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The birds of the Fraser River delta: populations, ecology and international significance

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Dedication

This report is dedicated to Robert D. Harris and Ernest W. Taylor, whose pioneering efforts helped preserve the haunts of birds in the Fraser River delta for future generations.

Abstract

The Fraser River delta is the largest estuary on the Pacific coast of Canada. In concert with the Copper River delta in Alaska and the wetlands of California, the Fraser River delta is a link in a chain of vital bird habitats between breeding grounds in Canada, Alaska and the eastern USSR and wintering areas in the southern USA and Central and South America. It also supports the highest densities of waterbirds, shorebirds and raptors in Canada in winter.

Native people hunted birds in the delta for at least 3000 years before the arrival of European settlers in the mid-1800s; since that time, about 75% of the flooded portion of the delta has been diked, drained and cultivated. In an average year, about 500 000 waterbirds use the delta; in some years, as many as 1.4 million birds (about 4200 birds per square kilometre) — 300 000–750 000 waterfowl, 200 000–600 000 shorebirds and 60 000 gulls — migrate through the Fraser River delta. In winter, about 135 000 waterbirds (about 410 birds per square kilometre of aquatic habitat) use the delta, attracted by its mild winter climate, extensive marshes and mud flats and abundant food. During winter and migration, the Fraser River delta supports internationally significant populations of the Snow Goose (*Anser caerulescens*), Green-winged Teal (*Anas crecca*), Mallard (*Anas platyrhynchos*), American Wigeon (*Anas americana*), Canvasback (*Aythya valisineria*), Greater Scaup (*Aythya marila*), Surf Scoter (*Melanitta perspicillata*), White-winged Scoter (*Melanitta fusca*), Black Scoter (*Melanitta nigra*), Common Goldeneye (*Bucephala clangula*), Bufflehead (*Bucephala albeola*), Common Merganser (*Mergus merganser*), Ruddy Duck (*Oxyura jamaicensis*), Western Sandpiper (*Calidris mauri*), Dunlin (*Calidris alpina*) and Glaucous-winged Gull (*Larus glaucescens*). No other site north of California on the Pacific coast has such large bird populations in winter.

Over half of the freshwater species of fish in British Columbia have been recorded in the Fraser River, and, at most times of year, one or more fish species are moving through the river to spawn. The fish species most important to birds are the eulachon (*Thaleichthys pacificus*), herring (*Clupea harengus pallasi*), flounders (Pleuronectidae) and sculpins (Cottidae). In spring, during the herring spawning season, thousands of ducks and gulls gather in Boundary Bay. At the same time, spawning eulachons attract birds, sea lions, seals and whales into the river. Flounders and sculpins provide food for diving and wading birds.

The distribution of birds in the Fraser River delta is affected by tides, weather and habitats. Daily tides affect feeding patterns of herons, shorebirds, gulls and waterfowl by flooding and exposing the feeding areas. In winter, high tides in daytime force herons and waterfowl to feed in fields. However, freezing weather exacerbates the shortage of feeding areas by precluding field-feeding by waterfowl and restricting the feeding areas on intertidal mud flats of wintering Dunlin and Snow Geese. In contrast, heavy rains flood agricultural fields and attract waterfowl from the foreshore and herons in search of voles. Most diving ducks avoid the silt-laden waters near the brackish marshes in favour of clearer water near Boundary Bay and near Iona Island, whereas dabblers frequent all of those areas.

About 1% (6.22 km^2) of the Fraser River delta has been protected by government legislation for the primary use of wildlife. Other forms of protection exist, including parks, private land holdings and restrictions imposed by government environmental review programs for proposed developments. Those incidental forms of protection do not necessarily ensure a long-term commitment to preserve the habitat for wildlife. There is an urgent need to protect seaward mud flats and to replace some old fields and flooded meadows destroyed by past diking and draining schemes. The presence of cultivated fields is probably essential to maintain the current populations of waterfowl.

Résumé

Le delta du fleuve Fraser est le plus grand estuaire de la côte canadienne du Pacifique. Avec le delta de la rivière Copper, en Alaska, et les zones humides de la Californie, ce delta forme un maillon de la chaîne d'habitats vitaux pour les oiseaux que constituent les aires de nidification situées au Canada, en Alaska et dans l'est de l'URSS, et les aires d'hivernage du sud des États-Unis et des Amériques centrale et du Sud. En hiver, on trouve également dans le delta du Fraser la plus grande densité au pays de rapaces et d'oiseaux aquatiques et de rivage.

Les Autochtones ont chassé les oiseaux du delta pendant au moins 3 000 ans avant l'arrivée des colons européens, au milieu du 19e siècle. Environ 75 % de la partie inondée du delta a toutefois été cultivée depuis, à la suite de la construction de digues et de divers travaux de drainage. Une moyenne d'à peu près 500 000 oiseaux aquatiques visitent le delta annuellement. Certaines années, jusqu'à 1,4 million d'oiseaux (environ 4 200 oiseaux par kilomètre carré) — de 300 000 à 750 000 oiseaux aquatiques, de 200 000 à 600 000 oiseaux de rivage et 60 000 goélands et mouettes — empruntent le delta lors de la migration. En hiver, quelque 135 000 oiseaux aquatiques (près de 410 individus par kilomètre carré d'habitat aquatique) séjournent dans le delta, attirés par son climat doux, les vastes terrains marécageux et battures vaseuses, et l'abondance de nourriture. L'hiver et en période migratoire, le delta héberge de nombreux spécimens des espèces suivantes: l'Oie blanche (*Anser caerulescens*), la Sarcelle à ailes vertes (*Anas crecca*), le Canard malard (*Anas platyrhynchos*), le Canard siffleur d'Amérique (*Anas americana*), le Morillon à dos blanc (*Aythya valisineria*), le Grand Morillon (*Aythya marila*), la Macreuse à front blanc (*Melanitta perspicillata*), la Macreuse à ailes blanches (*Melanitta fusca*), la Macreuse à bec jaune (*Melanitta nigra*), le Garrot commun (*Bucephala clangula*), le Petit Garrot (*Bucephala albeola*), le Grand Becscie (*Mergus merganser*), le Canard roux (*Oxyura jamaicensis*), le Bécasseau du Nord-Ouest (*Calidris mauri*), le Bécasseau variable (*Calidris alpina*) et le Goéland à ailes grises (*Larus glaucescens*). Il n'existe aucun endroit comparable, au nord de la Californie et le long de la côte du Pacifique, quant à l'abondance des populations aviennes en hiver.

Plus de la moitié des poissons dulçaquicoles de la Colombie-Britannique ont été observés dans le fleuve Fraser, sans compter que d'autres l'adoptent à un moment ou l'autre comme zone de frai durant la majeure partie de l'année. Les espèces préférées des oiseaux sont l'eulakane (*Thaleichthys pacificus*), le hareng du Pacifique (*Clupea harengus pallasi*), les poissons plats (Pleuronectidés) et les chabots (Cottidés). Au printemps, des milliers de canards, de mouettes et de goélands se rassemblent dans la baie Boundary pour se nourrir du hareng du Pacifique qui vient y frayer. Au même moment, les oiseaux, les otaries, les phoques et les baleines sont attirés par la présence de l'eulakane, également en frai. Les poissons plats et les chabots sont les éléments de base de l'alimentation des plongeurs et des échassiers.

Les marées, les conditions météorologiques et les habitats que l'on trouve à l'intérieur du delta ont une incidence sur la distribution des oiseaux à cet endroit. Ainsi, le rythme quotidien des marées influe sur le comportement alimentaire des hérons, des oiseaux de rivage, des mouettes et goélands, et des Anatidés en inondant ou en asséchant leurs aires d'alimentation. En hiver, la marée haute de jour force les hérons et les Anatidés à aller se nourrir dans les champs. Toutefois, les gelées rendent la situation encore plus grave en enlevant cette dernière option aux Anatidés et en diminuant l'étendue des aires d'alimentation du Bécasseau variable et de l'Oie blanche sur les battures vaseuses de la zone intertidale. À l'opposé, les fortes pluies inondent les terres agricoles et attirent les Anatidés de l'estran ainsi que les hérons à la recherche de campagnols. Contrairement aux canards de surface qui se retrouvent partout, la plupart des canards plongeurs délaissent les eaux chargées de limon que l'on trouve près des marais d'eau saumâtre pour les eaux plus claires des environs de la baie Boundary et de l'île Iona.

Près d'un pour cent (soit 6,22 km^2) du delta du fleuve Fraser a été réservé principalement à l'intention de la faune par des moyens législatifs. Les autres mesures de protection comprennent des parcs, des propriétés privées et des restrictions imposées à l'aménagement par le truchement des programmes gouvernementaux d'évaluation de l'environnement. Ces formes secondaires de protection ne garantissent cependant pas la préservation à long terme des habitats fauniques. Il faut de toute urgence protéger les battures vaseuses et prévoir de nouvelles friches et prairies d'inondation pour remplacer celles qui ont été détruites par les digues et les travaux de drainage. Par ailleurs, la présence de terres cultivées est probablement essentielle pour maintenir à leur niveau actuel les populations d'oiseaux aquatiques.

Resumen

El delta del río Fraser es el estuario más grande de la costa canadiense del Pacífico. Conjuntamente con el delta del río Copper en Alaska y las zonas húmedas de California, este delta constituye un eslabón vital del conjunto de habitats que integran las zonas de nidificación situadas en Canadá, en Alaska y en la región oriental de la URSS, así como las áreas de invernada escalonadas a lo largo del sur de los Estados Unidos y de América Central y del Sur. Aquí se encuentra asimismo en invierno la mayor densidad de aves acuáticas, aves costeras y aves de rapiña.

La caza de pájaros en el delta fue practicada por los aborígenes durante 3000 años por lo menos, antes de la llegada de los colonizadores europeos, a mediados del siglo XIX. Sin embargo, en el curso de los últimos cien años, tras la construcción de presas y diversos trabajos de drenaje, se ha cultivado aproximadamente el 75% de la porción inundada del delta. Este es utilizado todos los años, como promedio, por unas 500.000 aves acuáticas, cantidad que ciertos años puede llegar hasta unas 1.400.000 aves, o sea casi 4.200 aves por kilómetro cuadrado. En su migración el delta es utilizado anualmente por 300.000 a 750.000 aves acuáticas, 200.000 a 600.000 aves costeras y 60.000 gaviotas. En invierno, aproximadamente 135.000 aves acuáticas, o sea cerca de 410 aves por kilómetro cuadrado, habitan el delta, atraídos por su clima benigno, la extension de terrenos pantanosos y las zonas de depósitos aluviales, así como por la abundancia de los alimentos. Durante el período migratorio, en invierno, el delta alberga a numerosas poblaciones de pájaros de una u otra de las especies siguientes: *Anser caerulescens*, *Anas crecca*, *Anas platyrhynchos*, *Anas americana*, *Aythya valisineria*, *Aythya marila*, *Melanitta perspicillata*, *Melanitta fusca*, *Melanitta nigra*, *Bucephala clangula*, *Bucephala albeola*, *Mergus merganser*, *Oxyura jamaicensis*, *Calidris mauri*, *Calidris alpina*, y *Larus glaucescens*. No existe otro lugar similar, al norte de California, a lo largo de la costa del Pacífico, donde haya mayor abundancia de poblaciones de aves en la época invernal.

En el río Fraser se han encontrado más de la mitad de los peces de agua dulce de la Colombia Británica, sin contar con todos los peces que lo utilizan en un momento u otro, durante la mayor parte del año, como zona de desove. Las especies que constituyen las presas predilectas de los pájaros son los eulachon (*Thaleichthys pacificus*), herrings (*Clupea harengus pallasi*), flounders (Pleuronectidae), y sculpins (Cottidae). En primavera, miles de patos y gaviotas se reúnen en Boundary Bay, atraídos por la presencia del arenque del Pacífico que viene a desovar en esta época. Al mismo tiempo, la presencia del eulachon, que viene también a desovar, atrae a pájaros, lobos marinos, focas y ballenas. Los peces favoritos de las aves zambullidoras y aves zancudas son los flounders y sculpins.

Las mareas, las condiciones meteorológicas y la presencia o ausencia de habitats influyen sobre la distribución geográfica de las aves en el delta del río Fraser. El ritmo cotidiano de las mareas influye sobre el comportamiento alimentario de las garzas, aves costeras, gaviotas y aves acuáticas al inundar o dejar expuestos sus zonas de alimentación. En invierno, la marea alta diurna obliga a las garzas y aves acuáticas a retirarse a los campos para alimentarse. Sin embargo, las heladas que sobrevienen a veces en tiempo frío reducen aún más las zonas alimentarias impidiendo a las aves acuáticas el acceso a su alimentación en los campos y reduciendo las zonas de alimentación de los *Calidris alpina* y *Anser caerulescens* en las zonas aluviales de la parte intermareal. En cambio, las fuertes lluvias anegan las tierras agrícolas y atraen a las aves acuáticas y a las garzas en su búsqueda de Voles lejos del litoral. Contrariamente a los patos de superficia que se encuentran en todas partes, la mayoría de los patos zambullidores se trasladan de las aguas llenas de depósitos aluviales cercanas a los pantanos de aguas salobres a las aguas más claras de Boundary Bay y de Iona Island.

En virtud de disposiciones legislativas gubernamentales, cerca de 1%, o sea 6.22 km^2 del delta del río Fraser está reservado en prioridad al uso de la fauna. Las demás medidas de protección incluyen la creación de parques, las tenencias de tierra privadas y las restricciones impuestas al ordenamiento o desarrollo en virtud de programas gubernamentales de evaluación del ambiente. Estas secundarias formas de protección no significan necesariamente un compromiso a largo plazo con miras a preservar los habitats de la fauna. Existe la necesidad urgente de proteger las tierras aluviales y prever nuevos eriales y llanos inundados para reemplazar los destruidos por las canalizaciones y los trabajos de drenaje. Por otra parte, la existencia de tierras cultivadas probablemente es esencial para mantener el nivel actual de las poblaciones de aves acuáticas.

Introduction

The Fraser River delta, on the extreme southwest mainland of British Columbia (49°10′, 123°05′W), contains the largest estuary on the Pacific coast of Canada. From its headwaters near Mount Robson on the western slope of the Canadian Rockies, the Fraser River scours 1360 km of mountain valleys across the width of British Columbia before emptying into the Strait of Georgia near Vancouver. The delta's extensive marshes and mud flats and relatively mild winter climate attract migrating birds from Asia, the Canadian Arctic and Central and South America and support the highest densities of waterbirds in Canada during winter.

Documentation of the birds of the Fraser River delta began in 1858 with a list of birds seen in British Columbia, some of which were reported from the delta (Lord 1866). Anderson (1882) referred to "wild geese and ducks [that] abound along the sloughs" in Richmond and stated that "wildfowl gather in vast numbers late in fall; Canada, white [Snow Goose] and crow goose [Brant], Mallard, Pintail" in Delta. Brooks and Swarth (1925) and Munro and Cowan (1947) reported on the birds of British Columbia, including the Fraser River delta, earlier this century. Godfrey (1986) provided some recent records from the Fraser River delta. However, the most significant contributions appeared only during the past two decades. Canadian Wildlife Service (CWS) biologists R.D. Harris and E.W. Taylor began regular surveys of waterfowl between 1966 and 1974. Their findings were published and cited in numerous publications dealing with the delta (e.g., Campbell *et al.* 1972*a*; Vermeer and Levings 1977; McKelvey *et al.* 1985). Campbell *et al.* (1972*a*) published an annotated list of birds seen in the Vancouver area in 1970, including the Fraser River delta. Subsequent annual summaries of birds seen in the Greater Vancouver area in 1971 and 1972 were published by Campbell *et al.* (1972*b*, 1974). However, there are no reports on the status of all birds and their habitats in the Fraser River delta. In this paper, we document changes in habitats and populations, summarize ecological studies, provide an annotated list of bird species, review present and future threats and provide recommendations for the preservation of the bird populations in the Fraser River delta.

Study area

1. The Fraser River delta

1.1. Study area

The Fraser River delta (Fig. 1) includes the area bounded by the Canada–US border in the south, Burrard Peninsula in the north, Surrey uplands in the east and the Strait of Georgia in the west. It covers about 681 km^2 and stretches 30 km from New Westminster in the east to Sand Heads lighthouse in the west and 22 km from the Canada–US border at Point Roberts north to Iona Island. Formerly, much of the delta flooded during the spring freshet of the Fraser River, but today most of the area is diked. Outside the dikes the aquatic environment includes estuarine, marine and riverine components (see section 2.). The area enclosed by dikes is cultivated and contains suburban and industrial developments, woodlots and bogs (Fig. 2) (see section 3.).

