COSEWIC
Assessment and Status Report

on the

Leach's Storm-Petrel
Oceanodroma leucorhoa

Atlantic population

in Canada

THREATENED
2020

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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Leach's Storm-Petrel — Photo credit: Bruce Mactavish (used with permission).

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COSEWIC
Assessment Summary

Assessment Summary – November 2020

Common name
Leach's Storm-Petrel - Atlantic population

Scientific name
Oceanodroma leucorhoa

Status
Threatened

Reason for designation
This small, long-lived pelagic seabird has an extensive global range, nesting on offshore islands in disjunct populations in the North Atlantic and North Pacific Oceans. The Atlantic population nests in underground burrows at more than 80 colonies in eastern Canada. Birds often fly hundreds of kilometres from colonies to forage on tiny bioluminescent fish. This population overwinters in productive equatorial waters of the Atlantic Ocean, with some birds reaching waters off South Africa and Brazil. Surveys at eight major colonies indicate that the number of individuals has declined by 54% over the past three generations (44 years), and the rate of decline is increasing. Some Quebec colonies have been lost in recent years, and expanding Atlantic Puffin colonies are displacing this species from preferred nesting habitat at several large colonies. Low adult survival related to higher predation rates by gulls appears to be a key demographic factor in the observed declines. These declines are expected to continue. Additional threats include changes in the food web of the northwest Atlantic, as well as offshore oil and gas production and attraction to human sources of light which cause collisions and stranding of young birds. Despite declines, the overall population remains large and widespread, with about 5 million mature individuals estimated to breed in Canada.

Occurrence
Quebec, New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland and Labrador, Atlantic Ocean

Status history
Designated Threatened in November 2020.

COSEWIC
Executive Summary

Leach’s Storm-Petrel
Oceanodroma leucorhoa

Atlantic population

Wildlife Species Description and Significance

Leach’s Storm-Petrel is the smallest (~45 g) and the most wide-ranging procellariiform (petrel) species breeding in the Northern Hemisphere. This tube-nosed seabird is characterized by dark blackish-brown plumage, a forked tail, a broad pale diagonal wing-bar, and a distinctive white rump patch. It breeds in large colonies, nesting in underground burrows that it excavates on coastal and offshore islands.

Canada has considerable global responsibility for Leach’s Storm-Petrel, hosting about 40% of the world’s breeding population. The Atlantic Leach’s Storm-Petrel population in Canada represents about a third of global numbers, with the species’ largest colony at Baccalieu Island, Newfoundland. This species was designated Globally Threatened in 2016 by BirdLife International and uplisted to *Vulnerable* on the IUCN Red List, based on significant population declines, particularly in the western Atlantic.

Distribution

Leach’s Storm-Petrel breeds mainly in the Northern Hemisphere on offshore islands of the Atlantic (south to ~41° N) and Pacific (south to ~25° N) oceans. Atlantic and Pacific populations are considered to be separate designatable units (DUs), as they are geographically disjunct with very limited opportunities for gene exchange, and only the Atlantic DU is considered here.

There are up to 93 active Atlantic Leach’s Storm-Petrel breeding colonies in eastern Canada, from southern Labrador to the mouth of the Bay of Fundy in New Brunswick, including the Gulf of St. Lawrence in Quebec. The species breeds most abundantly along Newfoundland’s east and south coasts and Nova Scotia’s Atlantic coast. Atlantic Leach’s Storm-Petrel over-winters primarily between equatorial Atlantic waters and the southwest coast of Africa, as well as in the western Atlantic Ocean off Brazil.

Habitat

Leach’s Storm-Petrel breeds on vegetated islands generally free of mammalian predators, and prefers well-drained habitats suitable for excavating underground burrows, such as low forest and meadow. Atlantic Leach’s Storm-Petrel usually nests on islands occupied by other seabirds, often including large gulls, and tends to use different habitat from other burrow-nesting species. The quantity and quality of suitable habitat has decreased at some colonies, primarily as a result of encroachment by species such as Atlantic Puffin.

Atlantic Leach’s Storm-Petrel is a surface-feeder, foraging over or beyond the continental shelf during the breeding season. It travels 400-800 km from colonies to forage nocturnally in open oceanic waters on vertically migrating bioluminescent lantern-fish, among other prey. During the non-breeding period, Atlantic Leach’s Storm-Petrel is primarily associated with warm productive waters, in areas with high nutrient upwelling or in coastal regions.

Biology

Atlantic Leach’s Storm-Petrel typically first breeds at 6-7 years of age in Canada, with a generation time estimated at 14.8 years under normal conditions. However, in eastern Canada, effective generation time is likely to be lower, as adult survival is estimated at only ~0.78-0.86 across several colonies in Atlantic Canada. Adults are monogamous and show high nest site fidelity, generally returning to the same nesting burrow each year to raise a single chick. In contrast, young birds rarely return to their natal colony to breed, suggesting that Leach’s Storm-Petrel colonies across the Atlantic Ocean act as one metapopulation as a result of high natal dispersal. Incubation takes 37-50 days, and chicks fledge at 58-77 days of age. Atlantic Leach’s Storm-Petrel is strictly nocturnal at the colony, where all adult arrivals, departures, and chick fledging take place at night.

Population Size and Trends

A total of 106 colonies either currently or previously supported breeding Leach’s Storm-Petrels in eastern Canada, with the current population estimated at about 5,277,000 mature individuals. Twenty islands that each support colonies with over 2,000 mature individuals collectively host 99.7% of the population. Ten colony sites which previously hosted breeding storm-petrels are known to have been abandoned within the past three generations, resulting in an estimated decline in the index of area of occupancy of about 11% over that period.

Trend analyses were conducted for eight colonies that account for about 91% of the eastern Canadian population, and include all major colonies. An average annual rate of decline of -1.74%/year was observed at monitored colonies over the past three generations (44 years), with a steeper decline of -2.64%/year observed over the past two generations (30 years). Estimated reductions are similar over these two time periods because the rate of decline steepened in recent years, with a -55.2% decline over the past two generations, and -53.8% over the past three generations. Paleo-ecological studies at Baccalieu Island show a peak population size in the mid-1980s followed by a rapid decline, corroborating population trends estimated using traditional surveys. Populations of Leach's Storm-Petrel at a colony in Saint-Pierre et Miquelon, France, adjacent to Newfoundland, appear to be generally stable, and the much smaller Maine population in the United States is increasing. However, all potential source colonies in the eastern Atlantic are declining.

Threats and Limiting Factors

Factors driving the decline of Atlantic Leach's Storm-Petrel population are currently unknown, but are likely multi-factorial. Low annual adult survival rates at colonies across eastern Canada appear to be a key demographic factor contributing to observed declines, and are partly influenced by high predation by large gulls at some breeding colonies. Poor annual survival for Atlantic Leach's Storm-Petrel contrasts with estimates of ~0.97 for populations along Canada's Pacific coast. Atlantic Leach's Storm-Petrel is threatened by offshore oil and gas production and other marine industries, primarily through light attraction causing collisions and strandings on offshore structures and vessels. Artificial lights in communities or industrial sites near colonies cause recently fledged Leach's Storm-Petrels to collide with structures or become stranded on the ground, where they are vulnerable to predation. Expanding Atlantic Puffin colonies are encroaching onto nesting habitat at the largest storm-petrel colonies. Rising global temperatures appear to be causing reduced breeding success in some colonies at the southern edge of the range. The incidence of severe weather events associated with climate change is increasing, contributing to mass strandings of Leach's Storm-Petrels, and ecosystem changes associated with abnormally high temperatures may affect prey availability on their breeding and wintering grounds. Exposure to high levels of mercury, as well as other contaminants acquired through the ingestion of plastic particles, may have negative effects on adult survival, reproductive success, and recruitment.

Protection, Status and Ranks

Leach's Storm-Petrel is protected in Canada under the federal *Migratory Birds Convention Act, 1994* and parallel legislation in the United States and Mexico. Currently in Canada, 29 islands, which together host 93% of the Atlantic Leach's Storm-Petrel population, are protected federally as Migratory Bird Sanctuaries or National Parks, or provincially as Wildlife Management Areas or Seabird Ecological Reserves.

TECHNICAL SUMMARY

Scientific name: *Oceanodroma leucorhoa*

English name: Leach's Storm-Petrel (Atlantic population)

French name: Océanite cul-blanc (population de l'Atlantique)

Range of occurrence in Canada: Quebec, New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland and Labrador, Atlantic Ocean

Demographic Information

Generation time (usually average age of parents in the population)	Approximately 14.8 years; based on IUCN estimate provided by BirdLife International (Bird *et al*. 2020)
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes; observed continuing decline, based on counts in Canadian colonies
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations, whichever is longer up to a maximum of 100 years]	-55.2% over two generations (1988-2018); observed decline, based on counts in Canadian colonies
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	-53.8% over three generations (1974-2018); observed reduction, based on counts in Canadian colonies
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Reduction in number of mature individuals projected to continue into the future, based on assessed high overall threat impact
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any period [10 years, or 3 generations, whichever is longer up to a maximum of 100 years], including both the past and the future.	Observed reduction in number of mature individuals of -55.2% over past two generations projected to continue into the future, based on assessed high overall threat impact
Are the causes of the decline: a. clearly reversible and b. understood, and c. ceased?	a. Partly; some causes are reversible (e.g., high predation at colonies and strandings associated with light attraction) b. No, causes of the decline are only partly understood c. No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	850,992 km²; based on a minimum convex polygon around recent colony sites (those with confirmed breeding since 1970)

Index of area of occupancy (IAO); reported as a 2x2 km grid value.	284 km²; based on a 2x2 km grid over recent colony sites (those with confirmed breeding since 1970)
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of "locations" (use plausible range to reflect uncertainty if appropriate)	82-93 locations; equal to the number of active colonies (predation at individual colonies is considered the most serious plausible threat)
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes; observed decline of about 11% over three generations
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Not applicable
Is there an [observed, inferred, or projected] decline in number of "locations"*?	Yes; observed loss of ten colonies (= locations) over past three generations (about 11%)
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes; observed decline in extent of terrestrial habitat, and inferred decline in quality of at-sea habitats
Are there extreme fluctuations in number of subpopulations?	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 subpopulation)

Provincial/Regional Totals (no identifiable subpopulations)	**N Mature Individuals**
 Labrador Newfoundland Nova Scotia New Brunswick Quebec	Estimates based on colony surveys: 276 4,914,504 318,540 43,586 36
Total	5,277,000 (range: 4,235,000-5,954,000)

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	Unknown; analysis not conducted.

Threats:

A threats calculator was completed on 13 January 2020 by: Sabina Wilhelm, April Hedd, Greg Robertson, Ingrid Pollet (report writers), Richard Elliot (SSC Co-chair), David Fraser (facilitator), Marie-France Noël (COSEWIC secretariat), Courtney Baldo, Louise Blight, Neil Burgess, Josh Cunningham, Dave Fifield, Marcel Gahbauer, Carina Gjerdrum, Rielle Hoeg, Andy Horn, Jessica Humber, Elsie Krebs, Bob Mauck, Mark McGarrigle, Pam Mills, Bill Montevecchi, Allison Moody, Jean-François Rail, Michael Rodway, Rob Ronconi, Donald Sam, Dave Shutler, Iain Stenhouse, Laura Tranquilla

The assigned overall threat impact is **High-High**, and the following contributing threats were identified, listed in decreasing order of impact:

3.1 Oil and gas drilling (Medium)
8.2. Problematic native species (Medium)
9.6 Excess energy (Medium-low)
11.1 Habitat shifting and alteration (Medium-low)
8.1 Invasive non-alien/native species (Low)
9.2. Industrial and military effluents (Low)
9.4 Garbage and solid waste (Low)
11.4 Storms and flooding (Low)
7.3 Other ecosystem modifications (Negligible)
6.1. Recreational activities (Negligible)
6.3. Work and other activities (Negligible)
3.3. Renewable Energy (Unknown)
9.5. Air-borne pollutants (Unknown)

What additional limiting factors are relevant?

As Atlantic Leach’s Storm-Petrel has low reproductive potential (first breeding at 6-7 years and raising a maximum of one chick/year), consistently low annual adult survival rates currently observed at many colonies contribute to population declines, and severely limit their ability to recover. High fidelity to specific breeding colonies exhibited by breeding-age adults may limit colony growth, by preventing adults from moving to other colonies if local conditions contribute to low adult survival. High natal dispersal rates exhibited by juvenile Atlantic Leach’s Storm-Petrels may be a limiting factor if emigration of young birds from Canadian colonies exceeds immigration from colonies in other countries in the North Atlantic.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Although some colonies close to Canada are stable or increasing, most outside sources are declining. Grand Colombier (Saint-Pierre et Miquelon; 399,870 individuals) appears to be stable; Maine (62,500 individuals) is increasing; other possible source colonies, including the largest eastern Atlantic colonies in Iceland and Scotland, are declining.

Is immigration known or possible?	Yes. Widespread inter-colony movement of pre-breeding storm-petrels occurs but established breeders return to the same colony.
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?	Yes, in some areas; conditions in some colonies deteriorating primarily as a result of encroachment by other species
Are conditions for the source (i.e., outside) population deteriorating?	Yes, in some areas; conditions likely deteriorating at colonies in the Northeast Atlantic, Saint-Pierre et Miquelon and Maine
Is the Canadian population considered to be a sink?	Unlikely
Is rescue from outside populations likely?	Possible, but unlikely; as numbers of potential immigrants from outside colonies likely insufficient

Data Sensitive Species

Is this a data sensitive species?	No

Current Status

COSEWIC Status History:
Designated Threatened in November 2020.

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric codes:** Meets criteria for Endangered, A2bce+4bce, but designated Threatened, A2bce+4bce, as the population remains widespread and abundant, and is thus not facing imminent extirpation.

Reasons for Designation:
This small, long-lived pelagic seabird has an extensive global range, nesting on offshore islands in disjunct populations in the North Atlantic and North Pacific Oceans. The Atlantic population nests in underground burrows at more than 80 colonies in eastern Canada. Birds often fly hundreds of kilometres from colonies to forage on tiny bioluminescent fish. This population overwinters in productive equatorial waters of the Atlantic Ocean, with some birds reaching waters off South Africa and Brazil. Surveys at eight major colonies indicate that the number of individuals has declined by 54% over the past three generations (44 years), and the rate of decline is increasing. Some Quebec colonies have been lost in recent years, and expanding Atlantic Puffin colonies are displacing this species from preferred nesting habitat at several large colonies. Low adult survival related to higher predation rates by gulls appears to be a key demographic factor in the observed declines. These declines are expected to continue. Additional threats include changes in the food web of the northwest Atlantic, as well as offshore oil and gas production and attraction to human sources of light which cause collisions and stranding of young birds. Despite declines, the overall population remains large and widespread, with about 5 million mature individuals estimated to breed in Canada.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2bce and A4bce. Observed 54% decline in number of mature individuals over the past three generations (44 years), based on trends from breeding colony surveys, is higher than threshold level. This decline is based in part on declines in the index of area of occupancy and the extent and quality of habitat, and on effects of competition for nesting habitat, gull predation and light pollution. These declines and effects are likely to continue into the future, based on assessed high overall threat impact, with a likely population decline >50% over a three-generation period spanning past and future.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable, as EOO of 850,992 km^2 is higher than thresholds, and IAO of 284 km^2 is lower than the threshold for Endangered, but population is not severely fragmented, occurs at more than 10 locations, and does not experience extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable, as population estimate of 5,277,000 mature individuals is higher than thresholds.
Criterion D (Very Small or Restricted Population): Not applicable, as population estimate of 5,277,000 mature individuals is higher than thresholds, and index of area of occupancy exceeds 20 km^2.
Criterion E (Quantitative Analysis): Not applicable, as analysis not conducted.

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
(2020)

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 and Climate Change Canada
Canadian Wildlife Service

Environnement et Changement climatique Canada
Service canadien de la faune

Canada

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

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific name: *Oceanodroma leucorhoa*
English name: Leach's Storm-Petrel (Atlantic population)
French name: Océanite cul-blanc (population de l'Atlantique)
Classification: Class: Aves
Order: Procellariiformes
Family: Hydrobatidae

Vernacular synonym names in Newfoundland include Mother Carey's Chicken, Mother Carey's Chick, Pall Carey, Carey's Chicken, Carey's Chick, Carey, and Mother Careys (Montevecchi and Wells 1987).

The scientific name *Oceanodroma leucorhoa* (Vieillot 1818) is synonymous with *Hydrobates leucorhous*, the latter proposed in the *Handbook of the Birds of the World* (Carboneras *et al.* 2019) and by BirdLife International (BirdLife International 2018), and subsequently adopted by many international bodies.

Morphological Description

Leach's Storm-Petrel is a small (~45 g) tube-nosed-seabird with dark blackish-brown plumage, long wings angled at the carpal joint, and a forked tail (cover page photo). It has a broad pale diagonal wing-bar formed by the greater secondary coverts, and throughout much of its range, including Canada, it has a distinctive white rump patch (Pollet *et al*. 2019a). Juveniles resemble adults upon fledging, but with dark grey as opposed to blackish-brown plumage. Breeding and basic (winter) plumages are similar, except that the dark feathers become gradually browner with wear for all age classes. The species is sexually monomorphic (Pollet *et al*. 2019a).

Population Spatial Structure and Variability

Leach's Storm-Petrel breeds on offshore islands in the North Atlantic and North Pacific Oceans, in colonies that range in size from tens to millions of breeding pairs. Although the taxonomy of Leach's Storm-Petrel has been somewhat controversial and confused (Pollet *et al*. 2019a), two subspecies are currently recognized; *O. l. leucorhoa* and *O. l. chapmani*. The latter subspecies breeds only on islands off the Baja California peninsula of Mexico, and only *O. l. leucorhoa* occurs in Canada.

About 500,000 pairs (1 million mature individuals) from the Pacific population breed in colonies widely scattered along the British Columbia coast (Hipfner 2015). Leach's Storm-Petrel populations breeding along Canada's Atlantic and Pacific coasts are genetically distinct. Bicknell *et al.* (2012) and Taylor *et al.* (2018) studied the population genetic structure of *O. l. leucorhoa* throughout the North Atlantic and part of the North Pacific range using mitochondrial DNA and microsatellite markers. Both studies revealed significant differentiation between populations breeding in the Atlantic and the North Pacific Oceans.

Population genetics studies suggest that Leach's Storm-Petrel breeding throughout the Atlantic Ocean area act as a single metapopulation (Bicknell *et al.* 2012). The genetic structure is homogeneous across colonies within the Atlantic Ocean (Bicknell *et al.* 2012), driven by high rates of dispersal, as most immature birds emigrate from their natal colonies and recruit into other colonies across the Atlantic Ocean (Bicknell *et al*. 2013), although adults of breeding age are not known to move among colonies.

Designatable Units

There is compelling evidence for considering the Leach's Storm-Petrel populations breeding on the Atlantic and Pacific coasts of Canada as discrete and evolutionarily significant, and thus as two separate designatable units (DUs) for the purpose of status assessment. As detailed above (see **Population Spatial Structure and Variability**) genetic analyses indicate that these populations are genetically distinct (Bicknell *et al.* 2012; Taylor *et al.* 2018). They are also geographically disjunct and occur in different Canadian ecozones. Furthermore, there is no overlap between their over-wintering grounds; birds from Atlantic colonies over-winter from equatorial to temperate waters in the South Atlantic Ocean, while birds from Pacific colonies over-winter in the Eastern Tropical Pacific Ocean (Pollet *et al.* 2014; Halpin *et al.* 2018; Pollet *et al.* 2019b; Hedd unpubl. data.). Population sizes and trends are relatively well-known for the Atlantic population and poorly known for the Pacific. Because they occur in different ocean basins, natural and anthropogenic factors influencing population size and trends are likely to differ. Although Bicknell *et al.* (2012) provide evidence of very limited gene exchange between the oceans, the highly philopatric nature of adults following recruitment (Pollet *et al*. 2019a), and limited opportunity for Atlantic and Pacific breeders to mix during the non-breeding season, suggests that this flow would be unlikely to limit local adaptations.

