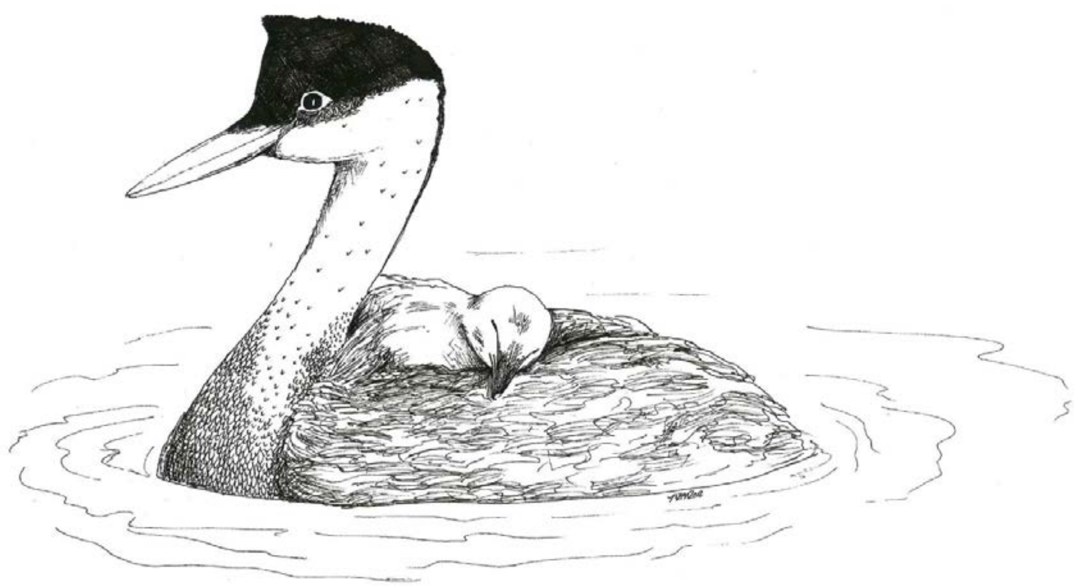
COSEWIC
Assessment and Status Report

on the

Western Grebe
Aechmophorus occidentalis

in Canada



SPECIAL CONCERN
2014

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

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Western Grebe — Photo by Naomi Man in 't Veld.

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COSEWIC
Assessment Summary

Assessment Summary – May 2014

Common name
Western Grebe

Scientific name
Aechmophorus occidentalis

Status
Special Concern

Reason for designation
Although population declines have occurred within this waterbird's Canadian wintering area on the Pacific coast, this could largely be the result of a southern shift in wintering distribution rather than a true loss in population size. Nevertheless, on a continental scale, wintering populations have undergone a 44% decline from 1995 to 2010 based on Christmas Bird Count data. Some of this decline may also be the result of declines on the Canadian breeding grounds. In addition, this species' propensity to congregate in large groups, both in breeding colonies and on its wintering areas, makes its population susceptible to a variety of threats, including oil spills, water level fluctuations, fisheries bycatch, and declines in prey availability.

Occurrence
British Columbia, Alberta, Saskatchewan, Manitoba

Status history
Designated Special Concern in May 2014.

COSEWIC
Executive Summary

Western Grebe
Aechmophorus occidentalis

Wildlife Species Description and Significance

The Western Grebe is a large and conspicuous waterbird. Adapted for an aquatic lifestyle, with lobed feet set well back on a streamlined body, Western Grebes are powerful swimmers but awkward on land. Their white throat, breast and belly contrast with the black and grey plumage of their crown, neck, back and wings. They have bright red eyes and a long, pointed yellowish-green bill. The Western Grebe has been suggested as a bioindicator for wetland ecosystems.

Distribution

The Western Grebe breeds in British Columbia, Alberta, Saskatchewan, Manitoba, and throughout the western United States. It is a colonial breeder, with an uneven and clustered breeding distribution. It winters mainly in coastal areas from southern Alaska to Mexico, and on inland lakes, particularly in the southern portion of its range. Large numbers formerly occurred in the Salish Sea (Strait of Georgia, Juan de Fuca Strait, and Puget Sound), but in recent years the wintering distribution has apparently shifted southward to California.

Habitat

Western Grebes nest on marshes and lakes with stands of emergent vegetation, stable water levels, extensive areas of open water, and sufficient populations of prey fish. During migration, they stop mainly on large lakes, but sometimes also use sloughs and river backwaters. On their coastal wintering grounds, they are generally found in sheltered salt or brackish water, in bays, inlets, estuaries, lagoons, and channels.

Biology

The Western Grebe is the most gregarious species of North American grebe; wintering flocks of over 10,000 individuals have been observed and nesting colonies can contain thousands of pairs. It engages in complex courtship rituals and is seasonally monogamous. Pairs build a nest together, which they defend aggressively, and they alternate incubation duties. The downy young leave the nest immediately after hatching and are then brooded on their parents' backs. Western Grebes are mainly piscivorous and both parents feed the young, until they are independent at about 8-10 weeks of age. They usually produce one clutch per year. Typical clutches contain 1-4 eggs and annual productivity ranges from 0.39 to 0.88 young per breeding adult.

Population Sizes and Trends

The Western Grebe is a challenging species to monitor, and survey efforts at breeding colonies have been intermittent, and thus it is difficult to accurately estimate breeding numbers or trends in abundance. The North American breeding population of Western Grebes is estimated to be ~100,000 mature individuals, including at least 20,500 in Canada. Colony sizes range from a few individuals to over 5000 birds. Most of the Canadian breeding population is concentrated in 12 colonies in Alberta and Manitoba, with ~25% breeding at a single colony in Manitoba.

Although the Christmas Bird Count is not a particularly robust method for surveying this species, results for the 15-year period from 1995-2010 suggest that the continental population declined by 44%, while numbers wintering in Canada have apparently declined by 87%. Reduction in the Canadian wintering population may represent a shift in geographic distribution of wintering birds rather than a true loss in the overall population size.

Threats and Limiting Factors

On breeding areas, the primary threats to Western Grebes are human disturbance of colonies (e.g., by powerboats and personal watercraft) and habitat degradation (especially destruction of emergent vegetation). Their breeding success and survival can also be negatively impacted by fluctuations in water levels during nesting, disturbance leading to predation on eggs, introduction of non-native fish, recreational and commercial fisheries, declines in prey availability (e.g., due to winterkill of fish), and chemical pollution and contaminants. On coastal wintering areas, oil spills are a major threat. Additional threats in coastal areas include low-volume chronic oil pollution, other chemical pollution and contaminants, harmful algal blooms, bycatch in gillnet fisheries, mortality in derelict fishing gear, changes in prey availability and/or abundance, and possible increases in predation by Bald Eagles.

Number of Locations

There are about 110 breeding colonies of Western Grebes in Canada, which approximates the number of locations for this species.

Protection, Status, and Ranks

Of former and current breeding colonies, 40 are on lakes adjoining or within provincially protected areas and two are in federal Migratory Bird Sanctuaries/National Wildlife Areas. Most of the land surrounding lakes with Western Grebe colonies is privately owned. Western Grebes are protected in Canada under the *Migratory Birds Convention Act*. In British Columbia, they are on the Red List, and in Alberta they are listed as Sensitive and a Species of Special Concern. In Saskatchewan and Manitoba, they are not provincially listed as species at risk. On the IUCN Red List they are ranked as Least Concern, their NatureServe status is Globally Secure, and they are ranked nationally as Secure by the National General Status Program. The Northern Prairie and Parkland Waterbird Conservation Plan lists the Western Grebe as a species of High Concern. Likewise, the species is assigned a high conservation priority in Canada's Waterbird Conservation Plan, and is ranked as high concern in the Waterbird Conservation Plan for the Northern Prairie and Parkland region.

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TECHNICAL SUMMARY

Aechmophorus occidentalis
Western Grebe Grèbe élégant
Range of occurrence in Canada: British Columbia, Alberta, Saskatchewan, Manitoba

Demographic Information

Generation time Generation time = 1/adult mortality + age of first reproduction Adult mortality unknown for Western Grebe, so 0.25 was used, based on the similar Great Crested Grebe; age of first reproduction = 1 (IUCN 2011).	5 yrs
Is there an inferred continuing decline in number of mature individuals? Breeding trends are based on declines that have been noted in Alberta. Wintering trends are based on CBC results for North America.	Breeding: Possible Wintering: Possible
Estimated percent of continuing decline in total number of mature individuals within 2 generations (10 years) Wintering trends based on analysis of Christmas Bird Count data for 2000-2010 for North America show a statistically non-significant population increase of 12% (95% CI: -15, 47). See **Fluctuations and Trends** for discussion of limitations of this data set.	Unknown
Estimated percent reduction in total number of mature individuals over the last 3 generations (15 years) Wintering trends are based on analysis of Christmas Bird Count data for 1995-2010 for North America. The Canadian count data indicate a 87% decline, but this is believed to largely reflect a geographic shift in the population. See **Fluctuations and Trends** for discussion of limitations of this data set.	Breeding: Unknown Wintering: -44% (95% CI: -64, -14)
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	~830,000 km²
Index of area of occupancy (IAO) IAO is estimated based on the number of breeding colonies, assuming that each one is contained within a single 2x2 km grid, though a few large colonies will encompass more than one grid.	~440 km^2
Is the population severely fragmented?	No
Number of locations The number of breeding colonies approximates the number of locations, as the most serious plausible threats would likely occur at the scale of a single lake, thereby affecting a single colony in most cases.	~110

Is there an observed continuing decline in extent of occurrence? The extent of occurrence (EO) in Alberta has decreased from 380,700 km^2 to 186,400 km^2 (ASRD/ACA 2013.). The EO in British Columbia likely has not changed since it decreased in the 1960s, and there are insufficient data to determine whether EO has changed in Saskatchewan or Manitoba.	Yes
Is there an inferred continuing decline in index of area of occupancy? Based on a greater number of colony extirpations than recolonizations in Alberta	Yes
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Not applicable
Is there an observed continuing decline in number of locations? Based on a greater number of colony extirpations than recolonizations in Alberta	Yes
Is there an inferred continuing decline in area and quality of habitat? Breeding habitat has likely declined in area and quality, while wintering habitat has possibly declined in quality	Yes
Are there extreme fluctuations in number of populations?	Not applicable
Are there extreme fluctuations in number of locations?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Total Canadian Breeding Population (for details, see **Population Sizes and Trends**)	20,660 – 26,596

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Analysis not done

Threats (actual or imminent, to populations or habitats)

Breeding: Human disturbance of colonies (e.g., powerboats, personal watercraft); habitat degradation (especially destruction of emergent vegetation); fluctuations in water levels; increased predation on eggs; introduction of non-native fish; recreational and commercial fisheries; declines in prey availability (e.g., due to winterkill of fish), and chemical pollution and contaminants.

Wintering: Oil spills and low-volume chronic oil pollution; other chemical pollution and contaminants; harmful algal blooms; bycatch in gillnet fisheries; mortality in derelict fishing gear; changes in prey availability and/or abundance; possibly increased predation by increasing numbers of wintering Bald Eagles.

Rescue Effect (immigration from outside Canada)

Status of outside population? In states bordering the Canadian breeding distribution, NatureServe status for Western Grebes is Vulnerable (S3) in Washington, Imperilled (S2) in Idaho, Apparently Secure (S4) in Montana, and Not Ranked in North Dakota and Minnesota. There have been regional increases in abundance of wintering Western Grebes in southern California, but the overall continental abundance appears to have declined by ~52% from 1975 to 2010.	Possibly declining

Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Possible, depending on viability of the U.S. population

Data-Sensitive Species

Is this a data-sensitive species?	No

Status History

COSEWIC: Designated Special Concern in May 2014.

Status and Reasons for Designation:

Status:	**Alpha-numeric code:**
Special Concern	Not applicable
Reasons for designation: Although population declines have occurred within this waterbird's Canadian wintering area on the Pacific coast, this could largely be the result of a southern shift in wintering distribution rather than a true loss in population size. Nevertheless, on a continental scale, wintering populations have undergone a 44% decline from 1995 to 2010 based on Christmas Bird Count data. Some of this decline may also be the result of declines on the Canadian breeding grounds. In addition, this species' propensity to congregate in large groups, both in breeding colonies and on its wintering areas, makes its population susceptible to a variety of threats, including oil spills, water level fluctuations, fisheries bycatch, and declines in prey availability.	

Applicability of Criteria

Criterion A: Not applicable. Could meet Threatened A2b because the North American wintering population is estimated to have declined by >30% over 3 generations. However, the current surveys of wintering birds are not judged to accurately reflect the status of the Canadian breeding population.
Criterion B: Not applicable. Although IAO is likely <500 km² and there is evidence of population decline, there are more than 10 locations, the population is not fragmented, and the species does not undergo any extreme fluctuations.
Criterion C: Not applicable; exceeds population thresholds.
Criterion D: Not applicable; exceeds thresholds.
Criterion E: Not calculated.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS
(2014)

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

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

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

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

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

Canada

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

COSEWIC Status Report

on the

Western Grebe
Aechmophorus occidentalis

in Canada

2014

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Order: Podicipediformes

Family: Podicipedidae

Scientific name: *Aechmophorus occidentalis* (Lawrence, 1858)

English name: Western Grebe

French name: Grèbe élégant (Grèbe de l'ouest)

The Western Grebe and the closely related Clark's Grebe (*Aechmophorus clarkii*) were originally described as separate species (*Podiceps occidentalis* and *P. clarkii*) by Lawrence (in Baird, 1858), and were subsequently assigned to the genus *Aechmophorus* (Coues 1862). However, from 1886 to 1985, they were considered colour morphs of a single species – the Western Grebe (*A. occidentalis*; American Ornithologists' Union 1985). Much of the literature prior to 1985 refers simply to Western Grebes, without specifying the colour morph, and thus may pertain to either or both of the currently recognized species. The species was subsequently split on the basis of assortative mating, ecological segregation and colour differences in hatchlings (Ratti 1979). Nuechterlein (1981b) provided evidence that assortative mating was linked to differences in advertising calls used during courtship. There are two subspecies of each species. For Western Grebe, *A. o. occidentalis* breeds in southwestern Canada, western United States and northern Baja California while the smaller *A. o. ephemeralis* is resident on the Mexican Plateau. The two subspecies of Clark's Grebe (*A. c. transitionalis* and *A. c. clarkii*) are broadly sympatric with the Western Grebe, but are rare in Canada (Storer and Nuechterlein 1992).

Morphological Description

The Western Grebe is one of the largest grebe species and, like all members of this family, is adapted for an aquatic lifestyle (Figure 1). With lobed feet and legs set well back on sleek bodies, Western Grebes are powerful foot-propelled divers but are awkward on land (Storer and Nuechterlein 1992). Sexes are similar in appearance, but males are slightly larger and heavier, with an average mass of 1429 g compared to an average of 1199 g for females. Wing length is also greater in males (average: 204 mm) than females (average: 190 mm; Storer and Nuechterlein 1992).

