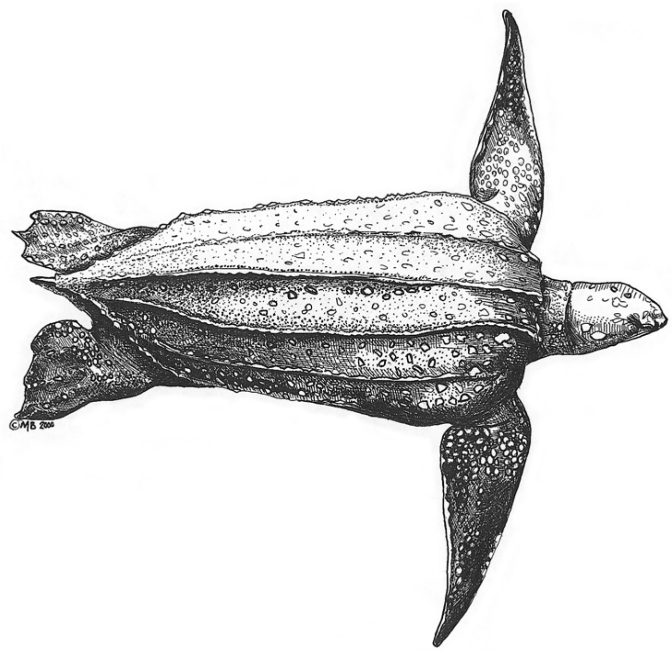
COSEWIC
Assessment and Update Status Report

on the

Leatherback Turtle
Dermochelys coriacea

in Canada



ENDANGERED
2001

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION DES
ESPÈCES EN PÉRIL
AU CANADA

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COSEWIC
Assessment Summary

Assessment Summary – May 2001

Common name
Leatherback turtle

Scientific name
Dermochelys coriacea

Status
Endangered

Reason for designation
The leatherback turtle is undergoing a severe global decline (> 70 % in 15 years). In Canadian waters, incidental capture in fishing gear is a major cause of mortality. A long lifespan, very high rates of egg and hatchling mortality, and a late age of maturity makes this species unusually vulnerable to even small increases in rates of mortality of adults and older juveniles.

Occurrence
Pacific Ocean and Atlantic Ocean

Status history
Designated Endangered in April 1981. Status re-examined and confirmed in May 2001.

COSEWIC
Executive Summary

Leatherback Turtle
Dermochelys coriacea

Species information

The leatherback turtle (*Dermochelys coriacea*) is a large marine turtle; specimens can grow up to 2 m long and have an average weight of 500 kg. The leatherback's carapace is not covered by scales, but instead has a leathery, cartilagenous covering. The paddle shaped front flippers are usually equal to or longer than half the animal's body. Leatherbacks have black or dark blue backs with white and pink blotches and a white belly. Individual turtles can be recognized by the size, shape, colour and pattern of the "pink spot" on top of their heads. The leatherback turtle is unique in being the only marine turtle that does not have scales.

Distribution

Leatherbacks range from 70° 15'N to 27°S in the Atlantic, Pacific and Indian Oceans. The major nesting beaches are located in Mexico, Costa Rica Irian Jaya, French Guiana, Suriname and Gabon. In Canada, there have been sightings of the turtles in the waters off Nova Scotia, New Brunswick, Newfoundland, and Prince Edward Island.

Habitat

Virtually nothing is known about hatchling and juvenile habitat requirements, however, since they are never seen in temperate waters, it can be assumed that the leatherbacks gain cold tolerance as they mature, possibly due to increased body size. The adult leatherbacks are highly migratory and spend the majority of their lives in the open sea. They are regularly observed along the continental shelf off the coast of Canada, presumably because of a high concentration of prey. Their use of temperate water habitat seems to be dependent on prey abundance.

Biology

Not much is known about leatherback mating, either in terms of where or when it occurs. The females nest in the tropics on open beaches with minimal amounts of abrasive material. They prefer beaches with deep-water approaches because they are very awkward on land. The leatherback females excavate the nest with their hind flippers and lay 50-166 eggs; a large number of yolkless eggs are often laid at the top of the nest. They lay an average of 6 clutches each season, at 8-12 day intervals. The eggs hatch in about 60-65 days. The sex ratio of the hatchlings is determined by nest temperature during development (temperature dependent sex determination). There is high mortality in the egg and hatchling stages as a result of poor nest site selection and predation. The adult leatherbacks have few natural predators — only sharks and killer whales.

Leatherbacks can retain an internal body temperature 18° higher than the ambient temperature, allowing them to survive in colder environments. They also have specialized tear glands to expel the excess salt that they obtain from their diet of jellyfish. The main prey items are jellyfish and other soft-bodied vertebrates, but added invertebrates are often eaten incidentally along with the preferred prey. Leatherback turtles migrate to tropical waters to nest and then follow the abundance of jellyfish into temperate waters. The turtles are attracted to the continental shelf area, and areas of thermal, salinity or colour changes because of the high levels of prey.

Population sizes and trends

Population estimates of leatherback turtles are based on the number of nesting females. Estimates made in 1982 (115,000) and 1995 (approximately 34,500) suggest large population declines in the Pacific. The Atlantic population appears to be more stable, but shows dramatic fluctuations in the number of nesting females from year to year. There are no good population estimates for leatherbacks in Canadian waters.

Limiting factors and threats

Nests are subject to both natural and human created pressures. The turtle's preference for open beaches as nest sites results in nests being destroyed by flooding and erosion. Increased human use of the beaches discourages nesting, while after nesting humans harvest the eggs for consumption. Since the sex ratio of the nests is determined by temperature, there are suggestions that global warming could affect the demographics of the leatherback populations.

The adult turtles are threatened by entanglement in fishing gear, which can result in death by drowning or serious injuries. In addition, adult leatherbacks often mistake floating garbage as jellyfish (for example, plastic bags). Ingestion of such materials inevitably results in death.

Special significance of the species

The leatherback is one of only two marine turtles that are regularly found in Canadian waters.

Existing protection

The leatherback turtle is listed as globally endangered and endangered in Canada. It is listed as critically endangered by CITES, however, it is categorized as Appendix I or II, depending on country. Since it is a migratory species, these inconsistencies in level of protection pose serious problems for conservation. Some of the species' critical nesting beaches have been protected as national parks or reserves. Also, devices to prevent turtles from drowning in fishing gear have been mandated for use in several countries.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, subspecies, varieties, and nationally significant populations that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fish, lepidopterans, molluscs, vascular plants, lichens, and mosses.

COSEWIC MEMBERSHIP

COSEWIC comprises representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership), three nonjurisdictional members and the co-chairs of the species specialist groups. The committee meets to consider status reports on candidate species.

DEFINITIONS

Species	Any indigenous species, subspecies, variety, or geographically defined population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* 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.

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.

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.

Update
COSEWIC Status Report

on the

Leatherback Turtle
Dermochelys coriacea

in Canada

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2001

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SPECIES INFORMATION

Common name of species: Atlantic leatherback, leatherback, leatherback turtle, trunkback turtle, leathery turtle, tortue luth

One of only seven species of marine turtle, the leatherback (*Dermochelys coriacea*) (Fig.1) is the sole member of the family *Dermochelyidae*, a lineage that diverged from other turtles during the Cretaceous or Jurassic Period, 100-150 million years ago (Zangerl, 1980). Leatherbacks may attain a straight carapace length of nearly 2 metres. Body mass is typically less than 500 kg (Zug & Parham, 1996), however, there is a record of a male turtle weighing 916 kg (Eckert & Luginbuhl, 1988). Unlike all other sea turtles, leatherbacks do not have scales, nor do they possess claws. Lacking shell scutes, the leatherback's carapace is composed of four centimetres of tough, slightly flexible, cartilagenous, oil-saturated connective tissue. The carapace is conspicuously elongate and tapers to a supracaudal point. A mosaic of thousands of small dermal bones underlies the leathery outer skin of the carapace and seven longitudinal ridges run along it. The immense paddle-shaped front flippers often equal or exceed half the carapace length. The dorsum of the turtle is black, or bluish-black, with scattered white and pink blotches, while the ventrum is predominantly white. One external characteristic unique to each adult leatherback is the size, shape, colour and pattern of the pineal spot or "pink spot" on the top of the head (McDonald & Dutton, 1996).

Figure 1. Adult *Dermochelys coriacea* photographed off Nova Scotia, 1998.
Photo: L. Hatcher, Nova Scotia Leatherback Turtle Working Group.