Leach's Storm-Petrel (Atlantic population), or Atlantic Leach's Storm-Petrel, refers here to the DU which includes birds breeding in eastern Canada, in the provinces of Newfoundland and Labrador, New Brunswick, Nova Scotia, and Quebec, and its status is assessed in this report. The population breeding on the Pacific coast of British Columbia is considered in this report to be a separate DU, referred to as Leach's Storm-Petrel (Pacific population) or Pacific Leach's Storm-Petrel, and its status is not assessed here.

Special Significance

Leach's Storm-Petrel is the smallest and the most wide-ranging procellariiform species breeding in the Northern Hemisphere (Pollet *et al*. 2019a), with a global population estimated to number over 16 million individuals (Pollet *et al*. 2019a). Canada has considerable global responsibility for the species, hosting close to 40% of the world's breeding population. The Atlantic Leach's Storm-Petrel population in Canada represents about a third of the global breeding population, with the species' largest colony at Baccalieu Island, Newfoundland and Labrador (Sklepkovych and Montevecchi 1989; Pollet *et al*. 2019a; Wilhelm *et al.* 2020). Aboriginal Traditional Knowledge was not available for Atlantic Leach's Storm-Petrel. However, the species is part of coastal and marine ecosystems that are important to Indigenous people, who recognize the interconnectedness of all species within the ecosystem.

DISTRIBUTION

Global Range

Leach's Storm-Petrel has an extensive global range, with breeding confined mainly to the Northern Hemisphere on offshore islands of the Atlantic and Pacific Oceans (Figure 1). In the North Atlantic, major breeding centres occur in Canada and the adjacent French territory of Saint-Pierre et Miquelon, with smaller populations in the northeastern United States, Scotland, Iceland, Norway, the Faroe Islands (Denmark) and Ireland (Tables 1, 2). Very small numbers also breed on islands off South Africa (Underhill *et al.* 2002). Birds spend the nonbreeding season (November to April) exclusively at sea, where they are widely distributed. In the Atlantic, many winter in tropical regions, particularly off West Africa and Brazil (Pollet *et al.* 2014, 2019a; Hedd unpubl. data).

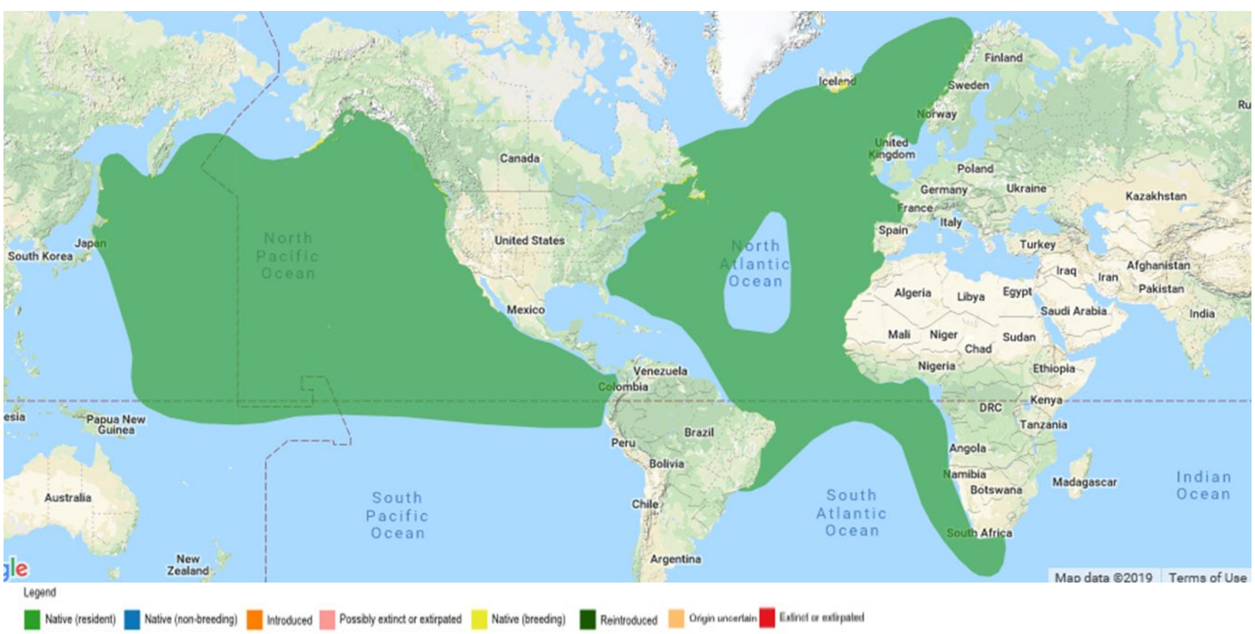


Figure 1. Global distribution of Leach's Storm-Petrel *Oceanodroma leucorhoa*. From BirdLife International (2019).

Atlantic Leach's Storm-Petrel Canadian Range

The Atlantic Leach's Storm-Petrel population breeds at 93 sites along the east coast of Canada (Tables 1 and 2), from southern Labrador to the mouth of the Bay of Fundy (Figure 2), including the Gulf of St. Lawrence and islands along Quebec's North Shore (Lormée *et al.* 2012; Wilhelm 2017; Rail unpubl. data). Eleven sites in Atlantic Canada host significant numbers (i.e., > 20,000 mature individuals), with birds breeding most abundantly along Newfoundland's east and northeast coasts and Burin Peninsula, and Nova Scotia's Atlantic coast (Figure 2). Smaller colonies are found in the Grand Manan Archipelago in the Bay of Fundy (New Brunswick), the Gulf of St. Lawrence (Quebec's North Shore, Gaspé Peninsula, and Magdalen Islands), and Newfoundland's Northern Peninsula and south coast. It is important to note that Grand Colombier, a seabird colony hosting a significant Atlantic Leach's Storm-Petrel colony (~ 400,000 mature individuals), is located 20 km off the coast of the Burin Peninsula of Newfoundland, but within the French territory of Saint-Pierre et Miquelon (Lormée *et al*. 2012; Duda *et al*. 2020a; Figure 2).

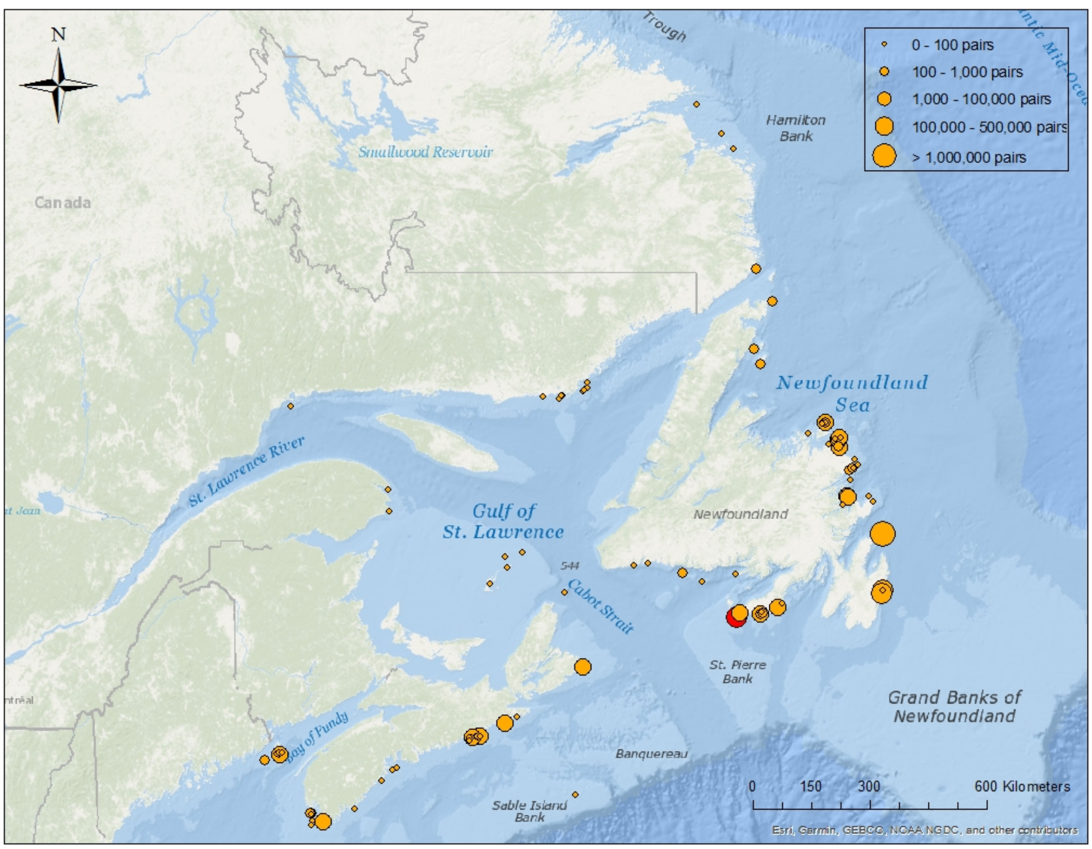


Figure 2. Distribution and relative size of Atlantic Leach's Storm-Petrel breeding colonies in eastern Canada (orange circles), and Saint-Pierre et Miquelon, France (red circle). Map prepared by S. Wilhelm based on information in Appendix 1.

Atlantic Leach's Storm-Petrels breeding in Newfoundland colonies forage over and beyond the continental shelf, from the Laurentian Fan onto the Grand Banks, Flemish Cap, and Orphan Basin, and beyond the shelf into the Newfoundland Basin as far north as the western Labrador Sea (Hedd *et al.* 2018; Figure 3). Storm-petrels breeding in Nova Scotia colonies also forage primarily in deep waters, off the Scotian Shelf and southwest of the Grand Bank (Hedd *et al.* 2018; Figure 3). In contrast, Leach's Storm-Petrels breeding in the Bay of Fundy, New Brunswick, forage in shallower waters within the Gulf of Maine and George's Bank (Hedd *et al.* 2018; Figure 3). Leach's Storm-Petrel does not breed on Prince Edward Island (Elliot 2015), although small numbers occur uncommonly but regularly several km off the northeastern and eastern shores of the province in late summer and early autumn (McAskill *et al.* 2014).

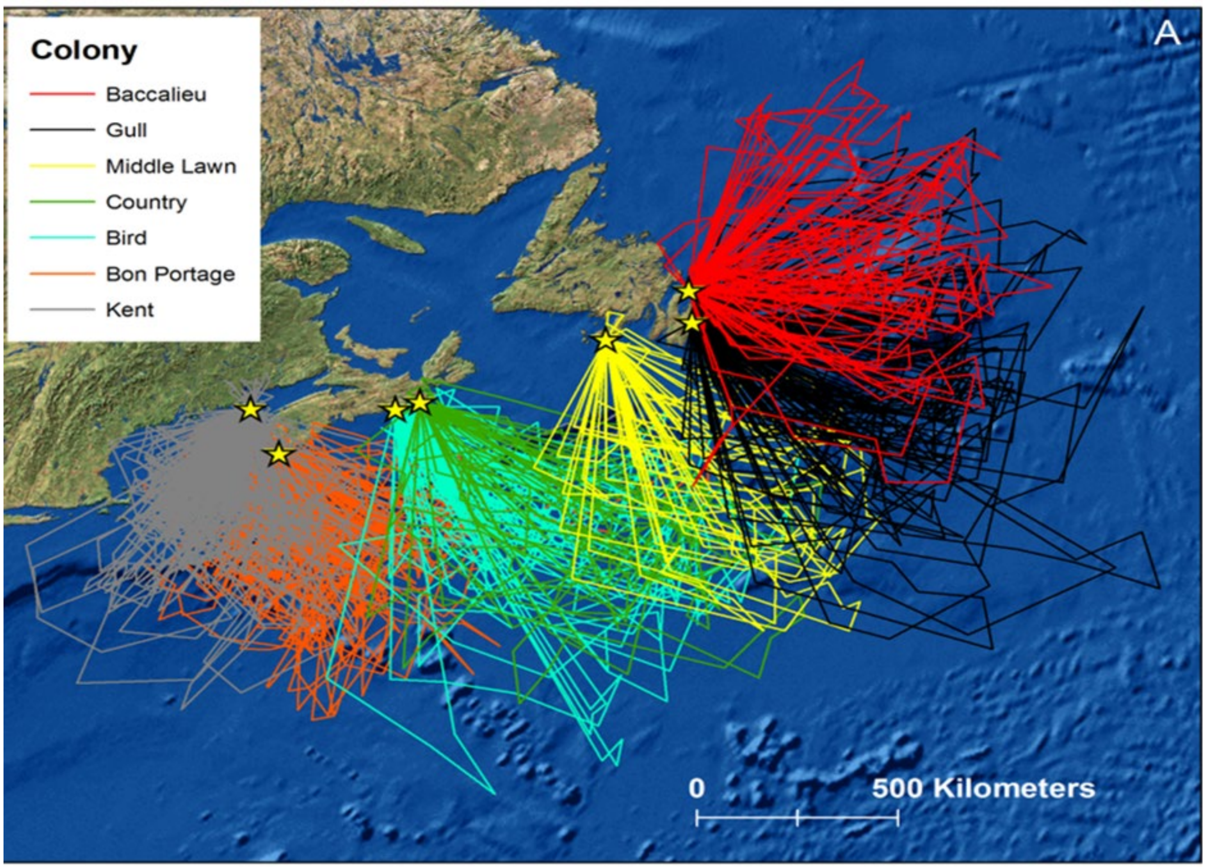


Figure 3. Tracks of foraging trips during the incubation period by 131 Atlantic Leach's Storm-Petrels from seven eastern Canadian breeding colonies, 2013-2014 (Hedd *et al.* 2018).

Tracking of Atlantic Leach's Storm-Petrels from five Canadian colonies indicates that birds range widely during the non-breeding season, wintering in the eastern Atlantic basin between the tropics and southern Africa and in the western Atlantic basin off the coast of Brazil (Pollet *et al.* 2014, 2019b; Hedd unpubl. data; Figure 4). About one third of Atlantic

Leach's Storm-Petrels outfitted with geolocation devices in Canadian breeding colonies wintered off the southwest coast of Africa, with the remainder off South America (Pollet *et al.* 2019b; Hedd unpubl. data).

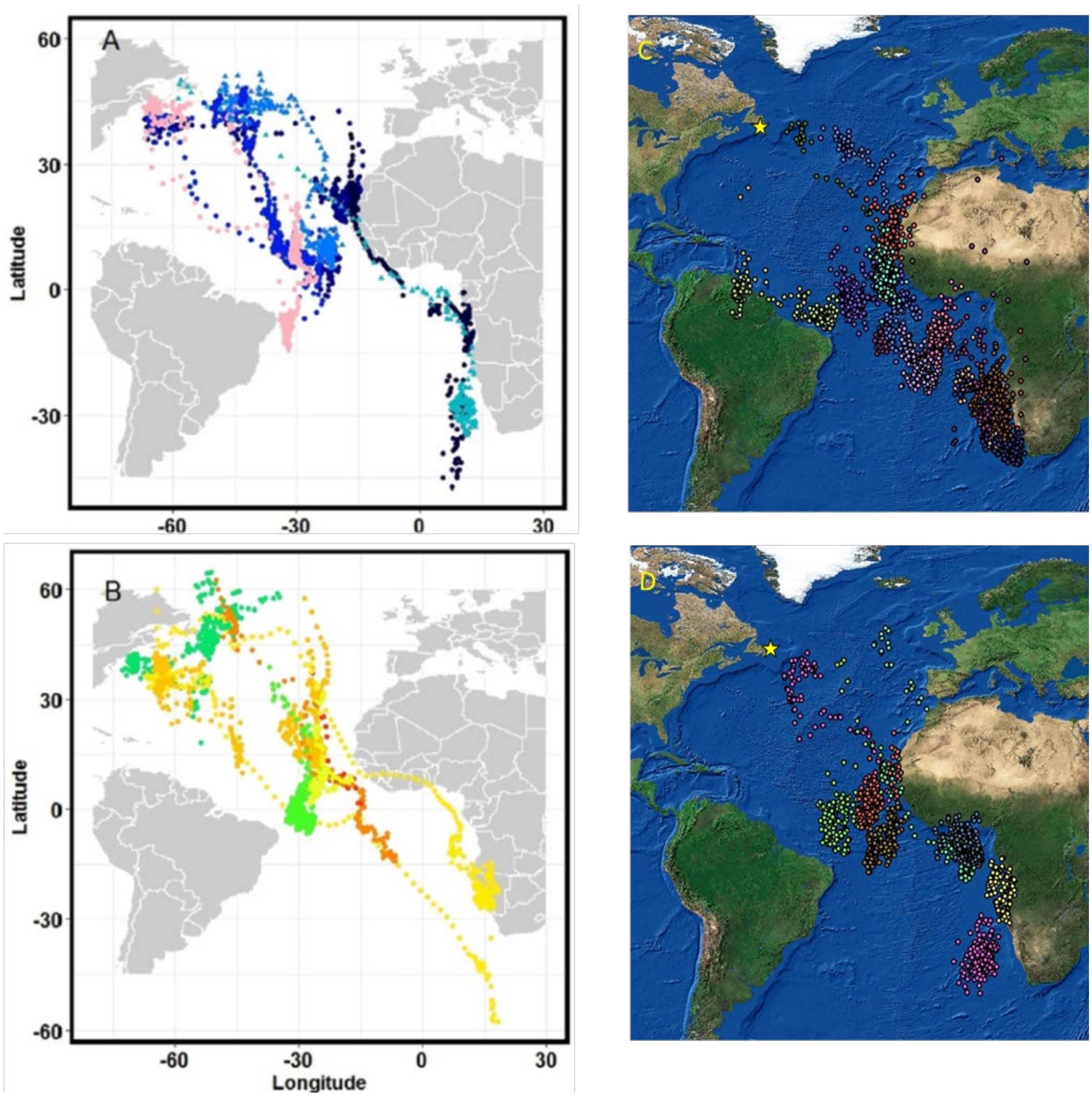


Figure 4. Non-breeding distribution of thirteen Atlantic Leach's Storm-Petrels tracked using GLS tags from Bon Portage Island and Country Island, Nova Scotia in (A) 2012-13 and 2013-14, and (B) 2014-15 and 2015-16 (Pollet *et al.* 2019b). Winter (December-February) distribution of twenty-two Atlantic Leach's Storm-Petrels tracked from (C) Gull Island (2012-13 and 2014-15), and (D) Baccalieu Island (2013-14 to 2017-18; Hedd unpubl. data), Newfoundland. Different colours in all panels represent records of different individuals.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) for Atlantic Leach's Storm-Petrel is estimated as 850,992 km^2, calculated as a minimum convex polygon around all Canadian colonies with confirmed breeding records since 1970 (Figure 5).

