COSEWIC
Assessment and Status Report

on the

Leatherback Sea Turtle
Dermochelys coriacea

Atlantic population
Pacific population

in Canada

ENDANGERED
2012

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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James, M.C. 2001. Update COSEWIC status report on the leatherback turtle *Dermochelys coriacea* in Canada, *in* COSEWIC assessment and update status report on the leatherback turtle *Dermochelys coriacea* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-25 pp.

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For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment Canada
Ottawa, ON
K1A 0H3

Tel.: 819-953-3215
Fax: 819-994-3684
E-mail: COSEWIC/COSEPAC@ec.gc.ca
http://www.cosewic.gc.ca

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COSEWIC
Assessment Summary

Assessment Summary – May 2012

Common name
Leatherback Sea Turtle - Atlantic population

Scientific name
Dermochelys coriacea

Status
Endangered

Reason for designation
Globally, this species is estimated to have declined by more than 70%. In the Atlantic, this species continues to be impacted by fisheries bycatch, coastal and offshore resource development, marine pollution, poaching of eggs, changes to nesting beaches and climate change. Canadian waters provide an important foraging area for these turtles. There they are threatened by entanglement in longline and fixed fishing gear.

Occurrence
Atlantic Ocean

Status history
The species was considered a single unit and designated Endangered in April 1981. Status re-examined and confirmed in May 2001. Split into two populations in May 2012. The Atlantic population was designated Endangered in May 2012.

Assessment Summary – May 2012

Common name
Leatherback Sea Turtle - Pacific population

Scientific name
Dermochelys coriacea

Status
Endangered

Reason for designation
The Pacific population of this species has collapsed by over 90% in the last generation. Continuing threats include fisheries bycatch, marine debris, coastal and offshore resource development, illegal harvest of eggs and turtles, and climate change.

Occurrence
Pacific Ocean

Status history
The species was considered a single unit and designated Endangered in April 1981. Status re-examined and confirmed in May 2001. Split into two populations in May 2012. The Pacific population was designated Endangered in May 2012.

COSEWIC
Executive Summary

Leatherback Sea Turtle
Dermochelys coriacea

Atlantic population
Pacific population

Wildlife Species Description and Significance

The Leatherback Sea Turtle (*Dermochelys coriacea*) is the largest of the seven extant species of marine turtles, and is the sole living member of the family Dermochelyidae. The leatherback has a shell covered by a leathery, slightly flexible, fibrous tissue embedded with tiny bones (osteoderms). The carapace is teardrop-shaped and has seven conspicuous longitudinal ridges. It is dark bluish-black, and the carapace, neck, head and front flippers are often covered with white, or bluish-white, blotches. The plastron is pinkish-white. Adults have a distinct pink spot on the top of the head.

Adult Leatherback Sea Turtles attain a straight line carapace length of over 2 m, and a mass of 900 kg. Most individuals found in Atlantic Canadian waters are large sub-adults or adults. They can attain a body mass of 640 kg and reach a curved carapace length of 175 cm. Comparable data are not available from Pacific Canadian waters.

Distribution

The Leatherback Sea Turtle is found in the tropical and temperate waters of the Atlantic, Pacific and Indian oceans, with a range extending from approximately 71ºN to approximately 47ºS. The species nests, usually at tropical latitudes, on Caribbean and the Indo-Pacific islands, and along the shores of every continent except Europe and Antarctica. This species does not nest in Canada.

Leatherbacks found in Atlantic Canada originate from nesting assemblages in the western North Atlantic and are widely distributed in Canadian waters, inhabiting both shelf and offshore waters between April and December where they forage on seasonally abundant gelatinous zooplankton (primarily jellyfish). Leatherback Sea Turtles are infrequently observed in Pacific Canadian waters. Observations are primarily in waters off Vancouver Island and Haida Gwaii from July to September. It is presumed that leatherbacks reach Pacific Canadian waters from California and Oregon either after crossing from Indonesia and the Solomon Islands or after swimming north from eastern Pacific nesting beaches in Mexico and Costa Rica. However, their origins have not been confirmed through DNA analysis.

Habitat

Leatherback Sea Turtles nest on land, but spend the rest of their lives at sea. After emerging from nests laid on sandy beaches, Leatherback Sea Turtle hatchlings move immediately to the marine environment. Male turtles never return to land. Female turtles return only to nest. Little is known about the movements or habitat needs of hatchling, juvenile and sub-adult Leatherback Sea Turtles. Adults make long-distance pelagic migrations sometimes over 10,000 km/year. Foraging grounds for turtles originating from western Atlantic nesting beaches are primarily located at temperate latitudes and include oceanic, coastal and continental shelf (neritic) habitats.

Leatherbacks in Atlantic Canada occur in both offshore and coastal waters (range 2 to 5,033 m depth). Most sightings are from continental shelf (waters inside the 200 m isobath). Median depth of sightings is 113 m and mean sea surface temperature (SST) is 16.6ºC.

Biology

There are five stages in the Leatherback Sea Turtle life cycle: egg and hatchling; post-hatchling; juvenile; sub-adult; and adult. Age at maturity has still not been conclusively determined, and recent estimates range from 16-29 years. There are no estimates of age composition of populations and growth rates in the wild are unknown.

The sex ratio is female-biased (1.86:1). Males linger offshore or travel among nesting beaches in advance of and until the peak of the nesting season. Females nest at 2- to 4-year intervals. The nesting season lasts 3 to 6 months and varies geographically. Females lay several clutches of approximately 80 eggs, typically at 8- to 12-day intervals. Incubation time is approximately 60 days.

Population Sizes and Trends

The size of the seasonal Leatherback Sea Turtle foraging population in Canada is not known, but sightings data suggest that it numbers in the thousands in Atlantic waters but many fewer in Pacific waters. Population estimates are currently based on abundance of adult females encountered on nesting beaches. Recent estimates range from 34,000 to 94,000 adults (males and females) in the North Atlantic. Leatherback Sea Turtle sightings in Pacific Canadian waters are sparse and the number of turtles using these waters is not known. The beaches from which they likely originate have had their numbers of nesting females reduced by more than 90%.

Current data on Leatherback Sea Turtles are insufficient to determine fluctuations and trends in the population in Canadian waters. Most major western Atlantic nesting populations may be stable or increasing slightly. In contrast, most nesting colonies in the Pacific are in steep decline, falling as much as 95% in less than one generation.

Threats and Limiting Factors

The primary threat to Leatherback Sea Turtles in Canadian waters is bycatch in fisheries. Individuals are vulnerable to entanglement in buoy lines, mooring lines, trip lines (or secondary buoy lines) and hi-flier lines, as well as in monofilament, cotton and polypropylene netting. Globally, the species faces a host of threats from fisheries bycatch, non-fisheries resource use (e.g., poaching), ship strikes, marine debris, construction and development, chemical pollution, ecosystem alterations, oil and gas exploration, and effects of climate change on nesting beaches and marine habitat.

Protection, Status, and Ranks

In Canada, Leatherback Sea Turtles are listed as “endangered” under the *Species at Risk Act* and also fall under the *Fisheries Act* and the *Oceans Act.* Since 2009, the species has been listed as Threatened in Quebec under the *Act Respecting Threatened or Vulnerable Species* and is therefore protected by the Quebec provincial *Act respecting conservation and development of wildlife* that prohibits collecting, buying, selling or keeping specimens in captivity. They are currently listed as “critically endangered” by the International Union for Conservation of Nature (IUCN).

TECHNICAL SUMMARY – Atlantic Population

Dermochelys coriacea
Leatherback Sea Turtle (Atlantic Population) Tortue luth (Population de l'Atlantique)
Range of occurrence in Canada: Atlantic Ocean

Demographic Information

Generation time *Estimates of age at maturity vary. Recently, Avens* et al*. (2009) suggested median values of 24.5 to 29 years and Jones* et al*. (2011) suggested that median age at maturity is 16.1 years. Overall, estimates have ranged from 3-30 years, with the most recent "consensus" being 16 years (Jones* et al*. 2011). Based on estimates from freshwater turtles that mature between 15-20 years, generation time is approximately 30-35 years*.	>30 years
Is there an observed or projected continuing decline in number of mature individuals? *The North Atlantic population of nesting females is considered to be stable or increasing (TEWG 2007), with recent decreases noted only in Costa Rica (Table 2.) Although these leatherbacks currently appear to be stable or increasing, these estimates are based on short-term (<1 generation) data, and may reflect more intensive survey effort rather than real "stability". Long-term (three generations) trends are likely downward. Given the prevalence of egg poaching, hunting and bycatch interactions and (in Canada, much higher fishing pressure historically than now, particularly in Atlantic Canada*), *we could infer that Atlantic leatherbacks have experienced significant declines in the past. Comparing the leatherback to other species of sea turtles, it is much more vulnerable to anthropogenic impacts. Given the declines seen in other Atlantic species of sea turtle, one can again infer the likelihood of previous leatherback declines*.	Possibly stable or slightly increasing in short term, and probably declined over the long term (3 generations = ~100 years)
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
Observed percent reduction in total number of mature individuals over the last [10 years, or 3 generations].	Uncertain for western Atlantic over 3 generations, but > 90 % globally
[Projected or suspected] percent [reduction] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[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.	Unknown
Are the causes of the decline clearly reversible and understood and ceased? *Some causes of decline are understood and in some parts of the species' range mitigation has been implemented. Fishing (bycatch) continues in Canadian waters and other areas. Marine debris and other contamination are still present. Poaching of nesting females and/or their eggs continues in other areas. Climate change continues and is likely to have negative impacts*.	Causes are partially understood, partially reversible and definitely not ceased
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)	IAO unknown
Is the total population severely fragmented?	No
Number of locations *The turtles that populate Atlantic Canadian waters probably originate from several nesting beaches, but occupy a single location in Canada where the major threat is probably mortality from fisheries bycatch.*	1
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?	Yes, there are observed and projected losses of number and quality of suitable nesting beaches
Is there an [observed, inferred, or projected] continuing decline in number of populations? *It is assumed that each nesting beach does not represent a separate population*.	No unless one considered nesting beaches to represent populations, but this is unknown
Is there an observed, inferred, or projected continuing decline in number of locations? There is an observed and projected decline for many nesting beaches, but not in the number of locations in Canada.	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 locations.	Unknown, but likely several thousand
Total	Several thousand

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: Leatherbacks are threatened in Canadian waters primarily by fishing interactions with many different fisheries. These impact on turtles from many nesting areas, and therefore are potentially having a higher impact on the species as a whole. Recent data presented in Halifax indicated that the fisheries' impacts and mortality in Canadian waters for leatherbacks is possibly much higher than previously estimated. Other threats in Canadian Atlantic waters include marine debris, offshore oil and gas production and other forms of contamination. Threats to other life history stages outside of Canadian waters: Major threats include fisheries bycatch; legal and illegal harvest of eggs and nesting females; vessel strikes; 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); oil and gas activities; loss of nesting beaches from rising sea levels and possibly from warming temperatures.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Classified as "endangered" in the USA (USFWS and NMFS 1970; NMFS and USFWS 2007) and "critically endangered" globally by the IUCN (2000, 2011).	
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes, foraging habitat, not nesting habitat
Is rescue from outside populations likely?	Shared stock with the US

Current Status

COSEWIC: Endangered (May, 2012). The species was considered a single unit and designated Endangered in April 1981. Status re-examined and confirmed in May 2001. Split into two populations in May 2012. The Atlantic population was designated Endangered in May 2012.

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** A2abd + 4abd
Reasons for designation: Globally, this species is estimated to have declined by more than 70%. In the Atlantic, this species continues to be impacted by fisheries bycatch, coastal and offshore resource development, marine pollution, poaching of eggs, changes to nesting beaches and climate change. Canadian waters provide an important foraging area for these turtles. There they are threatened by entanglement in longline and fixed fishing gear.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2abd with a decline of > 50 % over past 3 generations (~ 100 years) inferred from recent declines, historical declines in other sea turtles and levels of threats and direct exploitation. Causes of decline are known, but have not ceased and may not be reversible. Meets Endangered A4abd, with a decline of > 50% inferred and projected over 3 generations (100 years) based on a large number of major threats including mortality from fisheries bycatch, poaching of eggs and nesting females, and contamination of its environment. These threats are known, but are increasing and will be hard to mitigate.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet EO and IAO thresholds.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Population size exceeds thresholds.
Criterion D (Very Small or Restricted Total Population): Not applicable. Population size exceeds thresholds.
Criterion E (Quantitative Analysis): Not attempted.

TECHNICAL SUMMARY – Pacific Population

Dermochelys coriacea
Leatherback Sea Turtle (Pacific population) Tortue luth (Population du Pacifique)
Range of occurrence in Canada (province/territory/ocean): Pacific Ocean

Demographic Information

Generation time *Estimates of age at maturity vary. Recently, Avens* et al*. (2009) suggested median values of 24.5 to 29 years and Jones* et al*. (2011) suggested that median age at maturity is 16.1 years. Overall, estimates have ranged from 3-30 years, with the most recent "consensus" being 16 years (Jones* et al*. 2011). Based on estimates from freshwater turtles that mature between 15-20 years, generation time is approximately 30-35 years*.	>30 years
Is there an observed or projected continuing decline in number of mature individuals? *The most important nesting colony on the northwest coast of Papua, Indonesia, has declined from 13,000 nests annually in 1981 to ~3,000-4,000 nests annually in recent years (Hitipeuw* et al*. 2007) and several other nesting beaches in Central America, Mexico, and Malaysia have collapsed in the past 2-4 decades (IUCN 2011)*.	Yes
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
Observed percent reduction in total number of mature individuals over the last 10 years, or 3 generations *> 90% (Sarti* et al*. 1996; 2007), 95% between 1988 and 2004 (Santidrián Tomillo* et al*. 2007; 2008). The Mexican west coast leatherback nesting population, once considered the world's largest representing 65% of global nesting leatherbacks declined by 99% since 1980 (USFWS 2012)*.	> 90%
[Projected or suspected] percent [reduction] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[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. *Based on above estimates it would be decline of > 90%. Including the past and projections into the future (e.g., Spotila 2011; Santidrián Tomillo* et al*. 2012).*	> 90%
Are the causes of the decline clearly reversible and understood and ceased? *Some causes of decline are understood and in some parts of the species' range mitigation has been implemented. Fishing (bycatch) continues in Canadian waters and other areas. Marine debris and other contamination are still present. Poaching of nesting females and/or their eggs continues in other areas. Climate change continues*.	Causes are partially understood, partially reversible and definitely not ceased
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence: *Nesting beaches are the smallest areas essential at any stage to survival of existing populations*.	Unknown
Index of area of occupancy (IAO)	IAO unknown

Is the total population severely fragmented?	No
Number of "locations[*]" *The turtles that populate Canadian Pacific waters probably originate from several nesting beaches but occupy a single location in Canada*.	1
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Possibly
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Yes, there are observed and projected losses of suitable nesting beaches
Is there an [observed, inferred, or projected] continuing decline in number of populations?	No, unless one considered nesting beaches to represent populations.
Is there an observed, inferred, or projected continuing decline in number of locations? *There is an observed and projected decline for many nesting beaches, but not in the number of locations in Canada*.	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 Canadian waters, consisting of individuals from several nesting locations.	Unknown, but perhaps fewer than 100?
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 inferred, and possibly in fixed-gear fisheries, marine debris, offshore oil and gas production.

