

# *British Columbia Birds*



*Special Issue*

*Internationally important bird populations  
on the Fraser River Delta, British Columbia*

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## ***British Columbia Birds***

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**Front cover:** A murmuration of Dunlin over Boundary Bay, 11 November 2019 (Photo: Kate Paton). Flocks exceeding 120,000 birds have been recorded on the Fraser River delta. In addition to feeding on the mud and sand flats of the delta, Dunlin spend a large proportion of their time in terrestrial habitats, primarily farmlands (see page 31).

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# The status, ecology and conservation of internationally important bird populations on the Fraser River Delta, British Columbia, Canada

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**Abstract:** Approximately 1.7 million waterbirds and raptors used the Fraser River Delta annually between 1999 and 2019: 1.6 million chiefly frequented tidal flats, 207,000 used floodplain and 79,000 used estuarine habitats. Twenty-nine species occurred in globally, continentally or nationally significant numbers and 26 species are currently designated as national Species at Risk. A total of 263 species of birds, or nearly half of all 550 species of birds reported for British Columbia, occurred annually on the delta. We provide a Conservation Priority List for 69 species of birds that were designated as either globally, continentally or nationally important as identified by the Important Bird and Biodiversity Areas Program, Species at Risk under the federal Species at Risk Act, or on the provincial Red or Blue Lists. Industrial areas supported an estimated 35% of the natural floodplain avifauna compared to 59% in residential areas and 88% in farmland. Since the early 1990s much of the farmland has been under voluntary wildlife stewardship programs. Many important habitats have been designated for conservation purposes since 1987 with favourable results for most species. Birdwatching is estimated to bring \$11M annually into the local economy. We recommend a partnership of stakeholders be established to guide use of the delta to ensure birds are conserved for economic, social and cultural values.

**Key words:** Fraser River Delta, populations, Species at Risk, Biosphere Reserve, bird watching, conservation.

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## Introduction

The Fraser River Delta on the west coast of Canada is visited annually by approximately 260 species of birds whose combined ranges encompass much of the western hemisphere. The migratory flights across the delta connect to the Amazon Rainforest, the Atlantic and Pacific Coasts, the Canadian High Arctic, Russian Far East, and points in between.

The significance of the Fraser River Delta for birds of the western hemisphere became apparent over three decades ago in a review by Butler and Campbell (1987) who made a case that the delta met or exceeded criteria of many international conservation conventions. Following legal and civil challenges several habitats used by the delta's birdlife were assigned the highest conservation des-

ignations (Murray 2008). Since Butler and Campbell's (1987) publication, much has been learned about species of conservation interest, and new information prior to 1987 has come to light. Moreover, attitudes have changed about the values of birds in particular, and nature in general as well as a wider appreciation of the cultural connection of Indigenous people to the delta.

The written record for birds on the Fraser River Delta is only about 200 years old but the unwritten records that exist in remains of birds deposited by Coast Salish people outside their villages and harvesting sites along the Stó:lō (Fraser) River are centuries or millennia-old (Hobson and Driver 1989, Trost 2005, Murray 2008). People living on the delta from the time of its origins c.10,000 years ago developed a culture connected to the natural world which included birds (Vancouver 1798, Leach 1982, Suttles 1987). Nineteenth century natural historians commented on the

abundance of birds on the Fraser River Delta (Wark 1824, Lord 1866, Anderson 1884, Fannin 1891) and 20<sup>th</sup> century biogeographers expanded our knowledge of bird distribution in the province with notes about the Fraser River Delta (Kermode 1904, Brooks and Swarth 1925, Munro and Cowan 1947, Campbell *et al.* 1990a,b). Cumming (1932) summarized the status of birds in the vicinity of Vancouver, including the Fraser River Delta. Diet studies of birds were published by mid-century (*e.g.* Cowan 1942, Taylor 1950), citizen-science began with the Christmas Bird Count starting in Ladner in 1957, and Cumming (1932) and Benson (1961) described many of the species present and commented on their abundance. In the 1970s, annotated lists of birds of the Vancouver region including the Fraser River Delta were published (Campbell *et al.* 1972a,b; 1974). Vermeer and Levings (1977) described the distribution of waterfowl in the delta and Leach (1982) had made a plea to preserve wetlands for waterfowl.

Following Butler and Campbell's (1987) review a plethora of biogeographic surveys and ecological studies were done on the birds of the delta (*e.g.* McEwan and Whitehead 1984, Vermeer and Butler 1989, Butler 1997, Sullivan 1998, Evans-Ogden *et al.* 2005, Pomeroy 2006) and on contaminants in birds on the delta (*e.g.* Elliott *et al.* 1989, 1996, 1998a, Hart *et al.* 1991). Among the biogeographic studies was a year-round citizen-science survey of coastal birds on the Fraser River Delta (Butler and Canning 1989) followed by the Coastal Waterbird Survey (CWBS) coordinated by Birds Canada begun in 1999 (Badzinski *et al.* 2008, Ethier *et al.* 2020). Campbell *et al.*'s (1990a,b; 1997; 2001) and Davidson *et al.*'s (2015) province-wide reviews included in-depth information on the biology, distribution and abundance of birds on the Fraser River Delta.

The conservation issues facing the birds of the Fraser River Delta are extensive and not unlike many other estuaries in the world (Kehoe *et al.* 2020). Loss of original native habitat to agricultural, industrial and urban development naturally alters the composition of species that live there and is a major cause for loss of biodiversity and extirpations (Er *et al.* 2005). Two emerging events that lend additional support for biodiversity conservation is mounting evidence of health benefits derived from spending time in nature (Sandifer *et al.* 2015, Aerts *et al.* 2018, Methorst *et al.* 2020) and the economic potential of birdwatching (U.S. Fish and Wildlife Service 2013). With the abundance of birds, and the potential health benefits and increased interest in birdwatching, an opportunity has arisen to develop a new vision that sustains birds on the Fraser River Delta. Our purpose is to summarize current understanding of birds and propose measures to ensure ongoing conservation of the Fraser River Delta for its ecological, economic and cultural values.

## Study Area and Methods

### Study Area

In this report, the Fraser River Delta includes both the deltaic geological deposits and the overlying marine and fresh water, at the mouth of the Fraser River and in Boundary Bay (Clague *et al.* 1983). While some of the geological and ecological features of the Fraser River Delta and estuary extend onto the USA side of the border, the majority of the study area is within the jurisdiction of Canada.

The study area includes the land and water from Point Grey east to Annacis Island, south to the former floodplain farmlands along the Serpentine and Nicomekl river valleys and Crescent Beach, and Semiahmoo and Boundary Bay west beyond Roberts and Sturgeon to the drop off in about 2–300 m of water 3–5 nautical miles (5.6–9.3 km) from the shore at the lowest tide (Figure 1).

The Fraser River Delta's 885 km<sup>2</sup> footprint is made up of three major habitats that we refer to throughout this report as floodplain, tidal flat and estuarine (Figure 1). The floodplain is about 39,000 ha of deltaic deposits that historically were inundated during river flood and high tides (Table 1). We included the glacial deposits at Tsawwassen in this category even though they did not flood. The tidal flat includes the tidal portion of the Fraser River as far east as New Westminster, and the intertidal portion of Semiahmoo, Mud and Boundary bays, and Roberts and Sturgeon banks. The outer perimeter of the approximately 27,000 ha of tidal flat of the delta is about 27 km long at the mouth of the river and 13 km in Boundary Bay (Clague *et al.* 1983). The approximately 34,000 ha of estuarine habitat is defined as the subtidal waters off the mouth of the Fraser River to a 200–300 m depth, all of subtidal Boundary Bay, and the Fraser River to New Westminster.

### Floodplain

About 13,000 ha of agricultural land in Richmond and Delta are either planted in berries, vegetables, hay, turf and pastures, and left fallow, or covered with greenhouses to grow vegetables and cannabis (Table 1). Town centres in Richmond, Ladner, Tsawwassen and Tsawwassen First Nations Lands are largely residential and industrial developments, interspersed with gardens and parks. Burns Bog at nearly 3000 ha is predominated by heather family (*Eriaceae*) and sphagnum (*Sphagnum* spp.) interspersed with ponds, lodgepole pine (*Pinus*) and white paper birch (*Betula*; Hebda *et al.* 2000). A few small bogs remain such as in Richmond Nature Park. On high ground, in Tsawwassen and along English Bluffs, the forest remnants are dominated by western redcedar (*Thuja plicata*), Douglas-fir (*Pseudotsuga menziesii*), broad-leaf maple (*Acer macrophyllum*) and red alder (*Alnus rubra*).

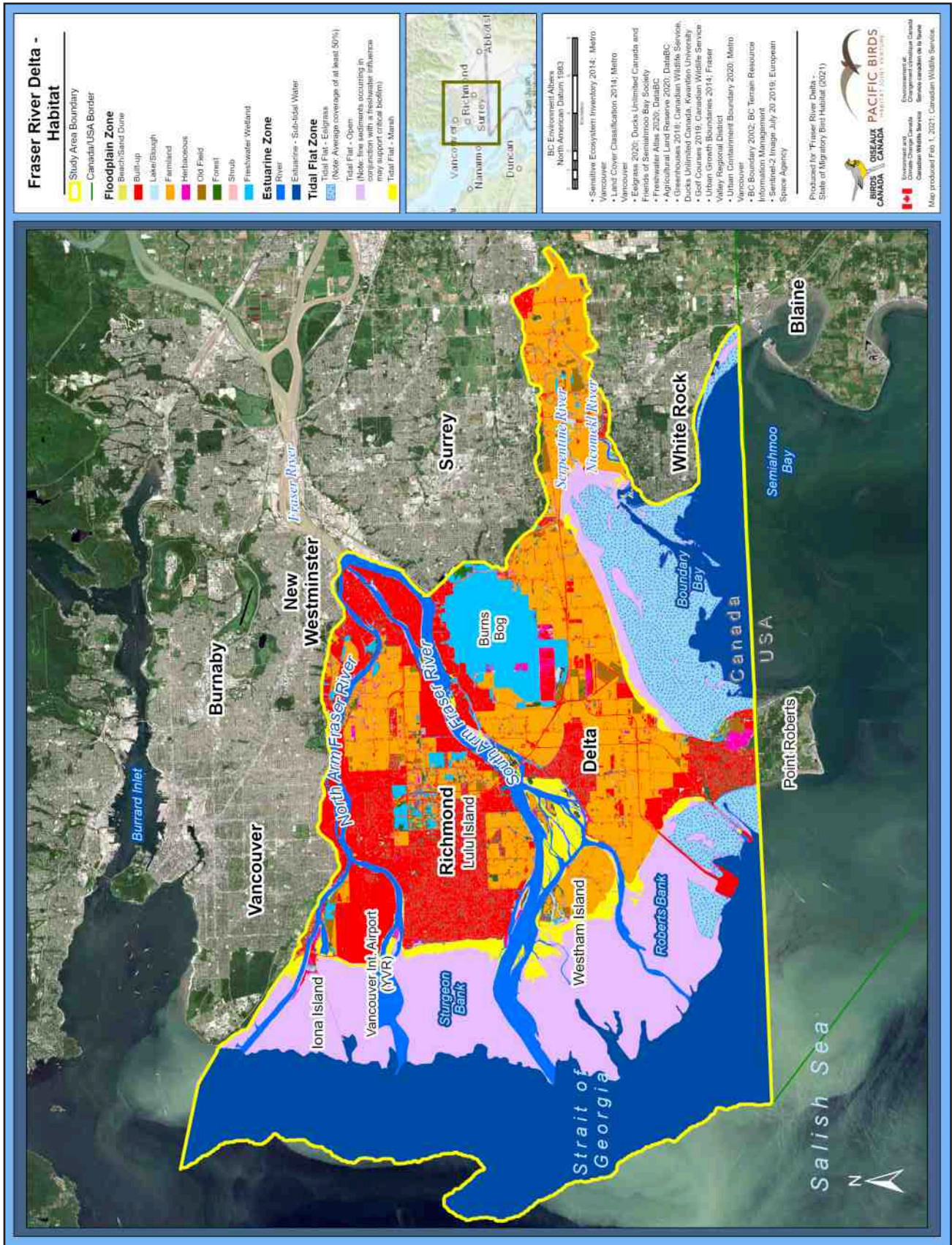


Figure 1. The Fraser River Delta study area showing extent of the floodplain, tidal flat and estuarine habitats.

Table 1. Habitat and cover type by area and percent cover of the Fraser River Delta, B.C.

Habitats	Cover Type	Hectares	Percent
Floodplain	Beach & Sand Dunes	11	<0.1
	Built-up industrial, urban, suburban	12,934	14.6
	Coniferous Forest	462	<1.0
	Deciduous Forest	2,525	2.9
	Farm Land	13,300	15.0
	Herbaceous	646	<1.0
	Shallow Water, Lakes and Sloughs	103	<1.0
	Old Field	668	<1.0
	Shrub	257	<1.0
	Wetland	3,358	3.8
	No data	53	<0.1
	Tidal Flat	Unvegetated	14,917
Eelgrass		6,828	7.7
Marsh		2,216	2.5
Estuarine	Subtidal Water	24,768	28.0
	Riverine	5,504	6.2
<b>Grand Total</b>		<b>88,550</b>	<b>100.0</b>

Fragments of floodplain riparian forest remain along the river outside of the dike such as on Lion, Gunn, and Don islands, and where the dike has been breached such as at Burnaby Foreshore Park. Floodplain riparian forests are dominated by a deciduous forest canopy of cottonwood (*Populus*), red alder (*Alnus*), and paper birch (*Betula*), and Pacific crabapple (*Malus fusca*) in remnant beach ridges (North *et al.* 1977). The understory is cascara (*Rhamnus*), salmonberry (*Rubus*), red-osier dogwood (*Cornus stolonifera*), thimbleberry (*Rubus parviflora*), snowberry (*Symphoricarpos albus*), elder (*Sambucus racemosa*), among other plants.

#### Tidal Flat

The tidal flat is hemmed along its upper edge by about 2,200 ha of brackish marsh at the mouth of the Fraser River and the river islands (Church and Hales 2007), and salt marsh on Roberts Bank and in Boundary and Mud Bays. Riverine marshes are dominated in the high marsh by cinquefoils (*Potentilla*), cattails (*Typha*), and grasses (*Agrostis*, *Distichlis*), the middle marsh by sedges (*Carex lyngbeii*; *Scirpus* spp.), and the low marsh by sedges (*Scirpus* and *Schoenoplectus*, Church and Hales 2007).

The south end of Roberts Bank and Boundary Bay hold over 6800 ha of eelgrass meadows (Table 1, Robinson and Yakimishyn 2013, Harrison and Dunn 2004). The introduced *Zostera japonica* established before 1982 (Harrison and Bigley 1982), and the native *Zostera marina* occur in Boundary Bay (Baldwin and Lovvorn 1994a).

By far, the greatest habitat on the tidal flats is the nearly 15,000 ha of unvegetated mud and sand on Roberts and Sturgeon banks and Boundary Bay (Table 1). A surface layer of microbes, organic detritus, and sediment in a mucilaginous matrix along with non-carbohydrate components secreted by microphytobenthos and benthic bacteria (Characklis and Marshall 1990) produce a biofilm that is widespread on the muddy portion of Roberts Bank and present in lesser amounts on Sturgeon Banks and in Boundary Bay (Jardine *et al.* 2015).

#### Estuarine

Deltaic sediments deposited by the Fraser River have settled in the subtidal (5–10 km) from the lowest tideline into the Strait of Georgia west of Roberts and Sturgeon banks in 200–300 m of water (Clague *et al.* 1983). The Fraser River carries sediments into the estuary clouding the estuary water often far from shore. A saltwedge penetrates up river creating estuarine conditions as far 16 km upstream of the river mouth (Neilson-Welch and Smith 2011).

#### Habitats

ArcGIS version 10.6.1 was used to estimate habitat areas in the delta from the following maps: Metro Vancouver Sensitive Ecosystem Inventory 2014 for lakes and sloughs, river, marsh, old field, freshwater wetland, and beach/sand dune; Metro Vancouver SEI 2014 and Metro Vancouver Land Cover 2014 for herbaceous; Metro Vancouver Land Cover 2014 for coniferous, deciduous, shrub, and farmland; Metro Vancouver Land Cover, Agricultural Land Reserve 2020, Urban Growth Boundary and Urban Containment Boundary, CWS map of golf courses, and CWS/Kwantlen/Ducks Unlimited Canada greenhouse maps for 'built up'; Ducks Unlimited Canada and Friends of Semiahmoo Bay Society (average coverage of at least 50%) for eelgrass; and Canadian Hydrographic Service chart 3463 for subtidal (to 200m depth) and tidal flats.

Delta Farmland & Wildlife Trust (DF&WT) estimated there was a total of 170 km of hedgerows in farmlands in Delta from Westham Island to 112<sup>th</sup> Street.

#### Abundance

Several early reports on birds that were unknown or unavailable to Butler and Campbell (1987) have come to our attention. We reviewed relevant passages on the early written record of bird life on the delta by Anderson (1884) and Benson (1961), and add new information from the City of Delta Archives and New Westminster Museum and Archives.

We derived estimates of the number of birds using the tidal flats from the 1999–2019 Coastal Waterbird Survey (CWBS) data set (Birds Canada 2020). The Survey comprises counts made from September to April when most species are abundant. We used the maximum count in any month on all surveys as our measure of the number of birds of each species of waterbird using the delta. We chose not to use averages because that would fail to account for the capacity in the numbers of birds that cross the delta each year with potentially negative outcomes for conservation and environmental assessments. For example, plans to provide enough habitat based on the average number of birds would result in an inadequate amount of habitat for years when they were more numerous.

The CWBS misses species that use the late spring and summer periods such as the nesting congregations of Great Blue Herons in May and June, and is not well designed to capture the pulse of migration by shorebirds. Where available, we used values from other surveys that more accurately depicted the true numbers present. For example, we used the number of heron nests tallied in recent years to estimate the number of herons on the delta (R. Venesland, unpublished data). For Western Sandpipers and Dunlins, we used Drever *et al.*'s (2014) estimates, for Snow Geese we used Canadian Wildlife Service surveys (W.S. Boyd, unpublished data), and for Brant we used Hagmeier *et al.*'s (2008) estimates.

We derived estimates of the number of birds using the estuarine habitats from surveys of Boundary Bay collected in 2006–07 (Middleton *et al.* 2018), and from the Fraser River estuary (Butler *et al.* 2018). Both of these surveys followed a similar protocol by tallying all birds along a fixed transect. We extrapolated the density of birds sampled along the transects to the entirety of Boundary Bay and the Fraser River Estuary to derive a total number of birds.

For the floodplain, we used unpublished counts of Bald Eagles at a roost and at the Vancouver landfill (Pers. comm., Myles Lamont, Surrey, B.C., 2019 November 28). We used Sullivan's (1992) estimate of the number of birds of prey counted in farmlands and the number of birds of prey estimated from single-day surveys of the entire IBA in November 2018 and 2019 (Birds Canada, unpublished data). Teams of observers were assigned portions of the IBA where they spent most of the day tallying all birds heard or seen.

## Population trends

To measure change in abundance since the 1980s, we compared the totals reported by Butler and Cannings (1989) survey to that of the CWBS between 1999 and 2019. In both surveys, birdwatchers estimated the numbers of birds seen on a designated day once each month along defined stretches of coastline. We assumed that totals reported by Butler and Cannings (1989) were un-

changed if they fell within the range reported on the CWBS in 1999–2019. The 1989 totals above and below the 1999–2019 range were considered to have declined and increased, respectively.

We also examined long-term trends in the 1999–2019 duration of the CWBS data set by estimating independently for each species using a Bayesian framework with Integrated Nested Laplace Approximation (R-INLA, Rue *et al.* 2014) in R (version 3.1.3; R Core Team 2014). The model estimates a continuous effect for year and fits a random effect (independent and identically distributed errors) for site and an AR1 (first order temporally autocorrelated errors) random effect for year.

Assuming a Poisson distribution of counts, year estimates and 95% credible intervals were back-transformed to annual rates of population change using  $100 \times (\exp(\text{estimate}) - 1)$ . Trends were calculated using the full dataset and are presented as %/year with lower and upper 95% credible intervals, which suggest that there is a 95% probability that the true trend falls within that range. A posterior distribution was also calculated to estimate the support for an increasing or declining trend. A value near 0.5 would suggest equal probability for an increasing and declining trend (little evidence for a change in counts over time), whereas a posterior probability near 1 will suggest strong support for the observed change in counts. The posterior probability can be used as a pseudo p-value, such that trends with a posterior probability  $> 0.9$  could be considered to have strong support. Annual indices of population size were estimated from the posterior distribution of the Poisson trend model.

## Diversity

We determined the number of species present each month from Weber *et al.*'s (2013) checklist. These authors presented bar charts for each species by month from which we recorded a species presence. Accidental records and those outside their normal range and habitat were omitted. We used species totals at 'hotspots' around the delta in eBird (2019) to compare diversity between sites.

We estimated the number of species using the delta floodplain prior to diking in the 19<sup>th</sup> century to present day farmland, residential land and industrial lands using personal knowledge of habitat use. North *et al.* (1977) described the 19<sup>th</sup> century floodplain as a mix of marsh, meadow, shrub, wetland, bog and forest types. We defined farmlands as areas of cultivated lands with adjacent hedgerows and ditches. Residential areas contained houses and roads with lawns and parks, garden shrubs and scattered trees. Industrial areas were defined as warehouses and factories with scattered lawns, shrubs and trees. We then assigned the number of Rare to Common annually occurring native species in Weber *et al.*'s (2013) checklist to each of these habitats.

## Species Accounts

We used American Ornithological Society 7<sup>th</sup> edition English and scientific names of birds (Chesser *et al.* 2019). This report focuses on species that are of national or international significance and therefore the Species Accounts deal with federally-listed species at risk, and Threshold Species in the Boundary Bay-Roberts Bank-Sturgeon Bank (Fraser Estuary) Important Bird and Biodiversity Area (IBA). The Fraser River Delta's birds meet or exceed IBA Criteria for 'Globally Significant' numbers of waterfowl, colonial waterbirds/seabirds, and shorebirds, 'Continentially Significant' numbers of Congregatory Species, and 'Nationally Significant' numbers of Threatened Species, Congregatory Species and Wading Bird Concentrations. To achieve these designations, a species must occur annually in numbers that meet or exceed 1% of a species global, continental or national population (the 'Threshold'). We also included the Sage Thrasher and Yellow-breasted Chat that are endangered species in Canada and sightings of single birds on the delta qualified them as nationally significant.

## Economic value of birding

We considered birders were people whose purpose of visiting was to see birds although they might do other things while there. Estimates of direct expenditures while birding in the Fraser River Delta were derived from tourism and visitor publications. Sexton *et al.* (2011) estimated daily expenditures of about US\$34 (C\$44) for local and US\$68 (C\$88) for out-of-region birders in Texas. Xie (2012) estimated US\$99 daily expenditures by 100,000 local and out of region visitors to Magee Marsh in Ohio. The Canadian Nature Survey (Federal, Provincial, and Territorial Governments of Canada 2014) estimated that Canadians spent an average of \$12 per day birding locally. We used the lower value of \$12/day for the Fraser River Delta where local birders typically spend half a tank of gas driving from their homes to birding locations, and stop for an inexpensive lunch at local restaurants. From our experience, out-of-region birders stay longer and eat at more expensive restaurants.