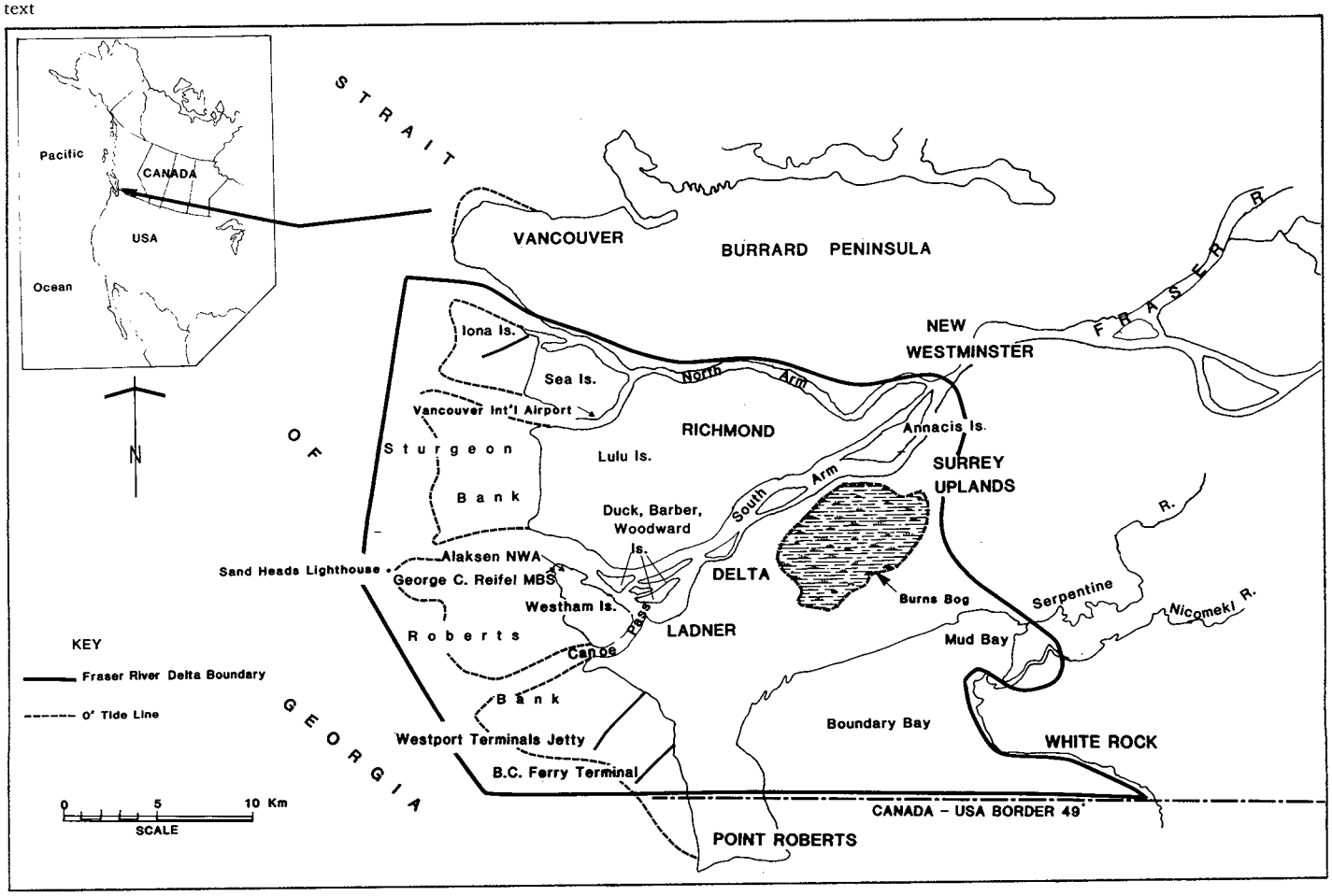
Sturgeon and Roberts banks and Boundary Bay mud flats are intertidal lands. Seaward of the banks lies the foreslope of the western delta front that extends into the Strait of Georgia with an average slope of 1.5° (Mathews and Shepard 1962). The Fraser River once flowed south into Boundary Bay, but today two small rivers that drain the Surrey Uplands — the Serpentine and Nicomekl — are the major sources of fresh water in the bay (Fig. 1). The tidal flats in Boundary Bay are 4 km wide and their foreslope is 13 km long.

1.2. Geological formation

The Fraser River delta began to fan out near New Westminster about 8000 years ago, resulting in deposits up to 215 m deep over Pleistocene sediments (Mathews and Shepard 1962). The current estimate of the rate of deposit along the western delta front in the Strait of Georgia is 12.7 $\times$ 10^6 m^3/yr. The major islands in the delta today include, from north to south, Iona, Sea, Lulu, Annacis, Duck, Barber, Kirkwood and Woodward.

Armstrong (1956, 1957) and Blunden (1973) described the surficial sediments of the delta. The northern half of Sea Island in Richmond Municipality is covered by about 1–4 m of clay silts, and sand silts 1–30 m deep cover the remainder of the island. The eastern two-thirds of Sea Island is covered by 6 m of peat bog. During high tides, Richmond Municipality lies below sea level, so that the diked lands are partially flooded for much of the winter. Dikes and pumps control much of the water in Richmond, but deep ditches are needed to prevent extensive flooding in many areas. The tidal flats outside the dikes are composed of sandy silts with thinner sequences of organic-rich muds.

Figure 1
Locations of the Fraser River delta (inset) and place names mentioned in the text



Delta Municipality, south of the South Arm of the Fraser River, is underlain with 0.4–3 m of silt clays or silt. Like Richmond, most of Delta is diked to prevent flooding.

The tidal flats on Sturgeon and Roberts banks contain hummocky muddy sediment beneath the tidal marsh and sand from the marsh to the delta front (Luternauer and Murray 1973). Sand-grain size is larger on Sturgeon Bank than on Roberts Bank. Coarse sediments, such as those on Sturgeon Bank, are deposited during high river flow. Jetties were erected along the mouth of the Fraser River after 1914 to redirect sediment flows from the river over the banks. In Boundary Bay, the salt marsh is underlain with silty and sandy peat; the tidal flats are sand (Kellerhals and Murray 1969). Finer sediments have accumulated in Mud Bay at the eastern end of Boundary Bay.

1.3. Climate

The Fraser River delta has one of the most pleasant climates in Canada. Winters are characteristically mild and wet, and summers are warm and dry. The range of temperatures is lower than in the interior of British Columbia but higher than on the outer west coast (Environment Canada 1980). Moderate climate and extended growing season partially determine the delta's importance in Canada for large concentrations of wintering birds — it provides food and a temperate environment when most of the rest of the country is frozen.

In summer, northwesterly sea breezes begin at about 1000 hours and continue to blow until sunset, when

Figure 2
Locations of major bird habitats mentioned in the text

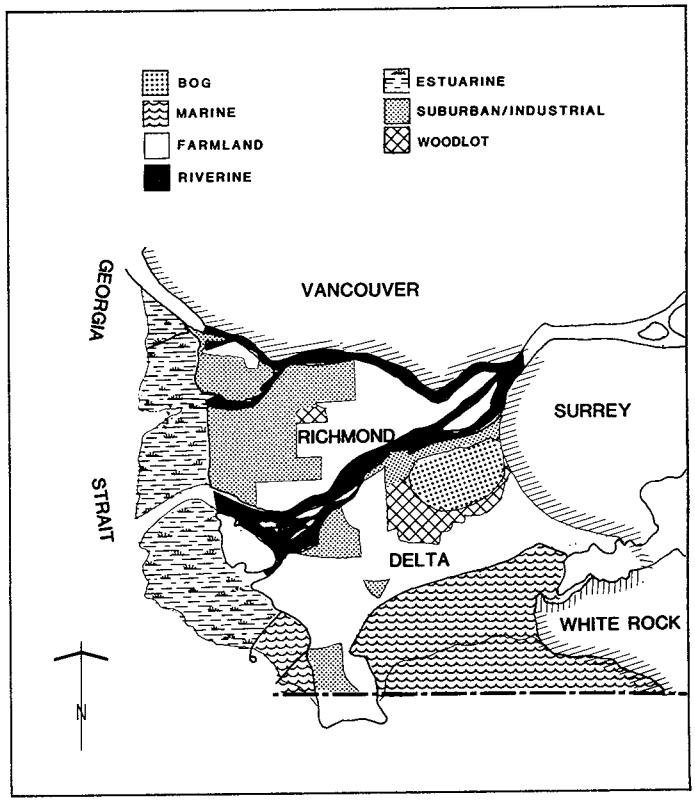


Table 1
Climatic normals at Vancouver International Airport, 1951–80 (from Environment Canada 1980)

Parameter	Month												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Daily temperature (°C)													
Maximum	5.2	7.8	9.4	12.8	16.5	19.2	21.9	21.5	18.3	13.6	9.0	6.5	13.5
Minimum	-0.2	1.4	2.1	4.7	7.9	10.9	12.6	12.6	10.1	6.4	2.8	1.2	6.0
Mean	2.5	4.6	5.8	8.8	12.2	15.1	17.3	17.1	14.2	10.0	5.9	3.9	9.8
Mean precipitation (mm)													
Rainfall	130.7	107.1	95.1	59.3	51.6	45.2	32.0	41.1	67.1	114.0	147.0	165.2	1055.4
Snowfall	25.7	7.5	6.6	0.3	0.0	0.0	0.0	0.0	0.0	Trace	2.8	17.5	60.4
Total	153.8	114.7	101.0	59.6	51.6	45.2	32.0	41.1	67.1	114.0	150.1	182.4	1112.6
Mean number of days													
With rain	17	15	15	13	10	10	6	8	10	15	18	19	156
With snow	6	2	2	<1	0	0	0	0	0	<1	1	4	15
With precipitation	20	16	16	13	10	10	6	8	10	15	18	21	163

a weaker offshore breeze blows onto the Strait of Georgia until morning. During winter, cold arctic air enters the delta periodically through the Harrison and Fraser river valleys and blows over the Strait, especially in the more unprotected southern end of the estuary. Calm periods, which occur less than 10% of the year, occur most often in autumn and allow daytime heating to rival late summer temperatures.

In winter, Pacific cyclones track on to the coast from the southwest and northwest. In summer, high-pressure systems redirect storms offshore, so that little more than 10% of the year's precipitation falls then.

Average daily temperatures at the Vancouver International Airport do not dip below freezing (Table 1). The coldest month is January, the wettest is December and the warmest and driest is July (Table 1). Rainfall increases to the north and east away from the coast. Tsawwassen Beach, near the Canada–US border, receives an annual mean rainfall of 857.5 mm, 13% less than in Ladner (910 mm), 23% less than at the Vancouver International Airport (1055 mm) and 21% less than in White Rock (1047 mm). The most dramatic difference occurs between Tsawwassen and the North Shore mountains, only 38 km apart. Tsawwassen receives about one-third of the precipitation at the ski resort atop Grouse Mountain (1128 m). Snow falls from November to March in the delta, but lies for no more than 6 days in any month, on average. Cold, arctic low-pressure systems are mostly held off the coast by the Coast Range Mountains. When these low-pressure systems cross the mountain barrier, strong easterly winds bring snow and freezing temperatures, which force many birds out of neighbouring fields and mountain slopes into the delta.

2. Aquatic environment

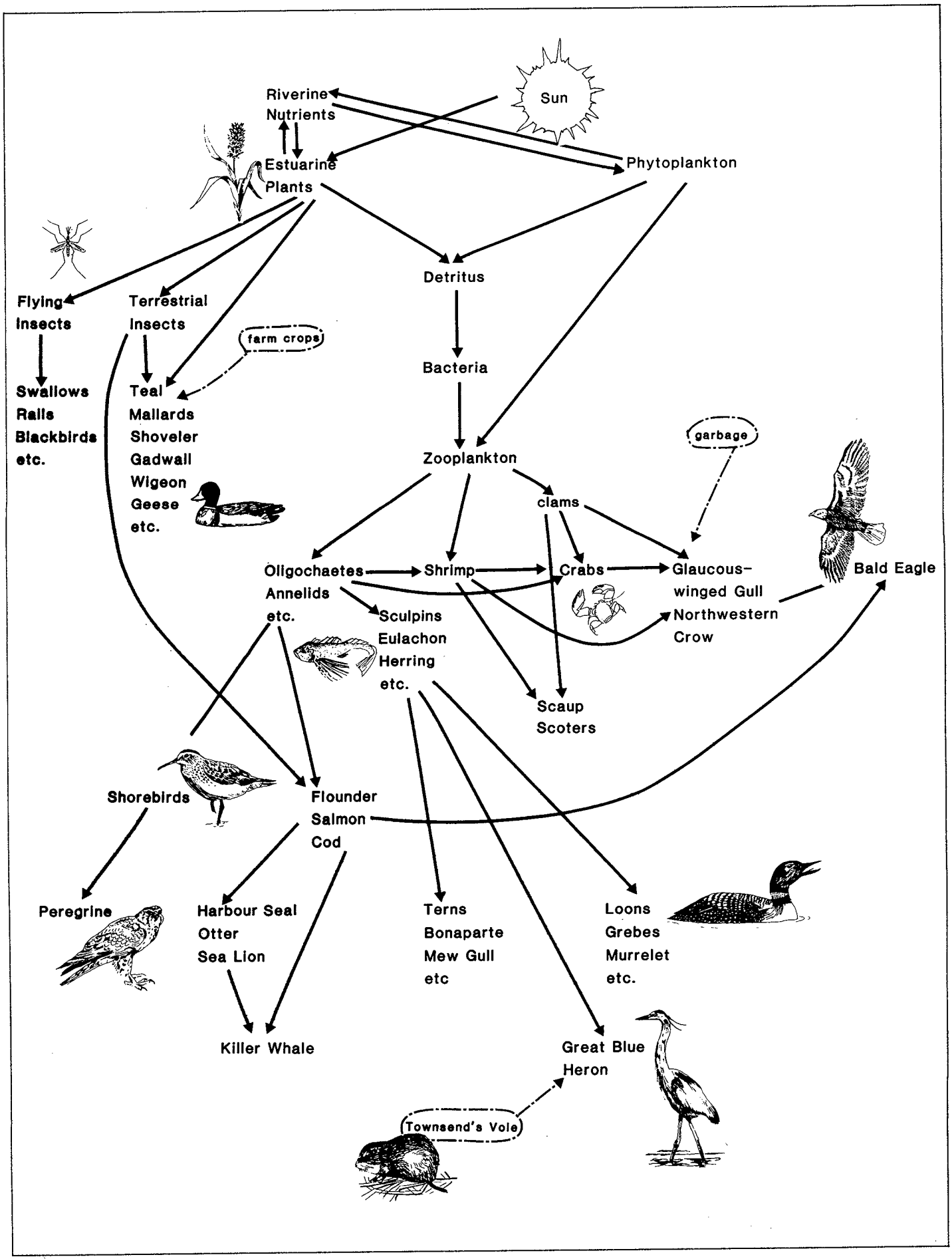
An estuary was traditionally defined as the lower deltaic portion of a river, but may now include bays, sounds and arms that receive considerable amounts of fresh water (Thomson 1981). Under that broad definition, the Strait of Georgia is a large estuary; the Fraser River contributes up to 60% of the dilution of the entire southwestern passage around Vancouver Island, from Juan de Fuca Strait in the south through the Strait of Georgia and Queen Charlotte Strait on the east (Thomson 1981). In this paper, we refer to the area from New Westminster to the river's mouth as riverine, to the Banks as estuarine and to Boundary Bay as marine (Fig. 2).

Salinity in the Fraser River delta varies depending on several factors, including river runoff, wind, tides and currents. Waldichuk (reported in Hoos and Packman 1974) defined the transition between fresh water and clear saline water as occurring at a salinity of 1.5%. Salinity in the northern Strait of Georgia away from the Fraser River's influence is about 2.5%; in the open Pacific Ocean it is about 3.3% (Thomson 1981). The freshwater/saline water boundary changes with tides and river outflow, but on most days includes the area we call estuarine located between Iona Island in the north and the Westport Terminal jetty on Roberts Bank in the south. An enormous amount of seawater is required to replace the water swept out to sea by the fresh water from the river. As a result, upwelling occurs at the mouth, creating immense biological productivity (Fig. 3).

The Fraser River is influenced by the tides of the Strait of Georgia, which are mostly semidiurnal, i.e., with two highs and two lows each lunar day (Thomson 1981). In addition to the lunar cycle, there are cycles of about two weeks' duration, so that the interval between successive tides advances about 1 h each day (Thomson 1981). Semiannual variation of the sun produces an annual cycle in which the lowest tides of the year occur near midnight in December and around noon towards the end of June. The tides at Sand Heads lighthouse in the South Arm range from about 3.1 m on average to as much as 4.8 m on spring tides (Thomson 1981). Tidal changes are felt as far upstream as New Westminster and can reduce river flow upstream as far as Chilliwack. In historic times, the tides at the mouth of the river reduced the flow of water enough to flood Sumas Lake near Chilliwack, 100 km upstream, which abounded with waterfowl (Laing 1979); Sumas Lake has now been drained.

The Fraser River is a "salt wedge" estuary influenced by tides and river discharge. Seawater, which has a lower specific gravity than fresh water, creeps upstream along the river bottom. The salt wedge reaches its maximum intrusion about 60–80 min after high tide at the river mouth. During low discharge in spring, the wedge penetrates as far as Annacis Island at the head of the estuary. In summer, during heavy discharge, the salt wedge barely enters the river, and fresh water skims across the Strait of Georgia to the Gulf Islands 30 km to the west of the river mouth (Thomson 1981). On certain tides, deep-draught vessels move upstream faster than the shallow-draught tugs that tow them.

Figure 3
A simplified food web in the Fraser River delta



2.1. Riverine

The Fraser River is controlled by 500 km of dikes along most of its course through the delta. Only small islands remain outside the dikes, the largest being the Duck-Barber-Woodward island complex near Ladner. Their shapes have changed dramatically in 38 years, mostly as a result of man-made structures that control the direction of the river's flow (Kistritz 1978).

The Fraser River divides at New Westminster into the North and South arms. Most (88%) of the river flows through the South Arm. The South Arm divides once more about 20 km downstream, creating Canoe Pass, which carries about 5% of the river flow along the south side of Westham Island. The North Arm splits off the Middle Arm to create Sea Island. Maximum flow occurs from May to July, when the mountain snowpack melts in the interior of British Columbia.

2.2. Estuarine

The Fraser River estuary is dominated by *Carex* and *Scirpus*, typical of brackish marshes in the Pacific Northwest. There are three distinct estuarine marsh communities at the mouth of the river (Kistritz 1978), characterized by: (1) cattail (*Typha latifolia*) and sedge (*Carex lyngbyei*) within a few hundred metres of the dikes; (2) bulrush (*Scirpus paludosus*) about 300–600 m seaward of the dikes; and (3) a second bulrush (*S. americanus*) 600–800 m from the dikes. Seaward of the brackish marshes are the extensive mud and sand flats of Roberts and Sturgeon banks. Organic material and invertebrate biomass are greatest along the marsh edge and tend to increase toward the south on the banks (Levings and Coustalin 1975). The major contributors to invertebrate biomass are two amphipods (*Corophium salmonis* and *C. insidiosum*) and a tanaid (*Tanais* sp.). A clam (*Macoma* sp.) dominates the lower intertidal reaches.

2.3. Marine

The salinity of water in Boundary Bay, exclusive of Mud Bay, and on Roberts Bank as far north as Westshore Terminals jetty (Fig. 1) exceeds 1.5% for most of the year (Hoos and Packman 1974), allowing a narrow remnant of the formerly extensive *Salicornia–Triglochin* salt marsh to skirt the upper edge of the beach (Yamanaka 1975). The salt marsh is rooted to a hummocky substrate produced by successive layers of flotsam and sand. Low on the beach there is a sand-flat area with algal mats (mostly *Ulva lactuca*), followed in deeper water by an eelgrass zone comprising *Zostera marina* and *Z. japonica*. Swinbanks (1979) described the flora, geology and macrofauna of the marine area between the Westport Terminals and BC Ferry jetties. Aside from changes to water currents created by the two jetties, part of the mud flat was covered by expansion of the Westshore Terminal ship-loading facilities in 1981–82 (Levings 1985). Since that expansion, extensive eelgrass beds have rooted between the jetties.

