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Red-necked Phalarope

2022

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For copies of the management plan, or for additional information on species at risk, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk (SAR) Public Registry[1].

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[1] www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of management plans for listed species of Special Concern and are required to report on progress within five years after the publication of the final document on the SAR Public Registry.

The Minister of Environment and Climate Change and Minister responsible for the Parks Canada Agency is the competent minister under SARA for the Red-necked Phalarope and has prepared this management plan, as per section 65 of SARA. To the extent possible, it has been prepared in cooperation with Fisheries and Oceans Canada, the Department of National Defense, the provincial/territorial governments of Alberta, British Colombia, Manitoba, Northwest Territories, Nunavut, Saskatchewan, and Yukon, Wildlife Management Boards, and Indigenous organizations as per section 66(1) of SARA.

Success in the conservation of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this plan and will not be achieved by Environment and Climate Change Canada, Parks Canada Agency, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this plan for the benefit of the Red-necked Phalarope and Canadian society as a whole.

Implementation of this management plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

[2] www.canada.ca/en/environment-climate-change/services/species-risk-act-accord-funding.html#2

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Executive summary

The Red-necked Phalarope (*Phalaropus lobatus*) is a medium-sized sandpiper from the family Scolopacidae. The Red-necked Phalarope is a circumpolar breeder and nests in northern regions of North America, Europe, and Asia; in North America, it nests continuously along the coast from Alaska to Newfoundland and inland through the Yukon across northern Manitoba, Ontario and Quebec to the Labrador coast. The Red-necked Phalarope migrates along the Atlantic and Pacific coasts and through interior North America to primarily winter offshore in the Humboldt Current, off the coast of Ecuador, Peru, and Chile.

The Red-necked Phalarope was assessed as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2014 and was listed as such in Schedule 1 of the *Species at Risk Act* in 2019. Since 2004, the IUCN Red List has ranked the global population as Least Concern and NatureServe has ranked the species as G4—Apparently Secure globally since 2001. The Red-necked Phalarope is protected in Canada under the *Migratory Birds Convention Act*.

There are an estimated 2.3 ± 0.7 million Red-necked Phalarope breeding in Canada based on the Arctic Program for Regional and International Shorebird Monitoring. Based on limited data, the population is believed to be declining. The Atlantic Canada and International Shorebird Surveys indicate that the population is declining at 7.6% annually over at least a portion of the range. Surveys at the Bay of Fundy, New Brunswick, a major fall migratory stopover, indicate that the population declined dramatically in the early 1980s. There has been speculation that initial declines were caused by an intense El Niño event from 1982 to 1983, when unusually extreme climatic conditions reduced food availability on the wintering grounds. These initial declines may have left the population vulnerable as numbers appear to have continued to decline.

The exact cause of decline is unknown. Climate change is degrading the Red-necked Phalarope's habitat and may be reducing both food availability and quality. Chronic and point-source oil pollution is a major threat to the species, particularly on the wintering grounds where the most North American nesting individuals concentrate. Plastic pollution is widespread in the ocean and contributes to reduced survival and poor health. Locally, some stopover lakes are drying up due to climate change-induced drought and/or poor water management and Snow Geese (*Chen caerulescens*) are degrading breeding habitat in some areas. Mercury pollution is widespread but levels of contamination may be below harmful levels.

The management objective is to achieve a stable or increasing population trend, measured over a period of 10 years, by 2040. The broad strategies identified in this management plan aim to monitor the population size and trends, conserve habitat, engage the public, prevent contaminants from threatening the species, and conduct research into additional threats. Population monitoring is the top priority as new information may change the species' conservation status.

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1. COSEWIC* species assessment information

Date of assessment: November 2014

Common name (population): Red-necked Phalarope

Scientific name: *Phalaropus lobatus*

COSEWIC status: Special Concern

Reason for designation:
This bird has declined over the last 40 years in an important staging area; however, overall population trends during the last three generations are unknown. The species faces potential threats on its breeding grounds including habitat degradation associated with climate change. It is also susceptible to pollutants and oil exposure on migration and during the winter. This is because birds gather in large numbers on the ocean, especially where currents concentrate pollutants.

Canadian occurrence:
Yukon, Northwest Territories, Nunavut, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland and Labrador, Pacific Ocean, Arctic Ocean, Atlantic Ocean

COSEWIC status history:
Designated Special Concern in November 2014.

* COSEWIC (Committee on the Status of Endangered Wildlife in Canada)

2. Species status information

In Canada, the Red-necked Phalarope (*Phalaropus lobatus*) was listed as Special Concern[3] under Schedule 1 of the *Species at Risk Act* (S.C. 2002, c. 29) in 2019 and assessed as Special Concern by COSEWIC in 2014. Provincially, the Red-necked Phalarope is a Blue List species in British Colombia and designated as Special Concern in Ontario. Additionally, the species has been identified as a priority species in 10 Bird Conservation Regions[4].

Globally, the species is ranked as G4—Apparently Secure by NatureServe (reviewed in 2016; see Table 1 for additional sub-rankings). The IUCN Red List has categorized this

[3] A Species of Special Concern is one which may become threatened or endangered because of a combination of biological characteristics and identified threats.
[4] Those Bird Conservation Regions are: the Arctic Plains and Mountains, the Atlantic Northern Forests, the Boreal Softwood Shield, the Boreal Taiga Plains, the Great Basin, the Northern Pacific Rainforest, the Northwestern Interior Forest, the Prairie Potholes, the Scotian Shelf, and the Taiga Shield and Hudson Plains.

species as Least Concern since 2004; it had previously been Lower Risk/Least Concern since its initial categorization in 1988 (Bird Life International 2018).

Table 1. Summary of national and provincial or state NatureServe ranks for the Red-necked Phalarope where it occurs in North America. Source: NatureServe, 2020.

Global (G) Rank	National (N) Ranks	Sub-national (S) Ranks
G4	Canada N4N5B, N3N4N, N4N5M	Alberta (SU), British Columbia (S3S4B), Newfoundland (S3S4N), Labrador (S4B,S4M), Manitoba (S3S4B), New Brunswick (S3M), Northwest Territories (S3B), Nova Scotia (S2S3M), Nunavut (S3B,S3M), Ontario (S3S4B), Prince Edward Island (SNA), Quebec (S3S4B), Saskatchewan (S4B,S3M), Yukon Territory (S3B)
	United States N4N5B	Alabama (SNRM), Alaska (S4S5B), Arizona (S4S5M), Arkansas (SNA), California (SNRN), Colorado (SNA), Delaware (SNA), District of Columbia (S1N), Florida (SNRN), Georgia (SNRN), Idaho (S3M), Illinois (SNA), Indiana (SNA), Iowa (S1N), Kansas (SNA), Kentucky (SNA), Maine (S3S4N), Maryland (SNA), Massachusetts (S4N), Michigan (SNRN), Minnesota (SNRM), Missouri (SNA), Montana (SNA), Navajo Nation (S4M), Nebraska (SNRN), Nevada (S4M), New Hampshire (SNA), New Jersey (S4N), New Mexico (S4N), New York (SNRN), North Carolina (SNA), North Dakota (SNRM), Ohio (SNA), Oklahoma (S2N), Oregon (SNA), Pennsylvania (S4M), Rhode Island (SNA), South Carolina (SNRN), South Dakota (SNA), Texas (SNA), Utah (S3N), Vermont (SNA), Virginia (SNA), Washington (S4N), Wisconsin (SNA), Wyoming (S3N)

National (N) and Subnational (S) NatureServe alphanumerical ranking: 1 – Critically Imperiled, 2 – Imperiled, 3 – Vulnerable, 4 – Apparently Secure, 5 – Secure, NR – Unranked, NA – Not Applicable, SU – Under Review. Occurrence definitions: B – Breeding, M – Migrant. The N3N4B range indicates the range of uncertainty about the status of the species.

3. Species information

3.1. Species description

The Red-necked Phalarope is a medium-sized sandpiper from the family Scolopacidae that exhibits sex-role reversal, whereby the males provide all parental care and the females compete for mates. As is typical of birds with sex-role reversal, Red-necked Phalarope females are slightly larger than the males (~40 g compared to ~33 g) and have brighter plumage during the breeding season (Rubega *et al.* 2000). The species is named for the bright chestnut-red plumage that circles the base of the neck and extends up the sides of the face during the breeding season. During the breeding season, the head, back, wings, and tail are dark-gray or black, and there are golden chestnut fringes along the mantle (upper part of the back) and scapulars (shoulder feathers). The underwings are white, as is the chin, belly, and eyespot (or sometimes stripe). During the non-breeding season, adult males and females are nearly identical, with a white head and a black streak through and behind the eye. There is a dark patch on the crown. The neck and breast are white, with gray wings and mantle. Juvenile plumage is similar to the non-breeding plumage, though juveniles have buffy stripes along the back. The species has black legs and a long needle-like black bill.

3.2. Species population and distribution

Figure 1. Breeding distribution of the Red-necked Phalarope in the Americas. From Bateman *et al.* 2019.

Distribution

The Red-necked Phalarope is a circumpolar breeder found breeding in Canada, Greenland, Spitsbergen, Iceland, Faeroes, Scotland, Norway, Sweden, Finland, Estonia, Russia, and Alaska (COSEWIC 2014). In the Americas, the species breeds continuously along the coast of Alaska from the Copper River Delta to Battle Harbor in Labrador (Figure 1). Breeding does not extend north of the southern portion of Victoria Island and the southern portion of Baffin Island. Inland, they breed across Central Alaska through the Yukon and into northeastern Manitoba, northern Ontario, along the southern coast of the Hudson Bay, and across northern Quebec to the Labrador coast. See Appendix B for specific provincial breeding distributions based on the Breeding Bird Atlases and Appendix C for breeding distributions based on the Arctic Program for Regional and International Shorebird Monitoring (PRISM). Recent updates through the Breeding Bird Atlases show that the distribution extends farther south into the boreal forest-tundra mosaic than previously thought.

The Red-necked Phalarope primarily migrates offshore, following either the Atlantic or Pacific coast, though a portion of the population migrates inland (Rubega *et al.* 2000). Birds migrate slowly, likely staging to feed along the way, either offshore, or, in the case of inland migrants, in saline lakes and other waterbodies (Smith *et al.* 2014; van Bemmelen *et al.* 2019). On the east coast, the Bay of Fundy, between Nova Scotia and New Brunswick is a major fall stopover site where birds stay for 11 to 20 days (Mercier 1985; Hunnewell *et al.* 2016). Historically, most birds had staged in the Passamaquoddy Bay, in the outer Bay of Fundy, but currently most phalarope stage near Brier Island, also in the outer Bay of Fundy, near to the Nova Scotia Coast (Duncan 1995; Wong *et al.* 2018). Other notable stopover sites in Canada include Last Mountain Lake, Chaplin Lake, and the Quill Lakes, Saskatchewan, all of which host many thousands annually (Rubega *et al.* 2000).

Figure 2. Wintering distribution of the Red-necked Phalarope in the Americas. Adapted from Rubega *et al.* 2000.

The Red-necked Phalarope winters at sea, which has made it challenging to identify their exact wintering sites. Currently, the birds breeding in North America are thought to winter in the Humboldt Current off the coast of Ecuador, Peru, and Chile (Figure 2). There had been some skepticism over whether phalarope that migrate through the Atlantic were truly wintering in the Pacific or whether there was a previously unknown wintering site. However, recent geolocation work has shown that birds from western Europe, Greenland, and Iceland migrate along the Atlantic coast to winter in the Humboldt Current (Smith *et al.* 2014; van Bemmelen *et al.* 2019). Such a migration suggests that individuals breeding in North America and migrating along the Atlantic coast also winter in the Humboldt Current. It is also possible that some of the western breeding birds migrate with the Siberian population to Indonesia (Mu *et al.* 2018), but there is currently no evidence to suggest this. The Red-necked Phalarope also congregates in smaller numbers seen wintering off the Pacific coast of Central America, Mexico, and California (Rubega *et al.* 2000), though the geolocation data suggests that these birds may be wintering primarily in the Humboldt Current but spending time north of the Humboldt Current during the beginning and end of the wintering period (van Bemmelen *et al.* 2019).

Population Size and Trends

The Red-necked Phalarope is difficult to survey because the species spends eight months of the year at sea and breeds across a wide, remote expanse. As a consequence, the data on their population size and trends are limited.