We multiplied the estimated number of birding visits by daily expenditures while in Delta (MetroVancouver Parks 2016). We used the proportion of all visits to the three major birding destinations—the George C. Reifel Migratory Bird Sanctuary, Boundary Bay, and Iona Island—to watch birds as an estimate of the number of annual birding visits. We assumed that all visits to Reifel were primarily to see birds (George C. Reifel Migratory Bird Sanctuary on line newsletter 11 April 2019). At Iona and Boundary Bay, MetroVancouver Parks (2016) did not specifically mention birdwatching so we used their 'wildlife viewing' as a surrogate measure. We assumed that 95% of all birders were local (*i.e.* Greater Vancouver) based on an estimate for Iona Island (Lees and Associates 2014).

## Results

### Habitats

John Wark (1824) on an exploratory visit for the Hudson's Bay Company in December 1824 described the Fraser River Delta as "low and flat, the bay appears to be shallow. In the river nothing but thick willows are seen for some distance from the water, where the banks though low are well wooded with pine, cedar, alder and some other trees". Sketches made a few years later and pieced together by North *et al.* (1977) showed an original delta of about equal parts of floodplain, tidal flat and estuarine habitats. By 2020, the 880 km<sup>2</sup> of the Fraser River Delta study area was about equal parts floodplain and estuarine habitats, with slightly less tidal flat (Table 1). However, flooding freshwater from the river and seawater at high tide and during spring freshet that unified these three habitats into a delta ecosystem has been greatly altered. Floodplain covers about 39% of the study area, of which about 15% is farmland, 15% suburban, urban or industrial (Table 1). About 27% of the delta area is tidal flat of which about 17% is unvegetated sand and mud tidal flat (Table 1). Water and sediment flow on the tidal flats has been extensively changed as a result of training walls, jetties and river dredging bringing sediment deposition and salinity changes allowing eelgrass meadows to become established between the B.C. Ferry Terminal and Deltaport jetties on Roberts Bank beginning in the late 1960s, with positive effects for herons and waterfowl, but a loss of sandy habitat that was a source of crabs and other food for Indigenous people, and disruption to salmon fry dispersal from the mouth of the Fraser River. The Iona Island outflow improved water quality that plagued Sturgeon Banks for years (Arvai *et al.* 2002). Over one-third of our study area was estuarine habitat, although the estuarine influence of the Fraser River was felt far beyond our study area into the Strait of Georgia (Table 1).

### Historical abundance

Humans have been part of the ecology of the Fraser River Delta for much or all of its existence. Indigenous people first inhabited the Fraser River Delta soon after the delta began to form about 10,000 years ago (Matson 1981, Clague *et al.* 1983, Murray 2008). When Europeans began to settle in the early 1800s, major Halq'emeyem towns, two villages, and 19 hamlets were recorded on the floodplain (Hayes 2005). Bird bones at some of the village sites revealed species that were present 250–1,200 years ago included Common Loons, grebes, geese, Mallards, teal, scaup, Long-tailed Ducks, scoters, goldeneyes and/or Buffleheads, mergansers, Bald Eagles, coots, gulls, shorebirds, crows, blackbirds and songbirds (Trost 2005).

We know very little about the birds of the delta in the early days of European settlement (Leach 1982) but re-



ports by Anderson (1884), Fannin (1891), Brooks (1900) and Kermodé (1904) prior to construction of most dikes suggest birdlife was abundant. Hudson's Bay fur trader A.C. Anderson (1884) wrote in the B.C. Directory that in Richmond "during fall and winter, wild geese and ducks abound along the sloughs and, after harvest, in stubble fields..." and in Delta, "wildfowl... gather here in vast numbers late in the fall." He identified flocks of Canada Goose, White [Snow Goose], Crow Goose [likely *B.c. hutchinsii*; Mowbray et al. 2002], Mallard, Pintail and "other unidentified" ducks. Fannin (1891) also referred to great numbers of waterfowl and geese at the mouth of the Fraser River in fall and winter including large numbers of Mallard in winter, the paucity of Blue-winged Teal and "great flocks" of Green-winged Teal and Northern Pintail. "During some winters," Fannin wrote "large numbers of Snow Geese congregate off the mouth of the Fraser". Greater White-fronted Goose was an abundant resident, and Canada Goose "appears in large flocks along the Lower Fraser River during winter months". He also noted the presence of Snowy Owl, Brewer's Blackbird, Townsend's Solitaire, and Mountain Bluebird, and that the Streaked Horned Lark was "nowhere common". Brooks (1900) and Kermodé (1904) compiled lists of birds in B.C. including the Fraser. North et al.'s (1977) map of the vegetation of the Fraser River Delta in the mid-19<sup>th</sup> century shows about half of the lowland delta covered in herbaceous plant growth. Much of the land shown as seasonal wet meadow in their map was converted into agricultural lands that are still in use today. Agricultural fields such as those historically located on the delta, have been shown to support many waterfowl elsewhere (Connor and Gabor 2006).

By the mid-20<sup>th</sup> century, there were "several 1000 ducks on the foreshore" of Sea Island including American Wigeon and Green-winged Teal, large flocks of shorebirds from August to early May and Snow Geese from November to April (Benson 1961). On Lulu Island, Snow Geese were more plentiful than on Sea Island and they foraged on the Quilchena Golf Course. American Wigeon moved offshore during hunting season and flew to farm fields under the cover of darkness, Canvasbacks along Westham Island and in Ladner Marsh were common, scaup were abundant near sewer outfalls, and swans [likely Tundra Swans] stopped on migration. Wood Ducks were present on Barber Island and many species of shorebirds during fall migration used Roberts Bank before the present-day jetties were built. However, Benson (1961) did not refer to the huge flocks that use the tidal flat today perhaps because his interest was waterfowl, the congregation of flocks is more recent or he was not there in spring when numbers are greatest. In his estimation, Boundary Bay was the "most spectacular waterfowl area on the foreshore" — "upwards of 100,000 ducks on most fall and winter days" were present after hunting season began. Brant were present in small numbers in winter, he wrote, and 30,000 would ar-

rive in March during spring migration. Mud Bay held 5,000 teal and wigeon which dropped to 600–1,500 during hunting season. Benson (1961) observed night flights of waterfowl to farmlands in Surrey and Langley which he posited occurred when the ducks exhausted sea lettuce (presumably *Ulva lactuca*) in Boundary Bay.

Benson (1961) summarized that between 30,000 and 140,000 waterfowl used the Fraser River Delta without explaining how he derived those estimates. He thought that "millions of waterfowl must migrate" across the delta each year. Waterfowl hunting was extensive by the mid-20<sup>th</sup> century according to game warden Warren (Slim) Cameron who said in an interview that 4,000–5,000 hunters descended on the delta to hunt waterfowl each fall. Benson (1961) reported that from 1952–1960 hunters presented at bag checks 729–4,686 Mallard, Northern Pintail, American Wigeon, Northern Shoveler, Canvasback and Wood Duck.

We can get a hint of waterfowl abundance from historical photos and hunter bag checks. A 1929 photo of the six men on board the vessel Baby Face, laden with waterfowl, shows about 18 geese and 45 ducks for a total of 63 birds or 10.5 birds per hunter (Figure 2). Bag limits of 20 ducks per day per hunter in 1920 dropped to six ducks per day by 1961 (Munro and Goodchild 1981). Benson (1961) reported mean bag limit for the first two days of the opening season on the Fraser River Delta between 1952 and 1958 was 1.6 birds (mean of his total kill and hunters, 1952–58 in his Table 1). Therefore, the bag limit did not appear to hamper the average hunter in those years. Conditions for hunters between 1929 and the 1950s are not directly comparable because a single image of single hunting trip is unlikely to represent the average take. However, hunters would have had more sophisticated rifles in the 1950s than in 1929 and the average hunter in the 1950s was getting less than one sixth (10.5/1.6) of the number shot by the hunters in 1929. Although we need to be cautious in interpreting these data, the results suggest that waterfowl were more numerous in the early 20<sup>th</sup> century than by mid-century.

### Recent Abundance and Diversity

At least 1.7 million birds, comprising about 260 species, use the Fraser River Delta each year (Table 2). To underscore the importance of the delta to birds in western Canada, we need to put this estimate in context. The density of birds in the CWBS was about 28 times greater on the Fraser River Delta than along the shore of east Vancouver Island — there was an average birds per polygon was 80,952 in 20 polygons on the Fraser River Delta and 2,856 birds per polygon in 189 polygons on Vancouver Island. The vast tidal flat was the largest draw for birds on the Fraser River Delta where an estimated 1.6 million birds were present. In contrast, 79,000 birds were present in the estuarine habitats, and 207,000 primarily in the floodplains. The estimates in Table 2 do not necessarily reflect how those birds use those habitats. Many species move be-

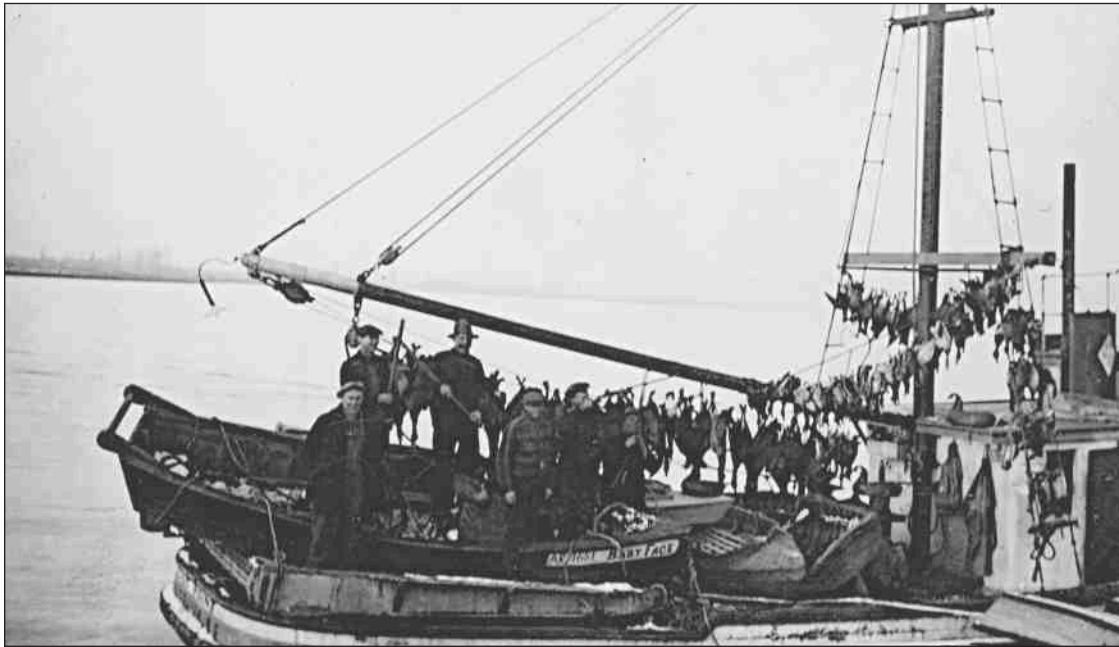


Figure 2. Hunting trip on the vessel Baby Face c.1929. Source: Delta Heritage Society and the City of Delta Archives. (Photo 1983-211-006).

tween habitats and to avoid double-counting, we chose to use the CWBS along the tidal flats to estimate the number of waterfowl on the delta. We have not included an estimate for the number of songbirds to Table 2 because surveys are yet to be done. However, with over 300 km<sup>2</sup> of bird habitat on the delta, and the large numbers tallied on Christmas Bird Counts, it is plausible that the number of breeding, wintering and migrating songbirds exceeds 100,000 birds.

There are 431 species reported in the Greater Vancouver area including the delta of which approximately 260 occur annually and nearly all occur on the delta making it one of

the most diverse assemblages of birds in Canada (Lepage 2019). Over 200 species have been recorded on eBird (2019) at six locations around the delta: Iona Island (287), George C. Reifel Migratory Bird Sanctuary (273), Blackie Spit (236), Boundary Bay Regional Park (219), Tsawwassen Ferry Jetty (210) and Beach Grove (200). The fewest species occur in January with 186 species present and the greatest number occurs in September when there are 256 species on the delta. The species mix changes over the course of a year but the delta is always occupied by a diversity of birds.

Much of the natural floodplain was converted to cultivation in the late 19<sup>th</sup> and early 20<sup>th</sup> century, and later be-

Table 2. Maximum single day estimate rounded to nearest 1000 of waterbirds and raptors on the Fraser River Delta, B.C. Waterfowl (c.100,000) and shorebirds (c. 50,000) in the lowland fields were excluded because they were already accounted for in the tidal flat counts.

Species group	Floodplain	Tidal flat	Estuarine	Total no. individuals
Waterfowl	201,000 <sup>1</sup>	206,000 <sup>5</sup>	34,000 <sup>8</sup>	240,000 <sup>9</sup>
Loons and grebes	0	7,000 <sup>6</sup>	3,000 <sup>8</sup>	10,000
Shorebirds	1,000 <sup>2</sup>	1,414,000 <sup>7</sup>	0	1,414,000 <sup>9</sup>
Seabirds	0	19,000 <sup>6</sup>	42,000 <sup>8</sup>	61,000
Raptors	4,000 <sup>3</sup>	268 <sup>6</sup>	0	4,000
Hérons	1,200 <sup>4</sup>	1,200 <sup>4</sup>	0	1,200 <sup>9</sup>
<b>Total</b>	<b>207,200</b>	<b>161746<sup>8</sup></b>	<b>79,000</b>	<b>1,730,000<sup>9</sup></b>

<sup>1</sup> 100,000 Snow Geese (W.S. Boyd, unpublished data) + 101,000 ducks (CWBS 1999-2019) in agricultural lands. Assume about 1000 Killdeer, plovers, yellowlegs and Dunlin

<sup>2</sup> 4000 eagles at the landfill (Pers. comm., Myles Lamont, Surrey, B.C., 2019 November 28) and 609 raptors counted in the IBA in 2019 (B.C. unpublished data).

<sup>3</sup> 600 heron nests X 2 (R. Vennesland, unpublished data)

<sup>4</sup> 100,000 Snow Geese (W.S. Boyd, unpublished data) + 101,000 ducks (CWBS 1999-2019) + 5200 Brant (Hagmeier et al. 2008).

<sup>5</sup> Coastal Waterbird Survey (CWBS) 1991-2019

<sup>6</sup> Drever et al. (2014) spring estimate for Western Sandpiper and Dunlin + fall migration estimate of 250,000 (Table 13) + other species on CWBS = 39,000.

<sup>7</sup> Boundary Bay and Fraser River Estuary (Butler et al. 2018)

<sup>8</sup> Total number of individuals excludes floodplain totals for species that move between the tidal flats and floodplain to minimize double counting the same birds.

Table 3. Number of species that used the floodplain prior to 19th century dikeing, and in present day farmland, residential and industrial lands on the Fraser River Delta, B.C.

Species groups	Original floodplain	Farmlands	Residential	Industrial
Waterfowl	27	22	6	2
Wading birds	4	2	0	0
Raptors	14	13	9	4
Shorebirds	30	30	1	1
Gulls	10	9	7	2
Owls	9	8	6	4
Swift/Hummingbird/Woodpecker	10	9	10	5
Songbirds	99	89	84	56
<b>Total</b>	<b>214</b>	<b>189</b>	<b>127</b>	<b>75</b>

came residential and industrial lands. The effect of this conversion of use on the diversity of species is apparent in Table 3. Of an estimated 214 species present on the natural floodplain at the time of European settlement, 189 (88%) now use farmlands, 127 (59%) use residential areas, and 75 (35%) of species use industrial areas. Cooperative farmland stewardship programs have enhanced large areas of cultivated lands for wildlife but conversion of the delta to residential and industrial use will result in a measurable and significant decline in species (Kehoe *et al.* 2020).

### Threshold Species and Species at Risk

There were 68 species that were either Threshold Species, Species at Risk, or Red- Blue-listed (Table 4). Of those 68 species, 29 were Threshold species, eight of which were also either SARA or Red or Blue Listed. Thirty-nine species that did not meet Threshold criteria were either SARA, or Red and Blue Listed, or both. The total number of SARA and Red and Blue-listed Species was 47. This list of species deserves special conservation attention because they represent a substantial proportion of global, continental or national populations, or because of their scarcity.

The range of numbers of birds counted each year on the CWBS was highly variable and therefore it was not surprising to find that most of the species tallies reported by Butler and Cannings (1989) fell within those ranges (Table 5). Five species that were more numerous in the 1980s were the American Wigeon, Mallard, Western Sandpiper, Dunlin and Mew Gull and three species that were less numerous in the 1980s were the Green-winged Teal, Red-breasted Merganser, and Glaucous-winged Gull (Table 5). Overall, all species in Table 5 have changed little for several decades.

### Seasonal Use Patterns

About 260 species occur annually on the Fraser River Delta of which about two-fifths are most numerous on migration or in summer, a third are most numerous in winter, and a quarter reside year around. The migrant and summer species are dominated by insectivorous birds and shorebirds. Winter species are largely waterfowl, diving birds,

shorebirds, and sparrows. Year-round species are a mix of many species groups including, waterfowl, herons, owls, woodpeckers, chickadees, wrens, thrushes, sparrows and finches.

Birds that annually use the Fraser River Delta follow four generalized seasonal use patterns. *Resident* species such as the Great Blue Heron, Barn Owl, and Song Sparrow that spend their entire lives on the delta swell in number in summer when the young of the year are recruited into the population, and decline in autumn through natural mortality or dispersal. At the opposite extreme of the seasonal use continuum are the *Migrant* species that largely pass through the delta on spring, fall or both migrations such as Western Sandpiper, Bonaparte's Gull, and Yellow-rumped Warbler. *Migrant Breeders* that arrive in spring to nest on the delta and depart in the fall include species such as the Blue-winged Teal, Cinnamon Teal, Osprey, Caspian Tern, Barn and Cliff Swallows, Pacific Slope Flycatcher, Common Yellowthroat, and Savannah Sparrow. The mirror opposite to *Migrant Breeders* are the *Migrant Non-breeders* that come to the delta in fall following breeding elsewhere and depart in spring to return to distant breeding grounds. This group includes many of the waterfowl, loons and grebes, as well as the Rough-legged Hawk, Snowy Owl, Black Turnstone, Dunlin, Fox Sparrow, and Golden-crowned Sparrow.

The pattern of use by different species has implications for conservation strategies. As a general rule, most waterfowl, loons and grebes are *Migrant Non-breeders* that arrive in autumn to spend the winter before migrating out of the delta in spring. Few ducks follow the *Migrant* pattern of spring and autumn migrations, contrary to Benson's (1961) assumption that millions of waterfowl migrated through the delta. Our conclusion that the delta is the destination for most waterfowl concurs with McKelvey and Smith's (1990) analysis of the locations of Mallards, American Wigeon and Northern Pintails banded on the south coast of British Columbia and recovered in subsequent years. They showed that of banded ducks about 63% of pintails, and 70% of wigeon and Mallard recovered one or more years later were at or near their banding location. For wigeon banded in the Strait of Georgia, the recovery

Table 4. Conservation Priority List of birds on the Fraser River Delta, B.C., including IBA Threshold Species, Species at Risk, and B.C. Red- and Blue-listed Species on the Fraser River Delta. SARA=Species listed on Schedule 1 of the Species at Risk Act. \* see Remarks in Account section. \*\*indicates the COSEWIC assessment but the species has not been added to the SARA list. Red/Blue = B.C. Conservation Data Centre Red list (R) and Blue (B) list. G = Global, C = Continental, N= National, E = Endangered, T=Threatened, SC = Special Concern. Subspecies names are shown in italics.

Species	Threshold	SARA	Red/Blue list	Species	Threshold	SARA	Red/Blue list
Western Grebe	G	SC	R	◀			
Surf Scoter	G		B	Marbled Murrelet		T	B
Bonaparte's Gull	G			Red Knot		T	R
American Wigeon	G			<i>roselaari</i> type			
Northern Pintail	G			Ancient Murrelet		SC	B
Mallard	*			Band-tailed Pigeon		SC	B
Snow Goose	*			Long-billed Curlew		SC	B
Trumpeter Swan	G			Red-necked Phalarope		SC	B
Western Sandpiper	G			Short-eared Owl		SC	B
Black-bellied Plover	G			Common Nighthawk		SC	
Dunlin	G			Olive-sided Flycatcher		SC*	B
Red-necked Grebe	G			Rusty Blackbird		SC	B
Glaucous-winged Gull	G			Evening Grosbeak		SC	
Iceland Gull	G			Buff-breasted Sandpiper		SC	
<i>thayeri</i>	G			Horned Grebe		SC	
Northwestern Crow	G			Harris's Sparrow		SC*	
Long-billed Dowitcher	G			Canada Goose			
Red-breasted Merganser	G			<i>occidentalis</i>			R
Red-throated Loon	G			Brandt's Cormorant			R
Western Screech-Owl	C	T	B	Black-crowned Night-heron			R
<i>kennicottii</i>	C			Prairie Falcon			R
Brant	C		B	Whimbrel			R
Greater Scaup	C			Hudsonian Godwit			R
Green-winged Teal	C			Parasitic Jaeger			R
Mew Gull	C			Tundra Swan			B
Sanderling	C			Black Scoter			B
White-winged Scoter	C			Eared Grebe			B
Barn Owl	N	T	R	Double-crested Cormorant			B
Peregrine Falcon	N	SC	R	American Bittern			B
<i>anatum</i>	N			Green Heron			B
Great Blue Heron	N	SC	B	Gyr Falcon			B
<i>fannini</i>	N			Rough-legged Hawk			B
Peregrine Falcon	N	SC	B	American Golden-Plover			B
<i>pealei</i>	N			Wandering Tattler			B
Horned Lark		E	R	Short-billed Dowitcher			B
<i>strigata</i>				California Gull			B
Yellow-breasted Chat		E	R	Purple Martin			B
Vesper Sparrow		E	R				
<i>affinis</i>							
Black Swift		E	B				
Bank Swallow		T					
Barn Swallow		T	B				

rate was even higher at 93%. The authors concluded that the south coast was the winter destination for these species rather than a migratory stopover. Supporting evidence for this hypothesis comes from the seasonal use patterns of waterfowl. In autumn, a build-up of numbers occurs as ducks begin to arrive on the delta. Their numbers did not

decline substantially as expected if the birds stopped briefly on migration but instead, slowly waned through the winter likely due to local dispersal and mortality. Moreover, a spring peak does not appear in the data. Miller *et al.* (2005) using satellite tags showed that pintails, often made direct flights between Alaska and California. Kremetz *et*

Table 5. Estimates of the maximum number (rounded to nearest 1000 for counts >1000) of IBA Threshold Species that could be counted from shore on the Fraser River Delta, B.C., in 1988–89 (Butler and Cannings 1989 their Appendix 3) and the range in the Coastal Waterbird Survey 1999–2019.