Two subspecies have been described: *Dermochelys coriacea coriacea* (Linnaeus, 1766), the Atlantic leatherback, and *Dermochelys coriacea schlegelii* (Garman, 1884), the Pacific leatherback. However, these supposed subspecies are poorly differentiated, and distinctions based on colouration and differences in forelimb and head length are questionable (Pritchard, 1979). Therefore, one species is now generally recognized. Genetic analyses, revealing low mtDNA sequence divergence (0.0081) between Pacific and Atlantic populations (Dutton *et al.,* 1996), have corroborated this view. Low genetic variation between leatherbacks occupying Pacific and Atlantic waters may be a product of recent evolutionary separation between these populations. Alternatively, the leatherback's extraordinary migratory ability (e.g., Hughes *et al.,* 1998) and two to three year intervals between nestings (e.g., Hughes, 1996) may enable gene flow between these ocean basins (Binckley *et al.,* 1998).

Leatherbacks feed principally on jellyfish and other soft-bodied pelagic invertebrates (e.g., Lazell, 1980; Lutcavage & Lutz, 1986, Grant *et al*., 1996). Bleakney (1965) was the first to document scientifically the occurrence of leatherbacks in Eastern Canada. His analysis of 26 records of leatherbacks in this region (1889-1964) suggested a seasonal, rather than accidental, intrusion of the species into the cold waters of the northwest Atlantic. Examination of the digestive tracts of five of these animals yielded remains of *Cyanea capillata arctica*, a large, temperate species of jellyfish. Bleakney therefore concluded that leatherbacks venture to waters off Canada's Atlantic coast to forage on seasonally abundant populations of jellyfish. After collecting 20 records of free-swimming and entangled leatherbacks reported by fishers in Newfoundland waters (1976 to 1985), Goff and Lien (1988) also suggested that leatherbacks are regular migrants to waters off Atlantic Canada.

Recently, a fishermen-scientist collaborative venture –The Nova Scotia Leatherback Turtle Working Group - was initiated in Atlantic Canada to investigate the distribution of leatherback turtles in the northwest Atlantic (James, 2000). Over 300 leatherback sightings were reported through this program in 1998 and 1999. These results demonstrate that waters off the Atlantic provinces are within the normal range of this species. In an earlier status report on the leatherback in Canada, Cook (1981) stated that "There is no proof to date that leatherbacks which come this far north actually find their way south again to breed". A recent satellite telemetry study suggests that mature male and female leatherbacks do indeed successfully migrate to southern latitudes after foraging in Canadian waters (James, unpublished data).

DISTRIBUTION

The leatherback has the most extensive geographic range of any reptile. It is found in tropical and temperate waters of the Atlantic, Pacific, and Indian Oceans, with the northernmost latitude recorded at 70°15'N (Gulliksen, 1990), and the southernmost at approximately 27° S (Boulon *et al*., 1988). In the Pacific, major nesting beaches are located in Mexico, Costa Rica, and Irian Jaya. The largest Atlantic nesting colonies are located in French Guiana, Suriname, and Gabon, Africa, however, nesting also occurs in lower densities throughout the Caribbean and in Brazil (Fig. 2). The northernmost known nesting location on the Atlantic coast is Blackbeard Island, Georgia (Seyle, 1985), however, in the continental United States, Florida is the only state known to support a nesting population of this species (Calleson *et al*., 1998).

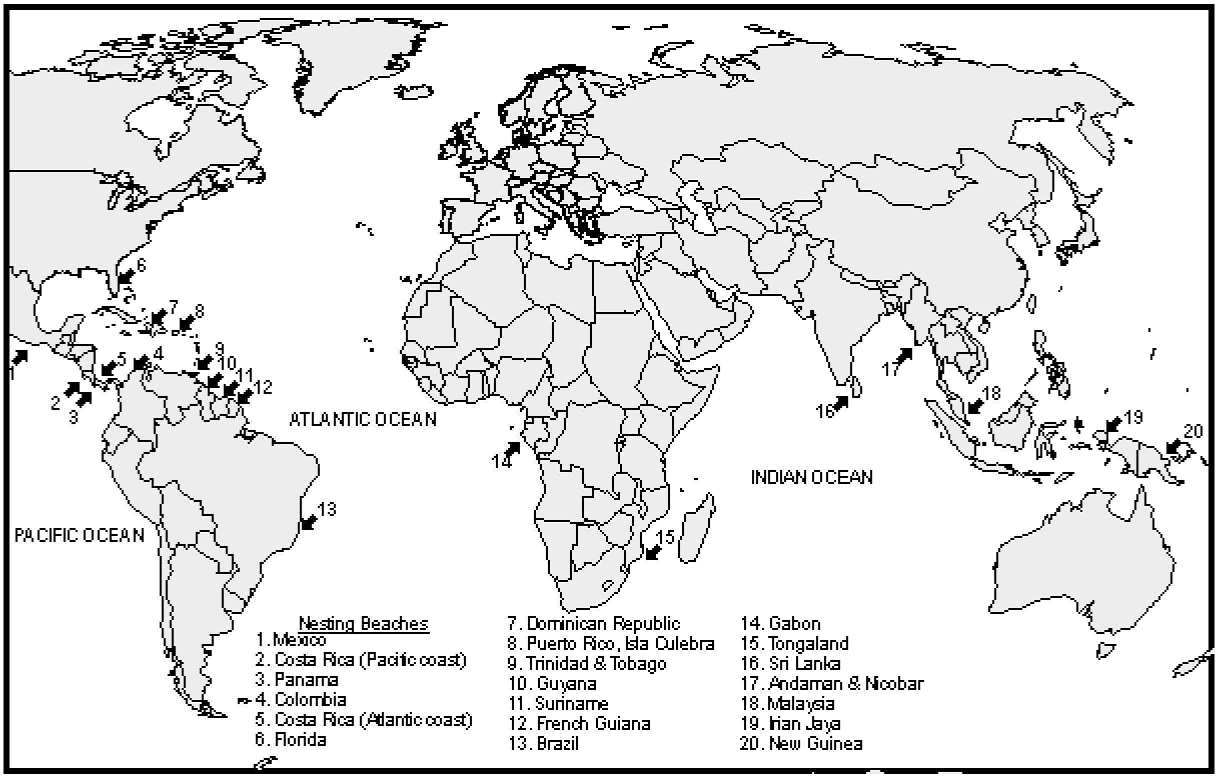

Figure 2. Global distribution of leatherback turtle (*Dermochelys coriacea*) nesting beaches.

Although leatherbacks do not nest in Canada, these turtles are found here annually, entering Canadian waters off both the Atlantic and Pacific coasts between June and November (Fig. 3). Only a small number of West coast records exist (e.g., Kermode, 1931; MacAskie & Forester, 1962; Carl, 1968). Leatherbacks encountered in the north Atlantic were formerly considered extralimital (e.g., Cook, 1981), however, recent research (James, 2000) suggests that leatherbacks regularly enter temperate waters off eastern Canada. Leatherbacks have been recorded off the coasts of Nova Scotia (e.g., Bleakney, 1965; James, 2000), Newfoundland (e.g., Goff & Lien, 1988) and Labrador (Threlfall, 1978). Reports from New Brunswick come from turtles sighted in the Bay of Fundy, the Northumberland Strait, and the Gulf of St. Lawrence. In Prince Edward Island, a small number of records come from coastal strandings and reports made by fishermen. Leatherbacks also have been reported in the Gulf of the St. Lawrence off Quebec (e.g., D'Amours, 1983; Bossé, 1994). Cultural artifacts from Baffin Island suggest that leatherbacks are occasionally encountered in that region of the north Atlantic (Shoop, 1980).

Figure 3. Distribution of the leatherback turtle in Canadian waters.
Map courtesy of M. Elliott, Environment Canada, 1999.

HABITAT

The leatherback's habitat requirements and preferences are poorly understood. Virtually nothing is known of the distribution of hatchling or juvenile turtles. While mature leatherbacks are regularly encountered in temperate waters, records of small juveniles (e.g., Grant, 1994; Sampaio, 1999) are from tropical waters. Juveniles may occupy characteristically different habitat from adults. Cold water tolerance observed in mature leatherbacks is partially a product of a large volume to surface area ratio (Frair *et al.*, 1972; Paladino *et al*, 1990). As increased cold-water tolerance in this species is conferred with greater body mass, it is possible that the distribution of smaller turtles (i.e., juveniles) is limited to warmer waters.