The Arctic PRISM calculated new Canadian population estimates in 2020. Currently, it is estimated that there are 2.3 ± 0.7 million Red-necked Phalarope breeding in Canada (Paul Allen Smith and Jennie Rausch pers. comm.) and 1.5 (95% CI = 1.1-2) million breeding in Alaska (currently includes only the North Slope, Yukon Delta and Alaska Peninsula; Brad Andres pers. comm.). PRISM estimates are based on surveys on the breeding grounds. However, PRISM does not monitor the southern breeding range of Red-necked Phalarope in Canada so probably underestimates the population. Still, the updated PRISM estimates are considerably larger than previous estimates, likely because previous estimates relied on counts at staging areas during fall migration and underestimated the number of birds that did not migrate through key stopover sites (Morrison *et al.* 2006; Andres *et al.* 2012a; COSEWIC 2014).

Based on data from the Atlantic Canada Shorebird Survey and the International Shorebird Survey, from 1974 to 1998, the Red-necked Phalarope that migrate through the North Atlantic have not significantly declined, but those that migrate through the interior have declined by 7.6% per year (Bart *et al.* 2007). While the Atlantic Canada Shorebird Survey does include the Bay of Fundy, the surveys are conducted from shore and may miss birds if they are far offshore. Additionally, neither survey covers the entire Red-necked Phalarope range and observed declines may be due to changing migration routes or phenology[5].

Though there is only limited data to assess trends over larger geographic areas, the Bay of Fundy migratory stopover has been surveyed extensively. The Red-necked Phalarope staging there have declined from two to three million in the 1970s and 1980s to 100,000-300,000 from 2008 to 2010 (Duncan 1995; Nisbet and Veit 2015; Hunnewell *et al.* 2016). Field surveys in the 1980s indicated that the population dropped off precipitously between 1985 and 1989 (Duncan 1995). Nisbet and Veit (2015) proposed that this dramatic decline happened in 1983, following the extremely intense 1982-1983 El Niño-Southern Oscillation[6] (ENSO), and was exacerbated by the 1986-1987 ENSO. ENSO conditions may have severely reduced zooplankton populations on the wintering grounds, leaving phalarope with little food available. Small scale breeding population surveys indicated that there were short-term declines at breeding populations in La Pérouse Bay, Manitoba between 1982 and 1984, which may support the hypothesis (Reynolds 1987). However, it is possible that the Red-necked Phalarope are taking a different migratory route and no longer stop at the Bay of Fundy or that European breeding phalarope that migrate along the Atlantic coast are declining, contributing the apparent decline of Canadian nesting phalarope.

There are also localized accounts of declines on the breeding grounds. On Herschel Island, Yukon, during the 1990s, the once common Red-necked Phalarope disappeared; the species has not bred in the area since 1999 (Cooley *et al.* 2012). There are also local reports of declines on the North Slope and Crow Flats, Yukon (Cooley *et al.* 2012; COSEWIC 2014). In Churchill, Manitoba, and the immediate

[5] Phenology: science dealing with the timing of annual phenomena of animal and plant life such as budding and bird migrations, especially in relation to climatic conditions.
[6] ENSO is a climatic index that depicts the periodic variation in winds and sea surface temperatures over the tropical eastern Pacific Ocean. ENSO affects weather conditions across much of the Americas.

surroundings, the Red-necked Phalarope population declined from the 1930s to 1990s but have been stable since then (Jehl and Lin 2001; COSEWIC 2014). However, declines in Churchill and La Pérouse Bay appear to be locally restricted as densities are high in the surrounding breeding area (Artuso 2018).

3.3. Needs of the Red-necked Phalarope

Breeding

The Red-necked Phalarope primarily breeds in the arctic tundra wetlands, where more than 43% of the landscape is covered in water (Andres *et al.* 2012b). Freshwater ponds serve as courtship grounds and provide food for the breeding pair and their offspring. The Red-necked Phalarope likely chooses to breed in particular ponds based on the presence of other phalarope (Walpole *et al.* 2008a). They are not territorial, but maintain a home range near open water, with graminoid vegetation, aquatic emergent plants, and minimal mud or shrubs (Rodrigues 1994; Walpole *et al.* 2008b). Preferred aquatic plants include *Arctophila* (a genus of aquatic grass) and water sedge (*Carex aquatilis*) (Andres *et al.* 2012b). The home range is usually on low center polygonal ground formed by the freeze/thaw permafrost cycle (Gratto-Trever 1996). Nests are located within the home range in places with more graminoid vegetation and near the water; the additional vegetative cover protects nests from visual predators (Walpole *et al.* 2008b).

The Red-necked Phalarope has also been documented breeding below the tree-line in the boreal forest in the southern portion of their range (Artuso 2018; Michel Robert pers. comm.). There the species nesting habitat includes fens, bogs, and other wetlands near open water sources. In Manitoba, the species nests near willow and other shrubs but avoids dense, tall shrubby areas (Artuso 2018). In Quebec, the species nests near open water in peatlands surrounded by graminoid vegetation (Michel Robert pers. comm.). Most information about the species' breeding biology comes from observations on the arctic tundra.

Like other phalarope, the Red-necked Phalarope displays sex role reversal, meaning that the females compete for mates and the males care for the offspring, including incubating the eggs (Rubega *et al.* 2000). Females arrive first on the nesting grounds, followed by the males (Reynolds 1987; Sandercock 1997). Most birds arrive unpaired, although some may pair during migration (Hildén and Vuolanto 1972). Pair bonds form quickly, sometimes within four hours after courtship begins (Reynolds 1987). Once paired, males stay within 5 m of their female mate 75% of the time, mate guarding and copulating extensively (Whitfield 1990; Schamel *et al.* 2004a). These tactics result in very low rates of extra-pair paternity (i.e., 98.3% of eggs in the clutch are sired by the male who provides parental care; Schamel *et al.* 2004a).

Males build the nests, though females begin the nest site selection process (Rubega *et al.* 2000). The female typically lays four eggs, which the male incubates. Males provide all care for the chicks until about 18 days of age when the chicks become fully independent (Rubega *et al.* 2000). When a nest fails, males often renest, usually choosing to mate with their original female if she is still in the vicinity rather than a new female to reduce the risk of extra-pair paternity (Hildén and Vuolanto 1972; Schamel *et al.* 2004b). However, because females do not incubate or care for their brood, his mate may have already left the area in search of a second mate (either a previously unmated male or a different male whose first nest failed).

Predation is the main cause of nest failure, affecting between 30 and 60% of nests yearly (Sandercock 1997; Walpole 2008b; Weiser *et al.* 2018). Nest predation may be higher in years with low lemming populations because when predators lose their preferred food source (lemmings), they switch to predate eggs and nestlings. Such cycles have been observed in other arctic-breeding shorebirds including the Red Knot and Curlew Sandpiper (Blomqvist *et al.* 2002) but have not been documented in the Red-necked Phalarope.

Migration

Females leave on migration before the males, who stay behind to perform parental care; juveniles leave last (Rubega *et al.* 2000). The Red-necked Phalarope flies approximately 120-130 km per day during migration (van Bemmelen *et al.* 2019). The Red-necked Phalarope stops to forage and rest for an extended period (i.e., more than two days at a time) more often during the fall migration than the spring migration (van Bemmelen *et al.* 2019). Most of these migrating Red-necked Phalarope are pelagic (found on or over open water, usually the ocean) and stage regularly on continental shelf breaks and upwellings where the ocean currents move zooplankton prey to the surface (Mercier and Gaskin 1985; Brown and Gaskin 1988). A portion of the population migrates over land through western North America, with tens of thousands of birds sighted at inland lakes (Rubega *et al.* 2000). These inland migrants forage and rest in wetlands and waterbodies, both freshwater and saline (Page *et al.* 1999; Jehl 1986). They are an abundant migrant in Saskatchewan, especially in the spring (Gratto-Trever *et al.* 2001). Salt lakes, including Mono Lake and Great Salt Lake, California, and Chaplin Lake, Saskatchewan, have particularly high abundances and serve as staging areas (Jehl 1986; Beyersbergen and Duncan 2007; Frank and Conover 2019; A. McKellar pers. comm.). Phalarope staging in saline lakes primarily spend their time foraging for invertebrates in the saline water, but will access small freshwater ponds to drink and bathe (Jehl 1986).

On the east coast, the Bay of Fundy, between Nova Scotia and New Brunswick is a major fall stopover site where birds stay for 11 to 22 days (Mercier 1985; Hunnewell *et al.* 2016; van Bemmelen *et al.* 2019). During this time, birds forage and replenish their fat stores at a rate of 1 g per day (Mercier 1985). New geolocation work has shown that phalarope migrating through the Quoddy region come from both North America and European breeding populations (Smith *et al.* 2014; van Bemmelen *et al.* 2019).

Non-breeding

The population winters at sea. Wintering birds stay within the northern Humboldt Current throughout the winter, moving to the Pacific coast of Central America just before the spring migration starts (van Bemmelen *et al.* 2019). The Red-necked Phalarope almost exclusively forages on the mid-shelf front, which mixes the productive nearshore waters with deeper water and concentrates zooplankton prey (Haney 1985). During migration, along the Atlantic coast, they often forage near mats of *Sargassum* seaweed, where invertebrate prey congregates (Haney 1986; Moser and Lee 2012).

Diet

The Red-necked Phalarope primarily eats aquatic invertebrates, usually copepods, fly larvae, and other insects, though their diet is flexible and largely depends on what food is locally available (Rubega *et al.* 2000). While in ponds and wetlands on the breeding ground, the species feeds on primarily on chironomids (aquatic larval midges; Hildén and Vuolanto 1972). At the Bay of Fundy, New Brunswick, phalarope migrating over the open ocean actively forage on the nutrient-dense and highly abundant copepod, *Calanus finmarchicus*, which makes up the bulk of their diet (Mercier and Gaskin 1985). During inland migration, at Mono Lake, California, brine flies make up 90% of the diet (Jehl 1986). Though brine shrimp are readily available in this salt lake, brine shrimp are less nutritious than brine flies and the Red-necked Phalarope preferentially avoids them (Jehl 1986). If fed a diet of exclusively brine shrimp, the Red-necked Phalarope will steadily lose body mass until they die, even as they consume massive quantities of shrimp (Rubega and Inouye 1994). On migration off the coast of North Carolina, Red-necked Phalarope that forage near *Sargassum* mats in the open ocean primarily eat Sargassum Shrimp (*Latreutes fucorum*) and a species of gastropod (*Litiopa melanostoma*) associated with the *Sargassum* mats (Moser and Lee 2012).

Phalarope have a number of unusual foraging methods. The Red-necked Phalarope pecks prey items out of the water, using surface tension to lift the prey in a water droplet up and into their beak, and then opening their beak slightly to release the leftover water (Rubega and Obst 1993). When there are no invertebrates on the water’s surface, the Red-necked Phalarope spins like a top to create an upwelling. This upwelling concentrates zooplankton prey to the surface from up to 50 cm below (Obst *et al.* 1996). Individual birds are “handed”, always spinning the same direction (Rubega *et al.* 2000). When foraging near *Sargassum* seaweed mats, birds peck prey items off the mat, without spinning (Moser and Lee 2012).

4. Threats

4.1. Threat assessment

The Red-necked Phalarope threat assessment is based on the IUCN-CMP (International Union for Conservation of Nature-Conservation Measures Partnership) unified threats classification system. Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future the destruction, degradation, and/or impairment of the entity being assessed (population, species, community, or ecosystem) in the area of interest (global, national, or subnational). Limiting factors are not considered during this assessment process. Historical threats, indirect or cumulative effects of the threats, or any other relevant information that would help understand the nature of the threats are presented in the Description of Threats section.

Table 2: Threat calculator assessment

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]
7	Natural system modifications	Unknown	Small (1-10%)	Unknown	High (Continuing)
7.2	Dams & water management/use	Unknown	Small (1-10%)	Unknown	High (Continuing)
8	Invasive & problematic species, pathogens & genes	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)
8.2	Problematic native plants & animals	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)
9	Pollution	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)
9.2	Industrial & military effluents	Unknown	Restricted (11-30%)	Unknown	High (Continuing)
9.4	Garbage & solid waste	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing
9.5	Air-borne pollutants	Unknown	Pervasive (71-100%)	Unknown	High (Continuing)
11	Climate change	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)
11.1	Ecosystem Encroachment	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)
11.3	Changes in temperature regimes	Unknown	Pervasive (71-100%)	Unknown	High (Continuing)
11.4	Changes in precipitation & hydrological regimes	Unknown	Restricted (11-30%)	Unknown	High (Continuing)

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]
11.5	Severe/extreme weather events	Unknown	Unknown	Unknown	High (Continuing)

[a] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each threat is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% declines), High (40%), Medium (15%), and Low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Not Calculated: impact not calculated as threat is outside the assessment timeframe (e.g., timing is insignificant/negligible or low as threat is only considered to be in the past); Negligible: when scope or severity is negligible; Not a Threat: when severity is scored as neutral or potential benefit.