Species	1988–89	1999–2019 Range	Species	1988–89	1999–2019 Range
Snow Goose	16,000	2500–30,000	◀		
Brant	2,000	22–2,000	Western Grebe	2,000	10–3,000
Trumpeter Swan	248	1–470	Great Blue Heron	295	27–332
American Wigeon	51,000	1944–43,000	Black-bellied Plover	5,000	34–8,000
Mallard	21,000	251–11,000	Sanderling	1,000	7–3,000
Northern Pintail	30,000	850–37,000	Western Sandpiper	56,000	53–10,000
Green-winged Teal	10,000	386–7,000	Dunlin	126,000	5,000–105,000
Greater Scaup	2,000	114–4,000	Long-billed Dowitcher	281	1–570
Surf Scoter	1,000	402–6,000	Bonaparte's Gull	1000	1–6,000
White-winged Scoter	1,000	164–3,000	Mew Gull	3,000	143–1,000
Red-breasted Merganser	3,000	19–300	Iceland Gull <i>thayeri</i>	232	2–320
Red-throated Loon	37	1–487	Glaucous-winged Gull	4,000	276–3,000
Red-necked Grebe	85	46–3,000	Peregrine Falcon	4	1–17

al. (2012) showed that some Mallards also made direct flights between winter quarters in Arkansas and breeding grounds in Canada. If direct flights are feasible for many species, then the conclusion that the Fraser River Delta is largely the winter destination for a population of 100,000–200,000 ducks seems plausible. These conclusions suggest that most of the large numbers of waterfowl previously suspected to pass through the delta on migration (Leach 1972) no longer do so but instead re-populate the delta each autumn following breeding elsewhere. A few exceptions exist such as the Snow Goose that splits its time between the Fraser River Delta and the Skagit River Delta in Washington, and some move south to California.

Shorebirds were a mix of *Migrants* that passed through on annual north and south migrations (e.g. Western Sandpiper, Least Sandpiper), and *Migrant Non-breeders* (e.g. Dunlin, Black-bellied Plover) that arrived in late summer and fall to spend the winter on the delta. Gulls and seabirds included a few *Residents* (e.g. Glaucous-winged Gull) and *Migrants* (e.g. Bonaparte's, Ring-billed and California gulls), and several *Migrant Non-breeders* (e.g. Marbled Murrelet, Pelagic Cormorant). Owls were either *Residents* (e.g. Barn Owl, Great Horned Owl) or *Migrant Non-breeders* (e.g. Snowy Owl, Saw-whet Owl). Among the hedgerow and forest birds were a mix of many *Residents* (e.g. Song Sparrow, Black-capped Chickadee, American Robin), *Migrant Breeders* (warblers and vireos), and a few *Migrants* (e.g. Mountain Bluebird, Yellow-rumped Warbler). Understanding how and when species use the delta will assist in providing conservation needs during those times. All species require cooperative conservation pro-

grams along the entire migration corridor, breeding and wintering sites. However, knowing the travel routes, destinations and needs along the way allows for targeted action.

Ten of the 68 species of Conservation Concern in Table 4 nest on the delta. The Northwestern Crow, Western Screech-Owl, Short-eared Owl, Barn Owl, Great Blue Heron, Horned Lark, Short-eared Owl, Black-crowned Night-Heron, American Bittern, Green Heron are *Residents* and the Purple Martin is a *Migrant Breeder*. The remaining 58 species are *Migrants* or *Migrant Non-Breeders*. This finding underscores the need for regional and international conservation to preserve birds on the delta.

### Spatial Use

We now look at how the species of conservation concern are distributed across the floodplain, tidal flats and estuarine habitats that make up the Fraser River Delta. The greatest diversity of the approximately 260 annually occurring species occurred on the floodplain. A total of 132 species used only the floodplain, followed by 52 only on the tidal flats, and 19 only in the estuarine habitats. A further 61 species used all three habitats. The floodplain species can be further divided into 48 forest species and 34 hedgerow species. Among the 68 Threshold, SARA or Red/Blue listed species shown in Table 4, far more species depend on the floodplain and tidal flat than the estuarine habitat (Table 6). This difference becomes even more apparent among SARA and Red/Blue listed species where 37 are dependent on the floodplain, 29 on the tidal flat and 12 on the estuarine habitat (Table 6). These habitats produce a

Table 6. Number of the 68 Threshold, Species at Risk, and Red/Blue listed species that use floodplains, tidal flats or estuarine habitats in the Fraser River Delta, B.C. Totals in table exceed 68 because some species use more than one habitat.

Habitat	Threshold	SARA	Red/Blue	Total
Floodplain	13	17	20	50
Tidal Flat	25	8	21	54
Estuarine	6	4	8	18
<b>Total</b>	<b>44</b>	<b>29</b>	<b>49</b>	<b>122</b>

smorgasbord of small fish, shellfish, marine invertebrates including biofilm, plants and seeds, insects, small mammals and birds that are eaten by these 68 species.

### Floodplain Birds

The agricultural lands in the Fraser River Delta subsidize nearly three-quarters of a million waterfowl, shorebirds and birds of prey including the following 14 IBA Threshold Species: American Wigeon, Northern Pintail, Mallard, Snow Goose, Trumpeter Swan, Black-bellied Plover, Dunlin, Great Blue Heron, Glaucous-winged Gull, Iceland Gull (Thayer's), Green-winged Teal, Great Blue Heron, Peregrine Falcon, and Barn Owl (Table 2). In Boundary Bay, about 100,000 ducks including American Wigeon, Northern Pintail, Mallard and Green-winged Teal deplete the food on the tidal flats by mid-winter then move into farm fields to eat discarded vegetable crops and planted grasses (Baldwin and Lovvorn 1994b). Snow Geese and Trumpeter Swans are increasingly dependent on the floodplain farms for food, indicating a growing role of farmland in the conservation of these birds (see **Species Accounts**).

Ducks are attracted to ploughed fields and those planted in pasture or other grasses, corn, potato, or other vegetables. They are widespread and use fields both night and day, tend to avoid field margins near busy roads and residential areas, and are attracted to fields near night-lit greenhouses (Breault and Butler 1992, Middleton 2016). The dependency of ducks on farms has created a hardship for the farmers who take the brunt of the damage to their planted fields (Bradbeer et al. 2012).

Floodplain fallow and old-fields are the home of small mammals that play an important role as prey for several avian predators in winter. The 'Big-Four' hawks and owls seen on nearly every winter trip to the farmlands are the Northern Harrier, Red-tailed Hawk, Rough-legged Hawk, and Short-eared Owl. Between Boundary Bay and Brunswick Point, Sullivan (1992) tallied 70 Northern Harriers, 34 Rough-legged Hawks and 45 Red-tailed Hawks with the greatest concentrations around Boundary Bay Airport. The nearly 700 ha of old-field habitat (Table 1) harbours Townsend's voles (*Microtus townsendii*) that are a frequent prey for these birds of prey. Harriers were significantly

more numerous in fields near the tidal flats and Short-eared Owls roosted in large numbers in the foreshore marshes (Sullivan 1992).

Of particular concern is the well-being of owls that reside on the floodplain. The Western Screech-Owl is now possibly extirpated on the delta, although it resides close by (Elliott 2006), the Barn Owl is Threatened, and the Short-eared Owl is designated a species of Special Concern. All of them depend on small mammals, especially the Townsend's vole, that live in old-fields, along roadside verges and farm fields (see **Species Accounts**). Observing owls in the wild is a major interest of birders, photographers and the general public and that interest can lead to harassment.

Farmlands once provided resting and feeding places for large numbers of shorebirds — over 17,000 Dunlins and 6,000 Black-bellied Plovers were counted in fields through the winter of 1988–89 (Butler 1992b). This phenomenon has been reduced as the shorebirds responded to the increasing presence of Peregrine Falcons on the delta in recent years (Ydenberg et al. 2010).

Many thousands of songbirds recorded on Christmas Bird Counts reflect the variety of habitats, mild climate and abundance of food provided on the delta. Steady flows of passage migrants are present in spring and autumn, and songbirds are widespread during the breeding season. About 90 regularly occurring forest dwelling species nest on the delta or nearby (Weber et al. 2013).

A visit to Don Island and Poplar Island on 18 June 2012, revealed the presence of the same species in mixed deciduous and coniferous forest in neighbouring upland forest (Er et al. 2015). On Don Island the species included Wilson's Warbler, Swainson's Thrush, Song Sparrow, Rufous Hummingbird, Black-throated Gray Warbler, Canada Goose, Yellow Warbler, Black-capped Chickadee, MacGillivray's Warbler, and Bewick's Wren. For Poplar Island the list included Yellow Warbler, Song Sparrow, American Robin, Spotted Towhee, Red-breasted Nuthatch, Swainson's Thrush, Black-headed Grosbeak, Bewick's Wren, Downy Woodpecker, Northern Flicker, European Starling, Spotted Sandpiper, Great Blue Heron and Barn Swallow.

Hedgerows with trees along farmland edges held 26 species during the breeding season and 40 species during the non-breeding season (Butler 1992a). Toshack (2018) showed that the number of songbirds and their abundance in blueberry farms in the Lower Fraser Valley, including the delta, were significantly greater when near forests but there was no significant difference between conventional and organic blueberry farms.

Four out of five species caught in mist nets at the Iona Island Bird Observatory in 2010–15 (Kissel and Scholefield 2016) were also the most often seen species at Alak-sen nearly three decades earlier (Butler and Campbell 1987). Iona captures were predominated by Wilson's War-

Table 7. Distribution of American Wigeon, Northern Pintail, Mallard and Green-winged Teal (1000's) along the tidal flats of the Fraser River Delta, B.C., in October–January 1966–69, and year-round 1988–89.

Region	1966–69	%	1988–89	%
Sea Island	26	12	11	3
Lulu Island	15	7	13	4
Westham + Tsawwassen	79	37	110	29
Boundary Bay	94	44	237	64
<b>Total</b>	<b>214</b>	<b>100</b>	<b>370</b>	<b>100</b>

bler, Yellow-rumped Warbler, Orange-crowned Warbler, Yellow Warbler and Violet-green Swallow. Fall migration was predominated by Yellow Warbler, Yellow-rumped Warbler, Orange-crowned Warbler, Common Yellowthroat, and House Finch, while Fox and Song Sparrows, Black-capped Chickadee, Spotted Towhee and Ruby-crowned Kinglet predominated in 23 winter captures. Many species use multiple habitats such as fields for foraging and hedgerows for safety. There were 34 predominantly hedgerow species and 48 predominantly forest species in the Fraser River Delta.

The nearly 13,000 ha of built-up habitat mostly in Richmond and Delta is similar to New Westminster and Vancouver where the predominant species are European Starling, Northwestern Crow, House Sparrow, House Finch, American Robin, Black-capped Chickadee, Rock Pigeon, Violet-green Swallow and Spotted Towhee (Melles *et al.* 2003, Butler *et al.* 2015). New Westminster had 73 breeding species compared to 153 species in Vancouver.

#### Tidal Flat Birds

The tidal flats on the Fraser River Delta were used by more than 200,000 waterfowl and 1.4 million shorebirds each year (Table 1) and by many species (Price 1990). Among the tidal flat birds were 16 species that met or exceeded IBA Threshold criteria: Snow Goose, Brant, Trumpeter Swan, American Wigeon, Mallard, Northern Pintail, Green-winged Teal, Black-bellied Plover, Sanderling, Dunlin, Western Sandpiper, Mew Gull, Iceland Gull (Thayer's), Glaucous-winged Gull, Great Blue Heron, and Peregrine Falcon.

There was a shift in the distribution of ducks along the tidal flats between the 1960s and 1980s. Table 7 shows Campbell *et al.*'s (1972a) summary of the distribution of American Wigeon, Northern Pintail, Mallard and Green-winged Teal between October and January 1966–69 from aerial surveys flown by Ernie Taylor. Also shown in Table 7 are the total number of these same species in Butler and Cannings (1989) report. Less than half the ducks were in Boundary Bay in the 1960s compared to over 60% in 1988–89 (Chi-square=219.8, df=3, p<0.001).

Tidal flats were heavily hunted by about 10 species of raptors. The most numerous species on a delta-wide single day tally in November 2018 and 2019 revealed 2-year to-

tals of 524 Bald Eagles, 186 Northern Harriers, and 156 Red-tailed Hawks accounting for over 90% of all birds of prey (Table 8). The Purple Martin is an example of recovery of a species led by citizen science and conservation groups. The species was not included in accounts by Butler and Campbell (1987) but thanks to a nest box program coordinated by the Western Purple Martin Foundation, the Purple Martin re-established in many estuaries along the south coast including the Fraser (Cousens and Davidson 2015). The recovery of the Trumpeter Swan and Peregrine Falcon from scarcity to abundance, are also noteworthy (See **Species Accounts**).

#### Estuarine Birds

The estuarine habitat supported nine IBA Threshold Species: Greater Scaup, Surf Scoter, White-winged Scoter, Western Grebe, Bonaparte's Gull, Mew Gull, Iceland Gull (Thayer's), Glaucous-winged Gull, and Red-throated Loon. Birds in the estuary were often far from shore and largely out of sight of land-based observers. The deep water in Boundary Bay was dominated by diving birds whereas mostly gulls inhabited the mouth of the Fraser River (Table 9).

In 2006–07, Middleton *et al.* (2018) counted all birds from a boat in Boundary Bay (summarized in Table 9). Twenty-three species were identified of which American

Table 8. Number of birds of prey counted in 2018 and 2019 in the Fraser River Delta IBA, B.C. (unpublished data, Birds Canada).

Species	2018	2019
Northern Harrier	90	98
Sharp-shinned Hawk	0	1
Cooper's Hawk	6	10
Bald Eagle	191	359
Red-tailed Hawk	60	101
Rough-legged Hawk	9	11
American Kestrel	1	4
Merlin	5	2
Peregrine Falcon	8	20
Northern Shrike	14	3
<b>Total</b>	<b>384</b>	<b>609</b>

Table 9. Monthly total number of all birds counted along 200 m-wide inshore, midshore and offshore transects in Boundary Bay September 2007–February 2008.

Date	Inshore <sup>1</sup>	Midshore <sup>1</sup>	Offshore <sup>2</sup>	Total
14-Sep-07	54	49	14	117
26-Sep-07	630	387	129	1,146
23-Oct-07	2,639	259	215	3,113
06-Nov-07	1,748	1,045	543	3,336
21-Nov-07	2,365	449	48	2,862
07-Dec-07	105	411	567	1,083
24-Dec-07	434	157	29	620
11-Jan-08	2,809	123	17	2,949
25-Jan-08	69	110	130	309
18-Feb-08	98	154	39	291

<sup>1</sup> Inshore corresponds with Tidal Flats in this report.

<sup>2</sup> Offshore corresponds with Estuarine in this report.

Wigeon, Surf Scoter, Long-tailed Duck and Western Grebe made up over 90% of all birds seen. The lowest number of birds was in September 2006 when 117 birds were counted on transects. The greatest inshore numbers occurred in January and, in the mid-shore area, in November (Table 9). From these counts, the estimated total number of birds present on transects in Boundary Bay was about 2,800 birds in October, November and January (Table 9). The transect area searched for birds was 360,000 m<sup>2</sup> in area (9,000m long x 200m wide x 2 transects). The entire area of Boundary Bay was 45,000,000 m<sup>2</sup> (5,000 m wide x 9,000 m long) and 125 times greater area than the transect. Therefore, the estimated number of birds in the entire Canadian portion of Boundary Bay (inshore and midshore) was 350,000 birds (2,800 birds x 125). Large numbers of Western Grebes were counted in the American portion of Semiahmoo Bay south of Boundary Bay.

Over 3,300 birds were recorded in 2016–17 along once monthly transects through a year in the estuarine habitat at the mouth of the Fraser River (Butler *et al.* 2018). Twenty-nine species were identified of which Mew Gull, Common Murre, Glaucous-winged Gull, Bonaparte's Gull, Marbled Murrelet, California Gull and Western Grebe made up about 80% of the total. The greatest number of birds occurred in January and the fewest in June. Butler *et al.* (2018) estimated the number of birds in their study area using the same method as used above for Boundary Bay to derive an estimated 32,000 birds being present in January and 1,950 in June over the entire Fraser River Estuary. Combining the highest estimates for Boundary Bay and the Fraser River mouth shows that about 383,000 birds were present on a single day in the estuarine habitat in winter. Our estimates based on single day counts once each month did not account for the scale of the passage of birds that annually migrated through the delta.

## Conservation Designations

There has been great progress in securing floodplain and tidal flat habitats for birds since Leach (1972) called for conservation areas within the coastal waters and tidal flats, estuarine habitat and deltaic farmlands. Butler and Campbell (1987) showed that that about 1% of the delta was designated for wildlife despite several species exceeding criteria for inclusion among the world's highest international conservation designations. Since then, the Fraser River Delta has received the highest level of international, national and regional conservation designations including as a Hemisphere Reserve under the Western Hemisphere Shorebird Reserve Network, a Ramsar Wetland of International Importance, and as Canada's premier Important Bird and Biodiversity Area. The Fraser River Estuary is among the first potential sites in Canada to be identified as a Key Biodiversity Area under the emerging global Key Biodiversity Area network because of its migratory birds, fish and species at risk (Key Biodiversity Areas Canada 2021). Over 33,000 ha (37.6%) of the delta has received legislated protection for wildlife, and non-legislated international designations have been applied to most of the delta (Table 10). The conventions and programs underscore our contention that the Fraser River Delta is one of the nation's great bird habitats.

## Cultural and Economic Significance

The archeological record of the ancestors of today's Coast Salish people dates to at least 5–8,000 years ago when the early people settled at səw̓qweqsən — also known as the Glenrose Cannery site — on the south bank of the Fraser River below the Delta escarpment (Matson 1981). The delta, still in its infancy, was emerging from sediments carried by glacial melt water (Clague *et al.* 1983). Sea level stabilized about 8,000



years ago allowing the delta to extend into the Strait of Georgia. There was no written record of those early people or their culture but numerous artifacts and oral stories of living ancestors tell of an ancient culture originating from a foundation of nature which is alive today (Ormerod 2014, Gaydos *et al.* 2015, Musqueam Indian Band 2020).

Bird hunting on the delta has a history going back for thousands of years (Hobson and Driver 1989). Market hunting by settlers occurred briefly from the late 19<sup>th</sup> century until 1917 with the passing of the Migratory Bird Convention Act, when bag limits for waterfowl were established. A hunter in B.C. was permitted to take 20 ducks per day in 1920, 12 ducks in 1937, seven ducks in 1946 and six ducks in 1961. Possession limits fell even faster from 150 per season in 1920 to 12 in 1961 (Munro and Goodchild 1981). In modern times, waterfowl hunting has focused on abundant populations in the delta (Demarchi 2006). Waterfowl Heritage Days have been enacted to encourage more young people to take up waterfowl hunting.

Birdwatching is an increasingly popular activity in North America. There are a number of nature clubs in and around the delta that have regular birdwatching and photography field trips and many thousands of people birdwatch independently on the delta every year (Table 11). eBird and iNaturalist entries are rising and many people use social media to enhance their birding activities. We estimated annual expenditures directly from birdwatchers on the Fraser River Delta were over \$11M (Table 11). Leisure activities including nature photography was estimated to be \$453M in B.C. in 2012 (Federal, Provincial, and Territorial Governments of Canada 2014). Nearly one in five British Columbia residents watched birds (19%) and 7% hunted them. British Columbians spent \$102M on birding and \$22M on waterfowl hunting in 2012.

The numbers of people visiting George C. Reifel Migratory Bird Sanctuary has risen steadily in recent years, and the Sanctuary attracted over 100,000 people in 2018 (Pers. comm., Kathleen Fry, December 2019). Around 12% of visitors to Vancouver come to see wildlife (Pers. comm., Paul Sontz, Tourism Vancouver, 2019 December).

Table 10. Area and proportion of the 88,551 ha Fraser River Delta, B.C., legislated for conservation.

Conservation Lands	Area (ha)	Proportion
Migratory Bird Sanctuary	376	0.40%
National Wildlife Area	342	0.40%
Federal Conservation Area	143	0.20%
Wildlife Management Area	29,010	32.80%
NGO Conservation Area	615	0.70%
Local Government Park Natural Area	3,967	4.50%
<b>Total</b>	<b>33,269<sup>1</sup></b>	<b>37.60<sup>1</sup></b>

<sup>1</sup> Total adjusted to eliminate overlapping designations

## Discussion

### Abundance and diversity

Unpublished and published reports on birds written between 1960 and 1987 formed the basis of Butler and Campbell's (1987) report. They estimated that 1.4 million waterbirds passed through the Fraser River Delta each year of which 300,000–750,000 were waterfowl, 200,000–600,000 were shorebirds, and 60,000 were gulls. The sum of the annual peak numbers of all species occurred in early winter when an estimated 135,000 waterbirds were present. Two years later, a clearer picture began to emerge on the numbers of birds and their seasonal movements across the delta. Butler and Cannings (1989) coordinated teams of birdwatchers on the first delta-wide survey of all birds using the tidal flats, a precursor to the CWBS. The greatest number counted in any month for all species of birds came to over 1.5 million birds of which over 211,000 were waterfowl, 127,000 were shorebirds, and 61,000 were gulls. Butler and Cannings (1989) showed that about 1.7 million waterbirds used the tidal flats in the period of 2009–19 of which about 240,000 were waterfowl, 1.4 million were shorebirds and 61,000 were seabirds including gulls (Table 2).

Table 11. Estimated revenue directly from bird watching in the Fraser River Delta, B.C.

Location	Number of birding visits	No. of local birding visits <sup>1</sup>	No. of out-of-region birding visits <sup>1</sup>	Expenditure <sup>2</sup>
GC Reifel Bird Sanctuary	100,000	95,000	3,500	1,448,000
Iona Island	162,760 <sup>3</sup>	154,622	8,138	2,571,608
Boundary Bay	457,520 <sup>4</sup>	434,644	22,876	7,228,816
<b>Total</b>	<b>720,280</b>	<b>655,766</b>	<b>34,514</b>	<b>11,248,424</b>

<sup>1</sup> Assume 95% are local based on estimate by Lees and Associates (2014) for Iona Island.

<sup>2</sup> Canadian dollars; assume \$12/d for local and \$88/d for out-of-region (Sexton *et al.* 2011)

<sup>3</sup> 52% of 313,000 (MetroVancouver Parks 2016) visited for 'wildlife viewing' (Lees and Associates 2014).

<sup>4</sup> 43% of 1,064,000 (MetroVancouver Parks 2016) visited for 'wildlife viewing' (Lees and Associates 2014).

Some of the differences in totals were likely due to census shortcomings and error, interannual variability, and changes in abundance. The peak numbers of each species on the CWBS are highly variable between years. Single day counts used by the CWBS can hit or miss the time when large numbers of migratory birds are present. Estimating large flocks of birds has a potentially large error. Large numbers of birds, especially in Boundary Bay, are a long way from the observers making identification and counting impossible. For example, the greatest single day count of Western Sandpipers on the CWBS was 10,000 birds, which was about 10 times lower than the peak number on daily counts during the migration and 60 times lower than the total number of individuals through the entire migration (Drever *et al.* 2014). A similar argument has been made for Brant on the Fraser River Delta (Hagmeier *et al.* 2008). Moreover, we do not have an estimate of the number of songbirds using the delta each year. Given these shortcomings, the estimate of 1.7 million waterbirds and raptors using the Fraser River Delta each year (Table 2) is likely very conservative. These examples indicate that to approach estimates of the true abundance of many species will require specially designed surveys that account for their seasonal distribution and abundance on the delta.

A fair argument can be made that farmland was a replacement habitat for many birds that used the natural floodplain. We showed in this paper that farmland supported 88% of the original native bird species compared to only about 35% on industrial lands. Most wetland birds lived outside farmlands, industrial, and residential areas. Declines in biodiversity occur where urbanization replaces natural habitats because of changes in habitat and competition from introduced species such as European Starlings, Rock Pigeons and House Sparrows (Shochat *et al.* 2010). A key element in maintaining abundance and diversity of bird species in the delta's agricultural landscape is heterogeneity of various crop types interspersed with naturalized greenspace.

