 2006); 2006 (n=561) (Fairfield-Walsh and Garrison 2007); 2007 (n=542) (Fairfield and Garrison 2008); and 2008 (n=772) (Garrison *et al*. 2009).

Quantifying the impact of this take on a population scale is difficult. In general, there is inadequate information to assess the size and status of the Loggerhead Sea Turtle stock. There is also insufficient information on the impact of foreign fisheries and other sources of mortality on this population (Lewison *et al*. 2004). Nonetheless, the significance of bycatch of juvenile Loggerhead Sea Turtles should not be underestimated (Crowder 2000; Lewison *et al*. 2004; Brazner and McMillan 2008; Mansfield *et al*. 2009). Mixed-stock analyses of juvenile Loggerhead Sea Turtles indicate that turtles from genetically distinct nesting assemblages mix extensively in oceanic habitats (Bowen *et al*. 2005; Bowen and Karl 2007). Juvenile Loggerhead Sea Turtles have the highest reproductive value to the species (Crowder *et al*. 1994). Therefore, longline and other fisheries capturing significant numbers of Loggerhead Sea Turtles per year may deplete some source populations throughout the region (Lewison *et al*. 2004; Bowen *et al*. 2005; Bowen and Karl 2007; Brazner and McMillan 2008; Alfaro Shigueto *et al*. 2008; Mansfield *et al*. 2009).

The literature on mitigation strategies as they apply to the United States pelagic longline fishery is extensive (e.g., Epperly and Boggs, 2004; Watson *et al*. 2005; Gilman *et al*. 2006), highlighting the usefulness of manipulating hook, gear type, and gear depth. In 2004, U.S. pelagic longline fleets switched from using primarily J-hooks to exclusively using 16/0- and 18/0-sized circle hooks. Although bycatch of Loggerhead Sea Turtles dropped in 2005, it has since rebounded to a level only slightly lower than pre-regulation period (Fairfield-Walsh and Garrison 2007; Fairfield and Garrison 2008; Garrison *et al*. 2009). Additional years of data are necessary to fully assess the impacts of these efforts to reduce Loggerhead Sea Turtle bycatch in the pelagic longline fishery (Fairfield-Walsh and Garrison 2007; Brazner and McMillan 2008; Fairfield and Garrison 2008; Garrison *et al*. 2009). Brazner and McMillan (2008) suggest that setting longlines on the cooler side of oceanic fronts might reduce Loggerhead Sea Turtle bycatch. Educating fishers about handling, dehooking, and release techniques is also an important measure in reducing post-hooking mortality (Martin and James 2005*b*; Ryder *et al*. 2006; Brazner and McMillan 2008).

<u>Pollution</u>

Loggerhead Sea Turtles ingest debris when it is mistaken for, or associated with, prey items. The effects can be lethal or non-lethal directly but also can have side effects that may increase probability of death (Balazs 1985; Carr 1987; McCauley and Bjorndal 1999; Witherington 2002; Mrosovsky *et al*. 2009). Side effects happen, for example, when non-nutritive debris replaces food in the gut; nutrient dilution occurs that may decrease somatic growth and reproduction (McCauley and Bjorndal 1999).

<u>Offshore oil and gas production</u>

Sea turtles at all life stages appear to be highly sensitive to oil spills, with effects including increased egg mortality; developmental defects; direct mortality due to oiling; impacts on the skin, blood, salt glands, and digestive and immune systems (Milton *et al*. 2003). Activities associated with offshore oil and gas production, including operational discharge (affecting water quality), seismic surveys, explosive platform removal, platform lighting and noise from drill ships and production activities are also known to impact Loggerhead Sea Turtles (Viada *et al*. 2008; Conant *et al*. 2009). Effects range from non-injurious (e.g., acoustic annoyance, mild tactile detection or physical discomfort) to non-lethal and lethal injuries (Viada *et al*. 2008). However, research in this area is still limited.

Climate change

Climate change and sea level rise have the potential to impact Loggerhead Sea Turtles in the marine environment, resulting in trophic level alterations that could affect the abundance and/or distribution of Loggerhead Sea Turtle prey (Chaloupka *et al*. 2008; Conant *et al*. 2009; Mazaris *et al*. 2009). Female Loggerhead Sea Turtles require at least a year to acquire sufficient fat stores necessary for reproduction as well as for the necessary energy required for migration. Cooler ocean temperatures are generally associated with increased productivity; a lag in productivity due to warmer temperatures can lead to reduced nesting and recruitment (Chaloupka *et al*. 2008; Mazaris *et al*. 2009).