Threats outside Canadian waters:
Major threats include fisheries bycatch; legal and illegal harvest of eggs and nesting females; vessel strikes; ecosystem alteration (beach erosion and accretion); pollution (light pollution, marine debris, oil pollution); construction and development (beach armouring, beach sand placement, coastal construction, dredging, oil and gas activities). Undoubtedly, climate change and resulting loss of suitable nesting habitat and illegal poaching of eggs and nesting females are serious threats.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Classified as "endangered" in the USA (USFWS and NMFS 2007; NMFS and USFWS 2007) and "critically endangered" globally by the IUCN (2000, 2011).	
Is immigration known or possible?	Yes

∗ See definition of location.

Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Unknown
Is rescue from outside populations likely?	Shared stock with the US

Current Status

COSEWIC:Endangered (May, 2012). The species was considered a single unit and designated Endangered in April 1981. Status re-examined and confirmed in May 2001. Split into two populations in May 2012. The Atlantic population was designated Endangered in May 2012.

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** A2abd
Reasons for designation: The Pacific population of this species has collapsed by over 90% in the last generation. Continuing threats include fisheries bycatch, marine debris, coastal and offshore resource development, illegal harvest of eggs and turtles, and climate change.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2abd. Decline > 50 % in past 3 generations, where causes have not ceased and may not be reversible. Based on direct observation (number of nesting females), an index of abundance (number of nests) and levels of exploitation (mortality from fishing by catch).
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable, as EO and IAO would exceed thresholds
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals exceeds thresholds.
Criterion D (Very Small or Restricted Total Population): Not applicable. Number of mature individuals exceeds thresholds.
Criterion E (Quantitative Analysis): Not attempted.

PREFACE

Over the past decade, considerable research has been conducted on the leatherbacks that forage in Atlantic Canadian waters. Although a dedicated effort was made to identify the presence and distribution of these animals in Pacific Canadian waters (Spaven *et al*. 2009), their scarcity (only 119 sightings reported from 1931-2009) precluded further assessment.

Population and Distribution

There are an estimated 34,000-94,000 adult Leatherback Sea Turtles in the North Atlantic (TEWG 2007). It is not possible to determine the current overall trend in the Atlantic Leatherback Sea Turtle population; however, since the last published global population assessment (Spotila *et al.* 1996), several "new" nesting colonies have been identified, including large rookeries in the Gulf of Uraba, Colombia (Patino-Martinez *et al*. 2008), Gabon (Witt *et al*. 2009), and Trinidad (TEWG 2007). Nesting population increases have been documented through long-term monitoring in French Guiana and Suriname (Girondot *et al.* 2007), St. Croix (Dutton *et al.* 2005), and Florida (TEWG 2007; Stewart *et al*. 2011). These modest apparent increases may reflect more intensive sampling or shifts of nesting females among beaches rather than real increases. Nesting females on beaches on the Caribbean coasts of Costa Rica and Panama may be stable or slightly decreasing (Troeng *et al.* 2004) or rapidly decreasing (Spotila 2011). In one analysis western Atlantic populations are thought to be "relatively low risk-low threat" compared to Pacific populations of leatherbacks (Wallace *et al*. 2011).

Nesting colonies in the Pacific are in steep decline. The important nesting colony on the northwest coast of Papua, Indonesia, has declined since 1981 from approximately 13,000 nests to 3,000 to 4,000 nests annually (Hitipeuw *et al*. 2007). In the Eastern Pacific, declines are even more precipitous. For example, beaches in Mexico that once serviced the largest population of nesting female leatherbacks in the world (65% of global population in 1980) have witnessed a decline of more than 90% of their breeding females between 1982 and 2004 (Sarti *et al*. 1996; 2007, Santidrián Tomillo *et al*. 2012; USFWS 2012), and numbers in Pacific Costa Rica plummeted 95% between 1988 and 2004, with the mortality rates for oceanic juveniles and sub-adults double those of a stable population (Santidrián Tomillo *et al*. 2007; 2008). Overall, these Pacific populations are considered high risk-high threat (Wallace *et al*. 2011).

Although numbers in the Atlantic appear encouraging, the dramatic decline of this species in the Pacific (>70% in 12 years, less than one generation), underlines the leatherback's limited adaptability and its sensitivity to anthropogenic threats (Spotila *et al.* 2000; Lewison 2004; Spotila 2011).

Sightings data obtained since the previous report (COSEWIC 2001) suggest that the Leatherback Sea Turtle population in the Canadian Atlantic numbers in the thousands, and that their relative density during the summer and fall may be higher than that documented in waters off the eastern United States (James *et al*. 2006*a*). In turn, these findings indicate that Atlantic Canadian waters are crucial to persistence of leatherbacks in the western Atlantic.

Leatherback Sea Turtles in Atlantic Canada exhibit a predictable migratory cycle, making annual return trips between southern feeding and breeding areas, and northern foraging habitat (James *et al*. 2005*c*). Although individual Leatherback Sea Turtles exhibit fidelity to broad high-latitude foraging zones in the eastern or western Atlantic, their migratory routes can vary among years (James *et al*. 2005*c*).

For Pacific Canadian waters, Spaven *et al*. (2009) summarize 119 geo-referenced Leatherback Sea Turtle sightings documented from 1931 to 2009 off the coast of British Columbia (Kermode 1932; MacAskie and Forrester 1962; Carl 1963; Stinson 1984; Hodge and Wing 2000; McAlpine *et al*. 2004). Of these, 65% were in waters off the west coast of Vancouver Island, 27% were off the north coast and Haida Gwaii, and 8% were off the central coast. Migration patterns along the Pacific North American coast have been inferred from satellite telemetry work on Leatherback Sea Turtles found off the coasts of California and Oregon or tagged at western Pacific nesting beaches (Benson *et al*. 2007*a,* Benson *et al.* 2011).

Threats to Leatherback Sea Turtles in Canadian waters have not changed since the last report, but they have generally gotten worse. Major threats remain interaction with fishing gear and marine pollution (including contaminants like oil). These threats in the Atlantic Canadian context appear to be much greater than previously surmised. Our understanding of the threats in Pacific Canadian waters remains limited by a lack of information on the presence, origin and behaviour of Leatherback Sea Turtles in those waters.

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
(2012)

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

on the

Leatherback Sea Turtle
Dermochelys coriacea

Atlantic population
Pacific population

in Canada

2012

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Since Boulenger (1889), *Dermochelys coriacea* has been considered the correct name for the Leatherback Sea Turtle (Eckert *et al*. 2009). Leatherback Sea Turtles are one of seven species of marine turtle and the sole living member of the family Dermochelyidae. Two subspecies have been described: *Dermochelys coriacea coriacea* (Linnaeus 1766)*,* the Atlantic leatherback, and *Dermochelys coriacea schlegelii* (Garman 1884), the Pacific Leatherback (COSEWIC 2001). However, these supposed subspecies are poorly differentiated, and distinctions based on colour and forelimb and head length are questionable (Pritchard, 1979).There are no recognized subspecies at present (Crother *et al*. 2011).

The Leatherback Sea Turtle is known by many local names worldwide (Eckert *et al.* 2009). However, in Canada, the turtle is known in English as the Leatherback Sea Turtle, leatherback turtle or leatherback. In French, it is called tortue luth.

Morphological Description

The Leatherback Sea Turtle (Figure 1) does not have scutes as do other species of sea turtle. It derives its common name from the leathery, slightly flexible, fibrous tissue covering its shell. This skin (~5 mm thick) covers a layer (up to 36 mm thick) of oil-saturated fat, connective tissue and a matrix of small bony plates (osteoderms); together they form the “dermal carapace” (Eckert *et al*. 2009). The carapace is teardrop-shaped, tapering in the rear to a supra-caudal point with seven conspicuous longitudinal ridges (keels). The carapace was thought to resemble a lyre (luth) in shape and form, and the lyre being Mercury’s instrument led to the leatherback being called Mercury’s Turtle for many decades (Pritchard 1971a). The carapace is dark bluish-black, although diatom growth on it can cause it to appear green or brown in the marine environment. The carapace is unusual in that it can change shape to accommodate seasonal fat deposits (Davenport *et al.* 2011). The carapace, neck, head, and front flippers are often, though not always, covered with white or bluish-white blotches (Figure 2). The plastron, or bottom shell, is pinkish-white.

Figure 1. Adult Leatherback Sea Turtle photographed at sea off Nova Scotia. Photo: Canadian Sea Turtle Network. Used with permission from the Canadian Sea Turtle Network.

Like all sea turtles, the Leatherback Sea Turtle has both front and rear flippers, but it is the only sea turtle without claws. The large front flippers are usually at least half as long as the carapace. The flippers are paddle-shaped, narrowing at the distal end. The species, like other sea turtles, cannot retract its head or flippers into its shell. The Leatherback Sea Turtle's upper jaw has two tooth-shaped projections, flanked by deep cusps for cutting gelatinous plankton, its primary prey (Figure 2). The Leatherback Sea Turtle's esophagus is lined with backward-pointing spines to aid in swallowing. This feature and other aspects of the species' digestive anatomy and physiology are posited to enable leatherbacks to capture and swallow prey continuously with a conveyer-like action (Bels *et al*. 1998).

Adults have a pinkish spot on the top of the head (Figure 2), which is believed to be associated with the underlying pineal gland, a dorsal extension of the brain that modulates biological rhythms (Wyneken 2001). Each pink spot is unique in size, shape, colour and pattern (McDonald and Dutton 1996).

Figure 2. Photograph of head of adult Leatherback Sea Turtle showing cusps, mottling and pink spot. Photo: Canadian Sea Turtle Network. Used with permission from the Canadian Sea Turtle Network.

Leatherback Sea Turtles are the largest of all sea turtles, with adults often measuring more than 2 m in total length. The body is almost barrel-shaped. Eckert *et al.* (2009) recognize the following size classes:

Hatchling:

First few weeks of life, characterized by the presence of an umbilical scar.

Juvenile:

This life stage is rarely seen, but is thought to occur in waters warmer than 26°C. Juveniles are characterized by lack of an umbilical scar and having a curved carapace length (CCL) ≤100 cm.

Subadult:

Characterized by a CCL >100 cm and growing to 120-140 cm CCL when they reach maturity (size at onset of maturity varies among nesting populations). Animals in this size class are able to exploit the species' full biogeographical range.

Adult:

Sexually mature individuals with a CCL >120-140 cm (depending on nesting population).

Most Leatherback Sea Turtles in Atlantic Canadian waters are large sub-adults or adults. They can attain a body mass of 640 kg and reach CCL of 175 cm (James *et al*. 2007). The sex ratio of Leatherback Sea Turtles found in Atlantic Canadian waters is female-biased (1.86:1) (James *et al*. 2007). The distribution of age classes and size of Leatherback Sea Turtle that frequent Pacific Canadian waters is unknown.

There is no apparent sexual, body-size dimorphism in adult leatherbacks (James *et al*. 2005*b*; 2007). The most apparent sexually dimorphic anatomical features are tail length and cloacal position. Males have a longer tail than do females (on average, two to three times longer than that of females of the same CCL), and the male's cloaca extends further beyond the posterior tip of the carapace (James 2004; James and Mrosovsky 2004; James *et al*. 2007).

Population Spatial Structure and Variability

The Leatherback Sea Turtle is the only surviving species of an evolutionary lineage (Dermochelyidae) that diverged from other turtles during the Cretaceous or Jurassic Period 100-150 million years ago (Zangerl 1980). Mitochondrial DNA analysis indicates that the species has low genetic diversity and shallow mtDNA phylogeny when compared with other sea turtles (Bowen and Karl 1996; Dutton *et al*. 1996). Based on the control region of mtDNA, mean global mtDNA sequence divergence is 0.00581, lower than global mtDNA surveys of other sea turtles (Dutton *et al*. 1999). Control region sequence divergence between Atlantic and Pacific Leatherback Sea Turtle stocks was estimated to be 0.0081 (Dutton 1996). Despite this shallow genetic structuring, mtDNA haplotype frequencies suggest nesting populations are strongly subdivided globally ($F_{ST}=0.42$; $p<0.001$), with $F_{ST}=0.25$ ($p<0.001$) among Atlantic populations and $F_{ST}=0.20$ ($p<0.001$) among Pacific populations (Dutton *et al*. 1999).

Although female Leatherback Sea Turtles demonstrate "nesting beach fidelity", i.e., females tend to return to the same areas to nest although not to specific locations on a beach, or even necessarily to the same beach (Nordmoe *et al*. 2004; Dutton *et al*. 2005), and they appear to exhibit weaker nesting beach fidelity than do other sea turtle species (Pritchard 1982; TEWG 2007). There are varying degrees of Leatherback Sea Turtle population structuring as a result of beach fidelity and possibly of natal beach homing (Dutton *et al*.1999, 2005). Just as mature female Leatherback Sea Turtles normally exhibit fidelity for nesting areas, most adult male Leatherback Sea Turtles return annually to the same breeding areas adjacent to nesting beaches (James *et al*. 2005*b*). It is not known if breeding area selection by males is influenced by proximity to their natal beaches.