## Gains and Losses

In this report we show that many species reported by Butler and Campbell (1987) have fared well in the ensuing years. Ethier *et al.* (2020) reached a similar conclusion for the Salish Sea where the abundances of 36 of 50 waterbird species examined were stable through 20 years of CWBS. On the plus side, the Fraser River Delta gained the Black Oystercatcher, Barred Owl, Eurasian Collared Dove, and Anna's Hummingbird as new, annually occurring, breeding species. The Black Oystercatcher first nested on the B.C. Ferry Terminal jetty in summer of 1993 (reported by Z. Bhatia in eBird) and up to four pairs have nested there ever since. Anna's Hummingbird became numerous in the past two decades, and Eurasian Collared Dove since about 2005. The Barred Owl arrived several decades ago (Campbell *et al.* 1990b).

Among the species gained, the reasons posited include range expansions due to climate change, habitat changes, supplemental feeding, and predation risk (Ydenberg *et al.* 2004, Bunnell *et al.* 2008, Greig *et al.* 2017). Black Oystercatchers began nesting in the delta after the construction of the B.C. Ferry terminal jetty inadvertently provided them suitable habitat. Barred Owls arrived in the Lower Mainland in the 1960s as part of a widespread westerly expansion (Campbell *et al.* 1990b) and the recent explosive arrival of the Eurasian Collared Dove is likely a result of its ability to exploit a new niche subsidized by bird feeding. The northward range expansion of Anna's Hummingbirds along the Pacific Coast was attributed to urbanization and the provision of feeders and not winter temperature (Greig *et al.* 2017).

Species that have increased since 1987 include the Trumpeter Swan, Wood Duck, Great Blue Heron, Osprey, Bald Eagle, Peregrine Falcon and Purple Martin. Species whose populations are below historical levels but slowly recovering include the Greater White-fronted Goose, Brant, and Sandhill Crane. Providing suitable habitat and limiting disturbance are the best courses of action for these species.

Species that appear to be declining on the delta include the Western Grebe, Western Screech-Owl, Common Nighthawk, and Barn Swallow. Western Grebes might have moved offshore and out of sight of land-based observers. Several hundred grebes were present in the middle of Semiahmoo Bay at the southern edge of the delta (Middleton *et al.* 2018). For the Common Nighthawk, Western Screech-Owl and Streaked Horned Lark, the declines are part of region-wide reductions. Targeting their specific needs would be the course of action required although it might be too late for the Horned Lark. A few species that are reasonably abundant but might be declining deserving of our attention include the Harlequin Duck, Ruddy Duck, Red-necked Grebe, Rufous Hummingbird, Red-throated Loon, Horned Grebe, Western Sandpiper, Marbled Murrelet, Barn Owl, Short-eared Owl, Olive-sided Flycatcher, Cliff Swallow, and Western Meadowlark.

The Fraser River Delta has lost the California Quail, American Black Duck, Crested Myna and possibly the Ruffed Grouse and Streaked Horned Lark. The quail, duck and myna were introduced species. A few sightings of individual grouse have been reported from Burns Bog (Gebauer 1999). The endemic Streaked Horned Lark is likely extirpated from Canada (Environment Canada 2014).

## Seasonal and Spatial Distribution

Given the national importance of the Fraser River Delta for birds, a regular assessment of how they are faring should be a conservation priority. However, to achieve that task for the 263 species that annually cross the delta would be daunting. At a basic level, general surveys such as the CWBS, Christmas Bird Count and Breeding Bird Survey

provide a broad view for the majority of species. However, the Conservation Priority species in Table 4 deserve unique surveys designed to capture their seasonal abundance to ensure prompt action. Coupled with surveys should be exploration into possible causes of declines targeted to each species. A regular Breeding Bird Survey and a winter bird survey for songbirds coupled with the Partners in Flight conservation assessment tool (<https://partnersinflight.org>) would complement the Conservation Priority list of mostly waterbirds shown in Table 4.

We concluded that the Fraser River Delta is the winter destination for most species of waterfowl rather than a migratory stopover site. We based our conclusion on seasonal use patterns and band recovery data. In the early 20<sup>th</sup> century, most waterfowl stopped on migration but departed soon after hunting season began (Benson 1961). There are several possible contributing factors to this shift in seasonal use including relaxed hunting pressure from fewer hunters and stronger conservation regulations, sanctuaries and higher recruitment of young birds into the breeding populations. The return of waterfowl for the winter is a return to historical use reported by Anderson (1884) and Fannin (1891) although former floodplain wetlands have been replaced with farmlands.

Some species have undergone substantial changes in distribution on the delta. American Wigeon have become less common on Sturgeon Banks and relatively more numerous in Boundary Bay (Table 7). Snow Geese, Canada Geese and Trumpeter Swans regularly use fields, playgrounds, or parks. Nesting has ceased by Glaucous-winged Gulls on a breakwater at Tsawwassen and by Double-crested Cormorants on river channels since the 1990s. Bald Eagles are widespread breeders and winter visitors. For the majority of songbirds using riparian forest habitat on the delta, there are few data to measure changes despite large numbers being present during the breeding season, on migration, and in the non-breeding season.

## Conservation Designations

The first bird sanctuary established on the Fraser River Delta was the George C. Reifel Migratory Bird Sanctuary on Reifel Island in 1963. By 1987, less than 1% of the delta was protected for wildlife (Butler and Campbell 1987). By 2019, about 332 km<sup>2</sup> of the delta received legislated protection (Table 10). The Ramsar, IBA and Shorebird Reserve designations cover much bigger areas and overlap the legislated areas but do not offer legal protection. The legislated protected area as of 2019 was about 38% (Table 10).

Among the international designations, the Ramsar Convention purpose is “the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world”. For the Fraser River Delta, shorebirds and waterfowl met or ex-

ceeded the qualifying threshold. The Western Hemisphere Shorebird Reserve Network aims to ‘protect the nesting, breeding and staging habitats of migratory shorebirds’. On the Fraser River Delta, the program identified the Western Sandpiper population to qualify for inclusion as a Hemisphere Reserve.

Nationally, the George C. Reifel Migratory Bird Sanctuary was established for the ‘primary benefit of waterfowl’. The Alaksen National Wildlife Area purpose was to ‘protect migratory birds, species at risk, and other wildlife and their habitats.’ Species identified are Snow Goose, Canada Goose, American Wigeon, Great Blue Heron and Barn Owl. The Important Bird and Biodiversity Areas (IBA) purpose is “to identify, conserve, and monitor a network of sites that provide essential habitat for Canada’s bird populations”. The Fraser River Estuary IBA exceeds all other nearly 600 IBA sites in Canada.

Regionally, the South Arm Marshes Wildlife Management Area was established to manage ‘critical habitat for fish, waterfowl, shorebirds, raptors, songbirds and small mammals.’ Roberts Bank Wildlife Management Area was established for the ‘management of critical habitat for fish, waterfowl, shorebirds, raptors, and other species’. Sturgeon Banks Wildlife Management Area purpose is ‘conservation of critical, internationally significant habitat for year-round, migrating and wintering waterfowl populations, along with important fish habitat’. Boundary Bay Wildlife Management Area purpose is ‘conservation of critical, internationally significant habitat for year-round, migrating and wintering waterfowl populations, along with important fish and marine mammal habitat’. The Serpentine Fen Wildlife Management Area purpose is to ‘provide habitat for migratory and resident wildlife of the Fraser River Delta and Serpentine River lowlands’. The Sea Island Conservation Area purpose is to manage ‘existing populations of wildlife that do not compromise aviation safety’.

The Fraser River Delta has received many conservation designations that underscore its world ranking as one of Canada’s premier bird habitats (Table 10). The overlapping designations appear bewildering but provide different roles. The provincial Wildlife Management Areas and federal National Wildlife Areas are legislated to allow mandated agencies to regulate use. These designations provide the strongest security when governments carry out their authority. The Western Hemisphere Shorebird Reserve and Ramsar Wetlands of International Importance designations rely on the good will of the landowners to maintain conditions favourable to birds. Although the uses are not legally mandated, these programs define the extent of the ecologically important places that support birds in the delta and have played important roles in planning and environmental assessments.

The outer estuary has not been designated or included in the IBA because not much was known about the area until recently (Butler *et al.* 2018). The agricultural lands

are largely privately owned where a few small tracts have been designated for conservation and where some of the most difficult conservation issues lie. Many farmers have accommodated birds in their farm management despite having to juggle economics, land prices, and outside pressures, including from conservation groups (King 2011). Creative solutions largely through the efforts of the Delta Farmland & Wildlife Trust and by Ducks Unlimited Canada's On-Farm Plan (Ducks Unlimited Canada 2017) are needed to ensure continuity.

The value of conservation designations has extended beyond simply securing the lands. By raising awareness of the delta's importance to the public, strengthened calls for habitat mitigation on the delta to compensate for industrial and residential developments, funding support for several organizations involved in managing and restoring habitats favourable to birds in the Fraser River Delta, and raising tourism potential.

The lion's share of the tidal flat and estuarine habitat at the mouth of the Fraser River Delta lies in Canada. However, securing the tidal flat around Point Roberts and estuarine habitat south of Boundary Bay and within the USA would assist in the conservation of many Threshold Species especially Surf Scoter, Western Grebe, Sanderling, Marbled and Ancient murrelet, and Great Blue Heron. The upland forest and meadows on Point Roberts offer an opportunity to aid in the recovery and maintenance of species of conservation concern such as the Common Nighthawk, Barn Owl, Olive-sided Flycatcher, and Barn Swallow.

## Food and Cultural Webs

The Fraser River Delta is very important for both environmental and economic reasons, two directions for which the goals are sometimes in opposition to each other. An understanding of ecosystem consequences of development plans and changes in bird populations on humans and other life forms is central to good environmental assessments. For example, the Great Blue Heron plays an important role in the ecology of eelgrass meadows (Huang *et al.* 2015), primary production by biofilm is important to the migration of Western Sandpipers (Sutherland *et al.* 2013, Elnor *et al.* 2005), many waterfowl and shorebirds rely on food from tidal flats and farmlands (Baldwin and Lovvorn 1994b, Boyd 1995, Middleton 2016, Evans Ogden *et al.* 2005), and predators such as Bald Eagles and Peregrine Falcons can influence the distribution of all of these examples (Ydenberg *et al.* 2002, Dekker *et al.* 2012, Middleton *et al.* 2018, see **Species Accounts**).

One of the first steps of understanding ecosystem functions is to quantify how food is produced and to identify the consumers, which is often illustrated as a food web. The food web on the Fraser River Delta has multiple pathways, which is a reason for the diversity of species found there. About 34% of the 263 annually occurring bird species are insectivorous, about 20% eat marine inverte-

brates, 19% are herbivorous, 18% are piscivorous, 6% eat mammals, and only 3% eat birds.

To provide the needs of birds requires the ecological factors that produce the food to continue to operate. The abiotic factors that dictate the growth and distribution of primary production include precipitation, salinity, tidal change, and sedimentation. Primary production in the estuarine habitat arises from an abundance of plankton that attracts secondary consumers mostly as small fish including Pacific herring (*Clupea pallasii*), smelt (*Hypomesus pretiosus*), sandlance (*Ammodytes hexapterus*), six species of salmon (*Onchorhynchus* spp.), sea perch (*Cymatogaster aggregata*) and anchovy (*Engraulis mordax*; Beamish 2014). Herring, sandlance and sea perch reproduce in the Fraser River Delta and several species travel up the Fraser River to spawn along its shores and in its tributaries, including the six species of salmon, and eulachon (*Thaleichthys pacificus*). Millions of salmon fry and smolts return to the estuary for varying lengths of time where some become prey to fish-eating birds (Beamish 2014).

The tidal flats' primary producers are eelgrass meadows, biofilm, and marshes. On the natural areas of the floodplain, primary producers are native seed and fruit producing plants, and shrubs and forests. Also, on the floodplain, the ecological function is largely dictated by human activity especially farming, urban and industrial developments, but also disposal of waste products. Determining how flexible these functions are to human-induced changes will be an important quest to understanding ecological resilience.

The food web concept, used widely in ecological studies, can be extended to include cultural activities connected to the natural world (Butler 2017). Recognition of the cultural web of many Indigenous people includes accessing natural products from the delta for cultural purposes (Suttles 1987, Tsawwassen First Nation 2010, Musqueam Indian Band 2020). We propose that a culture web has emerged that is dependent on the delta's ecological functions. To the marsh food web described above we can add hundreds of people who enjoy waterfowl hunting, 90,000 birdwatchers who annually visit the George C. Reifel Migratory Bird Sanctuary and other coastal locations within Delta and Richmond, the tens of thousands of people who attend the Steveston Fish Market and Salmon Festival, and the hundreds of thousands of people who walk the dike trails around the Fraser delta every year. The floodplain food web can extend to the hundreds of thousands of people who eat locally produced foods and enjoy being in natural areas of parks and protected spaces, members of clubs and events that draw people from outside the delta and around the world, and support region-wide events such as Greater Vancouver Bird Celebration and whale watching.

## Predator Landscapes

For many years, the conservation rubric on the Fraser River Delta has been to secure habitats to provide the

needs of its birds. Much of the floodplain agricultural lands are privately owned where creative stewardship options largely through the work of the Delta Farmland & Wildlife Trust has gone part way to cost share with farmers to make a living while providing for waterfowl, shorebirds and birds of prey.

The habitat approach has mostly been used to estimate the area of waterfowl habitat by deriving estimates of the amount of food the birds required through the winter (*e.g.* Hagy *et al.* 2014, Merckens *et al.* 2012). There is a growing appreciation of the interaction between presence of food and predators in affecting how birds use landscapes (Lima and Dill 1990, Butler *et al.* 2003, Pomeroy 2006, Ydenberg *et al.* 2002, 2007, Middleton 2016, Middleton *et al.* 2018).

Middleton (2016) showed that at a landscape scale, selection of fields by waterfowl was best explained by field-level danger from human residential activities and nearby roads, and that food energy and standing water were poor predictors of field-use by waterfowl. Danger and the presence of greenhouses had a positive effect by drawing ducks to fields with few people nearby. Her findings support McKinney *et al.*'s (2006) conclusion that the scale of residential areas was an important predictor of waterfowl densities in Atlantic estuaries. The conservation implications of these findings suggest that disturbance from human activities and predators needs to be a factor in future estimates of habitat area required to support waterfowl.

Hunting of birds on the delta is a centuries-old tradition first by Indigenous people and later by immigrant settlers (Matson 1981). By the late 1800s, uncontrolled market hunting began. One of the places the waterfowl were sold was in the store run by W.H. Vianen in New Westminster. "Last night, Mr. Vianen had a magnificent exhibition of dressed poultry of all descriptions, turkeys, geese, chickens, ducks, widgeon, grouse, partridge, and almost everything that does business on wings" (15 December 1889, *The British Columbia, Weekly Edition*. p. 24).

Market hunting was replaced by regulated recreational hunting that continues today but there was little refuge for waterfowl from the late 19<sup>th</sup> century through the 1960s (Leach 1972) after which a growing area of the delta was seasonally or permanently closed to hunting. Also in favour of waterfowl were the growth of extensive cultivated lands that provided places to forage and the demise of a major predator, the Bald Eagle, in part due to reproductive failure from industrial contaminants of their eggs in North America and from persecution largely in Alaska (Robards and King 1966). Through the 1980s and 1990s the equilibrium tipped in favour of waterfowl as there were fewer hunters, more wildlife refuges, and Bald Eagle numbers were only just beginning to recover. By the end of the 20<sup>th</sup> century, Bald Eagle numbers had recovered and appear to have stabilized, likely signalling the eagle and waterfowl populations are entering a phase of equilibrium (Elliott *et al.* 2006).

The impact of hunting and eagles has not been fully appreciated in our understanding of the Pacific Flyway waterfowl populations. Reports from the late 19<sup>th</sup> and early 20<sup>th</sup> century from the Central Valley of Oregon and California refer to many millions of waterfowl present in winter and current estimates are much lower (Gilmer *et al.* 1982). The loss of suitable habitat is the most oft cited and a reasonable explanation for the declines. However, the historic high numbers might have been the result of the establishment of California refuges beginning in 1908 where waterfowl could find food and rest.

The predator landscape suggests that the local and regional distribution of birds is a trade-off between food availability and danger. The recovery of eagles and falcons, and increased presence of humans, brought heightened fear to waterfowl and shorebirds altering how they used farmlands and tidal flats, and their choice of prey (Pomeroy 2006, Ydenberg *et al.* 2010, Dekker *et al.* 2012, Middleton 2016). Examination of the continental impact of hunting and eagle predators on refuge design and placement across the Pacific Flyway would be a worthy exercise to guide conservation in the next century.

## Conservation Risks

A substantial investment has been made to research, monitor and secure birds and their habitats on the Fraser River Delta. That investment is paying dividends in the form of recreation, ecosystem services, and our well-being. Here we identify risks that need to be addressed to ensure the continuation of the birds on the delta.

### Floodplain

Most of the delta's original floodplain ecosystem no longer exists. Water levels and flood prevention are now controlled by dikes and pumps. Farmlands on the floodplain partly filled the ecological needs of many birds, a fact well known to the conservation community. Risks include the loss of farmlands to other uses, and contamination and fragmentation of existing farmlands particularly by new and expanded highways and subdivisions or commercial/industrial complexes. Maintaining the provincial Agricultural Land Reserve (ALR) and the Urban Containment Boundaries has largely been deemed successful at containing urban sprawl across the Fraser delta (Burchfield and Kramer 2015). The demand for outdoor recreation has increased. The proximity of the Fraser River Delta to urban development boundaries has increased the pressure on land prices, including farmland (Tatebe *et al.* 2018). As a result of these economic pressures, farmland in the ALR has been purchased by non-farmers (*e.g.* as investments, for estates and/or commercial amenities) based on their non-farm and speculative values. Farmlands purchased by non-farmers are not being farmed to their full potential or may not be farmed at all (Metro Vancouver 2014). Existing farmland has been divided by highways, railways and roads and the

Pacific Gateway Transportation Strategy plans to invest at least \$25 billion dollars into trade capacity on the Pacific Coast requiring transportation infrastructure (Government of B.C. 2012). The choice of crops and farming methods also has an impact on ecological value, an issue that has been well addressed within Delta Municipality by the Delta Farmland & Wildlife Trust (DF&WT 2020)

There is a long history of contamination on the Fraser River Delta and vigilance is required to respond to emerging impacts. Since 1987, there have been instances of bird mortalities, reproductive and other health effects, and poisonings from toxic substances on the delta, (Jury 1981; Elliott *et al.* 1989, 1996, 1998a, 1998b, 2008, 2011; Hart *et al.* 1991; Wilson *et al.* 1996). Collaboration between government, agricultural researchers and the farming community led to the most toxic of the in-use insecticides sequentially being removed from the local market (Elliott *et al.* 2011), and chlorophenolic biocides and lead shot were banned, which led eventually to a nation-wide ban (Scheuhammer and Thomas 2011). Some toxic substances continue to have deleterious effects as they circulate through the ecosystem long after they stopped being applied (Brogan *et al.* 2017). Several cities and municipalities have banned the use of anticoagulant rodenticides in urban, industrial and agricultural areas to control rodents in response to the harm to owls and hawks (Albert *et al.* 2010; Thomas *et al.* 2011; Hindmarch and Elliott 2015).

#### Tidal Flat

The tidal flat has extensive flat surfaces with minimal erosion that are bathed daily by tidal flow of fresh and brackish waters. The marshes and seagrass meadows are important nurseries for fish and invertebrates, and the mudflats are important sources for biofilm. The risks to the functioning tidal flats arise from physical factors that erode the marshes and seagrass meadows, and hamper biofilm growth. Sea level rise potentially puts the marsh at risk by increased submergence time against hardened dikes. Redirection of river and tidal currents alters the sediment and salinity profiles potentially hampering biofilm growth. The B.C. Ferry and Deltaport jetties on Roberts Bank created favourable conditions for the spread of eelgrass which benefited Great Blue Herons and waterfowl (Butler 1997). On the other hand, another proposed shipping infrastructure project on Roberts Bank is adjacent to the most heavily utilized foraging habitat by Western Sandpiper on the Fraser delta (Jardine *et al.* 2015). An environmental assessment panel raised concerns that the proposed extension of the existing terminal and its jetty would alter the flow of ocean and river currents and potentially compromise the ecological processes currently supporting the production of biofilm eaten by migratory shorebirds. Spills of deleterious substances in the estuarine habitat also risks damage in the adjacent tidal flats. Invasive species such as *Spartina anglica*, could potentially outcompete native species leading to changes in food webs.

#### Estuarine

The convergence of fresh water flowing out of the Fraser River and into marine waters in the Strait of Georgia establishes favourable conditions for a plankton-based food web that includes birds. Sources of poor water quality include sewage disposal from treatment facilities, runoff from urban and rural areas, oil and other chemical spills, shipping spills and industrial processes (Nener and Wernick 1997). Maintenance or improvement of water quality by preventing pollution from industrial and other discharges and spills is a priority. Oil spills can have serious long-term consequences for the recovery of bird populations (Day *et al.* 1997). Negative ecological effects from poor water quality were evident on Sturgeon Banks until a sewage discharge pipe was relocated (Arvai *et al.* 2002) and many unintended introductions of non-native marine species have occurred (Murray 2008).

## Conclusions

Thanks to pro-active initiatives in farmland stewardship, habitat protection and contaminant controls, many species of birds on the Fraser River Delta have fared well since 1987 (Table 5). Provision of winter cover crops, grassland set-asides and hedgerow planting have benefited diverse species of waterfowl, shorebirds and birds of prey (DF&WT 2020). Reductions in some agricultural and industrial contaminants, improved water quality, and securement of conservation lands have contributed to a better functioning ecosystem (Arvai *et al.* 2002, Elliott *et al.* 2011). However, fragmentation and altered uses of habitats occupied by birds are issues that need to be addressed. The swelling numbers of Snow Geese and Canada Geese are a concern to farmers and to airport safety. Most songbird populations have not been adequately censused.

Butler and Campbell (1987) and Dawe *et al.* (2001) summarized the stages of exploitation of birds on the delta beginning with European settlement. Much progress has been made in securing land and understanding the ecological functions that support birds in the past 30 years. For example, the ecological needs of several species of international and national significance have been partly fulfilled by securing some of their habitats. We also showed that some species have responded well to conservation measures leading to a restoration of former abundance. Despite large advances in designating areas for wildlife and understanding of the biology of birds on the delta, the growth in human needs challenges long term conservation security (Kehoe *et al.* 2020). Farming is facing a host of challenges, and industrialization and urban development proposals on the delta are on-going. Concerns about climate change and sea level rise need to be addressed. We now need to ensure that wildlife popula-

tions are secure in designated areas and look to the potential return we can get by doing so.

We are entering a new stage in bird conservation on the Fraser River Delta, with the wider public recognition that spending time in nature has health and social benefits. Indigenous people are reaffirming the importance of their connection to the delta's land and water (Tsawwassen First Nation 2010, Musqueam 2020). The urgency for conservation was highlighted by Kehoe *et al.* (2020), who proposed a co-governance model with cost sharing as the most effective means to achieve conservation goals in the Fraser River Delta. The opportunity is for all who work, live and visit the delta to unite under a common vision of preserving nature, livelihoods and cultures.