3. Terrestrial environment

When the Royal Engineers surveyed the Fraser River delta in 1858, prior to the first European settlement in the 1860s, they discovered extensively burned areas where, for thousands of years, natives had set fires to prevent encroachment of pines into the bogs where blueberries

Estuarine marshes such as these at the Alaksen National Wildlife Area are feeding areas for the immense populations of waterfowl in the Fraser River delta.

(*Vaccinium* spp.) grew (Ward 1979). Following permanent diking of the Fraser River delta shortly after 1894, the land was quickly cleared, cultivated and eventually urbanized. Today most of the wooded and grassy areas are under cultivation or have become residential developments.

3.1. Woodlots and hedgerows

Shrubs and trees still skirt some farmland and line short stretches of the Fraser River and its delta, but woodlots are scarce. The largest woodlots are found around Burns Bog at the east end of the delta, on the uplands at Point Roberts, Washington, and near the Richmond Nature Park on Lulu Island (Fig. 2). The delta was logged in just over 100 years, but unmerchantable and inaccessible trees were left (Hoos and Packman 1974). The dominant trees now include big-leaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*) and Douglas fir (*Pseudotsuga menziesii*) on high ground, and lodgepole pine (*Pinus contorta*) and paper birch (*Betula papyrifera*) around bogs. The most thorough vegetation study done outside the bogs was by Weber (1982*a*), in conjunction with spring and summer bird surveys on the Alaksen National Wildlife Area. Weber surveyed the vegetation along the dikes in late June and July 1981 and assigned each major species an "importance" rating (Table 2). Deciduous trees were most widespread, with red alder predominating. R.W. Butler (unpubl. data) measured some alders on the Alaksen National Wildlife Area with a girth of over 3.6 m dbh (diameter at breast height) in 1984, although most were much smaller. Willows measured 0.6 m dbh and crabapples 0.4 m dbh. The shrub flora is dominated by Pacific coast species and exotics. Red elderberry (*Sambucus racemosa*), salmonberry (*Rubus spectabilis*) and red-osier dogwood (*Cornus stolonifera*) are native to the west coast. The two blackberries (*Rubus laciniatus* and *R. procerus*) are European species that have become naturalized in British Columbia. Although the delta lies within the coastal Douglas fir biogeoclimatic zone (Krajina 1965), the controlling conditions are mostly edaphic (Hebda and Biggs 1981).

3.2. Bog

Bogs often form in temperate climates where the water table is at or above ground level most of the year. Under those conditions, sphagnum moss (*Sphagnum* sp.) forms spongy hummocks. The water becomes acidic, preventing much decay, and creates deep layers of moss

Table 2
The mean importance of major trees and shrubs on six survey routes on the Alaksen National Wildlife Area (adapted from Weber 1982*a*)

Species	Mean importance* rating
Trees	
Red alder (*Alnus rubra*)	0.80
Black cottonwood (*Populus trichocarpa*)	0.50
Hawthorn (*Crataegus douglasii*)	0.40
Douglas fir (*Pseudotsuga menziesii*)	0.33
Pacific crabapple (*Pyrus fusca*)	0.29
Hooker's willow (*Salix hookeriana*)	0.25
Cherry (*Prunus avium*)	0.17
Paper birch (*Betula papyrifera*)	0.15
Cascara (*Rhamnus purshiana*)	0.14
Willow (*Salix lasiandra*)	0.11
Other (six species)	<0.40
Shrubs	
Red elderberry (*Sambucus racemosa*)	0.82
Himalayan blackberry (*Rubus procerus*)	0.75
Salmonberry (*Rubus spectabilis*)	0.64
Nootka rose (*Rosa nutkana*)	0.60
Evergreen blackberry (*Rubus laciniatus*)	0.51
Red-osier dogwood (*Cornus stolonifera*)	0.40
Hardhack (*Spirea douglasii*)	0.40
Black raspberry (*Rubus leucodermis*)	0.40
Holly (*Ilex aquifolium*)	0.40
Black twinberry (*Lonicera involucrata*)	0.15
Other (four species)	<0.40

* Importance (I) = abundance (A) × frequency (F), where A = common (2) or uncommon (1) and F = the proportion of all (N = 64) survey segments in which the plant species occurred. The maximum importance rating for a given species is 2.0 when A = 2 and F = 64/64 = 1.0.

Pacific crabapples once lined many natural levees in the Fraser River delta; today only a few remain. This particularly good stand on the Alaksen National Wildlife Area is an important habitat for migrant and wintering songbirds.

Table 3
Area and percentage of land types in the Fraser River delta (data from Delta and Richmond Municipalities)

	Richmond		Delta		Total	
Land type	ha	%	ha	%	ha	%
Agriculture	3 438	25.8	9 288	51.6	12 726	40.7
Residential	3 107	23.3	2 556	14.2	5 663	18.1
Commercial/industrial	862	6.5	1 332	7.4	2 194	7.0
Parks/recreation/institutions	600	4.5	1 044	5.8	1 644	5.2
Undeveloped	1 088	15.7	3 780	21.0	5 868	18.7
Other*	3 216	24.2	0	0	3 216	10.3
Total	13 311	100.0	18 000	100.0	31 311	100.0

* In Richmond, "other" includes roads, transportation corridors and unclassified areas.

known to gardeners as "peat moss." Nitrogen is lacking and iron is abundant, further restricting the spread of many plant species. In wet areas of Burns Bog, bog cranberry (*Vaccinium oxycoccus*), sundew (*Drosera* sp.) and cottongrass (*Eriophorum chamissonis*) are abundant (Hebda and Biggs 1981). In drier areas, swamp laurel (*Kalmia polifolia*), Labrador tea (*Ledum groenlandicum*) and several *Vaccinium* species grow. Lodgepole pine and paper birch occur on higher ground, with salal (*Gaultheria shallon*) in their shade.

Much of the eastern part of the delta was at one time bog, but was virtually destroyed by diking, farming and peat extraction. Much of the vegetation surrounding Burns Bog is a result of recent human activities. Hebda and Biggs (1981) estimated that 40% of the surface vegetation of the 4000-ha bog has been disturbed through peat removal. Portions of the birch forest along the eastern edge were destroyed in 1986 by construction of the approach to the Alex Fraser bridge. A small (62.7 ha) site on the eastern edge is protected as the Delta Nature Reserve. Originally, most of Burns Bog was dominated by heathlands or open-bog-type vegetation; lodgepole pine and paper birch were absent, and hardhack (*Spirea douglasii*) brushland was probably an original feature (Hebda and Biggs 1981).

3.3. Suburban and industrial

Suburban developments are typified by wood-frame houses surrounded by gardens and clumps of trees and bushes. They are mostly confined to the western side of Richmond, around the town of Ladner and in Tsawwassen. Industrial areas line much of the North Arm and portions of the South Arm near Tilbury Island and include warehouses, ship-loading facilities, lumber mills and processing plants. In 1985, residential developments covered 5663 ha (18.1%) of the delta (Table 3). The population of Richmond and Delta municipalities at the 1981 census was about 175 000 people.

3.4. Farmland

The single largest terrestrial habitat in the Fraser River delta is agricultural land (Table 3), which covers 40.7% of the diked portion of the delta. Agricultural lands are cultivated mostly for dairy cattle and horticultural products. Some fields are planted in fall or winter crops. As the cost of maintaining farmland has increased, many of the former edge habitats have been eliminated.

Methods

We divided the Fraser River delta into nine habitats (Table 4). To determine the former area of each habitat, we cut out and weighed to the nearest 0.001 g the nine major habitat types from a composite map of the vegetation in 1880 (North *et al.* 1979) and extrapolated their area from the weight of a scale-piece cut from the same map. We assumed that the area of the river and mud flats had not changed since the dikes were built along the river banks. Estimates of current areas were taken from many sources. The areas under cultivation and in suburban and industrial developments were obtained from planning departments in Richmond and Delta municipalities. The area of bog was obtained from Hebda and Biggs (1981) (Burns Bog) and measured with a ruler from an aerial photograph (Richmond Nature Park). Areas covered by trees and shrubs were visually estimated from aerial photos (percentage of cover). Extent of the salt marsh in Boundary Bay came from Yamanaka's (1975) study and was visually estimated from aerial photos of the Tsawwassen Indian Reserve. Areal estimates of brackish marsh came from Burgess (1970). The area of seasonally wet meadows included flooded fields on the Alaksen National Wildlife Area and Serpentine Fen (K.R. Summers, pers. commun.).

Terrestrial vegetation along dikes on the Alaksen National Wildlife Area was quantified in July on survey routes used for Breeding Bird Surveys (Weber 1982*a*) by assigning an abundance and frequency score to major plant species in tree, shrub and herb layers (Table 2).

Birds have been counted by many observers in a variety of ways. Williams (1978) counted birds in 53 surveys of the South Arm from 28 November 1976 to 30 November 1977. The study area was divided into three regions: (1) the South Arm; (2) Duck-Barber-Woodward islands, Ladner Marsh, Canoe Pass and Deas Slough; and (3) Tilbury Slough. Each region was counted about once per week. The first two regions were counted from a boat, and the third region was counted from the ground.

Waterbird populations have mainly been estimated from aerial surveys, first by Harris and Taylor (summarized in Vermeer and Levings 1977) and later by McKelvey *et al.* (1985) and Savard (1985). Savard (1982) cautioned against using data from aerial surveys, because cryptic species are difficult to see and observers must learn to recognize birds seen at oblique angles from fast-moving aircraft. However, aerial surveys are the only practical method of estimating birds beyond the range of telescopes. Regardless of differences in method, the pattern of seasonal abundance in the early and recent surveys remained the same.

In 1979, Dunlin (*Calidris alpina*) were surveyed once every two weeks from 22 October to 11 April in Boundary

Bay and on Roberts Bank (Fry 1980). On each survey, Fry made four estimates of all flocks using increments of 10, 100, 500 and 1000, depending on the size of the flock. In 1978, Western Sandpipers (*C. mauri*) were counted through binoculars and telescopes from dikes along Boundary Bay 1-3 times per week from 7 March to 22 October (G. Kaiser, unpubl. data). We assumed that Western Sandpipers stayed for the same length of time (2 days) in spring and summer in the Fraser River delta, as found by Butler *et al.* (1987) in summer on nearby Sidney Island. The size of the Western Sandpiper population was then estimated by summing the number counted every third day in Boundary Bay.

Upland birds along wooded dikes on the Alaksen National Wildlife Area have been surveyed in late winter-early spring (Fry 1984), spring-early summer (Weber 1982*a*) and late summer-fall (Kragh 1983). On all surveys, the same six routes were chosen to represent the variety of vegetation types on the Alaksen National Wildlife Area (Weber 1982*a*). Routes ranged from 415 to 760 m in length, and reference points were marked with flagging tape about every 75 m along each route. Most (42) of Weber's surveys were made in the morning. Birds seen on 64 surveys between 27 April and 20 June were marked on maps, which were used to reduce duplicate counts of migrants and delineate the location of breeding territories. Population estimates are expressed in birds per kilometre because of the linear arrangement of dike vegetation. The data can be converted to density (birds per square kilometre) by multiplying the linear estimates by a conversion factor of 33.33, which accounts for the average width (30 m) of the dike vegetation. Fall migrants were surveyed by Kragh (1983) along the same routes used by Weber (1982*a*) from 19 August to 26 November 1983. Fifteen surveys were made between 0645 and 1538 hours Pacific Standard Time (PST). All birds seen or heard within the survey transect were noted. Each transect was then covered in the reverse direction, and the maximum number of each species seen in either survey was used as the estimate. Early spring migrants at the Alaksen National Wildlife Area were surveyed from 25 February to 30 April 1984 by Fry (1984), who used the same method as Kragh (1983). Nine counts were made between 0620 and 1015 hours PST.

Fry (1984) surveyed birds on six fields on the Alaksen National Wildlife Area and compared them with bird use of the foreshore in March and April 1984. Four counts (two in the morning, two in the afternoon) were made per field on 7, 15, 22 and 29 March, and five counts (three in the morning, two in the afternoon) were made per field on 5, 12, 19 and 27 April.

Every December or January, all species of birds seen on 1 day have been counted on Christmas Bird Counts (CBCs) in Ladner (since 1957) and White Rock (since 1971) (Audubon Field Notes and American Birds 1958-84). Although CBC data suffer from uneven coverage — less conspicuous species are missing, grossly inaccurate estimates of large flocks have been made by some observers, and other technical problems exist — the counts are our only source of annual population information for many species over the long term. In the Annotated list of the birds of the Fraser River delta (see Results and discussion, section 3.), we have used CBC data in three ways. First, we report the mean number of birds of each species for Ladner and White Rock CBCs. They should be used with caution and are probably more useful as an indication of relative abundance between species than as population estimates. Second, we note the maximum number seen and the year in which it was recorded. This provides an upper limit of population size of conspicuous species in easily accessed habitat. Finally, we provide population trends for selected species by standardizing the count data against the count effort (number of individual birds counted/number of party-hours spent counting) in those CBCs in which more than 10 observers participated.

Table 4
Areas of habitats in the Fraser River delta in 1880 (prior to European settlement) and 1985

	Area (km^2)		Difference		Protected	
Habitat	1880	1985	ha	%	ha	%
River	66.1	66.1	0.0	0	0	0.0
Sand and mud flats	258.1	257.1*	-1.0	<1	0.14	<0.1
Tidal, brackish marsh*	1.4	0.3	-1.1	78.6	0.41	13.6
Salt marsh†	12.1	<0.1	-12.06	99.7	0.01	0.3
Seasonal wet meadows‡	147.1	<<0.1	-147.093	99.9	0.73	100.0
Bog	89.6	5.0	-84.6	94.4	0.64	0.1
Trees and shrubs	107.1	32.9§	-74.2	69.3	0.79	<0.1
Cultivated field	0.0	127.3	127.3	100.0	3.5‖	<0.1
Suburban and industrial	0.0	192.8	192.8	100.0	0	0.0
Total	681.5	681.5			6.22	0.9

* *Carex*, *Scirpus* and *Typha* marsh inundated by most tides.
† *Salicornia* and *Distichylis* marsh inundated by most tides.
‡ Grassland that flooded mostly during spring freshet.
§ Approximate area of wooded portion of Tsawwassen, Richmond Nature Park, Burns Bog and Annacis Island.
‖ Includes 153 ha of old field.

Results and discussion

1. The Fraser River delta — historical changes

1.1. Human occupation

As massive glaciers retreated from southwest British Columbia about 12 000 years ago, the Fraser River began spewing huge loads of outwash on the shores of the Strait of Georgia. At the same time, the land began to rebound from beneath the huge burden of ice that had towered over 1 km above sea level. Humans first inhabited the emerging Fraser River delta nearly 9000 years ago at the Glenrose Cannery site (Borden 1975) about 1 km upstream from the present Alex Fraser bridge. The Glenrose site was used for about 5000 years and showed a general adaptation by its inhabitants to riverine and foreshore resources (Matson 1976). Occupation of later sites in the delta, such as those at Marpole, Beach Grove and Crescent Beach, occurred as the delta progressed seaward. Although artifacts found at many sites suggest an increased reliance on riverine and intertidal foods, the best information on prehistoric bird presence in the delta has come from the St. Mungo cannery site, 1 km downstream from Glenrose (Boehm 1973).

The first Europeans visited the Fraser River delta about 200 years ago. Captain George Vancouver sailed into the Strait of Georgia in 1792 and surveyed Boundary Bay. Although Vancouver crossed the mouth of the Fraser River and named Sturgeon Banks, he probably never knew of the river's existence (Marshall and Marshall 1955), and he left with the impression that the Fraser River delta was "a swampy flat, that retires several miles, before the country rises to meet the rugged snowy mountains" (Ormsby 1958).

In 1808, after an arduous journey along the entire length of the Fraser River, Simon Fraser and his crew reached the delta, but were pursued up the river by hostile Indians. Fraser abandoned his expedition, but left his name to the river (Ormsby 1958).

By the early 1800s, the Northwest Company, concerned about losing control of the access to the interior of what is now British Columbia, sent a party from Fort Astoria at the mouth of the Columbia River in search of a possible outpost. In June 1827, Fort Langley was established on the banks of the Fraser River about 25 km upstream from the head of its delta (Ormsby 1958). However, it was not until gold was discovered in the Fraser River in the mid-1800s that the delta became settled. On a trip up the Fraser River during the gold rush, the Ladner brothers stopped near the present site of the town of Ladner (Ladner 1972), realized the fertility of the land and returned in 1868 to dike and drain it. The land was apparently a "haven for waterfowl" (Anderson 1884; Ladner 1972). The first settler in the present municipality of Richmond was Hugh McRoberts who, in 1862, developed a 648-ha farm on Sea Island and called it Richmond View after a former home in Australia.

The first bridge between Richmond and the mainland was built in 1889. In 1894, an exceptionally large spring freshet scoured the lower Fraser Valley, flooded out the railway for 41 days, broke the dikes and carried off livestock and buildings. No crops could be planted in Matsqui, Chilliwack, Sumas or the Fraser River delta (Ormsby 1958). As a result, the provincial government erected dikes around much of the delta land to protect the farms from spring floods. Many of those original dikes, or their upgraded versions, are in use today.

The Vancouver International Airport was built on Sea Island in 1931. Ten years later, the Boundary Bay Air Force Station was completed and significantly increased the population at Ladner, but not as much as the construction of the Deas Island (now George Massey) Tunnel built under the South Arm of the Fraser River in 1959, which linked Vancouver to the USA. By 1981, the population of Delta was about 75 000 and of Richmond nearly 100 000. In 1986, the Alex Fraser bridge was opened at the east end of the delta.