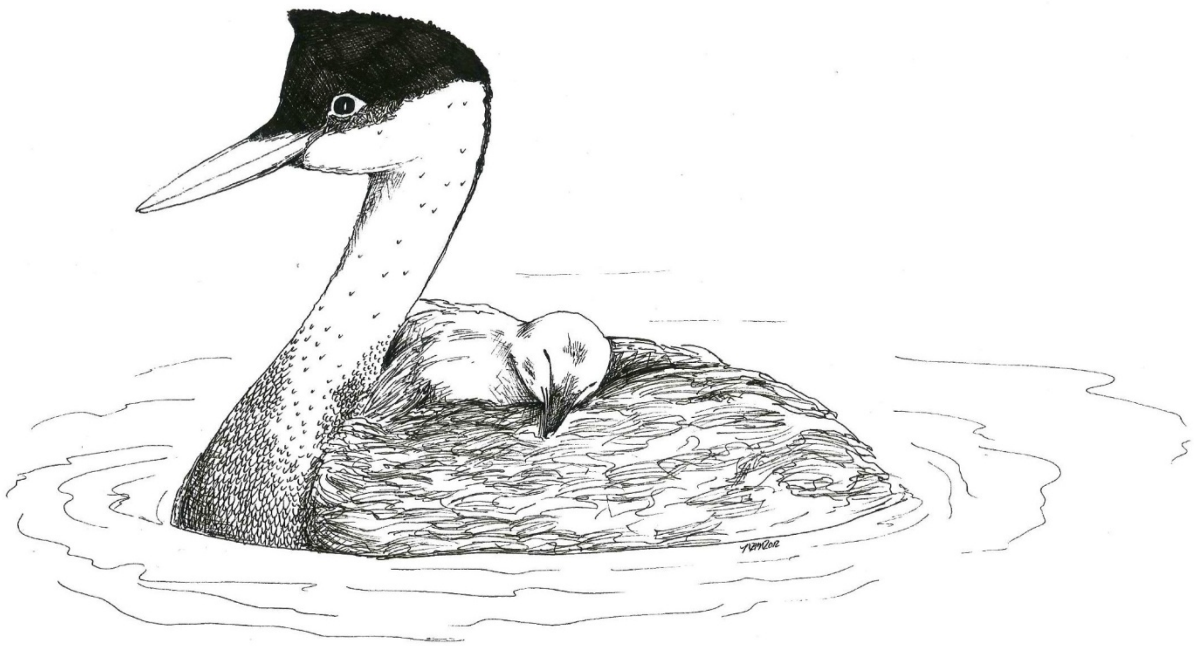

Figure 1. Adult Western Grebe with a young bird riding on its back. Illustration by Naomi Man in 't Veld

The Western Grebe has a long, slender neck, with the black coloration of the crown continuing down the dorsal side of the neck and over the back. The cheeks, throat, breast and belly are white. The eye is bright red. The back and wings are black to sooty grey. The variable amount of white on the wings does not form a well-defined patch. The flanks range from solid greyish-black to white with darker mottling. The tail is inconspicuous. Winter plumage is similar to breeding plumage, but may be less contrasting. The yellowish-green bill is long and pointed (Storer and Nuechterlein 1992). With some experience, sexes can be distinguished in the field. Females have a bill that is both absolutely and proportionately smaller than males; the female's bill also appears slightly upturned (Nuechterlein and Storer 1982). At hatching, the precocial young are downy; the face and underparts are white to pale grey and the upperparts are smoke grey; and the lores and a triangular crown patch are bare (Johnsgard 1987).

Western and Clark's grebes are very similar in appearance and for a century were considered dark and light colour morphs of a single species (Storer and Nuechterlein 1992). Clark's Grebes tend to have more white on the wings and flanks than do Western Grebes, but this distinction is variable, with overlap between the two species. In Clark's Grebes, the black crown does not extend down to the eyes and lores and thus white feathers surround the eye. The differences in facial plumage may be more marked during breeding than during the winter (Storer and Nuechterlein 1985). Clark's Grebes have a brighter yellow or orange-yellow, rather than yellowish-green, bill. Individuals with intermediate appearance do occur, and may be hybrids (Konter 2011).

Population Spatial Structure and Variability

Very little is known about the population structure of Western Grebes in Canada or throughout the rest of their range. Western Grebes from two breeding localities (Wabamun Lake, Alberta and Eagle Lake, California) and three wintering localities (coastal Washington, northern coastal California and southern coastal California) showed no genetic differentiation (Humple 2009). Although this study may be considered preliminary due to a small sample size (*n*=65) and low numbers of microsatellite loci (*n*=6), differentiation should have been detected if gene flow was low among these localities (Humple 2009). The overall F_{st} was not significantly different from 0 (F_{st} = 0.003, p = 0.32) and pairwise F_{st} values were very low for all localities, indicating relatively high levels of gene flow among the populations tested and/or recent population expansion (Humple 2009). Similarly, a study of mitochondrial DNA in *Aechmophorus* grebes from breeding sites across their range (California, Oregon, Utah, North Dakota, Minnesota, and Manitoba) found low population variation and no significant geographic structuring (Eichhorst 1994).

Lack of genetic differentiation does not necessarily imply absence of demographic structure in a population (Esler *et al*. 2006). Given that most Western Grebe breeding colonies are restricted to medium to large lakes with adequate populations of prey fish, their breeding distribution is naturally localized. However, location and size of Western Grebe colonies change, sometimes rapidly, indicating that breeding site fidelity is not absolute (Eichhorst 1994). Banding encounters provide some insight, but an assessment of demographic structure would require estimates of juvenile dispersal rates (or the inverse, natal philopatry) and adult site fidelity to both breeding and wintering sites, as well as knowledge of relevant behaviour, such as the timing of pair bond formation.

Conclusions about Western Grebe population structure and migratory connectivity based on banding data are limited, as few bands have been deployed (*n*=3052 on *Aechmophorus* grebes, as of 2008) and encounter rates are low (3.9%; Humple 2009). Between-season band recoveries (*n* = 46) have mostly been from birds banded during the breeding season in Manitoba and recovered on the Pacific coast. Sixty percent of these bands were recovered in coastal British Columbia/Washington and 23% in the San Francisco Bay area, showing that individuals from a relatively small part of the breeding range were widely distributed across the wintering range, but with some concentration in the northern part of the range (Figure 2 and Humple 2009). There is some evidence of fidelity to wintering sites, as bands that were deployed during winter and recovered in a subsequent winter (*n* = 7) have mostly been encountered in the same general area, except for one bird banded in the San Francisco Bay area that was recovered 2 years later in coastal Washington (Humple 2009). Between-year band encounters from the breeding season (*n* = 9) indicate that there is some dispersal between breeding areas. For example, two birds banded in Manitoba were later recovered in Alberta and Nevada (Humple 2009).

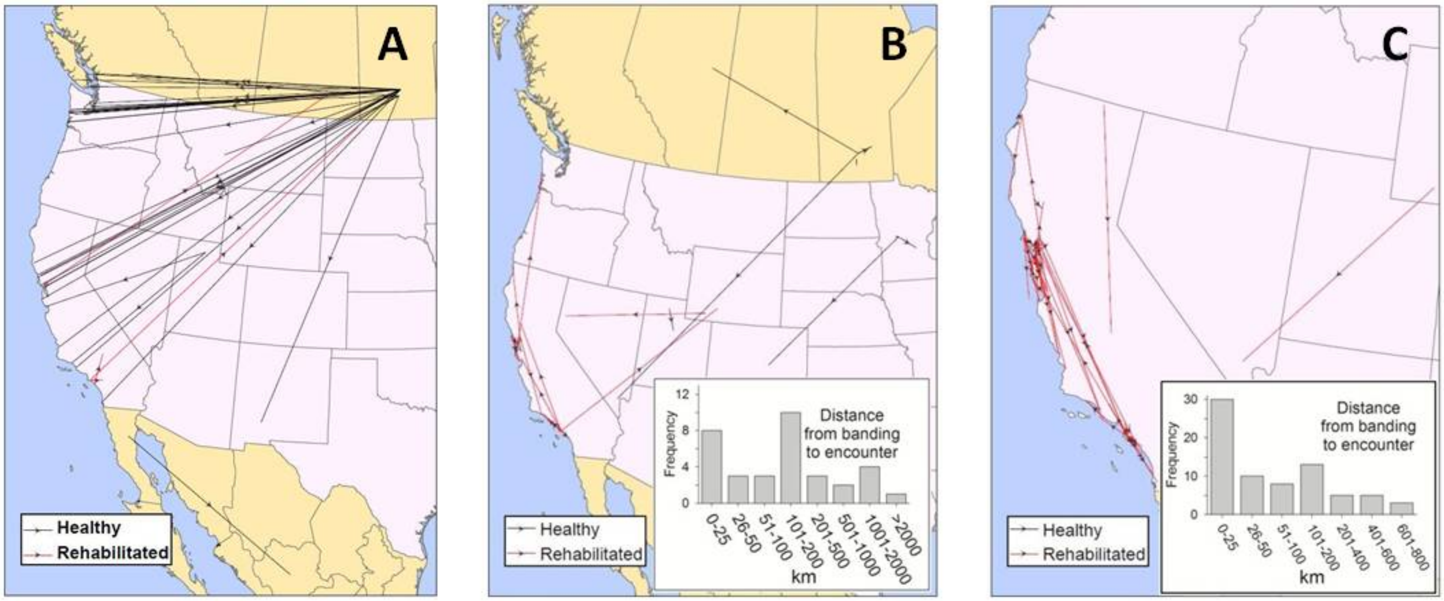

Figure 2. Band encounters for Western Grebes, where banding and encounters occurred (A) in different seasons, (B) in the same season, but in different years, and (C) in the same season of a single year. In B and C, the histograms show distances between banding and encounter sites. Arrows lead from banding to encounter sites, and birds that were normal and healthy when banded (black lines) are shown separately from those banded after rehabilitation (red lines). (Figure taken from Anderson *et al*. 2011).

Designatable Units

There is no evidence for the existence of more than one designatable unit of the Western Grebe in Canada.

Special Significance

With its graceful appearance and elaborate courtship displays, the Western Grebe is a well-known and charismatic species. Its dependence on wetland breeding areas could make it an appealing flagship species for these important ecosystems. Colonial waterbirds may be effective bioindicators for wetland health and diversity as they are near the top of the aquatic food web (Weseloh 2011). Grebe species in general have been suggested as keystone bioindicators, particularly in western North America (O'Donnel and Fjeldsa 1997), and the Western Grebe specifically has been identified as a potential indicator species for the Boreal Plains ecozone (Weseloh 2011).

In the Salish Sea (Strait of Georgia, Juan de Fuca Strait and Puget Sound), numbers of several avian species of forage fish specialists have decreased, with Western Grebes showing the most dramatic declines (Bower 2009; Davidson *et al*. 2010). Whether this observed decline is due to a reduction in their overall numbers and/or a shift in their wintering range, Western Grebes may be useful indicators of forage fish abundance and availability.

Documented Aboriginal traditional knowledge for the Western Grebe is not available at this time.

DISTRIBUTION

Global Range

The Western Grebe is endemic to North America (Figure 3). *A. o. occidentalis* breeds in southwestern Canada through the western United States into northern Baja California. *A. o. ephemeralis* is resident on the Mexican Plateau from Chihuahua to the Valley of Mexico (Storer and Nuechterlein 1992).

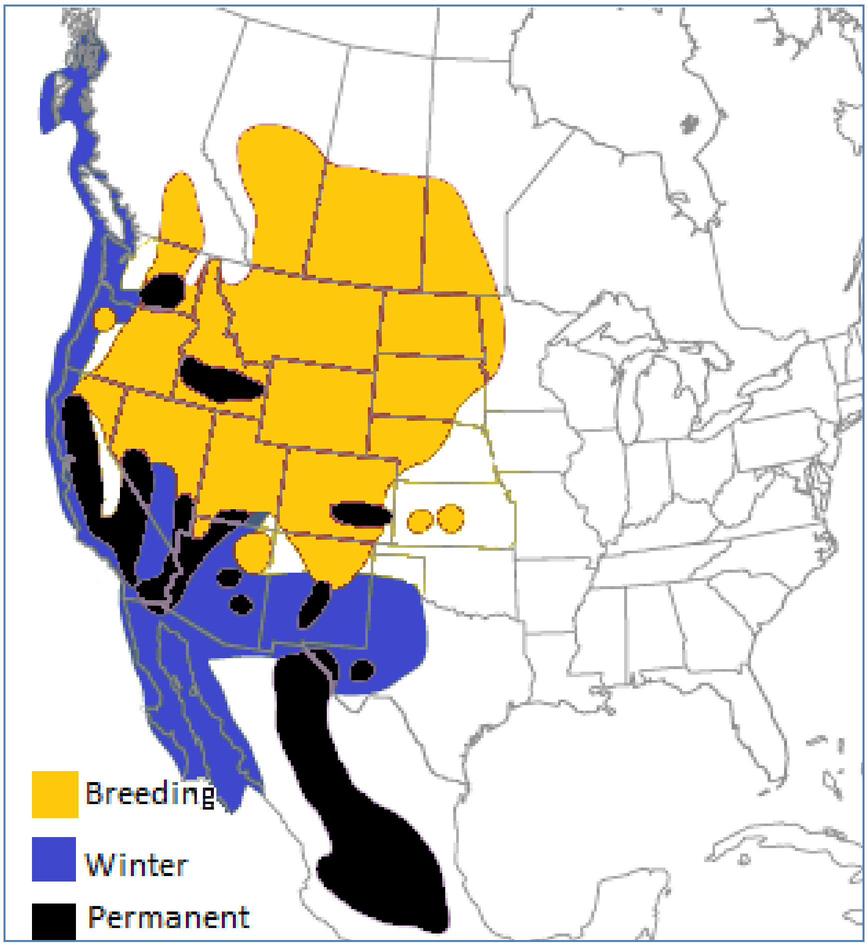

Figure 3. Breeding and non-breeding distribution of the Western Grebe. Within the Canadian breeding range, nesting colonies are localized and dispersed. Mapping is based on Storer and Nuechterlein (1992) and National Geographic (2002).

The Western Grebe (*A. o. occidentalis*) winters primarily on the Pacific coast of North America, from southern Alaska to Mexico (Figure 3). It also winters inland where open water is available, and in the southwestern interior of the United States its numbers are increasing (Wilson *et al.* 2013). There are casual records west to the Aleutians, north to southern Alaska and Yukon, and east to the New England coast, Florida, and southeastern Texas (Storer and Nuechterlein 1992).