## Recommendations

The Fraser River Delta supports wildlife populations of global, international and national importance. Strides have been made to identify and secure key areas, and to understand the ecology of species that occupy them. We now need to determine and secure the ecological functions of the estuarine habitat, tidal flat and floodplain that support the internationally and nationally important bird populations and other wildlife species. To achieve that protection, the following objectives must be met:

1. Support the Agricultural Land Reserve and the ability for farmers to maintain large tracts of open ground farmlands around Boundary Bay and the mouth of the Fraser River, with minimal roads and human disturbance, that provide habitat for seasonal wildlife including waterfowl, shorebirds and birds of prey.
2. Restore corridors of riverine marshes and floodplain forests along the Fraser River to provide and enhance habitat for songbirds and riverine birds, mammals, and fish, including Fraser River salmon.
3. Provide hedgerows and urban forests for winter and resident birds including songbirds, woodpeckers, hummingbirds, and owls.
4. Complete the studies of the ecological needs of international and national important bird species, and the ecosystem functions that support them.
5. Enhance transboundary collaboration so that the entire Fraser River Delta in Canada and the USA can be understood as an interconnected and shared system.
6. Establish a partnership with representation from all levels of government and First Nations, not-for-profit conservation organiza-

tions, industry and interested stakeholders, to create a unified vision for the Fraser Estuary and plan to:

- a) coordinate conservation and research,
  - b) enhance access to nature that respects habitats and wildlife;
  - c) secure and manage protected spaces;
  - d) promote economic and cultural opportunities derived from the delta's environment such as farming, fishing, birdwatching and tourism;
  - e) provide a forum to seek solutions for developments that potentially threaten the delta's ecosystem;
  - f) explore options for designations that enhance the stature of the Fraser River Delta for its natural and cultural assets, such as Biosphere Reserve or World Heritage Site designation, as part of a wider recognition and marketing of products derived from the delta.
7. The Partnership would work, among other things, to:
- a) maintain farmland and farming livelihoods that sustain the birds drawn to the delta each year;
  - b) mitigate the effects of erosion from sea level rise on the marshes, and impact of jetties and river channelization on biofilm and eelgrass meadows;
  - c) prevent deleterious substances from entering the waterway either from ships at sea or from the river runoff;
  - d) restore riverine marshes and floodplain forests along the North and Main Arms of the Fraser River to enhance fish rearing and migration, and provide bird habitat;
  - e) recover species at risk, maintain common species, and sustain the Threshold Species with a research focus on understanding the ecological processes that support large numbers of birds on the delta and along the Pacific Flyway;
  - f) promote economic and cultural opportunities compatible with maintaining the birds and their ecosystems;
  - g) market Fraser River Delta products that are compatible with long term bird and nature conservation;
  - h) provide educational information about the Partnership, its activities, and the birds of the Fraser River Delta.

8. Seek cooperation with U.S. partners to consider conservation designations for portions of the delta, including Point Roberts, in the USA.
9. Co-develop and enforce, with the respective cities of Vancouver, Delta, Richmond, Surrey and First Nations governments a bird disturbance reduction program along the Fraser delta. This should include motorized and non-motorized craft-use bylaws, as well as appropriate canine control bylaws that are both explicitly or implicitly enforced through a shared environmental responsibility campaign.

## Species Accounts

The following Species Accounts include species or groups of species that have been identified in conservation designations of: 1) Threshold Species used in the IBA designation and 2) Species at Risk nationally (Table 4). We also identify species that are on the provincial Red- and Blue-lists but do not provide accounts (Table 4).

*Conservation status:* For each species we refer to its IBA Threshold level where G=Global, C=Continental, and N=National significance; and its level of endangerment where E=Endangered, T=Threatened and SC= Special Concern. SARA refers to the federal Species at Risk Act and Schedule 1 refers to the species having been officially added to the SARA list of species, COSEWIC refers to the Committee on the Status of Wildlife in Canada, and Red-list (R) and Blue-lists (B) refers to the B.C. Conservation Data Centre.

*Occurrence:* Occurrence is derived from the bar graphs in Weber *et al.* (2013). Butler and Campbell (1987) and Weber *et al.* (2013) used similar frequency definitions for Casual to Common species (Table 12). Butler and Campbell (1987) further divided abundant species into three more categories than Weber *et al.* (2013). We use Weber *et al.* (2013) as the most recent reference point and compare to Butler and Campbell (1987) in the text.

*Ecology:* Here, we summarize the ecological role, what has been learned about the ecology of each species on the Fraser River Delta using published literature, personal communications with biologists and unpublished field notes, and make recommendations to fill ecological information gaps.

*Conservation:* We summarize and evaluate conservation actions since Butler and Campbell (1987), and make recommendations to sustain species on the delta.

*Remarks:* Here, we make comments about the species taxonomy, cultural significance, conservation status, and other features of a species while on the delta.

### Snow Goose *Anser caerulescens*

*Conservation status:* G.

*Occurrence:* Migrant Non-breeder that was *Very abundant* in fall, winter and spring, and *Rare* in summer (Butler and Campbell 1987). *Common* mid-October to mid-April, and *Casual* in summer (Weber *et al.* 2013). Hobson and Driver (1989) identified remains in centuries-old middens and large flocks occurred at the mouth of the river in 1824 and

Table 12. Frequency definitions used by Butler and Campbell (1987) and Weber *et al.* (2013) for the abundance of birds in the Fraser River Delta and Greater Vancouver Region, B.C., respectively.

Frequency	Butler and Campbell 1987 Individuals/day/ locality	Weber <i>et al.</i> 2013 Individuals/day/ locality
Very abundant	>1000 (often in large flocks)	ND <sup>1</sup>
Abundant	200–1000	ND
Very common	50–199	ND
Common	20–49	25+ seen or heard daily
Fairly common	7–19	5–25 seen or heard daily
Uncommon	1–6	0–5 seen or heard daily
Rare	1–6 individuals/season	1–10 records/year
Very rare	>6 records, infrequent	ND
Casual	1–2 records	2–20+ records/year
Accidental	1 record	ND
Introduced	Released into the wild	Established for >10 yr. with historically stable population

<sup>1</sup> Not defined



1891 (Wark 1824, Fannin 1891). In the 1950s and 60s, a few thousand were present in winter (Benson 1961, Leach 1972). The number of geese fluctuated between 15,000 and 55,000 from 1950 to 2000 (Boyd and Cooke 2000) after which steady growth saw the number approximate 100,000 geese by 2007–08 and 118,000 in 2018–19 (Sean Boyd, unpublished data). Some of this growth was likely due to improved conditions on Wrangel Island where good weather has resulted in an increase in gosling recruitment and survival (Pers. comm., Sean Boyd, Delta, B.C., 2019 November 1).

*Ecology:* Snow Geese on the Fraser River Delta originate from Wrangel Island, in the Russian Far East and spend the winter in North America with the majority going to California and the remainder wintering on the Fraser and Skagit River deltas (Boyd 1995). From 1960 through the 1970s, about 20–30% of the Wrangel population used the Fraser and Skagit River deltas as their winter destination. In the late 1980s and early 1990s about half the geese spent the winter there.

Historically, the geese settled in the marshes between Brunswick Point and Lulu Island in the spring largely eating rhizomes of marsh plants (Boyd 1995). Boyd (1995) and Demarchi (2006) predicted that the marshes would not be able to sustain large numbers of geese and as early as the 1980s, Snow Geese began to regularly visit agricultural fields to eat cover crops, potatoes and barley grain in the fall and early winter, followed by perennial forage crops in winter (Bradbeer 2005). By 2019, about 40% of the marshes in some areas of the delta reverted to mudflats in part due to intense goose grubbing, and possibly sea level rise, changes in salinity and sedimentation patterns (Pers. comm., Sean Boyd, Delta, B.C., 2019 November 1).

The impact of geese in the delta was partly contained by hunting (Bradbeer 2005). The geese moved outside of the Alaksen National Wildlife Area despite an open hunting season in November 2005 which Bradbeer (2005) speculated was due to food depletion within the Alaksen National Wildlife Area. However, hunting is not permitted in residential areas where geese learned that there was little to fear and so took to using parks and lawns.

*Conservation:* Leach (1972) believed that unregulated market hunting for the commercial trade drove geese away from the delta. With the establishment of refuges, the goose populations began to return. However, the recent growth in the number of Snow Geese is largely due to increased survival of young geese largely in response to warmer weather on the Russian nesting grounds (Boyd 1995). The recovery of geese is a conservation success story but their increasing numbers and movements into populated areas raise concerns over collisions with air traffic at Vancouver International Airport, impacts on agricultural lands, and nuisance effects on sports field, playgrounds and schoolyards.

### **Brant *Branta bernicla***

*Conservation status:* C.

*Occurrence:* Both *Migrants* and *Migrant Non-breeders*. *Uncommon* from late April to early June, *Rare* to end October, and *Fairly Common* from November to the end February (Weber et al. 2013).

*Ecology:* Brant are drawn to the delta by eelgrass as food (*Zostera japonica* and *Z. marina*; Baldwin and Lovvorn 1994a). There are two subspecies of Brant that annually transit the delta. Atlantic Brant (*B. b. hrota*), is the subspecies we suspect Leach (1979) surmised correctly bred in the Canadian High Arctic and Greenland (Reed et al. 1989, 1998, Clements et al. 2019) and is distinguishable by their broken ‘necklaces’ and grey bellies. The darker black Brant (*B. b. nigricans*) winters between Alaska and northwest Mexico (Clements et al. 2019). They arrive at the Fraser River Delta in spring in large numbers en route to breeding grounds in Alaska, the Canadian Low Arctic and northeastern Russia. While on the delta, both subspecies are found most often in eelgrass meadows in Boundary Bay and on Roberts Bank.

*Conservation:* The once extensive populations of Brant that spent the winter in the Salish Sea in the early 20<sup>th</sup> century collapsed by mid-century (Brooks and Swarth 1925, Munro and Cowan 1947, White and Spilsbury 1987). The Brant illustrates the outcome of misunderstanding the population consequences of our actions. The demise of Brant on the Fraser River Delta has been attributed to unrestricted harvesting about a century ago followed by a regulated hunt on the winter population (Leach 1979, 1982). There is some evidence that hunting mortality in goose populations is additive and can result in emigration for safer sites (Francis et al. 1992). When changes were made in the early 1990s to hunting regulations in Boundary Bay, the Brant harvest declined to a few hundred birds, mostly spring migrants from Mexico and the winter population on the delta increased to a current estimate of 3,000–4,000 birds (Pers. comm., Sean Boyd, Delta, B.C., 2019 November 1).

A winter population of Brant historically widespread on the South Coast was already in decline by the early 20<sup>th</sup> century (Brooks and Swarth 1925). Leach (1972) reported that a few dozen Brant spent the winter on the delta and thousands arrived on spring migration. Butler and Campbell (1987) surmised that the Brant that wintered on the Fraser River Delta were stragglers from the Alaskan Brant that migrated to Mexico each autumn but the story was more complex. Reed et al. (1998) revealed that the Brant in Boundary Bay were a mix of grey- and dark-bellied Brant from different breeding grounds in the Arctic (Reed et al. 1998). The thousands of black Brant arriving each spring from winter quarters in Mexico nested in Alaska and

the Low Western Canadian Arctic whereas the Atlantic Brant nested in the High Arctic. Hence, in our migration classification scheme (Figure 4) Black Brant are largely *Migrants* whereas Atlantic Brant are *Migrant Non-breeders*.

The Fraser River Delta plays an important role in the survival of Brant. The influx of Brant in March through late April was estimated to be about 29,000–33,000 individuals on the Fraser River Delta in 1999 and 21,000–25,000 individuals in 2000 corresponding to 18–26% of the entire Pacific Flyway brant population (Hagmeier et al. 2008). Overlying the need for places to stop and refuel, like the Fraser River Delta, are natural factors that influence their abundance. The number of Brant in the Pacific Flyway in recent years seems to be dictated by climatic features. Their numbers increased during warm phases of the Pacific Decadal Oscillation and decreased during the cool phase, likely as a result of whether there were favourable tailwinds during migration (Ward et al. 2009). More Brant are spending the winter in Alaska in recent years (Ward et al. 2009).

### **Trumpeter Swan *Cygnus buccinator***

*Conservation status:* G.

*Occurrence:* *Migrant Non-breeder*. *Common* in winter (Butler and Campbell 1987, Weber et al. 2013). *Casual* May to early-October. Swans reach peak abundance in January (Boyd 1994).

*Ecology and Conservation:* The Trumpeter Swan is a grazer in the marshes and in farm fields. Boyd (1994) estimated that the swans were responsible for about 6–8% of the grubbing impact on the marshes in the late 1980s and early 1990s. Their abundance is an example of how halting persecution and providing space are often the antidotes for recovery. Hudson's Bay Company records indicated that, between 1853 and 1877, nearly 18,000 Trumpeter Swan skins were imported to London to make powder puffs, and feathers to make writing and drawing quills along with eggs for collectors (Johnsgard 1978). The destruction of their prairie habitat was thought to be the final straw (Johnsgard 1978). Biologists worried that the swan might not recover (Munro and Cowan 1947). By the 1960s, the Trumpeter Swan on the delta was a rare migrant. Hunting of swans and collecting eggs were banned, and on the coast of British Columbia conservation organizations had begun to establish swan refuges. Two aerial surveys on the delta in 1977 showed 69 and 87 swans were present (Boyd 1994). By the time Butler and Campbell (1987) wrote their treatise, the Trumpeter Swan flocks were small ("rarely exceeding 75 swans") but the authors optimistically commented that the species was increasing in winter. In the 1970s and 1980s swan numbers grew by 7% per annum in the Pacific Northwest and 15% on the

delta. From 1987 to 1998, the increase surged to 18.4% per year resulting in 2,411 swans on the delta and lower Fraser Valley (Hawkings et al. 2002).

### **American Wigeon *Mareca americana***

*Conservation status:* G.

*Occurrence:* *Migrant Non-breeder* and the most numerous duck on the delta in winter. *Rare* from mid-June to mid-August, small breeding population, *Fairly common* from mid-August to late September, then *Common* until mid-March and *Uncommon* from late March to early June (Weber et al. 2013). Benson (1961) estimated 8,000 American Wigeon were present on the delta in the 1950s and their numbers plummeted soon after hunting season opened. Leach (1972) reported much greater numbers in the 1960s when over 45,000 wigeon were present on the delta in autumn but like Benson (1961) only a few thousand remained by January. He opined the shortage of safe places for waterfowl to find safety from hunters. The maximum count in 1988 was 50,610 wigeon (Butler and Cannings 1989) which was close to the CWBS maximum of 43,000 wigeon (Table 5). Recent estimates based on single day counts in mid-November place the number of American Wigeon at 52,000 in 2018 and 34,000 in 2019, similar to the numbers reported in the 1960s.

*Ecology:* The American Wigeon is an important grazer of eelgrass (*Z. marina*) and along with Brant removed an estimated half (262t) of the biomass in Boundary Bay (Baldwin and Lovvorn 1994a). Wigeon also consume large quantities of short-cropped grasses and pastures in farmlands.

Wigeon breed only sporadically on the Fraser delta, instead migrating to the interior of British Columbia to breed (Davidson et al. 2015). Centres of breeding distribution for the species are located in three main ecoprovinces: the Chilcotin and Cariboo plateaus in the Central Interior, the Thompson River drainage in the Southern Interior, and in the Peace River lowlands within the Boreal Plains. Following breeding and moulting, wigeon migrate to the Fraser River Delta in the fall, numbers peaking in October and November and declining thereafter (CWBS, unpublished data). While in the delta, wigeon mostly occur in the marshes and close to shorelines where they feed on vegetation, at times visiting the uplands to feed on leftover grains and vegetables.

Although the number of wigeon has remained steady for several decades, we showed earlier that the distribution has changed with increased use of Boundary Bay. Wigeon predominated off Sea and Lulu Islands in the 1960s, Green-winged Teal was the most numerous duck off Westham Island and Tsawwassen, and Northern Pintail predominated in Boundary Bay (Table 7). By 1989, American Wigeon predominated off Westham Island, Tsawwassen and in Boundary Bay. The southward shift on the delta of

wigeon is possibly the result of a combined effect of loss of farmland habitat in Richmond and the presence of turf farms and pasturelands in Delta.

*Conservation:* Southwestern British Columbia, including the Fraser River Delta, and Puget Sound hold some of the highest winter densities of American Wigeon in the world (Root 1988).

### **Mallard *Anas platyrhynchos***

*Conservation status:* C.

*Occurrence:* Common in summer, *Very abundant* in winter (Butler and Campbell 1987). *Common* year-round resident (Weber *et al.* 2013). Some of the delta's Mallards are *Residents* but mostly *Migrant Non-breeders*.

*Ecology:* The Mallard is one of the most numerous and widespread ducks on the delta. Mallards play an important ecological role as dispersers of a wide variety of aquatic, riparian and terrestrial seeds (Brochet *et al.* 2009, Lovas-Kiss *et al.* 2018). Mallards are prey for falcons and eagles. Mallards form large flocks on shallow intertidal waters and tidal flats where they forage until late autumn and early winter. They satisfy their food needs for the rest of the winter by feeding in farmlands, parks and drainage ditches.

*Conservation:* A key unanswered question in conservation is whether the Mallards in the Fraser River Delta are part of a flyway population that uses the delta on migration between winter and breeding ranges. In California, Mallards are mostly local (Feldheim *et al.* 2018). Most Mallards on the Fraser River Delta breed in western North America and arrive in autumn where they remain all winter. Monthly counts show increasing abundance through the fall to a peak number in December after which the numbers abruptly fall (Butler and Cannings 1989). The Fraser River Delta appears to be the final destination for all or most Mallards counted there. This hypothesis was supported by band recovery data. Most Mallards banded on the south coast of British Columbia were recovered there in subsequent years despite far more hunters being farther south (McKelvey and Smith 1990). More investigation is required to untangle these questions and to design conservation policy for this species.

The number of Mallards present on the Fraser River Delta has varied greatly over the years. Benson (1961) estimated 35,000 ducks were present in the 1950s but did not describe how he derived this estimate. Campbell *et al.* (1972a) reported Canadian Wildlife Service aerial survey estimates of about 25,000 Mallards on the delta in the 1960s. Vermeer and Levings (1977) also conducted aerial surveys and reported 50,000 Mallards present in the 1970s. Monthly shore-based counts in 1988–89 showed 21,000

Mallards were present (Butler and Cannings 1989). However, the CWBS maximum count between 1999 and 2019 was only 10,600 (in 2001; Table 5). Despite the variability in abundance, Crewe *et al.* (2012) did find a significant trend in the numbers of Mallards on the CWBSs in the Salish Sea and we found no difference on the delta in 1999–2019. These ambiguous results beg for some attention to explain these fluctuations.

The key conservation requirement for the Mallard is security of tidal flats and nearby farmlands as foraging habitat. The majority of Mallards in nearby Puget Sound were found on tidal flats adjacent to farmlands (Lovvorn and Baldwin 1996).

*Remarks:* The respective IBA thresholds are 190,000 and 93,700 for Global and Continental Significance. The 11,000–21,000 estimate of Mallards based on single day highest counts on the Fraser River Delta (Table 5) fails to meet either threshold. Butler and Cannings (1989) reported almost 21,000 in December 1988. However, both of these surveys are likely underestimates because they were designed to tally Mallards only on the tidal portion of the delta and therefore overlooked ducks using farmlands, parks and Burns Bog. An assessment of the number of Mallards using the delta in winter is required to determine if the species should continue as a Threshold Species.

### **Northern Pintail *Anas acuta***

*Conservation status:* G.

*Occurrence:* *Migrant Non-breeder. Uncommon* summer, *Abundant to Very Abundant* in winter, and bred in the delta (Butler and Campbell 1987). *Uncommon* in June and July, *Common* from late August to mid-May (Weber *et al.* 2013).

*Ecology:* The Northern Pintail in the late 19<sup>th</sup> century used the delta in great numbers according to Fannin (1891), which indicates that the pintail was numerous before many farms had been established and the ducks relied on naturally occurring food. The naturally occurring food lost during development of the delta was fortunately replaced by food now found on farmland. The seasonal pattern of use of the delta by pintail is to form large flocks on the tidal flats where they forage until late autumn and early winter before subsidizing their food needs for the rest of the winter by feeding in fields of nearby farmlands. Over 30,000 pintail were seen on the CWBS (1999–2019).

*Conservation:* The Northern Pintail is a numerous and widespread duck on the delta. The key conservation requirement for the Northern Pintail is security of tidal flats and nearby farmlands as foraging habitat. The majority of pintails in nearby Puget Sound were found on tidal flats adjacent to farmlands (Lovvorn and Baldwin 1996).

**Green-winged Teal *Anas carolinensis****Conservation status:* C.

*Occurrence:* *Migrant Non-breeder*. *Uncommon* in summer and *Very Abundant* in winter, *Uncommon* late May mid-August, a very few breed (Butler and Campbell 1987), *Fairly Common* by late August, and *Common* from September to end April. Fannin (1891) referred to the "great numbers at the mouth of the Fraser River fall, early winter". Leach (1972) said that 20,000 that were present in November soon fell to 3,000–4,000, possibly because of relentless hunting pressure. Those days are past and the teal is now an abundant widespread species in winter. Vermeer and Levings (1977) estimated that there were 50,000 teal on the delta in the mid-1970s, which seems high given that several counts soon after registered far smaller numbers. For example, the Ladner Christmas Bird Count registered a maximum count of 8,843 teal in 1981, and Butler and Cannings (1989) estimated only 10,000 were present. The IBA web site indicates a count in 1991 tallied 23,461 teal and the CWBS 1999–2019 had a high count of 10,000 teal in year 2000.

*Ecology and Conservation:* Autumn migration begins in September and reaches peak movement in November when flocks settle along all the tidal flats. Sea Island, Brunswick Point and Boundary Bay had especially high numbers of teal (Butler and Cannings 1989). Their foods are plant stems and seeds from the marshes and agricultural lands and possibly biofilm. This assumption needs corroboration and, if true, then the teal can be added to the growing list of shorebirds using this food web. The conservation requirement for Green-winged Teal is the presence of tidal flats and nearby farmlands for use as foraging habitat.

**Greater Scaup *Aythya marila****Conservation status:* C.

*Occurrence:* *Migrant Non-breeder*. *Uncommon* in summer, *Very Abundant* in winter (Butler and Campbell 1987). *Uncommon* from May to mid-September, *Fairly Common* in late September and *Common* from mid-October to the end of April (Weber *et al.* 2013). Greater Scaup using the Fraser River Delta likely nest in western Alaska (Kissel *et al.* 2002). The Greater Scaup is an early migrating duck that assembles in large numbers in late winter to feast on spawning herring in the Salish Sea (Sullivan *et al.* 2002).

*Ecology and Conservation:* Vermeer and Levings (1977) showed the scaup ate mostly algae, along with some plants, bivalves, and snails. Butler and Campbell (1987) estimated 30,000 Greater Scaup were present in winter and that hundreds moulted feathers there in 1970. The maximum reported on the CWBS (1999–2019) was about 4,200 and a significant decline was reported for scaup in the Salish Sea

between 1999 and 2011 (Crewe *et al.* 2012). These declines are also reflected in a continental decline (Afton and Anderson 2001). Tallying scaup that tend to stay farther from shores, where they are difficult to identify and count, presents a challenge when interpreting changes in abundance. The Greater Scaup requires attention to better understand its abundance and needs.

**Surf Scoter *Melanitta perspicillata****Conservation status:* G.

*Occurrence:* *Migrant Non-breeder*, *Common* in summer, *Abundant* in winter (Butler and Campbell 1987). *Fairly common* from mid-March to mid-September and *Common* for the rest of the year (Weber *et al.* 2013).