Adult leatherbacks are highly migratory and are believed to be the most pelagic of all sea turtles. However, in the northeastern United States (Shoop & Kenney, 1992) and in Canada (James, 2000), leatherbacks are regularly observed along the continental shelf. Leatherbacks normally inhabit areas where coelenterate productivity is high, along oceanic frontal systems and along vertical gradients located at oceanic fronts (Lutcavage, 1996). Therefore, habitat for this species may largely be determined by prey availability, with turtles moving from offshore waters into coastal areas to exploit seasonal proliferations of jellyfish.

BIOLOGY

Reproduction

Mating in leatherbacks was traditionally thought to occur in tropical waters at the time of nesting. However, Eckert and Eckert (1988) observed rapid colonization of female leatherbacks by pantropical barnacles (*Conchoderma virgatum*) after their first nesting of the season at St. Croix (U.S.V.I.). This suggests that gravid turtles do not arrive from temperate latitudes until just prior to nesting (Eckert & Eckert, 1988). Therefore, mating may take place prior to or during the migration from temperate to tropical waters. By contrast, two documented observations of copulating leatherbacks suggest that at least some mating occurs in the vicinity of nesting beaches. Carr and Carr (1986) observed a pair of leatherbacks copulating near Culebra Island, Puerto Rico, and Godfrey and Barreto (1998) observed leatherbacks copulating in shallow water off Matapica Beach, Suriname.

Leatherbacks primarily nest in the tropics (see distribution). They prefer open access beaches, with a minimal amount of coral, rocks, and other abrasive material. Unfortunately, many of these open beaches offer little shoreline protection and are therefore vulnerable to beach erosion triggered by seasonal changes in wind and wave direction. Movement on land is slow and laboured; therefore beaches with deep-water approaches are preferred as they allow the female to ride the waves high onto the beach (Mrosovsky, 1983).

When a nest site is chosen, the cavity is carefully excavated with the rear flippers, and 50-166 eggs may be deposited (Ernst *et al.*, 1994). The average clutch size among 13 nesting populations of leatherbacks studied by Van Buskirk and Crowder (1994) was 81.5. Pacific nesters are generally smaller and lay fewer eggs per clutch in comparison to Atlantic females (Van Buskirk & Crowder, 1994). A large number of yolkless eggs are typically deposited on top of fertile eggs. Once oviposition is complete, the eggs are covered, and the female returns to sea. Leatherbacks usually nest at 8-12 day intervals (Ernst *et al.*, 1994), but the internesting period may be considerably longer. Females lay an average of 6 clutches per season (Van Buskirk & Crowder, 1994). Incubation time is 60-65 days (Ernst *et al.*, 1994).

Developing leatherback embryos are subject to temperature dependent sex determination (TDSD). Studies on sex ratios of leatherbacks 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 & Liew, 1995). The constant temperature at which both sexes are produced (pivotal temperature) is 29.5°C, not necessarily in a 1:1 ratio, (Davenport, 1997).

Growth and Survivorship

Poor nest site selection can result in high egg mortality. Females will often nest in areas where their eggs are destroyed by tidal inundation. Hurricane-induced impacts on beaches, including storm-generated waves and wind, can erode nest sites, resulting in total nest loss (NMFS, 1992), and natural beach erosion can also destroy nests. Debris mats, consisting of large, dense masses of water hyacinth (*E. crassipes*), sargassum (*Sargassum* sp.) and piles of washed-up forest debris, will sometimes overlie nests. These mats can reduce gas exchange, thereby killing developing embryos, or act as a barrier, preventing hatchlings from crawling to the surface (Leslie *et al.*, 1996).

Predation is highest during incubation and emergence. Ghost crabs feed on eggs and embryos in the nest and attack emergent hatchlings as they scramble to the sea at night. Ants destroy nests, as do domestic and feral dogs. Vultures, skunks, raccoons, lizards, opossums, coatis, genet cats and jaguars have all been recorded preying upon nests and hatchlings. Those hatchlings that reach the water may be eaten by seabirds, including gulls and frigate birds, or sharks. Adult leatherbacks have few natural predators, only large sharks and killer whales (Caldwell & Caldwell, 1969).

Leatherbacks, which weigh approximately 30 g and measure about 6 cm in carapace length at hatching, can attain adult weights in excess of 650 kg and carapace lengths of up to 180cm. This represents a nearly 22,000-fold increase in body weight, and, as such, leatherback growth is unparalleled among marine turtles (Rhodin, 1985). Knowledge of juvenile growth rates in this species derives solely from a few individuals raised in captivity as it has proven difficult to mark hatchling leatherbacks so that they can still be recognized individually as adults (Zug & Parham, 1996). Captive juveniles exhibit faster growth than that documented in any other reptile, and it has been suggested that leatherbacks may therefore reach maturity in as few as 2 to 6 years (Rhodin, 1985). Hatchling leatherbacks fare poorly in captivity, and mortality is high (most perish in less than 100 days), hence, the validity of growth estimates based on studies of captive turtles is questionable. However, even captive hatchling leatherbacks dying from fungal infections, stress and other captivity factors show rapid growth (Zug & Parham, 1996).

Skeletochronological analyses of the sclerotic ossicles -- the ring of bony elements encircling the pupil within the sclera of the eyeball -- from both stranded and captive juvenile leatherbacks have recently been used to estimate age at maturity (Zug & Parham, 1996). This work suggests that female leatherbacks may mature in as few as 13-14 years, with a minimum age at maturity of 5-6 years. This translates into juvenile growth rates ranging from 8.6 cm to 39.4 cm per year (Zug & Parham, 1996). Although life expectancy is not known, the nesting lifetime of one turtle in Tongaland, South Africa, spanned 18 years (Hughes, 1996).

Physiology

Leatherbacks are capable of maintaining body core temperatures as much as 18°C above ambient water temperature (Frair *et al.*, 1972). This enables them to venture into cool temperate waters and range further than any other species of marine turtle. The endothermic capability exhibited by leatherbacks is made possible by a number of adaptations. These include large size and a thick layer of subcutaneous blubber (which favors heat retention from muscular activity), a high volume to surface area ratio (which minimizes heat loss), different compositions of peripheral and central lipids, and countercurrent vascular heat exchangers in the front and rear flippers (Davenport, 1997).

While cheloniid turtle distribution is normally constrained by the 20°C surface isotherm (Davenport, 1997), leatherbacks are routinely found cold temperate waters. For example, in March, 1984, a leatherback was observed by fishermen in Trinity Bay, Newfoundland swimming vigorously in water approximately 0°C (Goff & Lien, 1988).

Large, specialized lachrymal glands, designed for excreting salt, enable leatherbacks to maintain osmotic and ionic balance while consuming a diet of jellyfish (which are isotonic to salt water) (Hudson & Lutz, 1986).

Movement and Migration

At the end of the nesting season, leatherbacks follow drifting schools of jellyfish from tropical to temperate waters. In the course of such migrations, individual turtles may attain speeds of over 9km/h (Keinath & Musick, 1993).

Studies of the distribution of leatherbacks in the Gulf of Mexico (e.g., Fritts *et al.*, 1983), off the Atlantic coast of the United States (e.g., Lazell, 1980; Shoop & Kenney, 1992) and off the East Coast of Canada (James, 2000) suggest that these turtles may preferentially inhabit continental shelf waters. As fishing activity is often intense in these coastal areas, incidental catch of leatherbacks in fixed and mobile fishing gear is not uncommon, with some accompanying mortality (e.g., Lazell, 1976; Lutcavage & Musick, 1985; Goff & Lien, 1988).

Offshore, leatherbacks are regularly present along thermal fronts, including the edges of oceanic gyre systems (e.g., Collard, 1990; Lutcavage, 1996). These areas of strong thermal, water colour, or salinity differences are highly productive, concentrating hydromedusae and other soft-bodied invertebrates on which leatherbacks feed. Since pelagic fishes are found in these same feeding grounds, there is some incidental take of leatherbacks in different pelagic fisheries (Witzell, 1984).

Although flipper tag retention in leatherbacks is poor (McDonald & Dutton, 1996), tagged turtles have been documented far from nesting beaches. Pritchard (1976) reported on the recovery locations of 6 leatherbacks tagged in Suriname and French Guiana. Subsequently, one turtle was recorded off West Africa, one in the Gulf of Venezuela, two in the Gulf of Mexico and two on the Atlantic coast of the United States. Since 1978, an intensive flipper tagging program in French Guiana has yielded several tag returns from remote locales in the north Atlantic. For example, eight tagged turtles have been captured along the eastern United States, between Florida and South Carolina (Girondot & Fretey, 1996). Leatherbacks tagged in French Guiana have also been captured in the northeast Atlantic off the coasts of France, Spain and Morocco less than 12 months after nesting (Girondot & Fretey, 1996). In 1987, a leatherback tagged 128 days previously in French Guiana was discovered entangled in fishing gear in Placentia Bay, Newfoundland (Goff *et al.*, 1994). The turtle had travelled a minimum straight-line distance of over 5000 km.