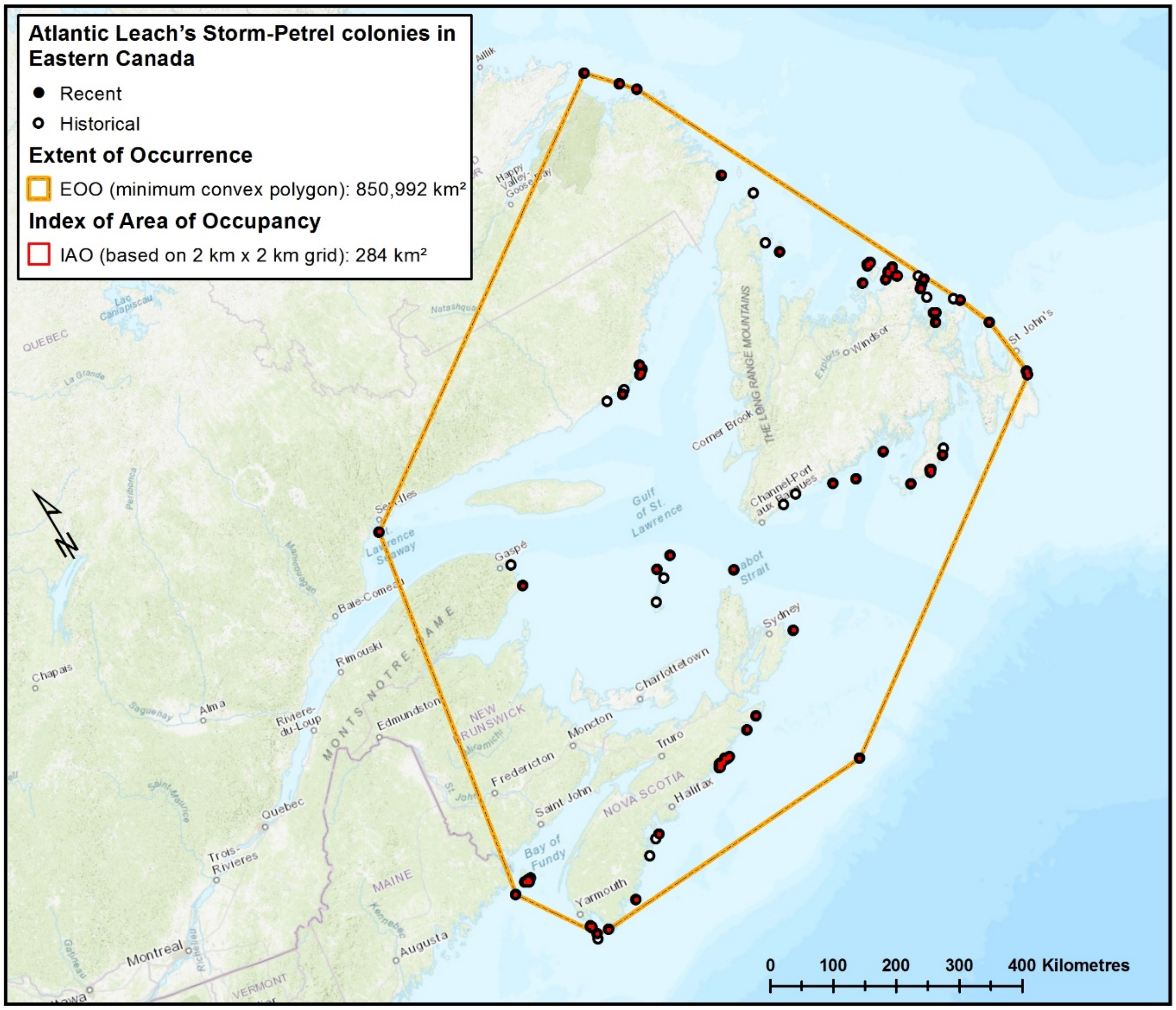


Figure 5. Map showing recent colonies with confirmed breeding records since 1970 (black dots) and historical breeding colonies (no confirmation since 1970; open dots) for Atlantic Leach's Storm-Petrel in Eastern Canada. Extent of occurrence (EOO) is shown within the orange polygon, and index of area of occupancy (IAO) is shown in red within black dots showing recent colony sites. Map prepared by S. Allen, COSEWIC Secretariat, based on information in Appendix 1.

The index of area of occupancy (IAO) is 284 km^2, calculated using the number of 2 x 2 km grid cells which include the coordinates of recent Atlantic Leach's Storm-Petrel colonies that have confirmed breeding records since 1970 (Figure 5).

The IAO has declined over the past three generations, as a result of the abandonment of ten colony sites within the current range that previously held small numbers of breeding storm-petrels, but where none were present when last visited (Figure 5, Appendix 1). The corresponding decline in IAO is estimated to be about 11% over three generations. As all colony visits that detected abandoned sites were conducted in 1990 or later (Appendix 1), this decline was actually detected within the past two generations. Note that this estimate is approximate, as some recent colonies may not have been active in 1970, and some others that have not been recently checked may also no longer be occupied.

Search Effort

The distribution and abundance of breeding Atlantic Leach's Storm-Petrels must be determined through ground surveys, because storm-petrels are not observed at colonies during the day due to their nocturnal habits during the breeding season. Systematic monitoring of important seabird colonies, initiated across eastern Canada in the 1970s and 1980s, was key to identifying the positions of major Leach's Storm-Petrel colonies, and providing robust population estimates (Nettleship 1980; Cannell and Maddox 1983; Cairns *et al.* 1989; Erskine 1992). Efforts have been made since 2001 to update population estimates at significant storm-petrel colonies across the region (Robertson *et al.* 2006; Wilhelm *et al*. 2015, 2017, 2020; Pollet and Shutler 2018; d'Entremont *et al.* 2020). Previously unreported colonies have been identified during surveys for other breeding seabirds in Nova Scotia and New Brunswick (Ronconi and Wong 2003; Wilhelm 2017). Furthermore, acoustic recording devices were installed on islands along Quebec's North Shore and in Nova Scotia to detect Leach's Storm-Petrel where colonies were previously known to be active, and to identify new colonies (Rail pers. comm. 2019; d'Entremont pers. comm. 2020). Combined, these approaches provide a comprehensive understanding of the current distribution and abundance of Atlantic Leach's Storm-Petrel.

TERRESTRIAL HABITAT

Terrestrial Habitat Requirements

Leach's Storm-Petrel nests on forested or otherwise vegetated islands in underground burrows that they excavate, or less frequently in natural crevices (Pollet *et al*. 2019a). Soil characteristics of different habitat types may influence the quality of habitat, and Leach's Storm-Petrel burrow density is positively correlated with soil depth, with deeper soil typically found in forest, grass, and meadow habitats (Grimmer 1980; Stenhouse and Montevecchi 2000), compared to heath (Sklepkovych and Montevecchi 1989). The compressibility of the soil, as well as its moisture content, further affects its quality, with Leach's Storm-Petrel showing a preference for excavating burrows in soil that is loose (Mackinnon 1988; Stenhouse and Montevecchi 2000) and dry (Fricke *et al*. 2015).

Changes in vegetation, sometimes associated with removal of invasive herbivores (d'Entremont *et al*. 2020), may result in changes of storm-petrel habitat use over time.

Habitat quality is also influenced by the presence of avian predators. For example, on islands where gulls (*Larus* spp.) are present and nesting in open habitats, Leach's Storm-Petrel predominantly nests in forested habitat (Mackinnon 1988; Stenhouse *et al*. 2000; Wilhelm *et al*. 2015); in the absence of large gull colonies, Leach's Storm-Petrel breeds in higher densities in open fern and grass habitats than in forested habitat (Wilhelm *et al.* 2020). Large-scale population declines of breeding Herring (*Larus argentatus*) and Great Black-backed Gulls (*L. marinus*) have occurred across eastern Canada since the reduction of groundfish fishing activities in the 1990s, and due to improvement of waste management practices, which had artificially increased gull numbers by providing anthropogenic food sources (Regular *et al.* 2013; Wilhelm *et al.* 2016). As a result of their large numbers, gulls had caused habitat alteration at Leach's Storm-Petrel colonies on both Gull and Great Islands, Newfoundland, in particular of meadow habitat occupied by storm-petrels (Bond *et al.* 2016). However, Herring Gulls have recently initiated or re-established a colony on Baccalieu Island, Newfoundland, following extirpation of resident Red Fox (Montevecchi pers. comm. 2020) which had likely deterred gulls from nesting there (Sklepkovych and Montevecchi 1989; Wilhelm *et al*. 2020).

Terrestrial Habitat Trends

Suitable breeding habitat is limited to offshore islands, and although terrestrial habitat trends are generally stable overall, some notable changes have occurred. For example, Atlantic Puffins (*Fratercula arctica*) are excavating nest burrows in grassy habitat used by nesting Leach's Storm-Petrels at the three largest colonies in Newfoundland, thereby displacing storm-petrels and/or reducing the quantity of preferred habitat (Wilhelm *et al.* 2015, 2020; Wilhelm unpubl. data). The proportions of habitat have changed on Baccalieu Island for unknown reasons, with a decline in forested habitat of 70.6 ha (25%) from 1984-2013 (Wilhelm *et al.* 2019). However, fern habitat, which supports the highest density of Leach's Storm-Petrel on Baccalieu, increased from 15.4 ha to 53.9 ha over the same period, and currently hosts over half the storm-petrel numbers on the island (> 2 million mature individuals; Wilhelm *et al*. 2020).

The spread of sphagnum moss (*Sphagnum* spp.) on Bon Portage Island, Nova Scotia, from 2001 to 2017 has reduced the quantity and quality of potential breeding habitat by creating moist ground unsuitable for Leach's Storm-Petrel nesting (Pollet and Shutler 2018). The quality of suitable terrestrial habitat there is further compromised by the presence of introduced White-tailed Deer (*Odocoileus virginianus*) and Snowshoe Hare (*Lepus americanus*), whose browsing prevents forest regeneration (Pollet pers. obs.; Shutler pers. comm. 2019). Snowshoe Hare had previously caused similar habitat degradation on Kent Island, New Brunswick, but these animals were eradicated by 2007 (Wheelwright 2016; d'Entremont *et al.* 2020).

MARINE HABITAT

Marine Habitat Requirements

Atlantic Leach's Storm-Petrel forages over the continental shelf during the breeding season, moving into open oceanic waters to feed on abundant small fish, primarily mesopelagic lantern-fish (family Myctophidae), and crustacea (Hedd and Montevecchi 2006; Hedd *et al.* 2009*,* 2018; see **Diet and Foraging Behaviour** below). As a consequence, habitat characteristics associated with foraging areas vary in depth (average 900-4000 m), sea surface temperature (10.6-23.3ºC), and chlorophyll-*a* concentration (0.2-0.9 mg/m^3) across their eastern Canadian summer foraging range (Hedd *et al.* 2018).

In winter, the probability of occurrence of Leach's Storm-Petrel is positively associated with high sea surface temperatures and high chlorophyll-*a* concentrations (Pollet *et al.* 2019b), in productive upwelling regions and highly eutrophic coastal regions. The latter Net Primary Production areas (Boyd *et al.* 2014; see **Marine Habitat Trends** below), include fronts and eddies where upwelling brings prey to the surface (Pollet *et al*. 2019a; see **Diet and Foraging Behaviour** below). Net Primary Production refers to the storage of energy produced by plants through photosynthesis and available to be consumed by zooplankton, which forms the basis of marine ecosystem food chains (Boyd *et al.* 2014). Plankton is a rich food source for small fish and copepods, which in turn form the basis of the Leach's Storm-Petrel diet (Hedd *et al.* 2009; see **Diet and Foraging Behaviour** below).

Marine Habitat Trends

Although changes in marine habitat of Leach's Storm-Petrel are currently not well understood, increasing anthropogenic activities in the vicinity of breeding colonies and the marine environment are degrading the quality of the marine habitat of Leach's Storm-Petrel.

Light pollution represents a threat to Leach's Storm-Petrel because of its nocturnal nature and vulnerability to light attraction, and is one of the most rapidly growing human-related pressures affecting the natural landscape globally (Cinzano *et al.* 2001). As a consequence, the quality of marine habitat of Leach's Storm-Petrel is decreasing along coastlines near important colonies in Newfoundland (Baccalieu, Gull and Great Islands) and Nova Scotia (Country Island), as a result of industrial and residential development (Wilhelm *et al.* 2013; Wilhelm unpubl. data). Leach's Storm-Petrel's offshore marine habitats are also experiencing ongoing degradation, due to increased oil and gas exploration and production in Canada and internationally. The quality of both breeding and wintering grounds is deteriorating with increased light and oil pollution, from sources that include flaring, vessel traffic, chronic operational discharges of hydrocarbons, and accidental oil spills (Fraser *et al.* 2006; Montevecchi 2006; Ellis *et al.* 2013; Ronconi *et al.* 2015; Falchi *et al.* 2016; see **Threats Category 3.1: Oil and Gas Drilling** below).

The production of plastic-generated waste is increasing globally (Jambeck *et al.* 2015), with plastics degrading the marine habitat of all seabirds, including Leach's Storm-

Petrel (O'Hanlon *et al.* 2017). Plastic pollution in the marine environment poses direct risks to Leach's Storm-Petrel, as adults are prone to ingesting small particles which can then be offloaded to their offspring (Bond and Lavers 2013; Krug 2020; Krug *et al*. 2020; see **Threats Category 9.4: Garbage and Solid Waste**).

Long-term trends predict that with climate change, Net Primary Production will decrease in the lower latitudes (i.e., the tropics) but will increase in the high latitudes (i.e., the Arctic; Boyd *et al.* 2014). Such trends would likely decrease the quality of Leach's Storm-Petrel winter marine habitat, which in turn could affect juvenile and adult survival on their wintering grounds (see **Threats Category 11.1: Habitat Shifting and Alteration**).

BIOLOGY

Atlantic Leach's Storm-Petrel has been the subject of continuous studies since 1955 on Kent Island (New Brunswick) and shorter studies on Machias Seal Island (New Brunswick); Baccalieu, Great and Gull Islands (Newfoundland); and Bon Portage and Country Islands (Nova Scotia). This section draws mainly on information from those islands, supplemented with additional information from the Birds of North America species account (Pollet *et al*. 2019a).

Life Cycle and Reproduction

A typical procellariform, Leach's Storm-Petrel is a long-lived species, with the oldest known breeding individual aged at least 36 years (Pollet *et al*. 2019a; Bird *et al.* 2020). BirdLife International recently estimated generation time to be 14.81 years for this species under normal conditions (Bird *et al*. 2020). Whereas high annual adult survival is considered necessary to maintain stable populations of long-lived seabirds, recent studies (2003-2018) suggest that annual adult survival of Atlantic Leach's Storm-Petrel is low across much of the eastern Canadian breeding range (Fife *et al.* 2015; Pollet *et al*. 2019a; Fraser and Russell unpubl. data; Hedd unpubl. data). Apparent survival was estimated at 0.78 ± 0.04 at Bon Portage Island, Nova Scotia from 2009 to 2014 (Fife *et al.* 2015), and unpublished estimates for three Newfoundland colonies, including Baccalieu (2013-2018), Gull (2003-2017; Hedd unpubl. data), and Middle Lawn (2003-2008; Fraser and Russell unpubl. data) Islands are in the range of ~0.79-0.86. Previous estimates for Kent Island, New Brunswick, indicated that while adult survival generally increased between breeding years 1-2, 2-3, and 3+, yearly-averaged annual survival from 1962 to 1995 for birds in their third breeding year and beyond was 0.87 ± 0.03 (Mauck *et al.* 2012).

Significantly, apparent annual survival, estimated using the same field techniques and within the same time period, was substantially higher for adult Pacific Leach's Storm-Petrel breeding at two sites on the coast of British Columbia, at 0.975 ±0.01 (2006-2010; Rennie *et al.* 2020). Survival rates in Atlantic Canada are generally below reports for Leach's Storm-Petrel globally (average of about 0.84; Bird *et al.* 2020), other storm-petrels, and most related tube-nosed seabirds (generally > 0.90; reviewed by Fife *et al*. 2015). High adult mortality may be due to a combination of factors (see **Threats** below).

The age of first breeding has been reported as early as 3 years, but most commonly occurs at age 5 or older, with the mean age of first breeding estimated at 6-7 years (Pollet *et al*. 2019a). Individuals may prospect empty burrows or dig new ones at least one season before actually breeding (Pollet *et al*. 2019a).

Atlantic Leach's Storm-Petrel typically returns to the colony in April or May (Pollet *et al*. 2019a). It is strictly nocturnal around the breeding colony, with individuals flying to and from their burrows only at night (Pollet *et al*. 2019a). Individual birds show high site fidelity, with pairs reuniting annually at their burrow (Pollet *et al*. 2019a). If an individual does move to a new burrow, it is typically within 20 m of the previous nest site (Morse and Buchheister 1979). Egg-laying occurs between the end of May and the end of July, with the incubation period ranging from 37 to 50 days (Pollet *et al*. 2019a). Females lay one egg/season, but may relay if the first egg is lost early in the breeding season (Bond and Hobson 2015). Leach's Storm-Petrel is monogamous, with no evidence of extra-pair fertilization (Mauck *et al.* 1995). Eggs hatch between early July and late September. Chicks are left unattended after being brooded for the first 1-5 days, and the adults only visit the burrow at night to feed their young (Pollet *et al*. 2019a).

Atlantic Leach's Storm-Petrels show variability in breeding success across their breeding range. Hatching success (proportion of eggs laid that hatched) tends to be lower than fledging success (proportion of chicks hatched that survived until mid-September) and both can vary considerably by site. In Newfoundland, recent studies monitoring reproductive success (proportion of eggs laid that resulted in chicks that survived until mid-September) report higher reproductive success than in the early 1980s (Pollet *et al*. 2019a), suggesting that breeding conditions have improved. In contrast, Leach's Storm-Petrels breeding in Nova Scotia and New Brunswick currently experience more variable annual reproductive success rates than reported prior to 1988, which may be due to negative effects of increasing ocean temperatures on foraging success during the breeding season (Pollet 2017; Mauck *et al.* 2018). Hatching and fledging success were higher in burrows surrounded by other occupied burrows, and occupied burrows tend to occur in areas of higher burrow density, suggesting that colonial living plays an important role for this species (Stenhouse and Montevecchi 2000; Fricke *et al.* 2015).

Chicks fledge on their own at night, aged 58-77 days (Mauck and Ricklefs 2005; Pollet *et al*. 2019a). Fledging occurs between mid-September and end of November, with some adults continuing to visit the burrow during the week after the chick has fledged (Pollet *et al*. 2019a).

Mortality appears to be highest during the first six months after the young leave the colony (Pollet *et al*. 2019a). Little is known about the pre-breeding years of Leach's Storm-Petrel, although, based on genetic studies, pre-breeders appear to disperse widely across the Atlantic Ocean and may visit several colonies before choosing one in which to breed (Bicknell *et al.* 2013; see **Dispersal and Migration** below).

Physiology and Adaptability

Leach's Storm-Petrel has a remarkable ability to undertake long foraging trips, showing extreme foraging range (Pollet *et al.* 2014). In addition, they are uniquely adapted to forage at night and feed on vertically migrating bioluminescent fish (Hedd and Montevecchi 2006; Hedd *et al.* 2009), thus avoiding competition with diurnal pelagic seabirds. However, because they feed on bioluminescent fish, Leach's Storm-Petrel may have evolved to seek light sources at night, making it susceptible to attraction to artificial lights (see **Threats Category 9.6: Excess Energy** and **Category 3.1: Oil and Gas Drilling**).

Diet and Foraging Behaviour

Leach's Storm-Petrel is a surface-feeder, pecking at prey items while hovering or pattering on the sea surface, and congregating at upwellings and ephemeral convergence lines (Brown 1988; Pollet *et al*. 2019a). Fish dominates the Atlantic Leach's Storm-Petrel's diet (90% of reconstructed mass) at Newfoundland colonies, with mature lantern fish (Myctophidae) and sand lance (*Ammodytes* spp.) being most commonly fed to chicks; the remainder of the diet is primarily crustacea (amphipods and euphausiids; Hedd and Montevecchi 2006; Hedd *et al.* 2009). Dietary studies from colonies in New Brunswick and Nova Scotia show higher proportions of crustaceans (particularly euphausiids) and lower proportions of lantern fish (Frith *et al*. 2020), compared to colonies in Newfoundland (Hedd *et al*. 2009).