Canadian Range

Western Grebes are widely distributed, but highly local, in western Canada (Figure 3 and Appendix A). About 30% of the area of the global breeding range is in Canada (ASRD/ACA 2006). In British Columbia, the breeding distribution is restricted to south central interior areas of the province in the Montane Cordilleran ecozone. In Alberta, Saskatchewan and Manitoba, colonies are found mainly in the Prairies and Boreal Plains ecozones (Storer and Nuechterlein 1992; Weseloh 2011).

In British Columbia, two former breeding colonies (Swan Lake, near Vernon and Williams Lake) are extirpated and only three known colonies persist (Creston Valley Wildlife Management Area, Shuswap Lake and Okanagan Lake; Burger 1997; Anderson *et al*. 2011). Western Grebes have occasionally been found breeding elsewhere in small numbers (1-4 pairs) and there are some unconfirmed historical reports of nesting at other sites in British Columbia (Burger 1997).

In Alberta, most of the major breeding colonies occur within the Boreal Forest in the central part of the province, but there are also colonies throughout southern Alberta (ASRD/ACA 2006; Wilson and Smith 2013). In Saskatchewan and Manitoba, breeding colonies occur mainly in the central and southern parts of the provinces (Wilson and Smith 2013). Alberta and Manitoba have comparable total breeding numbers, although Manitoba has fewer colonies and a larger average colony size; Saskatchewan's breeding numbers are small relative to the other Prairie Provinces (Wilson and Smith 2013).

Western Grebes wintering in Canada occur along the British Columbia coast, with the largest documented concentrations in the southern Strait of Georgia, Gulf Islands, Strait of Juan de Fuca, and sheltered waters of western Vancouver Island (Vermeer *et al*. 1983). Overwintering Western Grebes also have been reported in Alberta at Wabamun Lake, Waterton Lakes, and Lethbridge (Semenchuk 1992), and in British Columbia on southern interior lakes (Munro 1941; Campbell *et al*. 1990). However, wintering on freshwater lakes in Canada is uncommon.

Extent of Occurrence and Area of Occupancy

Based on the minimum convex polygon of occupied territory, the Canadian extent of occurrence is estimated to be about 830,000 km^2. An index of area of occupancy (IAO) is estimated based on the number of breeding colonies, assuming that the nesting area associated with each one occurs within a 2 km x 2 km grid (ignoring surrounding foraging areas). Roughly 110 breeding colonies occur in Canada (see Appendix A), which results in an estimated IAO of about 440 km^2. This estimate seems reasonable, and is line with the IAO of 72 km^2 that was recently calculated for Alberta (ASRD/ACA 2013).

Search Effort

In survey records, counts of Western and Clark's grebes were often combined, as they were considered to be a single species prior to 1985. Additionally, despite their current designation as separate species, they can be difficult to distinguish in the field and thus may be combined during surveys. However, Clark's Grebes are rare in Canada (<5% of breeding birds, Dunn *et al*. 2009), so most unspecified records are likely Western Grebes.

As Western Grebes are large, conspicuous, and gregarious birds, many of their nesting colonies have been found incidentally, rather than by targeted surveys. Recent surveys (aerial, boat, and ground) have been conducted in Alberta (2000-2009) to identify breeding colonies (Wollis and Stratmoen 2010). Western Grebe breeding colonies in Saskatchewan and Manitoba were surveyed between 2008 and 2012 by air, boat, and ground (Beyersbergen and Calvert 2008; Calvert 2009, 2011, 2012; Calvert and Wilson unpubl. data). In 1979, aerial surveys were conducted in southern Manitoba (Koonz and Rakowski 1985). Breeding Bird Atlas projects in British Columbia, Alberta, Saskatchewan, and Manitoba also have contributed to the confirmation of breeding colonies (Semenchuk 1992; Federation of Alberta Naturalists 2007; British Columbia Breeding Bird Atlas 2012; Government of Saskatchewan 2012; Manitoba Breeding Bird Atlas 2012). Vermeer *et al*. (1983) documented the distribution of marine birds, including Western Grebes, on the Pacific coast of British Columbia, based on boat and aerial surveys.

HABITAT

Habitat Requirements

Western Grebes breed across a range of ecoregions, but their breeding site requirements are quite specific and potential colony sites are limited (Storer and Nuechterlein 1992). They generally nest near shores of medium to large lakes or in marshes. They build nests of vegetation, which can be floating and anchored to emergent vegetation or built up from the lake bottom (Storer and Nuechterlein 1992).

Western Grebe colonies are usually located at sites that: (1) have stable water levels during the nesting period; (2) are protected from wind and waves, usually by vegetation; (3) have sufficient water depth (>25 cm) to allow adults to access and leave nests by diving; (4) allow access to open water and sufficient prey fish; (5) have an ice-free period long enough for the nesting period; and (6) have low levels of human disturbance (Forbes 1984). In Alberta, nests are usually located in water depths of 0.5-1.5 m, in stands of bulrush (*Schoenoplectus* spp.) or cattail (*Typha* spp.) and occasionally reeds (*Phragmites* spp.; Wollis and Stratmoen 2010). Sites where the previous year's vegetation is still standing may be advantageous, allowing grebes to build their nests early in the season, rather than waiting for sufficient growth of new vegetation (Wollis and Stratmoen 2010).

In Alberta, lakes with colonies of greater than 500 birds range from 7.5 – 1160 km^2 in size and from 1.7 - 49.9 m in depth (ASRD/ACA 2006). The persistence of occupancy of lakes in Alberta by Western Grebes was positively related to the amount of bulrush (*Scirpus lacustris*) along the shoreline and the extent of anthropogenic development in a 500 m buffer around the lakeshore and was inversely related to the amount of forest cover in the 500 m buffer (Erickson 2010). The correlation between human activity and occupancy by grebes likely occurs because both species are selecting deep, medium to large lakes with fish populations (Erickson 2010), rather than reflecting any particular affinity for human-modified habitat.

In coastal wintering areas, Western Grebes are usually found on salt or brackish bays, estuaries, sheltered inlets, channels and sounds, or relatively open water within 2 – 3 km of shore (Campbell *et al*. 1990; Storer and Nuechterlein 1992; Burger 1997). In the Salish Sea, Western Grebes mainly used protected bays and inlets with relatively low currents (Nysewander *et al*. 2005). Particularly in the southern United States, Western Grebes also winter on inland lakes (Storer and Nuechterlein 1992; Palm pers. comm. 2012).

In British Columbia, spring and fall migrants stop to rest and feed on lakes, sloughs and river backwaters, with most migrating grebes using larger lakes such as Okanagan, Shuswap, Kootenay, Osoyoos, Skaha, Vaseux, Kamloops, Nicola, Williams, Puntchesakut, Charlie, and Windermere (Campbell *et al*. 1990; Burger 1997).

Habitat Trends

Western Grebe breeding habitat is naturally localized, as the species requires medium-large water bodies with sufficient emergent vegetation and prey fish (Storer and Nuechterlein 1992). Assessing changes in Western Grebe habitat availability or occupancy is challenging, given the lack of comprehensive historical data on colony sites and sizes and on relevant habitat parameters. Information on shifts in distribution and/or abundance of Western Grebes may provide some insight into changes in habitat availability or quality for this species. In Canada, former colonies have apparently been abandoned because of human disturbance, habitat degradation, and changes in lake hydrology (Burger 1997; Beyersbergen and Calvert 2008; Erickson 2010; Calvert and

Wilson unpubl. data). However, Western Grebes will establish new colonies if suitable habitat is available or is restored (Burger 1997; Hanus *et al*. 2002a), so some habitat changes may only be temporary.

In British Columbia, Western Grebe breeding activity has been documented at 14 sites, but only 5 of those sites have supported more than 5 breeding pairs (Burger 1997). Of those 5 sites, 3 are still occupied by breeding Western Grebes while the other 2 were likely abandoned due to human disturbance and loss of emergent vegetation (Burger 1997).

In Alberta, Western Grebes were detected on more lakes during 1991-2011 than during 1970-1990 (Wilson and Smith 2013). However, surveys have been more extensive and frequent since 2000 (Wollis and Stratmoen 2010), so the increased number of sites is likely due in part to greater search effort rather than expansion into new habitats. Of the lakes that were surveyed during both periods, four lakes no longer had Western Grebes during the latter period (Wilson and Smith 2013). There is some recent evidence of both colony abandonment and establishment in Alberta (Erickson 2010; Wollis and Stratmoen 2010). During 2008, breeding birds were observed on only 10 of 21 lakes in the boreal region that formerly supported colonies (Erickson 2010). In southern Alberta, another colony of 100 adults was observed on Crow Indian Lake where breeding activity had not previously been documented, and at Gull and Murray Lakes historical colonies have been re-established (Wollis and Stratmoen 2010).

Some changes in Western Grebe colony sites in Alberta seem to be related to habitat changes – especially fluctuations in water levels. However, assessing effects of habitat change is difficult because most colony sites have not been monitored consistently, and data are lacking for key habitat variables such as presence of emergent vegetation, prey availability, and human disturbance. In the northeast boreal region (from Edmonton east to the Saskatchewan border and north to Lac La Biche) there were 11 lakes with colonies of >100 individual adults, but water levels in this area have dropped considerably since the 1970s and now only three lakes have colonies of >100 individual adults (Wollis and Stratmoen 2010). These three lakes (Lac La Biche, Moose and Cold Lakes) are all large and deep; in contrast, Hastings Lake, which is small and shallow, previously had >100 nesting individual adults, but because water levels have dropped the colony moved to a new site on the lake and only 14 nests have been located (Wollis and Stratmoen 2010). Lesser Slave Lake formerly supported a large colony, but in 2007 water levels increased and the spring ice pack scoured vegetation where the colony had been located; despite growth of new vegetation in this site, there were only two adults present in 2008 (Wollis and Stratmoen 2010). The lake was not surveyed in 2009 or 2010, but in 2011 the colony appeared to have become re-established (ASRD/ACA 2013).

In Saskatchewan, there have been few surveys of Western Grebes or other waterbird species until recent years (Beyersbergen and Calvert 2008), and so it is unclear how the number of colonies has changed over time. However, in 2008, breeding colonies were located on only 9 of the ~40 lakes that had been identified as historical Western Grebe breeding habitat (Beyersbergen and Calvert 2008). In 2009, high water levels on some lakes (e.g., Last Mountain Lake) may have caused abandonment of some colonies (Calvert 2009). Some individuals may have moved to lakes elsewhere in the province because Western Grebes were observed on a number of lakes that seemed to have marginal nesting habitat (Calvert 2009). In 2011, there were widespread water level fluctuations. As a result, all monitored Western Grebe colonies in Saskatchewan either failed completely or re-nested with insufficient time for young to fledge before fall migration (Calvert 2011).

A few previously undocumented Western Grebe colonies have recently been located in Manitoba (Manitoba Breeding Bird Atlas 2012; Calvert and Wilson unpubl. data). It is not clear whether these colonies established recently, perhaps as a result of habitat changes. A colony at Gimli Marshes, Lake Winnipeg, that once had 400 individual adults has apparently disappeared, likely due to development in the area (Calvert pers. comm. 2013). In 2009, there was a colony of about 100 birds at North Shoal Lake, but water levels increased there with subsequent disappearance of both emergent vegetation and the breeding colony (Calvert pers. comm. 2013).

There is no evidence of decreased extent of wintering range in coastal British Columbia. Apparent declines in numbers of wintering birds there may be the result of a southward shift in wintering range (Wilson *et al*. 2013). The reasons for these declines and/or redistribution are unknown, but may be related to changes in forage fish abundance and/or availability (Wilson *et al*. 2013). In some areas, Pacific Herring (*Clupea pallasi*) are believed to comprise a large portion of the diet of Western Grebes (Clowater 1998). Adult herring abundance in the Strait of Georgia and on the west coast of Vancouver Island is currently at or below averages observed since 1960 (Schweigert *et al*. 2010). Furthermore, there has been a reduction in the number of herring spawning areas and in the frequency of early and late season spawning; maturation also now occurs at a smaller size (Landis and Bryant 2009; Therriault *et al*. 2009). Conversely, the abundance of Pacific Sardine (*Sardinops sagax*) increased rapidly off the coast of California beginning in the 1980s (DFO 2004). Thus, relative shifts in forage fish availability towards the southern portion of the Western Grebe's wintering range may underlie the apparent corresponding shift in wintering distribution (Wilson *et al*. 2013).

Changes in the availability and quality of Western Grebe habitat in the U.S. are poorly documented. In Washington State, it is thought that current breeding sites are in marginal habitat compared to historical breeding sites (Gaydos and Nysewander in prep.). In California, wetland loss is likely responsible for some local declines in breeding numbers (Ivey 2004). In other regions, water level fluctuations have likely negatively affected Western Grebe breeding habitat (Ivey and Herziger 2006).

BIOLOGY

Life Cycle and Reproduction

Western Grebes usually nest in colonies on lakes and marshes. Occasionally pairs will nest singly or in small groups, while large colonies can contain up to several thousand nesting pairs (Storer and Nuechterlein 1992). In Alberta, colonies average about 600 adults (ASRD/ACA 2006) and range in size from 30 m x 100 m to 300 m x 400 m (ASRD/ACA 2013). Courtship and pair formation occurs in April and May, during spring migration and shortly after arrival at breeding areas (Storer and Nuechterlein 1992). However, observation of mate-feeding and other courtship behaviours during winter indicates that pair bonds also may be established or maintained during the non-breeding season (James 1989; Breault pers. comm. 2013). Western Grebes are seasonally monogamous, but there is no information on mate retention between years (Johnsgard 1987).

The exact timing of breeding is dependent on locality and environmental conditions, but through most of the Canadian breeding range nest initiation (including renesting attempts) takes place from late May until late July or early August (Storer and Nuechterlein 1992; La Porte 2012). Western Grebes spend 1-3 days building a nest, 3-6 days laying eggs, and 22-24 days incubating the clutch (Storer and Nuechterlein 1992). Prior to and during egg-laying, mate-guarding is intense and there are long bouts of mate feeding, with the female begging for food and the male diving for fish (Nuechterlein and Storer 1989).

Western Grebes normally produce one clutch per year, but often renest if a clutch is lost (Storer and Nuechterlein 1992; Calvert pers. comm. 2013). Clutch sizes usually range from 1-4 eggs, but may include up to 6 eggs (Lindvall and Low 1982; Forbes 1988; Storer and Nuechterlein 1992). Average clutch sizes ranged from 2.9-3.7 eggs in British Columbia (Forbes 1988) and from 1.2-2.9 in Alberta (Hanus 2002a,b; Found and Hubbs 2004). In Manitoba, average clutch sizes decreased through the breeding period from 4.2 eggs in May to 2.9 in July (La Porte 2012). Males and females alternate incubation duties (Lindvall and Low 1982). The eggs hatch asynchronously about 1 day apart; almost immediately afterwards the newly hatched chicks climb on the back of the incubating parent (Nuechterlein 1981a).