While tag return records are too infrequent to establish that post-nesting movements of leatherbacks are directed, rather than random, other evidence suggests that turtles dispersing from equatorial nesting beaches make determined migrations into temperate waters. Valuable information on the migration and dispersal of marine turtles has been obtained through studies of the barnacles they host. For example, Zullo and Bleakney (1966) reported platylepadine barnacles (*Stomatolepas elegans*) on the skin of leatherbacks recovered off Nova Scotia. As this genus is generally associated with tropical and subtropical conditions, *Stomatolepas* found on leatherbacks in temperate waters must first settle on these turtles in warmer waters (Zullo & Bleakney 1966). This finding supports the notion that marine turtles from tropical breeding populations make seasonal journeys into temperate waters.

More direct studies of leatherback migration have involved satellite tracking (e.g., Eckert *et al.*, 1989; Morreale *et al.,* 1996; Hughes *et al.*, 1998). One study has revealed long-distance movements from tropical nesting beaches to temperate waters of the north Atlantic (Eckert, 1998). Two leatherbacks tagged on a nesting beach in Trinidad migrated north to waters between 40 and 50 degrees latitude before swimming south to the coast of Mauritania, Africa (Eckert, 1998). More recently, five leatherbacks satellite-tagged in Eastern Canadian waters have been tracked on their southward migrations to subtropical and tropical waters (James, unpublished data). Three of these turtles represent the first male leatherbacks to be tracked via satellite telemetry.

Food Habits

Leatherbacks are rarely observed feeding in the wild (e.g., Eisenberg & Frazier, 1983; Grant & Ferrell, 1993), therefore, diet is typically inferred from the stomach contents of dead turtles. Stomach contents of stranded adult leatherbacks suggest a relatively specialized diet of soft-bodied pelagic invertebrates, including cnidarians (medusae and siphonophores), and tunicates (salps and pyrosomas) (e.g., Davenport & Balazs, 1991; Lutcavage, 1996). Small fish, crabs, amphipods and other crustaceans also have been documented in the digestive tracts of these turtles (e.g., Hartog & Van Nierop, 1984; Frazier *et al.*, 1985). However, as many of these organisms are known jellyfish commensals, they are likely ingested incidentally while leatherbacks feed on medusae (Frazier *et al.,* 1985).

Leatherbacks lack the massive jaw construction, crushing plates and musculature found in the cheloniid sea turtles that eat large, hard-bodied prey, such as crustaceans. Instead, *Dermochelys* exhibits several adaptations for its diet of buoyant, soft-bodied prey: the edges of the beak are sharp, and the long esophagus features numerous keratinized, backward-pointing spines, or papillae, which likely assist these turtles in swallowing their slippery prey (Bleakney, 1965). As hydromedusae consist of about 95% sea water and are energy poor, small leatherbacks may have to consume gelatinous prey equal to their biomass each day to maintain a normal metabolic rate

(Lutcavage & Lutz, 1986). Leatherbacks must therefore regularly find dense concentrations of prey. This may explain the presence of large numbers of leatherbacks in coastal areas and along oceanic frontal systems, where coelenterate productivity is especially high (e.g., Shoop & Kenney, 1992).

There is evidence that leatherbacks do not feed exclusively at the surface. Limpus (1984) has described a benthic feeding record (>50m) for a leatherback in Western Australia, and turtles equipped with time-depth recorders have been recorded diving beyond 1000m (Eckert *et al.*, 1989). This deep diving behaviour may reflect nocturnal foraging on siphonophore and salp colonies and medusae within the deep scattering layer (Eckert *et al.*, 1989).

Behaviour

Leatherbacks will readily consume a variety of edible and inedible slow-moving and buoyant objects. Though this behaviour is adaptive in exploiting large concentrations of medusae, these turtles regularly mistakenly ingest plastic bags and other floating marine debris (e.g., Mrosovsky, 1981; Fritts, 1982; Hartog & Van Nierop, 1984; Carr, 1987; Lucas, 1992). Marine debris accumulates at convergence zones, where prey is also naturally concentrated (Carr, 1987; Plotkin & Amos, 1990). Ingestion of plastics, styrofoam and other waste can be fatal (Plotkin & Amos, 1990).

The leatherback's insatiable appetite and foraging curiosity also may lead to entanglement in fishing gear. Front flipper entanglement in ropes and cables is common, and this may result from turtles approaching buoys and biting at them. Leatherbacks may also become entangled after being attracted to the jellyfish that foul fishing gear.

POPULATION SIZES AND TRENDS

As this is a largely pelagic species and, as such, is difficult to census in its marine environment, population estimates are currently based on the abundance of adult females encountered on nesting beaches. It is generally believed that all major nesting sites for this species have been identified, and nesting activity has been intensively monitored at most of these sites for several years (Spotila *et al.,* 1996).

Pritchard (1982) estimated the overall world population to be about 115,000 nesting females in 1980. In 1995, a revised estimate incorporating information from 28 nesting beaches throughout the world yielded approximately 34,500 females, with a lower limit of about 26,200 and an upper limit of about 42,900 (Spotila *et al.,* 1996). These figures reflect dramatic declines at several nesting locales, particularly in the Pacific (e.g., Chan & Liew, 1996; Steyermark *et al.*, 1996; Eckert & Sarti, 1997); there were 3103 leatherbacks nesting at Terengganu, Malaysia in 1968, 200 turtles in 1980, and only 2 in 1994 (Chan & Liew, 1996). Similar declines are occurring at other rookeries, including Playa Grande, Costa Rica, where annual mortality for nesting females is over 30% (Spotila *et al.*, 2000). A recent evaluation of trends at these and other nesting beaches suggests that the Pacific population of leatherbacks is facing imminent extinction (Spotila *et al.,* 2000).

Nesting activity in the Atlantic has been more stable, although it can fluctuate considerably from year to year; as a result trends can be difficult to discern. For example, the annual number of nests deposited in French Guiana has fluctuated between 10000 and 50000+ (females lay an average of 6 clutches per season) for the period 1978-1995 (Girondot & Fretey, 1996). Leatherbacks do not nest annually; inter-nesting intervals are 2-3 years. This can account for some of the annual variation in nesting population size.

A number of studies have used aerial and shipboard surveys to estimate the seasonal occurrence of leatherbacks in waters off the continental United States (e.g., Hoffman & Fritts, 1982; Shoop & Kenney, 1992; Epperly *et al.,* 1995). Shoop and Kenney (1992) calculated a mean summer leatherback density of 18.3 turtles/1000km after 3 years of surveying continental shelf waters from the Gulf of Maine to North Carolina. This was translated into abundance estimates of between 100 and 900 leatherbacks in the study area each summer. These overall ranges of abundance do not provide statistical confidence intervals, but are simply summaries from a series of point estimates. Similar abundance estimates are not available for Canadian waters, as dedicated line-transect aerial surveys for marine turtles have not been conducted, nor have true transect-based shipboard surveys. Instead, data have been gathered opportunistically from volunteer commercial fishers, who record sightings of leatherbacks while fishing or traveling to and from fishing grounds. The potential for observing or incidentally capturing leatherbacks in these areas and other areas of the Scotian Shelf is related to fishing effort. There are little data concerning the presence or absence of leatherbacks from areas where there is little or no fishing activity.

With these limitations, it is not possible to precisely assess abundance in eastern Canadian waters. Estimates may be suggested, however, relative to those made for other areas. For example, Shoop and Kenney (1992) recorded 128 turtles over 3 years and 454 dedicated aerial surveys of shelf waters from the Gulf of Maine to Cape Lookout, North Carolina, while over 300 turtles were opportunistically sighted by a sample of commercial fishers operating in waters off Nova Scotia during the summer and fall of 1998 and 1999 (James, 2000). Since, when compared to opportunistic sightings made from vessels, aerial surveys provide superior opportunities for spotting leatherbacks, it can be inferred that summer leatherback densities in eastern Canada may be higher than the estimate of 100 to 900 leatherbacks/summer reported by Shoop & Kenney (1992) for the much larger study area along the coast of the northeastern United States. In addition, abundance estimates based on aerial or shipboard surveys must be considered minimal, as these only include observations of turtles at the surface; they do not account for those turtles present at various depths (Shoop & Kenney, 1992).

LIMITING FACTORS

Nesting Beaches

Both natural processes and human activities on leatherback nesting beaches have been implicated in this species' decline.