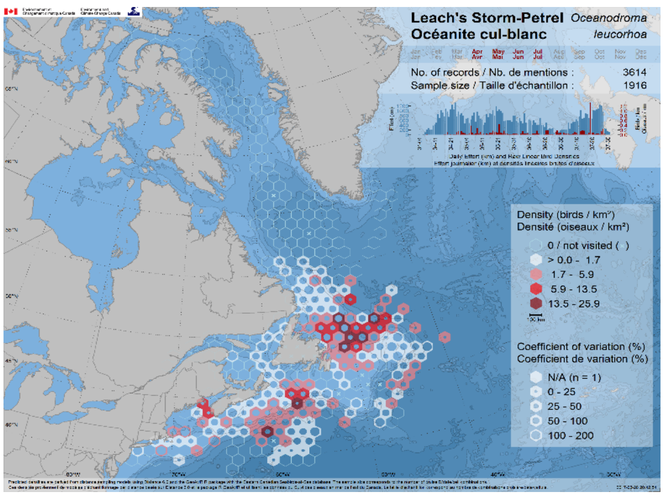
At-sea surveys confirm high densities of Atlantic Leach's Storm-Petrels between near-shore colonies and offshore feeding sites during the breeding season (April-November; Figure 6a,b).

Dispersal and Migration

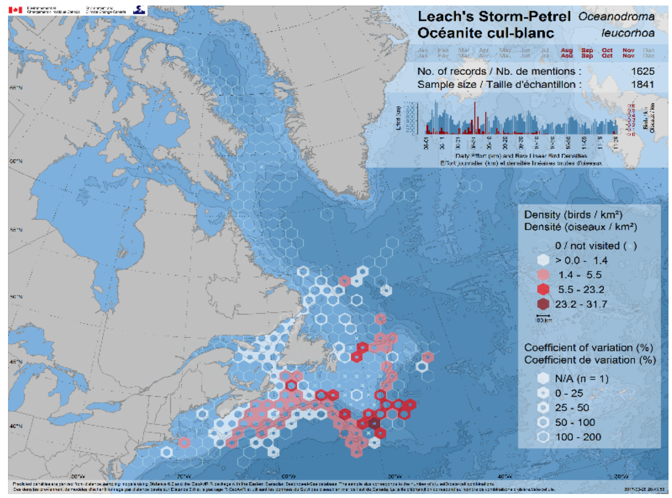
Adult Atlantic Leach's Storm-Petrels that have successfully raised a chick leave the colony between mid-September and mid-October (Pollet 2017), with some breeders staying as late as November (Fifield unpubl. data). Failed breeders may leave the colony earlier. Many storm-petrels migrate first to European waters, where peak numbers in November and December exceed the size of the European population alone, notably in the Bay of Biscay, France (Hémery and Jouanin 1988).

Data obtained from a limited number of deployed geolocators suggest that about two-thirds of breeding-aged Atlantic Leach's Storm-Petrels winter in equatorial waters, mainly in the North Atlantic, circling in a clockwise pattern east across the Atlantic Ocean during fall migration, south to their wintering area, and returning north to the colony during the spring migration; the remaining one-third appear to travel as far south as the waters off South Africa to overwinter (Pollet *et al.* 2019b; Hedd unpubl. data; Figure 4). Leach's Storm-Petrel is virtually absent from Canadian waters outside the breeding period (December-March; Figure 6c). No information is currently available on fidelity to wintering areas.

Unlike breeding adults, which show high breeding site philopatry (Fricke *et al.* 2015), pre-breeding Atlantic Leach's Storm-Petrels exhibit low natal philopatry, as shown through genetic studies which suggest that Leach's Storm-Petrel colonies across the Atlantic Ocean act as one metapopulation with high natal dispersal (Bicknell *et al.* 2012; 2013). Banding studies on Kent Island further corroborate high natal dispersal, where only ~1% of >10,000 chicks banded were later found breeding on the island (Pollet *et al*. 2019a; Mauck pers. comm. 2020).



a)



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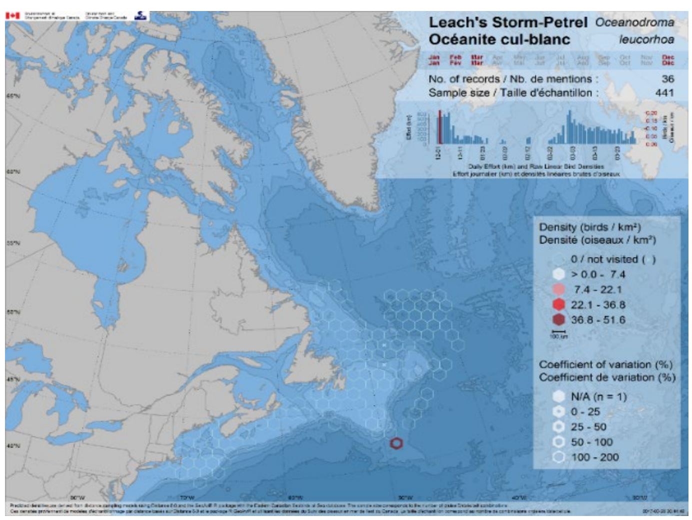

c)

Figure 6. At-sea distribution of Atlantic Leach's Storm-Petrel in waters off Atlantic Canada, during the breeding period (Panel a. April-July; and Panel b. August-November), and during the non-breeding period (Panel c. December-March). Map prepared by C. Gjerdrum based on information in the Atlas of Seabirds at Sea in Eastern Canada 2006-2016 (Environment and Climate Change Canada 2016).

Interspecific Interactions

In Newfoundland and the nearby colony in the French territory of Saint-Pierre et Miquelon, nesting Atlantic Puffins are encroaching on areas used by breeding Atlantic Leach's Storm-Petrel and thereby reducing the amount of available habitat (Lormée *et al.* 2012; Wilhelm *et al.* 2015, 2020).

In Canada, the most common avian predators on Atlantic Leach's Storm-Petrel are Herring and Great Black-Backed Gulls, which prey on adults (Stenhouse *et al*. 2000; Bond unpubl. data). Corvids, namely Common Raven (*Corvus corax*) and probably American Crow (*C. brachyrhynchos*), prey upon adults, eggs, and chicks by digging out burrows (Pollet *et al*. 2019a). Remains of Atlantic Leach's Storm-Petrel have been found in pellets of Great-Horned Owl (*Bubo virginianus*) and Short-Eared Owl (*Asio flammeus*; Holt 1987; Pollet and Shutler 2019).

Mammalian predators prey upon adults, eggs and chicks, and include American Mink (*Neovison vison*), River Otter (*Lontra canadensis*), Meadow Vole (*Microtus pennsylvanicus*), and Red Fox (Sklepkovych 1986; Pollet *et al*. 2019a; Rock unpubl. data). See **Category 8.2: Problematic Native Species**.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

A total of 106 colonies have been identified as either currently or previously supporting breeding Atlantic Leach's Storm-Petrel in eastern Canada (Appendix 1), using one of the following methods.

<u>Complete hole count</u>

At sites where the entire island can be searched for storm-petrel holes, the most accurate approach to survey small Atlantic Leach's Storm-Petrel colonies is by assessing all holes leading to burrows and multiplying the proportion of occupied burrows by the total number of holes counted. The most common method to determine the status of a burrow is through "grubbing", where the observer inserts an arm down each hole to assess its contents, and assigns each hole to one of the following categories: 1) extra entrance or entrance to another burrow, 2) too short to be a burrow (< 30 cm), or 3) burrow and status (empty, adult, adult and egg, egg only, adult and chick, chick only, or could not be determined). Burrow occupancy is then derived by calculating the proportion of occupied burrows (i.e., burrows containing an adult and/or an egg or chick) in relation to all burrows where contents were assessed (i.e., occupied burrows and empty burrows, but excluding entrances, burrows too short, or burrows where the contents could not be determined; Robertson *et al.* 2002; Wilhelm *et al.* 2015). Active burrows can also be detected through the use of playback, where Leach's Storm-Petrel calls recorded on a handheld device are played for several seconds at the mouth of a burrow; if a bird responds the burrow is deemed to be occupied. Correction factors are applied to occupancy estimates generated through playback techniques to account for the proportion of birds that fail to respond (Ambagis 2004).

Grid or transect approach

For larger colonies where complete hole counts are not feasible, the following standardized approaches are used, with details presented in Robertson *et al.* (2002) Lormée *et al.* (2012), Wilhelm *et al.* (2015), and d'Entremont *et al*. (2020). Island-wide grids or transects are established to: 1) determine or refine the area occupied by storm-petrels; and 2) measure occupied burrow density through plot assessments. Island-wide grids or transect lines are typically set 25-100 m apart and a minimum of 100 plots (ranging in area from 9-28.27 m^2) are established at grid intersections, or at regular or random intervals along a transect line. All Leach's Storm-Petrel holes within each plot are assessed through grubbing, as described above, and the occupied burrow density for each plot is calculated by multiplying occupancy rates by the burrow density of each plot. Population size estimates are obtained by multiplying the mean occupied burrow density by the estimated area occupied by storm-petrels.

Since 2011, a Geographic Information System (GIS) approach has been used to estimate area occupied by Atlantic Leach's Storm-Petrels, thereby fine-tuning the delineation of occupied area and improving population estimates (e.g., Wilhelm *et al*. 2015). On large and convoluted colonies where Leach's Storm-Petrel nests on slopes, maps of contour lines are incorporated into the GIS approach to provide more accurate estimated areas on slopes (e.g., Wilhelm *et al.* 2015, 2020). Because traditional non-GIS approaches can significantly underestimate the calculated sloped area occupied by storm-petrels compared to a GIS approach, it is important to ensure that previous survey methods yield comparable occupied area estimates prior to conducting a population trend analysis (e.g., Wilhelm *et al.* 2015, 2020).

Acoustic recording devices

Although Leach's Storm-Petrels are generally quiet during the daytime, they vocalize freely in colonies at night (Pollet *et al*. 2019a). Automated acoustic recording devices placed on islands suspected of supporting Leach's Storm-Petrel can be used to confirm that birds are present and possibly breeding (Buxton and Jones 2012). This approach has been used since 2014 to confirm the presence of Atlantic Leach's Storm-Petrels that are likely breeding at low densities on remote islands along Quebec's North Shore and in Nova Scotia (Rail pers. comm. 2019; d'Entremont pers. comm. 2020). This approach is limited as a survey tool as it can only indicate the presence of storm-petrels, and confirming that storm-petrels are breeding requires finding burrows and assessing their contents. Furthermore, caution is required in interpreting acoustic survey results, as the relationship between call-rates and relative abundance of breeding Leach's Storm-Petrel varies across habitat types (Gladwell 2019).

Abundance

Most Atlantic Leach's Storm-Petrel population estimates are published as numbers of breeding pairs. For the purpose of this report, we assume that one breeding pair equals two mature individuals, and have multiplied all breeding pair estimates by a factor of two. The current eastern Canadian population is estimated at about 5,277,000 mature individuals, with a range of 4,235,000-5,954,000 mature individuals, when considering the 95% confidence intervals for the major colonies where this information is available (Appendix 1).

There are 82 recent colonies in eastern Canada where breeding Atlantic Leach's Storm-Petrels were present when the colony was last surveyed or checked, at some time since 1970, and which are presumed to be active (Appendix 1). An additional 11 historical and small colony sites have not been surveyed or checked since 1970, which may still be active, giving a range of 82-93 active colony sites in eastern Canada (Table 1; Figure 2; Appendix 1). Most of the active breeding population occurs in insular Newfoundland (93%; Table 1; Figure 2; Appendix 1), including Baccalieu Island, the world's largest Leach's Storm-Petrel colony (Wilhelm *et al.* 2020). Twenty islands in eastern Canada support colonies of more than 2,000 mature individuals (14 in insular Newfoundland, five in Nova Scotia and one in New Brunswick), which collectively host 99.7% of the regional population (Appendix 1).

Table 1. Summary of the number of active Atlantic Leach's Storm-Petrel colonies (confirmed since 1970) and the estimated number of mature individuals in eastern Canada, by province and region (total numbers unrounded; summarized from information in Appendix 1).

Province or Region	Number of Active Colonies	Number of Mature individuals	Range (95% CI)	Proportion of Eastern Canada Population
Newfoundland	47	4,914,504	3,906,439 - 5,557,477	93%
Nova Scotia	26	318,540	293,786 - 343,294	6%
New Brunswick	8	43,586	34,186 - 52,986	<1%
Labrador	4	276	-	<0.01%
Quebec	8	36	-	<0.01%
Total	**93**	**5,276,942**	**4,234,723 - 5,954,069**	

There are an additional ten unoccupied colony sites which have hosted breeding storm-petrels within the past three generations (44 years), but where none were present when last visited (see **Extent of Occurrence and Area of Occupancy**; Figure 5; Appendix 1). Most abandonments were in Quebec (Figure 5, Appendix 1), possibly as a result of recent occurrences there of Red Fox (*Vulpes vulpes*) and American Mink (*Neovison vison*; Rail pers. comm. 2019).

Fluctuations and Trends

There is no evidence from colony surveys and field research in Atlantic Canada that breeding numbers of Atlantic Leach's Storm-Petrel are subject to population fluctuations, defined as rapid and frequent changes in the distribution or number of mature individuals. Paleo-ecological studies suggest that natural variation in breeding numbers may occur at some colonies, but these periods of growth and decline happen very gradually over a long period of time (i.e., hundreds to thousands of years; Duda *et al.* 2020a,b).

Trend assessments presented below are based on results of repeated surveys at colonies that together represent about 91% of the Atlantic Leach's Storm-Petrel breeding population in Canada (Robertson unpubl. data; Appendix 1).

<u>Insular Newfoundland</u>

Robertson *et al.* (2006) conducted the first province-wide trend assessment of Atlantic Leach's Storm-Petrels breeding in Newfoundland, accounting for any changes in survey and analytical methods. They found that the population size of three very large colonies (Gull, Great, and Green Islands; 100,000-1,000,000 mature individuals) showed little change between 1978 and 2001. However, two smaller colonies (Middle Lawn and Small Islands; 2,000-60,000 mature individuals) showed significant declines between 1981 and 2001 (Robertson *et al.* 2006). Since the early 2000s, significant efforts have been made to update the status and trends of Atlantic Leach's Storm-Petrels breeding at most major colonies in the province (Appendix 1). Recent trend analyses revealed that all six Newfoundland colonies for which reliable population estimates are available, including the three largest in eastern Canada, have declined by the following annual rates: Baccalieu Island: -2.1% (1984-2013), Gull Island: -1.4% (1979-2012), Great Island: -2.0% (1979-2011), Small Island: -12.3% (1984-2018), Middle Lawn Island: -1.3% (2001-2016), and Green Island: -1.9% (2001-2015; Figure 7; Appendix 2).

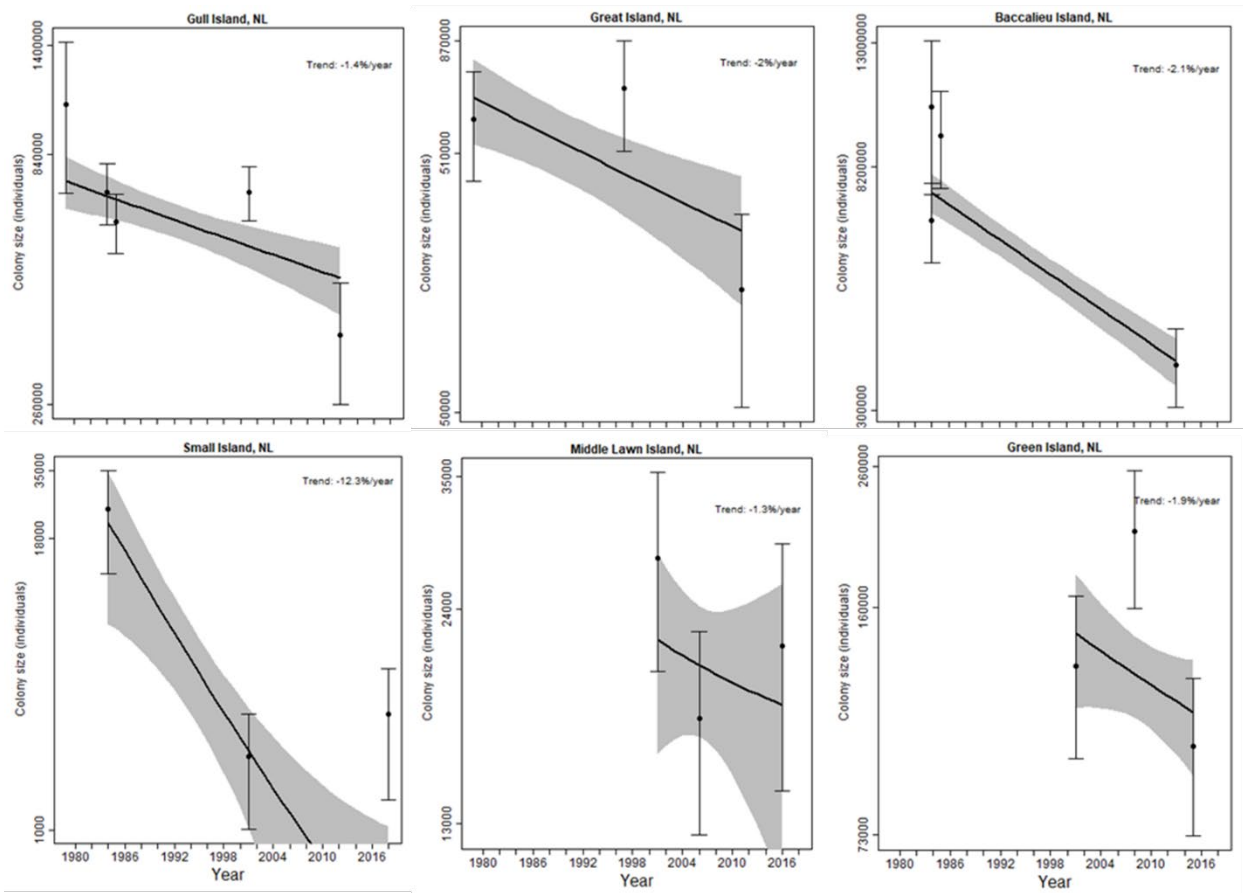

Figure 7. Population trends and associated 95% credible intervals of six Atlantic Leach's Storm-Petrel colonies in Newfoundland (Gull, Great, Baccalieu, Small, Middle Lawn, and Green Islands) from 1979 to 2018 (Robertson unpubl. data, based on information in Appendix 2). Colony size on the y-axis is shown on a $\log_{10}$ scale.

Nova Scotia and New Brunswick

Trend information is available for two of the six largest Leach's Storm-Petrel colonies in the Maritime Provinces, namely Bon Portage Island, located at the southern tip of Nova Scotia near the mouth of the Bay of Fundy, and Kent Island, part of the Grand Manan Archipelago on the New Brunswick side of the Bay Fundy (Figure 2). Trend analyses revealed annual population declines of -1.3% for Bon Portage Island (1983-2017) and -1.8% for Kent island (2000-2018; Figure 8; Appendix 2).