Tag-recapture data and satellite-telemetry studies have demonstrated that the Atlantic Canadian foraging population originates from nesting assemblages in the Western North Atlantic, including beaches in South and Central America, the Caribbean, and the United States (Figure 3). Although the nesting colony in Gabon, Africa, is now believed to be the largest Leatherback Sea Turtle nesting population in the world (Witt *et al*. 2009), individuals of eastern Atlantic nesting origin have not been detected in Canada. This finding is consistent with recent results from satellite telemetry (Witt *et al*. 2011) and tag-recapture studies (Billes *et al*. 2006) that show that turtles from Gabon typically undertake east-west migrations, rather than the north-south migrations characteristic of West Atlantic nesting Leatherback Sea Turtles. It is conceivable, based on genetic evidence, that these leatherbacks are a source for the increases observed in leatherbacks nesting in Suriname-French Guiana since the 1980s (Rivalan *et al.* 2006).

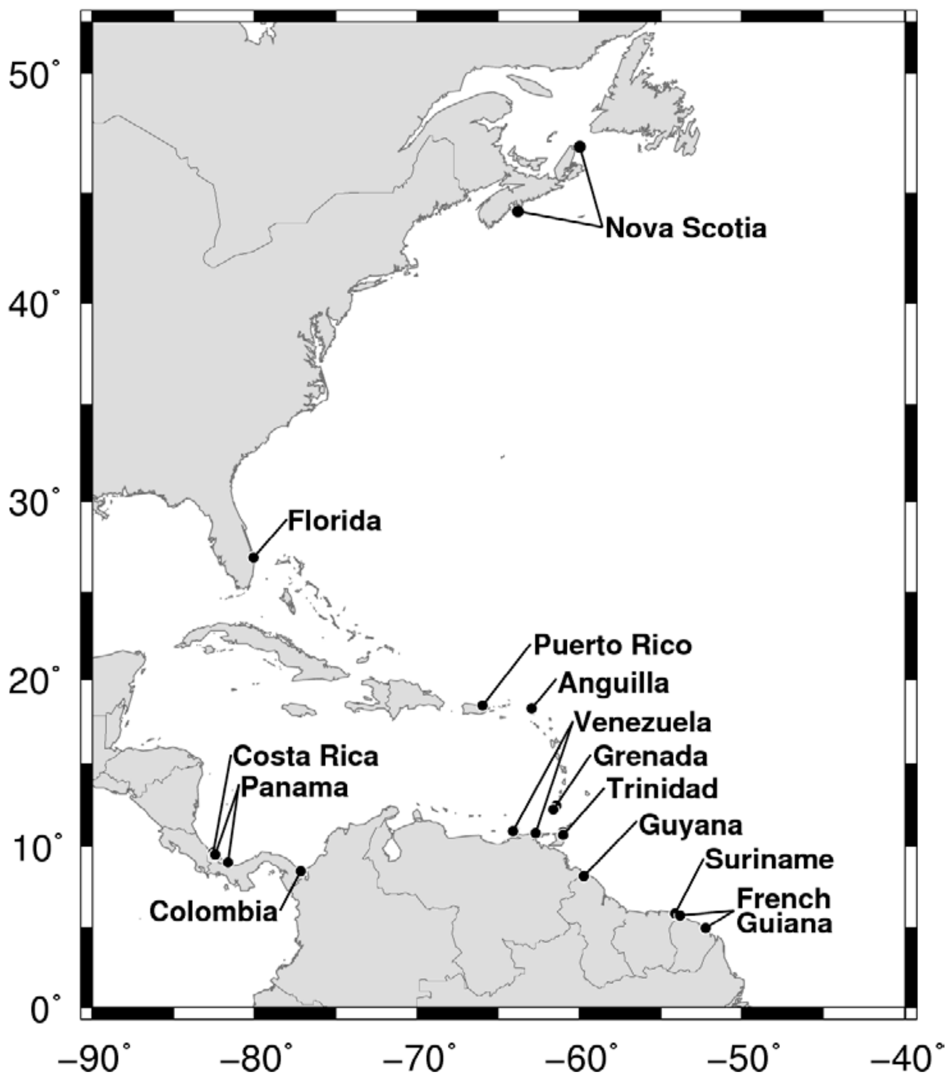

Figure 3. Nesting origins of Leatherback Sea Turtles encountered in Atlantic Canadian waters (n=43 turtles). Dark circles off Nova Scotia indicate areas where at-sea field research occurs. Adapted from James *et al*. 2007.

Although no genetic or satellite telemetry studies have been conducted on the Leatherback Sea Turtles in British Columbia, genetic and satellite studies conducted elsewhere suggest that most individuals found on the Pacific coast of North America nest in the western Pacific (Dutton *et al*. 2000; Benson *et al*. 2007*a*; *b*). Western Pacific nesting occurs at 28 sites, the majority of which (~75%) are concentrated along the northwest coast of Papua, Indonesia (Dutton *et al*. 2007).

Designatable Units

A single designation is not sufficient to portray accurately the status of Leatherback Sea Turtles in Canadian waters. The Atlantic and Pacific populations are discrete and evolutionarily significant. Although not currently divided into two designatable units (DUs), the species is managed as two DUs for recovery purposes, with a separate Recovery Strategy in place for each population (Atlantic Leatherback Turtle Recovery Team 2006; Pacific Leatherback Turtle Recovery Team 2006). Current understanding of population structure, sources, status and threats differ significantly between the Atlantic and Pacific Leatherback Sea Turtle populations in Canadian waters.

Although there is low genetic diversity and shallow mtDNA phylogeny, nesting populations are strongly subdivided globally (see **Population Sizes and Trends**), supporting the existence of separate Pacific and Atlantic DUs. Pacific and Atlantic Leatherback Sea Turtles are separated by major range disjunction, have different origins and occupy “differing eco-geographic regions” meeting COSEWIC (2009) DU guidelines for “Discreteness” (#3). In addition, the demonstrated importance of the Canadian Atlantic habitat to the population of Leatherback Sea Turtles satisfies COSEWIC DU guidelines for “Significance” (#4) (James *et al*. 2005a, 2006a, 2007).

Special Significance

Leatherback Sea Turtles are the largest species of turtle on earth and close to being the largest reptile. The leatherback is the only surviving member of an evolutionary lineage (Dermochelyidae) that diverged from other turtles over 100 million years ago (Zangerl 1980). Undoubtedly this divergence accounts for the species’ many unique features such as its carapace, clawless limbs, extensively cartilaginous skeleton, and functionally endothermic physiology. No other reptile can maintain its body temperature so far above ambient temperatures using physiological mechanisms. Leatherbacks can dive deeper than any other reptile with dives over 1000m being recorded (Doyle *et al.* 2008; Houghton *et al*. 2008). Leatherbacks are capable of huge migrations, often over 10,000 km, crossing the Pacific from Indonesia to North America, or travelling from northeast South America to maritime Canada. There is no other vertebrate like this species and its unique morphology, physiology, size and global range set it apart.

Atlantic Canadian waters are important foraging habitat for the Leatherback Sea Turtle in the Atlantic (James *et al*. 2006*a*), and are host to individuals from many nesting assemblages in the Western North Atlantic (Figure 4) (James *et al*. 2007). Therefore, Canada plays a key role in the life history of the western Atlantic populations of leatherbacks. Conservation of the Leatherback Sea Turtle receives strong public support in Canada and globally (Martin and James 2005*a*; CSTN 2010), and sea turtles in general have been employed worldwide as flagship species for conservation because of the widespread public interest they inspire (Bache 2005; Eckert *et al.* 2005; Eckert and Hemphill 2005; Frazier 2005; Martin and James 2005*a*; Martin and James 2005*b*).

DISTRIBUTION

Global Range

The Leatherback Sea Turtle has the most extensive geographic range of any reptile (Figure 4). It is found in the tropical and temperate waters of the Atlantic, Pacific and Indian Oceans, with a range that extends from approximately 71ºN (Carriol and Vader 2002) to approximately 47ºS (Eggleston 1971). The species nests on every continent except Europe and Antarctica, as well as on islands in the Caribbean and the Indo-Pacific. Large nesting colonies are rare, and nesting areas are largely confined to tropical latitudes, with the exception of the southeast coast of the USA, and KwaZulu-Natal, South Africa (Eckert *et al*. 2009). Leatherback Sea Turtles do not nest in Canada.

In the Atlantic, relatively dense Leatherback Sea Turtle nesting has been documented on the west coast of Africa, from Guinea-Bissau south to Angola, with the largest aggregations in Gabon (Witt *et al*. 2009). In the wider Caribbean Sea, nesting is broadly distributed across 36 countries or territories with major nesting colonies (>1000 females nesting annually) in Trinidad, French Guiana, and Suriname (Dow *et al*. 2007). In the Pacific, significant nesting aggregations occur primarily in Mexico, Costa Rica, Indonesia, the Solomon Islands, and Papua New Guinea (Eckert *et al*. 2009; NMFS 2009). In the Indian Ocean, nesting aggregations are reported in South Africa, India and Sri Lanka (Eckert *et al*. 2009; NMFS 2009). No Leatherback Sea Turtle nesting has been reported in the Mediterranean Sea (NMFS 2009).

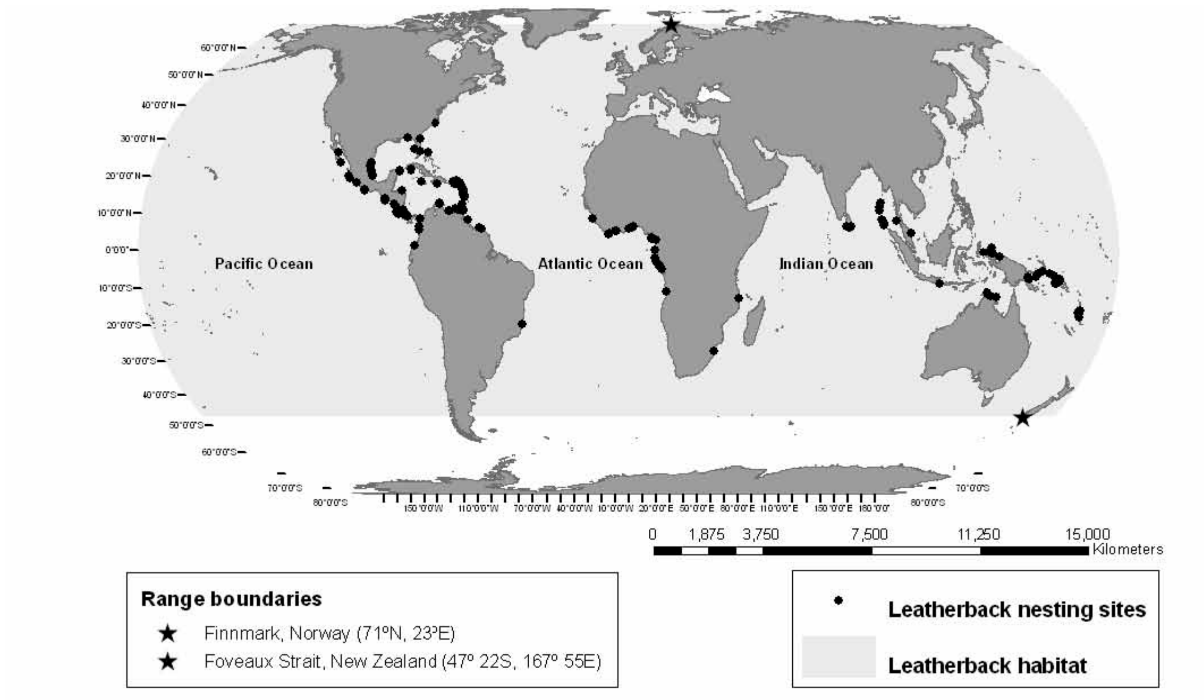

Figure 4. Global distribution of the Leatherback Sea Turtle and known nesting locations. From Eckert et al. (2009).

Canadian Range

<u>Atlantic Ocean</u>

Leatherback Sea Turtles are widely distributed in Atlantic Canada, inhabiting both shelf and offshore waters and the Gulf of St. Lawrence (James *et al*. 2005*a*; 2006a; Ouellet *et al*. 2006; Figure 5). Satellite telemetry studies and sightings indicate leatherbacks are present in Canadian waters between April and December with highest densities from July to September, and that Leatherback Sea Turtle distributions on the Scotian Shelf generally shift from southwest to northeast as the foraging period progresses (James *et al*. 2006c; 2007). However, some individuals also move directly into Canadian shelf waters from the offshore from May through to September (James *et al*. 2005*c,* 2006*a*; 2007). More southerly Canadian waters (e.g., slope waters of the Northeast Channel) may host Leatherback Sea Turtles throughout the summer and fall foraging periods. Shelf waters off Cape Breton Island, the south coast of Newfoundland, and the southern Gulf of St. Lawrence, as well as offshore waters including the Northeast Channel, constitute high-use habitat during late summer and early fall (James *et al*. 2005*a*; 2006*a*; Sherrill-Mix *et al*. 2008). Leatherback Sea Turtle distributions at high latitudes are presumed to largely reflect foraging strategies designed to maximize exploitation of gelatinous zooplankton (jellyfish), the species' principal prey.