For the first 7-10 days, chicks spend much of their time on their parents' backs (Lindvall and Low 1982). When chicks are young, violent wind storms can be a major source of chick mortality, particularly if they are unable to take refuge on their parents' backs (Nuechterlein 1981a). During feeding bouts, one parent broods all the chicks while the other dives for food (Nuecterlein 1981a). Parental care of the chicks lasts up to 8-10 weeks (Nuechterlein 1981a; Storer and Nuechterlein 1992).

Western Grebes are primarily piscivorous (80-100% of diet), but will eat crustaceans, polychaete worms, aquatic insects, and molluscs (Lawrence 1950; Johnsgard 1987; Storer and Nuechterlein 1992). Juvenile herring may be a preferred prey for Western Grebes wintering in the Strait of Georgia (Clowater 1998). However, detailed studies of diet are lacking and little else is known about the preferred prey species or size classes.

Survival rates for Western Grebes are not known, but adult annual survival is estimated at 0.75 for the Great Crested Grebe (*Podiceps cristatus*; Abt and Konter 2009), a species of similar size and life history traits. The longevity record for Western Grebes is 13 years (Eichhorst 1992). Although Western Grebes can probably breed when 1 year old, groups of non-breeding birds are often observed during the breeding period (Storer and Nuechterlein 1992) and it is possible that most do not breed until 2 years of age (Eichhorst 1994). Unpaired males usually outnumber unpaired females, indicating a male-biased sex ratio (Storer and Nuechterlein 1992). Individual lifetime breeding success has not been determined, but annual productivity ranges from 0.39 to 0.88 young per breeding adult (Nuechterlein 1975; Forbes 1988; La Porte 2012). Based on age at first reproduction (1 year old) and survival rate for Great Crested Grebes, generation time is estimated to be 5 years for Western Grebes. A life table approach including survival (from other grebe species) and fecundity rates (for Western Grebes) yielded estimates of generation time ranging from 2.5-5.2 years (ASRD/ACA 2013; Wilson and Smith 2013). Based on longevity records and age of first breeding, Eichhorst (1994) considered 5 years to be a reasonable estimate of generation length for Western Grebes; this value has also been accepted by ASRD/ACA (2013).

In areas of sympatry, Western and Clark's grebes occasionally hybridize, but assortative mating between the two species is strong (Ratti 1979; Nuechterlein 1981b; Konter 2011). At the Bear River Refuge, Utah, hybridization occurred at only 2% of the frequency expected if mating was random (Ratti 1979), and there was 95-99% reproductive isolation between the two species in the Klamath Basin National Wildlife Refuge near the Oregon-California border (Nuechterlein 1981b). A mixed pair of Western and Clark's grebes can produce viable young, and individuals that are intermediate in appearance between the two species are observed (Ratti 1979). However, mixed pairs may have lower nesting success than pairs of either species (Ratti 1979). *Aechmophorus* grebes of intermediate appearance (possibly hybrids) are fertile, but may have difficulty attracting mates, particularly if they are male (Nuechterlein 1981b). However, recent work suggests that rates of interbreeding between Western and Clark's grebes may be increasing slightly in California and Oregon (Konter 2011).

Western Grebes undergo a simultaneous flight feather moult in late summer into early fall, and they become flightless until sufficient feather regrowth has occurred (Stout and Cooke 2003). The timing and geographic location of this moult is quite variable, occurring on both large freshwater lakes and in coastal areas (Stout and Cooke 2003). They may moult on the same lakes that are used for breeding (Stout and Cooke 2003) or they may disperse by swimming (La Porte 2012). Western Grebes that were banded during breeding on Lake Manitoba and later caught on Lake Winnipegosis suggest that some individuals may undertake a post-breeding moult migration to other lakes (Storer and Nuechterlein 1992). Flocks of several thousand Western Grebes have been observed in Boundary Bay, British Columbia, during August to October, with at least some individuals confirmed to be moulting (Stout and Cooke 2003).

Physiology and Adaptability

Western Grebes are sensitive to human disturbance (Nuechterlein 1975; Berg *et al*. 2004; La Porte 2012). The adults alternate incubation duties, and do not usually leave their nests unattended (Storer and Nuechterlein 1992). However, human presence near nests may cause incubating grebes to leave abruptly, before covering their eggs with vegetation; this likely increases vulnerability to avian predators, which are able to spot the unguarded eggs (Lindvall and Low 1982; Berg *et al* 2004; La Porte 2012). Western Grebes will apparently abandon breeding colonies if human disturbance becomes too severe (Burger 1997). Breeding success also can be negatively affected by fluctuating water levels; rising water can flood nests while decreasing levels can cause nest instability or prevent adults from accessing nests (Nuechterlein 1975; Wollis and Stratmoen 2010). Furthermore, storms may destroy nests or cause high chick mortality if protection from wind and waves is not sufficient (Storer and Nuechterlein 1992; Allen *et al*. 2008).

Western Grebe colony sites can shift from year to year, depending on factors such as water levels, vegetation growth and human presence (Kemper *et al*. 2008; Wollis and Stratmoen 2010; La Porte 2012). There are several records of Western Grebes establishing new colonies in response to changes in water levels, vegetation growth, and/or prey availability (Forbes 1984; Hanus *et al*. 2002a).

Wintering areas can also change over time. Although grebe numbers have decreased in the northern portion of their wintering range, they have increased in southern coastal California, and this shift in distribution may be in response to changes in forage fish abundance and availability in the Salish Sea and California Current ecosystems (Wilson *et al*. 2013).

On coastal wintering areas, Western Grebes may congregate in large flocks in nearshore waters, and thus large numbers can be simultaneously impacted by events such as oil spills or harmful algal blooms (Humple *et al*. 2011). For example, during the winters of 1994-95 and 1995-96, flocks of several hundred grebes were often observed in the Saanich Inlet area of southern British Columbia (Clowater 1998) and flocks of >10,000 have been observed in British Columbia (Campbell *et al*. 1990).

Dispersal and Migration

Band encounters and observations of birds marked with nasal tags indicate that there is some natal philopatry to colonies, but the frequency of philopatry is unknown (Storer and Nuechterlein 1992). Similarly, the rate of breeding dispersal among colonies is unknown, but such dispersal certainly occurs. A few Western Grebes banded during the breeding season have been recovered in subsequent breeding seasons at different areas (see **Population Spatial Structure and Variability**).

Migratory routes of Western Grebes are poorly documented. Unlike the typical north-south migration of many North American migratory birds, Western Grebes follow a more east-west pattern between coastal wintering areas and inland breeding sites (Storer and Nuechterlein 1992). As there are increasing numbers of *Aechmophorus* grebes wintering in interior regions of the southwestern U.S. (Wilson *et al*. 2013), it is possible that some individuals follow a north-south or northeast-southwest migratory route, rather than flying westward to the coast (Humple 2009).

Western Grebes migrate in flocks, and migration is mainly nocturnal over land and may be partially diurnal along the coast (Munro 1941; Johnsgard 1987). The main autumn migration of Western Grebes from northern breeding areas occurs from September to November, peaking in October (Munro 1954; Stout and Cooke 2003). At most coastal areas, the first migrants arrive in September, with numbers increasing through the fall until December to February (Clowater 1998; Stout and Cooke 2003).

Interspecific Interactions

There are observations of predation on Western Grebe eggs by American Coots (*Fulica americana*), California Gulls (*Larus californicus*), Ring-billed Gulls (*Larus delawarensis*), Forster's Terns (*Sterna forsteri*), American Crows (*Corvus brachyrhynchos*), Common Ravens (*C. corax*), and Raccoons (*Procyon lotor*; Lindvall and Low 1982; Storer and Nuechterlein 1992; La Porte 2012; Boyd pers. comm. 2012). Predators of young Western Grebes include California Gulls, Ring-billed Gulls, Herring Gulls (*Larus argentatus*), Great Blue Herons (*Ardea herodias*), bass (*Micropterus* spp.) and pike (*Esox* spp.), while predators of adults include Raccoons, American Mink (*Neovison vison*), and River Otters (*Lontra canadensis*) (Stenson *et al.* 1984; Knapton 1988; Storer and Nuechterlein 1992; Wobeser 2000; Wollis and Stratmoen 2010; Boyd pers. comm. 2012). The extent of avian predation on eggs is highly variable and may be exacerbated by human disturbance, which can cause incubating grebes to leave their nests (Nuechterlein 1975; Lindvall and Low 1982). At Bear River, Utah, avian predators (mainly American Coots and California Gulls) caused a loss of 40% of nests (Lindvall and Low 1982). At Delta Marsh, Manitoba, predation on eggs (mainly by Forster's Terns and American Coots) was the most commonly observed form of predation (Nuechterlein 1975). However, more recently, there was little egg predation observed at Delta Marsh (La Porte 2012).

On coastal wintering areas, Western Grebe remains were found frequently at Bald Eagle (*Haliaeetus leucocephalus)* nests (Knight *et al*. 1990), and predation by Sea Otters (*Enhydra lutris*) has also been observed (VanWagenen *et al*. 1981; Riedman and Estes 1988). Western Grebe remains have also been associated with River Otters and Snowy Owls (*Bubo scandiacus*); other potential predators include Peregrine Falcons (*Falco peregrinus*), Killer Whales (*Orcinus orca*), and Harbour Seals (*Phoca vitulina*) (see Anderson *et al*. 2012).

During nesting, Western Grebes can be aggressive towards other waterbirds, including conspecifics, and have been seen chasing other species away from the immediate nest area (Storer and Nuechterlein 1992). However, they often nest in close proximity in mixed species colonies and may be found in association with Forster's Terns, American Coots, Eared Grebes (*Podiceps nigricollis*), Black-crowned Night-Herons (*Nycticorax nycticorax*), Franklin's Gulls (*Leucophaeus pipixcan*), Black Terns (*Chlidonias niger*), Red-necked Grebes (*Podiceps grisigena*), Redheads (*Aythya americana*), Soras (*Porzana carolina*), Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*), Red-winged Blackbirds (*Agelaius phoeniceus*), Ruddy Ducks (*Oxyura jamaicensis*), Common Terns (*Sterna hirundo*), Ring-billed Gulls and Marsh Wrens (*Cistothorus palustris*; Nero *et al*. 1958; Storer and Nuechterlein 1992; Hanneman and Heckebert 2001; Hanus *et al*. 2002a; Wollis and Stratmoen 2010). Breeding Forster's Terns were present at over half of the Western Grebe colonies at Delta Marsh (Nuechterlein 1981c).

Eared Grebes, Franklin's Gulls and Common Terns will sometimes use the abandoned nests of Western Grebes as a base for building their own nests (Wollis and Stratmoen 2010). Interspecific brood parasitism by Eared Grebes also occurs, and at a breeding colony in Alberta up to 20% of Western Grebe nests contained eggs of Eared Grebes (Hanus *et al*. 2002a), and there are reports that Eared Grebe eggs have been hatched by Western Grebes (Eichhorst pers. comm. *in* Storer and Nuechterlein 1992).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Breeding

Large-scale, long-term surveys targeting Western Grebes are lacking. Lack of monitoring has been attributed to three factors: they are not game birds; traditional ground-, air-, and boat-based survey methods are not very effective due to grebe avoidance behaviours; and their population status is often perceived to be secure (Hanus *et al*. 2002b). Furthermore, the location of colonies can change rapidly, making comprehensive surveys challenging. The North American Breeding Bird Survey (BBS) is a volunteer program that is a valuable source of data on the status and trends of species breeding across the continent. However, for Western Grebes the encounter rate on BBS survey routes is so low that population modelling is imprecise and/or inaccurate

(Sauer *et al*. 2012). There are provincial breeding bird atlas programs for the provinces in which Western Grebes breed. These atlases provide reasonably complete distributional coverage, though measures of abundance are not always included in atlas surveys. In British Columbia and Manitoba, the first atlas efforts are in progress with final surveys conducted in 2012 and 2014, respectively (British Columbia Breeding Bird Atlas 2012; Manitoba Breeding Bird Atlas 2012). The Saskatchewan Bird Atlas has been an ongoing project since the 1970s, with informal data collected from a wide variety of sources (Government of Saskatchewan 2012). In Alberta, two breeding bird atlases have been completed, one for 1987 to 1992 and an update for 2000 to 2005 (Semenchuk 1992; Federation of Alberta Naturalists 2007).

In British Columbia, the Shuswap Lake breeding colony has been monitored by volunteers since the 1980s. At Creston Valley Wildlife Management Area (CVWMA), survey efforts have increased since 2004, while the Okanagan Lake colony has only been sporadically surveyed (Burger 1997; Anderson *et al*. 2011). In 2000, Alberta Environment and Sustainable Resource Development conducted ground and aerial surveys for colonial nesting waterbirds on 36 lakes in the Northwest Boreal Region (Hanneman and Heckbert 2000). In 2001, an assessment of the provincial breeding population of Western Grebes was initiated (Hanus *et al*. 2002b). Historical records were examined, followed by surveys of lakes. Researchers are confident that no major colonies in Alberta remain undetected, as only two previously undocumented colonies with >50 nests were found in 9 years of surveys (Wollis and Stratmoen 2010). Environment Canada surveyed historical, probable, and known colonies by boat in Saskatchewan in 2008 and 2012, by boat in Saskatchewan and Manitoba in 2009 and 2011, and by air in Manitoba in 2011 and 2012 (Beyersbergen and Calvert 2008; Calvert 2009, 2011, 2012; Calvert and Wilson unpubl. data). In addition, 11 small lakes and several sites along the shores of the large Manitoba lakes were surveyed in 2009 (Calvert pers. comm. 2013).

Wintering

Several surveys in coastal British Columbia have documented Western Grebe presence and abundance at small scales, but there has been little effort to monitor overall trends. Anderson *et al*. (2011) replicated some of the most accessible and well-documented historical counts, enabling direct comparisons of Western Grebe abundance at eight sites in the Georgia Basin (Table 1 and Figure 4). In 2008-2009, 14 boat-based transect counts of marine mammals and birds, including Western Grebes, were conducted in the southern Gulf Islands along an 85 nautical-mile route (Davidson *et al*. 2010). Christmas Bird Count (CBC) data can be used to generate minimum annual estimates of the population, as well as trends in abundance and distribution (National Audubon Society 2012). The British Columbia Coastal Waterbird Survey (BCCWS), initiated in winter 1999-2000, is a volunteer-based program that monitors waterbird populations in coastal British Columbia, particularly the Georgia Basin (Crewe *et al.* 2012). Both the CBC and the BCCWS include counts of hatch-year birds as well as adults. Because recruitment and age-specific survival rates are unknown for Western Grebes, these surveys do not provide accurate estimates of the numbers of mature individuals in the population. While the data can be used to generate population indices, many of the survey routes and sites included in the CBC and the BCCWS are shoreline-based and close to urban areas, and so are not ideally suited for Western Grebes, which are highly mobile, may be sensitive to disturbance, and often occur in areas that are not readily visible from shore.