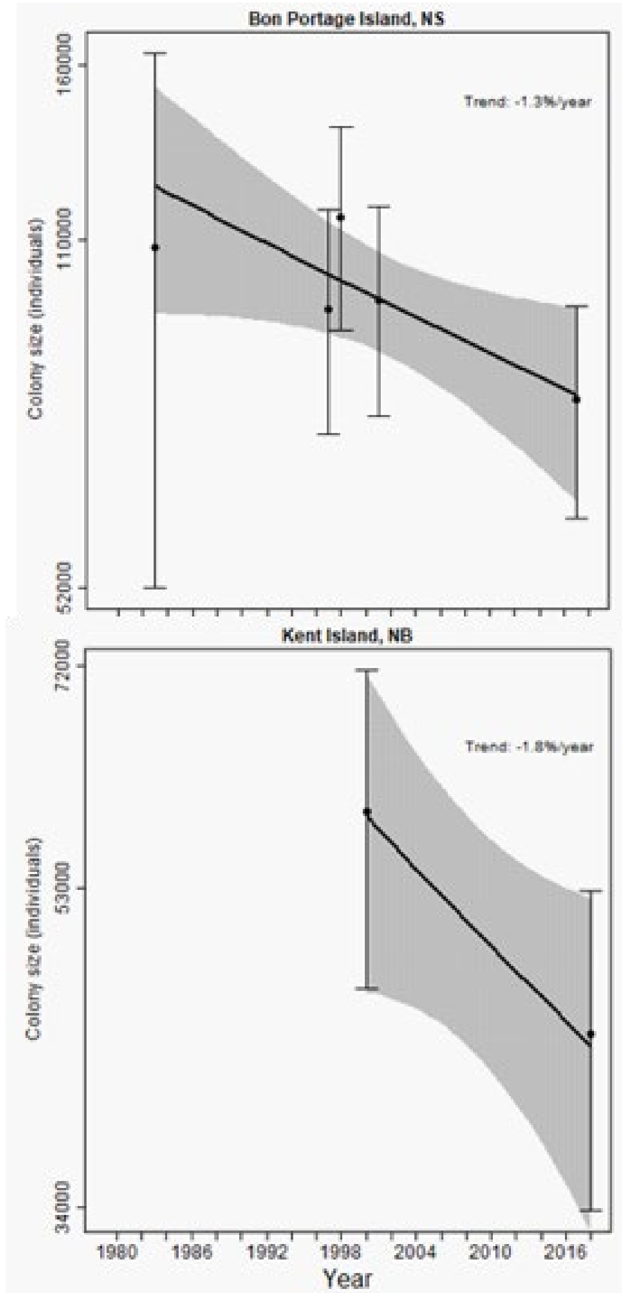

Figure 8. Atlantic Leach's Storm-Petrel population trends and associated 95% credible intervals of colonies on Bon Portage Island, Nova Scotia and Kent Island, New Brunswick, from 1983 to 2018 (Robertson unpubl. data, based on information in Appendix 2). Colony size on the y-axis is shown on a $\log_{10}$ scale.

Quebec

There are fewer than 20 records of Atlantic Leach's Storm-Petrel breeding sites in Quebec (Appendix 1). Colonies are small (<2,000 mature individuals), with burrows often widely dispersed and hidden in dense vegetation, making it difficult to obtain reliable colony size estimates. However, some trend information comes from regular surveys in Migratory

Bird Sanctuaries on the North Shore of the Gulf of St. Lawrence. Leach's Storm-Petrel colonies were detected in four sanctuaries in the 1980s, and in 1988 and 1993 they collectively totalled about 1,800 mature individuals. Very few breeding pairs have been documented at these sites since then, with several colonies apparently abandoned (Figure 9; Appendix 1; Rail unpubl. data).

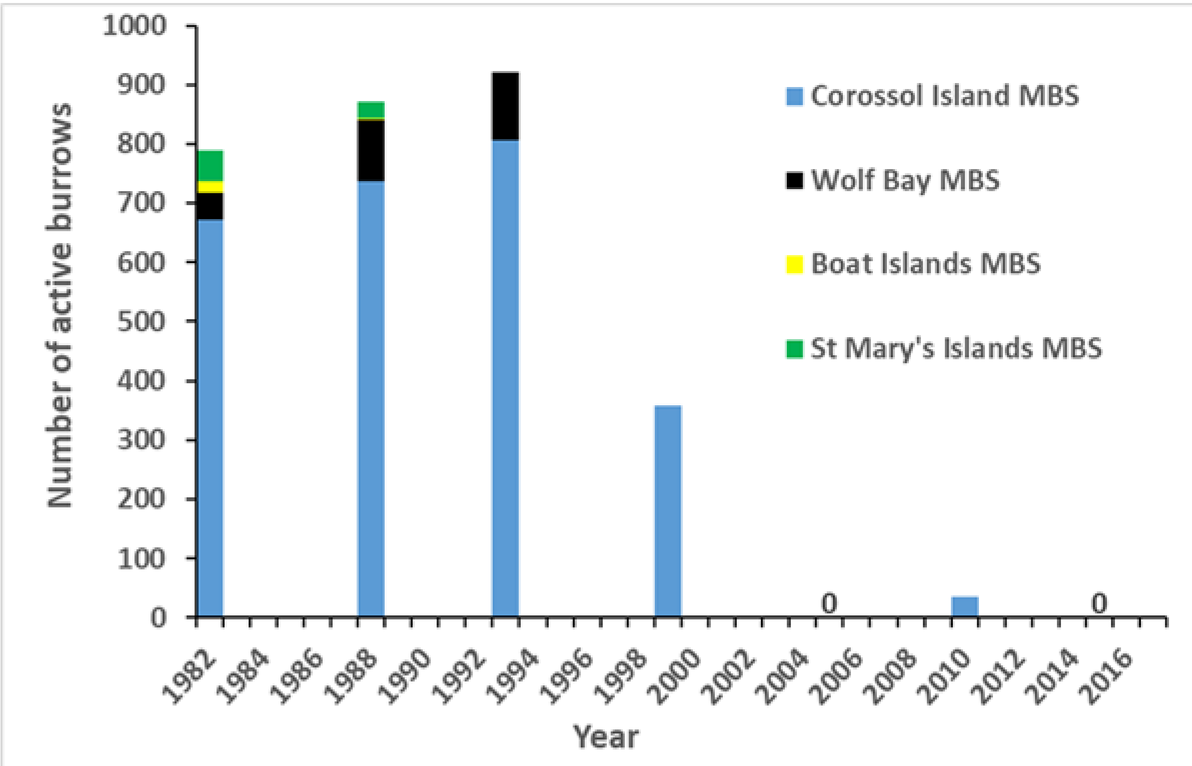

Figure 9. Population trends as indicated by the number of active nesting burrows in four Atlantic Leach's Storm-Petrel colonies in Quebec, at Corossol Island, Wolf Bay, Boat Islands, and St. Mary's Islands Migratory Bird Sanctuaries, from 1982 to 2016 (Rail unpubl. data).

Overall population trends

New trend analyses were undertaken by G.J. Robertson for this status assessment of eight Atlantic Leach's Storm-Petrel colonies monitored in eastern Canada that had two or more colony surveys with estimates of survey error. These include all major colonies in eastern Canada, and account for about 91% of the eastern Canadian population. Colonies surveyed during the 3-generation time period 1974-2018 (44 years) were selected (Appendix 2). This period includes the time when the first statistically defensible colony surveys were conducted. Colonies without estimates of error were excluded, as there was no means of assessing the precision of the survey or whether the methods used were appropriate. Details of the analysis are provided in Appendix 3.

The overall trend for the eight Atlantic Leach's Storm-Petrel colonies assessed declined at a rate of -1.74%/year, based on available surveys within the 3-generation period 1974-2018 (44 years; 95% CI: -2.35% to -1.08; Figure 10). The variance among colonies in their trend was small (σ_{trend} = 0.005, 95% CI: 0.001-0.015), which is reflected visually in the similar trends among colonies (Figures 7, 8). This change is the equivalent of a reduction in the population of -53.8% (95% CI: -38.0% to -64.9%) over three generations. Considering only the last 30 years (1988-2018), or two generations, a steeper but less certain decline of -2.64%/year (95% CI: -5.47%/year to +0.2%/year) is estimated, equivalent to a reduction of -55.2% (95% CI: -81.5% to +6.2%) over two generations.

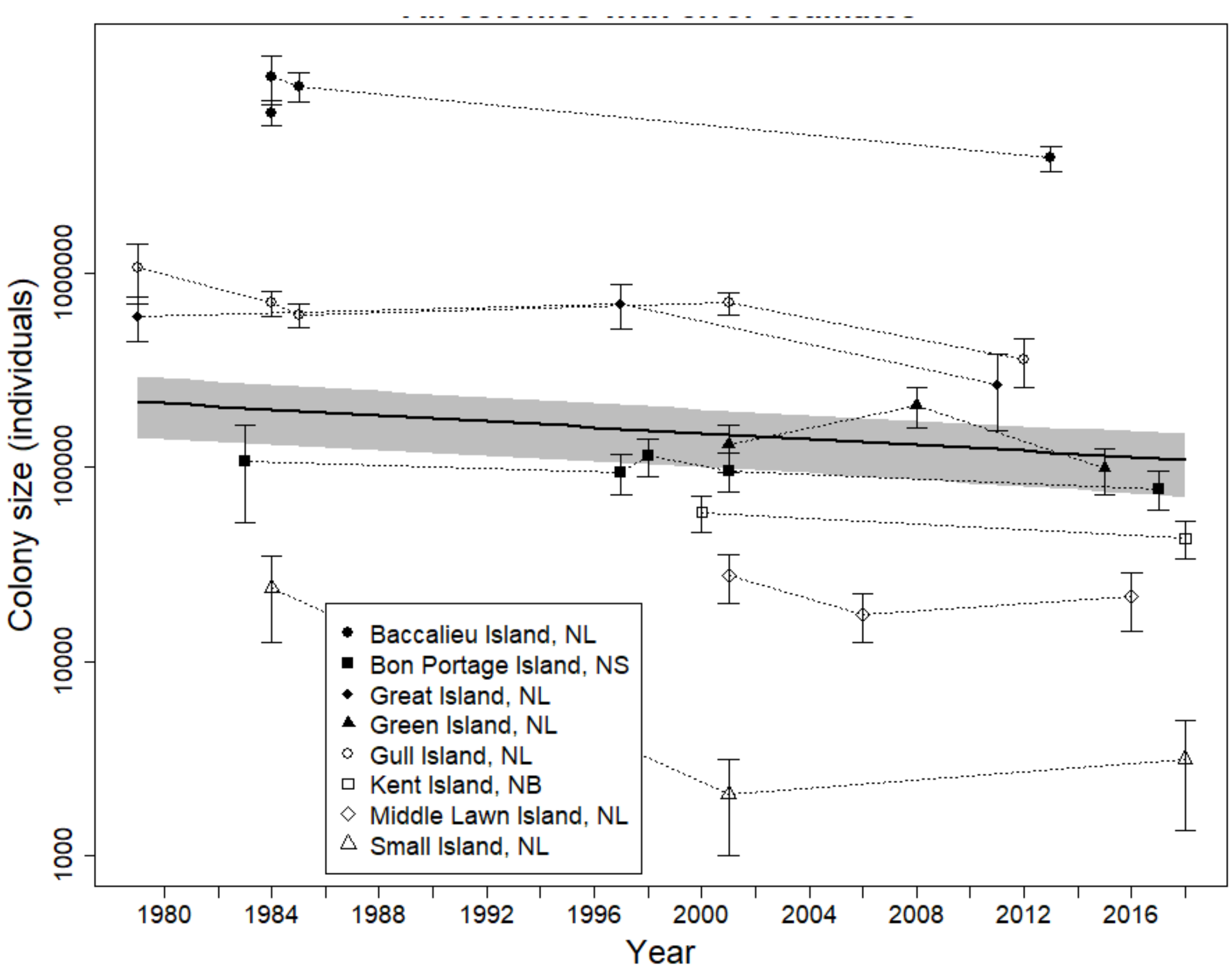

Figure 10. Population trends and associated 95% credible intervals at eight Atlantic Leach's Storm-Petrel colonies in eastern Canada, from 1979 to 2018. Dotted lines connect different survey dates for individual colonies, and solid black line depicts the overall trend over the past three generations (-1.74%/year; Robertson unpubl. data, based on information in Appendix 2). Colony size on the y-axis is shown on a $\log_{10}$ scale.

Further analysis was undertaken to examine the uncertainty in these population trends and the implications of that uncertainty related to estimates of population reduction over three generations. Each value in the posterior distribution of the trend (β_1) was raised to the

44th power (and thus projected over three generations), and that distribution was plotted with thresholds for a 30% decline (the threshold for Threatened under COSEWIC criterion A2) and a 50% decline (Endangered threshold under A2). Of the 30,000 MCMC outputs of the state-space model to estimate trends, 74.9% of the time the estimated trend was equivalent to a population reduction of 50% or more over three generations, and 99.3% of the time the estimated trend was equivalent to a population reduction of 30% or more over three generations (Figure 11).

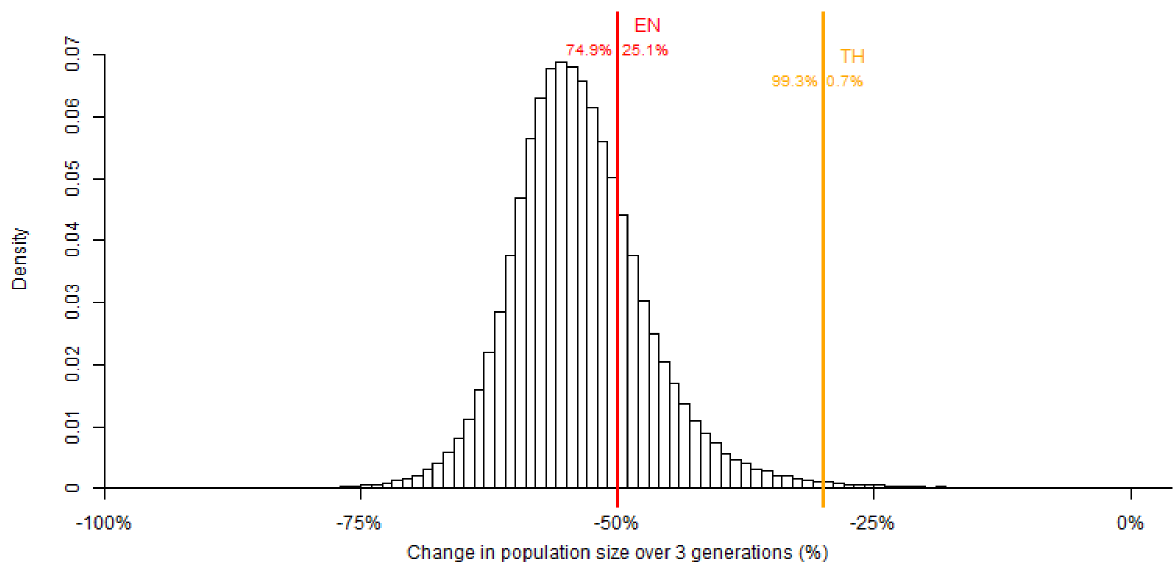

Figure 11. Posterior distribution of population trends (β_1) for Atlantic Leach's Storm-Petrel projected over three generations (44 years), estimated from a simple Bayesian state-space model (Appendix 3), using survey data from eight major colonies in Eastern Canada surveyed with statistically defensible methods (1974-2018). Thresholds are overlaid for declines of 30% over three generations (orange – Threatened under COSEWIC criteria A2, A4) and 50% (red – Endangered under COSEWIC criteria A2, A4), showing the probabilities of falling above or below those thresholds.

The steep population decline observed over the past two generations is consistent with observations that trends at large Leach's Storm-Petrel colonies in Newfoundland were relatively stable until the early 2000s (Robertson *et al.* 2006), but experienced declines since then of ~-40%, attributed in part to high levels of gull predation at two of the largest colonies (Gull and Great Islands; Wilhelm *et al.* 2015; Wilhelm 2017; Bond unpubl. data). Two large colonies in the Maritime provinces, Bon Portage and Kent Islands, have shown marked declines in just over one generation (-20% over 16 years, and -16% over 17 years, respectively), due to factors that are not clearly understood (Pollet and Shutler 2018; d'Entremont *et al*. 2020; see **Threats**). The large Atlantic Leach's Storm-Petrel colony on Baccalieu Island has only been surveyed during two time periods (1984-1985 and 2013), so timing and magnitude of a two-generation decline on this population remains unknown, but Baccalieu shows very steep declines overall, similar to other large colonies (Wilhelm *et al.* 2020). Duda *et al*. (2020b) recently reconstructed the past 1,700 years of Baccalieu Island's Leach's Storm-Petrel population, using paleo-environmental approaches. They showed that numbers were much lower historically, increased from the late 19th century throughout the 20th century with a peak in the mid-1980s, followed by a rapid decline, thereby corroborating recent population trends estimated using traditional colony survey methods (Duda *et al*. 2020b).

Trends in Neighbouring Countries

Saint-Pierre et Miquelon, France

Grand Colombier Island, located 20 km off Newfoundland's Burin Peninsula, currently hosts the second largest Atlantic Leach's Storm-Petrel colony in the northwest Atlantic, but belongs to the French territory of Saint-Pierre et Miquelon. Lormée *et al*. (2012) estimated the population of Grand Colombier at 727,574 mature individuals in 2008, more than double previous estimates from surveys conducted in the late 1980s and 2004, of ~356,000 and ~286,000 mature individuals, respectively (Desbrosse and Etcheberry 1989; Robertson *et al*. 2006). More recently, this colony was estimated at 292,426 mature individuals in 2011 (Appendix 1). Closer examination of these estimates revealed significant discrepancies in estimates of the overall colony area used by Leach's Storm-Petrels, which in this case, is most of Grand Colombier Island, prompting a re-analysis of previous surveys using a GIS approach to estimate occupied area (note: the survey in the late 1980s could not be re-analyzed due to insufficient information on how data were collected and the limited sampling effort as described by Desbrosse and Etcheberry 1989). Revised estimates suggest that the population size on Grand Colombier Island has ranged between about 347,000 (2004) and 507,000 (2008) mature individuals, with the most recent survey in 2011 resulting in an estimate of 400,000 mature individuals (Duda *et al*. 2020a). Results of the recent surveys, together with the original survey in the late 1980s, suggest variable but overall relatively stable numbers of breeding Leach's Storm-Petrel on Grand Colombier Island.

As with several large eastern Canadian colonies, terrestrial habitat for Atlantic Leach's Storm-Petrel breeding on Grand Colombier Island is declining in extent as a result of increases in the number of breeding Atlantic Puffins, which are encroaching on areas previously occupied by storm-petrels (Lormée *et al.* 2012). The presence of large gulls and Meadow Voles also affects the quality of storm-petrel breeding habitat on Grand Colombier. However, there is no indication that gull numbers are increasing, and overall impacts of gulls and voles on storm-petrels are thought to be minimal (Lormée *et al*. 2012).

Maine, United States

The coastal islands of Maine host over 99% of the United States' Atlantic Leach's Storm-Petrel population, with over 80% breeding at two colonies (Great Duck and Little Duck Islands; Schubel *et al.* 2019a). Based on the results of systematic surveys conducted at six major Maine colonies in 2018-19, the overall population trend in Maine appears to be increasing. Of six colonies surveyed, one declined (linked to the presence of mammalian predators), two were stable, and three increased significantly (Schubel *et al.* 2019b). The current estimate indicates 53,528 mature individuals breed on Great Duck and Little Duck Islands (Schubel *et al.* 2019b), more than double the previous estimate of 20,732 mature individuals reported for the 1990s (Chilelli 1999). Despite this apparent increase, the quality of breeding habitat on Great Duck Island appears to have declined over the long term, due to grazing by Snowshoe Hare introduced to the island in the 1960s (Schubel *et al.* 2019a).