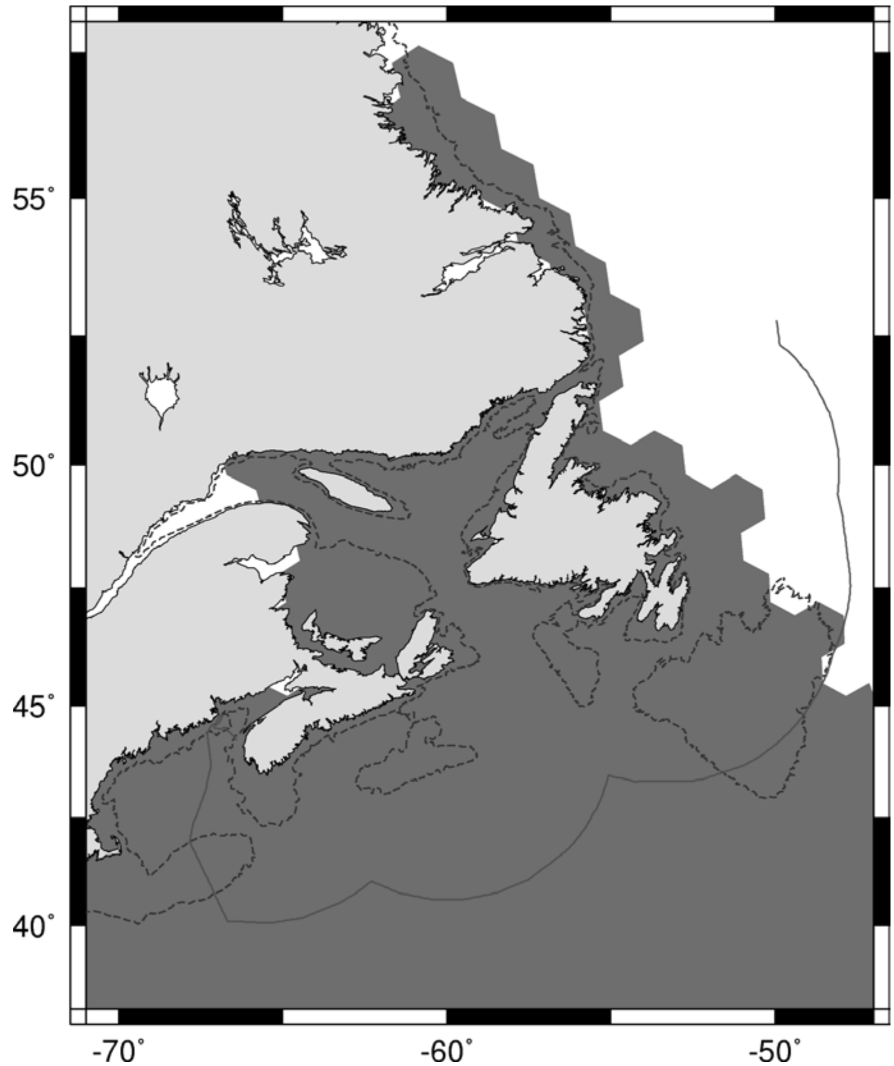

Figure 5. Distribution of the Leatherback Sea Turtle in Atlantic Canadian waters. Shaded areas represent areas of known occurrence from sightings and satellite telemetry data. Dashed line represents 100 m isobath. Solid line denotes Canadian 200 mile limit (Exclusive Economic Zone). Adapted from James *et al*. 2006*a*.

Leatherback Sea Turtles in eastern Canadian waters exhibit a predictable migratory cycle, which includes annual return trips between southern feeding and breeding areas, and northern foraging habitat (James *et al*. 2005*c*; Figure 6). In late winter and early spring, large sub-adults and adults migrate to Canadian waters to forage on gelatinous zooplankton (James *et al*. 2005*a*; 2006*b*; 2007). Individual turtles exhibit fidelity for broad high latitude foraging zones in the eastern or western Atlantic; however, their routes to and from these areas can vary between years (James *et al*. 2005*c*).

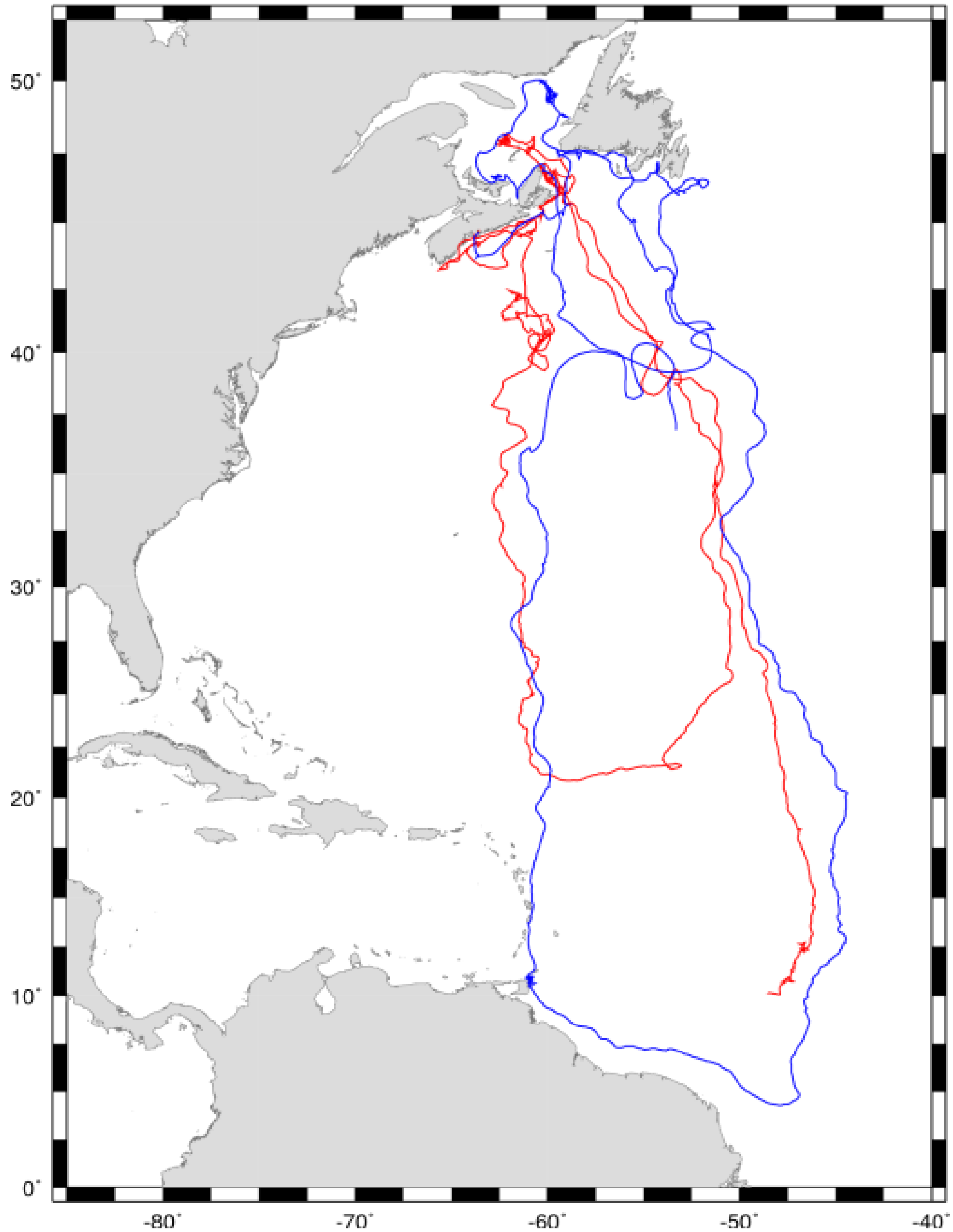

Figure 6. Return migrations of two Leatherback Sea Turtles satellite tagged off Nova Scotia. Adapted by M. James from James *et al*. 2005*b*; *c*.

Pacific Ocean

Leatherback Sea Turtle sightings in Pacific Canadian waters are sparse and the number of foraging turtles is unknown. Spaven *et al*. (2009) summarize 119 Leatherback Sea Turtle sightings documented from 1931 to 2009 off the coast of British Columbia (Kermode 1932; MacAskie and Forrester 1962; Carl 1963; Stinson 1984; Hodge and Wing 2000; McAlpine *et al*. 2004) (Figure 7). Sightings information was collected through a literature review, questionnaires, and ship-based and aerial surveys. Spaven *et al*. (2009) obtained geo-referenced coordinates for 118 of the records (Figure 7). Of these, 65% were in waters off the west coast of Vancouver Island, 27% were off the north coast and Haida Gwaii, and 8% were off the central coast. Since 2000, sightings are most frequent in neritic waters more than 55 km offshore (37%), followed by near-shore waters off southwest Vancouver Island (17%) (Spaven *et al*. 2009). Most Leatherback Sea Turtle sightings (n=80) occurred from July to September (Spaven *et al*. 2009). Spaven *et al*. (2009) note that patterns of Leatherback Sea Turtle occurrence are consistent with warm sea temperatures and areas of upwelling and areas of high oceanic productivity, as is common where Leatherback Sea Turtles are found (Stinson 1984; James *et al*. 2005*b* and Benson *et al*. 2007*c*). Although dedicated aerial surveys (n=4, 11-12 September 2005; 1-2 August 2006; 5-6 September 2006; and 24-25 August 2007) were flown for Leatherback Sea Turtles over areas where the species has been previously documented (32 hours of active searching covering ~3,790 km), no Leatherback Sea Turtles were sighted (Spaven *et al*. 2009).

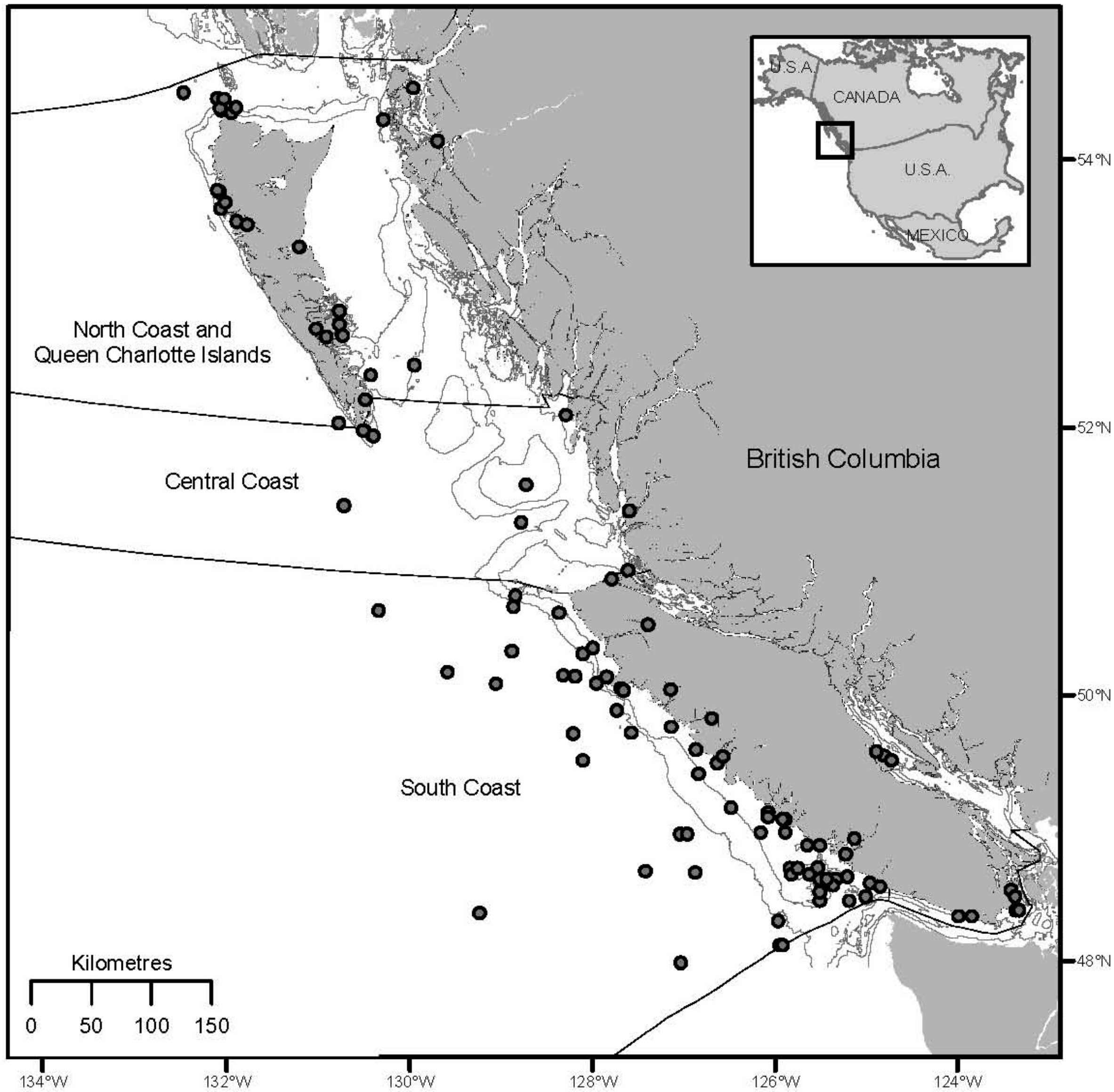

Figure 7. Leatherback Sea Turtle sightings (n=118) in Pacific Canadian waters noting geographic sub-regions. Dashed lines are the 100 m and 200 m isobaths. From Spaven *et al*. 2009.

HABITAT

Habitat Requirements

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

Nesting Habitat

Leatherback Sea Turtles nest on ocean beaches with coarse-grained sands that are deep and generally free of rocks, coral or other abrasive materials (Hendrickson and Balasingam 1966; TEWG 2007). The beaches tend to be high energy with a deep-water oceanic approach or a shallow-water approach with mud banks and no coral or rock formations (TEWG 2007). The strong waves and tides may help females ascend the beach as they emerge from the sea (Reina *et al*. 2002), and a steep profile helps the animal attain high ground while minimizing overland effort (Hendrickson and Balasingam 1966; Pritchard 1971*a*; Hendrickson 1980). The majority of nesting in the western Atlantic takes place at tropical latitudes, but nesting has occurred as far north as Assateague Island National Seashore, Maryland, USA (38ºN) (Rabon *et al*. 2003).

Marine Habitat

Leatherback Sea Turtle habitat is likely largely determined by the availability of prey. Leatherback Sea Turtles at all life stages eat gelatinous organisms including Cnidaria, Ctenophora and Urochordata (Tunicata).

Marine Habitat: Hatchlings

Little is known about the habitat needs of post-hatchling Leatherback Sea Turtles. There is no evidence that they associate with *Sargassum* or epipelagic debris as do other sea turtles (Carr 1987).

Marine Habitat: Juveniles and Sub-adults

Habitat requirements and preferences of juveniles and sub-adults are also poorly understood. In his summary of data on 98 small (<145 cm CCL) Leatherback Sea Turtles from around the world, Eckert (2002) determined that juveniles <100 cm CCL occur only in waters warmer than 26ºC, whereas turtles >100 cm CCL were found in waters as cool as 8ºC. It is possible that increased size, which reduces the surface area-to-mass ratio, creates sufficient thermal inertia to enable the animal to inhabit colder waters (Friar *et al*. 1972; Paladino *et al*. 1990).