[b] **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%; Negligible < 1%).

[c] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation timeframe. Usually measured as the degree of reduction of the species' population. (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).

[d] **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

4.2. Description of threats

The overall threat assessment score is medium. The exact causes of Red-necked Phalarope declines are unknown but declines are likely caused by a combination of climate change and pollution. Climate change is threatening habitat on the breeding ground and affecting food availability. Because they spend so much of their life at sea, oil and plastic pollution both affect the species. Other small-scale threats include low water levels at stopover lakes caused by drought or poor water management, mercury pollution, and habitat degradation by Snow Geese (*Chen caerulescens*) on the breeding grounds. Threats likely to affect the species within the next 10 years are described below, from highest to lowest impact (Table 2).

11. Climate change (Impact: Medium)

11.1 Ecosystem encroachment (Impact: Medium)

As in the case of many tundra breeding birds, climate change will dramatically alter habitat availability for the Red-necked Phalarope. In North America, climatic niche modelling predicted that over 90% of their current breeding range will become unsuitable due to climate change by 2070 (Wauchope *et al.* 2017). Similar changes were predicted in Scandinavia (Virkkala *et al.* 2008). However, the species may be able to relocate somewhat, particularly given that the Red-necked Phalarope displays low natal[7] and moderate adult philopatry[8] (Colwell *et al.* 1988; Reynolds and Cooke 1988). The National Audubon Society ranks the Red-necked Phalarope as highly vulnerable to climate change and modelled that 3°C of warming would reduce their breeding range by 58% of their breeding habitat and would open up an additional 11% of northern breeding habitat (Bateman *et al.* 2019). These estimates are speculative and subject to wide margins of error.

In North America, climate change is dramatically altering Red-necked Phalarope breeding habitat. The arctic ponds where phalarope often feed are drying up because climate change has accelerated the natural formation and decay of thaw lakes. In Utqiagvik (formerly Barrow), Alaska, from 1948 to 2013, the number of ponds declined by 15% and the total pond area declined by 30%, mainly because ancient ponds, which are larger and more stable, are drying up (Anderson and Lougheed 2015). Increased evaporation in the summer, caused by warmer air temperatures will also dry these ponds (AMAP 2012). At the same time, there are some new ponds being created as the permafrost thaws which may provide additional habitat, at least in the short term (Morrison *et al.* 2019).

On land, thawing permafrost is also allowing shrubs and woody vegetation to expand across the tundra. As the Arctic warms, shrubby vegetation is growing, particularly in wet areas (Elmendorf *et al.* 2012). For the most part, dwarf shrubs are expanding into the coldest areas and taller shrubs are growing elsewhere; shrub growth is often accompanied by declines in mosses, lichens, and graminoids (Elmendorf *et al.* 2012).

[7] Natal philopatry: the tendency for new breeders to return to breed near the area where they hatched.
[8] Adult philopatry: the tendency for adults to return to breed in the same area year after year.

This is all troublesome for the Red-necked Phalarope which prefers to breed in short vegetation near ponds (Walpole *et al.* 2008b). Another shorebird species, the Whimbrel (*Numenius phaeopus*) was documented losing breeding sites in Churchill, Manitoba due to shrub encroachment in the subarctic (Ballantyne and Nol 2015). The impact of shifting and altering habitat on the Red-necked Phalarope population in the next ten years is medium but this threat is likely to be one of the main causes of the decline over a longer timeframe.

11.3 Changes in temperature regimes (Impact: Unknown)

The Red-necked Phalarope may be experiencing a phenological mismatch[9]. Phalarope time their arrival to match the beginning of river ice break up, snow melt, and spring flooding (Ely *et al.* 2018) and begin breeding shortly thereafter when spring temperatures warm enough to melt the snow (Liebezeit *et al.* 2014; Saafeld and Lanctot 2017; Kwon *et al.* 2018). Although the Red-necked Phalarope appears to be able to delay or hasten breeding in response to local weather conditions, there is no indication that this species is consistently breeding earlier through time (Saafeld and Lanctot 2017; Ely *et al.* 2018 but see Liebezeit *et al.* 2014 for combined Red Phalarope [*Phalaropus fulicarius*] and Red-necked Phalarope), even though climate change is advancing spring snow melt (Saafeld and Lanctot 2017; Kwon *et al.* 2018) and spring temperatures are warming (Liebezeit *et al.* 2014). If the Red-necked Phalarope is not capable of advancing their nesting phenology to track changes in local weather conditions caused by climate change, the species may experience a phenological mismatch between when its invertebrate food source is most readily available and when its nestlings require abundant food (e.g., Tulp and Schekkerman 2008). Red-necked Phalarope nestling survival has declined since the 1990s, perhaps suggesting that this mismatch is occurring (Kwon *et al.* 2018).

Even the types of food available on the breeding ground may be shifting due to climate change. Climate change is thawing the permafrost that supplies the tundra ponds with additional nutrients, causing algal growth (Morrison *et al.* 2019). Likely as a result of these nutrient pulses and warming water temperatures, the zooplankton community in tundra lakes has shifted dramatically (Lougheed *et al.* 2011; Taylor *et al.* 2016). Predatory larval insects have come to dominate these communities (Lougheed *et al.* 2011; Taylor *et al.* 2016). The Red-necked Phalarope forages on a wide variety of invertebrates, but should warming temperatures shorten the length of the larval phase of their invertebrate prey (Lougheed *et al.* 2011), phenological mismatch may adversely affect the breeding population.

It has been theorized that the North American Red-necked Phalarope population initially crashed following an extreme El Niño year which reduced food availability on the wintering ground (Nisbet and Veit 2015). Under climate change, ENSO is expected to become more variable, with stronger extremes (Maher *et al.* 2018). More extreme

[9] Phenological mismatch: Phenological mismatch occurs when the phenology of two interacting species shifts such that the species interaction is no longer timed properly. This shift is often in response to climate change (e.g., caterpillars emerge earlier in response to climate change and birds that forage on those caterpillars now arrive too late on the breeding grounds to eat the caterpillars).

ENSO fluctuations may hinder Red-necked Phalarope populations from recovering or reduce the population further.

Warming temperatures do not just affect the Red-necked Phalarope through food availability; on the breeding ground, warming temperature may be increasing nest predation. Nest predation is the main cause of reproductive failure in the Red-necked Phalarope (Sandercock 1997; Walpole 2008b; Weiser *et al.* 2018), so increasing predation rates would have profound impacts on the overall population. Globally, daily nest predation rates of shorebirds may have tripled in the Arctic, paralleling both increasing and increasingly variable ambient temperature (Kubelka *et al.* 2018). There has however been controversy over the statistical methodology and validity of these results (Bulla *et al.* 2019; Kubelka *et al.* 2019).

Climate change may increase shorebird nest predation through multiple mechanisms. Predation pressure on arctic shorebirds appears to be linked to lemming densities. Lemmings are a preferred food source in the tundra ecosystems where the Red-necked Phalarope nests, but have cyclic population dynamics. When lemmings are abundant, predators prey on them, but when lemmings are scarce, shorebird nestling survival decreases as predation rates increase (Blomqvist *et al.* 2002; McKinnon *et al.* 2014). Climate change is predicted to destabilize lemming population cycles and ultimately reduce lemming abundance during “boom” years (Gilg *et al.* 2009), potentially exposing shorebird nestlings to greater predation rates (Kubelka *et al.* 2018). However, reduced lemming abundance in “boom” years may reduce overall predator abundance for some species (Gilg *et al.* 2009); for example, Arctic Fox (*Vulpes lagopus*) population dynamics rely on high reproduction during “boom” years (Fuglei and Ims 2008).

Climate change may change overall predator dynamics. Warming temperatures in the Arctic have increased primary productivity (Gauthier *et al.* 2013) and may allow more small prey species to expand into the area, potentially supporting new predator species, or larger populations of existing predators (Fuglei and Ims 2008; Kubelka *et al.* 2018 but see Gauthier *et al.* 2013). The Arctic Fox, a predator of the Red-necked Phalarope (Liebezeit *et al.* 2014; English *et al.* 2017), may be outcompeted by the larger Red Fox (*Vulpes vulpes*) whose range is also expanding due to climate change (Fuglei and Ims 2008). It is unclear how this will affect nesting shorebirds. Climate change may also affect predation rates by changing the habitat’s vegetation and reducing nest camouflage (Kubelka *et al.* 2018).

The combined impacts of changing temperature regimes across the full-annual cycle are unknown.

11.4 Changes in precipitation & hydrological regimes (Impact: Unknown)

Drought is primarily a concern for Red-necked Phalarope that migrate inland and stopover at saline lakes. When there is less water entering large saline lakes, salinity increases, which may kill the zooplankton and invertebrate prey the Red-necked Phalarope relies on (Rubega and Inouye 1994). For example, salinity in Lake Abert, Oregon increased and the shorebird populations disappeared in the 1930s during the Dust Bowl drought (Larson *et al.* 2016). The impact of drought on the Red-necked

Phalarope is unknown. However, the impact is largely restricted to the inland saline lakes such as Mono Lake and Great Salt Lake in California and Chaplin Lake, Saskatchewan, where the Red-necked Phalarope stages during migration.

11.4 Severe/extreme weather events (Impact: Unknown)

Climate change is expected to cause sea levels to rise by 0.9 to 1.6 m above the 1990 sea level by 2100 in the Arctic (AMAP 2012). As the permafrost thaws, rising sea levels will flood and erode some coastal areas that the Red-necked Phalarope breeds in. Additionally, storm surges and increased wave action are causing flooding inland and salinizing freshwater lakes near the coast (Jones *et al.* 2009). The impact of flooding on the population is unknown.

9. Pollution (Impact: Medium)

9.2 Industrial & Military effluents (Impact: Unknown)

Oil is toxic to most birds, but adults would have to ingest very large quantities to experience strong toxicity effects (Jenssen 1994). Instead, oil coats the feathers, sticking them together so that they are no longer water-repellant and insulating (Jenssen 1994). Birds may attempt to preen to clean the feathers, but that simply causes them to ingest the oil and spread it across any clean feathers remaining (Jenssen 1994). For a pelagic bird like the Red-necked Phalarope, being coated in oil and losing their insulation leaves them at risk of dying of hypothermia (Jenssen 1994). In fact, birds that live offshore are more commonly found washed up dead onshore covered in oil than nearshore birds, who can escape to shore to warm and dry themselves and are often found oiled but alive (Henkel *et al.* 2014). Because the Red-necked Phalarope gathers in large numbers offshore at both the migratory stopovers and on the wintering grounds, a point-source oil spill could be disastrous should it happen when large numbers of birds are present. Both international and Canadian oil tanker traffic represent a risk to the Red-necked Phalarope along the migratory route. In Atlantic Canada, oil tanker traffic has increased in the Bay of Fundy as ships supply the oil refineries in Saint John, New Brunswick (J. Paquet pers. comm.).

Large-scale oil spills, even after extensive clean up, may still impact Red-necked Phalarope habitat use. After the Exxon-Valdez oil spill in 1989, the Red-necked Phalarope population breeding along Kenai Peninsula, Alaska were less abundant in bays where there was more oil exposure. By 1991, two years later, the species was beginning to recover, but abundance was still depressed in bays that had been contaminated (Day *et al.* 1997a). These long-term effects were due to disruption of the shoreline and intertidal zone by the oil (and oil clean up), not by toxicity or direct impacts (Day *et al.* 1997a). In Prince William Sound, Alaska, Red-necked Phalarope density was equivalent in oiled habitat and unoiled habitat 2.5 years after the Exxon-Valdez spill (Day *et al.* 1997b).

It is not only large-scale oil spills that affect the Red-necked Phalarope. Oiled, dead Red-necked Phalarope are regularly found washed up on beaches in California, though, as migrants to the area, they are not one of the most common species that volunteers find oiled on the beach (Roletto *et al.* 2003; Henkel *et al.* 2014). Many of these birds were not exposed to a large scale oil spill but rather chronic oil pollution caused by small scale leaks and discharges which are usually unreported and do not trigger clean up procedures. Analysis of the British Columbia coastline suggests that chronic oil pollution is concentrated in two areas: the Hecate Strait and Dixon Entrance in the north, and around the Scott Islands in the south (Fox *et al.* 2016). An estimated 41% of the Red-necked Phalarope migrating along the British Colombia coast will be exposed to high-risk oil contamination areas, mainly in the southern portion of the coast (Fox *et al.* 2016). The risk outside of British Colombia has not been quantified.