The collection of leatherback eggs for sale in local and foreign markets is a serious and widespread problem for this species on its nesting grounds (e.g., Campbell *et al.*, 1996; Leslie *et al*., 1996).

As leatherbacks prefer to nest on open beaches, adjacent to deep water (and typically unprotected by fringing reefs), in some years large numbers of nests are lost to flooding and erosion (e.g., Whitmore & Dutton, 1985; Leslie *et al.*, 1996).

Although leatherback meat is considered unpalatable by most, poaching of free-swimming and nesting turtles does occur in some areas, most notably by indigenous peoples in the Indian Ocean and western Pacific Ocean (e.g, Chan & Liew, 1996; Suarez & Starbird, 1996).

Increasing beach development and use discourages females from nesting in many areas and may prevent females from reaching nesting sites (this is particularly true when retaining walls are erected as part of beach armouring projects) (NMFS, 1992). The mechanical raking of beaches and use of off-road vehicles may disturb nest sites, resulting in decreased hatching success and/or increased mortality among emergent hatchlings (Hosier *et al.,* 1981). Artificial lighting in the vicinity of nest sites can cause disorientation of both adults (Witherington, 1992) and hatchlings (Witherington & Bjorndal, 1991). This can result in failed nesting attempts and, in the case of hatchlings, failure to move towards the water and high mortality.

Many leatherback conservation programs operating on nesting beaches have collected eggs from unprotected nests and incubated them artificially, usually indoors in styrofoam boxes and at lower temperatures than in natural nests (Davenport, 1997). As leatherback embryos are subject to temperature-dependent sex determination, this widespread practice typically yields male-biased sex ratios amongst resulting hatchlings. Several authors have identified this as a possible conservation problem (Morreale *et al.*, 1982; Mrosovsky, 1982; Dutton *et al.*, 1985); however the implications of this practice for leatherback populations have not been quantified. Clearly, if eggs are to be incubated artificially, equal numbers of clutches should be incubated above and below the pivotal temperature of 29.5°C.

Global warming may interact with temperature-dependent sex determination to affect leatherback populations negatively. Even minute changes in climate could potentially alter the sex ratios across entire nesting beaches by increasing mean nest temperatures and favouring the production of females (Davenport, 1997). Global warming is predicted to have other deleterious effects on marine turtles. Alterations in ocean current patterns may accompany climate change, thereby affecting the migration and dispersal of marine turtles (Davenport, 1997). Increased hurricane activity also may be associated with global climate change. This could, potentially, result in increased nest loss due to amplified wind and wave erosion on leatherback nesting beaches (Davenport, 1997).

The Marine Environment

A number of widespread threats to leatherbacks have been identified in the marine environment. Principal among these is entanglement in different types of fishing gear. Leatherbacks become entangled in longlines, buoy anchor lines, and other ropes and cables (e.g., Chan *et al*., 1988; Goff & Lien, 1988; NMFS, 1992; Cheng & Chen, 1997; Godley *et al*., 1998). These incidents can result in serious injuries (rope or cable cuts on the shoulders and front flippers) or death by drowning. Although incidental take of marine turtles on pelagic longlines is common, the vast majority of turtles is released alive (Witzell, 1984); however, the post-capture mortality of these turtles is not known. Leatherbacks, like all sea turtles, demonstrate physiological tolerance to extended periods of anoxia (Shoop & Schwartz, 1992). This ability presumably enables some entrapped turtles to survive long periods of forced submergence (Shoop *et al.,* 1990).

The effects of marine pollution on sea turtles are not well understood. Therefore, the magnitude of pollution-related mortality is not known. There are many documented cases, however, of leatherback mortality associated with ingestion of and entanglement in marine debris. Leatherbacks are known to ingest a variety of anthropogenic marine debris, including plastic bags, tar balls, plastic sheeting, and fishing gear (e.g., Sadove, 1980; Hartog &Van Nierop, 1984; Lucas, 1992; Starbird, 2000). Ingestion of such materials may interfere with metabolism or gut function, or lead to blockages in the digestive tract and subsequent starvation (Plotkin & Amos, 1990).

As its diet of jellyfish is high in water, and low in organic content, the leatherback must consume large quantities of food (Lutcavage, 1996). Davenport and Wrench (1990) have suggested that the leatherback, as a presumably long-lived species (not confirmed), should serve as an ideal indicator of the degree of contamination of the oceanic food web by accumulating substances such as heavy metals and polychlorinated biphenyls (PCBs). Metal and PCB levels in the leatherback should represent a biomagnification of concentrations found in plankton-feeding jellyfish. However, tissue samples derived from leatherbacks in European waters have not revealed evidence of significant chemical contamination (Davenport *et al*., 1990; Godley *et al*., 1998).

SPECIAL SIGNIFICANCE OF THE SPECIES

The leatherback is globally endangered and recent population modeling suggests that at the current rate of decline, this species may be extinct in as little as 18 years (Spotila *et al*., 1996). In the past decade, several nesting populations have experienced severe declines (e.g., Mexico, Sarti *et al.*, 1996), and the Pacific population is facing imminent extinction (Spotila *et al*., 2000). Nesting populations in the Atlantic appear to be more stable, but trends cannot be derived with any degree of confidence because pertinent demographic data are lacking. For example, age at maturity and reproductive life span are not known, and the habitat of juveniles has not been identified.

Leatherbacks undertake long distance migrations that take them through the waters, and fishing zones, of many nations. Thus, conservation of this species is particularly challenging and clearly must involve international collaboration and cooperation.

The leatherback is one of only two species of marine turtle regularly encountered in Canadian waters (the other is *Caretta caretta*). Apart from commercial fishers, few Canadians have opportunities to encounter leatherbacks in their marine environment. Therefore, public awareness of this turtle outside fishing communities in Atlantic Canada is poor. It is important to recognize that although fishers and other residents of coastal communities may be familiar with the leatherback, they are generally not aware that this species is endangered and rapidly declining. Until recently, very few people recognized the importance of reporting sightings of these turtles (James, 2000).

EXISTING PROTECTION

The leatherback is globally endangered (Groombridge, 1982) and endangered in Canada (Cook, 1981). It has been listed as critically endangered by the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). Canada is a signatory country of this convention, as are many of the countries that host nesting or migratory populations of leatherbacks. However, the leatherback is afforded varying degrees of protection by CITES, as it is not listed as Appendix I (banned in international commerce) by all participating countries. For example, while the leatherback is listed as Appendix I by Suriname, Great Britain has listed the species in Appendix II. While CITES exists as a tool for regulating international trade in wildlife, unfortunately, it has no legally-binding provisions that impact directly on harvesting or harming endangered species within a country. The Convention on the Conservation of Migratory Species of Wild Animals (CMS) has some provisions that address the harvest of endangered species, however Canada is not currently a party to this convention.

As the leatherback is a migratory marine reptile that does not breed in Canada, historically it has not fallen clearly within the jurisdictions of federal or provincial wildlife agencies. Recent progress in tabling the federal Species at Risk Act (SARA, also known as Bill C-33) has resulted in the identification of marine turtles as a management responsibility of Fisheries and Oceans Canada. Once passed, SARA will prohibit the killing, harming, harassing, capturing or taking of endangered species, and destruction of their critical habitat. However, because Canada has yet to pass this legislation, the leatherback receives protection in Canada under provincial endangered species acts. As a result, only Nova Scotia and New Brunswick currently afford the leatherback legal protection.

During their long migrations, leatherbacks pass through the waters, and fishing zones, of many nations. Conservation measures for this species are in place in only a portion of these areas. Critical leatherback nesting beaches have been protected as national parks and reserves in several areas (e.g., St. Croix, USVI; KwaZulu-Natal, South Africa; Tortuguero, Costa Rica) and these sites are patrolled to discourage poaching of nesting females and their eggs. Unfortunately, law enforcement efforts on most nesting beaches have been unsuccessful in deterring poaching (NMFS, 1992; Troeng, 1998). Turtle Excluder Devices, designed to prevent sea turtles from drowning in shrimp trawls, have been mandated for use in several countries (including the U.S.A.) (Crowder *et al.*, 1995); however, the narrow diameters of these devices frequently preclude the release of trapped leatherbacks (Dalton, 2000).

In several countries (e.g. Malaysia, Costa Rica, Guyana), the eggs of the leatherback are considered a delicacy and, for some, an aphrodisiac (Lutcavage *et al.*, 1997). While egg collection on nesting beaches has been identified as a cause of leatherback decline, nesting females are not harvested in great numbers. This may be due to the fact that the oil-saturated flesh of the leatherback is generally considered unpalatable and perhaps even poisonous (after feeding on jellyfish, the flesh of *Dermochelys* may store nematocyst toxins) (Ernst *et al*., 1994). Despite these observations, a few traditional leatherback fisheries do exist. For example, in the Kai Islands, Indonesia, leatherbacks are regularly hunted for ritual purposes and for sustenance (Suarez & Starbird, 1996).