Rescue Effect

Atlantic Leach's Storm-Petrel colonies throughout the North Atlantic basin likely act as a single metapopulation through appreciable eastward and westward exchanges of pre-breeding Leach's Storm-Petrels among widely separated colonies (see **Population Spatial Structure and Variability**; Bicknell *et al.* 2012; 2013). The large and apparently stable Atlantic Leach's Storm-Petrel colony on Grand Colombier, Saint-Pierre et Miquelon, France (Duda *et al*. 2020a) and Maine's small, expanding population (Schubel *et al.* 2019b) could potentially serve as source populations for some declining colonies in Atlantic Canada. However, Grand Colombier and Maine currently only represent ~8% of the total Atlantic Ocean Leach's Storm-Petrel population (Table 2). Furthermore, the small populations in most Northeast Atlantic colonies are declining overall (Newson *et al.* 2008; Hansen unpubl. data), and St. Kilda, Scotland may be a population sink due to high predation by Great Skua (*Catharacta skua*) on non-breeding Leach's Storm-Petrels, likely including those that have immigrated from colonies elsewhere in the Atlantic basin, including Canada (BirdLife International 2018). Hence, with major population declines on both sides of the Atlantic Ocean, and because eastern Canada hosts about 91% of the Atlantic Ocean population (Table 2), rescue from colonies outside Canada is very unlikely.

Table 2. Estimated numbers of mature individual Atlantic Leach's Storm-Petrels breeding within the North Atlantic Ocean, by country.

Country	Number of Mature Individuals	Source
Eastern Canada	5,277,000	Appendix 1
Saint-Pierre et Miquelon, France	399,900	Duda *et al*. (2020a)
Maine, United States	62,500	Schubel *et al.* (2019b)
St. Kilda, Scotland	42,000	Newson *et al.* (2008)
Iceland	36,000	Hansen pers. comm. (2019)
Faroe Islands, Denmark	2,000	Pollet *et al.* (2019a)
Norway	2,000	Pollet *et al.* (2019a)

Country	Number of Mature Individuals	Source
Ireland	620	Pollet *et al.* (2019a)
North Atlantic Ocean Total	**5,822,020**	

Pacific Leach's Storm-Petrels breeding on the west coast of Canada are considered here to be a separate geographically disjunct DU (see **Population Spatial Structure and Variability**), and thus could not serve as a rescue population.

THREATS AND LIMITING FACTORS

Threats

Specific causes of Atlantic Leach's Storm-Petrel population decline are currently unknown, but are likely multi-factorial. Major threats faced by Leach's Storm-Petrels at their breeding colonies include predation by native species and habitat loss or degradation. At sea, the species is primarily threatened by light pollution, activities associated with oil and gas production, severe weather conditions, and predicted disruptions in food availability as a result of climate-induced oceanic change.

These threats are categorized below, following the IUCN-CMP (International Union for the Conservation of Nature – Conservation Measures Partnership) unified threats classification system (based on Salafsky *et al.* 2008). They are listed in order of decreasing severity of impact (greatest to least), ending with those for which scope or severity is unknown. The overall threat impact is considered to be High, corresponding to an anticipated further decline of between about 10-70% over the next three generations (Master *et al.* 2012; see Appendix 4 for details).

<u>Category 3.1: Oil and Gas Drilling (Medium threat impact)</u>

Many seabirds, including Leach's Storm-Petrel, aggregate around offshore structures, attracted by food availability, night lighting, and other visual cues. This increases their risk of mortality from physical impacts with structures, strandings on structures, predation by avian predators, incineration from flares, disorientation, and unnecessary energy expenditure (Wiese *et al.* 2001; Montevecchi 2006; Burke *et al*. 2012, Ronconi *et al.* 2015). Effects of lighting and flares are linked to **Category 9.6: Excess Energy** (see below). In Atlantic Canada, Leach's Storm-Petrel is the species most frequently recorded stranded on offshore platforms (90% of reports), with peak strandings in September and October (Gjerdrum *et al.* 2018). This coincides with the fledging period, suggesting that many storm-petrels affected have recently fledged from Canadian colonies.

Four offshore petroleum production facilities currently operate in waters of Newfoundland and Labrador (C-NLOPB 2019) and two in Nova Scotia waters (CNSOPB 2019). The foraging ranges of at least three of the largest Atlantic Leach's Storm-Petrel colonies in eastern Canada overlap with these offshore oil and gas fields during the breeding season (Hedd *et al.* 2018). Leach's Storm-Petrel is also threatened by offshore oil and gas activities on its wintering grounds off the coasts of western Africa and eastern Brazil (Pollet *et al.* 2019b; Hedd unpubl. data). As demand for oil and gas continues to rise to meet the needs of the world's increasing human population (International Energy Agency 2016), threats from offshore production facilities to Leach's Storm-Petrel are likely to continue to increase.

Category 8.2: Problematic Native Species (Medium threat impact)

Avian predators are a direct threat to Atlantic Leach's Storm-Petrels at several of the largest colonies in eastern Canada. Studies have shown that large gulls, primarily Herring Gulls, killed close to 49,000 adult storm-petrels on Great Island, Newfoundland in 1997 (Stenhouse *et al.* 2000) and over 110,000 adults on Gull Island, Newfoundland in 2012 (Bond unpubl. data). Predation rates were highest in May and June and decreased when spawning capelin moved inshore, reflecting a dietary shift by gulls to small fish (Stenhouse and Montevecchi 1999). Gulls likely take breeding Leach's Storm-Petrels early in the nesting season, and non-breeding storm-petrels later when they prospect at colonies (Stenhouse and Montevecchi 1999). Predation thereby impacts both adult survival (Fife *et al.* 2015) and recruitment.

Herring Gull numbers declined across eastern Canada following the groundfish fishing moratorium which began in 1992, as a result of reduced anthropogenic food sources (Wilhelm *et al*. 2016). However, some gull colonies still have access to food subsidies through human sources, such as mink farms, garbage dumps, fishing vessels, and fish processing facilities (Bennett *et al.* 2017; Shlepr 2017) which may result in some gull colonies still being maintained locally at artificially high levels (Ronconi pers. comm. 2020; Wilhelm pers. obs.). Despite the overall gull population decline, some Leach's Storm-Petrel colonies in eastern Newfoundland continue to experience high predation by gulls (Stenhouse *et al*. 2000; Bond unpubl. data). Gull predation also occurs at colonies in Nova Scotia and New Brunswick (Steenweg *et al.* 2011; Fife *et al.* 2015) and may influence nest site use (d'Entremont *et al.* 2020), although population-level impacts are unknown. Atlantic Leach's Storm-Petrel may experience future increased gull predation, as ongoing oceanic climate changes decrease the availability of forage fish near some seabird colonies (Regular *et al.* 2014; Fitzsimmons *et al.* 2017).

Increasing populations of Atlantic Puffin in eastern Canada are reducing the availability of suitable storm-petrel nesting habitat because puffins excavate nest burrows in habitats used by nesting Atlantic Leach's Storm-Petrels. Such encroachment has been observed at the three largest Atlantic Leach's Storm-Petrel colonies in Newfoundland; Baccalieu, Gull and Great Islands (Wilhelm *et al.* 2015, 2020; Wilhelm unpubl. data).

Great Horned Owls are known predators of Leach's Storm-Petrel at colonies such as Bon Portage Island, Nova Scotia (e.g., Pollet and Shutler 2019). Great Horned Owl numbers increased across eastern Canada from 1996 to 2003 (Artuso *et al.* 2013) and may be an increasing threat to Atlantic Leach's Storm-Petrel.

Predation by native mammals occurs at several colonies in eastern Canada. Red Fox may have contributed to recent declines in Quebec (Rail pers. comm. 2019). While a resident Red Fox population was present on Baccalieu Island, it was estimated that foxes consumed 31,000 individual storm-petrels annually, although they likely deterred gulls from nesting on the island (Sklepkovych 1986). That fox population was extirpated sometime between 1985 and the early 2000s (Montevecchi pers. comm. 2020), and a small Herring Gull colony (about 50-100 pairs) has since become established (Wilhelm *et al.* 2020). Country Island, Nova Scotia has a resident population of Meadow Voles which have been observed foraging on eggs, removing eggs from burrows and eating dead chicks (Rock pers. comm. 2019).

Category 9.6: Excess Energy (Medium-low threat impact)

Light pollution is one of the most rapidly increasing human-related activities producing global alterations to the natural environment (Cinzano *et al.* 2001), and onshore artificial lights near Leach's Storm-Petrel colonies are significant potential mortality sources. These largely nocturnal seabirds are attracted to artificial light, which may cause them to become disoriented, susceptible to collisions with human-made structures and vehicles, or forced to land on the ground where they are prone to starvation, dehydration, and predation (Le Corre *et al.* 2002; Miles *et al*. 2010; Rodriguez *et al*. 2014, 2017, 2019). Land-based light sources include lighthouses, residential communities, and industrial sites. Most seabirds attracted to lights on land are naïve fledglings going to sea for the first time (Le Corre *et al.* 2002; Miles *et al.* 2010; Rodríguez *et al.* 2017). In October 2018, over 500 Atlantic Leach's Storm-Petrel carcasses were collected over two nights at two industrial sites in southern Conception Bay, Newfoundland; all but one were fledglings which likely had just departed from Baccalieu Island and died due to trauma caused by striking industrial buildings (Wilhelm unpubl. data).

Storm-petrels become stranded on fishing, cargo, and seismic vessels at night, often as a result of being attracted or confused by their lights (Ellis *et al*. 2013; Gjerdrum unpubl. data; Wilhelm pers. obs.). Light pollution from offshore oil and gas production facilities is an increasing threat for Atlantic Leach's Storm-Petrel in both its summer and wintering areas (see **Category 3.1: Oil and Gas Drilling**).

Category 11.1 Habitat Shifting and Alteration (Medium-low threat impact)

The Northwest Atlantic ecosystem underwent major changes in demersal and pelagic food webs following a cold-water event in the early 1990s, caused by increased Arctic freshwater outflow, which affected the availability of key prey species to higher trophic levels (Head and Pepin 2010; Buren *et al.* 2014, 2018). This regime shift coincided with the collapse of Atlantic Cod (*Gadus morhua*) populations due to overfishing, further cascading effects of changes in the food web (Frank *et al.* 2005). Leach's Storm-Petrels breeding in eastern Canada feed primarily on small fish and supplement their diet with crustaceans (see **Diet and Foraging Behaviour**). However, the diversity of crustaceans in their diet has declined since this cold-water event, with small euphausiid species disappearing altogether (Hedd *et al.* 2009). Feather-based measures of stable isotopes suggest no change in diet of wintering Leach's Storm-Petrel over a 150-year period (Fairhurst *et al*. 2015), although ecosystem changes associated with abnormal water temperatures are likely to increase in the future as a consequence of climate change (Boyd *et al.* 2014).

Changing climatic conditions on breeding and wintering grounds can impact vital rates of migratory seabirds. Winter distribution of Atlantic Leach's Storm-Petrel is positively associated with high sea surface temperature and high chlorophyll-*a* concentrations, at both productive upwelling areas and highly eutrophic coastal regions of equatorial and South Atlantic (see Marine Habitat Requirements). Long-term models predict that Net Primary Production in these regions will decrease (Boyd *et al.* 2014), thereby decreasing winter habitat quality and likely negatively affecting Leach's Storm-Petrel survival. Because low adult survival is a key demographic factor contributing to Atlantic Leach's Storm-Petrel population declines, potential influence of variation in Net Primary Production and other climate-induced changes in oceanographic conditions in storm-petrel wintering areas requires investigation.

Mauck *et al.* (2018) found that Atlantic Leach's Storm-Petrel reproductive success follows a quadratic response to rising global mean temperatures, with hatching success increasing up to a critical point and then declining as the temperature continues to increase. Warming temperatures are thought to initially reduce thermoregulatory costs to incubating adults, but may indirectly reduce reproductive success once higher sea surface temperatures reduce prey availability within the foraging range (Mauck *et al.* 2018). This critical point has consistently been exceeded in the Gulf of Maine since 1988, resulting in variable breeding success at Kent, Machias Seal, and Bon Portage Islands (Mauck *et al.* 2018; Major unpubl. data; Pollet pers. obs.). Reproductive success has recently been consistently high at large colonies near the centre of the eastern Canadian breeding range (e.g., Gull and Baccalieu Islands), suggesting that current summer food supply is favourable (Hedd unpubl. data). This may change in future if global temperatures rise as a result of climate change and negatively impact food availability.

Category 9.2: Industrial and Military Effluents (Low threat impact)

Atlantic Leach's Storm-Petrel is vulnerable to coming into contact with oil sheens on the ocean surface caused by chronic ship-source oil discharges, allowable operational discharges from offshore oil and gas activities, and accidental discharges of larger amounts of oil from production platforms (Fraser *et al.* 2006; Wilhelm *et al.* 2007; Ellis *et al.* 2013; Robertson *et al.* 2014; Morandin and O'Hara 2016). Oil pollution from offshore oil and gas production facilities is an increasing threat to Leach's Storm-Petrel in both summer and wintering areas (see **Category 3.1: Oil and Gas Drilling**).

Leach's Storm-Petrel is vulnerable to oil because it spends extended periods at sea, feeds over wide areas, and makes frequent contact with the ocean surface. Exposure to oil, including sheens, disrupts the structure of feathers, destroying the thermal insulation and buoyancy provided by air trapped by the feathers, and causing oiled birds to suffer from hypothermia or drown (Jenssen *et al.* 1985; O'Hara and Morandin 2010). Ingestion of oil, through preening or consuming contaminated food or water, causes internal organ malfunction and hematological changes (Alonso-Alvarez *et al.* 2007; Horak *et al.* 2017). While such internal effects may not always be lethal, they may affect an individual's ability to reproduce successfully, by causing abnormal behaviours, decreased fertility, or premature death of offspring. Experimental studies of Leach's Storm-Petrel showed reduced reproductive success following internal or external exposure to oil (Trivelpiece *et al.* 1984; Butler *et al.* 1988).

Category 9.4: Garbage and Solid Waste (Low threat impact)

Marine debris, in particular plastic pollution, represents a growing threat to seabirds, including Leach's Storm-Petrel (O'Hanlon *et al.* 2017). Leach's Storm-Petrels ingest and retain small pieces of plastic in the gizzard, and breeding adults subsequently offload ingested plastics to their offspring (Rothstein 1973; Bond and Lavers 2013; Provencher *et al.* 2014), although a recent study suggests that high incidence of plastics in chicks did not preclude successful fledging (Krug 2020; Krug *et al*. 2020). In addition to direct negative impacts of having no nutritional value and damaging the digestive tract, ingested plastics may indirectly compromise the health of individuals through increased exposure to metals and other contaminants causing toxicity, which may negatively impact adult survival and reproductive success (reviewed in Lavers and Bond 2016; O'Hanlon *et al.* 2017).

Category 11.4: Storms and Flooding (Low threat impact)

Extreme weather events, such as storms of higher than normal intensity or duration, may flood nesting burrows with low drainage capability, and drown eggs or chicks that are present (Pollet *et al*. 2019a). Strong storms with onshore winds may blow Leach's Storm-Petrels ashore, stranding numbers ranging from a few individuals to thousands (Cramp and Simmons 1977; Hémery and Jouanin 1988; Ruckdeschel *et al.* 1994; Megson *et al.* 2014). When such wrecks occur in September and October, they primarily affect fledgling birds, although moulting adults may also be vulnerable to mass strandings when severe onshore winds occur during fall migration (Hémery and Jouanin 1988). Increased frequency of extreme weather events during the fall could increase the impacts of mass strandings on juvenile survival and recruitment.

Category 8.1: Invasive Non-Native/Alien Species (Low threat impact)

Domestic animals and introduced non-native mammals, such as rats (*Rattus* spp.) and Striped Skunks (*Mephitis mephitis*), can have devastating effects on Leach's Storm-Petrel colonies. For example, Seal Island, off southern Nova Scotia, hosted a large Atlantic Leach's Storm-Petrel colony during the early 1900s, which had been extirpated by 1959 due to predation by dogs, cats, rats, pigs, and skunks (Pollet *et al*. 2019a). American Mink were introduced to the island of Newfoundland through escapes or releases from commercial mink farms (Government of Newfoundland and Labrador 2019). Although mink are infrequently observed in Newfoundland, their presence can have devastating effects within storm-petrel colonies by killing significant numbers of breeding adults in a short period (Wilhelm pers. obs.; Fitzsimmons, pers. comm. 2019).

Category 7.3: Other Ecosystem Modifications (Negligible threat impact)

Breeding habitat degradation through grazing by introduced Snowshoe Hare and White-tailed Deer has caused habitat changes on islands hosting two of the largest Atlantic Leach's Storm-Petrel colonies in the Maritime Provinces: Kent and Bon Portage Islands (see **Terrestrial Habitat**). The browsing of young trees prevents forest regeneration in habitats used by breeding storm-petrels, and opens up the landscape for Herring Gulls to breed (Wheelwright 2016). While hare and deer are still present on Bon Portage Island (Shutler pers. comm. 2019), Snowshoe Hare was successfully eradicated from Kent Island in 2007 (Wheelwright 2016). Large-scale fisheries may affect marine community structure and food availability for seabirds (e.g., Cury *et al*. 2011), although most changes would be confined to shelf waters rather than deeper areas where storm-petrels usually forage during the breeding period (Hedd *et al*. 2018).

Category 6.1: Recreational Activities (Negligible threat impact)

Recreational activities, such as temporary camping and hiking, which occur on those islands that support breeding colonies but are not formally protected, could affect Leach's Storm-Petrels by trampling nesting burrows and disturbing birds.

Category 6.3: Work and Other Activities (Negligible threat impact)

Although designed to minimize effects on breeding Leach's Storm-Petrels, surveys and research activities on colonies throughout eastern Canada may disturb some nesting birds and their burrows; population-level effects are likely to be insignificant.

Category 3.3: Renewable Energy (Unknown threat impact)

Anticipated future development of offshore wind farms planned for the Gulf of Maine will have effects of yet-unknown scope and severity on Atlantic Leach's Storm-Petrels breeding in Bay of Fundy and Gulf of Maine colonies (Stenhouse pers. comm. 2020).

Category 9.5: Air-borne Pollutants (Unknown threat impact)

Mercury is most toxic when transformed into methylmercury in marine or freshwater ecosystems. Methylmercury exposure can have negative neurological, immunological, behavioural, endocrine, and reproductive effects on marine organisms feeding at higher trophic levels, including seabirds (Wolfe *et al.* 1998; Scheuhammer *et al*. 2015). Elevated levels of mercury are consistently found in breeding Atlantic Leach's Storm-Petrels (Bond and Diamond 2009; Pollet *et al.* 2017; Stenhouse *et al.* 2018), and Newfoundland storm-petrels appear to be exposed to higher mercury levels than those breeding in Nova Scotia and New Brunswick (Burgess unpubl. data). No relationship was found among mercury levels, reproductive success, and adult survival of Atlantic Leach's Storm-Petrels breeding on Bon Portage Island, Nova Scotia (Pollet *et al.* 2017), although studies are underway to assess possible mercury impacts on reproduction and survival at those Newfoundland colonies with significantly higher mercury exposures (Burgess pers. comm. 2019).