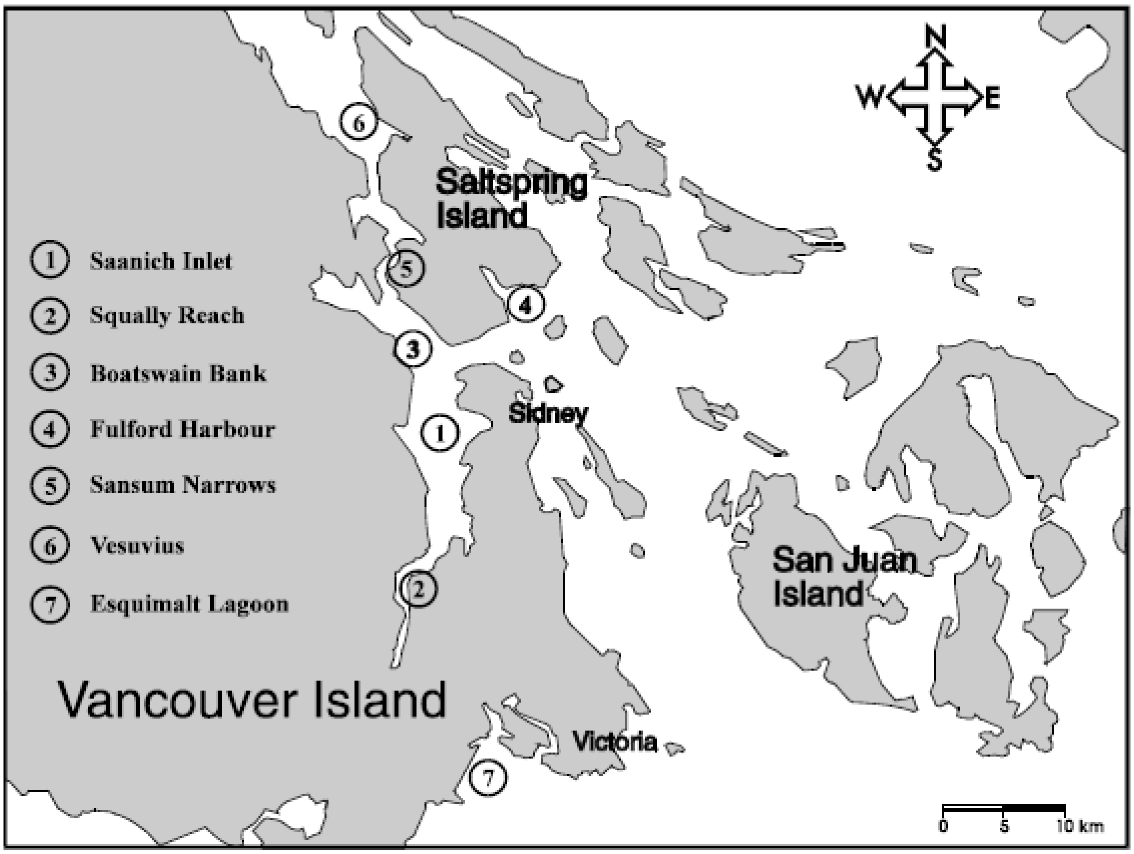

Figure 4. Locations of historical and replicate surveys of Western Grebes in the Georgia Basin. Surveys of Fulford Harbour, Boatswain Bank, Saanich Inlet and Squally Reach were conducted by boat, while Esquimalt Lagoon was surveyed from shore (reproduced from Clowater 1998).

In addition to surveys conducted in coastal British Columbia, surveys for Western Grebes in Washington State may be informative, as the Salish Sea is shared by these two jurisdictions. In 1978/79, the Marine Ecosystems Analysis (MESA) Puget Sound Project surveyed marine birds in the southern Strait of Georgia and northern Puget Sound; survey techniques included shore-based counts, transect counts from ferries and small boats, and aerial transects (Wahl *et al*. 1981). From 1992-1999, under the Puget Sound Ambient Monitoring Program (PSAMP), aerial transects were flown over the Salish Sea, including replicates of 54 of the MESA transects (Figure 5) (Nysewander *et al*. 2005; Bower 2009). The PSAMP aerial surveys annually covered

13-15% of nearshore waters (<20 m depth) and 3-5% of offshore waters (>20 m depth; Nysewander *et al*. 2005). In 2003-2005, Western Washington University (WWU) researchers replicated shoreline and ferry transect surveys from the MESA study (Bower 2009). The WWU surveys were conducted from September to May of 2003/04 and 2004/05 and included counts at 111 MESA shoreline sites and 25 transects on three ferry routes (Keystone – Port Townsend, WA; Anacortes, WA – Sidney, BC – San Juan Islands, WA; Tsawwassen – Sidney, BC) for a total of 1584 point counts and 211 ferry transects (Bower 2009). Comparisons among these data sets are limited to some extent by varying study designs, but these surveys provide some of the most intensive and large-scale data that are available for Western Grebe abundance in winter. When comparing the aerial transect data from the MESA and PSAMP surveys, it should be noted that transects were flown only once per winter, were limited to straight lines rather than following complex coastline contours, and used different kinds of aircraft (Bower 2009). The WWU surveys were planned in consultation with original observers from the MESA project, but only the shoreline and ferry transects were chosen for replication (Bower 2009). One major difference between the two surveys was that the WWU study involved 2-4 observers rather than the single observer typical of the MESA efforts.

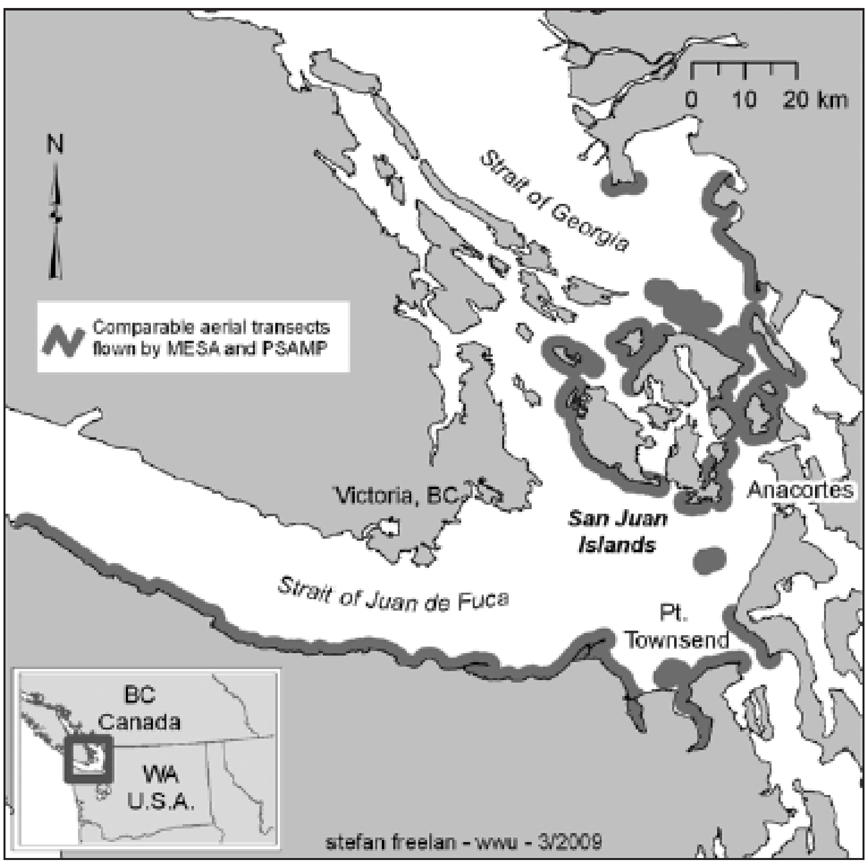

Figure 5. Aerial transects (grey lines) surveyed during the Marine Ecosystems Analysis (MESA) and Puget Sound Ambient Monitoring Project (PSAMP) studies (reproduced from Bower *et al*. 2009, modified from Nysewander *et al*. 2005).

Abundance

Estimates of the global abundance of Western Grebes range from >120,000 (O'Donnel and Fjeldsa 1997) to 130,000 birds (BirdLife International 2012), with breeding population estimates ranging from 70,000-100,000 (Eichhorst pers. comm. *in* O'Donnel and Fjeldsa 1997) to >110,000 mature individuals (Kushlan *et al*. 2002). The maximum Christmas Bird Count tally for Western Grebes in Canada and the United States combined was in 1989, when 106,920 Western Grebes and 30,990 unspecified *Aechmophorus* grebes were counted (National Audubon Society 2012). In 2004, the total was 104,008 birds; since 2005, totals have ranged from about 65,000-83,000 birds (National Audubon Society 2012). The CBC counts suggest that the continental population estimate of 120,000-130,000 birds may be too low. However, CBC counts include an unknown proportion of hatch-year birds as well as adults.

Breeding

The total number of mature Western Grebes breeding in Canada is likely at least 20,660 – 26,596, based on a compilation of available data from surveys and colony counts (Wilson and Smith 2013). The British Columbia breeding population has been consistently estimated at fewer than 400 breeding adults through the 1990s and 2000s (Burger 1997; Anderson *et al*. 2011). Breeding population estimates using data from 2002-2012 in the Prairie Provinces are: 9813-12,373 in Alberta; 1794-2421 in Saskatchewan; and 8653-11,403 in Manitoba (Wilson and Smith 2013). Surveyors either directly counted adults or doubled the number of active nests present in a colony (Beyersbergen and Calvert 2008; Wollis and Stratmoen 2010). Counts of adults on lakes without definitive breeding evidence were also included (Wilson and Smith 2013). As all colonies were not surveyed in any given year, three methods were used to summarize the data: (1) sum of most recent surveys of all known colonies; (2) sum of second most recent surveys (or most recent survey, for colonies that were only surveyed once); and (3) sum of average colony abundance over the 10-year interval (typically using three surveys, but only one or two surveys were available for some sites; Wilson and Smith 2013). The provincial estimates given above are averages of these three methods, except for Manitoba, where just the first method was used, as most colonies there were only surveyed once in the past 10 years (Wilson and Smith 2013). Some colonies in the prairies were not surveyed at all in the past decade, but because recent surveys have targeted all known large colonies, this should not affect the estimates greatly. To account for colonies that had not been surveyed since 2002, an upper estimate was generated by using previous count data for those colonies and a lower estimate was based on an assumption that those colonies no longer existed (Wilson and Smith 2013). The upper estimates may be low if recently unsurveyed colonies have grown in the past 10 years, if new colonies have formed and have not been located, and/or if surveyed colonies have been undercounted (Wilson and Smith 2013). Accuracy of estimates could also be affected by misidentification of nests, especially in mixed species colonies (Wilson and Smith 2013). For Alberta, the estimated range given above is comparable to other recent estimates of 10,738 (Kemper *et al*. 2008), ≥10,000 (Wollis and Stratmoen 2010) and 9913 (ASRD/ACA 2013), but is considerably higher than a recent estimate of 5400 (Erickson 2010).

Table 1. Historical and replicate surveys of wintering Western Grebes (*Aechmophorus occidentalis*) at sites in the Georgia Basin, British Columbia.

Site	Survey type	Historical surveys			Replicate surveys[6]		
		Year	No. of surveys	Total no. of individuals	Year	No. of surveys	Total no. of individuals
Baynes Sound[a]	Shore	1980-81[1]	24	7682	2010-2011	4	32
		2002-2005[2]	24	179			
Fulford Harbour[b]	Boat	1994-1996[3]	18	160	2010-2011	3	0
Boatswain Bank[b]	Boat	1994-1996[3]	63	260	2010-2011	3	0
Saanich Inlet[b]	Boat	1994-1996[3]	101	2005	2010-2011	4	155
Squally Reach[b]	Boat	1994-1996[3]	32	250	2010-2011	4	0
Esquimalt Lagoon[b]	Shore	1994-1996[3]	31	980	2010-2011	7	247
Indian Arm[c]	Boat	1990[4]	2	550	2010-2011	4	1
English Bay[d]	Shore	1980s[5]	Informal obs	>4000	2010-2011	5	2

[a] Coastline surveyed from Comox Harbour to Deep Bay, approximately 40 km in length, from shoreline to ~500 m offshore. Values are for maximum counts between Nov-Feb in each of the survey periods

[b] Historical and replicate surveys both conducted by Clowater (1998); remaining replicate surveys conducted by Anderson *et al* (2011).

[c] Indian Arm was surveyed in its entirety, including deep-water areas. Values are for maximum monthly counts.

[d] Historical values are for wintering abundance; on replicate surveys, 2 birds in total were observed.

[1] Dawe *et al*. (1997); [2]Boyd and Esler, unpubl. data; [3]Clowater (1998); [4]Burgesse and Bell (1992); [5]Schafer and Chen (1988); [6]Anderson *et al*. (2011).

Wintering

The highest CBC value for Western Grebes in British Columbia was over 33,000 birds in 1983; since 2005 the highest CBC count was just over 4500, and the 2011 count was only 1724 (National Audubon Society 2012). In 2011, the maximum monthly BC Coastal Waterbird Survey count was 578 Western Grebes (Bird Studies Canada 2012). The CBC and the BCCWS are not exhaustive surveys, so these counts are minimum estimates of the total population and plausible maximum values and/or confidence intervals are unavailable. Estimates of the total number of Western Grebes wintering in British Columbia range from 2500 (Wilson pers. comm. 2012) to >10,000 (Breault pers. comm. 2013).

Fluctuations and Trends

Breeding

Monitoring of Western Grebe colonies has not been consistent or sustained enough to assess trends in the overall Canadian breeding population. In British Columbia, numbers of breeding adults at the Salmon Arm colony remained fairly stable from 1990-2010 (Anderson *et al*. 2011). At Duck Lake in the Creston Valley Wildlife Management Area, surveys have not been systematic but 21-41 nests per year were counted during 1997-2008 (Anderson *et al*. 2011). No recent survey data are available for the colony at the North Arm of Okanagan Lake (Anderson *et al*. 2011).