EVALUATION AND PROPOSED STATUS

Leatherback decline is not fully understood, however several anthropogenic impacts are suspected to account for a high level of mortality. Foremost among these is incidental capture in fishing gear (e.g., Eckert & Sarti, 1997; Spotila *et al*., 1996, 2000). On nesting beaches, low recruitment rates due to high natural hatchling mortality and excessive human harvesting of eggs constitutes a threat to this species. Suspected impacts associated with global climate change may be underestimated. As sex determination in this species is determined by nest incubation temperature, even subtle temperature changes associated with global warming could potentially bias sex ratios.

The leatherback has exhibited a precipitous global population decline from 115,000 nesting females in 1980 (Pritchard, 1982) to 34,500 females in 1995 (Spotila *et al.,* 1996). This represents a 70% decline in only 15 years, or less than one generation. Long-term tagging studies on some nesting beaches have revealed annual rates of adult female mortality of up to 33% (Spotila *et al.*, 2000). Life history traits of sea turtles include a long life, delayed sexual maturity, and reproductive intervals of two to three years (Crouse *et al.,* 1987), and high subadult and adult survival rates (Congdon *et al*., 1993). However, in the case of the leatherback, widespread incidental capture in fisheries is now believed to account for a high level of mortality among adult and subadult turtles (Spotila *et al.,* 1996, 2000). Popular management techniques aimed at recovering sea turtle populations have traditionally focused on the protection of eggs on nesting beaches (Crouse *et al.,* 1987). In contrast, recent population models based on demographic data for loggerhead sea turtles (*Caretta caretta*) reveal that conservation practices aimed at enhancing the survival of juveniles and adults may be far more effective (Crouse *et al.,* 1987). The importance of focusing conservation efforts on later life-history stages has also been argued in the case of leatherbacks (e.g., Eckert & Sarti, 1997; Spotila *et al*., 2000). In fact, recent demographic modeling of this species suggests that without increased human intervention to reduce adult and subadult mortality arising from fisheries interactions, the leatherback faces extirpation throughout extensive parts of its range (Spotila *et al.,* 1996, 2000).

Based on skeletochronological analyses, Zug and Parham (1996) have described a relatively short maturation time for leatherbacks. Rapid maturation, coupled with this species' high fecundity, may enable some leatherback populations to recover if egg poaching and incidental capture and killing of large juveniles and adults can be dramatically reduced (Zug & Parham, 1996). Conversely, if these analyses have underestimated age at maturity, recovery of populations will be quite difficult and slow.

The leatherback was originally assigned status as ENDANGERED in Canada in 1981 (Cook, 1981). At that time, very little was known about the species' distribution and movements in Canadian waters. Subsequent work in Newfoundland (e.g., Goff & Lien, 1988) and Nova Scotia (e.g., James, 2000) has revealed that a portion of the Atlantic population range into waters off Canada's east coast each year. Leatherback presence in eastern Canada is related to seasonally abundant cnidarians (particularly *Cyanea* sp.), their principal prey (Bleakney, 1965; Goff & Lien, 1988; Shoop & Kenney, 1992; James, 2000). Although leatherbacks do not nest in Canada, waters off Atlantic Canada provide important seasonal foraging habitat for these turtles. Human activity in and degradation of the marine environment continue to result in an unknown level of annual mortality among leatherbacks in Canadian waters. It is recommended that the leatherback retain its status as ENDANGERED in Canada.

TECHNICAL SUMMARY

Dermochelys coriacea

Leatherback turtle | Tortue luth

Atlantic and Pacific Oceans

Extent and Area information	
• *extent of occurrence (km²)*	large
• *specify trend (decline, stable, increasing, unknown)*	decline
• *are there extreme fluctuations in extent of occurrence (> 1 order of magnitude)?*	no
• *area of occupancy (km²)*	large
• *specify trend (decline, stable, increasing, unknown)*	unknown
• *are there extreme fluctuations in area of occupancy (> 1 order magnitude)?*	no
• *number of extant locations*	-
• *specify trend in # locations (decline, stable, increasing, unknown)*	unknown
• *are there extreme fluctuations in # locations (>1 order of magnitude)?*	no
• *habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat*	declining
Population information	
• *generation time (average age of parents in the population) (indicate years, months, days, etc.)*	<30 years
• *number of mature individuals (capable of reproduction) in the Canadian population (or, specify a range of plausible values)*	unknown
• *total population trend: specify declining, stable, increasing or unknown trend in number of mature individuals*	declining
• *if decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period)*	>70%
• *are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?*	no
• *is the total population severely fragmented (most individuals found within small and relatively isolated (geographically or otherwise) populations between which there is little exchange, i.e., ≤ 1 successful migrant / year)?*	n/a
• *list each population and the number of mature individuals in each*	n/a
• *specify trend in number of populations (decline, stable, increasing, unknown)*	n/a
• *are there extreme fluctuations in number of populations (>1 order of magnitude)?*	no
Threats (actual or imminent threats to populations or habitats)	
-loss of habitat -pollution (e.g. pesticides) -urban or agricultural development	
Rescue Effect (immigration from an outside source)	
• *does species exist elsewhere (in Canada or outside)?*	yes
• *status of the outside population(s)?*	declining
• *is immigration known or possible?*	yes
• *would immigrants be adapted to survive here?*	yes, but not breed
• *is there sufficient habitat for immigrants here?*	yes
Quantitative Analysis	

Ron Brooks, March 2001

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LITERATURE CITED

Binckley, C.A., J.R. Spotila, K.S. Wilson, and F. Paladino. 1998. Sex determination and sex ratios of Pacific leatherback turtles, *Dermochelys coriacea*. Copeia 1998 (2): 291-300.

Bleakney, J.S. 1965. Reports of marine turtles from New England and Eastern Canada. Canadian Field-Naturalist 79: 120-128.

Bossé, L. 1994. Une gigantesque tortue marine dans un havre de la Gaspésie. L' Euskarien 16 (2): 39-40.

Boulon, R., K. Eckert, and S. Eckert. 1988. *Dermochelys coriacea* (leatherback sea turtle) migration. Herpetological Review 19(4): 88.

Caldwell, D.K., and M.C. Caldwell. 1969. Addition of the leatherback sea turtle to the known prey of the killer whale *Orcinus-Orca*. Journal of Mammalogy 50(3): 636.

Calleson, T.J., G.O. Bailey, and H.L. Edmiston. 1998. Rare nesting occurrence of the leatherback sea turtle, *Dermochelys coriacea*, in Northwest Florida, U.S.A. Herpetological Review 29(1): 14-15.

Campbell, C. L., C.J. Lagueux, and J. A. Mortimer. 1996. Leatherback turtle, *Dermochelys coriacea*, nesting at Tortuguero, Costa Rica, in 1995. Chelonian Conservation and Biology 2 (2): 169-172.

Carl, G. C. 1968. The Reptiles of British Columbia, 3rd Edition, Handbook No. 3. British Columbia Provincial Museum, Vancouver.

Carr, A. 1987. Impact of nonbiodegradable marine debris on the ecology and survival outlook of sea turtles. Marine Pollution Bulletin 18(6B): 352-356.

Carr, T., and N. Carr. 1986. *Dermochelys coriacea* (leatherback sea turtle) copulation. Herpetological Review 17: 24-25.

Chan, E.-H., H.-C. Liew, and A. G. Mazlan. 1988. The incidental capture of sea turtles in fishing gear in Terengganu, Malaysia. Biological Conservation 43: 1-7.

Chan, E-H., and H-C. Liew.1995. Incubation temperature and sex ratios in the Malaysian leatherback turtle, *Dermochelys coriacaea.* Biological Conservation 74: 169-174.

Chan, E-H., and H-C. Liew. 1996. Decline of the leatherback population in Terengganu, Malaysia, 1956-1995. Chelonian Conservation and Biology 2 (2): 196-203.

Cheng, I-J., and T-H. Chen. 1997. The incidental capture of five species of sea turtles by coastal setnet fisheries in the eastern waters of Taiwan. Biological Conservation 82: 235-239.

Collard, S. 1990. Leatherback turtles feeding near a watermass boundary in the eastern Gulf of Mexico. Marine Turtle Newsletter 50: 12-14.