While most research into the effects of oil pollution has occurred on the migratory corridor, Red-necked Phalarope are also at risk of both chronic oil pollution and catastrophic oil spills on their wintering grounds in the Humboldt Current. Petroleum extraction is a key economic industry in the region, resulting in high oil tanker traffic (UNEP 2006). There have been multiple smaller scale oil spills in the region, predominantly concentrated around shipping ports such as those in Guayaquil, Ecuador, Lima, Peru, and Puerto Quintero, San Vincente, and Punta Arenas, Chile (UNEP 2006).

The overall impact of point source and chronic oil pollution on Red-necked Phalarope populations in Canada is unknown.

9.4 Garbage & solid waste (Medium)

Plastic pollution is a growing problem in the oceans and most phalarope have likely ingested plastic particles. Off the North Carolina coast, 59 of 92 Red-necked Phalarope (64%), collected live, had ingested plastic, mainly plastic fragments, line, strips, wads of fibres, and film (Moser and Lee 1992). Across seabird species, species like the Red-necked Phalarope that forage at the surface on crustaceans were more likely to have eaten plastic particles (Moser and Lee 1992). For 53 Red Phalarope (*Phalaropus fulicarius*) shot across three sites on the California coast, the stomachs of 34 contained plastic particles (64%; Briggs *et al.* 1984). In a sample of seven Red Phalarope that struck utility lines in California, six had ingested plastic particles (86%; Connors and Smith 1982).

Ingesting plastic particles likely harms the Red-necked Phalarope. For the Red Phalarope, individuals who ingest more plastic (volume) had fewer fat reserves, suggesting that ingesting plastic was detrimental (Connors and Smith 1982). Additionally, of nine dead Red Phalarope collected in British Columbia, all had plastic particles in their stomachs and were severely underweight (Drever *et al.* 2018). Autopsies indicated that most birds died of starvation and found stomach lesions and acute intestinal hemorrhaging, indicating that when starving birds ate plastic particles, the plastics damaged the digestive tract (Drever *et al.* 2018; Jennifer Provencher pers. comm.). The birds moved closer to shore to search for food because unusually warm ocean temperatures reduced zooplankton abundance offshore, likely exposing them to higher levels of plastic pollution (Drever *et al.* 2018).

Plastics may be of particular concern during the non-breeding season. Ocean currents concentrate zooplankton in the Humboldt Front, making feeding easy for wintering Red-necked Phalarope. The same currents also concentrate plastics, leaving phalarope foraging amongst drifting garbage (Bourne and Clarke 1984). The overall impact of garbage and solid waste on Red-necked Phalarope populations is medium.

9.5 Air-borne pollutants (Impact: Unknown)

Though most industrial activities take place outside of the Red-necked Phalarope's breeding grounds, there has been substantial mercury deposition into arctic and sub-arctic waters since the 1960s (Muir *et al.* 2009). Thirteen Red-necked Phalarope individuals shot and collected in the Bay of Fundy, New Brunswick had very low muscle mercury concentration, likely because, by eating zooplankton, they avoid some of the bio-magnification of mercury faced by fish-eating birds (Braun *et al.* 1987). However, more recently, one individual from Utqiagvik (formerly Barrow), Alaska had a blood mercury concentration above the threshold for reduced reproductive success in other species (1.21 ug g^{-1}; Perkins *et al.* 2016). Additionally, one clutch of eggs tested for heavy metal contamination found that strontium concentrations were elevated, averaging 9.7 µg strontium per gram egg, which is above levels that hinder reproduction in other species (Saalfeld *et al.* 2016). Strontium may be transported long distances as aerosolized dust particles, ending up in the Arctic. The impact of air-borne pollutants on Red-necked Phalarope populations is unknown.

8. Invasive & problematic species, pathogens & genes (Impact: Low)

8.2 Problematic native plants & animals (Impact: Low)

There is some overlap between the Red-necked Phalarope breeding range and overabundant Snow Goose colonies, although most of the breeding range does not overlap. Agricultural changes have created abundant food for Snow Geese on their wintering grounds and allowed their populations to increase dramatically (Abraham *et al.* 2005). Greater Snow Geese have been designated as overabundant in Canada since 1998, Mid-continent Lesser Snow Geese since 1999, and Western Arctic Lesser Snow Geese since 2014. In response to this designation as overabundant, there are now spring conservation hunting seasons in many provinces and bag limits have been liberalized to encourage harvest of Snow Geese for population control.

When overabundant Snow Geese forage and grub the tundra soil, they leave behind patches of bare ground and less vegetation (Abraham *et al.* 2005; Peterson *et al.* 2013). Excessive Snow Goose grubbing alters soil characteristics and increases erosion, ultimately increasing salinity in freshwater ponds and altering composition and availability of invertebrate prey (Milakovic *et al.* 2001). Even once Snow Geese are removed from the landscape, changes to the vegetation may persist for years before recovery begins (Peterson *et al.* 2013).

The number of Red-necked Phalarope breeding in Cape Churchill, Manitoba declined following increased Snow Goose activity in the 1990s (Sammler *et al.* 2008). While there are no colonies located at Cape Churchill, the colony breeding in La Pérouse Bay walks their goslings over to Churchill Bay to grub in the vegetation (Cooch *et al.* 1993), likely reducing habitat quality for breeding Red-necked Phalarope (Sammler *et al.* 2008). La Pérouse Bay currently has lower densities of Red-necked Phalarope compared to the surrounding areas (Artuso 2018) but densities of Red-necked Phalarope declined in La Pérouse Bay in 1983, prior to the Snow Geese becoming abundant enough to impact habitat quality. This timeline suggests that the extreme 1982-1983 ENSO, not Snow Geese, may have caused the initial declines (Reynolds 1987; Nisbet and Veit 2015; C. Gratto-Trevor pers. comm.). However, habitat alteration by Snow Geese may have contributed to the continued depression of Red-necked Phalarope abundance.

Ultimately, the effect of problematic native species on Red-necked Phalarope populations is likely low because there is limited range overlap between breeding Red necked Phalarope and overabundant Snow Goose colonies. Habitat degradation by Snow Geese is most problematic on the west coasts of Hudson Bay and James Bay, Ontario, in the Queen Maud Gulf Migratory Bird Sanctuary, Nunavut, and across Southampton Island, Nunavut (COSEWIC 2014).

7. Natural system modifications (Impact: Unknown)

7.2 Dams and water management/use (Impact: Unknown)

Human water management is of concern to the Red-necked Phalarope during migration. Many birds migrate through arid regions and forage in heavily managed waterbodies. For instance, at Mono Lake, California, an inland saline lake, salt concentrations have risen as water was diverted for human use beginning in the 1940s. The Red-necked Phalarope's prey of choice there, brine flies, is sensitive to rising salinity and in the 1990s there was concern that brine flies would disappear altogether, leaving the Red-necked Phalarope without a ready source of food (Rubega and Inouye 1994). Today, Mono Lake water levels are still below those ordered by state law. Other terminal lakes are experiencing similar challenges; in fact, phalarope staging at Lake Abert, Oregon may have declined due to recent salinity increases (Larson *et al.* 2016). Regardless, water management is a local issue with limited scope and, though the ultimate impact on the population is unknown, it is expected to be limited.

5. Management objective

The management objective for the Red-necked Phalarope is to have stable or increasing population trends by 2040.

Rationale for management objective

The management objective is to achieve stable or increasing trends in Red-necked Phalarope population abundance by 2040. This management objective recognizes that the Red-necked Phalarope population is likely large enough to maintain a breeding population (approximately 2.35 million in Canada), and that the Red-necked Phalarope has been listed as Special Concern due to declines at migratory stopovers in the past 40 years, not concern over current population sizes. Trends will be measured based on population monitoring at the migratory stopovers. A ten-year timeframe was selected for this species because breeding success and thus population size may be cyclic, in part because predators switch between preying on lemmings and shorebird nests, based on lemming population dynamics (Blomqvist *et al.* 2002). A longer timeframe will prevent possible cyclic population dynamics from influencing the trends. This management objective addresses the species' decline which was the reason for its designation as Special Concern (COSEWIC 2014) and should be achievable by conserving habitat across the full annual cycle and managing the risk of oil spill contamination. However, if the population declines are due to or exacerbated by climate change related threats, this management objective may be difficult to achieve, even if the suite of conservation measures described below are implemented.

6. Broad strategies and conservation measures

6.1. Actions already completed or currently underway

- Breeding Red-necked Phalarope are monitored through the Arctic Program for Regional and International Shorebird Monitoring (PRISM). However, the breeding range extends south of the range covered by PRISM so this monitoring program will underestimate population size for this species. Regardless, these are some of the best estimates currently available and can be used to monitor trends.
- Since 2005 in the Atlantic and 1996 in the Pacific, Seabirds at Sea surveys have monitored offshore seabirds from boats. In the Atlantic, historical data is available from the Programme intégré de recherches sur les oiseaux pélagiques (PIROP) which ran from 1966 to 1992, while in the Pacific, the Pelagic Seabird Survey Database compiles long-term opportunistic data from 1982 to 2010.
- The International Shorebird Survey and the Atlantic Canada Shorebird Survey both monitor a portion of the migratory population and have been used to assess population trends, but since these surveys are conducted from shore, they likely miss large portions of the offshore populations.
- Many of the migratory stopover sites where the Red-necked Phalarope congregates to refuel have been designated as Sites of Regional or Hemispheric Importance by the Western Hemisphere Shorebird Reserve Network (WHSRN). Some of these sites conduct regular site specific monitoring of the Red-necked Phalarope and other shorebirds.
- The Red-necked Phalarope is one of five priority species in the Americas Flyway listed under Arctic Migratory Birds Initiative (CAFF 2019).
- The Multi-species Action Plan for Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve, and Haida Heritage Site (PCA 2016) recognizes a need for oil spill preparedness planning in the park, which would benefit the Red-necked Phalarope and other coastal and marine species in the park.
- In 1994, the California State Water Resources Control Board required Los Angeles to restore water flow into Mono Lake. Restoring the flow has allowed water levels to rise at Mono Lake. This work has set a legal precedent for limiting water rights in favor of "public trust values" such as wildlife populations.

- In 2018, Canada signed onto the international Ocean Plastics Charter and invested in a marine litter mitigation fund to reduce plastic pollution in the ocean.
- The United Nations Development Programme (UNDP) and the Global Environment Facility (GEF) funded the GEF-UNDP-Humboldt Project from 2010 to 2016. This project assisted the Chilean and Peruvian governments as they developed an ecosystem-based management approach for the area.
- In 2016, GEF and UNDP funded a complementary project in the Humboldt Current Large Marine Ecosystem to extend the previous conservation work. Of particular relevance to the Red-necked Phalarope, the new priority list includes monitoring for contaminants in the region.
- Peru established the Guano Islands, Islets, and Capes National Reserve System in 2009. This reserve conserves ~84,500 hectares of marine habitat in the Humboldt Current and ~3,000 hectares of Peruvian coastline.
- Juan Fernández Multiple Use Marine Protected Area (and its five associated Marine Parks) covers ~24,000 square kilometers offshore of Chile in the Humboldt Current. Chile implemented a multi-use plan for the protected area which allows for a tourism industry and sustainable lobster fisheries.
- The first international Phalarope Working Group met in June, 2019 to discuss the threats facing the Red-necked Phalarope, Red Phalarope, and Wilson's Phalarope (*Phalaropus tricolor*), and set priorities for research and conservation. The priorities identified by the group are:
    - Researching the natural history of the species
    - Determining the population size and trends by coordinating consistent survey efforts
    - Using the Motus Wildlife Tracking System[10] telemetry network to track migrating phalaropes and determine turnover rates to better estimate population size; using this network will likely require putting up additional antennae in the western U.S.
- A five-year survey of phalarope at Mono Lake, California began in 2019. This set of surveys builds on those previously conducted in the area, though early surveys used different methodology. Current survey design has been improved.

6.2. Broad strategies

The broad strategies to achieve the management objectives for the Red-necked Phalarope are as follows:

- Population Monitoring
- Habitat Conservation
- Public Engagement
- Contaminant Prevention
- Threat Research

[10] The Motus Wildlife Tracking System is an international collaborative research network that uses a coordinated automated radio telemetry array to track the movement and behavior of birds and other flying animals.

6.3. Conservation measures

Table 3. Conservation measures and implementation schedule. Threat numbers correspond to the threat number in Table 2.