North Pacific Population

Unfortunately, no exhaustive analysis of threats of the kind that exists for the northwest Atlantic population of Loggerhead Sea Turtles (NMFS and USFWS 2008) exists for the North Pacific population of Loggerhead Sea Turtles. Pacific Loggerhead Sea Turtles face many of the same threats as their counterparts in the northwest Atlantic. The following is an overview of primary threats based on available research for the North Pacific Loggerhead Sea Turtle population.

North Pacific Population: Terrestrial environment

Coastal development has reduced the habitat available for eggs and hatchlings in Japanese nesting colonies (Suganuma 2002; Kamezaki *et al*. 2003; Kudo *et al*. 2003). Coastal development includes building sea walls, dams and/or erosion control structures; removing sand and/or native vegetation from beaches; planting non-native vegetation on the beaches; as well as increasing beachfront lighting and vehicular and pedestrian traffic. (See detailed explanation for each of these threats in “**Habitat Trends**.”) Unfortunately, there are no quantitative studies to determine the direct impact of these threats on Pacific Loggerhead Sea Turtle nesting populations (Kamezaki *et al*. 2003). Nonetheless, it is clear that nesting habitat has been impacted by these factors, which have contributed to unusually high mortality of eggs and pre-emergent hatchlings (Matsuzawa 2006). Beach debris also contributes to the deaths of hatchlings and nesting adults (Conant *et al*. 2009).

Egg harvesting of Loggerhead Sea Turtles no longer presents a problem in Japan (Kamezaki *et al*. 2003; Takeshita 2006). However, in northwestern Mexico, sea turtles are killed for human consumption despite a federal ban on turtle hunting and trade (Gardner and Nichols 2001; Nichols 2003). Sea turtles that are retrieved dead as bycatch are usually discarded; in general, only live turtles are retained or hunted for personal consumption or black market sale (Nichols 2003; Nichols and Safina 2004). Peckham *et al*. (2008) estimate Loggerhead Sea Turtle mortality due to human consumption (n=~50/year at a minimum), and indicate a need for further research to understand its effects on the population.

Climate change will increase the erosion rate along nesting beaches as a result of factors such as rising sea levels, and the increase of storm frequency and/or changes in prevailing currents (Antonelis *et al*. 2006; Baker *et al*. 2006). In low-lying nesting areas, erosion will cause the sea to inundate nesting sites and decrease available nesting habitat (Daniels *et al*. 1993; Fish *et al*. 2005; Baker *et al*. 2006). In addition, climate change may also affect Loggerhead Sea Turtle sex ratios because the species exhibits temperature-dependent sex determination. Increasing global temperatures may result in warmer incubation temperatures, and therefore, highly female-biased sex ratios (Mrosovsky and Provancha 1992; Davenport 1997; Glen and Mrosovsky 2004; Hawkes *et al*. 2009).

North Pacific Population: Marine environment

The greatest anthropogenic threat to this population is commercial fishing. It affects both juveniles and adults in the neritic zone. Coastal fisheries in Baja California Sur, Mexico, and Japan kill a significant number of turtles (Kamezaki *et al*. 2003; Peckham *et al*. 2007; Peckham *et al*. 2008). A large number (n=~1,500/year at minimum) die in Baja bottom-set gillnet/longline fisheries (Koch *et al*. 2006; Peckham *et al*. 2007; Peckham *et al*. 2008). There is also recorded fishery bycatch in the Western Pacific neritic foraging areas (Cheng and Chen 1997). Recent research suggests pound net fisheries off coastal Japan also pose a major threat (Conant *et al*. 2009).

Quantifying the magnitude of the threat to Loggerhead Sea Turtles posed by fisheries in the North Pacific is difficult because there is little observer coverage or investigation into bycatch conducted by countries that have large fishing fleets in the area. Lewison *et al*. (2004) tried to quantify the effect of longline fishing on Loggerhead Sea Turtles in the Pacific Ocean, analyzing data reflecting fishing effort for the year 2000. They estimated that between 2,600 and 6,000 Loggerhead Sea Turtles were killed annually through immediate or delayed mortality as a result of interacting with the gear. This suggests that vulnerable Loggerhead Sea Turtles in the region are taken as bycatch on average once every two years (Lewison *et al*. 2004).