Congdon, J. D., A.E. Dunham, and R. C. Van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's turtles (*Emydoidea blandingii*): Implications for conservation and management of long-lived organisms. Conservation Biology 7: 826-833.

Cook, F. R. 1981. Status report on the leatherback turtle, *Dermochelys coriacea.* Committee on the Status of Endangered Wildlife in Canada, Ottawa, 17 pp.

Crouse, D.T., L.B. Crowder, and H. Caswell. 1987. A stage-based population model for loggerhead sea turtles and implications for conservation. Ecology 68: 1412-1423.

Crowder, L. B., S.R. Hopkins-Murphy, and J. A. Royle. 1995. Effects of turtle excluder devices (TEDs) on loggerhead sea turtle strandings with implications for conservation. Copeia 1995(4): 773-779.

Dalton, P.D. 2000. Endangered and threatened wildlife; Sea turtle conservation requirements. Federal Register 65 (66): 17852-17854. National Oceanic and Atmospheric Administration.

D'Amours. 1983. Une tortue-luth (*Dermochelys coriacea*) dans les eaux côtieres du Québec (A leatherback turtle (*Dermochelys coriacea*) on the coast of Quebec). Naturaliste Can. 110 (1983): 481.

Davenport, J., J. Wrench, J. McEvoy, and V. Camacho-Bar. 1990. Metal and PCB concentration in the 'Harlech' leatherback. Marine Turtle Newsletter 48: 1-6.

Davenport, J., and J. Wrench. 1990. Metal levels in a leatherback turtle. Marine Pollution Bulletin 21 (1): 40-41.

Davenport, J., and G.H. Balazs. 1991. Fiery bodies: are pyrosomas an important component of the diet of leatherback turtles? British Herpetological Society Bulletin 37: 33-38.

Davenport, J. 1997. Temperature and the life-history strategies of sea turtles. Journal of Thermal Biology 22 (6): 479-488.

Dutton, P.H., C.P. Whitmore, and N. Mrosovsky. 1985. Masculinisation of leatherback turtle *Dermochelys coriacea* hatchlings from eggs incubated in styrofoam boxes. Biological Conservation 31: 249-264.

Eckert, K.L., and S.A. Eckert. 1988. Pre-reproductive movements of leatherback sea turtles (*Dermochelys coriacea*) nesting in the Caribbean. Copeia 1988 (2): 400-406.

Eckert, S.A., and C. Luginbuhl. 1988. Death of a giant. Marine Turtle Newsletter 43: 2-3.

Eckert, S.A., K.L. Eckert, P. Ponganis, and G.L. Kooyman. 1989. Diving and foraging behavior of leatherback sea turtles (*Dermochelys coriacea*). Canadian Journal of Zoology 67: 2834-2840.

Eckert, S. A., and L. Sarti. 1997. Distant fisheries implicated in the loss of the world's largest leatherback nesting population. Marine Turtle Newsletter 78: 2-6.

Eckert, S. A. 1998. Perspectives on the use of satellite telemetry and other electronic technologies for the study of marine turtles, with reference to the first year-long tracking of leatherback sea turtles, p. 294. *In:* Proceedings of the Seventeenth

Annual Sea Turtle Symposium. S. P. Epperly and J. Braun (eds.). NOAA Technical Memorandum NMFS-SEFC-415, Miami.
Eisenberg, J.F., and J. Frazier 1983. A leatherback turtle (*Dermochelys coriacea*) feeding in the wild. Journal of Herpetology 17: 81-82.
Epperly, S.P., J. Braun, and A.J. Chester. 1995. Aerial surveys for sea turtles in North Carolina inshore waters. Fishery Bulletin 93: 254-261.
Ernst, C.H., R.W. Barbour, and J. Lovich. 1994. Turtles of the United States and Canada. Smithsonian Institution, Inc., Washington.
Frair, W.R., R.G. Ackman, and N. Mrosovsky. 1972. Body temperature of *Dermochelys coriacea*: warm turtle from cold water. Science 177: 791-793.
Frazier, J., M.D. Meneghel and F. Achaval. 1985. A clarification on the feeding habits of *Dermochelys coriacea*. Journal of Herpetology 19(1): 159-160.
Fritts, T.H. 1982. Plastic bags in the intestinal tracts of leatherback marine turtles. Herpetological Review 13 (3): 72-73.
Fritts, T.H., W. Hoffman, and M.A. McGehee. 1983. The distribution and abundance of marine turtles in the Gulf of Mexico and nearby adjacent waters. Journal of Herpetology 17 (4): 327-344.
Gilhen, J. 1984. Amphibians and reptiles of Nova Scotia. Nova Scotia Museum, Halifax.
Girondot, M., and J. Fretey. 1996. Leatherback turtles, *Dermochelys coriacea*, nesting in French Guiana, 1978-1995. Chelonian Conservation and Biology 2(2): 204-208.
Godfrey, M. H., and R. Barreto. 1998. *Demochelys coriacea* (leatherback sea turtle): copulation. Herpetological Review 29: 38-39.
Godley, B.J., M.J. Gaywood, R.J. Law, C.J. McCarthy, C. McKenzie, I.A.P. Patterson, R.S. Penrose, R.J. Reid, and H.M. Ross. 1998. Patterns of marine turtle mortality in British waters (1992-1996) with reference to tissue contaminant levels. Journal of the Marine Biological Association (U.K.) 78: 973-984.
Goff, G.P. and J. Lien. 1988. Atlantic leatherback turtles, *Dermochelys coriacea*, in cold waters off Newfoundland and Labrador. Canadian Field-Naturalist 102: 1-5.
Goff, G. P., J. Lien, G.B. Stenson and J. Fretey. 1994. The migration of a tagged leatherback turtle, *Dermochelys coriacea*, from French Guiana, South America to Newfoundland, Canada in 128 days. Canadian Field-Naturalist 108: 72-73.
Grant, G.S., and D. Ferrell. 1993. Leatherback turtle, *Dermochelys coriacea*, in cold waters off Newfoundland and labrador. Canadian Field-Naturalist 102: 1-5.
Grant, G.S. 1994. Juvenile leatherback turtle caught by longline fishing in American Samoa. Marine Turtle Newsletter: 3-5.
Grant, G.S., H. Malpass, and J. Beasley. 1996. Correlation of leatherback turtle and jellyfish occurrence. Herpetological Review 27(3): 123-125.
Groombridge, B. 1982. Red Data Book, Amphibia-Reptilia, Part I: Testudines, Crocodylia, Rhynchocephalia. International Union for the Conservation of Nature and Natural Resources (IUCN), Gland, Switzerland.
Gullicksen, B. 1990. Observation of the leatherback turtle (*Dermochelys coriacea*) in Northern Norway (Nord-Troms) autumn, 1989. Fauna (Oslo) 43:45.
Hartog, J.C. den, and M.M. Van Neirop. 1984. A study on the gut contents of six leathery turtles *Dermochelys coriacea* (Linnaeus) (Reptilia: Testudines: Dermochelyidae) from British waters and from the Netherlands. Zoologische Verhandelingen (Leiden) No. 209.

Hoffman, W., and T. Fritts. 1982. Sea turtle distribution along the boundary of the Gulf Stream current off Eastern Florida. Herpetologica 38: 405-409.

Hosier, P.E., M. Kochhar, and V. Thayer. 1981. Off-road vehicle and pedestrian track effects on the sea-approach of hatchling loggerhead turtles. Environmental Conservation 8: 158-161.

Hudson, D.M., and P.L. Lutz. 1986. Salt gland function in the leatherback sea turtle, *Dermochelys coriacea*. Copeia 1986(1): 247-249.

Hughes, G.R. 1996. Nesting of the leatherback turtle (*Dermochelys coriacea*) in Tongaland, KwaZulu-Natal, South Africa, 1963-1995. Chelonian Conservation and Biology 2(2): 153-158.

Hughes, G.R., P. Luschi, R. Mencacci, and F. Papi. 1998. The 7000 km oceanic journey of a leatherback turtle tracked by satellite. Journal of Experimental Marine Biology and Ecology 229: 209-217.

James, M.C. 2000. Distribution of the leatherback turtle (*Dermochelys coriacea*) in Atlantic Canada: Evidence from an observer program, aerial surveys, and a volunteer network of fish harvesters. M.Sc. Thesis. Biology Department. Acadia University, Wolfville, Nova Scotia, 71 pp.

Keinath, J.A., and J.A. Musick. 1993. Movements and diving behavior of a leatherback turtle. Copeia 1993 (4): 1010-1017.