Conservation measure	Priority[e]	Threats or concerns addressed	Timeline
Broad strategy: population monitoring			
Centralize data from past site surveys in a shared database.	High	All	2022-2027
Coordinate data collection from ongoing surveys at migratory stopovers and on the breeding range to enable comparison and calculation of North America wide estimates where possible.	High	All	2022-2027
Track the North American migration routes and determine the turnover and residency times at migratory stopover sites.	High	All	2022-2032
Calculate new population estimates and trends.	High	All	2027-2032
Broad strategy: public engagement			
Engage and educate the public about the species and the threats it faces. Encourage actions that may help mitigate the effects of these threats.	Low	All	Ongoing
Encourage the public to report sightings and promote participation in citizen-science programs (e.g., eBird, Beach Watch).	Low	All	Ongoing
Broad strategy: habitat conservation			
Conserve water and manage watersheds surrounding migratory stopover sites to maintain appropriate water levels in saline lakes.	Medium	Threats 7.2 and 11.2	Ongoing
Identify and conserve habitat on both breeding grounds and migration routes that models indicate is currently suitable habitat and will remain suitable as the effects of climate change progress (i.e., climate resilient habitat).	High	Threats 11.1, 11.2, 11.3, and 11.4	2027-2032
Work with international partners to support seabird conservation within the Humboldt Current Large Marine Ecosystem.	Medium	Threats 9.2 and 9.4	2027-2032

Broad strategy: contaminant prevention			
Incorporate information about the Red-necked Phalarope's migratory and wintering ranges into environmental assessments for any projects that increase the risk of either chronic or catastrophic oil spills in key areas for the species.	High	Threat 9.2	Ongoing
Ensure that there are oil spill response plans in place, which consider offshore seabirds and habitat used by the Red-necked Phalarope.	High	Threat 9.2	Ongoing
Encourage measures to prevent plastic ingestion by Red-necked Phalarope	Medium	Threat 9.4	Ongoing
Broad strategy: threat research			
Determine where Red-necked Phalarope ingest most plastics and how much they are ingesting.	Medium	Threat 9.4	2027-2032
Investigate changes in the abundance of zooplankton and other food sources at key migratory stopovers (e.g., Bay of Fundy) and wintering grounds.	Medium	Threat 11.3	2022-2027

[e] "Priority" reflects the degree to which the measure contributes directly to the conservation of the species or is an essential precursor to a measure that contributes to the conservation of the species. High priority measures are considered those most likely to have an immediate and/or direct influence on attaining the management objective for the species. Medium priority measures may have a less immediate or less direct influence on reaching the management objective, but are still important for the management of the population. Low priority conservation measures will likely have an indirect or gradual influence on reaching the management objective, but are considered important contributions to the knowledge base and/or public involvement and acceptance of the species.

6.4. Narrative to support conservation measures and implementation schedule

The conservation measures for the Red-necked Phalarope were developed to address threats facing this species across its range. The conservation measures focus on addressing the most pressing threats and gathering information necessary to address any remaining threats in the future.

To date, there is great uncertainty surrounding the exact size of the North American Red-necked Phalarope population. Without accurate, multi-year population estimates, it is difficult to say with any confidence how much the population has declined. It is possible (although unlikely) that the Red-necked Phalarope population has not in fact declined but that its distribution or migratory routes have shifted. To that end, the first priority must be to determine overall size and short-term population trends through population monitoring.

To calculate a more accurate population estimate, there are multiple components of monitoring the migratory Red-necked Phalarope population that should be improved. Because many sites have already conducted some monitoring, the Phalarope Working Group proposed managing a shared database to centralize all data from past and future surveys. Integrating this data with information from offshore seabird surveys like Seabirds at Sea and the Pelagic Seabird Survey Database may improve estimates of the offshore migrants. To facilitate calculating a new North American Red-necked Phalarope population estimate, surveys on migration at disparate sites should, whenever possible, be conducted concurrently and use similar protocols as proposed by the Phalarope Working Group. It may also be beneficial to conduct surveys at additional migratory stopovers to improve coverage. These estimates may be used as a cost effective way to measure population trends. To calculate a population estimate, managers will need to know the turnover and residency times at the migratory stopovers. Recent work using geolocations has provided some estimates for birds migrating along the Atlantic coast (Smith *et al.* 2014, van Bemmelan *et al.* 2019). However, given the low recapture rates of geo-tagged Red-necked Phalarope, tracking using Motus may be more feasible, particularly for the inland migrants. However, using Motus will require additional Motus antennae to fill in gaps in the Motus Network surrounding the inland migratory stopovers. The Phalarope Working Group has proposed building Motus towers at Mono Lake and Great Salt Lake, California. Finally, on the breeding ground, improving monitoring in under surveyed areas will allow for an undated distribution map and population estimates. A clear, accurate map of the overall distribution is necessary to rule out the possibility that migratory routes or distribution have shifted. Integrating monitoring data on the breeding grounds and migratory stopovers may be the most effective way to calculate reliable population estimates.

Climate change may ultimately have the largest impact on the Red-necked Phalarope's population trajectory due in large part to changes on the Red-necked Phalarope's arctic breeding grounds. Current projections estimate that the species will to lose 90% of its current breeding range by 2070 as the climate becomes unsuitable (Wauchope *et al.* 2017) and lose 42% of its breeding range with a 3°C temperature increase (Bateman *et al.* 2019). Following a 3°C increase, 11% of the breeding range may be gained as climatically suitable habitat shifts north (Bateman *et al.* 2019). It will be crucial to conserve habitat on both the breeding grounds and migration routes that climate change projection models indicate will remain suitable habitat into the future (i.e., climate resilient habitat).

If water levels drop excessively, saline lakes may become too salty to support the invertebrate prey the Red-necked Phalarope rely on during migration. Although watershed managers cannot prevent droughts, limiting the amount of water diverted for human use will maintain the lakes' water levels and keep habitat in the saline lakes suitable for phalarope. Supporting water conservation and conservative water management in these watersheds will be crucial to preserving these important stopover sites.

Red-necked Phalarope commonly ingest plastic particles which appear to reduce body condition and overall health. Because the Red-necked Phalarope spends most of the year foraging on surface zooplankton offshore, it likely ingests more small plastic particles than other shorebirds. More research is needed to determine both how much plastic phalarope are ingesting, and where phalarope are ingesting most of the plastic (i.e., wintering, breeding, or migration grounds). When available information allows, targeted activities aimed at preventing Red-necked Phalarope from ingesting plastics should be encouraged. However, activities aimed at reducing plastic pollution broadly would benefit many species in the short term, including Red-necked Phalarope and other aquatic birds.

More research is also needed to assess whether the Red-necked Phalarope still has adequate food available at migratory stopovers and on the wintering grounds. Climate change may be causing zooplankton blooms to happen at a different time or location, leaving the Red-necked Phalarope without a ready food source, but to date there is little evidence to suggest whether or not this is occurring.

Because the Red-necked Phalarope spends so much of their life at sea, both chronic and catastrophic oil spills pose a risk to the population. To mitigate this risk, the Red-necked Phalarope's migratory and wintering ranges should be incorporated into environmental assessments of projects that may increase this risk. Additionally, in areas where chronic or catastrophic oil spills are likely, there should be an oil spill response plan in place which considers offshore seabirds like this species.

Most Red-necked Phalarope nesting in Canada congregate in the Humboldt Current during the winter, which means that any threats to this region could be devastating to the population. Therefore, it will be important to encourage seabird conservation within the Humboldt Current Large Marine Ecosystem by working with international partners. In particular, Peru and Chile have both created large marine protected areas in this region. Conserving the population on the wintering grounds will require implementing an oil spill response plan, as an oil spill in the region at the wrong time would devastate the entire population and current oil spill planning is inadequate at best.

Finally, public engagement can be an important aspect of any management plan. The public can be engaged through education about the Red-necked Phalarope. This should include spreading awareness of the threats facing the species, such as climate change, and encouraging public efforts to address them. Members of the public may report sightings of nesting or migrating Red-necked Phalarope through citizen science programs such as eBird. In coastal areas, the public may participate in citizen science beach watch programs and monitor for Red-necked Phalarope and other seabirds that wash ashore dead or oiled. These programs help assess the effects of plastic and oil pollution.

7. Measuring progress

The performance indicators presented below provide a way to measure progress towards achieving the management objectives and monitoring the implementation of the management plan.

- By 2030, an accurate North American population size estimate is available.
- By 2030, a North America-wide trend estimate is available. This trend estimate should be robust enough to detect a 30% decline over a 10-year period.
- By 2040, the population trend of the Red-necked Phalarope is stable or positive as measured by population monitoring at migratory stopovers over a 10-year period.

8. References

Abraham, K.F., R.L. Jefferies, and R.T. Alisauskas. 2005. The dynamics of landscape change and snow geese in mid-continent North America. Global Climate Change Biology 11:841-855.

AMAP. 2012. Arctic Climate Issues 2011: Changes in Arctic snow, water, ice, and permafrost. Arctic Monitoring and Assessment Programme. Oslo, Norway. xi + 98 pp.

Andersen, C.G., and V.L. Lougheed. 2015. Disappearing Arctic tundra ponds: Fine-scale analysis of surface hydrology in drained thaw lake basins over a 65 year period (1948-2013). Journal of Geophysical Research: Biogeosciences 120: 466-479.

Andres, B.A., P.A. Smith, R.I.G. Morrison, C.L. Gratto-Trevor, S.C. Brown, and C.A. Friis. 2012a. Population estimates of North American shorebirds 2012. Wader Study Group Bulletin 119:178- 94.

Andres, B.A., J.A. Johnson, S.C. Brown, and R.B. Lanctot. 2012b. Shorebirds breed in unusually high densities in the Teshekpuk Lake Special Area, Alaska. Arctic 65: 411-420.

Artuso, C. 2018. Red-necked Phalarope in C. Artuso, A.R. Couturier, K.D. De Smet, R.F. Koes, D. Lepage, J. McCracken, R.D. Mooi, and P. Taylor (eds.). The Atlas of the Breeding Birds of Manitoba, 2010-2014, Bird Studies Canada, Winnipeg, Manitoba.

Bateman, B.L., L. Taylor, C. Wilsey, J. Wu, G.S. LeBaron, and G. Langham. 2019. Risk to North American birds from climate change related threats. bioRxiv: 798694.

Ballantyne, K., and E. Nol. 2015. Localized habitat change near Churchill, Manitoba and the decline of nesting Whimbrels (*Numenius phaeopus*). Polar Biology 38: 529-537.

Bart, J., S. Brown, B. Harrington, and R.I.G. Morrison. 2007. Survey trends of North American shorebirds: population declines or shifting distributions? Journal of Avian Biology 38:73-82.

Beyersbergen, G. W. and D. C. Duncan. 2007. Shorebird Abundance and Migration Chronology at Chaplin Lake, Old Wives Lake and Reed Lake, Saskatchewan: 1993 and 1994. Canadian Wildlife Service Technical Report Series No. 484. Prairie and Northern Region. Edmonton, Alberta. 57 pp.

Blomqvist, S., N. Holmgren, S. Åkesson, A. Hedenström, and J. Pettersson. 2002. Indirect effects of lemming cycles on sandpiper dynamics: 50 years of counts from southern Sweden. Oecologia 133: 146-158.

Bulla, M., J. Reneerkens, E.L. Weiser, *et al.* 2019. Comment on “Global pattern of nest predation is disrupted by climate change in shorebirds”. Science 364: eaaw8529.

Braun, B.M. 1987. Comparison of total mercury levels in relation to diet and molt for nine species of marine birds. Environmental Contamination and Toxicology 16:217-224.

BirdLife International. 2018. *Phalaropus lobatus*. The IUCN Red List of Threatened Species 2018. e.T22693490A132530453.

Bourne, W.R.P., and G.C. Clarke. 1984. The occurrence of birds and garbage at the Humboldt Front off Valparaiso, Chile. Marine Pollution Bulletin 15: 143-144.

Briggs, K.T, K.F. Dettman, D.B. Lewis, and W.B. Tyler. 1984. Phalarope feeding in relation to autumn upwelling off California. Marine Birds 1984: 51-62.

Brown, R.G.B., and D.E. Gaskin. 1988. The pelagic ecology of the Grey and Red-necked Phalarope *Phalaropus fulicarius and P. lobatus* in the Bay of Fundy, eastern Canada. Ibis 130: 234-250.

CAFF. 2019. Arctic Migratory Birds Initiative (AMBI): Workplan 2019-2023. CAFF Strategies Series No. 30. Conservation of Arctic Flora and Fauna, Akureyri, Iceland. 56 pp.

Di Corrado, C. 2015. Red-necked Phalarope in Davidson, P.J.A., R.J. Cannings, A.R. Couturier, D. Lepage, and C.M. Di Corrado (eds.). The Atlas of the Breeding Birds of British Columbia, 2008-2012. Bird Studies Canada. Delta, B.C.

Colwell, M.A., J.D. Reynolds, C.L. Gratto, D. Schamel, and D. Tracy. 1988. Phalarope philopatry. Proceedings of the International Ornithological Congress 19: 585-593.

Connors, P.G., and K.G. Smith. 1982. Oceanic plastic particle pollution: Suspected effect on fat deposition in Red Phalarope. Marine Pollution Bulletin 13: 18-20.