Limiting Factors

Leach's Storm-Petrel is a *k*-selected species, characterized by high adult survival, delayed onset of maturity (first breeding at 6-7 years, on average), and low reproductive output (raising a maximum of one chick per year; Pollet *et al*. 2019a; see **Life Cycle and Reproduction**). Annual survival rates of such species tend to be high, and for procellariiform seabirds, they are typically over 0.90 (Schreiber and Burger 2001). Annual survival for Pacific Leach's Storm-Petrel in British Columbia has been estimated at 0.975 ± 0.01 (Rennie *et al.* 2020). This contrasts markedly with Atlantic Leach's Storm-Petrel, where apparent annual adult survival rates at colonies monitored across the eastern Canadian range since 2000 have been consistently low (~0.78-0.86; Fife *et al*. 2015; Pollet *et al*. 2019a; Fraser and Russell unpubl. data; Hedd unpubl. data). Low annual adult survival is likely a key factor contributing to current population declines of Atlantic Leach's Storm-Petrel (see **Life Cycle and Reproduction**).

Individual Leach's Storm-Petrels appear to exhibit high fidelity to their breeding sites once they begin to breed (see **Life Cycle and Reproduction**), which may limit the population growth of specific colonies by preventing adults from moving to other colonies if local conditions are poor for adult survival (e.g., high predation rates) or reproductive success (e.g., chronic poor food availability).

High natal dispersal rates exhibited by Atlantic Leach's Storm-Petrel are beneficial in increasing gene flow across the Atlantic Ocean (see **Dispersal and Migration**). However, this may also be a limiting factor if the emigration of young birds from the eastern Canadian colonies, which host some of the largest breeding numbers in the north Atlantic (see **Population Sizes and Trends**), exceeds immigration from colonies in other countries.

Number of Locations

Each location for Atlantic Leach's Storm-Petrel is a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals present. The most serious plausible threat that could rapidly affect Atlantic Leach's Storm-Petrel appears to be that posed by Problematic Native Species (**Threat Category 8.2**), related to the risk of predation at colonies from native predators, especially gulls, owls, foxes, voles and mink, and encroachment of other species, such as Atlantic Puffin, on storm-petrel breeding areas. Leach's Storm-Petrel in eastern Canada nests on coastal islands, which reduces the risk of predation, especially from ground predators. However, these ground predators sometimes occur, even intermittently, on islands that support colonies. The threat posed by problematic native species is likely independent for each island, reflecting the likelihood of predators being present, the numbers present, colony size, and factors affecting the risk of predation, such as the type of nesting habitat. Each island is therefore a geographically distinct area in which this single threatening factor could rapidly affect all individual Leach's Storm-Petrels present.

The number of active locations is considered to be 82-93, equal to the number of coastal island sites currently supporting active Atlantic Leach's Storm-Petrel colonies in eastern Canada. There is evidence that the number of locations has been declining in Quebec and at scattered islands elsewhere in Atlantic Canada (Appendix 1). Most islands on which storm-petrels are no longer detected previously hosted very few mature individuals (usually 20 pairs or fewer). Furthermore, these remote colonies are only visited briefly and infrequently by researchers during the day, which may result in the presence of storm-petrel burrows being overlooked, especially on large islands (Rail pers. comm. 2019). However, an ongoing decline in the number of locations is considered likely, reflecting the loss of small colonies in Quebec and elsewhere.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Leach's Storm-Petrel is protected in Canada under the federal *Migratory Birds Convention Act 1994* (MBCA; Government of Canada 2017) and parallel legislation in the United States (USFWS 2016) and Mexico. The MBCA protects individual Leach's Storm-Petrels, their nests and their eggs throughout Canada, and prohibits the dumping of substances that are deleterious to migratory birds in waters or areas frequented by them. Additional protection for this species is also afforded through provincial acts, namely: *Fish and Wildlife Act* (New Brunswick) and *Wildlife Act* (Nova Scotia and Newfoundland and Labrador). In Quebec, Leach's Storm-Petrel is included on the list of wildlife species at risk of being designated threatened or vulnerable (*Liste des espèces susceptibles d'être désignées menacées ou vulnérables*; Gouvernement du Quebec 2019).

Non-Legal Status and Ranks

At a global level, Leach's Storm-Petrel is considered Vulnerable according to the IUCN Red List (IUCN 2016) and Secure (G5) by NatureServe (2019). Nationally, Leach's Storm-Petrel is currently ranked as N4B (Apparently Secure, Breeding population; NatureServe 2019) in Canada. At the subnational level in the eastern Canadian provinces, Atlantic Leach's Storm-Petrel is ranked as S2B (Imperilled, Breeding population) in Labrador, New Brunswick, and Quebec, S3B (Vulnerable, Breeding population) in Nova Scotia, and S4B (Apparently Secure, Breeding population) on Newfoundland Island (NatureServe 2019). The species is considered Secure (N5B) at the national level within the United States (US) breeding range (NatureServe 2019). It is considered Imperilled/Vulnerable (S2S3) in Maine, the US state bordering the species' eastern Canadian breeding range (NatureServe 2019).

Leach's Storm-Petrel is identified as a conservation priority species in one Marine Biogeographical Unit (MBU) in Newfoundland (MBU 10; Environment Canada 2013a), in two Bird Conservation Regions (BCRs) in Quebec (BCR 8 and 14; Environment Canada 2013b,c), in one MBU in New Brunswick (MBU 11; Environment Canada 2013d), and in two MBUs in Nova Scotia (MBU 11 and 12; Environment Canada 2013e).

Habitat Protection and Ownership

Of the 93 active Atlantic Leach's Storm-Petrel colonies in eastern Canada, 29 are located on islands federally protected as Migratory Bird Sanctuaries or National Parks, or provincially protected as Wildlife Management Areas or Seabird Ecological Reserves (Appendix 1). In addition, three colonies are on privately owned islands operated as research stations (Bon Portage Island, Nova Scotia, owned by Acadia University and protected by a conservation easement between the university and the Nova Scotia Nature Trust, and Kent and Hay Islands, New Brunswick, owned by Bowdoin College). One colony is on Country Island, Nova Scotia, owned by the Department of Fisheries and Ocean's Canadian Coast Guard and operated as a research station by ECCC-CWS. Collectively, these protected islands support 93% of the Atlantic Leach's Storm-Petrel population in Canada (Appendix 1).

In the Maritime provinces, all known large (> 2,000 mature individuals) Atlantic Leach's Storm-Petrel colonies are either legally protected under Nova Scotia's *Wildlife Act* as Wildlife Management Areas or owned by crown or private organizations that focus on the conservation of wildlife (Appendix 1). In Newfoundland and Labrador, four of the largest colonies, including Baccalieu Island, the world's largest colony, are protected under Newfoundland's *Wilderness and Ecological Reserves Act* as Seabird Ecological Reserves. However, there are at least nine significant colonies with no protection, which host between 2,600 and potentially up to 200,000 mature individuals (Appendix 1). While some islands are likely too far from shore or are too steep to attract many human visitors (e.g., Coleman and Corbin Islands), others are easy to access and colonies may be experiencing some level of disturbance by local people due to recreational activities (e.g., berry picking, exploring). Most notably, the Little Fogo Islands, which host at least three colonies with over 3,000 mature individuals (see **Fluctuations and Trends**), are a resettled fishing community where remaining houses are used as summer cabins. Furthermore, several large colonies are located on islands with navigational aids or lighthouses, which require regular maintenance by the Canadian Coast Guard which may inadvertently disturb Leach's Storm-Petrels. In particular, the lighthouse on Green Island, near Fortune Bay, Newfoundland and Labrador, which hosts about 100,000 mature individuals, is staffed year-round, therefore increasing the risk of chronic disturbance by humans and domestic animals, or the inadvertent introduction of non-native species.

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Sabina I. Wilhelm is a seabird biologist with over 20 years of experience working on a variety of seabird species. She obtained her Ph.D. in 2004 from Memorial University's Cognitive and Behavioural Program, and began working as a Wildlife Biologist with Environment and Climate Change Canada's Canadian Wildlife Service in St. John's, Newfoundland the same year. Sabina is currently leading the Colonial Seabird Monitoring Program for the Atlantic Region. Since 2011, her efforts have focused on monitoring the population status and trends of Atlantic Leach's Storm-Petrels at various colonies in the Atlantic provinces, and she has published several peer-reviewed papers on the ecology and status of this species.

April Hedd has over 20 years of research experience with seabirds and is currently a research scientist with the Wildlife and Landscape Science Directorate of Environment and Climate Change Canada in St. John's, Newfoundland. She earned a Ph.D. from the University of Tasmania, Australia in 1999, focused on the foraging ecology of Shy Albatrosses and their interactions with fisheries. Upon returning home to Newfoundland, she began studying Atlantic Leach's Storm-Petrels as a post-doctoral fellow in 2002, and continues to work there today. Her work combines long-term demographic and food web studies with spatial and toxicological datasets to understand drivers of the species' decline throughout the North Atlantic. April's research interests lie in conservation ecology, in particular, in understanding how natural and anthropogenic factors influence distribution and population trends of marine birds.

Gregory J. Robertson has 30 years of experience researching and monitoring fish and wildlife populations, mainly in northern coastal and marine habitats. He obtained his Ph.D. from the Centre for Wildlife Ecology at Simon Fraser University, and started working as a federal research scientist in 1998 in St. John's, Newfoundland. Greg is currently a senior research scientist with Environment and Climate Change Canada and the Department of Fisheries and Oceans, working on priority wildlife issues in coastal ecosystems, and quantitative stock assessments of commercially important groundfish. Greg re-initiated Atlantic Leach's Storm-Petrel monitoring programs in Newfoundland in the early 2000s, and contributed the quantitative trend analysis to this assessment.

Ingrid L. Pollet received a technical diploma in agronomy in 1996 from Université Claude Bernard, in France. She subsequently immigrated to Canada where she worked in medical research for several years, eventually finding her passion in several songbird studies, before focusing her interest on seabirds. She recently completed her Ph.D. co-supervised at Acadia and Dalhousie Universities, studying the extrinsic factors that influence movement and reproductive success of Atlantic Leach's Storm-Petrels. Ingrid has just completed a postdoctoral research position at Justus-Liebig University in Giessen, Germany.

COLLECTIONS EXAMINED

No collections were examined for the preparation of this report.

Appendix 1. Most recent population estimates available of all active and historical (not assessed since 1970) Atlantic Leach's Storm-Petrel breeding colonies in eastern Canada and Saint-Pierre et Miquelon, France, listed by colony name and province (LB = Labrador, NF = insular Newfoundland, NB = New Brunswick, NS = Nova Scotia, QC = Quebec) or region.

Colony	Province or Region	Latitude	Longitude	Protection status	Estimated no. of mature individuals	Lower 95% CI	Upper 95% CI	Survey Year	Source
Gannet Clusters	LB	53.9332	-56.5321	Seabird Ecological Reserve	Present			1999	Robertson and Elliot (2002)
Double Island, Island #1 West of Saint Peter Islands	LB	52.0499	-55.7322		260	260	260	1978	Brown and Lock (1979)
Herring Islands	LB	54.3333	-57.0988		10	10	10	1978	Brown and Lock (1979)
Bird Island (Labrador South)	LB	53.7332	-56.2488		6	6	6	1978	Brown and Lock (1979)
White Head Island (Grand Manan Archipelago)	NB	44.6325	-66.6922		Present			1935	Wilhelm (2017)
Hay Island (Grand Manan Archipelago)	NB	44.5952	-66.7637	Private Research Station	Present			2001	Ronconi and Wong (2003)
North Green Island (Grand Manan Archipelago)	NB	44.6194	-66.7621		Present			2001	Ronconi and Wong (2003)
Outer Wood Island (Grand Manan Archipelago)	NB	44.6115	-66.8191		Present			2001	Ronconi and Wong (2003)
South Green Island (Grand Manan Archipelago)	NB	44.6117	-66.7524		Present			2001	Ronconi and Wong (2003)
Wood Island (Grand Manan Archipelago)	NB	44.6167	-66.8326		Present			2001	Ronconi and Wong (2003)
Kent Island (Grand Manan Archipelago)	NB	44.5852	-66.7583	Private Research Station	43,286	33,886	52,686	2018	d'Entremont (2020)
Machias Seal Island	NB	44.5018	-67.1019	Migratory Bird Sanctuary	300	300	300	2017	Diamond unpubl. data
Duck Island, North (near Fogo)	NF	49.5382	-53.9272		Present			1975	Cairns *et al*. (1989)
Grassy Islands	NF	49.6433	-54.5050		Present			1975	Cairns *et al*. (1989)
Seals Nest Islets	NF	49.7999	-54.1988		Present			1975	Cairns *et al*. (1989)
White Island (Notre Dame Bay)	NF	49.5615	-53.8955		Present			1975	Cairns *et al*. (1989)
Baccalieu Island	NF	48.1165	-52.7988	Seabird Ecological Reserve	3,909,786	3,366,772	4,487,714	2013	Wilhelm *et al*. (2020)
Gull Island (Witless Bay)	NF	47.2383	-52.7804	Seabird Ecological Reserve	359,486	260,156	458,814	2012	Wilhelm (2017)

Colony	Province or Region	Latitude	Longitude	Protection status	Estimated no. of mature individuals	Lower 95% CI	Upper 95% CI	Survey Year	Source
Great Island (Witless Bay)	NF	47.1873	-52.8140	Seabird Ecological Reserve	268,278	153,636	382,918	2011	Wilhelm *et al.* (2015)
Corbin Island	NF	46.9649	-55.2095		200,000	200,00	200,00	1974	Cairns *et al.* (1989)
Green Island (Fortune Bay)	NF	46.8776	-56.0899		98,810	72,678	124,944	2015	Wilhelm (2017)
Middle Lawn Island	NF	46.8692	-55.6158	Seabird Ecological Reserve	21,582	14,280	28,882	2017	Wilhelm (2017)
Penguin Island, South	NF	49.4332	-53.7905		17,074	8,966	2,182	2018	Jenkins *et al.* (2018)
Coleman Island, Wadham Islands	NF	49.5498	-53.8155		5,812	3,108	8,516	2018	Wilhelm, unpubl. data
Double Turr Cliff, Little Fogo Islands	NF	49.8169	-54.1114		4,888	1,491	8,285	2014	Wilhelm (2017)
Bakeapple Island, Little Fogo Islands	NF	49.8155	-54.1127		4,634	3,602	5,666	2014	Wilhelm (2017)
Shag Islands	NF	48.7048	-53.6250		3,400	3,400	3,400	1974	Cairns *et al.* (1989)
Small Island, Wadham Islands	NF	49.5798	-53.7788		3,156	1,350	4,962	2018	Jenkins *et al.* (2018)
Single Turr Cliff, Little Fogo Islands	NF	49.8185	-54.1137		3,046	3,046	3,046	2014	Wilhelm (2017)
Little Denier Island	NF	48.6833	-53.5920		2,600	2,600	2,600	1975	Cairns *et al.* (1989)
Rouge Island	NF	50.8999	-55.7655		2,000	2,000	2,000	1943	Wilhelm (2017)
Big Shag Rock	NF	49.0930	-53.5575		2,000	2,000	2,000	1980	Montevecchi unpubl. data
Ramea Colombier Island	NF	47.5060	-57.4349		2,000	2,000	2,000	1989	Montevecchi unpubl. data
White Islands	NF	51.5832	-55.3488		800	800	800	1943	Wilhelm (2017)
Puffin Island, Little Fogo Islands	NF	49.8104	-54.1110		770	178	1,362	2014	Wilhelm (2017)
Isle Aux Canes	NF	50.6832	-55.6155		600	600	600	1986	Wilhelm (2017)
Offer Island, Lawn Islands	NF	46.8577	-55.6221	Seabird Ecological Reserve	448	448	448	1978	Wilhelm (2017)
Penguin Island, North	NF	49.4482	-53.8122		400	400	400	1984	Cairns *et al.* (1989)
Butterfly Islets	NF	49.1276	-53.4835		400	400	400	1967	Wilhelm (2017)
Wadhams Harbour Island	NF	49.8120	-54.1194		400	400	400	2012	Montevecchi unpubl. data
Colombier Islands, Lawn Islands	NF	46.8898	-55.5752	Seabird Ecological Reserve	250	250	250	1977	Grimmer (1980)
Little Bakeapple 1, Little Fogo Islands	NF	49.81451	-54.1108		226	226	226	2014	Wilhelm (2017)
Little Storehouse Island, Little Fogo Islands	NF	49.8188	-54.1809		200	200	200	1984	Cairns *et al.* (1989)
Pass Island	NF	47.4903	-56.1973		200	200	200	1978	Cairns *et al.* (1989)
Penguin Islands	NF	47.3832	-56.9823		200	200	200	1978	Cairns *et al.* (1989)
Offer Gooseberry Island	NF	48.9401	-53.5383		200	200	200	1945	Wilhelm (2017)
Wreck Island, Garia Bay	NF	47.6278	-58.5467		200	200	200	1944	Wilhelm (2017)

Colony	Province or Region	Latitude	Longitude	Protection status	Estimated no. of mature individuals	Lower 95% CI	Upper 95% CI	Survey Year	Source
Swale Island	NF	46.8945	-55.6051		176	176	176	1975	Wilhelm (2017)
Flowers Island	NF	49.1332	-53.4655		150	150	150	1945	Wilhelm (2017)
Bird Island, South	NF	48.6247	-53.0091		100	100	100	1985	Cairns *et al*. (1989)
Gull Island, Cape Freels	NF	49.2564	-53.4296		50	50	50	1945	Wilhelm (2017)
Ladle Island	NF	49.4898	-54.0488		40	40	40	1985	Cairns *et al*. (1989)
Green Island, White Bay	NF	47.2382	-52.7801	Seabird Ecological Reserve	40	40	40	1979	Nettleship (1980)
Offer Wadham Island	NF	49.5832	-53.7655		36	36	36	1979	Cairns *et al*. (1989)
Green Island, Cape Bonavista	NF	48.6979	-53.1023		20	20	20	1945	Wilhelm (2017)
Copper Island	NF	48.5748	-53.7122		20	20	20	1987	Montevecchi unpubl. data
Hennessey Island	NF	49.8158	-54.1154		18	18	18	2014	Wilhelm (2017)
Cabot Island, North	NF	49.1715	-53.3688		6	0	10	2018	Jenkins *et al.* (2018)
Grand Bruit Island	NF	47.6666	-58.2157		2	2	2	1945	Wilhelm (2017)
Iron Island, Southwest	NF	47.0415	-55.1197		0			2015	Wilhelm (2017)
Dorts Island	NS	45.2169	-61.2491		Present			2017	Wilhelm (2017)
St. Paul Island	NS	47.1998	-60.1486		Present			1971	Wilhelm (2017)
Mark’s Island	NS	43.6342	-66.0431		Present			2020	d’Entremont pers. comm. (2020)
Spectacle Islands	NS	43.6283	-66.0573		Present			2020	d’Entremont pers. comm. (2020)
Scatarie Island	NS	46.0130	-59.7360	Wildlife Management Area	141,000	141,000	141,000	2002	Williams and Cameron (2010)
Bon Portage Island	NS	43.4689	-65.7511	Private Research Station	77,832	60,334	95,330	2017	Pollet and Shutler (2018)
Long Island, White Islands	NS	44.8848	-62.1288	Wildlife Management Area	60,000	60,000	60,000	1995	Paterson and Snyder (1999)
Country Island	NS	45.1018	-61.5426	Crown Research Station	24,460	17,204	31,716	2013	Wilhelm (2017)
Little White Island	NS	44.8935	-62.1000	Wildlife Management Area	11,118	11,118	11,118	2017	Wilhelm (2017)
Bird Islands (group of four islands)	NS	44.8667	-62.2787	Wildlife Management Area	2,402	2,402	2,402	1981	Wilhelm (2017)
Inner Bald Tusket Island	NS	43.6104	-66.0229		400	400	400	1989	Wilhelm (2017)
Half Bald Tusket Island	NS	43.6189	-66.0374		360	360	360	1989	Wilhelm (2017)
Sable Island	NS	43.9316	-59.9030	National Park	200	200	200	2003	Wilhelm (2017)
Camp Island	NS	44.8822	-62.1559	Wildlife Management Area	176	176	176	1977	Wilhelm (2017)
Pumpkin Island	NS	44.8210	-62.3803	Wildlife Management Area	156	156	156	1971	Wilhelm (2017)