1.2. Habitat

As Europeans arrived in the Fraser River delta, land surveyors were instructed to survey boundary lines of land subdivisions prior to sale. During their surveys, they noted several details of the land, including its vegetation, for the information of would-be purchasers. From those notes, North and Teversham (1984) compiled a map of the vegetation of the delta in 1859. The vegetation was prone to brief or extended periods of inundation of fresh, brackish or salt water, creating bands of vegetation with marshes along the delta front. (Salt marshes occur today where salinity remains about 16–18%, with freshwater or brackish marshes where salinities are lower.) Grasslands occurred behind the areas that flooded daily by tides, but became waterlogged when the tides backed up the river, especially during spring freshet. Behind the grasslands grew shrubs in pockets that were seldom flooded, and behind those sitka spruce (*Picea sitchensis*) forest occasionally occurred.

Along the storm beach of Lulu and Westham islands, heaps of seaweed accumulated over the years and provided nutrients for a dense stand of Pacific crabapple (*Pyrus fusca*) (North and Teversham 1984). Tiny remnants of crabapple forest remain on the Alaksen National Wildlife Area on Westham Island. Channels within the delta were lined by natural levees which supported wet coniferous forest.

Over the past 125 years, the river channels, sand flats and mud flats have changed little in area (Table 4), but have been altered by dredging. In contrast, the marshes, wet meadows, bogs and wooded habitats have undergone massive alterations. Diking destroyed virtually all seasonally flooded meadows, salt marshes, bogs and about three-quarters of the wooded areas and brackish marshes (Table 4). Those habitats have been converted primarily to cultivated fields and residential or industrial developments.

1.3. Bird populations

Dramatic changes have occurred in the past century in the local populations of some bird species that use the Fraser River delta. The Sandhill Crane (*Grus canadensis*) and Horned Lark (*Eremophila alpestris*) have disappeared, and the Western Bluebird (*Sialia mexicana*), Purple Martin (*Progne subis*) and Yellow-billed Cuckoo (*Coccyzus americanus*) no longer breed (Table 5). The Wood Duck (*Aix sponsa*) declined dramatically in the lower Fraser Valley through the 1960s, but a concerted effort by local Fish and Game Clubs and the Pitt Valley Waterfowl Association increased the population substantially by artificial restocking.

In contrast, the number of open-country or habitat-edge species has increased with the development of agricultural land. The most abundant species in CBCs are the European Starling (*Sturnus vulgaris*), Brewer's Blackbird (*Euphagus cyanocephalus*), Red-winged Blackbird (*Agelaius phoeniceus*), Northwestern Crow (*Corvus caurinus*), American Robin (*Turdus migratorius*) and Dark-eyed Junco (*Junco hyemalis*) (see Annotated list of the birds of the Fraser River delta, Results and discussion, section 3.) The Brown-headed Cowbird (*Molothrus ater*) is attracted to large mammals, especially cattle, and its numbers have increased in summer with the advent of dairy farms in the Fraser River delta. Both Brown-headed Cowbirds and Brewer's Blackbirds have increased their range in North America (Stepney 1975; Rothstein *et al.* 1980). The Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*) is a recent addition to the delta's nesting avifauna, but it is rare because of little suitable habitat. Common Barn-Owls (*Tyto alba*) are also recent arrivals (1940s), limited by the number of barns for nesting and roosting. Introduced populations of Ring-necked Pheasant (*Phasianus colchicus*) and Canada Goose (*Branta canadensis*) are widespread in cultivated areas. It is difficult to determine how greatly waterfowl populations have changed since the arrival of Europeans. The BC Directory (Anderson 1884) mentions that large numbers of wild geese and grouse occurred in Richmond in 1882–83. It also refers to the presence of the Snow Goose (*Anser caerulescens*), Brant (*Branta bernicla*), Canada Goose, Mallard (*Anas platyrhynchos*) and Northern Pintail (*Anas acuta*), all of which occur today. No estimate of numbers was made. However, only 21.4% of the tidal, brackish marshes present a century ago still exist. Today the remaining marshes are used by about 86 000 ducks in fall (Table 6). If similar densities occurred in the past, then 350 000 ducks might have been present throughout an average autumn. Today over three times the monthly mean are counted on some days, so that the former populations may have reached 1.2 million birds. One species that appears to have declined recently in the delta is the Brant. It was market-hunted in Mud Bay for the Christmas season around the turn of the century (A.E. Barnard, pers. commun.), but today rarely occurs in Mud Bay in fall and winter (see Annotated list of the birds of the Fraser River delta, Results and discussion, section 3.)

Table 5
Species that are threatened or extirpated in the Fraser River delta

Species	Status*	Reference
Snowshoe hare (*Lepus americanus washingtoni*)	Extirpated 1950	Cowan and Guiguet 1965
Roosevelt elk (*Cervus elaphus roosevelti*)	Extirpated 1850	Cowan and Guiguet 1965
Cougar (*Felix concolor*)	Extirpated 1900	Anderson 1884
Wolf (*Canis lupus fuscus*)	Extirpated	Cowan and Guiguet 1965
Yellow-billed Cuckoo (*Coccyzus americanus*)	Extirpated 1950	Munro and Cowan 1947
Purple Martin (*Progne subis*)	Extirpated 1966	Weber 1980
Western Bluebird (*Sialia mexicana*)	Extirpated 1971	Weber 1980
Horned Lark (*Eremophila alpestris*)	Extirpated 1981	R.W. Campbell, unpubl. data
Burrowing Owl (*Athene cunicularia*)	Extirpated 1976	BCWRS
Black bear (*Ursus americanus*)	Threatened 12 individuals	Kucy 1971
Sandhill Crane (*Grus canadensis tabida*)	Threatened 4 individuals	Weber 1980
Common Barn-Owl (*Tyto alba*)	Threatened 26 individuals	Campbell *et al.* 1972*a*
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)	Threatened 40 individuals	Weber 1980

* Extirpated = no longer occurs (mammals) or nests (birds) in the Fraser River delta; threatened = numbers declining and will be extirpated if present conditions prevail, or occurs in such low numbers that its future existence is precarious.

Table 6
Maximum means* reported† for major aquatic bird groups in spring, summer, fall and winter‡ in the Fraser River delta, 1966–85, rounded to the nearest hundred

	Spring		Summer		Fall		Winter		Total	
Group	Mean	%	Mean	%	Mean	%	Mean	%	Mean	%
Geese	19 200	12.4	200	0.5	20 800	11.7	18 400	13.6	58 600	11.6
Ducks	29 200	18.9	17 900	45.0	86 100	48.6	58 100	43.1	191 300	37.8
Gulls	15 600	10.1	9 400	23.6	23 300	13.1	14 400	10.7	62 800	12.4
Shorebirds	90 500	58.6	12 300	30.9	47 100	26.6	44 000	32.6	193 900	38.3
Total	154 500	100.0	39 800	100.0	177 300	100.0	134 900	100.0	506 600	100.1
Percentage of yearly total	30.5		7.9		35.0		26.6			

* Most authors presented their data as monthly means. Here, we took the maximum mean reported for each month and calculated the overall average for each three-month period.
† Data from McKelvey *et al.* (1985); Vermeer and Levings (1977); E. McEwan, pers. commun.; G. Kaiser, unpubl. data; and this study.
‡ Spring = 1 March to 31 May; summer = 1 June to 31 August; fall = 1 September to 30 November; winter = 1 December to 28 February.

1.4. Other wildlife

In the past 100 years, human activities in the Fraser River delta have affected wildlife other than birds. Mule deer (*Odocoileus hemionus*), raccoon (*Procyon lotor*) and beaver (*Castor canadensis*) were among the mammals captured by early inhabitants (Matson 1976). The race of elk (*Cervus elaphis roosevelti*) that inhabits the coastal rain forest (Cowan and Guiguet 1965) was also an important part of the diet of early peoples in the delta for thousands of years (Matson 1976), but disappeared about 100 years ago (Cowan and Guiguet 1965). The wolf (*Canis lupus fuscus*) and cougar (*Felis concolor*) were reported in the area (Anderson 1884), but disappeared probably before 1900. The black bear (*Ursus americanus*) was abundant (Anderson 1884), but is now confined to Burns Bog, where 12 animals were believed to be present in 1971 (Kucy 1971). Large mammals that still occur in the delta include the black-tailed deer (*Odocoileus hemionus columbianus*) on land and the marine northern sea lion (*Eumetopias jubatus*), California sea lion (*Zalophus californianus*), killer whale (*Orcinus orca*) and harbour seal (*Phoca vitulina*) (App. 1).

There are records in the British Columbia Wildlife Record Scheme at the British Columbia Provincial Museum of 18 species of amphibians and reptiles in the lower Fraser River valley, including the delta (App. 2). The bullfrog (*Rana catesbiana*), green frog (*Rana clamitans*) and snapping turtle (*Chelydra serpentina*) were introduced into British Columbia; the first two species are well established, whereas the third species was last seen in 1923 near Steveston (Green and Campbell 1984; Gregory and Campbell 1984). The northern leopard frog (*Rana pipiens*) and painted turtle (*Chrysemus picta*) were probably introduced from eastern British Columbia, as the ranges are disjunct and few coastal records exist (Green and Campbell 1984; Gregory and Campbell 1984). Most amphibians are secretive animals that require fresh water to keep their skin moist. However, in spring, the pacific treefrog (*Hyla regilla*), bullfrog and green frog reveal their presence by their croaking calls. The creation of dikes may have improved the habitat for garter snakes by providing them access to the delta, places to escape enemies and hibernacula. The common garter snake (*Thamnophis sirtalis*) frequents the dikes on the Alaksen National Wildlife Area on Westham Island and is very abundant on the west end of Annacis Island (I. Robertson, pers. commun.).

2. Present bird populations

Estimates of the numbers of birds in the Fraser River delta vary from year to year (e.g., McKelvey *et al.* 1985). Tables 6 and 7 provide monthly means; the maximum number of waterfowl and gulls counted on peak days was over three times greater than the mean, so that up to 750 000 waterfowl and 180 000 gulls could use the Fraser River delta annually. The most numerous shorebird, the Western Sandpiper, migrates quickly through the delta: individuals stay only about 2 days (Butler *et al.* 1987). We estimated that about 1.2 million shorebirds use the delta annually. Shorebirds (38.3%) and ducks (37.8%) were the most abundant groups over the entire year (Table 6). The largest number of birds occurred in fall (35.0%) and spring (30.0%), and slightly more used the marine habitat (47.4%) than the estuary (40.3%) (Table 7). Estimates of the maximum number of all waterfowl species indicate that the Fraser River delta supports large numbers of Mallard, Green-winged Teal (*Anas crecca*), American Wigeon (*Anas americana*), Northern Pintail, Snow Goose, Greater Scaup (*Aythya marila*) and Lesser Scaup (*Aythya affinis*) (Table 8).

Table 7
Maximum mean* numbers of birds counted† in spring, summer, fall and winter‡ in the aquatic habitats of the Fraser River delta, rounded to the nearest thousand

Habitat	Spring	Summer	Fall	Winter	Total	%
Estuarine	63 000	14 000	68 000	59 000	204 000	40.3
Marine	75 000	21 000	89 000	55 000	240 000	47.4
Riverine	16 000	5 000	20 000	21 000	63 000	12.3
Total	154 000	40 000	177 000	135 000	507 000	100.0
%	30.5	7.9	35.0	26.6		

* Most authors presented their data as monthly means. Here, we took the maximum mean reported for each month and calculated the overall average for each three-month period.
† Data from Williams 1978; McKelvey *et al.* 1985; Savard 1985; and this study.
‡ Spring = 1 March to 31 May; summer = 1 June to 31 August; fall = 1 September to 30 November; winter = 1 December to 28 February.

2.1. Riverine

The most comprehensive study of birds in the lower Fraser River was conducted by Williams (1978) (Table 9). The highest number of birds (29 512) was seen in the week of 20–28 February, the lowest (1143) on 20 June. There were two seasonal peaks in bird abundance in the Fraser River: in February (15.5% of yearly total) and October (12.8%) (Table 9). The February peak resulted from an influx of gulls and dabbling ducks; 89% of the October peak consisted of gulls (Table 9). Gulls were also numerous in September and November, mostly because of a large influx of postbreeding Ring-billed Gulls (*Larus delawarensis*) and California Gulls (*L. californicus*) from the Canadian Prairies (Vermeer 1970; Houston 1977) and Glaucous-winged Gulls (*L. glaucescens*) from coastal British Columbia (Butler *et al.* 1980). Diving ducks, mergansers and coots peaked from January through March. Double-crested Cormorants (*Phalacrocorax auritus*) used the river year-round, but occurred in small numbers in the summer breeding season. R.W. Butler discovered about 100 nesting pairs of Double-crested Cormorants on pilings at the river mouth in 1985; they also nest on pilings between Westport and BC Ferry Terminal jetties (M. Taitt, pers. commun.).

Gulls and dabbling ducks were the most abundant groups of birds in the river in spring, summer, fall and winter (Table 9). In total, those two groups included from 71.3% (in summer) to 91.9% (in fall) of the birds counted. The populations in spring, summer, fall and winter included 64.9, 61.1, 85.1 and 61.0% gulls, and 22.2, 10.2, 6.8 and 22.0% dabbling ducks, respectively. The most abundant gulls through the entire year were Glaucous-winged (75.2%), Mew (*L. canus*) (12.6%), Herring (*L. argentatus*) [probably Thayer's Gull (*L. thayeri*)] (5.9%), California (3.6%), Bonaparte's (*L. philadelphia*) (2.2%) and Ring-billed (<1%) (Table 10). The most abundant dabbling ducks over the entire year were American Wigeon (40.4%), Mallard (32.1%), Green-winged Teal (13.9%) and Northern Pintail (10.9%) (Table 10).

2.2. Estuarine

2.2.1. Foreshore marshes

Autumn migration begins as early as late July when Mallards and Northern Pintails arrive in the Fraser River delta. However, most Mallard, Northern Pintail, American Wigeon and Green-winged Teal arrive in September and October. Surveys of waterfowl in the brackish foreshore marshes conducted from 1966 to 1974 by E.W. Taylor and

R.D. Harris showed that numbers of birds gradually increased in autumn, peaked between late October and December and decreased through April (Vermeer and Levings 1977). The same pattern was found by Williams (1978) in the Fraser River. Presumably, birds concentrated in areas closed to hunting during hunting season (October–January), after which they spread throughout the delta. The most abundant dabbling ducks were American Wigeon, Mallard, Northern Pintail and Green-winged Teal (Vermeer and Levings 1977; Savard 1985). Savard (1985) counted 39 457 ducks along the foreshore during a ground survey of Boundary Bay, Roberts Bank and Sturgeon Bank on 19 and 21 December 1977, of which 95% were those four species. Savard was unable to identify a large number of ducks far from shore and noted that his estimates were minimal counts. Vermeer and Levings (1977) reported over 60 000 ducks in November counts, and McKelvey *et al.* (1985) tabulated 75 207 ducks in November 1982.

Spring migration begins in about mid-March when Northern Shoveler (*Anas clypeata*) and Cinnamon Teal (*A. cyanoptera*) arrive, followed about one month later by Blue-winged Teal (*A. discors*) (Campbell *et al.* 1972*a*). Gadwall (*A. strepera*) began nesting in the 1960s and were first recorded on the Ladner CBC in 1965. Between 1970 and 1985, 2289 Gadwall eggs from Alberta were hatched and released at the Serpentine Fen and the Pitt River Valley, in the lower Fraser Valley. The Gadwall is now an abundant duck on the foreshore from May to July.

Summer waterfowl populations are less than 10% of the number that use the Fraser River delta at other times of year. In 1974, about 500 ducks were observed on the tidal flats during each aerial survey from May to July, of which 400 were Gadwall (Vermeer and Levings 1977). During 11 ground surveys between 7 May and 29 July 1985, R.W. Butler (unpubl. data) counted all birds in the foreshore marshes seen from a rock jetty off the northwest corner of the Alaksen National Wildlife Area. The mean number of

Table 8
Population estimates of maximum number of waterfowl by species during winter in the Fraser River delta

Species	Population estimates	Relative abundance (%)	Reference
Trumpeter Swan	125	<0.1	R. McKelvey (pers. commun.)
Tundra Swan	125	<0.1	R. McKelvey (pers. commun.)
Greater White-fronted Goose	25	<0.1	This study
Snow Goose	40 000	13.0	McKelvey *et al.* 1985
Brant (*nigricans* group)	4 500	1.5	McKelvey *et al.* 1985
Canada Goose*	100	<0.1	This study
Green-winged Teal	50 000	16.3	Vermeer and Levings 1977
Mallard	50 000	16.3	Vermeer and Levings 1977
Northern Pintail	35 000	11.4	Vermeer and Levings 1977
Northern Shoveler	100	<0.1	Campbell *et al.* 1972*a*
American Wigeon	62 000	20.2	Vermeer and Levings 1977
Canvasback	1 600	0.5	This study
Scaup†	30 000	9.8	Vermeer and Levings 1977
Oldsquaw	1 200	0.4	Vermeer and Levings 1977
Scoters‡	14 000	4.6	Savard 1985
Goldeneye§	1 600	0.5	Savard 1985
Bufflehead	5 900	1.9	Savard 1985
Merganser‖	1 000	0.2	Savard 1985
Ruddy Duck	9 200	3.0	Savard 1985
Total	306 575	100.0	

* Does not include 8000–10 000 introduced Canada Geese.
† Greater and Lesser Scaup.
‡ Black, Surf and White-winged Scoter.
§ Mostly Common Goldeneye and some Barrow's Goldeneye.
‖ Common and Red-breasted Mergansers.

Table 9
Average numbers of birds counted by month in boat surveys in the South Arm of the Fraser River from Annacis Island to Westham Island between December 1976 and December 1977 (from Williams 1978)*

	Month											
Group	Jan. (4)	Feb. (4)	Mar. (4)	Apr. (3)	May (4)	Jun. (5)	Jul. (4)	Aug. (5)	Sep. (4)	Oct. (4)	Nov. (5)	Dec. (5)
Loons	4	4	2	1	0	0	0	0	1	1	2	1
Grebes	171	275	233	326	1	1	1	<1	2	118	288	117
Cormorants	13	25	92	112	81	4	2	10	15	11	22	26
Canada Goose	17	81	23	103	73	43	60	135	151	72	8	22
Dabblers	1 648	7 139	5 397	3 257	449	189	172	728	2 420	703	393	390
Divers	603	633	676	373	90	2	<1	<1	4	16	193	233
Mergansers	153	120	206	203	34	4	7	1	17	19	30	58
Raptors	22	19	11	7	6	3	6	5	11	13	21	27
Herons	27	37	31	38	44	31	38	48	49	44	38	32
Coots	82	80	67	91	6	<1	0	<1	12	26	26	20
Shorebirds	940	2 014	74	536	155	40	298	229	270	544	1 069	459
Gulls	7 307	11 674	9 348	7 134	10 159	984	1372	4146	13 328	16 635	14 004	6436
Passerines	184	334	238	306	479	641	630	523	260	189	221	257
Others	5	5	4	568	41	72	115	103	190	199	59	5
Total	11 176	22 440	16 402	13 055	11 618	2014	2701	5928	16 730	18 590	16 374	8083
%	7.7	15.5	11.3	9.0	8.0	1.4	1.9	4.1	11.5	12.8	11.3	5.5

* Number of counts appears in parentheses below months.