Marine Habitat: Adults

Adults make long-distance pelagic migrations between nesting and foraging grounds (Ferraroli *et al*. 2004; Hays *et al*. 2004; James *et al*. 2005*a*; *b*; Eckert 2006; Eckert *et al*. 2006; Benson *et al*. 2007*a,* Shillinger *et al*. 2008, Witt *et al*. 2011). In a single year, an individual may swim more than 10,000 km (Eckert 2006; Eckert *et al*. 2006). Foraging grounds for Leatherback Sea Turtles of western Atlantic origin are primarily at temperate latitudes and include oceanic habitat (especially in winter) as well as coastal and continental shelf habitats (favoured in spring through fall) (Bjorndal 1997; Godley *et al*. 1998; James *et al*. 2005*a*; Eckert 2006; Eckert *et al*. 2006; Murphy *et al*. 2006; Wallace *et al*. 2006; James *et al*. 2007). New data are being gathered about the location and relative importance of these foraging grounds, the fidelity of individual turtles to specific foraging areas, and distribution of foraging populations by size or class. While on temperate foraging grounds, individuals spend most of their time near the surface (Eckert 2006; James *et al*. 2006*b*; Benson *et al*. 2007*b;* Innis *et al.* 2010). Time spent at the surface may represent resting, basking, and/or extended handling of larger prey captured at depth (James and Mrosovsky 2004; James *et al*. 2005*c*). In contrast to these north-south movements, the migratory pattern for leatherbacks of eastern Atlantic (African) origin involves movements between the eastern and western Atlantic, with many animals foraging off South America outside the nesting season (Witt *et al*. 2011).

Based on 851 geo-referenced records collected in Atlantic Canada from 1998-2005, James *et al*. (2006*a*) determined that Leatherback Sea Turtles typically occur in Canadian waters between April and December, with peak numbers in July through September (Figure 8). Records were from both offshore and coastal waters (range 2 to 5,033 m) with 80.2% reported on the continental shelf (waters inside the 200 m isobath), with a median depth of 113 m (Figure 9). Mean SST was 16.6°C, with 19.7% of sightings reported in waters <15°C.

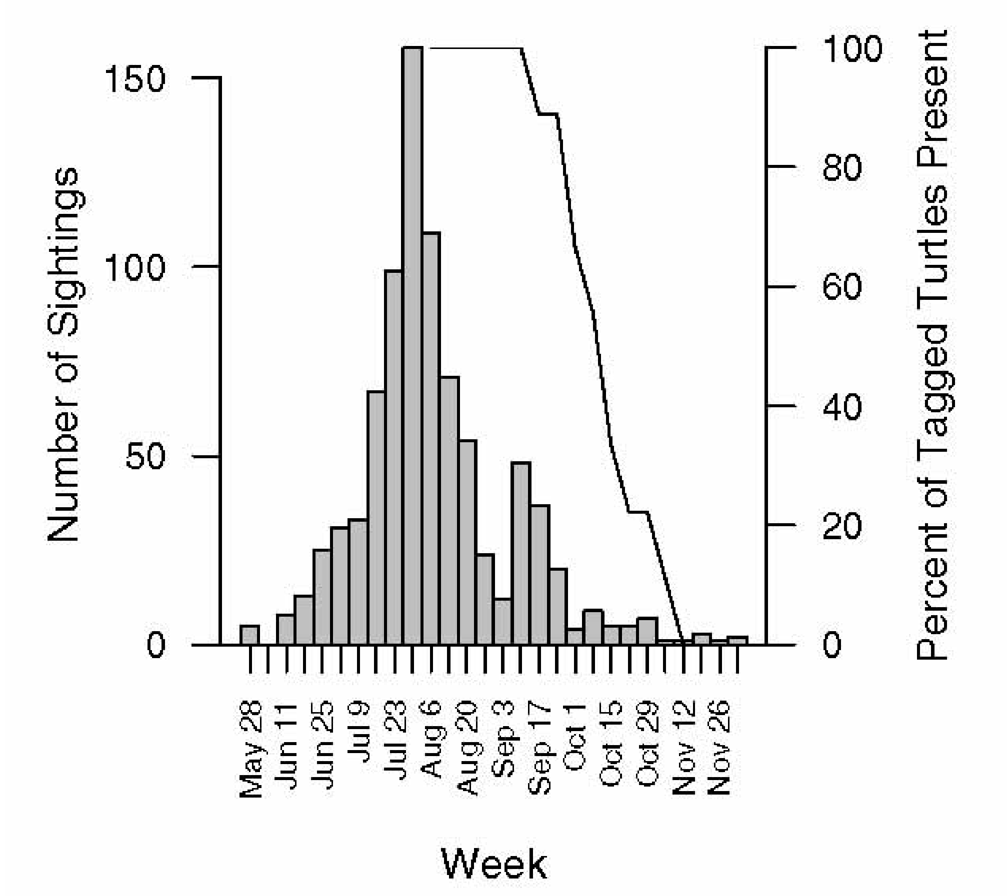

Figure 8. Temporal distribution of Leatherback Sea Turtle sightings compared to the end of the residency period for Leatherback Sea Turtles in Canadian waters as indicated by satellite telemetry. Bars show frequency of voluntarily reported sightings of Leatherback Sea Turtles by week for all years (1998-2005). Solid line represents percent of nine Leatherback Sea Turtles satellite tagged off Nova Scotia remaining in Canadian waters. From James *et al*. 2006*a*.

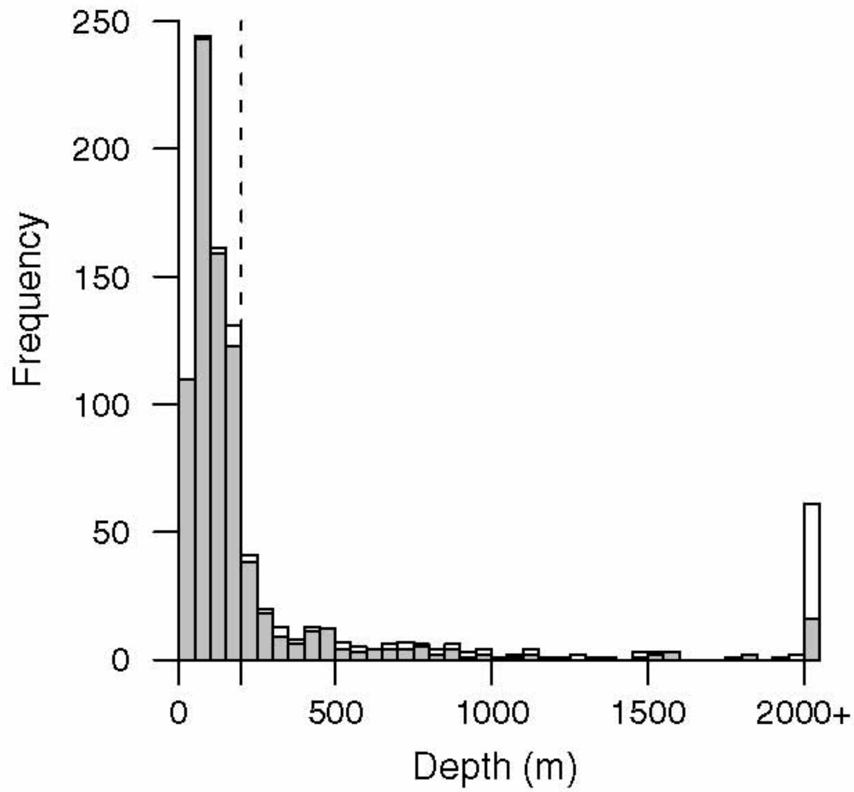

Figure 9. Bathymetry associated with sightings of Leatherback Sea Turtles in Atlantic Canada (1998-2005). Depth is binned in 50 m increments. Shaded portions of bars indicated volunteered sightings (n=851); open portions of bars indicate reports from pelagic fisheries observers (n=120). Dashed line indicates 200 m depth. From James *et al*. 2006*a*.

Habitat Trends

Data required to determine habitat trends over the last three generations are not available. There are indications, however, that climate change and the associated rise in sea surface temperatures could affect the abundance and/or distribution of Leatherback Sea Turtles and their prey (Lyman *et al.* 2010; Santidrián Tomillo *et al*. 2012). Specifically, climate change is expected to expand Leatherback Sea Turtle foraging habitats into higher-latitude waters (James *et al*. 2006*c*; McMahon and Hays 2006). Also, climate change causes sea level rise that erodes and destroys nesting beaches, and is associated with increasingly stronger storms and storm surges that contribute to beach erosion (Santidrián Tomillo *et al.* 2012).

Although trends are not well documented, nesting habitat continues to be increasingly negatively affected by coastal development and construction (e.g., Lutcavage *et al*. 1997; Formia *et al*. 2003; Villaneueva-Mayor *et al*. 2003; Sounguet *et al*. 2004; Eckert *et al*. 2009; KWATA 2009). Programs to protect nesting sea turtles generally focus on securing nests and nesting females (e.g., Hughes 1996; Dutton *et al*. 2005). There are programs in place (e.g., Florida Fish and Wildlife Conservation Commission 2011) that address beach armouring and lighting issues, though these programs vary drastically internationally. Habitat quality continues to degrade because of increased fishing activity, and increased levels of plastic waste (Goldstein *et al.* 2012).

BIOLOGY

Life Cycle and Reproduction

There are five recognized stages in the Leatherback Sea Turtle life cycle: egg and hatchling; post-hatchling; juvenile; sub-adult; and adult. Age at maturity is uncertain. Direct field measurements of age are problematic, so inferential or correlative analyses have been used to generate estimates of age at maturity (Eckert *et al*. 2009). One study, based on skeletochronological data from scleral ossicles, estimated that Leatherback Sea Turtles in the western North Atlantic may not reach maturity until 24.5-29 years of age (Avens *et al*. 2009), significantly longer maturation times than earlier estimates (Pritchard and Trebbau 1984: 2 to 3 years; Rhodin 1985: 3 to 6 years; Zug and Parham 1996: 13 to 14 years for females; Dutton *et al*. 2005: 12 to 14 years for the St. Croix, USVI nesting population). The most recent study, incorporating growth rates of captive juvenile turtles, indicates potential for more rapid maturation (6.8-16.1 yrs; Jones *et al*. 2011). There are no data available to estimate the overall age composition of Leatherback Sea Turtle populations. Wild growth and annual survival/mortality rates are unknown, so a precise estimate of generation time is not possible. However, given the range in age at maturity >30 years is a reasonable estimate of generation time.

Observations of courting and/or mating in Leatherback Sea Turtles are rare and largely anecdotal; however, courtship behaviour has been documented off the Pacific coast of Costa Rica using cameras attached to nesting females (Reina *et al*., 2005). Lazell (1980) suggested that in any given year, males migrate to and from the nesting beach to inseminate females prior to their first oviposition, and then leave the breeding grounds before females complete nesting. James *et al*. 2005*a* used satellite tracking data on male Leatherback Sea Turtles to confirm that males linger at, or travel among, nesting colonies well in advance of the nesting season, remaining until its peak.

Females usually nest on sandy, tropical beaches at 2-4-year intervals (McDonald and Dutton 1996; Garcia and Sarti 2000; Spotila *et al*. 2000). The timing and duration of nesting varies geographically, lasting between 3-6 months in a nesting year. Females lay clutches of approximately 80 (range 23-166) eggs several times during a nesting season, typically at 8-12-day intervals (Ernst and Lovich 2009). Leatherback Sea Turtle eggs are the largest of any sea turtle. Nesting is typically nocturnal, although daylight nesting does occur. Female Leatherback Sea Turtles appear to exhibit more variable nesting site fidelity than other species of sea turtle, and they may nest at more than one beach in a single season (Eckert *et al*. 1989*a*; Keinath and Musick 1993; Steyermark *et al*. 1996; Dutton *et al*. 2005). Nesting behaviour follows the sequence: emergence from sea onto the nesting beach; overland traverse to, and selection of, a suitable nesting site; excavation of a body pit; excavation of the nest chamber; oviposition; filling the nest chamber; covering and concealing the nest site; returning to the sea (Eckert *et al*. 2009).

Incubation time of Leatherback Sea Turtle eggs is approximately 60 days (Ernst *et al*. 1994; Eckert *et al*. 2009). Emergence success (distinct from hatching success) is approximately 50% worldwide, lower than that of any other sea turtle (Miller 1997). Developing leatherback embryos are subject to temperature-dependent sex determination. Studies on sex ratios of Leatherback Sea Turtles have shown that constant incubation temperatures below 29.25°C produce 100% male hatchlings, whereas constant temperatures above 29.75°C produce 100% females (Chan and Liew 1995). The approximate pivotal temperature at which both sexes are produced is 29.5°C (Mrosovsky *et al*. 1984; Dutton *et al*. 1985; Godfrey *et al*. 1996; Davenport 1997), although it may vary geographically (Eckert *et al*. 2009).

Leatherback Sea Turtle hatchlings are the largest of any sea turtle species, and weigh approximately 40 g; mean carapace length, carapace width, and body mass of Leatherback Sea Turtle hatchlings are similar worldwide (Eckert *et al*. 2009). Hatchlings emerge from the nest one to seven days after “pipping” (chipping an opening in the egg) (Lohmann *et al*. 1997). Following pipping, the hatchings remain quiescent in the nest absorbing their yolk sac and allowing time for their plastrons to straighten before emerging from the nest en masse and quickly crossing the beach to reach the sea. Hatchling movements on land are laboured (Davenport 1987). Once they reach the sea, hatchlings may swim away from land in a continuous “frenzy” lasting for up to 24 h (Wyneken and Salmon 1992). Activity during the frenzy is fuelled by yolk not consumed during embryonic development (Wyneken 1997).

A comparison of sex ratios between some Atlantic and Pacific nesting beaches indicate that Pacific populations may be more female-biased (Binckley *et al*. 1998) than Atlantic populations (Godfrey *et al*. 1996; TEWG 2007). However, sex ratios may vary among beaches or even among clutches on a single beach (NMFS 2009). Strandings data from the Atlantic coast of the United States and the Gulf of Mexico show that 60% of strandings were females, with similar proportions among adults (57%) and juveniles (61%) (TEWG 2007). A study of large sub-adults and adults off Nova Scotia (n=152) conducted between 1999 and 2006 showed a female-biased sex ratio (1.86:1) (James *et al*. 2007).

There are few reliable estimates of survivorship and mortality at any of the life-history stages. Existing data suggest that the life-history strategy is similar to that of other long-lived species with a delayed age of maturity, low and variable survival in egg and juvenile stages, and a relatively high and constant annual survival (from natural predation) in subadult and adult stages (Spotila *et al*. 1996; 2000; Crouse 1999; Heppell *et al*. 1999; 2003; Chaloupka 2002).