Cooch, E.G., R.L. Jefferies, R.F. Rockwell, and F. Cooke. 1993. Environmental change and the cost of philopatry: an example in the lesser snow goose. Oecologia 93: 128-138.

Cooley, D., C.D. Eckert, and R.R. Gordon. 2012. Herschel Island – Qikiqtaruk inventory, monitoring and research program: Key findings and recommendations. Yukon Parks, Department of Environment, Whitehorse, Canada. 49 pp.

COSEWIC. 2014. COSEWIC assessment and status report on the Red-necked Phalarope *Phalaropus lobatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 52 pp.

Day, R.H., and S.M. Murphy. 1997a. Effects of the Exxon Valdez oil spill on habitat use by birds along the Kenai Peninsula, Alaska. Condor 99: 728-742.

Day, R.H., S.M. Murphy, J.A. Wiens, G.D. Hayward, E.J. Harner, and L.N. Smith. 1997b. Effects of the Exxon Valdex oil spill on habitat use by birds in Prince William Sound, Alaska. Ecological Applications 7: 593-613.

Drever, M.C., J.F. Provencher, P.D. O'Hara, L. Wilson, V. Bowes, and C.M. Bergman. 2018. Are ocean conditions and plastic debris resulting in a "double whammy" for marine birds? Marine Pollution Bulletin 133: 684-692.

Duncan, C.D. 1995. The migration of Red-necked Phalarope: ecological mysteries and conservation concerns. Birding 34:122-132.

Elmendorf, S.C., G.H.R. Henry, R.D. Hollister, *et al.* 2012. Plot-scale evidence of tundra vegetation change and links to recent summer warming. Nature Climate Change 2: 453-457.

Ely, C.R., B.J. McCaffery, and R.E. Gill, Jr. 2018. Shorebirds adjust spring arrival schedules with variable environmental conditions: Four decades of assessment on the Yukon-Kuskokwim Delta, Alaska. Pp. 296-211 in W.D. Shuford, R.E. Gill Jr., and C.M. Handel (eds.). Trends and traditions: Avifaunal change in western North America, Western Field Ornithologists, Camarillo.

English, W.B. E. Kwon, B.K. Sandercock, and D.B. Lank. 2017. Effects of predator enclosures on nest survival of Red-necked Phalarope. Wader Study 124: 00-00.

Frank, M.G., and M.R. Conover. 2019. Threatened habitat at Great Salt Lake: Importance of shallow-water and brackish habitats to Wilson's and Red-necked Phalarope. Condor 121: 1-13.

Fox, C.H., P.D. O'Hara, S. Bertazzon, K. Morgan, F.E. Underwood, and P.C. Paquet. 2016. A preliminary spatial assessment of risk: Marine birds and chronic oil pollution on Canada's Pacific coast. Science of the Total Environment 573: 799-809.

Fuglei, E. and R.A. Ims. 2008. Global warming and effects on the arctic fox. 2008. Science Progress 91: 175-191.

Gauthier, G. J. Bêty, M.-C. Cadieux, P. Legagneux, M. Doiron, C. Chevallier, S. Lai, A. Tarroux, and D. Berteaux. 2013. Long-term monitoring at multiple trophic levels suggests heterogeneity in responses to climate change in the Canadian Arctic tundra. Philosophical Transactions of the Royal Society B 368: 20120482.

Gilg, O., B. Sittler, and I. Hanski. 2009. Climate change and cyclic predator-prey population dynamics in the high Arctic. Global Change Biology 15: 2634-2652.

Gratto-Trevor, C.L. 1996. Use of landstat TM Imagery in determining important shorebird habitat in the outer Mackensie Delta, Northwest Territories. Arctic 49: 11-22.

Gratto-Trevor, C.L., G. Beyersbergen, H.L. Dickson, P. Erickson, R. MacFarlane, M. Raillard, and T. Sadler. 2001. Prairie Canada shorebird conservation plan. Prairie Habitat Joint Venture Partners, Edmonton, Alberta.

Haney, J.C. 1985. Wintering phalarope off the southeastern United States: Application of remote sensing imagery to seabird habitat anaylsis at oceanic fronts. Journal of Field Ornithology 56: 321-333.

Haney, J.C. 1986. Shorebird patchiness in tropical oceanic waters: The influence of Sargassum reefs. Auk 103:141-151.

Henkel, L.A., H. Nevins, M. Martin, S. Sugarman, J.T. Harvey, and M.H. Ziccardi. 2014. Chronic oiling of marine birds in California by natural petroleum seeps, shipwrecks, and other sources. Marine Pollution Bulletin 79: 155-163.

Hildén, O. and S. Vuolanto. 1972. Breeding biology of the Red-necked Phalarope *Phalaropus lobatus* in Finland. Ornis Fennica 49:57-85.

Hunnewell, R.W., A.W. Diamond, and S.C. Brown. 2016. Estimating the migratory stopover abundance of phalarope in the outer Bay of Fundy, Canada. Avian Conservation and Ecology 11:11.

Jehl, Jr., J.R. 1986. Biology of Red-necked Phalarope (*Phalaropus lobatus*) at the western edge of the Great Basin in fall migration. Great Basin Naturalist 46: 185-197.

Jehl, Jr., J.R., and W. Lin. 2001. Population status of shorebirds nesting at Churchill, Manitoba. The Canadian Field-Naturalist 115: 487-494.

Jenssen, B.M. 1994. Review Article – Effects of oil pollution, chemically treated oil and cleaning on the thermal balance of birds. Environmental Pollution 86: 207-215.

Jones, B.M., C.D. Arp, M.T. Jorgenson, K.M. Hinkel, J.A. Schmutz, and P.L. Flint. 2009. Increase in the rate and uniformity of coastline erosion in Arctic Alaska. Geophysical Research Letters 36: L03503.

Kubelka, V., M. Ŝálek, P. Tomkovich, Z. Végvári, R.P. Freckleton, and T. Székely. 2018. Global pattern of nest predation is disrupted by climate change in shorebirds. Science 362: 680-683.

Kubelka, V., M. Ŝálek, P. Tomkovich, Z. Végvári, R.P. Freckleton, and T. Székely. 2019. Response to Comment on “Global pattern of nest predation is disrupted by climate change in shorebirds”. 2019. Science 364: eaaw9893.

Kwon, E., W.B. English, E.L. Weiser, S.E. Franks, D.J. Hodkinson, D.B. Lank, and B.K. Sandercock. 2018. Delayed egg-laying and shortened incubation duration of Arctic-breeding shorebirds coincide with climate cooling. Ecology and Evolution 8: 1339-1351.

Larson, R., J. Eilers, K. Kreuz, W.T. Pecher, S. DasSarma, and S. Dougill. 2016. Recent desiccation-related ecosystem changes at Lake Albert, Oregon: A terminal alkaline salt lake. Western North American Naturalist 76: 389-404.

Liebezeit, J.R., K.E.B. Gurney, M. Budde, S. Zack, and D. Ward. 2014. Phenological advancement in arctic bird species: relative importance of snow melt and ecological factors. Polar Biology 37: 1309-1320.

Lougheed, V.L., M.G. Butler, D.C. McEwen, and J.E. Hobbie. 2011. Changes in tundra pond limnology: resampling Alaskan ponds after 40 years. AMBIO 40: 589-599.

Maher, N., D. Matel, S. Millinski, and J. Marotzke. 2018. ENSO change in climate projections: Forced response or internal variability? Geophysical Research Letters 45: 11390-11398.

McKinnon, L., D. Berteaux, and J. Bêty. 2014. Predator-mediated interactions between lemmings and shorebirds: A test of the alternative prey hypothesis. Auk 131: 619-628.

Mercier, F.M. 1985. Fat reserves and migration of Red-necked Phalarope (*Phalaropus lobatus*) in the Quoddy region, New Brunswick. Canadian Journal of Zoology 63: 2810-2816.

Mercier, F. and D.E. Gaskin. 1985. Feeding ecology of migrating Red-necked Phalarope (Phalaropus lobatus) in the Quoddy region, New Brunswick, Canada. Canadian Journal of Zoology 63: 1062-1067.

Milakovic, B., T. Carleton, and R.L. Jefferies. 2001. Changes in midge (Diptera: Chironomidae) populations of sub-arctic supratidal vernal ponds in response to goose foraging. Ecoscience 8: 58-67.

Morrison, M.Q., O. Volik, R.I. Hall, J.A. Wiklund, M.L. Macrae, and R.M. Petrone. 2019. Effects of shoreline permafrost thaw on nutrient dynamics and diatom ecology in a subarctic tundra pond. Journal of Paleolimnology 62: 151-163.

Morrison, R.I.G., B.J. McCaffery, R.E. Gill, S.K. Skagen, S.L. Jones, G.W. Page, C.L. Gratto-Trevor, and B.A. Andres. 2006. Population estimates of North American shorebirds, 2006. Wader Study Group Bulletin 111: 67-85.

Moser, M.L. and D.S. Lee. 1992. A fourteen-year survey of plastic ingestion by western North Atlantic seabirds. Colonial Waterbirds 15: 83-94.

Moser, M.L. and D.S. Lee. 2012. Foraging over *Sargassum* by western north Atlantic seabirds. Wilson Journal of Ornithology 124: 66-72.

Mu, T., P.S. Tomkovich, E.Y. Loktionov, E.E. Syreochkovskiy, and D.S. Wilcove. 2018. Migratory routes of red-necked phalarope *Phalaropus lobatus* breeding in southern Chukotka revealed by geolocators. Journal of Avian Biology 49: e01853.

Muir, D.C.G., X. Wang, F. Yang, N. Nguyen, T.A. Jackson, M.S. Evans, M. Douglas, G. Kock, S. Lamoureux, R. Pienitz, J.P. Smol, W.F. Vincent, and A. Dastoor. 2009. Spatial trends and historical deposition of mercury in Eastern and Northern Canada inferred from lake sediment cores. Environmental Science and Technology 43: 4802-4809.

NatureServe. 2020. NatureServe Explorer: An online encyclopaedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Web site: http://www.natureserve.org/explorer [Accessed November 2020].

Nisbet, I.C.T., and R.R. Veit. 2015. An explanation for the population crash of Red-necked Phalarope *Phalaropus lobatus* staging in the Bay of Fundy in the 1980s. Marine Ornithology 43: 119-121.

Nol, E. and B. Beveridge. 2007. Red-necked Phalarope, pp. 254-255 in Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier, eds. Atlas of the Breeding Birds of Ontario, 2001-2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature,Toronto, xxii + 706 pp.

Obst, B.S., W.M. Hamner, P.P. Hamner, E. Wolanski, M. Rubega, and B. Littlehales. 1996. Kinematics of phalarope spinning. Nature 384: 121-121.

Page, G.W., L.E. Stenzel, and J.E. Kjelmyr. 1999. Overview of shorebird abundance and distribution in wetlands of the Pacific Coast of the contiguous United States. Condor 101: 461-471.

Parks Canada Agency. 2016. Multi-species Action Plan for Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve, and Haida Heritage Site. *Species at Risk Act* Action Plan Series. Parks Canada Agency, Ottawa. vi + 25 pp.

Perkins, M. L. Ferguson, R.B. Lanctot, I.J. Stenhouse, S. Kendall, S. Brown, H.R. Gates, J.Ok. Hall, K. Regan, and D.C. Evers. 2016. Mercury exposure and risk in breeding and staging Alaskan shorebirds. Condor 118: 571-582.

Peterson, S.L., R.F. Rockwell, C.R. Witte, and D.N. Koons. 2013. The legacy of destructive Snow Goose foraging on supratidal marsh habitat in the Hudson Bay Lowlands. Arctic, Antarctic, and Alpine Research 45: 575-583.

Reynolds, J.D. 1987. Mating system and nesting biology of the Red-necked Phalarope *Phalaropus lobatus*: what constrains polyandry? Ibis 129: 225-242.

Reynolds, J.D. and F. Cooke 1988. The influence of mating systems on philopatry: a test with polyandrous Red-necked Phalarope. Animal Behavior 1988: 1788-1795.

Rodrigues, R. 1994. Microhabitat variables influencing nest-site selection by tundra birds. Ecological Applications 4: 110-116.

Roletto, J., J. Mortenson, I. Harrald, J. Hall, and L. Grella. 2003. Beached bird surveys and chronic oil pollution in central California. Marine Ornithology 31: 21-28.

Rubega, M.A., and C. Inouye. 1994. Prey switching in Red-necked Phalarope *Phalaropus lobatus*: Feeding limitations, the functional response and water management at Mono Lake, California, USA. Behavioral Conservation 70: 205-210.