Loggerhead Sea Turtles are killed or injured by collisions with boat hulls and propellers, though the population effect of this source of mortality has not been quantified (Conant *et al*. 2009). Impacts of oil and gas industries, climate change and sea level rise and marine pollution are similar to those described for the Atlantic populations.

SPECIAL SIGNIFICANCE OF THE SPECIES

The Loggerhead Sea Turtle is listed as threatened under the United States' *Endangered Species Act* (USFWS and NMFS 1978) and as endangered by the International Union for Conservation of Nature (IUCN 1996). The species is a routine visitor to Atlantic Canadian waters; as a result, Canada plays a key role in the conservation of the northwest Atlantic population of Loggerhead Sea Turtles.

There is little information on the quantitative interaction of Loggerhead Sea Turtles with their environment or with other species (Bjorndal 2003). However, sea turtles have been employed worldwide as flagship species for conservation because of the widespread public support for these creatures (Frazier 2005; Martin and James 2005*a*; Martin and James 2005*b*).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Loggerhead Sea Turtles receive some protection from the *Fisheries Act.* The federal government fulfills its constitutional responsibilities for sea coast and inland fisheries through the administration of the *Fisheries Act*. The Act provides Fisheries and Oceans Canada (DFO) with powers, authorities, duties and functions for the conservation and protection of fish and fish habitat (as defined in the *Fisheries Act*) essential to sustaining commercial, recreational and Aboriginal fisheries.

The Loggerhead Sea Turtle is listed as "endangered" by the International Union for Conservation of Nature (IUCN) on its Red List (1996). It is an Appendix I species of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES 2009), which prohibits the international trade of the species or its parts. Canada is signatory to CITES.

In the United States, the Loggerhead Sea Turtle was listed as threatened throughout its range on July 28, 1978, under the *Endangered Species Act* (USFWS and NMFS 1978).

The United States is party to the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC), the only binding international treaty dedicated exclusively to marine turtles (IAC 2003). The objective of the IAC is to "promote the protection, conservation and recovery of sea turtle populations and of the habitats on which they depend, based on the best available scientific evidence, taking into account the environmental, socioeconomic and cultural characteristics of the Parties" (IAC 2001).

The United States is also signatory to the Protocol Concerning Specially Protected Areas and Wildlife (SPAW) to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention), which lists Loggerhead Sea Turtles in Annex II. Annex II prohibits the “taking, possession or killing (including, to the extent possible, the incidental taking, possession or killing) or commercial trade in [listed] species, their eggs, parts or products; [and] to the extent possible, the disturbance of such species, particularly during periods of breeding, incubation, aestivation or migration, as well as other periods of biological stress" (NOAA 2009).

Loggerhead Sea Turtles are listed in Appendices I and II of the Convention on Migratory Species (CMS 2006), where they are protected by (a) the Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia; and (b) the Memorandum of Understanding Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa. Canada and the United States are not signatory to the CMS.

TECHNICAL SUMMARY

Caretta caretta
Loggerhead Sea Turtle — tortue caouanne
Range of Occurrence in Canada: Atlantic Ocean