*Ecology:* The Surf Scoter arrives on the south coast in great flocks in autumn, many of which remain for the winter before the return of spring migrants moving up the coast and into the interior of North America to breed. While on the B.C. coast, Surf Scoters feed largely on mussels before switching to clams and other marine invertebrates in winter, herring eggs in February and March, and an array of foods that varies by site before departing in April (Anderson and Lovvorn 2011, Lok *et al.* 2012).

Large numbers of scoters frequent Boundary Bay in winter where they keep far from shore to mitigate eagle depredation (Vermeer and Levings 1977, Middleton *et al.* 2018). At the end of the day, scoters move up to 4 km from foraging sites to spend the night and return in the morning (Hamilton 2015).

Non-breeding scoters remain on the south coast, including Boundary Bay in summer, where they are flightless as they undergo a feather moult (Dickson *et al.* 2012). In the 1970s, the greatest numbers of scoters were present in the bay in August when nearly 10,000 birds were seen (Vermeer and Levings 1977). Tschaekofske (2010) in personal communication with Joe Evanson from the Washington Department of Fish and Wildlife also reported 10,000 scoters moulting on the Fraser River Delta, an extraordinary number if correct. Scoters are flightless during the feather moult (Dickson *et al.* 2012).

*Conservation:* The Surf Scoter is most vulnerable during the feather moult when it is flightless and most susceptible to oil spills. The Fraser River Delta appears to be one of the largest moulting sites on the coast of British Columbia. Scoters are also vulnerable when large numbers assemble to feed on herring eggs.

**White-winged Scoter *Melanitta deglandi****Conservation status:* C.

*Occurrence:* Mostly a *Migrant Non-breeder*. *Fairly common* in summer and *very common* in winter (Butler and

Campbell 1987). *Fairly Common* from mid-March to mid-September and *Common* for the rest of the year (Weber et al. 2013). Maximum single count was over 3,000 birds (CWBS 1999–2019). Flocks of a few hundred or less are present in summer undergoing a feather moult.

*Ecology and Conservation:* White-winged Scoters are mollusc specialists (Vermeer and Levings 1977, Anderson et al. 2008, Anderson and Lovvorn 2011). The White-winged Scoter is dependent on molluscs for food and on quiet bays in summer to moult feathers.

### **Red-breasted Merganser *Mergus serrator***

*Conservation status:* G.

*Occurrence:* Migrant Non-breeder, *Casual* June through August, *Common* from early November to end April after which the birds depart the delta for breeding. eBird (2019) sightings show over 100 mergansers at Iona Island in October through December and again in April, and the CWBS maximum single day count was 300.

*Ecology:* Mergansers in British Columbia eat sculpins, herring and eggs of herring, coho and chum salmon (Munro and Clemens 1939). Sightings are clustered along the outer shores of the delta and lower reaches of the river (eBird 2019), and where sculpins, young salmon and other small fish are abundant (Gordon and Levings 1984).

*Remarks:* Their presence coincides with the abundance of their salmon prey (Wood 1987). Juvenile pink salmon migrating out of the Fraser River reach peak abundance in mid-April and remain in the top 15 cm of the water column where mergansers forage (Beamish 2014). From mid-March to the end of April, chum salmon also pass through the river's mouth for the open Strait. Sightings of large numbers (>100) of mergansers reported in eBird (2019) were from the North and Main Arms of the Fraser River and Crescent Beach at the mouth of the Nicomekl River at this time of year. If the relationship is correct, then the presence of the large number of mergansers is a result of salmon rearing streams and riverine marshes along the Fraser River.

### **Red-throated Loon *Gavia stellata***

*Conservation status:* G.

*Occurrence:* Mostly a *Migrant Non-breeder* on the delta. *Rare* during the breeding season from June to mid-September, *Uncommon* from mid-September through October as migrants return, and *Fairly Common* from November to mid-April. Red-throated Loons are scattered over the delta on most days and only occasionally assemble into large flocks. eBird records show mostly individual loons or flocks of <100 birds in the estuarine habitat, and along

the tidal flats including the river. Counts between 1988/89 and 1999–2019 and counts within the 1999–2019 period show big swings in numbers (Table 5). A maximum of 487 loons was seen on the CWBS between 1999 and 2019 and in most years <50 loons were seen. The reasons loons occasionally assemble in large flocks is probably related to migration, the presence of fish prey and herring spawning events.

*Ecology and Conservation:* The Red-throated Loon regularly enters the lower reaches of the Fraser River. Little is known about this species on the Fraser River Delta despite the importance of river as a winter habitat. Understanding the reasons for occasional large assemblages is important to conserve the species.

### **Red-necked Grebe *Podiceps grisegena***

*Conservation status:* G.

*Occurrence:* The Red-necked Grebe is a *Migrant Non-breeder* on the delta. Butler and Campbell (1987) recorded the grebe as *Uncommon* in summer and *Fairly Common* in winter. Weber et al. (2013) considered Red-necked Grebes to be *Rare* from mid-May to early August and *Common* through September before falling to *Fairly Common* until the end of April. Stout and Cooke (2003) recorded as many as 1,689 moulting grebes in September 1997 and 2,229 in 1998 in Boundary Bay. By mid-October, the grebes had begun to disperse. Red-necked Grebes are widespread in winter along the B.C. Coast (Campbell et al. 1990).

*Ecology and Conservation:* Boundary Bay is an important moulting site for Red-necked, Western and Horned Grebes which are flightless or compromised from late summer to early fall. Minimizing disturbance and prevention of discharges of deleterious substances on to the water are key actions. Maintaining eelgrass habitat as a source of fish prey is also important.

### **Western Grebe *Aechmophorus occidentalis***

*Conservation status:* G, SARA SC, Schedule 1, R.

*Occurrence:* *Fairly Common* summer and *Very Abundant* winter (Butler and Campbell 1987). *Common* mid-September to mid-May and *Fairly Common* for the rest of the year (Weber et al. 2013). Maximum single day count on the CWBS was 3,200 grebes. Widespread in the estuary. Up to 3,000 counted in Boundary Bay of which at least some were moulting wing feathers making them flightless (Stout and Cooke 2003).

*Ecology and Conservation:* Western Grebes feed on small schooling fish, in particular herring (Clowater 1993). Large numbers that assembled each autumn in Vancouver Harbour in the 1970s (Campbell et al. 1972a) declined through

the 1990s adding to concerns about range-wide declines (COSEWIC 2014a). The reason for the decline on winter quarters has been suggested to be a result of distributional shifts away from northern latitudes (Wilson *et al.* 2013). However, large numbers of grebes were discovered in late summer moulting feathers (Stout and Cooke 2003) and later seen offshore in the estuarine portion of Boundary Bay where they would have gone undetected by land-based observers — 1,580 grebes on 6 November 2007, 749 on 7 December 2007, and 670 on 18 February 2008 (RWB, unpublished field notes). Maintaining eelgrass habitat as a source of fish prey and minimizing disturbance and prevention of discharges of deleterious substances on to the water are key actions.

### **Great Blue Heron *Ardea herodias fannini*.**

*Conservation status:* N; SARA SC, Schedule 1, B.

*Occurrence:* Resident breeder Common year-round (Butler and Campbell 1987, Weber *et al.* (2013). Butler and Campbell (1987) reported a total of 275 nests from the delta. The number of nesting pairs at Tsawwassen increased between 1980 and 1990, and have fluctuated between 282 and 469 pairs since 2000 (Pers. comm., Ross Vennesland, Delta, B.C., 2020 January 24).

*Ecology:* Seasonal tides play a key role in the ecology of the Great Blue Heron on the Fraser River Delta (Butler 1993, 1995, 1997) so that the increasing diurnal low tide in spring allows herons more time to pursue their fish prey. The growing number of daylight hours and exposure by low tides stimulates growth of eelgrass which attracts small fish and herons. In winter, the tides make beaches available to herons for <10% of a typical December day compared to 70–80% in May and June when fish are most numerous. The consequence is that the food threshold to produce eggs by a female heron is exceeded in April and remains high through August.

Major fish prey caught in eelgrass meadows include gunnels, sticklebacks, sculpins, bay pipefish and shiner sea perch (Butler 1995). Huang *et al.*'s (2015) discovery of the cascading ecological effect in eelgrass meadows of heron predators mediated through small fish and invertebrates hints at the Great Blue Heron's important role as a key-stone predator in the Fraser River Delta ecosystem. About one in two eggs results in a fledged young but the greatest mortality occurs after leaving the nest (Butler 1995). About three quarters of the fledglings do not survive their first year. Young herons are incompetent fishers that require twice as long to catch the same food as the adults. The low tides become increasingly nocturnal and by November, juvenile herons seek prey on the delta to augment dwindling supplies from the tidal flats. The main prey of herons off the tidal flats were small mammals, in particular the Townsend's vole caught in grasslands. Post-mortems of

dead young herons on the delta indicated that they died from injuries (Butler 1995).

The heron has been a valuable bio-indicator of environmental contamination in the Fraser River Delta since the 1970s. The discovery of elevated levels of several industrial contaminants in their eggs in the 1970s through 1990s contributed to new regulations that resulted in improved conditions. While that is good news, new contaminants have emerged in recent years such as flame-retardant compounds that could potentially compromise herons (Elliott *et al.* 2005).

Through the 1990s and early 2000s, a recovery in Bald Eagle numbers resulted in more incursions into colonies, widespread nesting failures, and relocation of colonies, resulting in part, to the listing as a Species at Risk (Vennesland and Butler 2004, COSEWIC 2008a). A large colony on Point Roberts moved to Tsawwassen, and a moderate colony along the Nicomekl River moved to the Boundary Bay Airport. A large colony of herons that nested in Pacific Spirit Park a few kilometres north of the delta and that foraged on the delta, relocated to Stanley Park. Butler (1995) showed that colonies near eagle nests had a lower rate of abandonment which he proposed arose from territorial nest defence by eagles that inadvertently benefited nearby nesting herons. Such a situation was confirmed when a colony of herons at Tsawwassen nested near a pair of nesting eagles who scavenged fish and hunted birds on the extensive tidal flat and showed little interest in the herons. Inadvertently through territorial defence of their eyrie, the nesting eagles created a relatively safe zone for herons (Jones *et al.* 2013). This colony is by far the largest in B.C.

*Conservation:* One outcome of the ecological research was the designation of the *fannini* subspecies of heron inhabiting the delta as a Species at Risk, Schedule 1, *Special Concern*, due to a small population, declining nesting success, and impact from Bald Eagle depredation, habitat loss, and human disturbance. Herons at the large colony at Tsawwassen have adapted to the presence of eagles (Jones *et al.* 2013) and the number of nesting pairs appear to have stabilized. The Fraser River Delta is the centre of the population of this subspecies and warrants investigation to ensure its continuity. A better understanding of the ecosystem functions that provide the delta with small fish, in particular the shiner sea perch, and small mammals such as Townsend's vole, would help secure the heron's food supplies.

*Remarks:* Residual effects of proposed port expansion on Roberts Bank on nesting herons was identified by a Review Panel of port expansion plans on Roberts Bank that is before the Minister of Environment (Review Panel for Roberts Bank Terminal 2 Project 2020).

Long ago the Great Blue Heron was portrayed on a pestle from the Marpole archeological site (Ormerod

2014). In modern times, the Great Blue Heron captured the imagination of residents of the delta where a stylized heron serves as the logo for the City of Richmond and City of Delta uses a cattail, symbolic of the heron's habitat.

### **Black-bellied Plover *Pluvialis squatarola***

*Conservation status:* G.

*Occurrence:* Migrant Non-breeder, Abundant to Very Abundant transient, Rare in summer, and Very Common in winter (Butler and Campbell 1987). Uncommon from June to the end of July after which post-breeding birds arrive to become a Common species on the delta until the following May when it becomes Uncommon (Weber et al. 2013). The maximum single day count on the CWBS was 8,000 plovers.

*Ecology and Conservation:* Plovers and other shorebirds use large fields with autumn mowing, laser leveling, and application of fertilizer and manure (Evans Ogden et al. 2008). The over summer birds are of particular interest as to why they choose not to return to the nesting grounds.

### **Sanderling *Calidris alba***

*Conservation status:* C.

*Occurrence:* Migrant Non-breeder. Rare in summer and Very Common in fall and winter (Butler and Campbell 1987). Absent in June, Casual to Rare in July, Fairly Common in mid-August and Common from late August to late April, after which numbers quickly decline through May as the birds depart to breed (Weber et al. 2013). A few thousand occur on the delta each year (Table 5).

*Ecology and Conservation:* Sanderlings are High Arctic breeders that spend the winter on tidal flats across the globe. This is the species most people think of as a sandpiper (Paulson 1993). Sanderlings frequent tidal flats around the delta, especially in Boundary Bay usually in flocks of <100. Not much more is known about the Fraser River Delta Sanderlings such as what they eat and where they go on high tides to await the falling tide, but eBird sightings suggest they roost on jetties and breakwaters. Sanderlings seem less reliant on floodplain fields than Western Sandpipers, Dunlins and Black-bellied Plovers.

### **Western Sandpiper *Calidris mauri***

*Conservation status:* G.

*Occurrence:* Migrants. Very abundant in spring, summer and fall and Rare in winter (Butler and Campbell 1987). Rare from November to March, Uncommon in early April, and Common to early May after which numbers quickly dropped. Fairly Common to Common through August and September. By early October the numbers waned and the species became Fairly Common for the rest of the month

(Weber et al. 2013). The Western Sandpiper is one of the most numerous shorebird species in the western hemisphere and the Fraser River Delta holds more Western Sandpipers than any other place in Canada. For a few weeks each year, the sandpiper is the most abundant bird species on the Fraser River Delta. From mid-April to early May, adult migrants rush north to nest in western Alaska and northeastern Russia, and before summer officially arrives, the vanguard of southbound migrants return to cross the delta. Return passage by adults begins in late June and extends into August where it overlaps with southbound juveniles on their inaugural flights to the southern USA, and Central and South America (Butler et al. 1987, Franks et al. 2014). A few remain through the winter.

No one seemed aware of the huge numbers of sandpipers crossing the delta each spring, including Butler and Campbell (1987), until the early 1990s when preliminary estimates of their numbers led to annual tallies on Roberts Bank (Drever et al. 2014). The Western Sandpiper is the first species in which an estimate was made of the total number of individuals using Roberts Bank (Iverson et al. 1996, Warnock and Bishop 1998, Drever and Hrachowitz 2017). Drever et al. (2014) estimated that 600,000 Western Sandpipers typically pass through Roberts Bank in spring, although this number can be as low as 300,000 and as high as 1,800,000 birds. Smaller numbers were tallied on the southward migration, although the sandpiper was widespread in Boundary Bay and on Roberts Bank at Brunswick Point (Table 13). Counts did not include Sturgeon Banks.

*Ecology:* Much has been learned about the ecology of the Western Sandpiper while on the delta including, variously, how they mitigate danger on a local (Ydenberg et al. 2002, 2004, 2010; Pomeroy 2006) and regional scale (Butler et al. 2003, Lank et al. 2003), where large numbers spend the winter (Butler et al. 1992, Engilis et al. 1998, Fernandez et al. 1998, Morrison et al. 1994, how they fuel migratory flights (Kuwaie et al. 2008, Schnurr et al. 2020), how they use the delta and their ecological role (behaviour Butler et al. 2002, 2003, Sutherland et al. 2013, Jardine et al. 2015).

Clark and Butler (1999) developed a computer simulation of migration to measure the effect of a changing flyway on the Western Sandpipers. They estimated an expected loss in fitness, measured as delayed arrival time on the breeding ground, as a consequence of various food shortages at single and multiple sites on the along the Pacific Coast. The outputs of the model closely matched real world migration timing. The model predicted that with a 50% decline in food availability on the Fraser River Delta, the fitness of individual females would decline by 4% if they were unable to adapt to change and 2% if they could adapt. Far more worrisome would be a simultaneous decline in food availability at all stopover sites. Under this

Table 13. Number of Western Sandpiper and Black-bellied Plover in Boundary Bay and on Brunswick Point, B.C., in June–September 1990.

Date	Western Sandpiper		Black-bellied Plover	
	Brunswick Point	Boundary Bay	Brunswick Point	Boundary Bay
29-Jun	30	305	0	178
3-Jul	0	4,171	0	83
5-Jul	500	20,870	0	1,825
9-Jul	180	13,916	0	75
12-Jul	0	18,045	0	900
16-Jul	0	0	0	0
19-Jul	300	550	0	0
23-Jul	200	16,412	0	0
27-Jul	0	70	0	0
30-Jul	1,225	0	0	0
2-Aug	260	150	0	0
7-Aug	230	8,600	0	515
10-Aug	8,200	25,300	0	350
13-Aug	3,000	2,300	16	40
16-Aug	2,260	43,030	20	130
20-Aug	4,900	37,925	6	0
23-Aug	12,300	13,890	11	1,405
27-Aug	5,900	116	65	420
30-Aug	2,210	9,690	0	1,650
5-Sep	0	220	0	970
8-Sep	0	6	0	240
11-Sep	0	0	0	450
14-Sep	0	0	0	705
<b>Total</b>	<b>41,695</b>	<b>215,566</b>	<b>118</b>	<b>9,936</b>

scenario, the model predicted fitness of individual females unable to adapt plummeted by 35% and by 17% if they can adapt. Clark and Butler (1999) concluded that the birds can compensate for limited environmental change.

*Conservation:* The discovery of large numbers of Western Sandpipers on the Fraser River Delta raised its currency as a species requiring conservation attention. Proposals to build airport and port facilities along the delta coastline heightened the need. A central question in the assessment of development proposals is the total number of birds that might be affected. For Western Sandpipers, Drever *et al.* (2014) arrived at 600,000 birds using Roberts Bank as an approximation for spring migration but cautioned that there was wide variation in the counts. They concluded that single day counts typically reached about 150,000 Western Sandpipers on Roberts Bank. Substantial numbers of sandpipers also use other parts of the delta (Butler *et al.* 2002, Jardine *et al.* 2015). Therefore, the counts of Drever *et al.* (2014) are a useful reflection of the use of the tidal flat on Roberts Bank by Western Sandpipers.

The research so far indicates that a substantial proportion of the entire species of Western Sandpipers use the delta on their northward migration each year, and a smaller but important number use it going south. Moreover, the sandpipers occur on the muddy intertidal of the entire delta, but are especially dense on Roberts Bank. Biofilm

plays an important role in the diet of many sandpipers including the Western Sandpiper (Elner *et al.* 2005, Kuwae *et al.* 2008, Jardine *et al.* 2015) and spring migration appears to coincide with the production of fatty acids in biofilm used to fuel flights (Schnurr *et al.* 2020). High Lipid Producing Biofilm (HLPB) is thought to be targeted as food by migrating Western Sandpipers where fine sediments and salinity influenced by estuarine conditions occur on Roberts Bank (Schnurr *et al.* 2020) and possibly on Sturgeon Banks and in Boundary and Mud bays. The loss of this food source on the Fraser River Delta could theoretically reduce fitness and the opportunity to breed (Clark and Butler 1999, Drever *et al.* 2014) with likely population consequences. Understanding how human activities tilt the interaction between food availability, in particular biofilm, and the risk of predation from falcons, will be central to the conservation of Western Sandpipers.

*Remarks:* An ongoing conservation concern is whether a proposed port expansion on Roberts Bank could impact the quantity and quality of biofilm as food for refuelling sandpipers. The Panel couldn't conclude with confidence if the fatty acid production by biofilm would be adversely affected by the proposed port expansion. A decision on port development on Roberts Bank is before the Minister of Environment (Review Panel for Roberts Bank Terminal 2 Project 2020).



**Dunlin *Calidris alpina****Conservation status:* G.

*Occurrence:* *Migrant Non-breeder*, *Very abundant* in fall, winter and spring (Butler and Campbell 1987, Weber *et al.* 2013) *Rare* from June to mid-October, and *Common* the rest of the year.

*Ecology:* A few Dunlin can sometimes be seen on the delta as early as late September, but the large migratory flocks arrive in October and November. Great ‘murmurations’ of Dunlins twist and turn across Boundary Bay in autumn in flocks exceeding 100,000 birds (Table 5). By winter, the Dunlin have settled into a pattern of daily movements dictated by tides and risk of predation. Four fifths of the Dunlin on Boundary Bay used terrestrial habitats, usually during high tide, primarily at night, and most notably farmlands with pastures (Shepherd and Lank 2004). Dunlin use of fields peaks in January. Over the winter 6% of adults and 13% of juvenile Dunlin got >75% of their food from farmlands (Evans-Ogden *et al.* 2005) which included agricultural pest species such as leatherjacket (Tipulidae) larvae and wireworm (*Agriotes* spp.; Evans-Ogden 2008). During daytime high tides, Dunlins were pursued by Peregrine Falcons starting in earnest in the 1990s so that now great flocks await the falling tide on the wing far out in Boundary Bay (Dekker and Ydenberg 2004). Shepherd (2001) showed that there were three distinct groups of Dunlin on the Fraser River Delta. Carrying miniature transmitters, the Dunlins tended to stay either in eastern Boundary Bay, Western Boundary Bay and Tsawwassen Beach, or Brunswick Point–Westham Island.

*Conservation:* The maintenance of large fields of soil-based agricultural crops, particularly naturally fertilized pastures, might be required to support the large numbers of Dunlin and other shorebirds wintering in the Fraser delta. (Shepherd and Lank 2004).

*Remarks:* Wark (1824) noted in his journal on 13 December 1824 large flocks of plovers on the delta. He wrote “The point above [Point Roberts] mentioned to which it was intended to cross in the morning is represented by the Indians to form the entrance of Coweechan River (which is supposed to be the same with Fraser’s), on the S. E. side it projects far out to sea and appears like an island but seems to be joined to the mainland which is very low by a sandy ridge which probably may be covered at high water, immense flocks of plover were observed flying about the sand.”

Pearse (1968) erroneously added “at Point Roberts off Lulu Island, B.C.” in Wark’s quote. Wark’s party travelled up the Nicomekl River on December 13 and so the large flocks were more likely in Boundary Bay. Pearse (1968) surmised Wark might have been referring

to the Pacific Golden Plover, which does not occur in large flocks on the Fraser River Delta. It is more likely Wark saw Dunlin.

**Long-billed Dowitcher *Limnodromus scolopaceus****Conservation status:* G.

*Occurrence:* *Migrant Non-breeder*. Migration peaks mid-April to late May when it is *Fairly Common*, and mid-August until mid-November when the species is *Common*. *Uncommon* late November to mid-April and *Rare* June and July. The maximum single day count on the CWBS was 570 dowitchers.

*Ecology and Conservation:* The dowitcher is found on tidal flats and pond edges on the delta where it can probe soft sediments in search of invertebrate prey (Takekawa and Warnock 2000). Nothing is known about its ecology on the delta. Preservation of tidal flats with invertebrate prey is probably the most important conservation activity for this species.

**Bonaparte’s Gull *Chroicocephalus philadelphia****Conservation status:* G.

*Occurrence:* *Migrant Non-breeder*. *Common* April and May and *Uncommon* from mid-June to mid-July. *Common* during southward migration August to late November after which it becomes *Rare*.

*Ecology and Conservation:* The Bonaparte’s Gull is drawn to the shores of the delta on its migration to feed on small fish. Flocks of up to a few hundred gulls have been seen at Iona, Westham Island, and Crescent Beach during high tides (eBird 2019). Preserving beaches that support sand lance and herring is important for its conservation.