Physiology and Adaptability

Leatherback Sea Turtles are capable of maintaining body core temperatures as much as 18°C above ambient water temperatures (Paladino *et al*. 1990; James *et al*. 2006*c*). In temperate or even sub-arctic waters, Leatherback Sea Turtles are capable of maintaining body core temperatures several degrees above ambient (James and Mrosovsky, 2004). This enables them to venture into cool temperate waters and range further than any other species of marine turtle. The endothermic capability is facilitated by a number of adaptations. These include large size and a thick layer of subcutaneous blubber that favours heat retention from muscular activity (Goff and Lien 1988; Davenport *et al*., 1990; Davenport 1997); sub-carapacial insulating fat (Goff and Lien 1988; Davenport *et al*. 1990), intracranial blubber and other fat deposits in the dorsal and lateral surfaces of the neck, surrounding the esophagus, and between the oropharyngeal cavity and the palate (Davenport 2009); gigantothermy (Paladino *et al*. 1990), a high volume-to-surface-area ratio that minimizes heat loss (Paladino *et al*. 1990); a countercurrent circulatory system (Greer *et al*. 1973; Davenport 1997); the ability to elevate body temperature through increased metabolic activity (Southwood *et al*. 2005; Bostrom and Jones 2007). Although cheloniid turtle distribution is normally constrained by the 20°C surface isotherm (Davenport 1997), Leatherback Sea Turtles are routinely found in cold temperate waters (James *et al.* 2006*a, c*).

Large, specialized lachrymal glands behind the eyes designed for excreting salt in tears, enable Leatherback Sea Turtles to maintain osmotic and ionic balance while consuming a diet of jellyfish, which are isotonic to salt water (Hudson and Lutz 1986).

Dispersal and Migration

Despite the great distances travelled by Leatherback Sea Turtles, orientation and navigation mechanisms used by these turtles are not well understood. The primary cue that leads emerging hatchlings to the sea is light: the differential in brightness between the open ocean horizon and the darker land (Mrosovsky 1972; 1977; Salmon *et al*. 1992; Lohmann *et al*. 1997). Upon entering the sea, hatchlings maintain seaward orientation using incoming waves as a cue (Lohmann *et al*. 1990).

Movements and migrations of hatchlings and juveniles are largely unknown. After swimming steadily away from their natal beach for approximately 24 h, hatchlings settle into a diel swimming pattern (Carr and Ogren 1959; Fletemeyer 1980; Hall 1987; Wyneken and Salmon 1992). The relatively limited range of swimming modes exhibited by Leatherback Sea Turtles may reflect the need to swim steadily over long distances (Eckert *et al*. 2009). Hatchlings are capable of diving shortly after they enter the ocean (Davenport 1987; Price *et al*. 2007). Salmon *et al*. (2004) observed that hatchlings between the ages of 2-8 weeks dove deeper and longer with age, and that they foraged throughout the water column exclusively on gelatinous prey. Nothing is known about the dispersal of hatchlings in the open sea.

The oceanic distribution of juveniles and adults most likely reflects the distribution and abundance of prey as well as the animal's thermal niche (James and Herman 2001; James and Mrosovsky 2004; James *et al*. 2005*a*; 2006*a, b, c*; 2007; Eckert *et al*. 2009).

Interspecific Interactions

Hybridization

There are no reports of hybridization involving Leatherback Sea Turtles (Eckert *et al*. 2009).

Diet

Bleakney (1965) concluded that the diet of the Leatherback Sea Turtle "consists chiefly of jellyfish and their parasites and symbionts." Subsequent research has confirmed that at all life stages, the Leatherback Sea Turtle consumes gelatinous organisms primarily Cnidaria, Ctenophora and Urochordata (Tunicata) (Bjorndal 1997, Dodge *et al*. 2011). Such gelatinous prey is found in subtropical, temperate and boreal latitudes. Preferred prey items at high latitudes are *Cyanea* spp., *Aurelia* spp., *Stomolophus* spp., Atlantic Sea Nettle (*Chrysaora quinquecirrha*), and ctenophores, while a smaller proportion of their diet comes from holoplanktonic salps and sea butterflies (Cymbuliidae) (Bleakney 1965; Lazell 1980; James and Herman 2001; Murphy *et al*. 2006, Dodge *et al.* 2011). The Leatherback Sea Turtle is not a discriminating feeder, which may predispose them to swallow anthropogenic debris such as plastic (Mrosovsky 1981; Hartog and van Nierop 1984; Mrosovsky *et al*. 2008). Because of the unusual trophic position that the Leatherback Sea Turtle occupies, there are no documented competitors for food resources (Hendrickson 1980). The Ocean Sunfish (*Mola mola*) is the only other known top-level medusivore, and even though concentrations of both species overlap in time and space (Houghton *et al*. 2006), there is no evidence whether or not the two species compete.

<u>Natural Predators</u>

Table 1 documents the taxonomic identity of known natural predators of Leatherback Sea Turtles at all life stages. Natural predators of eggs and hatchlings vary by region. They include: ants (e.g., army ants), fly larvae, locust larvae, crickets (e.g., mole crickets), ghost crabs, fish (e.g., horse-eye jack, gray snapper, tarpon), reptiles (e.g., monitors), birds (e.g., buzzard, white heron, vulture, crow, hawk, gull, frigate bird, tern, eagle), and mammals (e.g., mongoose, dogs, striped jackal, armadillo, opossum, coatis, raccoon, wild boar) (Eckert *et al*. 2009). Predation is most severe at oviposition and hatchling emergence. After the nesting crawl is no longer discernible (within days of laying), few terrestrial predators can locate the eggs again until just before hatchling emergence (Carr and Ogren 1959).

Table 1. Predators of Leatherback Sea Turtles found in Canadian waters and in western Atlantic and western Pacific nesting regions. Taxonomic detail reflects that given in the source reference. Life stage affected: E= egg; H=hatchling; J=juvenile; A=adult. Adapted from Eckert *et al*. (2009).

Predator	Life stage
Ants	
Unspecified	E, H
Flies (larvae)	
Megaselia scalaris	E
Dipteran larvae	E, H
Locusts (larvae)	
Acrididae	E
Crickets	
Scapteriscus didactylus (mole cricket)	E, H
Crabs	
Ocypode quadratus (ghost crab)	E, H
Ocypode occidentalis	E, H
Fish	
“Carnivorous” fish	E, H
Caranx latus (horse-eye jack)	H
L. griseus (grey snapper)	H
Megalops atlanticus (tarpon)	H
Sphyraena sp. (barracuda)	J
Shark	H, J, A
Grey reef shark	A
Reptiles	
Varanus sp.	E, H
Crocodilus porosus	A
Birds	
Corvus albus (crow)	E
Coragyps atratus (vulture)	E, H
Buzzards	H

Predator	Life stage
Casmerodius albus (white heron)	H
Fregata magnificens (frigatebird)	H
Haliaetus leucogaster (sea eagle)	H
Larus atricilla, argentatus (gulls)	H
Nyctanassa violacea (night heron)	H
Pandion haliaethus (eagle)	H
Stema maximus (tern)	H
Haliastus indus (Brahmini kite)	H
Hawk	H
Mammals	
Canis adjustus (striped jackal)	E
Dasypus novemcinctus (armadillo)	E
Procyon lotor (raccoon)	E
Didelphis sp. (opossum)	E
Procyon cancrivorus (raccoon)	E, H
Sus scrofa sulawensis (wild boar)	E, H
Canis vulgaris (common dog)	E, H
Canis familiaris (domestic dog)	E, H
Nasua nasua (South American coati)	E, H
Nasua naricai (white-nosed coati)	E, H
Genetta sp. (genet cat)	H
Herpestes auropunctatus (mongoose)	H
Felis bengalensis (tiger)	A
Pantera onca (jaguar)	A
Orcinus orca (killer whale)	A

Predators of juveniles, sub-adults and adults include sharks, barracuda, crocodiles, jaguars and killer whales (Eckert *et al*. 2009), although the large body size of adults reduces the threat of predation by most animals.

Parasites and Commensals

Parasites and commensals of Leatherback Sea Turtles found in Canadian waters include flatworms (*Calycodes anthos*, *Cymatocarpus* sp., *Pyelosomum renicapite* (Threlfall 1979); crustacea (*Stomatolepas dermochelys*) (Zullo and Bleakney 1966); and fish (*Nucrates doctor, Remora remora*) (CSTN 2010). Other parasites and commensals of Leatherback Sea Turtles include: segmented worms (*Ozobranchus branchiatus*) (Sarti *et al*. 1987); isopods (*Excorallana acuticauda*) (Williams *et al*. 1996); barnacles (*Balanus trigonus, Chelonibia testudinaria, Conchoderma auritum, Conchoderma virgatum, Lepas anatifera, Lepas* sp.*, Platylepas* sp. (Bacon 1970; Benabib 1983; Eckert and Eckert 1988; Tucker 1988; Williams *et al*. 1996); and fish (*Echeneis naucrates*) (Eckert and Eckert 1988).

Adaptability

The lineage of the Leatherback Sea Turtle dates back 100-150 million years (Zangerl 1980). This longevity indicates its ability to adapt to natural changes in both the marine and terrestrial environments it inhabits. However, the ability of Leatherback Sea Turtles to survive anthropogenic threats is questionable, exemplified by the reported dramatic decline of the species in the Pacific (>70% in 12 years, less than one generation) (Pritchard 1982; Sarti *et al.* 1996; Spotila *et al*. 1996; 2000).

Leatherback Sea Turtles have not been successfully maintained for long periods in laboratory or aquarium settings. Adults kept in captivity usually die soon after acquisition (e.g., Birkenmeier 1972; Levy *et al*. 2005), and hatchlings have also proven difficult to rear, succumbing to bacterial and fungal infections (e.g., Birkenmeier 1971; Witham 1977; Johnson 1989; Jones 2009, Jones *et al.* 2011). Jones (2009) successfully maintained captive hatchling leatherbacks for 815 days, the longest time on record, all but the animals eventually died of bacterial pneumonia.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Data are drawn from voluntary sightings programs, aerial surveys, ship-based surveys and questionnaires, and nesting beach surveys. The details for the methodology associated with each of these follows.

There has been no direct stock assessment of Leatherback Sea Turtles in Canadian waters. Data for abundance in Atlantic Canadian waters were compiled from Bleakney (1965), Goff and Lein (1988), James *et al*. (2006*a)*, Ouellet *et al*. (2006), and CSTN (2010). Both Bleakney (1965) and Goff and Lein (1988) summarize observations of small numbers of turtles primarily found entangled in near-shore fishing gear. Bleakney's records (n=29) spanned 140 years of data (1824-1964), and Goff and Lien's records (n=20) spanned 10 years (1976-1985).

James *et al*. (2006*a*) present the most comprehensive dataset, which includes data from the Canadian Sea Turtle Network (CSTN) database, from aerial surveys, and from the Canadian pelagic fisheries observer database. Locations of Leatherback Sea Turtle interaction with the Canadian pelagic longline fisheries (n=120; 1998-2005) were obtained from the DFO Maritimes At-Sea Observers Database (Fisheries and Oceans Canada 2006).

Aerial surveys for North Atlantic Right Whales (*Eubalaena glacialis*) in Atlantic Canada occurred in the summers of 1998 and 1999 (Brown and Tobin 1999, 2000). Survey tracklines were limited to areas of known North Atlantic Right Whale habitat on the southwest portion of the Scotian Shelf and in the Bay of Fundy, bordered by 67.25°W and 62°W longitude (survey design is described in Brown and Tobin 1999, 2000), yielding 31 Leatherback Sea Turtle sightings.

Sightings information in the CSTN was obtained through a voluntary sea turtle reporting program targeting commercial fishers in Atlantic Canada, with the primary emphasis on fishers in Nova Scotia (Martin and James 2005*a*). The resulting data are limited not only by which fishers were aware of the program, but which were willing to report in a reluctant reporting climate (Martin and James 2005*b*). The sightings themselves are limited by fishing effort (James *et al.* 2006). Thus, sightings collected through this program represent only a very small fraction of the total number of turtles present in Canadian waters during the study period.

Spaven *et al*. (2009), compiled sightings in Pacific Canadian waters from historical records, aerial and ship-based surveys, and questionnaires. The review included records from as early as 1931 (Kermode 1932; MacAskie and Forrester 1962; Carl 1963; Stinson 1984; Hodge and Wing 2000; McAlpine *et al*. 2004). Questionnaires (n=~1,500) were sent to commercial fishers (tuna and halibut hook-and-line fishery, salmon troll and seine fisheries, groundfish trawl, and urchin and clam diving fisheries), other mariners (ecotourism operators, recreational fishers, First Nations bands, marine researchers, ferry captains, and members of the Canadian Coast Guard), and to coastal aircraft pilots. Overall, 201 questionnaires were returned, yielding 34 Leatherback Sea Turtle sightings.

The ship-based surveys (n=21), designed for multi-species marine mammal observations, were conducted over 29,165 km of the BC coast during 1,808 h of effort. Three Leatherback Sea Turtles were sighted.

Aerial surveys (n=4) were specifically conducted to find Leatherback Sea Turtles. They were flown over neritic waters off the west coasts of Haida Gwaii and Vancouver Island, covered ~3,790 km and represented approximately 32 hours of active searching. No sea turtles were found during aerial surveys.

The population and nesting trend status of Atlantic nesting stocks (known, or suspected to contribute to the population found in Atlantic Canada) were most recently assessed by the Turtle Expert Working Group (TEWG 2007). Their report includes an extensive explanation of how their data were derived. A summary follows:

The Turtle Expert Working Group (TEWG) found that time series less than 10 years were inadequate to determine true population growth rate for nesting populations. In many cases, the estimated trend for time intervals less than 10 years was opposite to the "true" trend. Analyses were restricted to time-series datasets with relatively consistent monitoring for at least 10 consecutive years. TEWG employed two approaches to determine the trend at each of these eligible datasets: regression analyses and Bayesian modelling. The purpose of this trend analysis was to identify the most likely exponential rate, which can serve as an index of population status.

TEWG used simple linear regression analyses to make inferences about population trends of nesting stocks. They used two methods: the natural log of the observed female or nest counts against time, and the natural log of the observed growth rates (i.e., the ratio between two consecutive counts) against the square root of the duration in years between the two counts (Morris and Doak 2002).