The historical population of breeding Western Grebes in Alberta has been estimated at >22,000, based on maximum counts available for each surveyed breeding colony from 1971 to 2008 (Erickson 2010). It is quite possible that this is an overestimate, as there are large annual fluctuations in the size of individual colonies, indicating movement among colonies (Wilson and Smith 2013). An estimated 76% decline over a 40-year period for the Alberta breeding population was based on this historical estimate and an estimated breeding population of 5400 in 2008 (Erickson 2010). However, this trend should be interpreted with caution, as it is based on a summary of intermittent survey data collected over four decades, which were then compared to a current estimate based on a single breeding season. ASRD/ACA (2006) used survey data from 2000-2004 to estimate provincial breeding numbers of over 13,000 adults. If this is compared to the most recent estimate (method 1) from Wilson and Smith (2013), it suggests an 8-27% decline in less than a decade. Three colonies in the Stony Plain area of Alberta were surveyed every year from 2001-2010 (ASRD/ACA 2013) and while there have been large annual fluctuations, particularly at Wabamun Lake (the largest colony), numbers within all three colonies appear to have declined during this period (Figure 6).

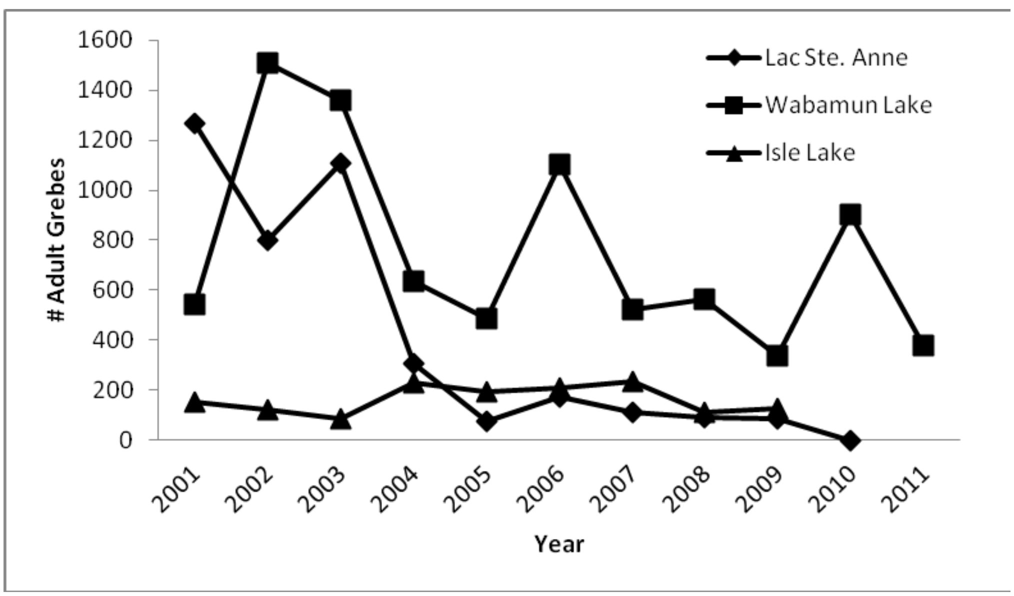

Figure 6. Counts for three Western Grebe breeding colonies in the Stony Plain region of Alberta in 2001-2011. At Isle Lake, Western Grebes were present in 2010 and 2011, but an estimate is not available, and Lac Ste. Anne was not surveyed in 2011 (ASRD/ACA in prep.).

Trend data are not available for Saskatchewan. Surveys prior to 2008 were too limited to allow informative comparisons with current population estimates (Wilson and Smith 2013). While survey efforts have also been limited in Manitoba, an aerial survey in 1979 of all known Western Grebe sites yielded a provincial estimate of 10,270 adults at 11 colonies (Koonz and Rakowski 1985), which is comparable to the current estimate of 8653-11,403 birds (Wilson and Smith 2013). While some colonies have disappeared in Manitoba and some new ones have been located, the provincial population seems relatively stable, and yearly fluctuations are not as large as observed at colonies in Alberta and Saskatchewan (Wilson and Smith 2013).

Western Grebes are counted on Breeding Bird Survey routes, but the survey design is not well-suited to colonial species or waterbirds (Droege 1990), as demonstrated by the poor reliability rating of the trend data (Table 2). While the survey-wide estimate is a small, non-significant decline over the entire survey period (1966-2010), the trends for Canada and the U.S. show slight (statistically non-significant) increases. The 95% credible intervals overlap zero for most regions, again indicating the high degree of uncertainty associated with the estimates.

Table 2. Western Grebe abundance trend estimates with 95% credible intervals from North American Breeding Bird Survey data (Sauer *et al*. 2012).

			1966-2010	**1999-2010**
Region[a]	**No. of routes**	**Reliability code[b]**	**Trend (95% CI)**	**Trend (95% CI)**
Overall	245	Yellow	-0.1 (-4.8, 2.3)	6.7 (1.8, 13.9)
Canada	45	Red	0.4 (-5.9, 5.8)	5.7 (-1.6, 16.5)
United States	200	Blue	0.2 (-3.1, 2.8)	6.7 (1.3, 14.8)
British Columbia	12	Red	-8.8 (-18.1, 0.1)	-5.3 (-23.2, 13.5)
Alberta	13	Red	5.3 (-4.0, 16.8)	10 (-4.4, 33.1)
Saskatchewan	15	Red	4.1 (-1.4, 9.7)	4.3 (-3.6, 12.6)

[a] Trend estimates are not available for Manitoba.

[b] Red – data with an important deficiency; the regional abundance is very low (<0.1 birds/route), the sample size is very small (<5 routes) or the results are very imprecise (a 5%/year change would not be detected over the long-term).

Yellow – data with a deficiency; the regional abundance is low (<1.0 birds/route), the sample size is small (<14 routes) or the results are imprecise (a 3%/year change would not be detected over the long-term).

Blue – data is sufficient, with ≥14 samples with at least moderate abundance on routes and moderate precision of estimates.

Wintering

Based on an analysis of Christmas Bird Count data, continental numbers of wintering *Aechmophorus* grebes have undergone a statistically significant 52% decline from 1975 to 2010 and a significant 44% decline for the 3-generation period extending from 1995 to 2010 (Table 3; Wilson *et al*. 2013, Wilson pers. comm. 2013). The analysis was restricted to CBC circles where ≥10 grebes were detected and in which surveys occurred in ≥50% of the years between 1975 and 2010. The analysis included ~98% of all *Aechmophorus* grebe observations recorded during the CBC from 1975-2010 (2,478,449 observations in 163 circles). The count data were modelled as hierarchical over-dispersed Poisson variables and the models were fit using Markov Chain Monte Carlo methods. Survey effort was included in the models, as well as a binary metric to account for whether a boat was used in a particular survey. Survey coverage increased during the study period, but the increase was similar in all regions, except northern BC and Alaska, where there was a greater relative increase in coverage. After 1985, Western and Clark's grebes were identified to species when possible, with Western Grebes comprising 98% of observations, indicating that trends can be attributed primarily to Western rather than Clark's grebes. This is particularly true for northern regions, where Clark's Grebes were rarely documented.

For Western Grebe, the continental CBC results reported above are a better reflection of the status of the species in Canada than the CBC results for Canadian waters alone, given that unknown numbers of Canadian birds winter outside the country. Nevertheless, based on data from the Canadian portion of the CBC in coastal and interior British Columbia, Western Grebe numbers declined by 87% between 1995 and 2010 and declined by 95% between 1975 and 2010 (Wilson pers. comm. 2013). The annual percent change was calculated from the geometric mean change between the years at the endpoints of each interval, and so may over- or underestimate trends if the years used are anomalous. The counts in Canada and the Salish Sea were high in 1995 and so the actual decline may be less than estimated for 1995 to 2010. However, for the continental numbers from 1975-2010, similar trend results were obtained based on both the geometric mean of changes and the log-linear trend coefficient over the full time series (Wilson *et al.* 2013). The calculation of these trends may be influenced by counts at a few CBC sites in southern British Columbia and may not be representative of trends in other areas of the province where data are lacking.

The continental decline has been particularly strong in the northern portion of the wintering range, specifically the Salish Sea, and declines were particularly steep after the late 1980s (Wilson *et al*. 2013). During this period, however, numbers of *Aechmophorus* grebes also increased in coastal southern California and northern Mexico, interior California and Nevada and the southwestern interior states, indicating that the extreme declines in the northern part of the wintering range may be partially due to redistribution throughout the wintering range (Wilson *et al*. 2013). There were no significant changes in grebe numbers in coastal Alaska and northern British Columbia, the outer Washington and Oregon coasts, coastal northern California or the northern interior. It is possible that large numbers of Western Grebes have moved to areas without extensive CBC coverage (e.g., the Pacific coast of Mexico and much of British Columbia), so further surveys are required to determine to what extent the CBC data are representing true declines versus a shift in wintering distribution (Wilson *et al*. 2013). Recent surveys in Baja California, Mexico have documented moderate numbers of Western Grebes, but not enough to account entirely for the apparent continental decline (Palm pers. comm. 2012), but surveys of coastal British Columbia are again lacking. The CBC also does not provide extensive coverage of open water, so if use of offshore habitats by Western Grebes has increased then the declines may be overestimated.

On a smaller scale within British Columbia, replicates of historical surveys indicate declines at several wintering sites throughout the Georgia Basin. Western Grebes declined in Baynes Sound by >99% from 1980-1981 to 2010-2011, and between 1994-1996 and 2010-2011 they disappeared from three sites and declined by 75% and 92% at two other sites on southeastern Vancouver Island (Table 1; Anderson *et al*. 2011). In 2010-2011, Western Grebes were almost completely absent from both Indian Arm and English Bay where abundances were previously 300-550 birds (in 1990) and >4000 (in 1980s), respectively (Table 1; Anderson *et al*. 2011). In the southern Gulf Islands, Western Grebes were formerly present at densities of 87.5 per km^2 (March-April) and 172.9 per km^2 (November), but the highest estimates from recent surveys were ~0.4 per km^2 (Davidson *et al*. 2010). The British Columbia Coastal Waterbird Survey data for Western Grebes wintering in the Strait of Georgia showed a decline of 16.4% per year ($p<0.05$) for the 12 years from 1999-2011 (Crewe *et al*. 2012), which corresponds to a total decline of about 88% over that time period. A power analysis indicated that the data would be sufficient to allow detection of a significant trend of at least 3.6% over 10 years of surveys at 160 sites (an average of ~175 sites were surveyed each year; Crewe *et al*. 2012).

Surveys of Western Grebes wintering in coastal Washington indicate that large declines in abundance have occurred since the late 1970s (Bower 2009). Based on a comparison of nearly identical aerial transects surveyed by MESA (1978/79) and PSAMP (1992-1999), Western Grebe density decreased by 95% ($p < 0.001$) over two decades (Nysewander *et al*. 2005). To compare the MESA data with WWU surveys from 2003-2005, Bower (2009) used a paired design in which mean counts were calculated for every site in each of the two studies. Wilcoxon signed-rank tests were then conducted on the mean counts from the MESA and WWU surveys, and thus significant declines indicate consistent changes in abundance across the study area (Bower 2009). For Western Grebes, the decline was estimated to be 81.3% ($z = -4.91$; $n = 56$, $p < 0.001$).

Table 3. Trends in abundance of *Aechmophorus* grebes in North America over 10-, 15- and 35-year periods, based on Christmas Bird Count data (Wilson *et al*. 2013; Wilson pers. comm. 2013).

Region	# of CBC circles in region	2000-2010		1995-2010		1975-2010	
		Annual % change (95% CI[a])	Total % change (95% CI)	Annual % change (95% CI)	Total % change (95% CI)	Annual % change (95% CI)	Total % change (95% CI)
Canada	31	-7.93 (-14.26, -2.26)	-56 (-79, -20)	-12.73 (-17.79, -8.86)	-87 (-95, -75)	-8.37 (-10.54, -6.37)	-95 (-98, -90)
Salish Sea	34	-10.88 (-13.32, -8.37)	-68 (-76, -58)	-18.83 (-21.25, -16.41)	-96 (-97, -93)	-9.30 (-10.33, -8.24)	-97 (-98, -95)
North America[b]	163	1.10 (-1.62, 3.90)	12 (-15, 47)	-3.83 (-6.52, -1.03)	-44 (-64, -14)	-2.10 (-3.04, -1.09)	-52 (-66, -32)

[a] CI = credible intervals from Bayesian hierarchical analysis; there is a 95% probability that the annual % change falls within the given interval.

[b] Mainly Canada and the U.S., as CBC coverage is low in Mexico.

Accuracy and precision of abundance and trend estimates for wintering Western Grebes are limited by data availability. Western Grebes are a highly vagile species that may be sensitive to human disturbance and can be difficult to observe from shore. The CBC and BCCWS are primarily shore-based surveys and cover only a small portion of the coastline of British Columbia. Intensive replicated surveys that were designed to detect Western Grebes (Anderson *et al*. 2011) have occurred only in discrete areas in the Georgia Basin. Despite the shortcomings of the survey techniques used, data from a variety of independent sources indicate that Western Grebe abundance has decreased significantly in the Salish Sea in the past several decades. However, it remains unknown whether decreases in Western Grebe numbers are the result of continental population decreases and/or shifts in distribution. The mean centre of occurrence has apparently shifted south by almost 900 km in the past 30 years, based on CBC records (Wilson *et al*. 2013). However, it is also possible that the distribution of Western Grebes has changed within coastal British Columbia and that the new distribution is not represented by CBC and BCCWS coverage.

While there is a great deal of uncertainty associated with estimated declines in the abundance of breeding and wintering Western Grebes in Canada, these trends should likely be considered continuing declines.

Rescue Effect

If the number of Western Grebes breeding in Canada decreases, rescue from the U.S. population is possible but the probability is unknown. There are few data on the degree of movement between breeding localities and Western Grebes are likely declining in parts of the U.S. breeding range (Robison *et al*. 2008; Gaydos and Nysewander in prep.). Apparent declines in numbers of wintering Western Grebes in coastal British Columbia may be at least partially due to a southward shift in the non-breeding range (Wilson *et al*. 2013). If this is the case, then it is conceivable that a northward shift could occur in the future, which would lead to increased numbers of Western Grebes wintering again in Canada. However, the reasons for this putative southward shift are highly uncertain (Wilson *et al*. 2013), and it is impossible to predict whether the current trend will be reversed.

THREATS AND LIMITING FACTORS

Breeding

Human disturbance at breeding colonies (e.g., powerboats, personal watercraft, low-flying aircraft) can cause adults to abandon their nests and in extreme cases may cause desertion of colony sites (Storer and Nuechterlein 1992; Hanus *et al*. 2002a). For example, a former breeding colony at Williams Lake, British Columbia supported 5-35 nests from the 1930s to 1964, but breeding activity ceased after an increase in powerboats, industrial activities, and housing development (Burger 1997). Additionally, powerboat wakes and personal watercraft can flood nests (Berg *et al*. 2004; ASRD/ACA 2006; La Porte 2012). Parents and chicks also become separated during encounters with boats, leaving young chicks vulnerable to predators (Knapton 1988) or death from exposure to cold water (Storer and Nuechterlein 1992). Human disturbance of nesting adults likely increases vulnerability to egg predators (Nuechterlein 1975; Lindvall and Low 1982). Nest depredation by corvids at Wabamun Lake, Alberta may have been a primary cause of nest failure and/or abandonment, and numbers of corvids likely increased due to increased human presence (Hanus *et al*. 2002b).