Colony	Province or Region	Latitude	Longitude	Protection status	Estimated no. of mature individuals	Lower 95% CI	Upper 95% CI	Survey Year	Source
Mud Island	NS	43.4863	-65.9884		100	100	100	2016	Wilhelm (2017)
Little Halibut Island	NS	44.9016	-62.2005	Wildlife Manage-ment Area	78	78	78	1981	Wilhelm (2017)
Middle Halibut Island	NS	44.8987	-62.1987	Wildlife Manage-ment Area	60	60	60	1967	Wilhelm (2017)
Brother Islands East	NS	44.8246	-62.3564	Wildlife Manage-ment Area	50	50	50	1980	Wilhelm (2017)
Long Island, White Islands, peninsula	NS	44.8856	-62.1209	Wildlife Manage-ment Area	44	44	44	1977	Wilhelm (2017)
Outer Bald Tusket Island	NS	43.5992	-66.0232		42	42	42	2016	Wilhelm (2017)
Pearl Island	NS	44.3837	-64.0491	Wildlife Manage-ment Area	24	24	24	2008	Wilhelm (2017)
Inside Eastern Harbour Island	NS	44.8731	-62.3232	Wildlife Manage-ment Area	14	14	14	1981	Wilhelm (2017)
Bald Harbour Islands	NS	44.8693	-62.3527	Wildlife Manage-ment Area	12	12	12	1981	Wilhelm (2017)
Brother Islands West	NS	44.8234	-62.361	Wildlife Manage-ment Area	8	8	8	1980	Wilhelm (2017)
Ram Island	NS	43.6843	-65.0303		4	4	4	2016	Wilhelm (2017)
Big Duck Island	NS	44.3444	-64.1457		0			2017	Wilhelm (2017)
Indian Island, Southwest	NS	44.1611	-64.4006		0			2017	Wilhelm (2017)
Seal Island	NS	43.4108	-66.0126		0			1959	Pollet *et al*. (2019a)
Bird Rock	QC	47.8381	-61.1455	Migratory Bird Sanctuary	Present			1983	Rail unpubl. data
Boat Island no. 1, Îles aux Perroquets; St. Mary's Islands	QC	50.2818	-59.7315	Migratory Bird Sanctuary	Present			2015	Rail unpubl. data
Cliff Island, St. Mary's Islands	QC	50.3045	-59.6901	Migratory Bird Sanctuary	Present			2015	Rail unpubl. data
Fly Island	QC	50.4082	-59.6317		Present			2015	Rail unpubl. data
Île du Corossol	QC	50.0559	-66.5026		Present			2015	Rail unpubl. data
Wolf Island, Wolf Bay	QC	50.1720	-60.2925	Migratory Bird Sanctuary	Present			2015	Rail unpubl. data
Bonaventure Island	QC	48.4657	-64.2114	Migratory Bird Sanctuary	30	30	30	2016	Rail unpubl. data
Brion Island	QC	47.7584	-61.5361		6	6	6	2017	Rail unpubl. data
Boat Island no. 5, Îles aux Perroquets; St. Mary's Islands	QC	50.2849	-59.7406	Migratory Bird Sanctuary	0			2015	Rail unpubl. data

Colony	Province or Region	Latitude	Longitude	Protection status	Estimated no. of mature individuals	Lower 95% CI	Upper 95% CI	Survey Year	Source
Cap-aux-Meules Island, Gros Cap	QC	47.3492	-61.8848		0			1991	Rail unpubl. data
East Island, St. Mary's Islands	QC	50.3325	-59.6256	Migratory Bird Sanctuary	0			2015	Rail unpubl. data
Forillon National Park	QC	48.8024	-64.2333	National Park	0			1937	Rail unpubl. data
Fox Island, St. Mary's Islands	QC	50.2985	-59.6984	Migratory Bird Sanctuary	0			2015	Rail unpubl. data
Île aux Goélands de l'Est	QC	50.1935	-60.6681		0			1860	Rail unpubl. data
Île aux Loups Marins	QC	47.5992	-61.4911		0			1990	Rail unpubl. data
Island no. 4, Wolf Bay	QC	50.2123	-60.2304	Migratory Bird Sanctuary	0			2015	Rail unpubl. data
Island no. 5, Wolf Bay	QC	50.2159	-60.2139	Migratory Bird Sanctuary	0			2015	Rail unpubl. data
Total eastern Canadian population (mature individuals)					***5,276,942***	***4,434,723***	***6,154,069***		
Number of recent eastern Canadian colonies (since 1970)					***93***				
Number of eastern Canadian colony sites					***106***				
Grand Colombier, Saint-Pierre et Miquelon	France	46.8167	-56.1667		399,870	343,418	457,144	2011	Duda *et al.* (2020a)

Appendix 2. Estimated number of mature individuals and associated 95% confidence intervals, for the ten Atlantic Leach's Storm-Petrel colonies in Newfoundland, Nova Scotia, and New Brunswick which were used to estimate the rate of population reduction over three generations for eastern Canada.

Colony	Year	Mature individuals	95% CI	Reference
Baccalieu Island, NL	1984	6,720,000	460,000	Sklepkovych and Montevecchi (1989)
Baccalieu Island, NL	1984	10,243,466	2,861,298	Wilhelm *et al*. (2020)
Baccalieu Island, NL	1985	9,205,208	1,637,776	Wilhelm *et al.* (2020)
Baccalieu Island, NL	2013	3,909,786	563,614	Wilhelm *et al.* (2020)
Gull Island, NL	1973	420,000	-	Brown *et al.* (1975)
Gull Island, NL	1979	1,060,000	360,000	Cairns and Verspoor (1980)
Gull Island, NL	1984	703,610	100,968	Robertson *et al.* (2002)
Gull Island, NL	1985	611,452	83,186	Robertson *et al.* (2002)
Gull Island, NL	2001	703,732	89,288	Robertson *et al.* (2002)
Gull Island, NL	2012	359,484	99,328	Wilhelm *et al.* (2015)
Great Island, NL	1973	340,000	-	Brown *et al.* (1975)
Great Island, NL	1979	599,168	152,330	Wilhelm *et al.* (2015)
Great Island, NL	1997	694,032	177,188	Wilhelm *et al.* (2015)
Great Island, NL	2011	268,278	114,642	Wilhelm *et al.* (2015)
Small Island, NL	1973	3,950	-	Robertson and Elliot (2002)
Small Island, NL	1979	13,112	-	Cairns and Verspoor (1980)
Small Island, NL	1984	23,876	11,232	Robertson and Elliot (2002)
Small Island, NL	2001	2,076	1,064	Robertson and Elliot (2002)
Small Island, NL	2018	3,156	1,806	Jenkins *et al*. (2018)
Coleman Island, NL	1979	7,000	-	Cairns and Verspoor (1980)
Coleman Island, NL	1984	10,000	-	Cairns *et al.* (1989)
Coleman Island, NL	2018	5,812	2,704	Jenkins *et al*. (2018)
South Penguin Island, NL	1979	15,600	-	Nettleship (1980)
South Penguin Island, NL	1984	18,000	-	Cairns *et al.* (1989)

Colony	Year	Mature individuals	95% CI	Reference
South Penguin Island, NL	2018	17,074	8,108	Jenkins *et al*. (2018)
Middle Lawn Island, NL	1974	22,380	-	Robertson *et al.* (2002)
Middle Lawn Island, NL	1975	32,100	-	Robertson *et al.* (2002)
Middle Lawn Island, NL	1977	38,954	-	Robertson *et al.* (2002)
Middle Lawn Island, NL	2001	27,758	7,702	Robertson *et al.* (2002)
Middle Lawn Island, NL	2006	17,546	4,958	Wilhelm (2017)
Middle Lawn Island, NL	2016	21,580	7,300	Wilhelm (2017)
Green Island, NL	1978	144,000	-	Cairns *et al.* (1989)
Green Island, NL	2001	130,560	35,696	Robertson *et al*. (2002)
Green Island, NL	2008	207,766	48,622	Russell (2008)
Green Island, NL	2015	98,810	26,132	Wilhelm (2017)
Bon Portage, NS	1983	108,000	56,176	Pollet and Shutler (2018)
Bon Portage, NS	1997	94,758	22,338	Pollet and Shutler (2018)
Bon Portage, NS	1998	115,206	24,868	Pollet and Shutler (2018)
Bon Portage, NS	2001	96,486	21,402	Pollet and Shutler (2018)
Bon Portage, NS	2017	77,832	17,498	Pollet and Shutler (2018)
Kent Island, NB	1966	30,000	-	Cannell and Maddox (1983)
Kent Island, NB	2000	58,832	12,802	d'Entremont (2020)
Kent Island, NB	2018	43,286	9,400	d'Entremont (2020)

Appendix 3. Details of population trend analyses developed for Atlantic Leach's Storm-Petrel status assessment (G.J. Robertson unpubl. data.).

A simple state-space model was employed to assess population trend at colonies of Atlantic Leach's Storm-Petrel in eastern Canada. The state of each colony (true population size at time *t*, x_t) cannot be directly observed, but rather estimates of the colony size and associated error are available in certain years ($y_t \pm \sigma_t$). With annual estimates of colony size, a time series analysis which includes autocorrelation across years can be used to estimate trend, but for storm-petrels only 2-5 surveys were available over this 44-year period, so a simple Poisson regression was used to model trend.

A random effect was included for colony-specific trends, to account for possible differences from the overall trend across all colonies. Formally, the model took the following form, where *t* is time (or year) and *c* is colony:

$$x_{ct} \sim Poisson(\mu_{ct})$$
$$E(x_{ct}) = \mu_{ct} \text{ and } Var(x_{ct}) = \mu_{ct}$$
$$\log(\mu_{ct}) = \beta_0 + \beta_1 \times t + \beta_{2c} \times colony_c + b_c \times colony_c \times t$$
$$y_{ct} \sim N(x_{ct}, \sigma_{ct})$$
$$b_c \sim N(0, \sigma_{trend})$$

Models were fitted in a Bayesian framework using JAGS (Plummer 2003), via the r2jags interface (Su and Yajima 2015). Vague priors were used for all regression parameters. Given that order-of-magnitude differences exist among the colony sizes (ranging from 100s to millions of individuals), non-zero starting values and priors for the reference level colony size (β_0) were supplied (~12 on the natural logarithm scale), while other intercepts and trend were assigned priors with 0 mean, and variances of 10,000. The variance in the random effect for trend (σ_{trend}) was modelled with a prior based on a half (positive values only) Student's t distribution, with a mean of 0, a variance of 625 and four degrees of freedom (Robertson *et al.* 2017). Models were run with three Markov Chain Monte Carlo (MCMC) chains, each with 10,000 iterations, and a burn-in period of 5,000 iterations. Mixing was assessed after these 15,000 iterations, by visually examining MCMC chains and examining values of R-hat (which should be less than 1.1; Gelman *et al.* 2013). Posterior distributions of annual predicted values were also calculated and extracted for plotting purposes. In some cases, mixing was not well achieved, generally with one of the three chains taking a different trajectory. This was resolved by either running further iterations (another 10,000 or 20,000 iterations), or re-starting the model run and adjusting the initial value for the reference colony intercept. To calculate and plot colony specific trends, an additional interaction term ($\beta_{3c} \times colony_c \times t$) was added to the linear predictor, while the random effects in trend (b_c) were removed. Bayesian 95% credible intervals (CI), extracted from the posterior distributions of the MCMC chains, are presented for all parameter estimates.

Appendix 4. Threats calculator table for Atlantic Leach's Storm-Petrel in Canada.

Species or Ecosystem Scientific Name	Leach's Storm-Petrel (Atlantic Population)		
Element ID		**Elcode**	
Date (Ctrl + ";" for today's date):	13/01/2020		
Assessor(s):	Sabina Wilhelm, April Hedd, Greg Robertson, Ingrid Pollet (report writers), Richard Elliot (SSC co-chair), David Fraser (facilitator), Marie-France Noël (COSEWIC secretariat), Courtney Baldo, Louise Blight, Neil Burgess, Josh Cunningham, Dave Fifield, Marcel Gahbauer, Carina Gjerdrum, Rielle Hoeg, Andy Horn, Jessica Humber, Elsie Krebs, Bob Mauck, Mark McGarrigle, Pam Mills, Bill Montevecchi, Allison Moody, Jean-François Rail, Michael Rodway, Rob Ronconi, Donald Sam, Dave Shutler, Iain Stenhouse, Laura Tranquilla		
References:	Based on draft Leach's Storm-Petrel (Atlantic Population) status report (November 2019) and draft threat assessment calculator (January 2020)		

Overall Threat Impact Calculation Help:			**Level 1 Threat Impact Counts**	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	0	0
	C	Medium	4	3
	D	Low	0	1
Calculated Overall Threat Impact:			High	High
Assigned Overall Threat Impact:				
Impact Adjustment Reasons:				
Overall Threat Comments			Leach's Storm-Petrel (Atlantic Population) was assessed as one designatable unit. Generation time was assumed to be approximately 14.8 years.	

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development						
1.1	Housing & urban areas						
1.2	Commercial & industrial areas						The effects of bright lights from industrial developments in causing disorientation and strandings are considered in **Category 9.6 Excess Energy**.
1.3	Tourism & recreation areas						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						
3	Energy production & mining	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
3.1	Oil & gas drilling	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	Adults and recently-fledged juveniles may die from physical impacts with offshore oil exploration and production structures and supply vessels, strandings on structures and vessels, predation by avian predators, incineration from flares, disorientation by lights or flares, and unnecessary energy expenditure. Effects of lighting and flares are linked to **Category 9.6 Excess Energy**. Leach's Storm-Petrel is the seabird species most frequently recorded stranded on offshore platforms in Atlantic Canada, with peak stranding occurring during the fledging period. It likely faces similar threats on its wintering grounds off the coasts of western Africa and eastern Brazil.
3.2	Mining & quarrying						
3.3	Renewable energy		Unknown	Unknown	Unknown	Moderate - Low	Anticipated future development of offshore wind farms in the Gulf of Maine will have effects of yet-unknown scope and severity on Leach's Storm-Petrel from Bay of Fundy colonies.
4	Transportation & service corridors						
4.1	Roads & railroads						
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources						Commercial fishing does not significantly impact Leach's Storm-Petrel or its food sources in a direct way. Possible ecosystem-level effects of large-scale fisheries are considered in **Category 7.3 Other Ecosystem Modifications**.
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Activities such as hiking and camping may occur on colony islands that are not formally protected, and can destroy nesting burrows and disturb breeding birds.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Although designed to minimize effects on breeding Leach's Storm-Petrel, surveys and research activities on colonies throughout Atlantic Canada may disturb some nesting birds and their burrows, although population-level effects are likely to be negligible.
7	Natural system modifications		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	
7.1	Fire & fire suppression						
7.2	Dams & water management/use						
7.3	Other ecosystem modifications		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Grazing by introduced domestic sheep, Snowshoe Hare and White-tailed Deer has caused habitat degradation on some nesting islands, such as Kent and Bon Portage. Note that hares were successfully eradicated from Kent Island in 2007. Large-scale fisheries may affect marine community structure and food availability, although most changes will be confined to shelf waters rather than deeper areas where storm-petrels usually forage.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8	Invasive & other problematic species & genes	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	
8.1	Invasive non-native/alien species	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Domestic animals, such as cats and dogs, and introduced non-native mammals can have devastating effects through predation of eggs, nestlings and adults at colonies, and introduced rats had extirpated storm-petrels from Seal Island, Nova Scotia by 1959. American Mink were introduced to Newfoundland by commercial mink farming, where they can have devastating effects within colonies by killing significant numbers of breeding adults in a short period.
8.2	Problematic native species	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	Native avian predators are a direct threat at several of the largest colonies, and the numbers of several predator species, especially Herring and Great Blacked Gulls, are maintained at artificially high levels through access to food from human sources such as mink farms, garbage dumps, fishing vessels and processing facilities. Gulls depredate 50,000-100,000 storm-petrels annually at Great and Gull Island. Red Fox may have contributed to recent declines in Quebec, and a previous resident fox population on Baccalieu Island consumed ~31,000 storm-petrels annually, but became extinct between 1985 and 2013; the small gull population established there since is anticipated to increase. Increasing Atlantic Puffin populations are displacing storm-petrels from nesting habitats at Baccalieu, Gull and Great Islands.
8.3	Introduced genetic material						
9	Pollution	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
9.1	Household sewage & urban waste water						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.2	Industrial & military effluents	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Storm-petrels come in contact with oil sheens on the ocean surface caused by regular and allowable operational discharges of hydrocarbons from offshore oil and gas activities, and from shipping activity (including cargo, petroleum industry, and fishing vessels), which may affect the hydrophobic qualities of their plumage. Petroleum spills from offshore platforms and shipping likely occasionally affect storm-petrels at sea.
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Leach's Storm-Petrel is thought to be particularly prone to plastic ingestion. Adults ingest small plastic particles and offload plastics to their young, potentially depriving them of nutritious foods. However, a recent study found that high incidence of plastics in chicks apparently did not reduce fledging success. Ingested plastics may also compromise the health of individuals through exposure to metals and other contaminants.
9.5	Air-borne pollutants		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Elevated levels of mercury are found in adult Leach's Storm-Petrel across its Atlantic Canada breeding range, although no effects have yet been detected on reproductive success or adult survival. Further studies are underway to assess the impacts of mercury loads on these parameters.
9.6	Excess energy	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Artificial lights from commercial and industrial developments along shores near colonies often disorient recently-fledged Leach's Storm-Petrels and may cause mass strandings during the fledging period. For example, over 500 juveniles were found dead over two nights at two industrial sites in Conception Bay, Newfoundland, in October 2018. Adult and juvenile storm-petrels are often stranded at night on fishing, cargo or petroleum industry vessels, and on oil rigs, when disoriented by their bright lights. Storm-Petrels are regularly attracted to, and destroyed by, large flares associated with offshore petroleum extraction and onshore processing facilities.
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
10.3	Avalanches/landslides						
11	Climate change & severe weather	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
11.1	Habitat shifting & alteration	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	The Northwest Atlantic marine ecosystem underwent major changes in food web structure in the early 1990s, impacting the availability of key prey species for Leach's Storm-Petrel. Modelling of long-term trends predicts that with continuing climate change, Net Primary Production will decrease in lower latitude areas where a significant proportion of the Atlantic Leach's Storm-Petrel population over-winters. This could decrease the quality of their winter habitat and reduce survival. Rising sea surface temperatures that exceed a critical point can affect foraging effectiveness and lead to decreased breeding success, as observed since the late 1980s in the Gulf of Maine. Although breeding success in Newfoundland colonies is currently still relatively high, it may decline over the next 10 years as waters continue to warm.
11.2	Droughts						
11.3	Temperature extremes						There are no anticipated direct threats from temperature extremes, and ecosystem-level changes related to rising temperatures are considered in **Category 11.1 Habitat Shifting and Alteration**.
11.4	Storms & flooding	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	High (Continuing)	As a consequence of changing climates, extreme weather events such as storms are anticipated to increase in frequency and severity, and may flood nesting burrows and drown eggs or chicks. Extreme weather events during migration may increase the frequency of mass strandings and their effects on survival and recruitment.
Classification of threats adopted from IUCN-CMP; Salafsky *et al.* (2008).							