Demographic Information

Generation time Age at maturity is still disputed and estimates range from ~16-35 years. The mean of these is used here = 25 years. Gen Time = AM + (1 + 1/Annual rate of mortality) = 25 + (1 +1/0.05) = 25 +1 + 20 = 46 years (see p 20 for more detail).	46 years
Is there an observed or projected continuing decline in number of mature individuals?	Yes, observed and projected
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations] (a) based on 1.6% decline calculated by (NMFS and USFWS) for the Peninsular Florida Recovery Unit (PFRU) using data collected from 1989-2008. PFRU chosen because 80% of all nesting in the Atlantic Ocean occurs there. (b) based on 2.6% decline calculated by (TEWG 2009) for the PFRU using data collected from 1983-2005.	a) 7.7% [calculated over 5 years]; 77.3% [calculated over 2 generations, or 92 years] (b) 12.3% [calculated over 5 years]; 91.1% [calculated over 2 generations, or 92 years]
[Observed percent reduction in total number of mature individuals over the last [10 years, or 3 generations]. (a) based on 9.1% calculated by TEWG considering only the last 10 years of data (1997-2007) for PFRU	(a) 9.1% [calculated over the last 10 years] 93% [calculated over 100 years]
[Projected or suspected] percent [reduction] in total number of mature individuals over the next [10 years, or 3 generations]. (a) based on 1.6% decline calculated by (NMFS and USFWS) for the Peninsular Florida Recovery Unit (PFRU). PFRU chosen because 80% of all nesting in the Atlantic Ocean occurs there. (b) based on 2.6% decline calculated by (TEWG 2009) for the PFRU. (c) Data not available for North Pacific population	(a) 14.9% [calculated over 10 years]; 80.1% [calculated over 100 years] (b) 23.2% [calculated over 10 years]; 92.8% [calculated over 100 years]
[Estimated percent reduction in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future. (a) based on 1.6% decline calculated by (NMFS and USFWS) for the Peninsular Florida Recovery Unit (PFRU). PFRU chosen because 80% of all nesting in the Atlantic Ocean occurs there. (b) based on 2.6% decline calculated by (TEWG 2009) for the PFRU.	(a) 14.9% [calculated over 10 years]; 80.1% [calculated 100 years] (b) 23.2% [calculated over 10 years]; 92.8% [calculated over 100 years]
Are the causes of the decline clearly reversible and understood and ceased? Some causes of decline are understood and in some parts of the range of the species mitigation measures have been implemented. Fishing (bycatch) continues in Canadian waters. Bycatch in other areas continues. Loss of nesting habitat continues.	No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	Unknown
Index of area of occupancy (IAO) (Always report 2x2 grid value; other values may also be listed if they are clearly indicated (e.g., 1x1 grid, biological AO)).	Unknown
Is the total population severely fragmented?	No
Number of "locations*"	N/A
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] continuing decline in number of populations?	No
Is there an [observed, inferred, or projected] continuing decline in number of locations?	No
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Yes observed, inferred and projected
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
One population in Atlantic Canadian waters, consisting of individuals from several nesting populations; Mean annual number of nesting females ~17,000 for the Northwest Atlantic population	Unknown
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	NA

Threats (actual or imminent, to populations or habitats)

In Canadian waters:
Fisheries bycatch (identified in the Atlantic pelagic longline fleet), marine debris, offshore oil and gas production, and climate change.

Threats to other life history stages outside of Canadian waters:

Northwest Atlantic Ocean
Threats (n=59) are detailed in Table 2. Major threats include fisheries bycatch (particularly in bottom trawl, pelagic and demersal longline, dredge fisheries and gillnets); ecosystem alteration (beach erosion and accretion); pollution (light pollution, marine debris, oil pollution); construction and development (beach armouring, beach sand placement, coastal construction, and dredging); and non-fisheries resource uses (legal and illegal harvest of eggs and nesting females, vessel strikes, and oil and gas activities).

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*See definition of location.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Decreasing in U.S. waters	
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Shared stock with the U.S. Rescue is unlikely because the Northwest Atlantic population as a whole is declining

Current Status

COSEWIC: Endangered (April 2010)

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** A2b+4b
Reasons for designation: This species is declining globally and there are well documented, ongoing declines in the Northwest Atlantic population from which juveniles routinely enter and forage in Atlantic Canadian waters. The Canadian population is threatened directly by commercial fishing, particularly bycatch in the pelagic longline fleet, and by loss and degradation of nesting beaches in the southeastern USA and the Caribbean. Other threats include bycatch from bottom and midwater trawls, dredging, gillnets, marine debris, chemical pollution and illegal harvest of eggs and nesting females.	

Applicability of Criteria

Criterion A: Meets Endangered A2b+4b. The decline (based on the number of nesting females) over the past 3 generations (100 years) exceeds 50% and causes have not ceased nor are they well-understood. A continued decline in the Canadian Northwest Atlantic population of the species is suspected due to continued (unmitigated) fisheries bycatch interactions and ongoing development and loss of nesting habitat.
Criterion B: Does not meet criterion. EO and IAO values are not available, but they are estimated to exceed thresholds.
Criterion C: Does not meet criterion as number of mature individuals likely exceeds thresholds (although technically all individuals in Canadian waters are juveniles).
Criterion D: Does not meet criterion for the same reasons as criterion C.
Criterion E (Quantitative Analysis): Not available.

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Kathleen Martin, Hon. B.A. with Distinction (University of Toronto), M.A. (Queen’s University), is Executive Director of the Canadian Sea Turtle Network, a non-profit group dedicated to conserving the endangered leatherback turtle. She has worked with the group since it began in 1997. Martin was previously a lecturer in the communications department at Acadia University, and is currently adjunct professor in the School for Resource and Environmental Studies at Dalhousie University.