Western Grebes are reliant on stands of emergent or submergent vegetation to protect their nests from wind and waves, and destruction of this vegetation limits their ability to nest successfully (Allen *et al*. 2008; Wollis and Stratmoen 2010; La Porte 2012). Shoreline vegetation is often cleared in conjunction with recreational or residential property development, but may also be damaged by ranching and agricultural activity or by the use of snowmobiles and all-terrain vehicles (Burger 1997; Kemper *et al*. 2008) or by ice scouring (Calvert pers. comm. 2013).

Fluctuations in water levels, either natural or anthropogenic (e.g., for irrigation, flood control, management of fish populations), during nesting can either flood nests or leave them stranded and inaccessible (Nuechterlein 1975; Wollis and Stratmoen 2010). For example, artificially high water levels at Last Mountain Lake, Saskatchewan, in 2009 flooded two Western Grebe colonies, forcing the grebes to relocate and rebuild nests, and perhaps causing some individuals to leave the lake entirely (Calvert 2009). Conversely, long-term stabilization of water levels can lead to changes in wetland vegetation that adversely affect Western Grebe productivity (La Porte 2012).

Introduction of non-native fish can negatively affect Western Grebes in a variety of ways. At Delta Marsh, Manitoba, non-native carp (*Cyprinus carpio*) may be reducing Western Grebe productivity in several ways (La Porte 2012). A direct effect was destruction of 41 Western Grebe nests by spawning carp (La Porte 2012). Additionally, carp resuspend sediments and uproot vegetation, increasing water turbidity, and thereby perhaps decrease the foraging success of Western Grebes, which are highly visual piscivores (La Porte 2012). Carp are also known to reduce abundance and diversity of macrophytes and thus may decrease available nesting habitat (La Porte 2012). Introduced fish also may reduce availability of prey fish (Feerer and Garrett 1977; Hanus *et al*. 2002b).

Recreational and commercial fishing activity can cause direct mortality of Western Grebes. In the 1970s, nearly 100 Western Grebe carcasses were recovered in a single week from fishers on Lake Winnipegosis, Manitoba (Nuechterlein pers. comm. *in* O'Donnel and Fjeldsa 1997), and in 2009 and 2010, 64 Western Grebes drowned in gillnets at Delta Marsh (La Porte 2012). At Lac La Biche, Alberta, about 80 adult Western Grebes drowned in nets set for fish during May and June 2006 (Miller pers. comm. *in* Kemper *et al*. 2008) and it is estimated that up to 100-150 grebes die annually in fishing nets at Lac La Biche (Davis pers. comm. *in* ASRD/ACA 2013). This source of mortality may be more widespread (Wollis and Stratmoen 2010), and should be quantified on lakes where fisheries occur during the breeding season. Spring fisheries involving nets set near Western Grebe colonies may be particularly problematic, but summer fisheries may also be harmful (Wollis and Stratmoen 2010). Grebes can also become entangled in discarded fishing line (Storer and Nuechterlein 1992; Hanus *et al*. 2002a; Berg *et al.* 2004; Ivey 2004).

Declines in numbers of Western Grebes breeding on some Alberta lakes may be caused by decreases in prey fish due to combined effects of winterkill (linked to low water levels) and eutrophication (Kemper *et al*. 2008; Wollis and Stratmoen 2010). A near complete winterkill of minnows at Delta Marsh, Manitoba caused the colony site to be abandoned for a breeding season (Nuechterlein pers. comm. *in* Allen *et al*. 2007). Access to prey fish could also be reduced by the presence of the invasive aquatic plant watermilfoil (*Myriophyllum* spp.), which is abundant on some lakes with Western Grebe colonies and can restrict the extent of open water available for foraging (Burger 1997). However, grebes also use floating watermilfoil mats as a nesting substrate (Burger 1997); the impact of this invasive plant remains uncertain and requires further study.

While chemical pollution and contaminants do not seem to be a significant threat in most Canadian breeding areas, Western Grebe productivity has been reduced by pesticide application at breeding lakes in California (Feerer and Garrett 1977). Rotenone treatment to eradicate 'non-desirable' fish species can also reduce prey available (Allen *et al*. 2007). In August 2005, 700,000 L of bunker fuel and pole-treating oil spilled into Wabamun Lake, Alberta, after derailment of a CN train and at least 368 Western Grebes, mainly adults, were directly affected (ASRD/ACA 2006). Of these, 333 were found dead or were euthanized and 35 were rehabilitated and released (ASRD/ACA 2006). While events like this are rare, at least 69% of the breeding population at Wabamun Lake (once a nationally important breeding site) was lost due to that single oil spill (ASRD/ACA 2006).

Western Grebe mortality due to avian botulism (Types C and E) and avian cholera has been documented in the U.S. (Ivey 2004). It is unknown whether these diseases pose a significant threat to Western Grebes in Canada, but the geographic area affected by these diseases has been increasing (Friend *et al*. 2001).

Wintering

Oil spills are thought to be one of the most serious threats to Western Grebes while they are in marine waters (Storer and Nuechterlein 1992). From 1971 to 2005, there were documented mortalities of over 9700 Western Grebes associated with oil spills along the coasts of Washington, Oregon and California, with actual mortality likely much higher (Gaydos and Nysewander in prep.). In oil spills on the Pacific coast from British Columbia to California, the Western Grebe is one of the most commonly killed bird species (Ivey 2004) and a single oiling incident in California in 2005 (the Ventura Oiled Bird Incident) killed about 2500 *Aechmophorus* grebes (Humple *et al*. 2011). In addition to large spills, Western Grebes are also likely affected by low-volume chronic oil pollution (Burger 1993). As high-level predators, Western Grebes are possibly at risk due to bioaccumulation and biomagnification of toxins, and exposure to contaminants, particularly mercury, should be examined (Elliott pers. comm. *in* Anderson *et al*. 2011). In Western Grebes collected in British Columbia from 1988-1993, concentrations of chlorinated hydrocarbon contaminants were at or above levels reported to cause toxicological effects in other species (Elliott and Martin 1998).

Although systematic studies of the diet of Western Grebes are lacking, they are mainly piscivorous (Lawrence 1950; Johnsgard 1987; Storer and Nuechterlein 1992). Declines in Western Grebes in the Salish Sea may be linked to changes in the abundance and availability of preferred prey species and size classes (Wilson *et al*. 2013). Declines in abundance were detected in all feeding guilds of marine birds in the Salish Sea from 1978/79 to 2003-2005, but piscivores showed the highest number of declines (Bower 2009). However, in each guild (except planktivores), there were also species that increased in abundance, suggesting that prey availability was not the only important factor.

There have been two documented cases of mass marine bird mortalities caused by harmful algal blooms on the Pacific coast; Western Grebes were one of the species most commonly recovered (Jessup *et al*. 2009; Phillips *et al*. 2011). In both incidents, large blooms of a dinoflagellate (*Akashiwo sanguinea*) produced a proteinaceous film that fouled plumage, compromising waterproofing and leading to death and debilitation, with symptoms similar to those observed in oiling events (Jessup *et al*. 2009; Phillips *et al*. 2011). Harmful algal blooms may be increasing in frequency and are possibly linked to changing climate or oceanographic conditions (Jessup *et al*. 2009).

Wintering Western Grebes are caught as bycatch in gillnet fisheries in British Columbia (Hamel *et al*. 2009), but annual mortality from this threat is unknown. Gillnetting is a serious problem for many grebe species around the world (O’Donnel and Fjeldsa 1997) and this risk merits further study (Burger 1997; Gaydos and Nysewander in prep.). Western Grebe carcasses have also been recovered from derelict fishing gear in Washington, but again, the extent of this impact is unknown (Gaydos and Nysewander in prep.).

Predation by Bald Eagles on Western Grebes may have increased in recent decades. Bald Eagle populations have increased in coastal areas over the past 40 years, and at the same time some traditional prey species (e.g., Pacific salmon [*Oncorhynchus* spp.] and herring) of eagles have declined (Anderson *et al*. 2011).

There are currently no offshore wind farm developments on the west coast of North America, but there is widespread interest in developing this energy resource. Studies on the effects of wind turbines on grebes are lacking, but a wind farm sensitivity index for seabirds has been developed (Garthe and Huppop 2004). This index was intended for use in Europe, but both grebe species considered (Great Crested Grebe and Red-necked Grebe) ranked moderately high on the species sensitivity index (Garthe and Huppop 2004). The high ranking was due to factors such as low flight manoeuvrability, susceptibility to disturbance, habitat requirements and limited population size (Garthe and Huppop 2004).

While Western Grebes appear to be sensitive to disturbance by human activity during breeding, it is unknown whether disturbance is a significant factor during winter, and further study is required. Western Grebe declines in British Columbia have accelerated in recent years (Wilson *et al*. 2013), including in some areas where disturbance is either low and/or has not likely changed during the relevant time period (e.g., Indian Arm and some areas of Puget Sound).

Christmas Bird Count data indicate that the continental abundance of Clark's Grebes changed very little between 1990 to 2010 (1.20%/year; 95% CI: -1.17, 3.50), while decreases in the numbers of Western Grebes in the Salish Sea have been particularly steep since the late 1980s (Wilson *et al*. 2013). This could suggest that factors contributing to declines (1) are more acute in the northern portion of the combined range of these species (where Western Grebes are much more common) and/or (2) affect habitat components that are more heavily relied upon by Western Grebes. The degree of ecological segregation between the two species has not been well-studied, but Clark's Grebes may forage in deeper water farther from shore (Ratti 1985; Nuechterlein and Buitron 1989) and consume smaller fish (Feerer 1977 in Nuechterlein and Buitron 1989) than Western Grebes.

Migration

Threats to Western Grebes during migration are mostly unknown. Migration routes are poorly understood, stopover sites have not been systematically documented, and virtually nothing is known about fidelity to stopover sites or habitat requirements at those sites.

Number of Locations

For the purposes of this report, location refers to a geographically or ecologically distinct area in which a single threatening event can rapidly affect all present individuals of the species. Location should be defined by the most serious plausible threat, if the species could be affected by more than one threatening event (IUCN 2011).

<u>Breeding</u>

The most serious plausible threats to Western Grebes during the breeding season are habitat degradation, direct human disturbance, and declines in forage fish availability. These threats would likely occur at the scale of a single lake, thereby affecting a single colony in most cases, or potentially several colonies on one lake. Based on surveys from 1970-2011, there are up to 110 possible breeding colony sites in Canada: 5 in British Columbia; 60 in Alberta, 24 in Saskatchewan, and 21 in Manitoba (Anderson *et al*. 2011; Wilson and Smith 2013; see Appendix A). There is some uncertainty in the exact number of sites for several reasons: (1) some colonies identified during 1970-1990 have not been surveyed in more recent years so it is unknown whether they still persist; (2) Western Grebes have been observed on some lakes during the breeding season, but definitive breeding evidence (i.e., eggs or young) has not been identified; (3) some colony locations have changed; and (4) some colonies are inactive for a period and then are re-established. In Manitoba, the larger lakes support several colonies, which are counted separately: 3-4 on Lake Winnipeg, 2-4 on Lake Manitoba (including Delta Marsh, which itself has several sub-colonies), and 1-2 on Lake Winnipegosis (Wilson and Smith 2013).

Wintering

Delineating wintering sites for Western Grebes in coastal areas is challenging. Oil spills are likely the most threatening event for Western Grebes in coastal areas. A spill could rapidly affect most or all individuals in an impacted area. The distribution of Western Grebes wintering in coastal British Columbia has changed in recent decades (Anderson *et al*. 2011; Wilson *et al*. 2013), and further surveys are required to determine which areas are currently being used, as well as intra- and interannual site fidelity. This information could be used in combination with models predicting the size, extent, and probability of oil spills in the region to then estimate the number of locations occupied by Western Grebes. Threats to Western Grebes on coastal areas are poorly quantified, and it is possible that other threats (e.g., reductions in prey availability, fisheries bycatch) should be considered in determining number of locations. It is possible that the number of locations for Western Grebes wintering in Canada is lower than the number of breeding locations, but the latter is currently judged to be the best feature for assessment purposes.

PROTECTION, STATUS AND RANKS

Western Grebes are protected in Canada under the *Migratory Birds Convention Act, 1994* (Government of Canada 2012) and are protected by similar legislation in the United States under the *Migratory Bird Treaty Act* (USFWS 2012). These acts confer protection on birds and their nests and eggs.

In British Columbia, the Western Grebe is on the provincial Red List but has not been designated as Endangered or Threatened under the *Wildlife Act* (Government of British Columbia 2012a). The BC Conservation Framework gives Western Grebes priority level 1 under its third goal, the maintenance of the diversity of native species and ecosystems (Government of British Columbia 2012b). In Alberta, the Western Grebe was designated as a Species of Special Concern in 2007 (Gutsell pers. comm. 2013) and it has been ranked as Sensitive since 2000 (reaffirmed in 2010) in the General Status of Alberta Wild Species (Government of Alberta 2001, 2011). Under the province’s *Wildlife Act,* the Western Grebe is protected as a Non-game Animal, which confers protection on individuals and nests from activities such as hunting, disturbance and trafficking (Gutsell pers. comm. 2014). More recently, Alberta’s Endangered Species Conservation Committee has recommended that the Western Grebe be designated under the *Wildlife Act* as Threatened, based on population declines and significant threats (Gutsell pers. comm. 2014). The Western Grebe is not included on the Saskatchewan list of Wild Species at Risk under *The Wildlife Act, 1998* (Saskatchewan CDC 2012b). It is not listed as a Species at Risk under the Manitoba *Endangered Species Act* (Government of Manitoba 2012a).

On the global IUCN Red List, Western Grebe is ranked as Least Concern, because of its large range and population size; although its numbers appear to be declining, the declines are not considered rapid enough to merit listing as Vulnerable (BirdLife International 2012). The NatureServe status (last reviewed in 1996) is Globally Secure (G5) and the Canadian breeding population is also ranked as Secure (N5B), but the Canadian nonbreeding population is considered Vulnerable (N3N; NatureServe 2012). The Canadian Western Grebe population is ranked nationally as Secure by the Natural General Status Program (Canadian Endangered Species Conservation Council, 2011). See Table 4 for NatureServe rankings and General Status (GS) ranks by province.

Table 4. Conservation status of the Western Grebe (*Aechmophorus occidentalis*) according to NatureServe and the Canadian Endangered Species Conservation Council.