Kermode, F. 1931. A remarkable capture of leatherback turtles off Bajo Reef, near Nootka Sound, west of Vancouver Island, British Columbia. Annual Report: British Columbia Museum of Natural History and Anthropology, Victoria, B.C.

Lazell, J.S. 1976. Cape Cod and the islands: amphibians and reptiles in this broken archipelago. Quadrangle Press, New York.

Lazell, J.D. 1980. New England waters: critical habitat for marine turtles. Copeia 1980 (2): 290-295.

Leslie, A., Penick, D.N., Spotila, J.R., and F. Paladino. 1996. Leatherback turtle, *Dermochelys coriacea*, nesting and nest success at Tortuguero, Costa Rica, in 1990-1991. Chelonian Conservation and Biology 2 (2): 159-168.

Limpus, C.J. 1984. A benthic feeding record from neritic waters for the leathery turtle (*Dermochelys coriacea*). Copeia 1984 (2): 552-553.

Lucas, Z. 1992. Monitoring persistent litter in the marine environment on Sable Island, Nova Scotia. Marine Pollution Bulletin 24 (4): 192-199.

Lutcavage, M. 1996. Planning your next meal: leatherback travel routes and ocean fronts. Proceedings of the Fifteenth Annual Symposium on Sea Turtle Biology and Conservation. J.A. Keinath, D.E. Barnard, J.A. Musick and B.A. Bell, compilers. NOAA Technical Memorandum NMFS-SEFSC-387: 174-178.

Lutcavage, M., and P.L. Lutz. 1986. Metabolic rate and food energy requirements of the leatherback sea turtle, *Dermochelys coriacea*. Copeia 1986 (3): 796-798.

Lutcavage, M., and J.A. Musick. 1985. Aspects of the biology of sea turtles in Virginia. Copeia 1985 (2): 449-456.

Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human impacts on sea turtle survival *In* The Biology of Sea Turtles, P.L. Lutz and J.A. Musick, eds. CRC press, Boston.

MacAskie, I.B., and C.B. Forrester. 1962. Pacific leatherback turtle (Dermochelys) off the coast of British Columbia. Copeia 1962 (3): 646.

McDonald, D.L. and P.H. Dutton. 1996. Use of PIT tags and photoidentification to revise remigration estimates of leatherback turtles (*Dermochelys coriacea*) nesting in St. Croix, U.S. Virgin Islands, 1979-1995. Chelonian Conservation and Biology 2 (2): 148-152.
Morreale, S.J., G.J. Ruiz, S.R. Spotila, and E.A. Standora. 1982. Temperature-dependant sex determination: current practices threaten conservation of sea turtles. Science 216: 1245-1247.
Morreale, S.J., E.A. Standora, J.R. Spotila, and F.V. Paladino. 1996. Migration corridor for sea turtles. Nature 384: 319-320.
Mrosovsky, N. 1981. Plastic jellyfish. Marine Turtle Newsletter 17: 5-7.
Mrosovsky, N. 1983. Sex ratio bias in hatchling sea turtles from artificially incubated eggs. Biological Conservation 23: 309-314.
Mrosovsky, N. 1983. Ecology and nest-site selection of leatherback turtles, *Dermochelys coriacea*. Biological Conservation 26: 47-56.
Mrosovsky, N. 1994. Sex ratios of sea turtles. Journal of Experimental Zoology 270: 16-27.
NMFS. 1992. Recovery plan for leatherback turtles in the U.S. Caribbean, Atlantic and Gulf of Mexico. National Marine Fisheries Service, Washington, D.C.
Paladino, F. V., O'Connor, M. P., and J. R. Spotila. 1990. Metabolism of leatherback turtles, gigantothermy, and thermoregulation of dinosaurs. Nature 344: 858-860.
Plotkin, P., and A.F. Amos. 1990. Effects of anthropogenic debris on sea turtles in the northwestern Gulf of Mexico *In* Proceedings of the Second International Conference on Marine Debris, 2-7 April 1989, Honolulu, Hawaii, S. Shomura and M.L. Godfrey, eds., pp. 736-743.
Pritchard, P.C.H. 1976. Post-nesting movements of marine turtles (Cheloniidae and Dermochelyidae) tagged in the Guianas. Copeia 1976 (4): 749-754.
Pritchard, P.C.H. 1979. Encyclopedia of Turtles. T.F.H. Publications, Inc. Hong Kong.
Pritchard, P.C.H. 1982. Nesting of the leatherback turtle, *Dermochelys coriacea*, in Pacific Mexico, with a new estimate of the world population status. Copeia 1982 (4): 741-747.
Rhodin, A. G. 1985. Comparative chondro-osseous development and growth of marine turtles. Copeia 1985 (3): 752-771.
Sadove, S. 1980. Marine turtles. SEAN Bulletin 5 (9): 15.
Sampaio, C. L. S. 1999. *Dermochelys coriacea* (leatherback sea turtle) accidental capture. Herpetological Review 30: 39-40.
Sarti, M.L., Eckert, S.A., Garcia, T.N., and A.R. Barragan. 1996. Decline of the world's largest nesting assemblage of leatherback turtles. Marine Turtle Newsletter 74: 2-5.
Seyle, C. W., Jr. 1985. Correction of the northernmost leatherback nesting on the U.S. Atlantic coast. Herpetological Review 16: 38.
Shoop, C.R. 1980. Inuit turtle song: leatherback turtles near Baffin Island? Marine Turtle Newsletter 15: 130-131.
Shoop, C.R., Ruckdeschel, C.A. and R.E. Wolke. 1990. The myth of the drowned turtle. Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFC-278.

Shoop, C.R. and R.D. Kenney. 1992. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetological Monographs 6: 43-67.

Shoop, C.R. and M. Schwartz. 1992. Sea turtles and anoxia. Maritimes 36(1): 3-5.

Spotila, J.R., Dunham, A.E., Leslie, A.J., Steyermark, A.C.,Plotkiin, P.T. and F.V. Paladino. 1996. Worldwide population decline of *Dermochelys coriacea*: Are leatherback turtles going extinct? Chelonian Conservation and Biology 2(2): 209-222.

Spotila, J. R., Reina, R. D., Steyermark, A. C., Plotkin, P. T. and F. V. Paladino. 2000. Pacific leatherback turtles face extinction. Nature 405: 529-530.

Starbird, C. 2000. *Dermochelys coriacea* (leatherback sea turtle). Fishing net ingestion. Herpetological Review 31: 43.

Steyermark, A.C., K. Williams, J.R. Spotila, F.V. Paladino, D.C. Rostal, S.J. Morreale, M.T. Koberg, and R. Arauz. 1996. Nesting leatherback turtles at Las Baulas National Park, Costa Rica. Chelonian Conservation and Biology 2: 173-183.

Suarez, A., and C.H. Starbird. 1996. Subsistence hunting of leatherback turtles, *Dermochelys coriacea*, in the Kai Islands, Indonesia. Chelonian Conservation and Biology 2(2): 190-195.

Threlfall, W. 1978. First record of the Atlantic leatherback turtle (*Dermochelys coriacea*) from Labrador. Canadian Field-Naturalist 92(3): 287.

Troeng, S. 1998. Poaching threatens the green turtle rookery at Tortuguero, Costa Rica. Marine Turtle Newsletter 79: 11-12.

Van Buskirk, J. and L.B. Crowder. 1994. Life-history variation in marine turtles. Copeia. 1994 (1): 66-81.

Whitmore, C. P., and P. H. Dutton. 1985. Infertility, embryonic mortality and nest-site selection in leatherback and green sea turtles in Suriname. Biological Conservation 34: 251-272.

Witherington, B. E. 1992. Behavioral responses of nesting sea turtles to artificial lighting. Herpetologica 48: 31-39.

Witherington, B. E., and K. A. Bjorndal. 1991. Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles, *Caretta caretta*. Biological Conservation 55: 139-149.

Witzell, W. 1984. The incidental capture of sea turtles in the Atlantic U.S. Fishery Conservation Zone by the Japanese Tuna longline fleet, 1978-81. Marine Fisheries Review 46: 56-58.

Zangerl, R. 1980. Patterns of phylogenetic differentiation in the Toxochelyid and Cheloniid sea turtles. American Zoologist 20: 585-596.

Zug, G.R., and Parham, J.F. 1996. Age and growth in leatherback turtles, *Dermochelys coriacea* (Testudines: Dermochelyidae): a skeletochronological analysis. Chelonian Conservation and Biology 2 (2): 244-249.

Zullo, V.A., and J.S. Bleakney. 1966. The cirriped *Stomatolepas elegans* (Costa) on leatherback turtles from Nova Scotian Waters. Canadian Field Naturalist 80 (3): 162-165.

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