Rubega , M.A., and B.S. Obst. 1993. Surface-tension feeding in phalarope: Discovery of a novel feeding mechanism. Auk 110: 169-178.

Rubega, M.A., D. Schamel, and D. Tracy. 2000. Red-necked Phalarope (*Phalaropus lobatus*) in A. Poole (ed.). The Birds of North America Online, Cornell Lab of Ornithology, Ithaca.

Saalfeld, D.T., A.C. Matz, B.J. McCaffery, O.W. Johnson, P. Bruner, and R.B. Lanctot. 2016. Inorganic and organic contaminants in Alaskan shorebird eggs. Environmental Monitoring and Assessment 188: 276.

Saafeld, S.T., and R.B. Lanctot. 2017. Multispecies comparisons of adaptability to climate change: A role for life-history characteristics? Ecology and Evolution 7: 10492-10502.

Sandercock, B.K. 1997. The breeding biology of Red-necked Phalarope *Phalaropus lobatus* at Nome, Alaska. Wader Study Group Bulletin 85:50-54.

Sammler, J.E., D.E. Andersen, and S.K. Skagen. 2008. Population trends of tundra-nesting birds at Cape Churchill, Manitoba, in relation to increasing goose populations. Condor 110: 325-334.

Schamel, D., D.M. Tracy, and D.B. Lank. 2004a. Mate guarding, copulation strategies and paternity in the sex-role reversed, socially polyandrous Red-necked Phalarope *Phalaropus lobatus*. Behavioral Ecology and Sociobiology 57: 110-118.

Schamel, D., D.M. Tracy, and D.B. Lank. 2004b. Male mate choice, male availability and egg production as limitation on polyandry in the Red-necked Phalarope. Animal Behavior 67: 847-853.

Smith, M., M. Bolton, D.J. Okill, R.W. Summers, P. Ellis, F. Liecht, and J.D. Wilson. 2014. Geolocator tagging reveals Pacific migration of Red-necked Phalarope *Phalaropus lobatus* breeding in Scotland. Ibis 156: 870-973.

Taylor, D.J., M.J. Ballinger, A.S. Medeiros, and A.A. Kotov. 2016. Climate-associated tundra thaw pond formation and range expansion of boreal zooplankton predators. Ecography 39: 43-53.

Tulp, I., and H. Schekkerman. 2008. Has prey availability for arctic birds advanced with climate change? Hindcasting the abundance of tundra arthropods using weather and seasonal variation. Arctic 61: 48-60

United Nations Environmental Programme (UNEP). 2006. Permanent Commission for the South Pacific (CPPS). Humboldt Current, Global International Waters Assessment Regional Assessment 64. University of Kalmar, Kalmar, Sweden.

van Bemmelen, R.S.A., Y. Kolbeinsson, R. Ramos, O. Gilg, J.A. Alves, M. Smith, H. Schekkerman, A. Lehikoinen, I.K. Peterson, B. Þórisson, A.A. Sokolov, K. Välimäki, T. van der Meer, J.D. Okill, M. Bolton, B. Moe, S.A. Hanssen, L. Bollache, A. Petersen, S. Thorstensen, J. González-Solís, R.H.G. Klaassen, and I. Tulp. 2019. A migratory divide among Red-necked Phalarope in the western Paleartic reveals contrasting migration and wintering movement strategies. Frontiers in Ecology and Evolution 7: 86.

Virkkala, R., R.K. Heikkinen, N. Leikola, and M. Luoto. 2008. Projected large-scale range reductions of northern-boreal land bird species due to climate change. Biological Conservation 141: 1343-1353.

Walpole, B., E. Nol, and V. Johnston. 2008a. Pond characteristics and occupancy by Red-Necked Phalarope in the Mackenzie Delta, Northwest Territories, Canada. Arctic 61: 426-432.

Walpole, B., E. Nol, and V. Johnston. 2008b. Breeding habitat preference and nest success of Red-necked Phalarope on Niglintgak Island, Northwest Territories. Canadian Journal of Zoology 86:1346-1357.

Wauchope, H.S., J.D. Shaw, Ø. Varpe, E.G. Lappo, D. Boertmann, R.B. Lanctot, and R.A. Fuller. 2017. Rapid climate-driven loss of breeding habitat for Arctic migratory birds. Global Change Biology 23: 1085-1094.

Weiser, E.L., S.C. Brown, R.B. Lanctot, *et al.* 2018. Effects of environmental conditions on reproductive effort and nest success of Arctic-breeding shorebirds. Ibis 160: 608-623.

Whitfield, D.P. 1990. Male choice and sperm competition as constraints on polyandry in the Red-necked Phalarope *Phalaropus lobatus*. Behavioral Ecology and Sociobiology 7: 247-254.

Wong, S.N.P, R.A. Ronconi, and C. Gjerdrum. 2018. Autumn at-sea distribution and abundance of phalarope *Phalaropus* and other seabirds in the lower Bay of Fundy, Canada. Marine Ornithology 46: 1-10.

9. Appendix A: Effects on the environment and other species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*[11]. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the Federal Sustainable Development Strategy's[12] (FSDS) goals and targets.

Conservation planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that implementation of management plans may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the management plan itself, but are also summarized below in this statement.

Activities that benefit the Red-necked Phalarope are likely to benefit other phalarope, migratory shorebirds, and seabirds. The Red Phalarope and the Wilson's Phalarope (*Phalaropus tricolor*) both use the same migratory stopovers as the Red-necked Phalarope, so conservation measures aimed at conserving water levels and researching food availability will likely benefit these species as well.

[11] www.canada.ca/en/environmental-assessment-agency/programs/strategic-environmental-assessment/cabinet-directive-environmental-assessment-policy-plan-program-proposals.html
[12] www.fsds-sfdd.ca/index.html#/en/goals/

10. Appendix B: Breeding Bird Atlas maps for the Red-necked Phalarope

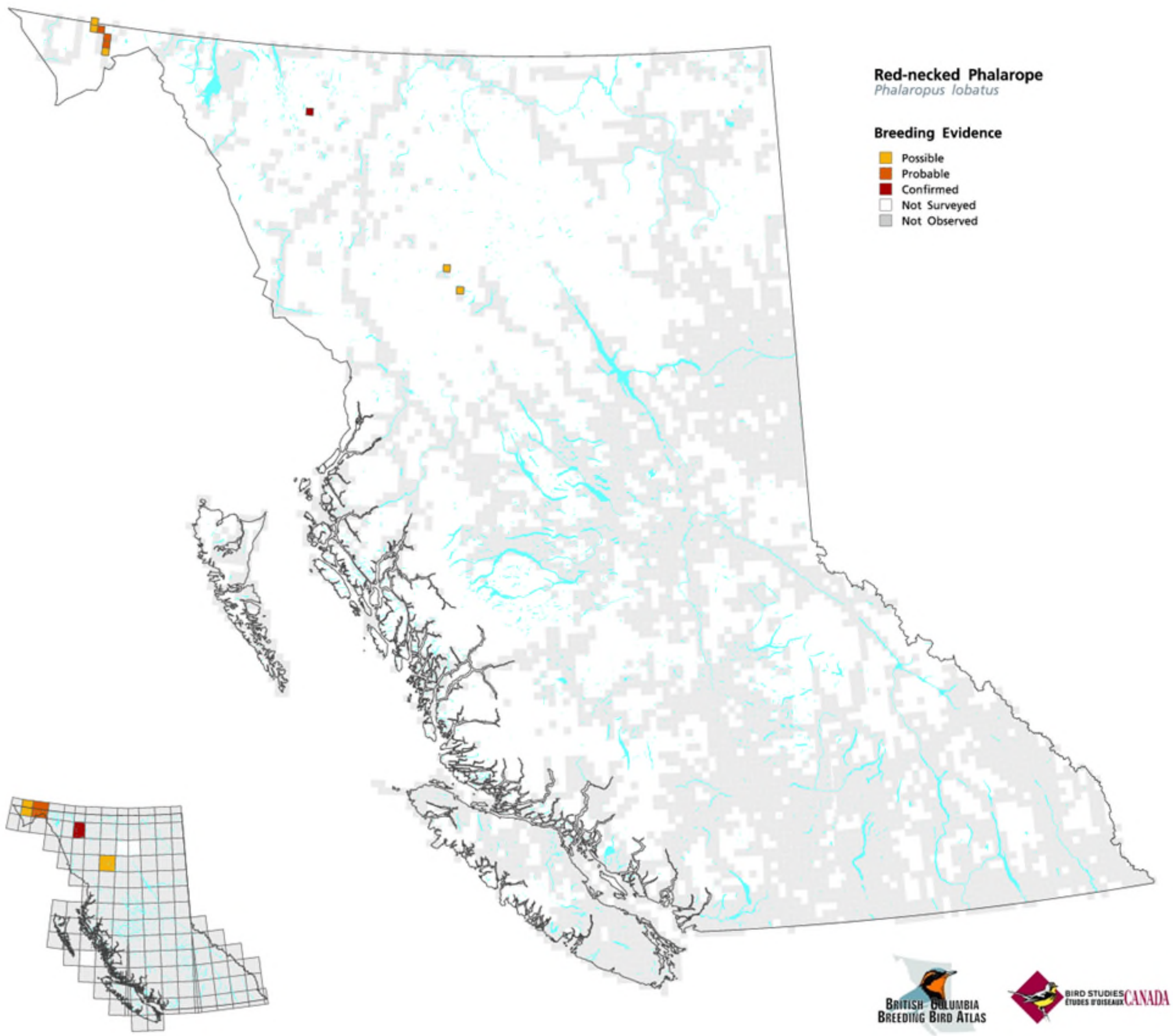
The Breeding Bird Atlases from British Columbia, Manitoba, Ontario, and Quebec all provide detailed maps of the breeding distribution of the Red-necked Phalarope. There is only a single possible occurrence of breeding Red-necked Phalarope in the Saskatchewan Breeding Bird Atlas. The Alberta Breeding Bird Atlas notes that while the Red-necked Phalarope is known to breed in the northern part of the province in the boreal forest natural region, it is rare and all observations noted during Atlas 2 were migrant so this map has not been included.

In British Colombia, observations were primarily in the Tatshenshini Basin, in the northwestern corner of the province, with some confirmed breeding farther east, currently representing the southernmost breeding record in the province (Di Corrado 2015). In the province, the Red-necked Phalarope nests in wet, subalpine sedge and willow near small ponds, but there is still limited survey coverage of such habitat (Di Corrado 2015).

In Manitoba, the 2010-2014 Breeding Bird Atlas expanded the known breeding range of the Red-necked Phalarope, which now includes some records well south of the treeline (Artuso 2018). In Manitoba, the species is usually nestling in fens, peat bogs, and sedge meadows near small waterbodies. The species will nest near willow and shrubs, but seems to avoid areas with tall, dense shrubs (Artuso 2018).