TEWG used a Bayesian state-space modelling approach to estimate annual growth rate of the nesting female segment of the population. In constructing a statistical model for nesting Leatherback Sea Turtles in the Atlantic, they made the following assumptions: (1) the number of females or nests at each nesting beach is well below the carrying capacity so that there is no density dependence; (2) the observed number of females or nests annually is a random sample from the total stock; (3) the number of females observed annually is a random sample from a uniform distribution between 0 and the total population size; (4) all nesting females are observed; and (5) each stock abundance follows a geometric population growth model.

Abundance

Although surface time correction factors have been calculated from satellite telemetry studies (James *et al*. 2006*b*), standardized aerial surveys throughout the spatial and temporal extent of the leatherback foraging season in Canadian waters, and spanning multiple years, have not been conducted to assess Leatherback Sea Turtle numbers and distributions in Atlantic Canada. Therefore, estimates of the size of the seasonal Leatherback Sea Turtle foraging population in Canada are limited both spatially and temporally. However, opportunistic, aerial, and observer program sightings data collectively suggest that the population numbers in the thousands of individuals. However, although standardized aerial surveys can provide some indication of the relative number of turtles in different areas, detection of turtles is hampered by weather, sea state, glare, size of individuals, and other factors, and is also limited to turtles at or near the surface, thereby missing the majority of animals in any particular area.

Although Atlantic Canadian waters provide important habitat to a relatively large number of individuals (James *et al*. 2005*a*; 2006*a*; 2007), there is no population estimate for the species in Atlantic or Pacific Canadian waters. The relative density of Leatherback Sea Turtles present in Atlantic Canadian shelf waters during the summer and fall appears to be higher than that documented in waters off the eastern United States (James *et al*. 2006*a*). Population estimates are currently based on the abundance of adult females encountered on nesting beaches. As genetic analyses have revealed that the stock composition of leatherbacks in Canadian waters mirrors the relative sizes of the various contributing nesting assemblages, population trends in nesting areas likely provide an indication of population trends in Canada. In 1996, Spotila *et al*. revised Pritchard's (1982) global tally of 115,000 nesting females to just 35,000 nesting females (range 26,200 to 42,900), reflecting the precipitous decline of the species in the Pacific. However, since this time, several more nesting colonies have been recognized, including large rookeries in the Gulf of Uraba, Colombia (Patino-Martinez *et al*. 2008), Gabon (Witt *et al*. 2009), and Trinidad (TEWG 2007). Of course, these rookeries existed when Pritchard made his estimates and like most other rookeries they likely have had declines in abundance since 1982. A review of recent estimates involving nesting populations contributing to, or thought to contribute to, the population of Leatherback Sea Turtles in Canadian waters follows.

TEWG (2007) estimated 34,000 to 94,000 adult Leatherback Sea Turtles (males and females) in the North Atlantic. The large range of this estimate reflects the authors' uncertainty about nest numbers and their extrapolation to adults (TEWG 2007). The largest nesting colonies were in French Guiana (which has contiguous nesting with neighbouring Suriname) and Trinidad. In French Guiana-Suriname, an estimated 5,029 (in 1980) to 63,294 (in 1988) nests were laid annually Girondot *et al*. (2007) and the population was described as "stable or slightly increasing." However, the population appears to have been nearly zero as recently as the 1950s and genetic evidence suggests that the large increases since then come from leatherbacks immigrating from other areas, such as the eastern Atlantic/west coast of Africa (Rivalan *et al.* 2006). In Trinidad, approximately 52,796 in 2007 and 48,240 in 8 nests were laid (Eckert *et al*. 2009). Only 10 nesting colonies in the Wider Caribbean Region (clustered in French Guiana, Suriname, Trinidad and Panama) had more than 1,000 nesting attempts (combining successful and unsuccessful attempts) (Dow *et al*. 2007, Ordonez *et al*. 2007, Patino-Martinez *et al*. 2008). An additional four colonies (in Guyana, Suriname, Costa Rica, and the U.S. Virgin Islands) had between 500 and 1,000 attempts per year (Dow *et al*. 2007). Of known nesting beaches in the Wider Caribbean Region, 58% supported small nesting colonies with <25 attempts per year (Dow *et al*. 2007).

Dutton *et al*. (2007) studied status and genetic structure of nesting populations in the Western Pacific, recording 28 nesting sites in Papua New Guinea, Solomon Islands, Vanuatu and Indonesia (Papua). Collectively, these sites hosted approximately 5,000 to 9,200 nests per year (Dutton *et al*. 2007). Approximately 75% of nesting activity is concentrated at four sites along the northwest coast of Papua (Dutton *et al*. 2007).

Fluctuations and Trends

Current data on Leatherback Sea Turtles in Canada 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 Leatherback Sea Turtle population found in Canadian waters as proxies. COSEWIC calculations for decline (over 10 years or three generations, whichever is longer) cannot be applied to historical data available for this species as these data do not extend back beyond one generation. Generation time for Leatherback Sea Turtles is estimated at >30 years. Major western Atlantic nesting populations currently appear to be stable or increasing (Table 2) (TEWG 2007), whereas trends over the past 100 years are apparently unknown. Given the data on other western Atlantic sea turtles over the past few centuries (Jackson *et al*. 2001; McLenachan *et al*. 2006), and the precipitous collapse of Pacific populations of leatherbacks over the past few decades (see next part of paragraph) it is not unreasonable to infer significant past declines in Atlantic leatherback populations. In contrast, it is well established that nesting colonies in the Pacific are in steep and continuing decline, and a recent global assessment of all marine turtles ranked leatherbacks in the eastern Pacific as one of the most vulnerable ‘populations’ (Wallace *et al*. 2011). The important nesting colony on the northwest coast of Papua, Indonesia, has gradually declined since 1981 from approximately 13,000 nests to an estimated 3,000 to 4,000 nests annually (Hitipeuw *et al*. 2007). In the Eastern Pacific, declines are precipitous. For example, Mexico has witnessed an ongoing decline of more than 90% of its breeding females between 1982 and 2004 (Sarti *et al*. 1996; 2007), and numbers in Pacific Costa Rica plummeted 95% between 1988 and 2004, with the mortality rates for oceanic juveniles and sub-adults double those of a stable population (Santidrián Tomillo *et al*. 2007; 2008).

Table 2. Results of short-term (< one generation) trend analyses for western Atlantic nesting beaches with sufficiently long time series. The numbers in parentheses under locations indicate the most recent counts. M&D refers to the technique presented in Morris and Doak (2002). Table from TEWG (2007). ***Note: replace Locations with Nesting Sites in Table***

Locations		Log-transformed regression	M&D regression 3 yr running sum	Bayesian State-Space Model	
	Duration of data	Mean λ [95% C.I.]	Mean λ [95% C.I.]	Median λ [95% P.I.]	$Pr(\lambda > 1.0)$
North Caribbean					
British Virgin Islands (39; nests)	1994-2004 T = 11	1.20 [1.09, 1.32]	1.24 [0.97, 1.58]	1.17 [0.97, 1.31]	0.94
Puerto Rico (697; nests)	1984-2005 T = 22	1.11 [1.07, 1.14]	1.10 [1.01, 1.28]	1.10 [1.02, 1.13]	0.997
US Virgin Islands (144; females)	1986-2005 T = 19	1.09 [1.07, 1.12]	1.11 [1.03, 1.26]	1.09 [1.07, 1.11]	1.0
West Caribbean					
Tortuguero, Costa Rica (767; nests*)	1995-2005 T = 11	0.98 [0.92, 1.05]	1.00 [0.90, 1.13]	NA	
Gandoca & Pacuare, Costa Rica (1348; nests)	1995-2005 T = 11	0.96 [0.91, 1.02]	0.95 [0.87, 1.09]	0.93 [0.85, 1.01]	0.03
Southern Caribbean/Guianas					
Trinidad (Matura Beach) (2096; females)	1994-2005 T = 12	1.09 [1.03, 1.17]	1.11 [0.94, 1.38]	1.05 [0.95, 1.13]	0.81
Suriname & French Guiana (21066;nests)	1967-2005 T = 39	1.01 [1.00, 1.03]	1.03 [0.94, 1.13]	1.04 [0.99, 1.05]	0.95
Guyana (656; nests)	1986-2005 T = 18	1.13 [1.02, 1.23]	NA	1.17 [1.07, 1.21]	1
Florida (262; nests)	1989-2005 T = 17	1.16 [1.13, 1.20]	1.14 [1.04, 1.27]	1.18 [1.10, 1.21]	1
South Africa (86; females)	1963-1997 T = 35	1.06 [1.04, 1.07]	1.06 [1.00, 1.13]	1.04 [1.03, 1.05]	1
Brazil (68; nests)	1988-2003 T = 16	1.07 [1.02, 1.14]	1.11 [1.00, 1.39]	1.08 [1.04, 1.13]	0.999

Rescue Effect

The highly migratory behaviour of Leatherback Sea Turtles makes them a shared resource among many countries. Therefore, international conservation efforts are interdependent. Recovery of the species hinges on successful management of threats at the level of Large Marine Ecosystems (LMEs). The loss of any of the world's population segments would result in a significant gap in the range of the taxon. The Canadian foraging habitat is perhaps particularly important in this respect, as it plays host to individuals from source populations throughout the western Atlantic (James *et al*. 2007) and there is some evidence to suggest in the northeast Pacific as well (Benson *et al*. 2007*a*, *c*).

As ocean temperatures rise as a result of climate change, it is possible that increased numbers of Leatherback Sea Turtles will expand their thermal niche into Canadian waters (James *et al*. 2006*c*).

THREATS AND LIMITING FACTORS

Threats in Canadian Waters

Threats to leatherbacks in Canadian waters are significant and their impact is magnified because these turtles come from many different nesting populations in the western Atlantic. As well, anthropogenically caused mortalities of adults and older juveniles, the demographic groups frequenting Canadian waters, have significant and long-lasting impacts on the western Atlantic population. Like other long-lived, late maturing species, leatherbacks have low resilience to added adult and older juvenile mortality (Wallace and Saba 2000; Santidrián Tomillo *et al.* 2012).

Bycatch

By far the greatest threat to leatherbacks while they are in Canadian waters comes from their extensive interactions with fisheries. Satellite telemetry has revealed that large sub-adults, and mature males and females in their inter-nesting years return annually to high-latitude foraging areas (James *et al.* 2005*c*), where they are vulnerable to incidental capture by many fisheries (James *et al*. 2005*a*). Although recent measures have been adopted by some countries to reduce injury and mortality associated with incidental capture of Leatherback Sea Turtles on pelagic longlines (Watson *et al*. 2005), little effort has been made to address fisheries interactions and other anthropogenic impacts in temperate shelf Canadian waters of the western Atlantic (James *et al*. 2006*a*).

It is widely recognized that vertical lines and surface lines associated with fixed fishing gear pose a serious entanglement hazard to Leatherback Sea Turtles throughout much of their range, including Canadian waters (TEWG 2007). Leatherback Sea Turtles are also vulnerable to entanglement in buoy lines, mooring lines, trip lines (or secondary buoy lines) and hi-flier lines. They can also become entangled in monofilament, cotton, and polypropylene netting. In Atlantic Canada, Leatherback Sea Turtles have been recorded incidentally captured or entangled in the following fisheries: pelagic longline, tuna rod and reel, fish traps, lobster, snow crab, rock crab, jonah crab, whelk, hagfish, bait nets, and gill nets (CSTN 2010). Entanglement normally involves lines wrapped around one or both front flippers and also often the neck (James *et al*. 2005*a*). The Leatherback Sea Turtle mortality rate in Canadian Atlantic from 2006 to 2010 was roughly estimated to be 21-49% for large pelagic longline gear interactions and was suggested to be 20-70% for interactions with other fixed gear fisheries based on available information and expert opinion (DFO 2012). Permits are issued to licensed commercial fishers in Atlantic Canada to carry out activities that are known to incidentally capture Leatherback Sea Turtles. *Species at Risk Act* (SARA) logbooks that document leatherback interactions are part of the conditions of these permits and have been instituted for most Atlantic Canada Fisheries since 2005. While there have been some issues with compliance and incomplete coverage of fisheries, SARA logbooks do provide evidence of interactions between leatherbacks and a variety of fishing gear types. In some regions of Atlantic Canada these logbooks indicate that interactions between leatherbacks and some fisheries may be greater than what is suggested by observer data (DFO 2012). Permit conditions also stipulate that any incidentally caught leatherbacks be returned to the place from which they were taken, and where they are alive, in a manner that causes them the least harm. Some mitigation measures are in place for the Canadian pelagic longline fleet in an effort to mitigate turtle bycatch, including mandatory sea turtle de-hooking and disentanglement training and a license requirement for the use of corrodible circle hooks.

Spaven *et al*. (2009) note that 10 of 118 sightings of Leatherback Sea Turtles off Pacific Canada were entanglements (gillnets: n=6, seine nets: n=2, troll stabilizer: n=1, unidentified line—reported as likely demersal longline n=1. Seven of the 10 were released alive, although it is recognized that fishers are more likely to report turtles found alive versus dead in their gear. All entanglements occurred in July, August or September, but they were not clustered in one particular area.

Threats Outside Canadian Waters

Globally, leatherbacks are faced with a host of major anthropogenic threats. Along with fisheries interactions, these turtles are impacted by poaching on their nesting beaches, pollution from plastics that they ingest while feeding, oil and other chemical pollutants, beach development, ship strikes, noise pollution, and rising temperatures and sea level, which affect survival and sex ratio of hatchlings.

Threats in the Terrestrial Environment

Leatherback Sea Turtles do not come onto land in Canada; however, threats faced in both the marine and terrestrial environments are relevant. Threats to Leatherback Sea Turtles on nesting beaches in other countries directly affect individuals that use foraging habitat in Canadian waters (James *et al*. 2007). In their assessment of the Atlantic Leatherback Sea Turtle population, TEWG (2007) determined that populations at greatest risk from the combination of terrestrial and marine threats are in Gabon and other areas of West Africa, Guyana, Trinidad and the Dominican Republic (Figure 10) (but see Wallace *et al*. 2011). Guyana and Trinidad are both confirmed source populations for Leatherback Sea Turtles in Atlantic Canadian waters (James *et al*. 2007).