Martin has an extensive background as a writer and editor. She has published peer-reviewed articles on the potential for resource users to become dedicated stewards of the environment and has routinely written, edited and adapted academic scientific content for a variety of audiences. She is a member of the Atlantic Leatherback Turtle Recovery Team, and has prepared a range of documents for Fisheries and Oceans Canada. She is also author of seven science books for children (Lerner Publishing Group, Minneapolis, MN) and is an award-winning journalist. In 2007, she shared the Gold Canadian Environment Award for Conservation.

COLLECTIONS EXAMINED

Canadian Sea Turtle Network, Halifax, Nova Scotia.

Appendix 1. The following seven tables are the results of the north Atlantic Loggerhead Sea Turtle threat analysis conducted by the NMFS and USFWS (2008). They address each of the threats described in Table 2. Detailed information used to derive estimated annual mortality is available: www.nmfs.noaa.gov/pr/recovery/plans.htm#turtles.
The colour coding matches Table 3.

Table A1. Results of the threat analyses for fisheries bycatch.

LIFE STAGE	ECOSYSTEM	TRAWL (BOTTOM)	TRAWL (TOP/ MID-WATER)	DREDGE FISHERIES	LONGLINE (PELAGIC)	LONGLINE (DEMER-SAL)	GILLNET (DEMER-SAL, LG. MESH)	GILLNET (DEMER-SAL, SM. MESH)	GILLNET (DRIFT)	POUND NETS AND WEIRS	POT/TRAP FISHERIES	HAUL SEINES	CHANNEL NET	PURSE SEINE	OTHER HOOK & LINE (RECREA-TIONAL)	OTHER HOOK & LINE (COMM-ERCIAL)	SUM	RRV	TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)
Nesting female	Terrestrial Zone																0	1.000	0
Egg	Terrestrial Zone																0	0.004	0
Hatchling stage	Terrestrial Zone																0	0.004	0
Swim frenzy, transitional stage	Neritic Zone		1														1	0.004	0
Juvenile stage	Oceanic Zone				30,000	1			1								30,002	0.029	870
Adult stage	Oceanic Zone				1				1								2	0.789	2
Juvenile stage	Neritic Zone	30,000	1	300	1	3,000	3,000	300	30	30	30	1	1	1	30	30	36,755	0.235	8637
Adult stage	Neritic Zone	3,000	1	30	1	300	300	30	3	3	30	1	1	1	3	3	3,707	0.789	2925
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		9417	1	94	872	942	942	94	10	9	31	1	1	1	9	9			

Table A2. Results of the threat analyses for resource use (non-fisheries).

Life Stage	Ecosystem	LEGAL HARVEST	ILLEGAL HARVEST	OIL AND GAS ACTIVITIES	VESSEL STRIKES	BEACH CLEANING	HUMAN PRESENCE	RECREA- TIONAL BEACH EQUIPMENT	BEACH VEHICULAR DRIVING	POWER GENER- ATING ACTIVITIES	CONSER-VATION/ RESEARCH ACTIVITIES	MILITARY ACTIVITIES	SALVAGE OPERATIONS	SUM	RRV	TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)
Nesting female	Terrestrial Zone								3			1		4	1.000	4
Egg	Terrestrial Zone		3,000			1		1	1		300	1		3,304	0.004	13
Hatchling stage	Terrestrial Zone					1	1	1	1		1	1		6	0.004	0
Swim frenzy, transitional stage	Neritic Zone											1		1	0.004	0
Juvenile stage	Oceanic Zone	30	30	1	1									62	0.029	2
Adult stage	Oceanic Zone			1	1									2	0.789	2
Juvenile stage	Neritic Zone	3,000	300	30	300					3	3	1		3,637	0.235	855
Adult stage	Neritic Zone	300	30	3	300					3	3	1		640	0.789	505
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		943	107	10	308	0	0	0	3	3	4	2	0			

Table A3. Results of the threat analyses for construction and development.

Life Stage	Ecosystem	BEACH SAND PLACEMENT	BEACH ARMORING	OTHER SHORELINE STABILIZ- ATIONS	SAND FENCES	DREDGING	STORM- WATER OUTFALLS	COASTAL CONSTRUC- TION	CHANNEL BLASTING	BRIDGE BLASTING	SUM	RRV	TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)
Nesting female	Terrestrial Zone	1	3	1				1			6	1.000	6
Egg	Terrestrial Zone	3,000	30,000	1			1	3,000			36,002	0.004	144
Hatchling stage	Terrestrial Zone	3,000	1	1	1			1			3,004	0.004	12
Swim frenzy, transitional stage	Neritic Zone			1							1	0.004	0
Juvenile stage	Oceanic Zone										0	0.029	0
Adult stage	Oceanic Zone										0	0.789	0
Juvenile stage	Neritic Zone					30					30	0.235	7
Adult stage	Neritic Zone					3					3	0.789	2
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		25	123	1	0	9	0	13	0	0			

Table A4. Results of the threat analyses for ecosystem alterations.