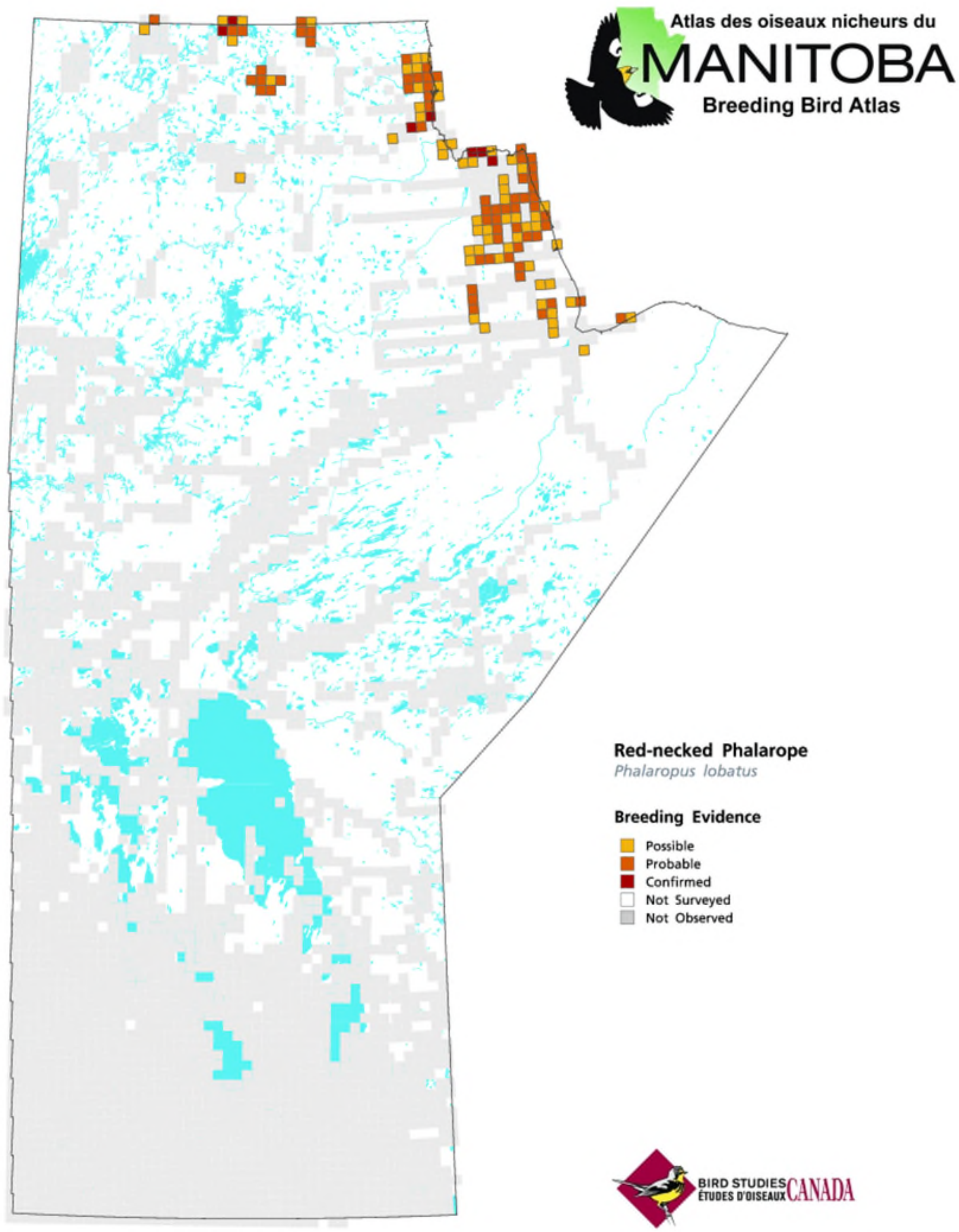
In Ontario, the Red-necked Phalarope was observed in the northern most plots surveyed. Confirmed breeding is primarily in graminoid and sedge-dominated wetlands and at the edge of shallow ponds (Nol and Beveridge 2007).There was one confirmed observation in quaking peat mat in poorly-surveyed boreal forest-tundra mosaic, suggesting that greater survey effort may reveal a larger breeding range in Ontario (Nol and Beveridge 2007).

In Quebec, the second breeding bird atlas has extended the known breeding range from Northern Quebec to south of the border with Labrador . In Quebec, the species commonly nests in boreal and tundra environments where there are ponds and peatlands surrounded by graminoid vegetation (Michel Robert, pers. comm.).



1266

1267 **Figure B1:** Red-necked Phalarope breeding distribution in British Colombia from the Atlas of the
1268 Breeding Birds of British Columbia, 2008-2012 (Source: Di Corrado 2015)



1269

1270 **Figure B2:** Red-necked Phalarope breeding distribution in Manitoba from the Atlas of the Breeding Birds
1271 of Manitoba, 2010-2014 (Source: Artuso 2018)
1272

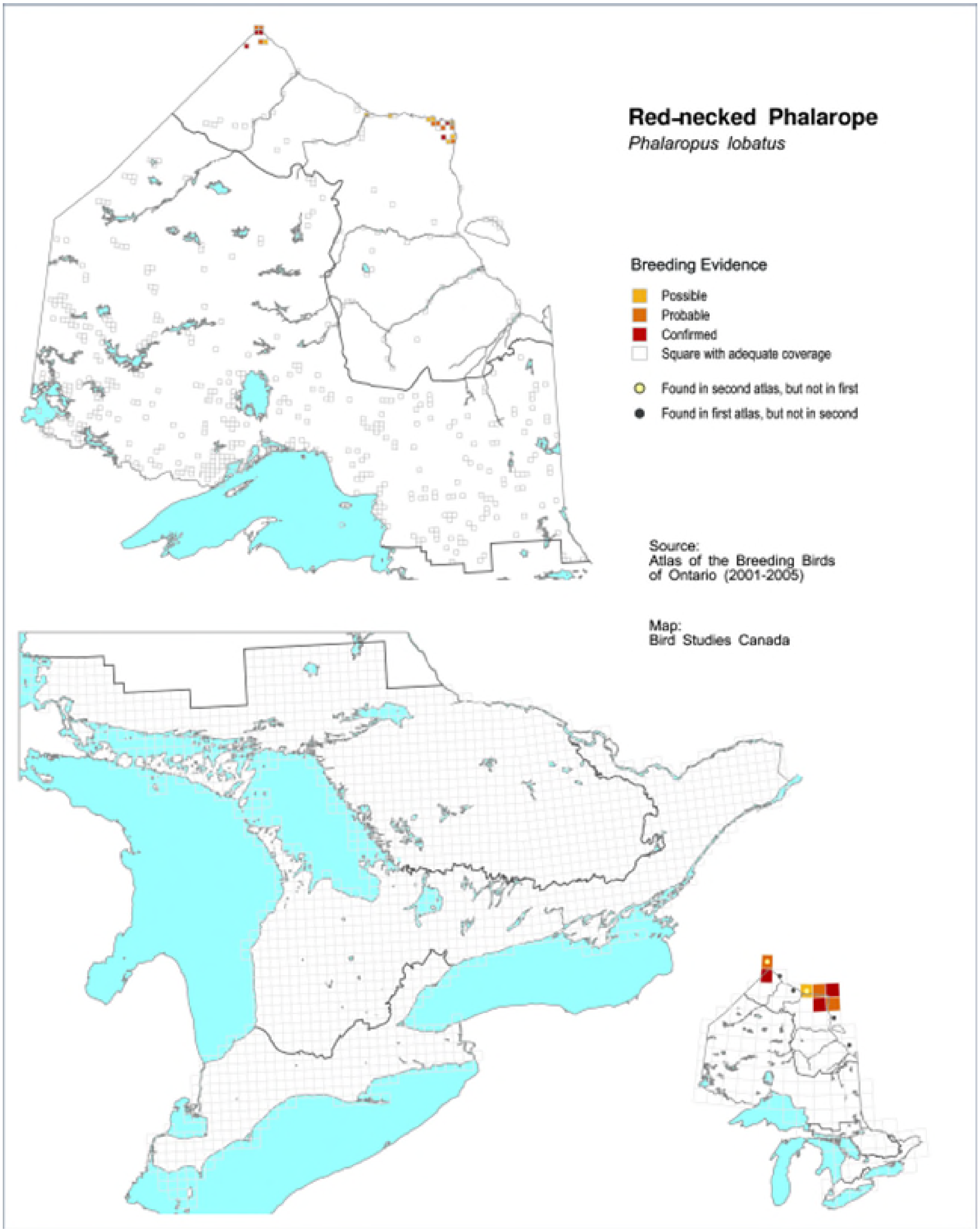


Figure B3: Red-necked Phalarope breeding distribution in Ontario from the Atlas of the Breeding Birds of Ontario, 2001-2005. (Source: Nol and Beveridge 2007)

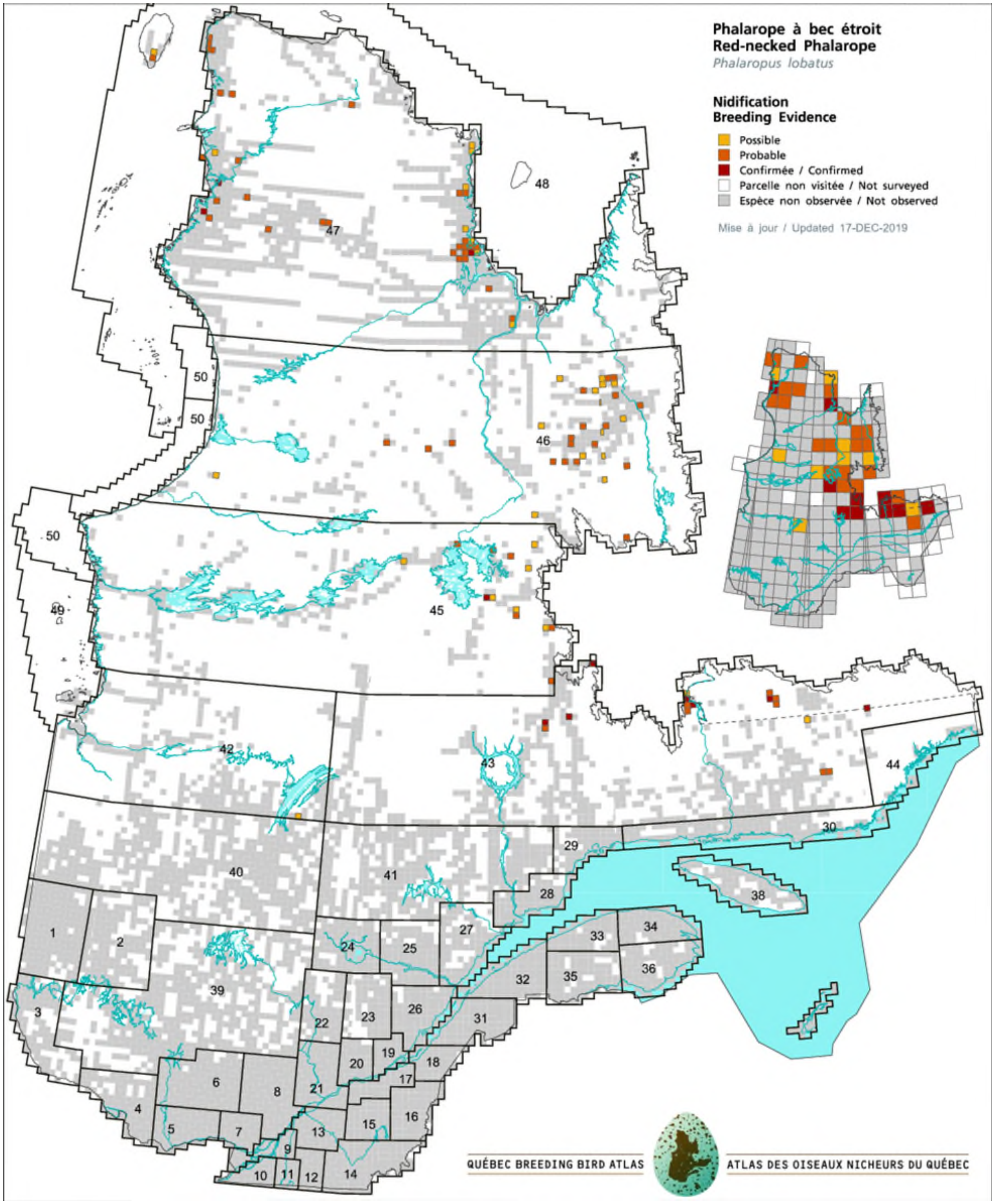


Figure B4: Red-necked Phalarope breeding distribution in Quebec from the Atlas of the Breeding Birds of Quebec, 2010-2019 (Source: https://www.atlas-oiseaux.qc.ca/donneesqc/cartes.jsp?lang=en)

11. Appendix C: Arctic PRISM distribution map for the Red-necked Phalarope

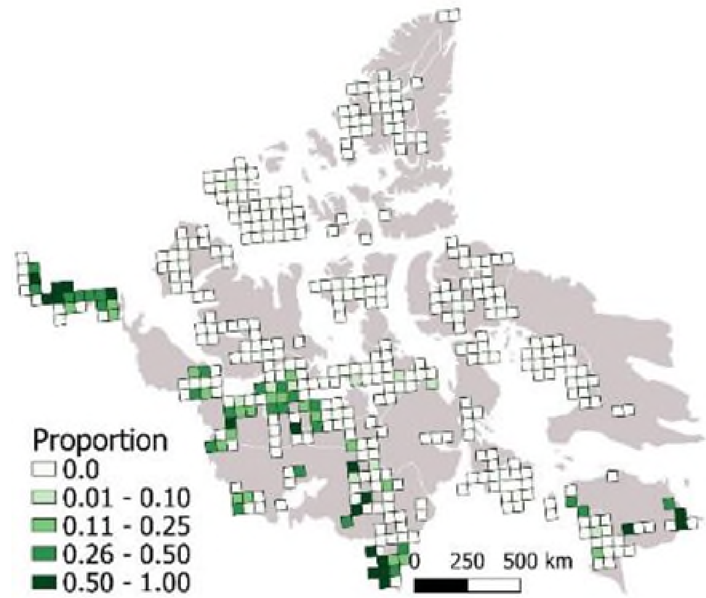


Figure C1: Proportion of 25 x 25 km blocks in which the species was recorded during the Arctic PRISM (Paul Allen Smith and Jennie Rausch, pers. comm.).