Table 10
Species composition of birds counted in the South Arm of the Fraser River in 1977–78 (data from Williams 1978)

Group	%
Dabbling ducks (N = 80 069)	
American Wigeon	40.4
Mallard	32.1
Green-winged Teal	13.9
Northern Pintail	10.9
Blue-winged Teal	0.9
Gadwall	0.6
Northern Shoveler	0.5
Wood Duck	0.5
Cinnamon Teal	0.2
Diving ducks (N = 11 236)	
Greater and Lesser Scaup	41.2
Bufflehead	23.0
Common and Barrow's Goldeneye	18.2
Surf Scoter	8.9
Canvasback	5.4
Oldsquaw	2.1
Ruddy Duck	1.2
Mergansers (N = 3126)	
Red-breasted Merganser	52.0
Common Merganser	47.6
Hooded Merganser	0.4
Gulls (N = 347 118)	
Glaucous-winged Gull	75.2
Mew Gull	12.6
Herring Gull	5.9
California Gull	3.6
Bonaparte's Gull	2.2
Ring-billed Gull	0.5
Raptors (N = 512)	
Red-tailed Hawk	41.9
Northern Harrier	37.6
Bald Eagle	9.2
Rough-legged Hawk	9.2
Peregrine Falcon	0.8
Sharp-shinned Hawk	0.6
American Kestrel	0.4
Great Horned Owl	0.2

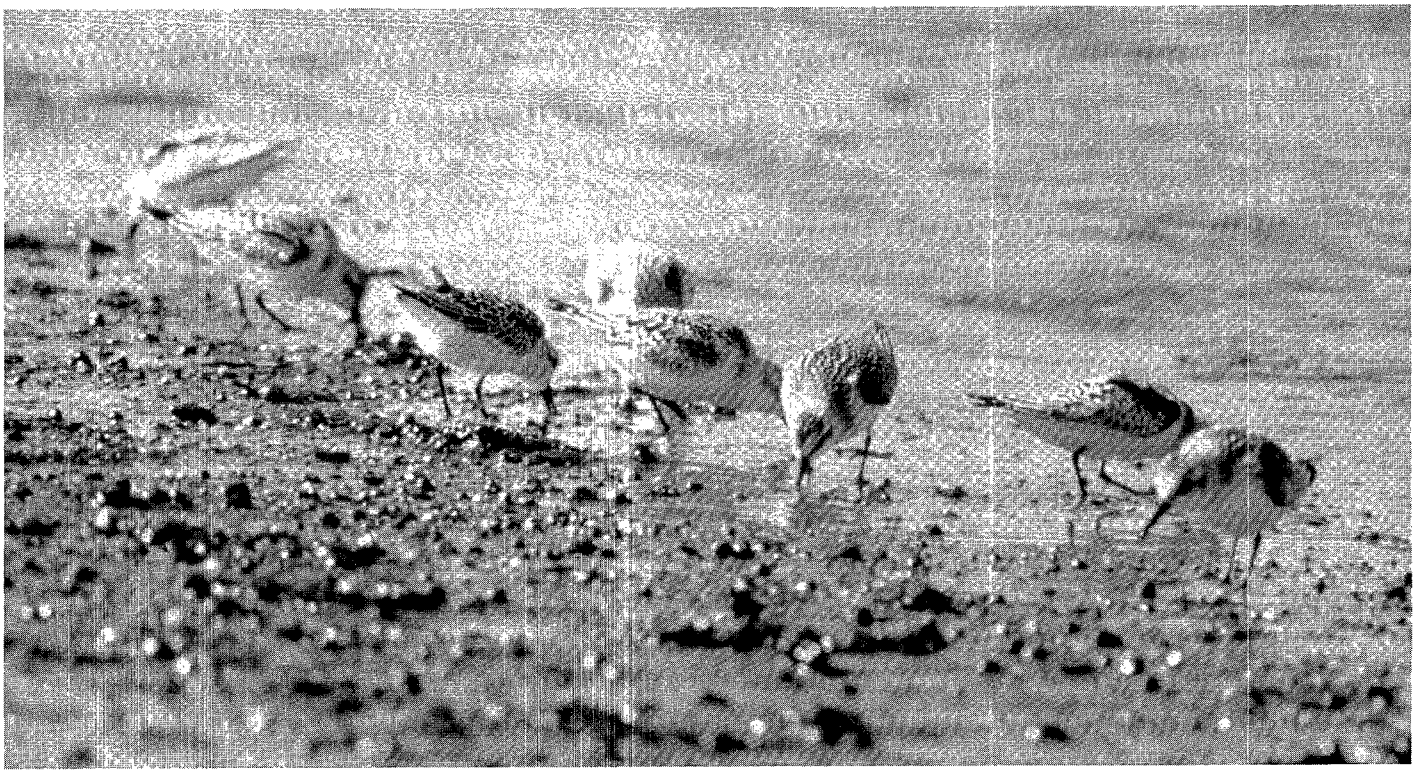
ducks counted was 143 (SD = 78). The most abundant duck was the Northern Shoveler (39.1%), followed by American Wigeon (34.4%), Mallard (9.4%), Cinnamon Teal (6.2%), Gadwall (4.7%) and Northern Pintail and Blue-winged Teal (3.1% each), based on maximum counts for each species. The surveyed area enclosed about 35 ha or about 2% of the vegetated portion of the foreshore. By assuming an even distribution of ducks throughout the foreshore marshes, we estimated that there might have been a summer population of 7150 dabbling ducks in 1985. The proportion that bred there is unknown.

2.2.2. Foreshore mud flats

Surveys of birds on the extensive mud and sand flats on Sturgeon and Roberts banks have been sporadic. Small numbers of Ring-billed and California gulls move through in spring, and thousands gather along the foreshore to moult from mid-June through October. Both of those species breed in Saskatchewan (Vermeer 1970; Houston 1977) and have recently begun to breed in British Columbia (British Columbia Nest Record Scheme). The largest number of Ring-billed Gulls on the coast away from the Fraser River delta recorded in the BC Wildlife Record Scheme at the BC Provincial Museum was 200 at Clover Point, Victoria. R.W. Butler (unpubl. data) estimated that 1000–3200 Ring-billed Gulls roosted near Deas Island in the Fraser River on 17 and 29 July and 6 August 1985. He also saw 100–300 Ring-billed Gulls near Tsawwassen and Westham and Iona islands in July 1985. The Fraser River delta appears to be the only area on the coast used by this species in summer. In contrast, California Gulls disperse over much of the south coast and are found in large numbers on the west coast of Vancouver Island (e.g., Hatler *et al.* 1978).

The Mew Gull and Glaucous-winged Gull are also abundant on the foreshore, especially in winter. The Mew

The largest populations of shorebirds on the British Columbia coast are found on mud flats and upland roosts in the Fraser River delta.



Gull uses mainly the banks and farm fields, whereas the Glaucous-winged Gull uses the entire delta.

Use of the foreshore mud flats by shorebirds is poorly documented. Flocks of thousands of small shorebirds roost at Iona Island, at the north end of Sturgeon Bank, and R.W. Butler (unpubl. data) has counted up to 5000 at southern Roberts Bank.

Great Blue Herons (*Ardea herodias*) gather from May to August near Iona Island from a nesting colony on the nearby University of British Columbia endowment lands to feed on fish stranded in tidal pools (Krebs 1974) or killed in the poorly oxygenated water near the Iona Island Sewage Treatment Plant (I. Birtwell, pers. commun.).

2.3. Marine

Boundary Bay is the most important coastal bay for shorebirds and waterfowl on the coast of British Columbia. They use three habitats: (1) the intertidal beach; (2) inshore (1–4 m water depth); and (3) offshore (>4 m).

2.3.1. Intertidal beach

The mud and sand flats are used by the largest numbers of shorebirds on the British Columbia coast. The most numerous of the 29 species frequenting the delta are the Western Sandpiper, Least Sandpiper (*Calidris minutilla*) and Dunlin. We estimated that in 1977 254 000 Western Sandpipers used Boundary Bay in spring and 585 000 in fall. Similar numbers were seen on Roberts Bank that year, suggesting that the total numbers of Western Sandpipers using the Fraser River delta might be about 500 000 birds in spring and 1.2 million in fall. Least Sandpipers migrate at the same time as Westerns and occur in a ratio of 1:10 in mist net catches, suggesting that about 25 000 Least Sandpipers migrate through the delta in spring and 58 000 in autumn. The accuracy of those estimates requires verification.

The Dunlin is the most abundant shorebird in winter. Boundary Bay is one of the most northerly wintering areas for Dunlin in North America. McEwan and Farr (1986*a*) estimated 30 000–40 000 wintering birds. Fry (1980) estimated that 109 000 birds used the bay during migration in November.

The sand and mud flats are used by large numbers of gulls and Great Blue Herons. Immature Glaucous-winged Gulls are rarely seen near breeding colonies in summer, but they are common in Boundary Bay. In winter, Glaucous-winged and Mew gulls use the beaches. Great Blue Herons nest on Point Roberts, Washington, and on the Nicomekl River a few kilometres east of Mud Bay, and feed in the eelgrass beds of Boundary Bay, Mud Bay and near the BC Ferry Terminal on Roberts Bank. Herons from another colony near the University of British Columbia feed mostly near Iona and Sea islands. In winter, Bald Eagles (*Haliaeetus leucocephalus*) and Snowy Owls (*Nyctea scandiaca*) feed on duck carcasses on the beach, and Merlin (*Falco columbarius*) and Peregrine Falcons (*Falco peregrinus*) hunt shorebirds.

2.3.2. Inshore habitats

Shallow areas of Boundary Bay are used mostly by dabbling ducks and geese. Canada Geese are most abundant from September to January, and Brant from February to April (McKelvey *et al.* 1985). Small numbers of Brant stop in the Fraser River delta during fall migration; most fly directly from Alaska to their wintering grounds in Mexico in about 45–60 h (King and Hodges 1979; Kramer *et al.* 1979). In spring, Brant feed in the eelgrass beds in Boundary Bay on their northward migration. Numbers begin to increase in February, with the peak occurring in March and April. McKelvey *et al.* (1985) recorded a mean of 1943 Brant (SE = 315.2, N = 7 surveys) in April 1982 and 1983.

Dabbling ducks gather along the tide line, moving on to the mud flats during calm weather and into Mud Bay at the east end of Boundary Bay on windy days (McKelvey *et al.* 1985). Aerial surveys in 1966–74 indicated that American Wigeon made up 19% of the ducks present, Northern Pintail 37%, Mallard 35% and Green-winged Teal 9%. The mean numbers of ducks seen in aerial surveys each month from September to April, 1982 and 1983, ranged from 1200 (April) to 38 000 (November) (McKelvey *et al.* 1985). American Wigeon was the most abundant dabbler (50%), followed by Northern Pintail (32%), Mallard (15%) and Green-winged Teal (3%) (McKelvey *et al.* 1985).

Most Greater Scaup (97%) and Bufflehead (*Bucephala albeola*) (87%) occur in water less than 2 fathoms (1.9 m) deep, and Oldsquaw (*Clangula hyemalis*) (61%) and scoters (75%) in 2–4 fathoms (1.9–3.8 m) (Savard 1985).

2.3.3. Offshore habitats

Waterbirds in deep waters off Boundary Bay are most abundant during October (McKelvey *et al.* 1985) or November (Vermeer and Levings 1977). McKelvey *et al.* (1985) estimated that the number of offshore birds present from September to April in 1982–83 and 1983–84 ranged from 27 000 to 128 000. Diving ducks were 64.8% of all birds seen in 1983, 56.4% in 1984. The most abundant divers were Greater Scaup (57.4% of all sightings), Surf Scoter (*Melanitta perspicillata*) (11.1%), Bufflehead (6.6%), Ruddy Duck (*Oxyura jamaicensis*) (4.8%), White-winged Scoter (*Melanitta fusca*) (2.3%) and Oldsquaw (1.3%) (Savard 1985). As the counts were made from the shore, offshore species such as White-winged Scoter and Oldsquaw were probably underestimated. Most Western Grebes (*Aechmophorus occidentalis*) (88%) occurred in 4–10 fathoms (3.8–19.0 m) of water. Pacific Loons (*Gavia pacifica*) were about equally abundant in 0–2 fathoms (0–1.9 m) (27%) and 2–4 fathoms (1.9–3.8 m) (31%), but most abundant (45%) in 4–10 fathoms (3.8–19.0 m) (Savard 1985).

In most years, Pacific herring (*Clupea pallasii*) spawn in Boundary Bay in March, attracting thousands of loons, grebes, ducks and gulls that gather to feast on the eggs, creating one of the greatest wildlife spectacles on the west coast of British Columbia.

2.4. Terrestrial

2.4.1. Woodlots and hedgerows

Woodland birds are defined here as all species that rely on shrubs or forests for their survival, including woodpeckers, hummingbirds, some raptors and most passerines. At the Alaksen National Wildlife Area, where birds have been well surveyed (Weber 1982*a*; Kragh 1983; Fry 1984), there are records for 101 woodland species, of which 39 (38.6%) breed and 21 (20.8%) reside. Most (61.4%) are either migrants or spend the winter on the Alaksen National Wildlife Area. Alaksen is more heavily treed than much of the Fraser River delta and its bird fauna more diverse.

The American Robin breeds in greater density than any other species of woodland birds at Alaksen. Weber (1982*a*) recorded twice as many robins as the next abundant species, the Song Sparrow (*Melospiza melodia*) (Table 11). Other abundant breeding species were the American Goldfinch (*Carduelis tristis*) (4.3 breeders per kilometre of wood-

land), Red-winged Blackbird (3.1), European Starling and House Finch (*Carpodacus mexicanus*) (2.5 each), Black-capped Chickadee (*Parus atricapillus*) (2.4), Cedar Waxwing (*Bombycilla cedrorum*) and Tree Swallow (*Tachycineta bicolor*) (1.7 each) and Brown-headed Cowbird (1.4). The paucity of breeding species is probably a result of the relatively homogeneous and linear arrangement of the woodland vegetation on the Alaksen National Wildlife Area. For example, few Swainson's Thrushes (*Catharus ustulatus*) breed at Alaksen, although they are common in nearby forests along the coast.

Less systematic work has been done on woodland birds in winter than at other times of the year. Seventy passerine species have been reported on the Ladner and White Rock CBCs since they began in 1957 and 1971, respectively. We calculated the relative abundance of the 12 commonest species (>1000 individuals seen on average on combined Ladner and White Rock CBCs). They were the European Starling (54%), Northwestern Crow (12%), Brewer's Blackbird (9%), Dark-eyed Junco (5%), American Robin (4%), House Finch (3%), Pine Siskin (*Carduelis pinus*) (3%), House Sparrow (*Passer domesticus*) and Song Sparrow (2% each), Black-capped Chickadee (2%), Red-winged Blackbird (2%) and Golden-crowned Kinglet (*Regulus satrapa*) (2%) (N = 110 134 birds counted). All, except the Dark-eyed Junco, breed locally (Table 11). The mild climate is reflected in the number of reports of species that normally vacate the rest of Canada in winter. Among the warblers, the Yellow-rumped (*Dendroica coronata*) has been seen most often (13 counts), followed by Orange-crowned (*Vermivora celata*) (5 times), Wilson's (*Wilsonia pusilla*) (twice) and Townsend's (*Dendroica townsendi*), Common Yellowthroat (*Geothypis trichas*) and Northern Waterthrush (*Seiurus noveboracensis*) (once each). There are also reports of Barn Swallows (*Hirundo rustica*) (two counts), Hermit Thrush (*Catharus guttatus*) (9 counts) and Swainson's Thrush and Townsend's Solitaire (*Myadestes townsendi*) (one count each). About 75% (31 of 41 species) of the species that occur regularly (more than once every three CBCs) on these two CBCs nest in the Fraser River delta. This suggests that the delta supports some species, such as the American Robin, with both migratory and resident populations (Smith 1986).

Migration of woodland birds begins in the last week of February, when Tree and Violet-green (*Tachycineta thalassina*) swallows enter the delta, and ends over three months later in early June, when Common Nighthawks (*Chordeiles minor*) arrive. However, there are several "waves" of arriving species of birds. The Varied Thrush (*Ixoreus naevius*), Dark-eyed Junco and Golden-crowned and Ruby-crowned (*Regulus calendula*) kinglets depart in early April, followed one week later by the arrival of Barn and Cliff (*Hirundo pyrrhonota*) swallows. The largest wave of migrants occurs in the last week of April and first week of May, and includes the Yellow-rumped, Orange-crowned, Yellow (*Dendroica petechia*) and Black-throated Gray (*D. nigrescens*) warblers, Golden-crowned (*Zonotrichia atricapilla*) and White-crowned (*Z. leucophrys*) sparrows, Hermit Thrush, Hammond's (*Empidonax hammondii*) and Western (*E. difficilis*) flycatchers, Western Wood-Pewee (*Conotopus sordidulus*) and Lincoln's Sparrow (*Melospiza lincolnii*). Straggling species arrive in the next week: Warbling Vireo (*Vireo gilvus*) (mid-May), Swainson's Thrush, Cedar Waxwing, Western Tanager (*Piranga ludoviciana*) and Black-headed Grosbeak (*Pheucticus melanocephalus*) (late May). The Yellow-rumped Warbler outnumbers any other species nearly fivefold (Table 12). The ratio of *Dendroica coronata auduboni* to *D. c. coronota* was 2:1 (Weber 1982*a*), similar to

Table 11
Number of breeding woodland birds per kilometre on the Alaksen National Wildlife Area in 1982 (adapted from Weber 1982a)

Species	No. of breeders/km
American Robin	12.8
Song Sparrow	6.4
American Goldfinch	4.3
House Finch	2.5
European Starling	2.5
Black-capped Chickadee	2.4
Tree Swallow	1.7
Cedar Waxwing	1.7
Ring-necked Pheasant	1.5
Brown-headed Cowbird	1.4
Western Flycatcher	1.1
Bewick's Wren	1.1
Pine Siskin	1.1
Bushtit	0.7
Wood Duck	0.6
Black-headed Grosbeak	0.4
Mourning Dove	0.3
Rufous Hummingbird	0.3
Warbling Vireo	0.3
Yellow Warbler	0.3
Yellow-rumped Warbler	0.3
Cooper's Hawk	+*
Red-tailed Hawk	+
Bald Eagle	+
Common Flicker	+
Northwestern Crow	+
House Sparrow	+
Northern Oriole	+
Downy Woodpecker	+

* + = present in small (<0.3/km) numbers.