**Mew Gull *Larus canus****Conservation status:* C.

*Occurrence:* *Migrant Non-breeder*. *Uncommon* June and July, *Fairly Common* August to mid-September, and *Common* through to mid-May. The Mew Gull was the second most numerous species after the Common Murre reported in year-round transect surveys in the estuarine habitat (Butler *et al.* 2018). Mew Gulls were concentrated in the northern end of the Fraser River Estuary off the North Arm (Butler *et al.* 2018). Butler *et al.* (2018) estimated over 6400 Mew Gulls were in the estuarine habitat in January.

*Ecology and Conservation:* The North American population of Mew Gull breeds in northwestern North America and spends the winter along the Pacific Coast (Moskroff and Bevier 2002). In the estuarine habitat, the gulls were seen dipping on to the water surface in search of food per-

haps attracted by sewage discharge from the Iona Island Treatment Plant. Mew Gulls also forage and roost in agricultural fields and roost on tidal flats around the delta in mostly small flocks.

### **Iceland Gull *Larus glaucooides thayeri***

*Conservation status:* G.

*Occurrence:* *Migrant Non-breeder, Casual* from May to mid-September, *Common* through until mid-April, *Fairly Common* to the end of the month. The Iceland Gull (Thayer's) is occasionally reported among other gulls along the tidal flats of the delta and especially in Boundary Bay.

*Ecology and Conservation:* The Iceland Gull (Thayer's) seems to prefer marine waters more than estuaries although it is found in both habitats. Its diet is similar to other large gulls, which includes human refuse, fish, and marine invertebrates (Snell *et al.* 2018). There has been no definitive studies of its ecology on the delta but it appears to shun human and agricultural areas (Gutowsky *et al.* 2020).

*Remarks:* The English name for the Iceland Gull is a misnomer. The gull breeds in Canada and Greenland and all that use the Fraser River Delta are of Canadian origin (Snell *et al.* 2018, Gutowsky *et al.* 2020).

### **Glaucous-winged Gull *Larus glaucescens***

*Conservation status:* G.

*Occurrence:* *Resident, Common* year-round. A few gulls nest each spring among the Ferry Terminal infrastructure but most disperse to colonies in the Salish Sea to breed. Huge flocks of post-breeding gulls from local colonies and Alaska (Butler *et al.* 1980, Hatch *et al.* 2011) return throughout the delta to spend the winter. The CWBS maximum single day count was 3,000 gulls. Several thousand gulls use the landfill and form flocks in fields south of the landfill and on the shore of Boundary Bay (eBird 2019). The Glaucous-winged Gull was the third most numerous species in the Fraser River Estuary (Butler *et al.* 2018). A few hundred Glaucous-winged Gulls nested on the delta on the Tsawwassen Ferry Terminal Breakwater in the 1980s (Butler and Campbell 1987) which they abandoned likely from eagle depredations. The gull has small winter home ranges in the Salish Sea (Pers. comm. Mark Hipfner, Delta, B.C., 2020 May 26).

*Ecology and Conservation:* The Glaucous-winged Gull frequents every habitat on the delta including the estuarine habitat, residential, industrial and agricultural lands, and tidal flats but it is most numerous around the landfill on the south edge of Burns Bog. The diet of nesting gulls at Tsawwassen in the 1980s determined

from regurgitated pellets indicated a diet of predominantly seafood and refuse. Twenty-nine regurgitates collected on the Tsawwassen breakwater on 27 May 1985 held herring, sand lance, and sculpins, refuse, crabs, cockles, sea stars and chicken bones. Twenty-seven regurgitates on 16 July 1985 had herring, perch, sculpin, prickleback and ling cod, crabs, sea stars, chicken bones, refuse and gull egg shell (RWB, unpublished field notes). Davis *et al.* (2015) using similar methods found more recently that gulls in Salish Sea colonies were concentrating on sand lance over herring eaten in earlier years. Gulls patrol roadsides, landfills, parks, school grounds, and around urban and industrial sites for discarded food. They also visit tidal flats to hunt and scavenge crabs, sea stars, and fish. In December 2019, a huge school of anchovies swarmed off the White Rock pier attracting thousands of gulls. No conservation action is recommended.

### **Marbled Murrelet *Brachyramphus marmoratus***

*Conservation status:* SARA T, Schedule 1, B.

*Occurrence:* *Resident species, Fairly Common* resident, and most numerous in winter (Butler and Campbell 1987). Weber *et al.* (2013) considered the murrelet to be *Uncommon* in every month. Not long ago, the Marbled Murrelet was frequently seen especially off Point Roberts where up to 50 birds were seen in summer (Campbell *et al.* 1972). Butler and Campbell (1987) reported that an aggregation of 2,125 birds on the 1976 Christmas Bird Count was a record high for British Columbia. There were indications of nesting taking place at the same time in Stanley Park and young were seen in a flock of 34 off Point Roberts. RWB (unpublished field notes) saw 30 Marbled Murrelets on 10 June 1985 between jetties which is significant because the date coincides with the breeding season. None were reported from shoreline counts on the delta between June and August 1988 (Butler and Cannings 1989) and four was the biggest single day count on the CWBS (1999–2019). However, murrelets might have been present but out of sight of land based observers. In 2016–2017, Butler *et al.* (2018) reported 242 murrelets were in the Fraser River estuary, mostly in January. The murrelets were far from shore.

*Ecology and Conservation:* Nothing is known about the ecology of murrelets while on the delta. However, murrelets are fish eaters and are likely drawn to the delta when small fish are present. Murrelets eat small fish and marine invertebrates (Sanger 1987). In the 1980s, Roberts Bank and Sturgeon Bank were used by large numbers of spawning and schooling sand lance (*Ammodytes hexapterus*; Gordon and Levings 1984). Prior to 1900, the diet was over 60% fish and 30% crustaceans (euphausi-

ids) and in the late 1960s the diet was mostly crustacea, coinciding with the decline of the murrelet population (Norris et al. 2007).

### **Barn Owl *Tyto alba***

*Conservation status:* N, SARA T, Schedule 1; R.

*Occurrence:* Resident breeder Fairly Common year-round (Weber et al. 2013). About 200 nesting pairs of Barn Owls reside in the Lower Fraser Valley (Cannings 2015a).

*Ecology and Conservation:* The foraging ecology and breeding biology of the Barn Owl in the Fraser River Delta and Lower Mainland was summarized by Campbell et al. (1990b) and COSEWIC (2010). The owl is a small mammal specialist, especially fond of Townsend's voles. The Barn Owl arrived on the delta in the 1940s (Butler and Campbell 1987) and expanded its range through the Lower Mainland. The population is small and hence vulnerable. The variables that best predicted the continued use and current occupancy of nesting sites were traffic exposure and the length of highways (Hindmarch et al. 2012). Barn Owls are often victims of collisions with vehicles while they hunt small mammals along road verges and not surprising, the owls were most likely to persist far from roadways. Secondary poisoning is also an issue especially along the edge of urban environments (Hindmarch and Elliott 2015). Nest boxes have been useful in locating owls in safer places on the delta.

*Remarks:* Of concern are effects of increased traffic from proposed port expansion on Roberts Bank and urbanization on the survival of Barn Owls if the mitigation measures were not implemented. A decision on port development on Roberts Bank is before the Minister of Environment (Review Panel for Roberts Bank Terminal 2 Project 2020).

### **Western Screech-Owl *Megascops kennicottii***

*Conservation status:* C; SARA T, Schedule 1; B.

*Occurrence:* Resident breeder, Rare year-round (Butler and Campbell 1987, Weber et al. 2013). One owl seen at the George C. Reifel Migratory Bird Sanctuary on 30 January 2000 was the only record in eBird (2019) since 1987. A Western Screech-Owl was heard in Richmond Nature Park in 2003 (Griffiths 2008). Elliott (2006) reported screech-owls in Burns Bog.

*Ecology and Conservation:* Western Screech-Owls frequent riparian forests such as those found on the delta (Cannings 2015b, COSEWIC 2012). The arrival of Barred Owls is a plausible reason for the demise and faint hope that open bog habitat and small riparian areas that Barred Owls avoid might continue to support a small population of Screech-Owls (Elliott 2006).

### **Peregrine Falcon *Falco peregrinus***

*Conservation status:* *P. f. pealei*: N; SARA SC, Schedule 1; B. *P. f. anatum/tundrius*: N; SARA SC, Schedule 1; R.

*Occurrence:* Rare from late May to end of July reflecting a small local breeding population, and Uncommon for the rest of the year (Butler and Campbell 1987, Weber et al. 2013). The taxonomy of the Peregrine Falcons is ambiguous. Three subspecies were thought to occur in British Columbia (Campbell et al. 1990b) but Brown et al. (2007) used genetic testing to conclude that *F. p. pealei* is well differentiated whereas *F. p. anatum* and *F. p. tundrius* subspecies were not. In this report, we consider two subspecies. All *F. p. pealei* and most *F. p. anatum/tundrius* are Migrant Non-breeders and a small number of Residents nest near the delta. The species breeds in the Lower Fraser River Valley but there are no known records for the delta (Chutter 2015).

The Peregrine Falcon in western North America underwent a rapid recovery through the 1990s which was reflected on the Fraser River Delta (Hoffman and Smith 2003, Ydenberg et al. 2002). Adult falcons begin to migrate north arriving in B.C. in early March followed by immature falcons by month's end (Campbell et al. 1990b). On the southward migration, immatures arrive first in mid-August followed in September by adults.

*Ecology:* The abundance of ducks and shorebirds on the Fraser River Delta draws Peregrine Falcons to the delta (Dekker 1987, Dekker and Ydenberg 2004). The influence of predators such as the Peregrine Falcon on the ecology and behaviour of other species has only recently begun to be understood (see **Predator Landscapes**). The Peregrine on the Fraser River Delta has become one of the poster-birds in this revised view of avian predators especially as a central player in the ecology of Western Sandpipers and Dunlins. With the recovery of the falcon, the risk of predation began to play out in how the sandpiper used the delta. Dunlin have abandoned traditional shoreline roost sites in favour of flying offshore during high tides to reduce falcon forays (Ydenberg et al. 2010). Sandpipers have mitigated the danger from falcons by adjusting their body mass, altering their distribution and timing of migration, and shortening their length of stay in dangerous locations (Ydenberg et al. 2004). The effect of the falcon on sandpipers reaches far beyond the Fraser River Delta (Butler et al. 2003).

In late summer, falcons pursue ducks until October or November when Bald Eagles return to the delta after scavenging salmon carcasses in coastal rivers to pirate Peregrines of their prey (Dekker and Ydenberg 2004). The falcon then switches to hunting smaller prey such as Dunlin that they can quickly carry to a safe plucking post (Dekker 1987, Dekker and Ydenberg 2004). The ecological consequences to Dunlin seem to be dictated by the number and date that eagles return to the delta, which in itself is

dictated by the size and duration of salmon spawning in B.C. and Alaska rivers. For the ducks, the return of eagles is no relief because eagles begin to hunt them directly.

### Northwestern Crow *Corvus caurinus*

*Conservation status:* G.

*Occurrence:* Resident breeder. *Very Common resident* (Butler and Campbell 1987). *Common* (Weber et al. 2013).

*Ecology:* The Northwestern Crow biology, ecology and behaviour are well studied in the Salish Sea (summarized by Verbeek and Butler 1999). Crows use the tidal flats and are widespread in the floodplain with the exception of Burn's Bog and east Richmond (eBird 2019). The crow was the most frequently encountered species using hedgerows (Butler 1989). Crows along the northern delta depart in winter for a large roost in Burnaby (Butler and Clulow 2020). Peterson et al. (2001) showed that they were efficient scavengers of duck carcasses.

*Remarks:* Slager et al. (2020) concluded that the crow in the Lower Mainland including the delta was the centre of a coastal hybrid zone between Northwestern Crow (*C. caurinus*) and American Crow (*C. brachyrhynchus*). The American Ornithologists Society considers the Northwestern Crow (*C. b. caurinus*) to be a subspecies of American Crow (Chesser et al. 2021).

### Horned Lark *Eremophila alpestris strigata*

*Conservation status:* SARA: E, Schedule 1; R.

*Occurrence:* Horned Larks on the Fraser River Delta include a migratory (*E. a. merrillii*) and resident subspecies (*E. a. strigata*). Butler and Campbell's (1987) account described the migrants as 'uncommon' (1–6 individuals per day) but the situation for the resident *strigata* subspecies was dire. Fannin (1891) over a century ago, referred to this subspecies as being 'nowhere common'. Butler and Campbell (1987) said the last nest was located in 1970 although fledged young in 1981 gave faint hope the subspecies was still present. eBird records for June and July stop in 1973. Weber et al. (2013) do not show any records for summer in the Greater Vancouver Bird Checklist Area. The subspecies is likely extirpated from the Fraser River Delta and is declining fast in neighbouring Puget Sound (Pearson et al. 2008).

*Conservation:* For conservation biologists, the declaration of an extirpated subspecies is a sign of failure. The historical distribution of the Horned Lark *strigata* in Canada was southeastern Vancouver Island and in the lower Fraser River valley from Chilliwack west to the Fraser River Delta (Environment Canada 2014). The recovery plan is likely too late for this subspecies (Environment Canada 2014).

### Barn Swallow *Hirundo rustica*

*Conservation status:* SARA T, Schedule 1; B.

*Occurrence:* The Barn Swallow is mostly a *Migrant Breeder* on the delta. Butler and Campbell (1987) reported the Barn Swallow to "occur widely in all open situations" and considered it to be *Very Common* during summer, *Very Abundant* in autumn, and *Casual* in winter. The swallow was widespread in many valleys in British Columbia, including the Fraser Valley and delta during the B.C. Breeding Bird Atlas (Hearne 2015) and Weber et al. (2013) assigned the species as *Common*, their highest frequency level, from May to the end of September, *Rare* in October and November and *Casual* in winter.

*Ecology:* The Barn Swallow nesting in nearby western Washington migrates along the Pacific Coast to spend the winter from Oregon to northern Colombia (Hobson et al. 2015). The swallow arrives in large numbers in April where it builds a mud and grass cup-shaped nest inside barns, under overhangs on shelters, breezeways and porches, and in vacated buildings on the Fraser River Delta. Food is comprised almost exclusively of flying insects caught on the wing near the nest and over marshes along tidal flats. Campbell et al. (2000) describe the breeding biology of the swallow in British Columbia. Large post-breeding flocks historically assembled on migration over the delta in late summer. On 8 August 1985, 1500 swallows were seen on the delta, and on 13 September 600 more swallows were seen along River Road, 150 on Westham Island and 200 at Alaksen National Wildlife Area (RWB, unpublished field notes).

*Conservation:* Surveys of many insectivorous species of birds, including the Barn Swallow declined significantly in North America (Michel et al. 2016). The swallow was listed as a Threatened species under the Species at Risk Act legislation (COSEWIC 2011). Among the possible causes were losses of nesting places, foraging habitats and insect prey, and cold weather during the nesting season (COSEWIC 2011). Garcia-Perez et al. (2014) showed that mortality of western populations of Barn Swallows correlated with the strength of ENSO (El Niño-Southern Oscillation) events. A new predator on the delta is the Barred Owl (Mahony 2017) that joins the already present Northwestern Crow (RWB, pers. obs.), and the Cooper's Hawk as potential predators. The number of nesting pairs of Barn Swallows plummeted on Westham Island after a Barred Owl began to depredate the nests (Mahony 2017). Barred Owls were first documented in the Lower Fraser Valley in 1966 and quickly increased in subsequent years (Campbell et al. 1990b). However, Butler and Campbell (1987) did not include the species in their review of the birds on the delta although the Barred Owl was an, albeit rare, resident in the Vancouver region by 1990 (Weber 1991). RWB saw

crows raiding nests at the Canadian Wildlife Service in the 1990s. Moreover, Barn Swallows in Europe have responded to increased predation risk by the ecological equivalent Eurasian Sparrow Hawk (*Accipiter nisus*) by reacting sooner to threats and relocating nest sites to less exposed locations in response to the (Moller 2014). Whether predation is an important factor on the delta has not been established.

Providing open places for swallows to nest such as inside farm buildings and under porches, and supplying them with nesting platforms would help alleviate any housing shortage. Barn Swallows were the fourth most often seen bird during hedgerow surveys so maintenance of insect producing habitats such as hedgerows, especially near mixed crops, as well as pastures, meadows, marshes, ditches and deciduous forests would contribute to the swallow's larder.

*Remarks:* A concern was raised in the report on the proposed port expansion on Roberts Bank and its impact the swallow, mostly from increased vehicle collisions. The Review Panel concluded that the Barn Swallow would be adversely affected if mitigation measures were not undertaken. A decision on port development on Roberts Bank is before the Minister of Environment (Review Panel for Roberts Bank Terminal 2 Project 2020).

#### **Ancient Murrelet *Synthliboramphus antiquus***

*Conservation status:* SARA SC, Schedule 1; B.

*Occurrence:* Ancient Murrelets are *Migrant Non-breeders* on the delta. Butler and Campbell (1987) reported the Ancient Murrelet to be *Uncommon* from October to March, which had changed little when Weber *et al.* (2013) considered it to be *Rare* from October to March with the exception of mid-October to mid-November when it became *Uncommon*. The Ancient Murrelet nests on remote islands around the North Pacific and spends the rest of the year at sea (Gaston 1992). Juan de Fuca Strait and the Strait of Georgia appear to be important post-breeding areas for the species in autumn (Davidson *et al.* 2010), including Boundary Bay. For example, RWB (unpublished field notes) counted 281 Ancient Murrelets in USA waters off Point Roberts on 7 December 2007. Fewer seem to use the Fraser River Estuary where Butler *et al.* (2018) saw two Ancient Murrelets in the Fraser River Estuary in December 2017 and there are many records of one or a few birds in eBird (2019).

*Ecology:* Ancient Murrelets eat mostly crustaceans during winter in waters near the Fraser River Delta (Gaston *et al.* 1993) but nothing is known about their ecology around the delta.

*Conservation:* We are reminded that the Fraser River Delta is the transition between freshwater and marine environments by the seabirds that grace its outer margins. Al-

though the Ancient Murrelet occurs in small numbers along the extreme western edge of the Fraser River Delta, understanding how the Fraser River contributes to its presence in the Strait of Georgia and Juan de Fuca Strait needs to be considered. A priority is to assess what proportion of the global population use these waters and the role of the Fraser River ecosystem in their presence.

#### **Band-tailed Pigeon *Patagioenas fasciata***

*Conservation status:* SARA SC, Schedule 1; B.

*Occurrence:* Most Band-tailed Pigeons are *Migrant Breeders* on the delta. Band-tailed Pigeons were considered *Fairly Common* in summer and *Uncommon* in winter in 1987 (Butler and Campbell 1987). Weber *et al.* (2013) concurred with this assessment and showed the pigeon to be *Fairly Common* from early April to early November.

*Ecology:* The south coast of British Columbia, including the Fraser River Delta is the centre of the summer range of the Band-tailed Pigeon in Canada. The pigeon is very elusive around its nest but nesting is confirmed on the delta (Davidson 2015). The pigeon is attracted to berry producing shrubs such as red elderberry (*Sambucus racemosa*) and other fruiting shrubs, oak trees with acorns, grains in agricultural areas, and to mineral sites that supplement its sodium needs.

*Conservation:* Concerns about long-term declines in Band-tailed Pigeon numbers prompted its addition to the lists of species of Special Concern and the Blue-list (COSEWIC 2008b). Preservation of berry producing shrubs in hedgerows and forests for nesting are the most important action that can be undertaken to benefit the species on the delta.

#### **Buff-breasted Sandpiper *Tryngites subruficollis***

*Conservation status:* SARA SC, Schedule 1.

*Occurrence:* The Buff-breasted Sandpiper is a *Migrant* species on the delta that by all accounts, has remained a rarely seen migrant species that transients the delta in late summer. Campbell *et al.* (1972a) reported a single sighting and considered the species to be a *Casual* transient (*i.e.* not occurring every year but reliable recent records). Butler and Campbell (1987) did not include the species in their account. Campbell *et al.* (1990) designated it as a *Casual transient* on the south coast and Weber *et al.* (2013) considered its presence in Greater Vancouver to be *Accidental* in July and *Rare* from August until mid-October. Most sightings are of single or a few birds from Boundary Bay and Iona Island (Price 1990, eBird 2019).

*Ecology:* The Buff-breasted Sandpiper frequents short grassy patches and damp areas around ponds on the Fraser

River Delta. Nothing is known of its ecology while on the delta due to its scarcity.

*Conservation:* Maintaining tidal flats and open grassy areas such as at Iona Island are the best courses of action.

#### **Common Nighthawk *Chordeiles minor***

*Conservation status:* SARA T, COSEWIC re-examined 2018 SC.

*Occurrence:* The Common Nighthawk is a *Migrant Breeder* on the delta. Butler and Campbell (1987) considered the Nighthawk to be *Uncommon* in summer and bred on the delta. Weber *et al.* (2013) concurred with this status. Butler and Campbell (1987) wrote that the species was “widespread throughout the delta and found roosting on fence posts, beach logs, buildings at Iona Island, jetties and dead trees” and refer to eight nest records from the delta. Gebauer (1999) reported one or two birds in Burns Bog.

*Ecology:* The nighthawk relies on flying insects for food that it catches in the air near dawn and twilight. On the ground in depression, the eggs are laid where the camouflaged adult sits unmoved (Campbell *et al.* 2006). A disturbance will send the nighthawk fluttering a feigned broken wing across the ground in an attempt to draw the intruder from the nest. The young are also well camouflaged and remain on the ground until capable of flight. To succeed at nesting, the nighthawk relies on quiet, undisturbed, open country, often on marginal lands or on rooftops.

*Conservation:* The Common Nighthawk listed as Threatened on the Species at Risk Act Schedule 1 was reassessed by COSEWIC in 2018 resulting in a recommendation to designate it is species of Special Concern. Campbell *et al.* (2006) pointed out that the Breeding Bird Survey did not adequately monitor the number of nighthawks but could only provide anecdotes and some data to support their view that the species had become less common in recent decades. Some of that decline, if real, occurred in urban settings where the loss of suitable gravel roof-nesting habitat, a decline in flying insect populations, and competition with other roof-nesting birds were offered as possible causes for local urban declines (Campbell *et al.* 2006). Gravel filled nesting boxes placed on roofs of industrial buildings would be an inexpensive action to test if nest sites are wanting.

#### **Horned Grebe *Podiceps auratus***

*Conservation status:* SARA SC, Schedule 1.

*Occurrence:* The Horned Grebe is a *Migrant Non-breeder* on the delta. Butler and Campbell (1987) considered the grebe to be *Uncommon* in summer and *Common to Very*

*Common* in winter. Weber *et al.* (2013) refined the dates using a status for Greater Vancouver to be *Common* (their highest frequency term) from mid-September to mid-May, and *Rare* in summer.

*Ecology:* The Horned Grebe looks all the part of a diving bird with legs set near the rear, a long neck and short bill but it does not look like it is designed for long flights. Not much is known about the ecology of the Horned Grebe on the Fraser River Delta. The grebe is widespread along the shoreline, mostly outside the river, and large numbers occur mostly in September and October during migration (eBird 2019).

*Conservation:* COSEWIC (2009) assigned Special Concern because of widespread declines on surveys. The causes are not well known but threats include loss of marshes for nesting and oil spills on the Pacific Coast. Despite the concerns, the Horned Grebe appears to be doing well on the delta. Butler and Cannings (1989) reported a maximum count in October 1988 of 154 grebes on the delta and the highest count in the CWBS was 650 grebes in 2001.