Conservation efforts in the Atlantic have traditionally focused on protecting nesting habitat and addressing threats to breeding females and their eggs. Increases in some nesting populations may attest to some modest success of such work (Hughes 1996; Dutton *et al*. 2005). However, despite similar efforts in other western Atlantic nesting areas, population trends there are less positive (Troëng *et al*. 2004). In the eastern Pacific, recent studies confirm that survival of eggs and hatchlings is low even with protection, and that climate change is leading to increased warming and drying in many nesting beaches, which is causing increased egg and hatchling mortality, both currently and in the future (Santidrián Tomillo *et al*. 2012).

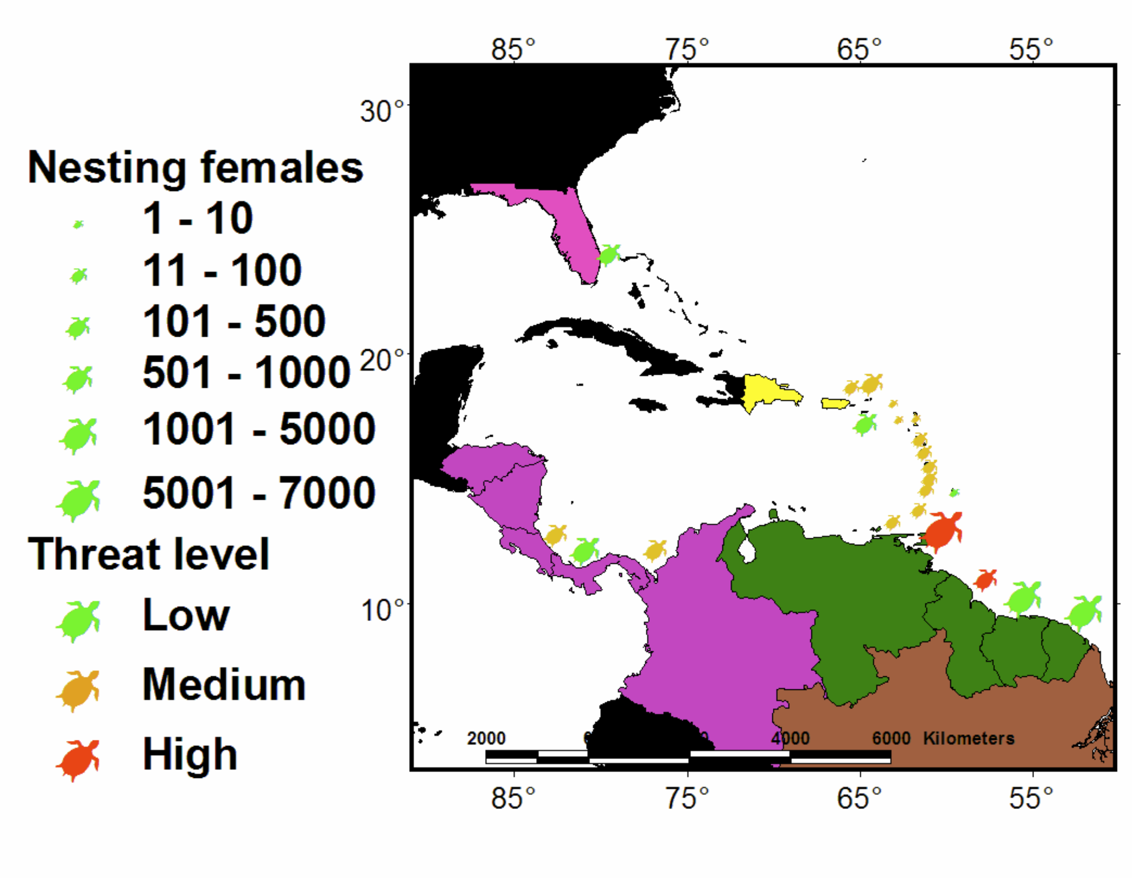

Figure 10. Estimated annual number of female Leatherback Sea Turtles per rookery, and threat level to that rookery. Threats were divided into two categories (nesting beach and inter-nesting habitat). Each rookery was given an expert opinion threat level rating of low, medium or high for each category. The categories were then combined to rate the overall threat level to each rookery represented by a qualitative overall value based on expert opinion. The combined threat level is indicated by the colour of each turtle symbol. From TEWG (2007).

<u>Anthropogenic Changes to Terrestrial Environment</u>

Coastal development and construction (e.g., construction of roads, buildings, harbours and breakwaters, as well as beach armouring) alter nesting habitat, usually making it less suitable for nesting females, egg incubation and/or hatchling emergence (e.g., Lutcavage *et al*. 1997; Formia *et al*. 2003; Eckert *et al*. 2009) (Figure 11). Beachfront lighting associated with coastal development disorients hatchling Leatherback Sea Turtles and disrupts their movement from their nests to the ocean. This disruption increases mortality from dehydration, exhaustion and predation (e.g., Villaneueva-Mayor *et al*. 2003; Sounguet *et al*. 2004; KWATA 2009).

Figure 11. A Leatherback Sea Turtle tagged in Atlantic Canadian waters by the Canadian Sea Turtle Network on 6 September 2007 tries unsuccessfully to nest on an armoured beach near an oil refinery on the south shore of St. Croix, USVI, on 16 April 2009. Photo courtesy of U.S. Fish and Wildlife Service and used with the permission of the U.S. Fish and Wildlife Service.

Direct Anthropogenic Threats on Nesting Beaches

The main terrestrial threat to Leatherback Sea Turtles is poaching of nesting females and their eggs. Eckert *et al*. (2009) note that “the literature is replete with references to the killing of leatherbacks by humans. Most killing occurs at the nesting beach where gravid females are slaughtered (for meat, oil and/or eggs), legally or illegally, in virtually every country where nesting occurs.” Eggs were or are harvested commercially for use in baking (D. Fraser pers. comm. May 2012).

Countries where Leatherback Sea Turtle meat is a staple of the local diet include Papua New Guinea and Equatorial Guinea (Anvene 2003; Kinch 2006). Consumption of leatherback meat occurs in many other countries, including Grenada, Dominican Republic and French Guiana (Pritchard 1971*b*; Ross and Ottenwalder 1983; Eckert and Eckert 1990). Leatherback Sea Turtle oil has been used for varnish, as a sealant on the hulls of small boats, as lamp oil, as an aphrodisiac, and medicinally (Eckert *et al*. 2009). TEWG (2007) suggests that although killing of nesting females was a major threat in many regions in the past, conservation efforts have significantly reduced this source of mortality. Nevertheless, most nesting beaches still have limited monitoring or protection or lack it altogether (many references).

Leatherback Sea Turtle eggs have been systematically or opportunistically collected from nesting beaches for generations. Collection remains a major threat on many beaches (TEWG 2007; Eckert *et al*. 2009) globally and in the Atlantic, most notably in Suriname where egg poaching approaches 100% on unmonitored beaches (de Dijn 2001; Hilterman and Goverse 2006). In Papua New Guinea, Philip (2002) notes that the largest remaining nesting colonies in the Pacific are “subjected to intensive egg harvest” (e.g., Betz and Welch 1992; Starbrid and Suarez 1994; Kinch 2006; Hitipeuw *et al*. 2007). For example, Kinch (2006) found that 40% of surveyed households along the Huon Coast reported consuming leatherback eggs “in the last year.”

Marine Debris

Ingestion of marine debris can result in both sub-lethal (e.g., interference with metabolism or gut function) and/or lethal effects (e.g., blockages in the digestive tract leading to starvation). A recent study revealed that incidence of plastics ingestion among Leatherback Sea Turtles is high (>30 % of examined carcasses), although associated mortality cannot be quantified (Mrosovsky *et al.* 2008). In another recent study, it was reported that the amount of small floating plastic in the northeast Pacific has increased 100-fold over the past 40 years (Goldstein *et al*. 2012). Bioaccumulation of contaminants has also been documented in Leatherback Sea Turtles and may have associated health impacts (Storelli and Marcotrigiano 2003).

Ship Strikes

Leatherback Sea Turtles have been known to be hit and/or killed by ship strikes and resulting propeller wounds (Fretey 1976; Ogden *et al*. 1981; Rhodin and Schoelkopf 1982; Stinson 1984; Dwyer *et al*. 2003). Eckert *et al*. (2009) report that approximately 20% (108/574) of Leatherback Sea Turtle stranded along the coast of Florida between 1980 and 2007 had propeller wounds.

Oil and Gas Exploration

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 to 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 known to impact other 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 sparse.

Sensitivity of Leatherback Sea Turtle hearing and its role in the ecology of this species is not fully understood; however, it is possible that exposure to anthropogenic sources of acoustic noise in foraging areas could negatively impact the species. For example, noise may displace turtles from preferred foraging areas, with accompanying energetic costs and/or temporary or permanent damage to auditory structures (Viada *et al*. 2008).

Climate Change: Beach Erosion, Temperature Change

Climate change and the associated rise in sea surface temperatures may result in trophic alterations that affect abundance and/or distribution of Leatherback Sea Turtle prey, including quantity and quality of foraging habitats in higher-latitude waters (James *et al*. 2006*c*; McMahon and Hays 2006). Meteorological events such as tsunamis (Hamann *et al*. 2006) and unusually high “king tides” (Kinch 2006; Tapilatu and Tiwari 2007; Hitipeuw *et al*. 2007) threaten coastal nesting habitat, as does beach erosion (TEWG 2007). A recent study found that storminess of oceans reduced sea turtle hatching success in the Caribbean (van Houtan and Bass 2007).

Leatherbacks have temperature-dependent sex determination such that eggs incubated at higher temperatures produce females (e.g., Mrosovsky *et al*. 1984). Climate change could lead to a shift toward one sex either locally or over a wide area (e.g., Hays *et al*. 2003).

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

The Leatherback Sea Turtle is listed under Schedule 1 of Canada’s *Species at Risk Act* (SARA 2002). The primary purpose of this Act is to prevent wildlife species from becoming extinct by providing for their recovery (SARA 2002). Since 2009, the species is listed as Threatened/menacé in Quebec by the provincial government under the *Act Respecting Threatened or Vulnerable Species*. Therefore, the species is protected by the provincial *Act respecting conservation and development of wildlife*. The S-Rank is S1N. Leatherback Sea Turtle is listed under the New Brunswick *Endangered Species Act*, which states that no one shall possess, kill, injure, disturb or interfere with an endangered species, or destroy, disturb or interfere with the nest, nest shelter or den of an endangered species.

The Leatherback Sea Turtle is in Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES 2010), which prohibits the international trade of the species or its parts. Canada is signatory to CITES.

In the United States, the Leatherback Sea Turtle was listed as endangered on June 2, 1970, under the *Endangered Species Act* (USFWS and NMFS 1970). Pursuant to a joint agreement, the U.S. Fish and Wildlife Service (USFWS) has jurisdiction over sea turtles on land, whereas the National Marine Fisheries Service (NMFS) has jurisdiction over sea turtles in the marine environment.

The United States is party to the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC) (to which Canada is not party), 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) in the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention), which lists Leatherback 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).

Leatherback 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 signatories to the CMS.

As noted in a global study by the United Nations Environment Programme (2003), "the Leatherback is nominally protected by legislation in most countries where nesting occurs." Legislation in these countries primarily mitigates threats to nesting female Leatherback Sea Turtles, their nests and eggs, as well as Leatherback Sea Turtle hatchlings, although some legislation also includes the nesting beaches and adjacent coastal waters (Fahey 2008). National laws are often successful when they are combined with proper enforcement and sufficient funding and support for conservation projects that actively protect nesting habitats (Navid 1979; NMFS & USFWS 1992, 2007; UNEP 2003). However, in many instances, national laws have not been properly implemented, leaving nesting Leatherback Sea Turtles unprotected (UNEP 2003; Troëng *et al.* 2007; Fahey 2008).

Non-Legal Status and Ranks

The Leatherback Sea Turtle is listed as "Critically Endangered A1abd ver 2.3" by the International Union for Conservation of Nature (IUCN) on its Red List (2009).

Habitat Protection and Ownership

In Canada, Leatherback Sea Turtle habitat can be protected under the *Species at Risk Act* (SARA 2002), the *Fisheries Act* (Fisheries Act 1985) and the *Oceans Act*

(Department of Justice Canada 2004). The *Species at Risk Act* creates prohibitions to protect listed endangered species and their critical habitat. A legislated requirement of SARA is the precise delineation of critical habitat areas in Canadian waters, and although this delineation is currently underway, critical habitat has not been identified.

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 *Oceans Act* provides for DFO to establish Marine Protected Areas (MPAs) to protect and conserve important fish and marine mammal habitats, endangered marine species, unique features, and areas of high biological productivity or biodiversity. In the Atlantic Ocean, the Gully MPA includes some Leatherback Sea Turtle habitat. The Gully MPA comprises an area of about 2,364 km^2 (http://www.dfo-mpo.gc.ca/media/back-fiche/2004/hq-ac61a-eng.htm), and is located approximately 200 km off Nova Scotia, to the east of Sable Island, on the edge of the Scotian Shelf (contained within a rhumb line drawn from a point 44º 13’ N, 59º 06’ W to a point 43º 47’ N, 58º 35’ W, then to a point 43º 35’N, 58º 35’ W, then to a point 43º 35’ N, 59º 08’ W, then to a point 43º 55’ N, 59º 08’ W, and then to a point 44º 06 N, 59º 20’ W) (Department of Justice Canada 2004). The protected area includes the seabed, the subsoil to a depth of 15 m, and the water column above the seabed (Department of Justice Canada 2004). MPA protection means that no person shall disturb, damage, destroy, or remove from the Gully any living marine organism or any part of its habitat or any part of the seabed; and that no person can carry out any activity in the MPA or in the vicinity of the MPA that is likely to result in the disturbance, damage or removal of any living marine organism or any part of its habitat or any part of the seabed (Department of Justice Canada 2004).

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Karen Eckert
Executive Director
Wider Caribbean Sea Turtle Network
Ballwin, Missouri

COSEWIC Secretariat
Canadian Wildlife Service
Ottawa, Ontario

Roger Gallant
Mi'kmaq Alsumk Mowimsikik Koqoey Association
Corner Brook, Newfoundland and Labrador

Dr. Michael James
Department of Biology
Dalhousie University
Halifax, Nova Scotia

Soazig LeBreton
Agence Mamu Innu Kaikusseht
Sept-îles, Quebec

Lisa Spaven
Fisheries Technician
Fisheries and Oceans Canada
Nanaimo, British Columbia

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

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.