Life Stage	Ecosystem	TROPHIC CHANGES FROM FISHERY HARVEST	TROPHIC CHANGES FROM BENTHIC HABITAT ALTERATION	BEACH EROSION (WASHOUTS) AND ACCRETION	AQUA-CULTURE	EUTROPHI- CATION	SUM	RRV	TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)
Nesting female	Terrestrial Zone						0	1.000	0
Egg	Terrestrial Zone			300,000			300,000	0.004	1,200
Hatchling stage	Terrestrial Zone						0	0.004	0
Swim frenzy, transitional stage	Neritic Zone						0	0.004	0
Juvenile stage	Oceanic Zone						0	0.029	0
Adult stage	Oceanic Zone						0	0.789	0
Juvenile stage	Neritic Zone						0	0.235	0
Adult stage	Neritic Zone						0	0.789	0
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		0	0	1,200	0	0			

Table A5. Results of the threat analyses for pollution.

Life Stage	Ecosystem	MARINE DEBRIS INGESTION	MARINE DEBRIS ENTANGLE-MENT IN DERELICT FISHING GEAR	MARINE DEBRIS ENTANGLE-MENT IN NON-FISHING GEAR	BEACH DEBRIS	OIL POLLUTION	LIGHT POLLUTION	NOISE POLLUTION	THERMAL POLLUTION	CHEMICAL POLLUTION	SUM	RRV	TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)
Nesting female	Terrestrial Zone						3				3	1.000	3
Egg	Terrestrial Zone					1				1	2	0.004	0
Hatchling stage	Terrestrial Zone				1	1	300,000				300,002	0.004	1200
Swim frenzy, transitional stage	Neritic Zone	30,000	1	1		30,000	1			1	60,004	0.004	240
Juvenile stage	Oceanic Zone	1	1	1		1				1	5	0.029	0
Adult stage	Oceanic Zone	1	1	1		1				1	5	0.789	4
Juvenile stage	Neritic Zone	1	300	30		30				1	362	0.235	85
Adult stage	Neritic Zone	1	30	30		3				1	65	0.789	51
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		122	95	32	0	130	1203	0	0	2			

Table A6. Results of the threat analyses for species interactions.

Life Stage	Ecosystem	PREDATION BY NATIVE SPECIES	DISEASE AND PARASITES	HARMFUL ALGAL BLOOMS	PREDATION BY EXOTIC SPECIES	EXOTIC DUNE AND BEACH VEGETATION	SUM	RRV	TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)
Nesting female	Terrestrial Zone						0	1.000	0
Egg	Terrestrial Zone	300,000	see comment		30,000	1	330,001	0.004	1320
Hatchling stage	Terrestrial Zone	3,000			1	1	3,002	0.004	12
Swim frenzy, transitional stage	Neritic Zone	300,000					300,000	0.004	1200
Juvenile stage	Oceanic Zone	1	1				2	0.029	0
Adult stage	Oceanic Zone	1	1				2	0.789	2
Juvenile stage	Neritic Zone	1	1	30			32	0.235	8
Adult stage	Neritic Zone	1	1	30			32	0.789	25
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		2414	0	31	120	0			

Table A7. Results of the threat analyses for other factors.

Life Stage	Ecosystem	CLIMATE CHANGE	NATURAL CATAS-TROPHES	COLD WATER	OTHER (EGG STAGE ONLY)	SUM	RRV	TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)
Nesting female	Terrestrial Zone					0	1.000	0
Egg	Terrestrial Zone	1	see comment		300,000	300,001	0.004	1200
Hatchling stage	Terrestrial Zone	1	1			2	0.004	0
Swim frenzy, transitional stage	Neritic Zone		1	1		2	0.004	0
Juvenile stage	Oceanic Zone			1		1	0.029	0
Adult stage	Oceanic Zone					0	0.750	0
Juvenile stage	Neritic Zone			30		30	0.235	7
Adult stage	Neritic Zone					0	0.750	0
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		0	0	7	1200			