#### **Olive-sided Flycatcher *Contopus cooperi***

*Conservation status:* COSEWIC SC; B.

*Occurrence:* The Olive-sided Flycatcher is a *Migrant* species on the delta. Butler and Campbell (1987) considered it to be a *Rare* transient and Weber *et al.* (2013) *Uncommon* from mid-May to end of August. The Olive-sided Flycatcher frequents mountainous regions and only passes over the delta on migration. eBird shows a scattered distribution across the delta of the flycatcher, often where there is forest such as Burns Bog, Westham and Lulu islands, and along the Fraser River.

*Conservation:* Preservation of shrubby and forested habitats is the most important action that can be undertaken for the species on the delta.

#### **Red-necked Phalarope *Phalaropus lobatus***

*Conservation status:* SARA SC, Schedule 1; B.

*Occurrence:* *Migrant.* Butler and Campbell (1987) reported that the phalarope was *Rare* in spring and *Uncommon* in autumn. Weber *et al.* (2013) considered it *Uncommon* from late August to mid-September, and *Rare* about a month before and after this period. They considered spring records as *Accidental*. Migration is largely offshore and substantial (Paulson 1993) but on the Fraser River Delta, sightings are scarce at any time.

*Ecology:* Red-necked Phalaropes are coastal migrants along the west coast of British Columbia between breed-

ing grounds in the Arctic and winter quarters along the South American coast. eBird records show the species mostly frequented tidal flats on Iona, Sea and Westham islands, in the South Arm Marshes, and shores of Boundary and Mud bays.

*Conservation:* The Red-necked Phalarope was considered Special Concern by COSEWIC (2014b) largely because of declines in the Bay of Fundy. Despite large numbers migrating along the B.C. coast in spring and late summer, the few sightings on the Fraser River Delta do not warrant special attention. Maintaining tidal flats on the Fraser River Delta is the best course of action.

### **Short-eared Owl *Asio flammeus***

*Conservation status:* SARA SC, Schedule 1, B.

*Occurrence:* Resident and *Migrant Nonbreeder*. Butler and Campbell (1987) ranked the owl as a breeding species that was *Uncommon* in summer, *Fairly Common* in winter. Weber *et al.* (2013) indicated that the owl was *Rare* from mid-May to mid-September and mostly *Fairly Common* the remainder of the year. The Short-eared Owl on the Fraser River Delta contains a small resident breeding population and a much larger non-breeding population. The numbers of Short-eared Owl have declined on surveys in recent years prompting the listing of Special Concern, and nearly to the level of Threatened (Environment Canada 2016). There is some evidence that the number of breeding owls might have been more numerous on the delta in the past. Campbell *et al.* (1972a) said the owl was *Frequent* (not every field trip, but usually found) in summer and not too dissimilar to *Uncommon* (1–6 individuals per day per locality) by Butler and Campbell (1987) whereas Weber *et al.* (2013) considered it *Rare*. Christmas Bird Counts through the 1970s and 1980s fluctuated widely (Campbell *et al.* 1990b) and that the 1969 tally was the highest count reported on North America Christmas Bird Counts (Campbell *et al.* 1972a). Campbell *et al.* (1990b) wrote that from 1964–67 an astounding 426 Short-eared Owls were trapped and banded as part of a bird control program at Vancouver International Airport.

*Ecology:* Campbell *et al.* (1990b) summarize the breeding and winter ecology of the Short-eared Owl in British Columbia. The species is considered a possible breeding species on the delta in the B.C. Breeding Bird Atlas (Cannings 2015c).

*Conservation:* The Short-eared Owl requires serious attention on the Fraser River Delta given the historical high abundance and apparent decline (Cannings 2015c). The proposed Species at Risk Management Plan for this species' recovery plan has three actions: conservation and management of the species and its suitable habitat

across the breeding, migrating and wintering ranges; conducting surveys, monitoring and research on the species, its habitats and threats across the breeding, migrating and wintering ranges; and promoting awareness and partnerships related to conservation priorities (Environment Canada 2016). Maintaining old field habitat on the Fraser River Delta would be an important step toward the first action. Dedicated surveys specifically to locate and record the distribution of Short-eared Owl nest and winter sites are urgently needed. Interactions with people and competitors should be documented. Photographers and birdwatchers can also help by not disturbing roosting owls.

### **Evening Grosbeak *Coccothraustes vespertinus***

*Conservation status:* SARA SC Schedule 1.

*Occurrence:* The Evening Grosbeak on the delta was *Rare* in summer and *Uncommon* in winter according to Butler and Campbell (1987). Weber *et al.* (2013) considered the grosbeak to be *Fairly Common* at all times of the year. COSEWIC (2016) voiced concerns over widespread declines reported on surveys prompting the Special Concern designation. Grosbeak sightings mostly around Delta, and a few locations on Sea and Iona islands are scattered and of a few birds (eBird 2019).

*Ecology:* Annual fluctuations in numbers of grosbeaks in British Columbia appear to be related to biannual fluctuations in the seeds they eat (Campbell *et al.* 2001). See Campbell *et al.* (1991) for a summary of breeding biology in British Columbia.

*Conservation:* Too few grosbeaks use the Fraser River Delta for effective conservation.

### **Harris's Sparrow *Zonotrichia querula***

*Conservation status:* COSEWIC SC.

*Occurrence:* Butler and Campbell (1987) did not include this species on their list of birds of the Fraser River Delta, likely as an oversight because Campbell *et al.* (1972a) reported the species on Sea Island and Point Roberts, although none were seen on Christmas Bird Counts. Weber *et al.* (2013) considered the sparrow to be *Rare* from mid-September to mid-May.

*Conservation:* The Harris's Sparrow is Canada's only endemic nesting songbird. It frequents hedgerows and shrubby habitats such as on Sea Island, Westham Island, and along the dike on Boundary Bay. Preservation of shrubby habitats is the most important action that can be undertaken for the species on the delta. Declines in the mid-west prompted a Special Concern assessment.

**Bank Swallow *Riparia riparia***

*Conservation status:* SARA T, Schedule 1.

*Occurrence:* Butler and Campbell (1987) said the swallow was a *Rare transient* based on the few Bank Swallows seen in May and June, and up to 40 were in autumn. The numbers seem to have remained stable since the 1980s, and have not reflected the declines reported across North America (COSEWIC 2013). Weber et al. (2013) referred to the swallow as *rare* in spring, *casual* through the summer until mid-August to mid-September when it was *Fairly Common*. The Bank Swallow does not nest on the delta and there were no records on the coast known during the Breeding Bird Atlas (Howie 2015) but a colony was recently located in Abbotsford.

*Ecology:* The Bank Swallow nests in colonies in road cut banks, quarries, and riverbanks where they can dig out a nest hole. The swallows forage on flying insects near their colonies.

*Conservation:* The Bank Swallow has declined on surveys in Canada but the reasons are far from clear. Possible causes include loss of breeding and foraging habitat, destruction of nests, collisions with vehicles, widespread negative effects on insect prey from pesticide use, and climate change. No specific conservation actions on the delta are recommended because of the small number and transient nature on the delta. However, retention and restoration of ponds and marshes will provide the insects for migrant Bank Swallows and other swallows on the delta.

**Long-billed Curlew *Numenius americanus***

*Conservation status:* SARA SC; B.

*Occurrence:* One to three birds, *Casual* throughout the year except *Rare* during migration from mid-April to mid-May and mid-August to mid-September (Weber et al. 2013). There have been sightings reported on eBird along the foreshore from Iona to Mud Bay with the most sightings of single birds at Crescent Beach.

*Ecology:* The Long-billed Curlew probes soft sediments for food on the delta. A few sightings have been made of single birds in the agricultural lands near Boundary Bay.

*Conservation:* Conversion of native grasslands to agricultural crops and urban development are thought to be the major threats to the curlew (Environment Canada 2012). Preservation of soft sediment beaches particularly in Mud and Boundary Bay are recommended.

**Red Knot *Calidris canutus roselaari***

*Conservation status:* SARA T, R.

*Occurrence:* The Red Knot occurs annually usually as single or a few individuals. This assessment has not changed over the past 30 years. Butler and Campbell (1987) considered this species to be a *Rare transient* (i.e. 1–6 birds/d) and Weber et al. (2013) considered it *Uncommon* (0–5/d) in May, and also in August and September. Boundary Bay and Brunswick Point are likely places to find the species.

*Ecology:* The migration of Red Knots through British Columbia contains a mystery. There are possibly three populations of the subspecies *roselaari* that migrate through the Fraser River Delta (COSEWIC 2007). The Pacific coast population that breeds in northwestern Alaska and on Wrangell Island migrates along the Pacific coast, including the Fraser River Delta, from its winter quarters in California, the Pacific coast of northwestern Mexico, and possibly the Gulf of Mexico. The mystery is the migration routes and breeding areas of the other two populations. The Florida and southeastern United States, and the Brazilian populations are likely to breed in Alaska and the western Canadian Arctic, but it requires confirmation.

*Conservation:* The population of Red Knot subspecies *roselaari*, estimated to be about 13,000 birds in 2007, was down by 70% by the early 1990s, and by 2005 was between 1,500 and 3,000 adults prompting listing the species as Threatened by (COSEWIC 2007) and Red-listing by the provincial government. Maintaining tidal flats on the Fraser River Delta is the best course of action.

**Black Swift *Cypseloides niger***

*Conservation status:* SARA E, Schedule 1; B.

*Occurrence:* Butler and Campbell (1987) and Weber et al. (2013) considered the swift to be *Fairly Common* and widely distributed from mid-May to late September.

*Ecology:* Most of the world's Black Swifts are thought to nest in British Columbia but few have been found (COSEWIC 2015). Two nests found near Squamish and Whistler was a rare discovery of this elusive bird (Levesque and Rock 2017). Black Swifts from Colorado spent the winter in the Amazon Basin reveals an astonishing intercontinental connection (Beason et al. 2012).

*Conservation:* Although large declines on Breeding Bird Surveys prompted Endangered designation as a Species at Risk, the swift is regularly seen, albeit in mostly small numbers. No specific conservation actions on the delta are recommended.



**Yellow-breasted Chat *Icteria virens***

*Conservation status:* SARA E, Schedule 1; R.

*Occurrence:* Butler and Campbell (1987) did not include this species in their treatise and Weber *et al.* (2013) considered it accidental in winter and autumn, and casual in spring and summer. Campbell *et al.* (2001) described the chat's presence as very rare on the coast. The chat's coastal range extends north into western Washington and east of the Coast Range, the chat breeds in the southern Okanagan Valley, so sightings on the delta are extra-limital (Eckerle and Thompson 2001, Cannings 2015d). We include the species here because sightings on the Fraser River Delta might signal the start of a range expansion northwards into southern British Columbia. eBird sighting locations on the delta include west Boundary Bay, and Westham and Iona islands.

*Ecology:* The Yellow-breasted Chat, the lone representative species in the family Icteriidae, is large warbler-like bird that frequents riparian habitats, such as in hedgerows and abandoned farmlands around the delta (Eckerle and Thompson 2001). Elusive and skulking are terms that describe the chat's behaviour and its propensity to be overlooked.

*Conservation:* Preservation of shrubby habitats is the most important action that can be undertaken for the species on the delta (Cannings 2015d, Eckerle and Thompson 2001).

**Vesper Sparrow *Poocetes gramineus affinis***

*Conservation status:* SARA E, Schedule 1; R.

*Occurrence:* The Vesper Sparrow is strictly a *Migrant* on the delta, and a scarce one at that. Butler and Campbell (1987) made no mention of this species. Weber *et al.* (2013) refer to the sparrow as being *Rare* but regularly occurring, from mid-April to late May and mid-September to mid-October.

*Ecology:* The Vesper Sparrow uses weedy roadside verges and grassy habitats with scattered shrubs on migration (Jones and Cornely 2002).

*Conservation:* The Vesper Sparrow is a scarce migrant in the delta and about the only assistance that can be provided is the preservation of open grassy areas such as at Iona Island and along Boundary Bay.

*Remarks:* The source of sightings of Vesper Sparrows is not certain. The most likely possibility is from the nearest breeding population of the coastal *P. g. affinis* subspecies on Vancouver Island near the Nanaimo Airport, and due west of the Fraser River Delta (Ryder 2015). A second less likely possibility is the larger interior subspecies *P. g. confinis*, breeding

north and east of the delta, and east of the Coast Range in the B.C. interior (Ryder 2015). Attention to size differences might clarify which subspecies occurs on the delta.

**Rusty Blackbird *Euphagus carolinus***

*Conservation status:* SARA E, Schedule 1; R.

*Occurrence:* Rare October to early December (Weber *et al.* 2013).

*Ecology and Conservation:* The few Rusty Blackbirds that occur on the delta often associate with other blackbird flocks that forage in agricultural areas of the delta. The conversion of flood plain forests to agricultural lands in Mississippi and bird control programs in the southeastern USA are thought to be the major reason for declines (COSEWIC 2006).

**Proposed Changes to Threshold Species****Bald Eagle *Haliaeetus leucocephalus***

*Occurrence:* The Bald Eagle is a *Resident* and a *Migrant Non-breeder*. The Bald Eagle was *Uncommon* in Summer and *Fairly Common* in winter on the delta when Butler and Campbell (1987) wrote their report. Weber *et al.* (2013) updated the eagle's status to *Uncommon* from mid-May to mid-October after which it steadily increases from *Fairly Common* until mid-November and becomes *Common* from late November to mid-April when it becomes *Fairly Common*. Butler and Campbell (1987) knew of three nesting pairs and estimated the winter population to be about 20–30 birds. Jones (2009) reported that the 10 nests in the Lower Fraser Valley in 1994 grew to 27 nests by 2005. By 2018, there were about 80 nests on the delta (Pers. comm., Myles Lamont, Surrey, B.C., 2019 November 28).

Over the past 30 years, the abundance of non-breeding eagles has also dramatically changed. Thousands of eagles roost near the landfill and the Boundary Bay shoreline is lined with eagles during the day. The number of eagles present in winter and breeding seasons on south coast of British Columbia quadrupled through 1980s and the 1990s (Elliott *et al.* 2011). Banding teams working around the Vancouver Landfill estimated 4000 eagles foraged at the landfill and roosted in Burns Bog (Pers. comm., Myles Lamont, Surrey, B.C., 2019 November 28).

*Ecology:* The thousands of eagles residing on the delta in winter include local and distant breeding adults and immatures. The breeding population of Bald Eagles on the delta numbers about 80 pairs. The breeding season runs from January or February to July or early August. Reproductive success of eagles in the Lower Fraser River Valley, including the delta, was especially high most likely because of the abundance of bird prey relative to other coastal locations (Elliott *et al.* 1998b). Eagles in the Lower Fraser Val-

ley produced an average of 1.25 young in 203 nesting attempts between 1994 and 2005 (Jones 2009). Adults that breed away from the delta leave in winter along with immatures to feed on Pacific herring spawning along coastal tidal flats. The adults then fly to nesting sites in western Canada and Alaska.

Most breeding eagles on the delta depart in late July and August to eat spawning chum salmon (*Oncorhynchus keta*) in coastal rivers (Elliott et al. 2006). Several thousand eagles gather each autumn in the Harrison River. Large numbers of eagles return to the delta in October and November to forage and rest at the landfill, and to hunt ducks. The abundance of eagles in southern British Columbia appears to be dictated by temperatures in Alaska and spawning salmon abundance. In especially cold Alaskan winters and when chum salmon were abundant in local rivers, eagles were numerous on the delta (Elliott et al. 2006).

The seasonal movement of eagles establishes a relatively safe period for eagle prey in late summer and early fall, and a period of relative danger the rest of the year. The winter danger period is likely the reason that some waterfowl move away from the shore inhabited by eagles in search of safer, distant waters (Middleton et al. 2018).

Eagles on the Fraser River Delta are scavengers, predators and kleptoparasites (Peterson et al. 2001, Dekker et al. 2012, Middleton et al. 2018). Although thousands of eagles use the landfill site, their presence is largely as a roost to avoid inclement weather, and secondarily as a source of food (Elliott et al. 2006). The highest counts occurred in February when weather was especially cold and damp (Elliott et al. 2006).

*Conservation and Remarks:* The U.S. Fish and Wildlife Service (2016) estimated 143,000 Bald Eagles lived in coterminous USA states and Alaska. There are no current estimates for B.C. but in 1994, Blood and Anweiller (1994) estimated about 20,000 lived in the province. The trends for eagles have been generally upwards since then (Barry 2015). If reports of 4,000 eagles at the landfill (Myles Lamont, unpublished data) are substantiated, then the population would exceed the Global and Continental IBA Threshold of 3,300 eagles.

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## Appendix

### Results of binomial model trend analysis of Threshold species from 1999–2019 Coastal Waterbird Survey.

Analysis only included surveys performed closest to the second Sunday of each month, for months in which there was more than one survey conducted. Additional surveys were dropped. A zero-filled matrix was created to add zeros for date/time combinations in the dataset when a species was not observed, but at least on observation of another species was made. A new year/month variable was created since the winter surveys overlap two calendar years. The first winter month is September (1) and the last winter month is April (8). Surveys done outside these months were not included in the analysis. Data were limited to migration windows for each species. These were permanent windows based on expert opinion and are not updated annually.

Analysis was limited to species observed at least once per route (*i.e.* those with sum = 0 across months/years are dropped from the analysis). Analysis was limited to routes run for the entire survey window for a species (*i.e.* if the total number of months surveyed within a given year was less than the survey window, the route/year was dropped from the analysis). Analysis was limited to routes run >1 winter for each species. Analysis dropped species not detected on more than one

route with a region of interest (for this analysis the region of interest was the Fraser River Delta. The first year was 1999 and the last year was 2019.

### Response Variable

For each year, month and survey route, the total count for each species was the sum of counts across all distance bands. The basic statistical unit for all analyses was the mean total count of each species at a survey site across months within the species-specific survey window of each non-breeding season, e.g. December–February for most wintering birds.

### Population Trends

Generally, negative binomial (NB) and Poisson data distributions are compared using DIC, and the model which minimized DIC is used to estimate trends. However, DIC was always minimized by NB model, which has more parameters than the Poisson model. This suggests that DIC isn't useful for comparing NB and Poisson models (always chooses the model with more parameters). Therefore, only Poisson models were our best fit for the analysis.

Long-term trends in counts were estimated independently for each species using a Bayesian framework with Integrated Nested Laplace Approximation (R-INLA, Rue *et al.* 2014) in R (version 3.1.3; R Core Team 2014). The model estimates a continuous effect for year, which is back-transformed into a %/year trend. The model also fits a random effect (independent and identically distributed errors) for site and an AR1 (first-order temporally autocor-

related errors) random effect for year. Years were not weighted by the number of sites sampled each year. This is because the number of sites seems relatively consistent over time, but something to consider in future analysis. Also, the random year effect is not nested within site, because the number of years sampled for some sites might not be large enough to handle.

### Annual Indices

Annual indices were calculated from the posterior distribution of the Poisson trend model, as opposed to fitting a separate model with year as a categorical effect. To do this, 1,000 samples from the posterior distribution were taken to calculate the mean winter count for each year to use as an annual index.

In the Appendix Table 1 the species-specific trends are presented as %/year with lower and upper 95% credible intervals (*i.e.* the probability that the true trend falls within that range). A posterior distribution was also calculated to estimate the support for an increasing or declining trend. A value near 0.5 would suggest equal probability for an increasing and declining trend (little evidence for a change in migration counts over time), whereas a posterior probability near 1 will suggest strong support for the observed change in counts. The posterior probability can be used as a pseudo p-value, such that trends with a posterior probability > 0.9 could be considered to have strong support. Annual indices of population size were estimated as the mean daily count from the posterior distribution of the above model.

Appendix Table 1. Trend expressed as percent per year, confidence intervals, and probabilities for 20 species on the Coastal Waterbird Survey of the Fraser River Delta, B.C., 1999-2019.

Species	Trend	Lower conf. interval	Upper conf. interval	Probability
Brant	0	-1.58727	1.612869	0.51
Trumpeter Swan	-0.5982	-3.63239	2.531512	0.66
American Wigeon	-0.29955	-2.76116	2.326654	0.61
Northern Pintail	-0.29955	-2.76116	2.326654	0.6
Green-winged Teal	-0.29955	-2.85835	2.429032	0.6
Greater Scaup	-0.09995	-1.7839	1.511306	0.56
Surf Scoter	-0.3992	-3.34285	2.429032	0.63
White-winged Scoter	-0.3992	-3.05244	2.429032	0.61
Red-breasted Merganser	-0.29955	-2.85835	2.224378	0.61
Red-necked Grebe	-0.09995	-2.85835	2.634095	0.53
Western Grebe	-0.29955	-2.85835	2.224378	0.61
Black-bellied Plover	-0.1998	-2.66388	2.326654	0.56
Sanderling	0.10005	-2.95545	3.355054	0.53
Dunlin	-0.1998	-2.27375	1.918165	0.58
Bonaparte's Gull	0	-2.66388	2.73678	0.51
Mew Gull	0	-1.58727	1.816298	0.48
Glaucous-winged Gull	-0.09995	-2.56649	2.326654	0.55
Red-throated Loon	-0.3992	-2.85835	2.020134	0.66
Great Blue Heron	-0.29955	-2.66388	2.224378	0.6
Peregrine Falcon	-0.09995	-2.66388	2.531512	0.54

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## *From the Editor*

The Fraser River Delta is one of the richest and most important ecosystems for migrating and wintering birds in Canada. It is one of Canada's most impressive Important Bird and Biodiversity Areas (IBA) and is a significant candidate for one of Canada's most important Key Biodiversity Areas (KBA).

It is also a region of increasing human population and accompanying development pressure. Three decades ago *The birds of the Fraser River Delta: populations, ecology and international significance*, by R.W. Butler and R.W. Campbell, documented the importance of the region for birds and provided recommendations for the region's protection. Since then, many conservation measures have been implemented and much new information on the birds and biodiversity of the region has been acquired, but pressures from urbanization and industrial development continue. In this special issue of *British Columbia Birds*, current information is presented as well as a new set of recommendations for conservation of the region.

British Columbia Field Ornithologists is pleased to present this volume and to make it widely available on our website (<https://bcfo.ca>). We hope that it will be used as a stimulus for further conservation action.

My appreciation goes to the authors who have submitted this paper and to Neil Dawe who has done a particularly fine job of producing this issue of the journal. — Art Martell



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**Back Cover:** Snow Geese from Wrangel Island, Russia, on the Fraser River delta marshes west of the George C. Reifel Migratory Bird Sanctuary (top image), 14 November 1973 (Photo: Neil K. Dawe) and geese feeding in the agricultural fields, Delta, BC (bottom right), 8 January 2006 and in a municipal park in Richmond, BC (bottom left), 12 January 2012 (Photos: W. Sean Boyd; see page 22). In the 1970s, the Fraser/Skagit Snow Goose population was about 15,000 birds and rarely would they use agricultural fields. However, by the early 1980s, a few years after the Alaksen National Wildlife Area was established near Ladner, the geese began to feed on cover crops, pasture grasses and potatoes. That new foraging behavior has continued to the present and in the 1990s the geese even began using parks and school grounds in Richmond. The population gradually grew in size and, by the early 2020s, was over 135,000 geese (nine times that in the mid-1970s!). The geese still forage on farm crops but marsh plants continue to be an important part of their winter diet. Since the late 1980s the foraging pressure by so many Snow Geese has reduced the amount of estuarine marsh by more than 60%, which could be negatively affecting the entire estuarine food web.

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