Table 12
Number of spring migrant songbirds from 29 counts in woodlands between 27 April and 28 May 1982 on the Alaksen National Wildlife Area (adapted from Weber 1982*a*)

	No. of birds		
Species	Total counted	Mean/count	Mean/km
Yellow-rumped Warbler*	418*	9.08*	15.39*
Wilson's Warbler	89	1.93	3.28
Golden-crowned Sparrow	84	1.83	3.09
Orange-crowned Warbler	51	1.11	1.88
Hermit Thrush	38	0.83	1.40
Yellow Warbler	21	0.46	0.77
Ruby-crowned Kinglet	21	0.46	0.77
Varied Thrush	19	0.41	0.70
Warbling Vireo	17	0.37	0.63
Cedar Waxwing	17	0.37	0.63
Dark-eyed Junco	17	0.30	0.52
Fox Sparrow	13	0.28	0.48
White-crowned Sparrow	13	0.28	0.48
Swainson's Thrush	10	0.22	0.37
Black-headed Grosbeak	10	0.22	0.37
Western Wood-Pewee	8	0.17	0.29
Lincoln's Sparrow	7	0.15	0.26
Black-throated Gray Warbler	6	0.13	0.22
Townsend's Warbler	5	0.11	0.18
Western Flycatcher	4	0.09	0.15
Golden-crowned Kinglet	3	0.07	0.11
MacGillivray's Warbler	3	0.07	0.11
Western Tanager	2	0.04	0.07
Purple Finch	2	0.04	0.07
Hammond's Flycatcher	1	0.02	0.04
Red-breasted Nuthatch	1	0.02	0.04
Common Yellowthroat	1	0.02	0.04
Northern Oriole	1	0.02	0.04
Olive-sided Flycatcher	1	0.02	0.04
Total	88	19.15	32.42

* 63.9% of the Yellow-rumped Warblers were "Audubon's Warbler" (*Dendroica coronata auduboni*) and 36.1% were "Myrtle Warblers" (*D. c. coronata*).

that at other west-coast locations. Less than half (14 of 30; Table 11) of the spring migrant species breed in the delta.

Migration is briefer in fall than in spring, spanning about nine weeks. The pattern is in general a mirror image of spring migration: the species depart in the same order that they arrived. Violet-green Swallows leave by early August, followed by Tree Swallows a week later. Most warblers migrate through Alaksen from 7 to 30 September. Winter species, such as the Varied Thrush, Dark-eyed Junco and Ruby-crowned Kinglet, return in mid-October. An exception to the pattern of orderly arrival and departure by species is the Barn Swallow — many adults and recently fledged young remain in the delta until late October and have been reported twice on the Ladner CBCs.

Tall trees provide nest sites for Bald Eagles, Red-tailed Hawks (*Buteo jamaicensis*), Great Blue Herons and Great Horned Owls (*Bubo virginianus*). Three Bald Eagle nests in the Fraser River delta are built in large cottonwoods along the river's edge at Alaksen, on Annacis Island and near the Serpentine River. Red-tailed Hawks in the delta nest in tall deciduous trees, mostly around agricultural areas in the east end of Richmond Municipality (C. Runyan, pers. commun.) and on the Alaksen National Wildlife Area. Great Blue Herons nest in colonies in more concealed locations than the first two species, but also require tall trees. Most large trees were removed when the delta was cleared, so that now there are few woodpeckers, hole-nesting ducks or owls. The diminutive Downy Woodpecker (*Picoides pubescens*) and ground-foraging Northern Flicker (*Colaptes auratus*) are the only widespread woodpeckers.

2.4.2. Fields

Comparatively little attention has been paid to bird communities in fields in the delta. Weber (1982*a*) surveyed birds in three fields on the Alaksen National Wildlife Area (Fig. 1) on 12 and 18 May and 3 June 1982. One field was cropped by cattle and contained large amounts of *Juncus effusus*. A second field was planted in clovers (*Trifolium* spp.) and was mowed during the study. The third field was horse-grazed pasture. Nine species of birds used those fields: (in order of abundance) the European Starling, Canada Goose, American Robin, Savannah Sparrow (*Passerculus sandwichensis*), Water Pipit (*Anthus spinoletta*), Brown-headed Cowbird, Ring-necked Pheasant, Marsh Wren (*Cistothorus palustris*) and Red-winged Blackbird. The presence of many of those species was a result of particular field conditions (e.g., Marsh Wrens in *Juncus effusus*), the presence of nearby vegetation (e.g., Ring-necked Pheasants near hedgerows) and probably the protection afforded by the Alaksen National Wildlife Area (e.g., Canada Goose is a resident). Conditions on other fields in the Fraser River delta are often very different. Cultivated fields *per se* probably support fewer species.

Fry (1984) surveyed birds in six fields at Alaksen in March and April. Three fields were pastures grazed by livestock the previous summer, and the remaining three fields contained a mixture of unharvested faba beans (*Vicia faba*), potatoes and fallow land. With few exceptions, Fry found the maximum number of birds in fields during high (>3.0 m) tides. Mean densities of waterfowl in the six fields ranged from 0 to 527 birds per 50 ha. Pastures were used more often than other fields, perhaps because they contained puddles. The Canada Goose, Mallard and American Wigeon were most common, but Green-winged Teal, Gadwall, Northern Shoveler, Northern Pintail, Cinnamon Teal, Greater White-fronted Goose (*Anser albifrons*) and Snow Goose were also recorded. Among the shorebirds, Fry (1980) recorded Greater Yellowlegs (*Tringa melanoleuca*), Killdeer (*Charadrius vociferus*), Western Sandpiper and Dunlin. Passerines included the Water Pipit (300 birds on one field), European Starling (150 on one field), American Robin (25 on one field) and Savannah Sparrow (9 on one field).

Jury (1981) found that about 4000–5000 ducks, mostly Mallard, Northern Pintail and American Wigeon, used agricultural fields in the delta by day during the hunting season; 20 000–25 000 used them after the season closed in mid-February. The greatest use occurred at night, when as many as 50 000 ducks fed in cultivated fields. Fields in Surrey received more use than those in the delta, with those in Richmond being used least. Jury also found that ducks tended to return to the same field each night. Hirst and Easthope (1981) noted that American Wigeon, Northern Pintail and Mallard using agricultural fields preferred heavily flooded fields. American Wigeon preferred pastures and potato fields, Northern Pintail selected pastures only and Mallards showed no preference for field type. More ducks used fields under rainy, windy conditions than in dry, calm weather.

In winter, birds of prey are diverse and abundant in the Fraser River delta. The Vancouver Natural History Society conducted raptor counts in fields in 1971–72 (Campbell *et al.* 1972*b*; Douglas 1984). More (71.6% of 1266 birds) raptors were seen in winter (November–February) than in the rest of the year, most in December (344 birds) and fewest in June (31 birds). When the data are standardized by dividing the number of raptors counted by the effort spent searching for raptors (i.e., the number of party-days), a similar proportion results: 31.3 in December and 5.2 in August. The most abundant raptor in winter (November–February) was the Northern Harrier (*Circus cyaneus*) (5.7 birds per party-day), followed by Red-tailed Hawk, Short-eared Owl (*Asio flammeus*) (2.9 birds per party-day) and Rough-legged Hawk (*Buteo lagopus*) (1.1 birds per party-day). Fifteen other species were recorded less than once per party-day.

Between January 1964 and May 1967, the late William M. Hughes banded 383 Short-eared Owls in the Fraser River delta. Today, far fewer Short-eared Owls occur in the Fraser River delta, presumably because of the shortage of old-field habitats. They were most often seen in February, when 77 were counted by nine parties (8.5 owls per party) (Campbell *et al.* 1972*b*). Hughes captured three Burrowing Owls (*Athene cunicularia*). The last breeding pair in the delta was in Richmond in 1976. The Ring-necked Pheasant, Ruffed Grouse (*Bonasa umbellus*) and California Quail (*Callipepla californica*) are the only resident gallinaceous birds in the Fraser River delta. The pheasant was first introduced in 1891 by private citizens (Taylor 1950). Pheasants are now widespread in agricultural areas of the delta, but have apparently declined in number as farming practices have reduced blackberry tangles on the perimeter of fields. Grouse (presumably *Bonasa umbellus*) were widespread a century ago (Anderson 1884), but occur only in remnant woodlots today. California Quail were released into the Fraser River delta in the 1890s (Carl and Guiguet 1972) and became very abundant in and along farm fields and on dikes. Today, many hedgerows have disappeared and only small numbers of quail remain at Point Roberts, Washington, some of which stray on to Westham Island.

3. Annotated list of the birds of the Fraser River delta

This list includes 310 species recorded in the Fraser River delta in historic times.

3.1. Treatment, terms and references

The common and scientific names of each species follow the American Ornithologists' Union (1983) checklist and later supplements (Munroe 1985) except for Snow Goose.[1] Records of species outside their normal range without an accurate written description, photograph or specimen were omitted. Information came mainly from the British Columbia Wildlife Record Files, including the BC Photoduplicate File (Campbell and Stirling 1971) at the BC Provincial Museum, the published scientific literature and CWS files. We used annual Christmas Bird Counts (CBCs) published in the National Audubon Society's journal *American Birds* from Ladner (1957–84, except 1966 and 1967) and White Rock (1971–84). Most of the area included in the White Rock CBC survey and all of the Ladner CBC survey area fall within the boundaries of the Fraser River delta. We have provided accounts of 220 species that occur annually (frequency very abundant to rare) and appended a list of 92 species occurring irregularly (very rare to accidental) with the seasons for which records exist (App. 3) up to 31 December 1986. We used the frequency standards shown below, which apply to the appropriate season and habitat in which each species occurs (Campbell *et al.* 1987*c*). We recommend that others adopt the same format for consistency.

Terms

Early	The first 10 days of a given month (e.g., 1–10 May)
Mid	The second 10 days of a given month (e.g., 11–20 May)
Late	The last 10 (or 8–11) days of a given month (e.g., 21–28 February, 21–31 May)

Frequency

Regular occurrence

Very abundant	Over 1000 individuals per day per locality (often in large flocks)
Abundant	200–1000 individuals per day per locality
Very common	50–199 individuals per day per locality
Common	20–49 individuals per day per locality
Fairly common	7–19 individuals per day per locality
Uncommon	1–6 individuals per day per locality
Rare	1–6 individuals per season

Infrequent occurrence

Very rare	Over 6 records, but of very infrequent occurrence
Casual	Only 2–6 records yet noted
Accidental	Only 1 record
Introduced	Released to the wild

Abbreviations

ANWA	Alaksen National Wildlife Area
BCPM	British Columbia Provincial Museum, Victoria
BCPM Photo	British Columbia Photoduplicate File, British Columbia Provincial Museum, Victoria (Campbell and Stirling 1971)
BCWRS	British Columbia Wildlife Record Scheme housed at BCPM
GRMBS	George C. Reifel Migratory Bird Sanctuary
ROM	Royal Ontario Museum, Toronto
UBC	Cowan Vertebrate Museum, University of British Columbia, Vancouver

3.2. The birds

GAVIIDAE: Loons

Red-throated Loon (*Gavia stellata*)

Rare summer; *fairly common* winter.

Occurrence: The Red-throated Loon prefers the lower reaches of the Fraser River. Flocks of up to 100 are seen in migration; rarely more than 20 birds are seen together in winter. Most depart by mid-April and return in mid- to late September, building in numbers through October and early November. Christmas counts: Ladner — maximum 140 in 1973, average 44; White Rock — maximum 241 in 1973, average 44.

Pacific Loon (*Gavia pacifica*)

Rare summer; *uncommon* winter.

Occurrence: The Pacific Loon is most often seen off Tsawwassen jetty. It is rarely seen in flocks of more than 100 birds in migration. Spring migration takes place mostly in April; in some years a buildup occurs in March. Thousands gather in Boundary Bay when herring spawn there in March. Autumn movement is evident from September to November. Christmas counts: Ladner — maximum 197 in 1983, average 38; White Rock — maximum 174 in 1980, average 19.

Common Loon (*Gavia immer*)

Uncommon summer; *fairly common* winter.

Occurrence: The most visible loon throughout the year, the Common Loon is widely distributed in small numbers. It is most often seen in deep water near Point Roberts and Boundary Bay. Spring migration is most evident during the first half of April, autumn movement from mid-September to mid-October. Christmas counts: Ladner — maximum 119 in 1980, average 52; White Rock — maximum 87 in 1979, average 47.

Yellow-billed Loon (*Gavia adamsii*)

Very rare summer; *rare* winter.

Occurrence: This large loon has been a regular winter visitor during the past two decades along the west coast of North America to California (Remsen and Binford 1975). It is most common in the northern areas, especially British Columbia. The Yellow-billed Loon arrives in October and usually departs by April. It prefers more saline waters. Christmas counts: Ladner — 1 on six counts from 1963 to 1983; White Rock — 1 on four counts from 1973 to 1977.

[1] We followed the nomenclature of Bellrose (1976) and Palmer (1962), who include the Snow Goose in the genus *Anser*.

PODICIPEDIDAE: Grebes

Pied-billed Grebe (*Podilymbus podiceps*)
Uncommon summer; *fairly common* winter. Breeds.
Occurrence: The Pied-billed Grebe frequents open freshwater and marine habitats, rarely in flocks, but widespread. Its migration periods are not well defined. Spring movement probably occurs in March, autumn movement mainly in September. Christmas counts: Ladner — maximum 101 in 1978, average 9; White Rock — maximum 6 in 1981, average 2.
Breeding habits: Small numbers breed in freshwater and brackish marshes with emergent vegetation at GRMBS and ANWA, and occasionally on Iona Island sewage lagoons. Egg-laying occurs from late April through June; young appear mostly from late June through July.

Horned Grebe (*Podiceps auritus*)
Uncommon summer; *common* to *very common* winter.
Occurrence: The Horned Grebe frequents nearshore areas, including Boundary Bay and Nicomekl and Serpentine rivers. Spring migration occurs mostly in April; most birds depart by mid-May. In autumn the first influx is evident by mid-September and in some years carries on into early November. Christmas counts: Ladner — maximum 293 in 1980, average 97; White Rock — maximum 458 in 1974, average 93.

Red-necked Grebe (*Podiceps grisegena*)
Uncommon summer; *fairly common* winter.
Occurrence: The Red-necked Grebe is widely distributed in marine and riverine habitats in winter. Spring departure occurs mostly in late April and early May; by mid-May few birds remain. Large numbers are present in Boundary Bay in August (J.-P. Savard, pers. commun.). In autumn birds are numerous by mid-September, with some migratory movement occurring until late October. Christmas counts: Ladner — maximum 227 in 1974, average 24; White Rock — maximum 73 in 1980, average 23.

Eared Grebe (*Podiceps nigricollis*)
Very rare summer; *uncommon* winter.
Occurrence: Usually single birds are present in Boundary Bay. Most wintering birds depart by late April; first autumn migrants appear the third week in September, in some years a month later. Christmas counts: Ladner — maximum 8 in 1965, average 1; White Rock — maximum 11 in 1980, average 3.

Western Grebe (*Aechmophorus occidentalis*)
Fairly common summer; *very abundant* winter.
Occurrence: The most numerous and widely distributed grebe, the Western Grebe is often found in large, tight flocks. Winter concentrations are the largest in Canada. Aggregations are local and may shift from year to year, depending on weather, disturbance and food. Marine waters off Point Grey (just north of the study area), the Fraser River and Boundary Bay are favourite wintering areas. Christmas counts: Ladner — maximum 1067 in 1970, average 402; White Rock — maximum 380 in 1974, average 71.

PHALACROCORACIDAE: Cormorants

Double-crested Cormorant (*Phalacrocorax auritus*)
Common resident. Breeds.
Occurrence: Most abundant in Boundary Bay, Point Roberts and Tsawwassen in winter. During aerial surveys on 12 and 27 November, 10 December 1986 and 6 January 1987, 91% of 530 counted (mean 132, SE = 16.2) were marine and only 12 (9%) estuarine. Christmas counts: Ladner — maximum 336 in 1984, average 153; White Rock — maximum 101 in 1981, average 45.
Breeding habits: About 100 pairs nested on pilings and beacons near Sand Heads Lighthouse on the Main Arm in 1985, and about 30 pairs between Roberts Bank and Tsawwassen jetty in 1986. Numbers are probably increased by postbreeding dispersal of birds from Christie Islet, north of the study area (Campbell *et al.* 1972*a*, 1974).

Brandt's Cormorant (*Phalacrocorax penicillatus*)
Uncommon winter.
Occurrence: The Brandt's Cormorant is present in small numbers from late September through April, and most evident in November. Large concentrations (100+) are rare. Christmas counts: Ladner — maximum 336 in 1960, average 24; White Rock — maximum 2 in 1979, average 1.

Pelagic Cormorant (*Phalacrocorax pelagicus*)
Fairly common resident.
Occurrence: The Pelagic Cormorant is widely distributed in deep clear waters, such as near Point Roberts and White Rock. It tends to avoid the mouth of the Fraser River. Nearest breeding colonies are to the north of the delta at Prospect Point (64 pairs) and Passage Island (72 pairs) (Vermeer and Rankin 1984). This is the least gregarious cormorant and is rarely seen in flocks of over 10 birds. Christmas counts: Ladner — maximum 81 in 1961, average 32; White Rock — maximum 49 in 1977, average 18.