Region	NatureServe Rank[a]	CESCC Status
Global	G5	NA
Canada	N5B, N3N	Secure
British Columbia	S1B, S2N	May Be At Risk
Alberta	S3	Sensitive
Saskatchewan	S5B	Secure
Manitoba	S4B	Secure

[a] G=global, N = national, S = subnational; 1 = critically imperiled, 2 = imperiled, 3 = vulnerable, 4 = apparently secure, 5 = secure; B = breeding, N = nonbreeding.

In the North American Waterbird Conservation Plan, Western Grebe is identified as a species of Moderate concern (Kushlan *et al*. 2002). Although the population is deemed apparently stable, there are significant potential threats during both breeding and nonbreeding periods (Kushlan *et al*. 2002). In Canada's Waterbird Conservation Plan, Western Grebe is assigned Tier 1 priority despite a ranking of Moderate concern (Milko *et al*. 2003). The Northern Prairie and Parkland Waterbird Conservation Plan ranks the Western Grebe as a species of high concern (Beyersbergen *et al*. 2004). Additionally, the Western Grebe is a priority species in Bird Conservation Regions (BCRs) 5, 6, 9, 10 and 11 (Northern Pacific Rainforest, Boreal Taiga Plains, Great Basin, Northern Rockies, and Northern Prairie and Parkland, respectively). In the Intermountain West Waterbird Conservation Plan, Western Grebes were identified as high concern in BCRs 9 and 15 (Sierra Nevada) and moderate concern in BCRs 10 and 16 (Southern Rockies/Colorado Plateau).

In the United States, both the breeding and nonbreeding populations of Western Grebes are ranked as nationally secure (N5B, N5N, respectively), but have not been reviewed since 1997 (NatureServe 2012). Its status is: Critically Imperilled (S1) in two states (on the eastern periphery of their range), Imperilled (S2) in one state, Vulnerable (S3) in six states, Apparently Secure (S4) in six states, and unranked in 3 states (one of which is California, an important part of both the breeding and non-breeding range). In most of the non-breeding range in the United States, Western Grebes are ranked as Vulnerable (S3) but are again unranked in California (NatureServe 2012). Of the states in which the Western Grebe occurs throughout the annual cycle, Washington has listed it as a State Candidate on the Species of Concern List (Washington Department of Fish and Wildlife 2012) and California has designated it a species of “high concern” (Ivey and Herziger 2006). In Minnesota and Idaho, Western Grebes are considered a Species of Greatest Conservation Need (Idaho Fish and Game 2012; Minnesota DNR 2012a,b).

Habitat Protection and Ownership

Of the 80-100 breeding colonies in Canada, 40 are on lakes adjoining or within provincially protected areas (wildlife management areas, provincial parks, or bird sanctuaries), 2 are in federal Migratory Bird Sanctuaries, and 1 is in a national park. Of lakes that adjoin protected areas, often only a small portion of the shoreline is protected. Exact location data were not available for all colonies, so in some cases it is unclear whether colony sites are within protected areas. As Western Grebe breeding colony locations often change, habitat protection can be challenging.

Protection of Western Grebe breeding habitat is variable throughout its Canadian range. In British Columbia, the Creston Valley Wildlife Management Area (CVWMA) contains a relatively well-protected colony. However, CVWMA staff has little control of water levels, which are manipulated for flood prevention (Burger 1997). The colony near Salmon Arm on Shuswap Lake is protected by a boom that keeps powerboats out of the nesting area, and the colony is adjacent to 23 ha of land owned by the Nature Trust and the District of Salmon Arm and managed by the Salmon Arm Bay Nature Enhancement Society (Burger 1997).

In Alberta, of the Western Grebe colonies located during 1991-2011 (Wilson and Smith 2013), 30 were on lakes with no provincial or federal protection and First Nations reserves border five of these lakes. Ten of these colonies have supported 100-1000 breeding adults and two of them have colonies of >1000 adults. Thirteen lakes with colonies are adjacent to provincial parks, five colonies are on lakes with provincially designated natural areas, two colonies are on lakes that have both provincial parks and natural areas, and two colonies are on lakes with provincial recreation areas. Of the colonies on lakes partially surrounded by provincial parks or natural areas, five have supported 100-1000 breeding adults and five have supported >1000 breeding adults. First Nations reserves also border two of these lakes. Most of the provincial parks and natural areas protect only small stretches of the shoreline. One exception is at Lesser Slave Lake (>3700 breeding adults), where most of the north shore of the lake is protected by a combination of provincial parks and reserves, including Lesser Slave Lake Wildlands Provincial Park (Alberta Parks 2012). One of the largest Western Grebe colonies in Alberta is at Lac La Biche (>4600 breeding adults), the islands of which make up Sir Winston Churchill Provincial Park (Alberta Parks 2012). Although the importance of this lake for nesting waterbirds has been federally and provincially recognized, there are concerns that current protection is insufficient, and that recreational use and shoreline development are disturbing nesting colonies (IBA Canada 2012a). There is an ongoing effort to establish Protective Notations (PNTs) and seasonal sanctuaries for Western Grebe colonies on public lands in Alberta (Wollis and Stratmoen 2010), and PNTs have been established or applied for at all Western Grebe colonies in central and northwestern Alberta (ASRD/ACA 2013). However, much of the land adjacent to colonies is private, and so habitat protection is challenging (ASRD/ACA 2006). In central Alberta, eight of the ten largest Western Grebe colonies face threats such as shoreline development, recreational vehicle activity, agricultural development, fish winterkill, water level fluctuations, and petroleum spills (Kemper *et al*. 2008).

In Saskatchewan, colonies are protected within the Last Mountain Lake National Wildlife Area and Migratory Bird Sanctuary and the Old Wives Lake Migratory Bird Sanctuary (Environment Canada 2012). However, habitat at Old Wives Lake has changed significantly and the colony has not been sighted in several years (Calvert pers. comm. 2013). A colony at Valeport Marsh at the southeast end of Last Mountain Lake may fall within a provincial game preserve and Valeport Marsh has been designated an Important Bird Area (IBA Canada 2012b), although this does not confer any protection. Buffalo Pound, Crooked, Echo, Pasqua, Good Spirit, Katepwa and Waterhen lakes are partially bordered by provincial parks but Lac Des Îles is the only lake fully surrounded by a provincial park. In most provincial parks in Saskatchewan, powerboats and other recreational activities are permitted (Saskatchewan Parks 2012).

In Manitoba, the large colonies at Delta Marsh and Marshy Point, both on Lake Manitoba are fairly well protected; the 11,275 hectare Delta Marsh Wildlife Management Area includes most of the wetland complex and Marshy Point is protected by a 975 hectare Wildlife Management Area and a 15,110 hectare refuge on private ranch land. A third large colony on Lake Manitoba has not been surveyed recently, and it is unknown if it is still used; this site is not protected. The other large Manitoba colonies at Waterhen River and Netley Marsh, on Lake Winnipegosis, are not protected. Smaller colonies are in protected areas at Camp Morton and Hecla/Grindstone Provincial Parks; Dog Lake Wildlife Management Area (also a game bird refuge and the Dog Lake Islands have been recommended as an Ecological Reserve); and a recently identified potential colony site is in the Whitewater Lake Wildlife Management Area (Government of Manitoba 2012b; Wilson and Smith 2013). North Shoal Lake, which is unprotected but identified as an Important Bird Area (IBA Canada 2012), formerly supported a colony although no breeding Western Grebes were found there in 2012 (Calvert and Wilson, unpubl. data).

The Gulf Islands National Parks Reserve and the proposed Southern Strait of Georgia National Marine Conservation Area encompass areas that formerly supported large numbers of Western Grebes during winter (Parks Canada 2012).

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Rian Dickson recently completed an MSc at the Centre for Wildlife Ecology, Simon Fraser University. Her graduate worked focused on ecology of Surf and White-winged Scoters moulting on the Pacific coast of North America. She has worked on studies of both breeding and non-breeding sea ducks, as well as marine birds and mammals in British Columbia, Alaska, the Northwest Territories, Nunavut, Quebec, and Mexico. Rian has also worked as an educator at the Bamfield Marine Sciences Centre, and is interested in the social as well as ecological aspects of conservation and wildlife management.

Eric M. Anderson holds a faculty position in the Ecological Restoration Program at the British Columbia Institute of Technology, and is a Research Fellow of the Pacific WildLife Foundation. He is also the instructor of *Ecology and Conservation of Marine Birds and Mammals* at the University of Washington, Friday Harbor Labs. He received a BSc from the University of Puget Sound, and an MSc. and PhD in Zoology and Physiology from the University of Wyoming. His graduate, post-doctoral, and ongoing studies have focused on the marine ecology of nearshore marine birds along the Pacific coast. He is particularly interested in delineating the foraging strategies and habitat needs of marine birds within the context of increasingly urbanized marine habitats. Eric's post-doctoral position at the University of British Columbia entailed working with Peter Arcese to coordinate a multi-partner assessment of Western Grebe status in British Columbia. This entailed identifying critical information gaps, replicating historical surveys, organizing a focal meeting of regional experts to identify priorities for monitoring and research, and writing a status review for submission to Environment Canada (cited in this status report as Anderson *et al*. [2011]). Together with colleagues and students in the Ecological Restoration Program at BCIT, he helped initiate a project in 2012 to restore the seven estuaries that enter Burrard Inlet (Vancouver Harbour).

Dr. Dan Esler is a researcher with the Centre for Wildlife Ecology at Simon Fraser University, British Columbia, Canada. He leads a research program addressing waterfowl and waterbirds throughout western North America. Dr. Esler received his PhD from Oregon State University, an MSc from Texas A&M, and a BSc from Northland College, Wisconsin. Prior to his current position with SFU, Dr. Esler was employed by the U.S. Fish and Wildlife Service and the U.S. Geological Survey as a federal research scientist. Dr. Esler has long-standing interests in spatial ecology and population delineation, as well as population ecology of migratory birds. Among his current projects, Dr. Esler is evaluating Western Grebe population structure, as part of a research consortium addressing causes of observed numerical declines of Western Grebes.

Appendix A

Table A.1 Maximum counts of Western Grebes (may include non-breeding individuals) at breeding sites in British Columbia during June – August (Burger 1997; Anderson *et al*. 2011). Asterisks denote counts with only non-breeding adults and no suspected or confirmed breeding.

Site	1970-1990	1991-2011
Williams Lake[a]	28*	
Salmon Arm, Shuswap Lake	~200	~250
Swan Lake, Vernon[b]	60	6*
Okanagan Lake	70[c]	95
Creston Valley WMA	90 nests	141

[a] Breeding last reported in 1964.
[b] Breeding last reported in 1966, except for one brood observed in 1990.
[c] Maximum nest count was 83.

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Table A.2 Maximum counts of breeding Western Grebes at sites in Alberta during 1970-1990 and 1991-2011. Surveys were generally conducted during the nesting period in June and July. Note that 0 represents cases where the most recent survey in a time interval was conducted and no Western Grebes were found. A blank cell indicates no survey data were collected in that time interval.

Site	1970-1990	1991-2011
Angling Lake	1680	60
Big Lake	3	0
Blood Indian Creek Reservoir		3
Brock Lake		6
Buck Lake	63	32
Buffalo Lake		1030
Cardinal Lake	100	30
Coal Lake		6
Cold Lake	2012	1876
Conn Lake		300

Site	1970-1990	1991-2011
Cooking Lake		7
Crow Indian Lake		100
Deadhorse Lake		9
Dinosaur Provincial Park	1	
Driedmeat Lake	3	5
Eagle Lake	500	
Ethel Lake	84	0
Fincastle		47
Fork Lake		11
Frog Lake	750	600
Garner Lake	102	0
Gleniffer Lake		10
Gull Lake		320
Hastings Lake	225	440
Horsefly Res.		12
Isle Lake	138	228
Lac La Biche	3124	4612
Lac La Nonne	13	40
Lac Sante	50	150
Lac Ste. Anne	1256	1268
Lake Newell and Kitsim Reservoir		500
Lesser Slave Lake	1300	3742
Little Fish Lake	300	
Louisiana Lakes Res.		30
Manatokan Lake		9
Marguerite Lake	120	
Missawawi Lake		55
Moose Lake	400	376
Muriel Lake	386	760

Site	1970-1990	1991-2011
Murray Lake		107
Namaka Lake	500	
North Buck Lake		124
Pakowki Lake	12	present
Pigeon Lake	100	20
Pine Lake	6	3
Reita Lake	532	0
Sandy Lake		150
Seven Persons Lake		2
Shanks Lake		140
Skeleton Lake		25
Stobart Lake	500	12
Sylvan Lake		22
Taber Lake		2
Thunder Lake	273	3
Tilley 'B' Reservoir		100
Tyrell Lake		2
Utikuma Lake	206	1680
Wabamun Lake	184	1510
Winagami Lake		8
Wolf Lake	720	79

Table A.3 Population sizes of Western Grebes in Saskatchewan during 1970-1990 and 1991-2011 based on the maximum observed count at each site. Numbers refer to breeding adults observed on each lake during the nesting period. Asterisks denote sites with only non-breeding adults and no suspected or confirmed breeding.

Site	1970-1990	1991-2011
Buffalo Pound Lake		250
Crooked Lake		40
Deep Lake		34*
Doré Lake		800
Echo Lake		44
Fife Lake	300	0
Fishing Lake		76
Good Spirit Lake		105
Highfield Reservoir		60
Katepwa Lake		74
Lac Des Îles		327
Lake Diefenbaker	300	0
Last Mountain Lake		510
Lenore Lake		15*
Mud		14*
Mission Lake		53
Old Wives Lake		50
Pasqua Lake		86
Paysen Lake	300	0
Pelican Lake	50	30*
Round Lake		25
Saskatoon Area	277	
Thomson Lake		13*
Turtle Lake		100
Waterhen Lake		348

Table A.4 Population sizes of Western Grebes in Manitoba during 1970-1990 and 1991-2011 based on the maximum observed count at each site. Numbers refer to the estimated number of breeding adults on each lake during the nesting period.

Site	1970-1990	1991-2011
Between Fuller and R. Gazon Bays, Lake Winnipegosis	500	
Camp Morton Provincial Park, Lake Winnipeg		2
Delta Marsh	488	632
Dog Lake		100
Gimli Marshes, Lake Winnipeg	400	0
Hecla Island	140	
Inland Lake	400	
Lake Manitoba	100	
Lake Winnipeg	44	100
Lake Winnipegosis	1084	
Marshy Point, Lake Manitoba	4800	5798
MB BBA 2010, ID120432&120436		20
Netley Marsh, Lake Winnipeg	1266	1200
Oak Hammock Marsh	10	
Oak Lake/Plum Lake		12
Pelican Lake	88	100
Sandy Bay Marshes, Lake Manitoba	1000	
Shoal Lakes	800	100
Skylake	0	5
Swan Lake	200	0
Waterhen River, Lake Winnepegosis	800	594