ARDEIDAE: Bitterns and Herons

American Bittern (*Botaurus lentiginosus*)
Uncommon resident. Breeds.
Occurrence: The American Bittern frequents brackish marshes along Westham and Lulu islands. Flocks of over six birds are unusual. Christmas counts: Ladner — maximum 9 in 1984, average 2; White Rock — 1 in 1980 and 1983.
Breeding habits: The American Bittern nests in cattail (*Typha* sp.) marshes along the Fraser River foreshore. Egg-laying occurs from late April through May; young appear in June and July.

Great Blue Heron (*Ardea herodias*)
Common resident. Breeds.
Occurrence: The Great Blue Heron is widely distributed and uses both aquatic and terrestrial habitats. In summer, large numbers feed in eelgrass beds near the Tsawwassen Ferry Terminal jetty and in Boundary Bay, and on mud flats near Iona Island. In winter they spread out over the delta; flocks of 40 are frequently seen, and recent surveys suggest that as many as 300 herons use the foreshore marshes in winter. Christmas counts: Ladner — maximum 251 in 1981, average 124; White Rock — maximum 132 in 1974, average 76.

Breeding habits: The Great Blue Heron breeds singly (e.g., on Lulu Island) or in colonies, some of over 200 pairs. Colonies in the delta include Sea Island (4 nests), Point Roberts (220 nests) (Forbes *et al.* 1985*a*), Nicomekl River north (22 nests) and Nicomekl River south (29 nests). Egg-laying occurs from early April to mid-May; young can be found from early May to mid-July. In the Nicomekl south colony in 1986 the mean clutch was 4.4 eggs (SD = 0.7, N = 14) and 2.1 young (SD = 0.8) fledged per nest (N = 15). Forbes *et al.* (1985*b*) reported a mean of 2.5 young per successful nest (SE = 0.1, N = 917) for southwestern British Columbia.

Remarks: Herons are near the northern edge of their range in the Fraser River delta, and long periods of cold weather with snow cover appear to stress them. Human activities apply extra potential threats in the form of toxic substances in the food chain, shortage of suitable nest sites and destruction of old-field feeding habitats.

Krebs (1974), who studied herons near Iona Island, found that fish caught in seine nets where herons fed included staghorn sculpins (*Leptocottus armatus*: 37.6%) and starry flounder (*Platichthys stellatus*: 28.3%). In winter, herons feed on Townsend's voles (*Microtus townsendii*) in neighbouring old fields during the day (Taitt and Krebs 1983), to supplement food caught on beaches during low tides at night.

Cattle Egret (*Bubulcus ibis*)

Casual spring; *rare* winter.

Occurrence: First reported in British Columbia in 1970 (Campbell and Weber 1977), this species has become an annual visitor in late autumn to late winter (4 November to 12 February) and more recently in spring (Kragh 1982). The largest number reported was 10 on Westham Island on 8 November 1980. Christmas counts: Ladner — 3 in 1979; White Rock — 1 in 1974.

Green-backed Heron (*Butorides striatus*)

Uncommon summer; *rare* winter. Breeds.

Occurrence: First recorded in British Columbia in October 1953 at Chilliwack in the upper Fraser River valley (Wells 1954), the Green-backed Heron slowly became established during the next decade and extended its range westward. It reached the Fraser River delta in 1965 (Campbell 1972*a*) and today is frequently seen along sloughs, irrigation ditches and quiet stretches of rivers. Christmas counts: Ladner — 1 in 1968 and 1979; White Rock — not recorded.

Breeding habits: One confirmed record: a nest with four eggs found in bushes bordering a slough in ANWA on 14 June 1979.

Black-crowned Night-Heron (*Nycticorax nycticorax*)

Rare summer; *very rare* winter. Breeds.

Occurrence: The Black-crowned Night-Heron is most often seen along shores of wooded sloughs at GRMBS and ANWA. It has been recorded mainly from April through July. Christmas counts: Ladner — 1 in 1983 and 1984; White Rock — not recorded.

Breeding habits: The Black-crowned Night-Heron nests in dense shrub areas along back sloughs. Fledged young are seen in July. The only nest yet discovered in ANWA had three eggs on 24 May 1978.

The largest colonies of Great Blue Herons in British Columbia are found in woodlots in the Fraser River delta.

ANATIDAE: Swans, Geese and Ducks

Tundra Swan (*Cygnus columbianus*)

Fairly common winter.

Occurrence: Small numbers frequent the immediate foreshore areas such as Brunswick Point, including mud flats and marshes; it is occasionally found in fields and along rivers. Flocks are rarely larger than 20 birds. Most wintering birds depart by mid- to late April and return in mid- to late October. Christmas counts: Ladner — maximum 88 in 1978, average 21; White Rock — 1 in 1980.

Trumpeter Swan (*Cygnus buccinator*)

Common winter.

Occurrence: The Trumpeter Swan frequents foreshore marshes and fields, especially near Brunswick Point. Numbers vary from year to year; rarely are groups larger than 75 found. It often associates with Tundra Swans. Most depart by mid-April and begin returning in mid-October, with numbers building up through November. Christmas counts: Ladner — maximum 132 in 1984, average 16; White Rock — 1 in 1981.

Remarks: The Trumpeter Swan is a "threatened" species in Canada (Cook and Muir 1984), although numbers are increasing in winter in British Columbia, especially on Vancouver Island.

Greater White-fronted Goose (*Anser albifrons*)

Very rare summer; *uncommon* migrant; *rare* winter.

Occurrence: The Greater White-fronted Goose is most often seen in small numbers associating with Canada Goose. Most migrants bypass the study area using a more coastal route to the west. Spring movement occurs mainly in April, fall movement mainly in October. During some years, in unseasonable weather, flocks of hundreds can be heard passing overhead, mostly at night. Christmas counts: Ladner — maximum 12 in 1976, average 1; White Rock — 3 in 1974.

Snow Goose (*Anser caerulescens*)

Very abundant fall, winter and spring; *rare* summer.

Occurrence: The Snow Goose arrives in the Fraser River delta in October. A collared male seen at the ANWA in 1985 originated from a small colony of 250 pairs in Prudhoe Bay, Alaska, but most of the migrants and winter visitors probably breed on Wrangel Island, USSR. Numbers peak in November (maximum 40 000 in 1985) and decline through January and early February; a second peak occurs in March during the northward migration. Flocks move between the Fraser River delta and Skagit River in Washington State, where mid-winter (January) counts in 1948–78 averaged 21 461 geese (Jeffrey and Kaiser 1979). Blue morphs have been reported in the past (Noble 1972), but are believed to be part of a flock released at GRMBS in the early 1970s (A. Barnard, pers. commun.). Christmas counts: Ladner — maximum 15 101 in 1978, average 3669; White Rock — maximum 259 in 1984, average 24.

Remarks: The winter feeding ecology of the Snow Goose was studied by Burton (1977) in the foreshore marshes. He found that the geese selected mostly below-ground rhizomes of *Scirpus americanus* and *S. paludosus*. The quantity of rhizomes in different parts of the marsh ranged from 30.2 g/m^2 on Westham Island to 77.3 g/m^2 on Lulu Island. The mean crude protein and fibre contents varied between sites. In addition to variations in food supplies, hunting, predator avoidance and social interactions determined the movements of the geese. Snow Geese fed for an average of 29% of their time, both day and night. Each Snow Goose required an average of 294 g of rhizomes per day to provide the 420 kcal of energy needed in winter. Using those facts, Burton (1977) determined that the most important feeding areas for Snow Geese were, in descending order of importance, Brunswick Point, Lulu Island, Westham Island and Sea Island. Since 1981, the Snow Goose has regularly fed in fields in the Fraser River delta. In 1981, most field-feeding occurred in early spring, but, by 1983, feeding occurred in fall, winter and spring. The change in feeding behaviour is probably a result of increased populations reported by Jeffrey and Kaiser (1979).

Brant (*Branta bernicla*)

Very rare summer; *very common* spring migrant; now *uncommon* winter.

Occurrence: The Brant frequents tidal areas and beaches of Boundary Bay, Tsawwassen jetty and Roberts Bank, using those areas most heavily during spring migration. Brant wintering in Baja California (Mexico) begin moving northward in January (Moffitt 1939; Densen and Murrell 1962), with peak numbers occurring in California in the third week of March (Kramer *et al.* 1979). Spring concentrations in our study area occur as early as mid-February (Campbell *et al.* 1972*a*), but most birds arrive about a month later. The peak occurs during the first half of April; by early May most birds have departed. E.W. Taylor (pers. commun.) estimated that up to 50 000 Brant pass through the area each spring.

Remarks: Small numbers of Brant remain infrequently in Boundary Bay during the summer and moult (Barnard 1973).

The southward autumn movement (from Alaska) is rapid, generally offshore and direct to wintering grounds in Mexico (Hansen and Nelson 1957; Jones 1973). The main movement occurs in early November, with a minimum flight time of 45 h. Small numbers seen in the Fraser River delta are probably stragglers from the exodus.

During the past 50 years or so, the small population of Brant wintering in the Fraser River delta (formerly 600+ birds) has declined following a general trend along the Pacific coast of the United States (Kramer *et al.* 1979). Densen (1964) and Chattin (1970) attributed the decline to human disturbance, but noted that it coincided with an increase in wintering populations in western Mexico.

The decline in British Columbia is best shown from results of Ladner CBCs: 1960 — 600 birds, maximum recorded for province; 1962 — 83; 1970 — 37; 1982 — 29; long-term average 73. White Rock — maximum 33 in 1971, average 5.

Canada Goose (*Branta canadensis*)

Common resident. Breeds.

Occurrence: Dusky Canada Geese (*B. c. occidentalis*) migrate between their wintering area in the Willamette Valley, Oregon, and Alaska. Some may stop in the Fraser River delta, where a few Cackling Canada Geese (*B. c. minima*) occur in migration. They are now greatly outnumbered by resident geese resulting from introductions from the Canadian Prairies and Ontario. There were 8000–10 000 resident Canada Geese in the Fraser Valley west of Hope in 1984 (D. Wilson, pers. commun.). Christmas counts: Ladner — maximum 1731 in 1980, average 397; White Rock — maximum 1454 in 1982, average 442.

Breeding habits: Eggs can be found from early March through mid-May, mostly in early to mid-April (Dawe and Davies 1975). Young are seen in early May through mid-June, mostly in early to mid-May. Vermeer and Davies (1978) reported a mean clutch size of 6.21 ± 0.27 eggs in 1976 (N = 76); 89.7% of clutches hatched at least one egg.

Twenty-four Canada Geese were released on Westham Island in 1967, followed by 41 in the subsequent 5 years. In 1973, 56 pairs nested at Westham Island on islands, sloughs and peninsulas. Today, the Canada Goose population has taken on pest proportions in the lower Fraser Valley. Canada Geese also nest in city parks and gardens in Vancouver.

Remarks: After moulting, flocks of several hundred Canada Geese fly into recently harvested bean, pea and corn fields for the day and return to parks to roost in the evening. The dramatic increase of over 130-fold in 18 years underlines the potential for an introduced species (subspecies, in this case) to multiply when released into a suitable new environment.

Wood Duck (*Aix sponsa*)

Uncommon resident. Breeds.

Occurrence: The Wood Duck prefers freshwater habitats, including sloughs in ANWA and GRMBS, ditches and sewage lagoons; it avoids marine waters. A small influx of spring migrants occurs during the latter half of March. Autumn migrants arrive in September and increase in numbers throughout October and November. The winter population, the largest in the year, is probably less than 100 birds. Centres of abundance are the Serpentine and Nicomekl rivers, Ladner and ANWA. Wood Ducks were very rare around the Fraser River delta prior to the late 1960s, when the Vancouver Natural History Society initiated a nest box program. Much of the population is resident, especially at favourite feeding areas (e.g., Stanley Park, Burnaby Lake, Pitt Meadows), although there are autumn band returns of BC birds from Oregon. Christmas counts: Ladner — maximum 56 in 1972, average 10; White Rock — maximum 80 in 1978, average 10.

Breeding habits: All breeding records are from nest boxes erected throughout the area along sloughs, rivers and sewage lagoons commencing in 1965.

At GRMBS in 1970, 62 nest boxes were erected then checked, and 41 (66%) were occupied by European Starlings, 9 (15%) by both European Starlings and Wood Ducks and 5 (8%) by Wood Ducks only; 7 remained unoccupied (Campbell *et al.* 1972*a*). Egg-laying commenced in early April and peaked in early May. First broods were noticed on 16 May. The latest date for young to leave the nest box was 12 July.

Green-winged Teal (*Anas crecca carolinensis*)

Uncommon summer; *very abundant* winter. Breeds.

Occurrence: The Green-winged Teal is the second most numerous species of wintering waterfowl, along with Mallard (Table 8), frequenting mud flats, shallow marshes and flooded fields through the delta.

Spring migration occurs in March and April; flocks are rarely larger than 100 birds, and passage is rapid. The summer population is probably less than 100 birds. Autumn migration commences in September, builds in October and peaks in November, when the Green-winged Teal can be among the most numerous of the dabbling ducks (Campbell *et al.* 1972*a*). Boundary Bay, Brunswick Point and Westham Island are areas of heaviest use during migration.

The winter population in the Fraser River delta has been estimated at 50 000 birds (Table 8). Most teal are found in the vicinity of Sturgeon and Roberts banks and Boundary Bay. Christmas counts: Ladner — maximum 4920 in 1974, average 1599; White Rock — maximum 8843 in 1981, average 1208.

Breeding habits: There are only six breeding records: four from upland fields, two from banks of sewage lagoons. The earliest nest (six eggs) was located on 30 May, the latest (eight eggs) on 19 June. All records were from coastal areas close to water.

Remarks: Burgess (1970) listed 19 food items of importance to Green-winged Teal in the delta. Seven were found in tidal marshes; *Scirpus americanus, S. validus* and *Carex lyngbyei* were the most important. Of 12 items from agricultural areas, only *Polygonum lapathifolium* and *P. persicaria* were important. Small numbers of the Eurasian "Common Teal" (*A. c. crecca*) winter in the Fraser River delta (Campbell 1967).

American Black Duck (*Anas rubripes*)

Introduced. *Rare* resident. Breeds.

Occurrence: In 1971 at least four birds escaped from introduced stock at the GRMBS (Campbell *et al.* 1972*a*). Small numbers have since become residents in the delta. Marshes and protected sloughs with emergent growth and sewage lagoons are preferred habitats. The total population is probably less than 20 birds. Christmas counts: Ladner — maximum 10 in 1981, average 0.5; White Rock — 1 in 1981.

Breeding habits: Only two records, both of broods: Reifel Island, 5 June 1980 — female with five young (Class I); Ladner sewage lagoon, 17 June 1982 — female with six young (Class II).

Mallard (*Anas platyrhynchos*)

Common summer; *very abundant* winter. Breeds.

Occurrence: The most widely distributed duck in the delta and second most abundant in winter (about 50 000 birds; Table 8), the Mallard occurs in fields and every wetland habitat. Migration is most pronounced in autumn. The largest influx occurs in late October, building in numbers through November and December when wintering populations are established. The spring movement occurs mainly in March and is usually over by mid-April. Christmas counts: Ladner — maximum 18 012 in 1981, average 6471; White Rock — maximum 2421 in 1984, average 1115.

Breeding habits: Mallards nest in upland areas throughout the delta, rarely more than 100 m from water. Occasionally cattail marshes are used. Eggs are laid from 13 March to 17 July, with most egg-laying in late April and early May. Clutch sizes range from 4 to 13 eggs. One clutch (4 eggs) was found in an American Coot nest containing 2 eggs at the Iona Island sewage lagoon.

Remarks: Burgess (1970) listed 17 food items of importance to Mallards on the delta. Most (65%) were available in tidal marshes, the most important items being *Carex lyngbyei, Scirpus validus* and *S. americanus*. In agricultural areas, only *Polygonum* spp. was an important food item.

Northern Pintail (*Anas acuta*)

Uncommon summer; *abundant* to *very abundant* winter. Breeds.

Occurrence: The Northern Pintail is primarily a spring and autumn migrant, but considerable numbers (35 000; Table 8) winter in the delta. Flooded agricultural fields are preferred, but open waters, mud flats and shallow marshes are used extensively. Flocks range from less than 10 birds to several thousand during peak migration periods. Largest numbers are reported from Boundary Bay, Lulu Island and Westham Island (Campbell *et al.* 1972*a*).

The pintail is one of the first ducks to migrate north in spring and south in autumn. Spring migration occurs mainly from mid- to late March, with numbers decreasing rapidly by early to mid-April. The autumn passage commences in early to mid-August, but occurs mostly in October. By December, most have reached their main wintering grounds in California (Bellrose 1976). Christmas counts: Ladner — maximum 48 481 in 1982, average 9958; White Rock — maximum 13 011 in 1984, average 4205. The count in 1982 suggests that during mild winters the delta may support more pintail than previously believed (see Table 8).

Breeding habits: Very small numbers nest in relatively open, low, vegetated areas, such as banks of sewage lagoons and agricultural fields. Eggs are laid in April; the first brood reported was in late May. Two nests containing eggs (both six eggs) were within 30 m of water. In some summers breeding is not reported.

Remarks: Burgess (1970) listed 19 food items of importance to Northern Pintails on the delta. Nine were from tidal marshes, the most important items being *Carex lyngbyei, Scirpus validus* and *S. americanus*. Others were from agricultural areas, the most important plant being *Polygonum* spp.

Blue-winged Teal (*Anas discors*)

Fairly common summer; *very rare* winter. Breeds.

Occurrence: There appears to be no pronounced movement or concentration of birds in spring or autumn migration periods. Most summering birds arrive in late April and early May and depart in September, occasionally as late as mid-October. The earliest recorded arrival was of a flock of 10 birds at Iona Island on 28 March 1970 (Campbell *et al.* 1972*a*). A few winter infrequently on the delta, mostly at ANWA. Christmas counts: Ladner — 4 in 1962, 7 in 1970.

Breeding habits: Grassy areas bordering ditches, dikes, sloughs, ponds and sewage lagoons, as well as open farmlands, usually close to water are preferred. Egg-laying occurs mainly from late May to mid-June. Clutch size ranged from 6 to 10 eggs. The latest date on which young (Class II) were reported was 14 August 1972 (Campbell *et al.* 1974).

The total breeding population for the Fraser River delta is probably less than 50 pairs, although Leach (1972) mentioned that this species responds very readily to habitat manipulation and may, at places like ANWA, begin increasing in numbers.

Cinnamon Teal (*Anas cyanoptera*)

Fairly common to *common* summer; *very rare* winter. Breeds.

Occurrence: British Columbia is at the northern end of the range in North America (Palmer 1962), so spring migrants mostly represent breeders. Spring migrants may arrive as early as mid-March, but most settle down to breeding areas in late April and early May. Most birds depart in September; late migrants can occasionally be seen in early October. Small numbers winter infrequently, mostly in the vicinity of ANWA. Christmas counts: Ladner — maximum 8 in 1982 and 1983, average 0.7.

Breeding habits: Fairly dense cover along ditches, sloughs, dikes, sewage lagoons and marshes with banks is preferred. Most egg-laying occurs in the latter half of May. Clutch sizes range from four to nine eggs. The breeding population in the study area is probably less than 75 pairs.

Northern Shoveler (*Anas clypeata*)

Very common migrant; *uncommon* summer; *fairly common* to *common* winter. Breeds.

Occurrence: In migration, it prefers shallow, wet fields, ponds and sloughs, especially with mud flats and, in winter, shallower parts of tidal waters. Spring migration commences in March and in some years builds through most of April, giving this species an "unusually protracted" northward movement (Bellrose 1976). Fall migration commences in September, peaks in October and is usually over by mid-November. Flocks of over 700 birds may be seen in migration (e.g., 760 at Ladner, 1 November 1972; Campbell *et al.* 1974). Flocks of 50 birds are not uncommon in winter. Christmas counts: Ladner — maximum 340 in 1982, average 79; White Rock — maximum 17 in 1973, average 6. Winter populations disperse during freezing weather, some probably moving southward into the United States.

Breeding habits: Breeding occurs in short, dry grassy areas close to water, usually near still or very slow-moving water. Main breeding sites are Iona Island, Ladner and Westham Island. Egg-laying may occur in early May, but usually takes place later that month. The latest complete clutch was found on 22 July. Clutch sizes ranged from 6 to 11 eggs (mean 9.1; $N = 18$), close to the average (9.4) reported by Keith (1961) for Alberta. Broods were found from 3 June through 10 August. An average brood size (Class I) of 6.8 ($N = 9$) was recorded for Iona Island (Campbell *et al.* 1974), identical to that reported by Bellrose (1976).

Gadwall (*Anas strepera*)

Common summer; *fairly common* winter. Breeds.

Occurrence: Gadwalls frequent marshes and wet grassy areas, including fresh, marine and brackish waters. Spring migration occurs mostly from late March to early April; flocks rarely exceed 50 birds. A significant non-breeding summer population may exist along the Iona Island foreshore (e.g., 150 birds, 4 July 1971; Campbell *et al.* 1972*a*). Fall migration occurs mainly in September and is usually over by early October. Largest flocks during the fall approach 100 birds. During the past 15 years or so, Gadwalls have established a small wintering population of about 300 birds, mostly in the vicinity of Iona, Sea and Westham islands. Christmas counts: Ladner — maximum 132 in 1981, average 22; White Rock — maximum 12 in 1981, average 2.

Breeding habits: Gadwalls prefer edges of brackish waterways with short emergent growth (e.g., dikes, sewage lagoons), especially from Iona to Westham islands. Most egg-laying takes place from late May to early June. Replacement clutches are occasionally found in July. Clutch sizes for 29 nests ranged from 8 to 13 eggs (mean 9.7, slightly below the 10.0 mean reported by Bellrose (1976)). The latest brood (Class I, nine young) was reported from Iona Island on 14 August 1972 (Campbell *et al.* 1974).

Remarks: Until two decades ago the Gadwall was not known as a breeding bird west of the Cascade Range in British Columbia, Washington or Oregon (Munro and Cowan 1947; Jewett *et al.* 1953; Gabrielson and Jewett 1970). Small numbers started breeding in coastal British Columbia and Washington in the mid-1960s (Crowell and Nehls 1966, 1967) and slowly became well established (Canning and Herman 1983). Between 1970 and 1985 the Pitt Waterfowl Society, with the assistance of Ducks Unlimited, released Gadwalls hatched from 2289 eggs brought from Alberta. Today the total breeding population in the Fraser River delta probably approaches 100 pairs.

Eurasian Wigeon (*Anas penelope*)

Uncommon winter.

Occurrence: Records of the Eurasian Wigeon in North America to 1940 have been summarized by Hasbrouk (1944) and Edgell (1984). About 16% of the 520 records were from the Pacific coast, of birds probably originating from breeding grounds in Siberia. Today this species is a regular visitor to the Pacific coast, mainly between October and March. In British Columbia, Christmas counts are among the highest on the continent.

The number of records each year appears to be slowly increasing. In the Vancouver area, for example, there were 21 records in 1970, 39 in 1971 and 50 in 1972 (Campbell *et al.* 1972*a*, 1974). Birds were recorded from 9 October to 19 April. Flocks are rare. Single birds or small numbers usually associate with large flocks of American Wigeon: 12 males were counted in a single flock of 2500 American Wigeon on 7 November 1970 on Westham Island (Campbell *et al.* 1972*a*), and up to 18 males have been counted during censuses of wigeon on Westham Island. Most records in the study area are from GRMBS.

Christmas counts: Ladner — maximum 20 in 1983 and 1984, average 3; White Rock — maximum 8 in 1981, average 2.

American Wigeon (*Anas americana*)

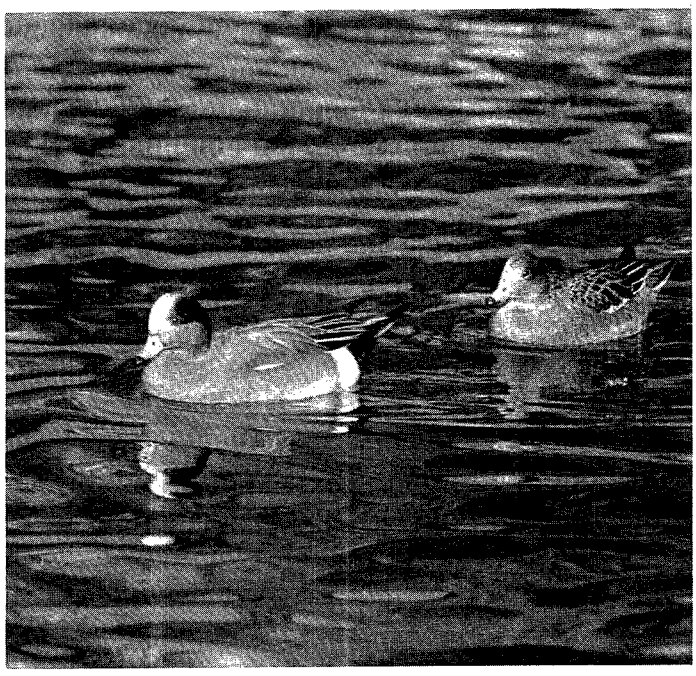
Uncommon summer; *very abundant* winter. Breeds.

Occurrence: During migration, the American Wigeon seems to prefer edges of brackish sloughs and marshes; in winter, it may rest and feed along shorelines, but feeds mostly on wet agricultural fields. It also grazes in municipal parks and golf courses and feeds on seaweed (*Ulva* sp.) along marine shores. This species is widely distributed, but weather often affects numbers and location. During fall and winter counts from 1966 to 1969, largest numbers occurred at the edge of marshes from Iona to Westham islands (Campbell *et al.* 1972*a*). Spring migration may commence in late March, but most birds pass through in April, and concentrations are rarely found after mid-May. Fall migrants may appear in early September. Numbers build up in October, with the peak movement around the delta occurring in November and December, when the wintering population becomes established. The American Wigeon is the most abundant duck in winter, with the average delta population estimated at 62 000 birds (Table 8). Christmas counts: Ladner — maximum 42 221 in 1982, average 12 826; White Rock — maximum 8164 in 1977, average 2856.

Breeding habits: Very small numbers, usually less than 20 birds, summer in the entire study area. Two nests with eggs have been found at Iona Island (eight eggs on 10 June 1976) and ANWA (nine eggs on 7 June 1983). In addition, broods have been reported from the same locations, the latest at Iona Island (10 August 1981, six young).

Remarks: Burgess (1970) listed 11 food items of local importance to American Wigeon. Foods found in tidal marshes did not appear to be an important component of their diet. Unlike the Green-winged Teal, Mallard and Northern Pintail, items consumed on agricultural areas were of greatest importance. Main items included *Lolium* sp. (winter rye), unidentified grasses (*Gramineae*) and other unidentified green vegetation.

American Wigeon is the most abundant duck in the Fraser River delta.



Canvasback (*Aythya valisineria*)

Uncommon summer; *common* to *abundant* winter.

Occurrence: The Canvasback prefers bays, often protected by artificial jetties (Roberts Bank, Iona Island), lower reaches of the Fraser River, sewage lagoons and, occasionally, large, deep sloughs. Spring migration may commence during the latter half of March and continue through April. Most birds depart by May. A large number, estimated at 1000 birds, was seen on 21 March 1972 off Iona Island (Campbell *et al.* 1974). Small numbers are seen in summer offshore. In autumn, migrants appear in mid-September, but most pass through a month later. Flocks are rarely larger than 100 birds during this period. Largest winter concentrations are found off Iona and Westham islands. The recent estimate of the wintering population for the Fraser River delta of 1600 birds is much larger than the 170 given by Bellrose (1976) for British Columbia. Christmas counts: Ladner — maximum 753 in 1975, average 76; White Rock— maximum 201 in 1978, average 75.

Redhead (*Aythya americana*)

Casual summer; *rare* winter.

Occurrence: The Redhead has been recorded in every month of the year, with most records occurring during migration periods, but it has not been found breeding in the delta. Usually fewer than 10 birds are noted, and most records are from Iona Island and GRMBS. Spring migration occurs during March and early April. Birds are rarely seen after mid-May, although a few single birds have been seen in summer. Autumn migration commences during the third week of September and carries on into November. Small numbers remain in winter, often with flocks of Canvasback. Christmas counts: Ladner — maximum 16 in 1977, average 2; White Rock — 9 in 1980.

Ring-necked Duck (*Aythya collaris*)

Very rare summer; *uncommon* winter.

Occurrence: Although recorded in every month of the year, most have been seen in late winter and early spring, from Iona Island and Ladner (sewage lagoons) and GRMBS (open, deep-water sloughs). Numbers in the delta, unlike nearby areas (e.g., Stanley Park, Pitt Meadows), are very small, rarely more than six birds. Migration periods are poorly known. Spring migration may occur in March and early April. Most birds depart by mid-May. There are records of pairs in summer, although as yet no evidence of breeding. Autumn migrants return in late September and the first half of October. Most winter records are from January and February. Christmas counts: Ladner — maximum 31 in 1977, average 2; White Rock — maximum 10 in 1982, average 1.

Tufted Duck (*Aythya fuligula*)

Casual summer; *very rare* winter.

Occurrence: The Tufted Duck was first recorded in British Columbia at Vancouver in November 1961 (Hughes 1963) and in the Fraser River delta at GRMBS on 11 November 1968 (Campbell and Weber 1976). During the past 17 years, this Eurasian diving duck has been found in the study area nearly every year, from October to June. Most records, however, are from the late autumn and winter, from sewage lagoons on Iona Island and in Ladner. Tufted Ducks associate mainly with flocks of Greater and Lesser scaup. The ones that appear in British Columbia probably accompany migrating flocks of Greater Scaup

originating in Alaska or Siberia (Kleen 1973). Christmas counts: not recorded.

Greater Scaup (*Aythya marila*)

Uncommon summer; *very abundant* winter.

Occurrence: Greater Scaup prefers marine and brackish waters of bays and rivers (see Table 10), usually offshore in Boundary Bay and near Iona Island. It is the most numerous diving duck in the delta. Spring migrants occur mainly during the latter half of April; by mid-May most birds have left the delta. Hundreds moult in the vicinity of Boundary Bay (200 birds on 28 July 1970), Crescent Beach (100 birds on 29 June 1971) and Iona Island during the summer. The autumn movement may commence in late September, but occurs mainly during late October and November. In some years, migration extends into early December. The winter scaup population of the delta has been estimated at 30 000 birds (Table 8), most of which are Greater Scaup. Concentrations are located mainly in Boundary Bay. Christmas counts: Ladner — maximum 3003 in 1980, average 872; White Rock — maximum 7017 in 1980, average 2352.

Remarks: Vermeer and Levings (1977) showed that the diet in the Fraser River delta is composed almost equally of plant and animal matter. Algae and vascular plants are the main plant items, whereas bivalves, snails and crustaceans account for most animal foods.

Lesser Scaup (*Aythya affinis*)

Uncommon summer; *very common* winter.

Occurrence: The Lesser Scaup prefers more brackish and freshwater habitats, including sloughs, rivers (Table 10), ponds and sewage lagoons, and more sheltered areas on marine waters than does the Greater Scaup. As many as 200 birds are regularly found at Iona Island, in the vicinity of Ladner sewage lagoon and at the mouth of the Serpentine River. Spring migration occurs mainly in March and early April to the third week of April. Small numbers, often pairs, spend the summer in freshwater habitats. Autumn migration commences during the second and third weeks of October and carries on into early December. The winter population is probably less than 4000 birds. Christmas counts: Ladner — maximum 248 in 1976, average 60; White Rock — maximum 2795 in 1978, average 411.

Harlequin Duck (*Histrionicus histrionicus*)

Fairly common summer; *common* winter.

Occurrence: Most often found in the vicinity of White Rock and Point Roberts, Washington, the Harlequin Duck frequents other rocky, marine shorelines in small numbers throughout the year, especially along artificial jetties and breakwaters at Tsawwassen, Roberts Bank and Iona Island. There are probably fewer than 20 birds in summer, males which return to the sea in the first half of June to moult after breeding in coastal streams in May. The winter population may approach 400 birds, most of which are found in the vicinity of White Rock. Christmas counts: Ladner — maximum 136 in 1980, average 49; White Rock — maximum 247 in 1975, average 62.

Oldsquaw (*Clangula hyemalis*)

Rare summer; *fairly common* winter.

Occurrence: The Oldsquaw frequents open waters in Boundary Bay and off Westham and Iona islands. Small numbers are found up the Fraser River, and singles are often reported in sewage ponds and large sloughs in summer. Spring migration occurs mostly in March (e.g., 2200 at Point Roberts, 13 March 1971; Campbell *et al.* 1972*a*), but small numbers pass through until early May. Most birds depart by mid-May. The summer population, mostly in Boundary Bay, consists of fewer than 20 birds. Autumn migration may be evident in some years in early October, but occurs mainly from mid-October onwards as wintering populations are established. The population has been estimated at 1200 birds for the study area (Table 8). Christmas counts: Ladner — maximum 498 in 1980, average 136; White Rock — maximum 165 in 1974, average 66.

Remarks: The summer and winter diet of Oldsquaw in the Fraser River delta has been examined by Vermeer and Levings (1977). Bivalves (mostly *Macoma* sp.), crustaceans (shrimp, amphipods and isopods) and snails comprise most of the annual diet. Bivalves and crustaceans are eaten more in summer, whereas bivalves and snails predominate in winter.

Black Scoter (*Melanitta nigra*)

Very rare summer; locally *common* winter.

Occurrence: The Black Scoter is the least common of the three scoters, but is equally distributed with the other species along marine shores. Areas of concentration include Blackie Spit, White Rock, Boundary Bay and Iona Island. Spring departure and migration probably occur in March and April, as most birds have usually left by May. Flocks of up to six birds are infrequently reported from Boundary Bay in summer. Autumn migration may commence in September, but is most evident in mid-October. Some birds remain to establish wintering populations. Numbers recorded during Christmas counts at White Rock are the highest reported for British Columbia and Canada. Christmas counts: Ladner — maximum 493 in 1980, average 163; White Rock — maximum 899 in 1973, average 247.

Remarks: The most important food for Black Scoters in the delta is bivalves, of which *Mytilus edulis* and *Mya arenaria* account for 85% of diet items (Vermeer and Levings 1977).

Surf Scoter (*Melanitta perspicillata*)

Common summer; *abundant* winter.

Occurrence: The Surf Scoter is the most common and visible of the scoters and is widely distributed; it is found in the lower reaches of the Fraser River as well as in bays (e.g., Boundary Bay). Spring migration commences in late March, but occurs mostly during the first three weeks of April. Most wintering birds depart by May. The summer population fluctuates from year to year and may comprise several thousand moulting birds (e.g., 3000 at Boundary Bay, 5 August 1970; Campbell *et al.* 1972*a*), but is usually in the low hundreds. Autumn migrants may arrive in September, but most of the influx occurs in October and November. Bays are preferred as winter habitat. The winter population for the three species of scoters in the delta is estimated at 14 200 birds (Table 8), of which the Surf Scoter makes up the "vast majority" (Vermeer and Levings 1977). The sex ratio in flocks observed in January and February 1972 (see Campbell *et al.* 1974) was 170 males per 100 females. Christmas counts: Ladner — maximum

1684 in 1979, average 633; White Rock — maximum 4280 in 1975, average 1158.

Remarks: The most important food items for Surf Scoters in the delta are bivalves, mostly *Mytilus edulis* and *Mya arenaria*. Snails and crustaceans are also utilized, the former being more important in winter, the latter, in summer (Vermeer and Levings 1977).

White-winged Scoter (*Melanitta fusca*)

Fairly common summer; *very common* winter.

Occurrence: Unlike other scoters, the White-winged Scoter is more often seen in brackish and less in saline waters, but it also occurs in open coastal marine waters. Spring migration occurs mostly in March, and few birds remain by mid-April. The summer population, largely moulting males, is composed of several hundred birds, with flocks in Boundary Bay (150 on 31 July 1970) and off Iona Island (280 on 17 July 1982). Early autumn migrants appear in September, but the main influx occurs in late October and carries on into early December. The wintering population in the delta probably approaches 1000 birds. Christmas counts: Ladner — maximum 477 in 1969, average 183; White Rock — maximum 297 in 1973, average 147.

Remarks: White-winged Scoters in the delta feed mainly on bivalves, chiefly *Clinocardium nuttallii* and *Protothaco staminae* (Vermeer and Levings 1977). Barnacles and crabs are also eaten. Molluscs (bivalves and snails) are important in both the summer and winter diet, whereas crustaceans (barnacles and crabs) are eaten mainly in summer.

Common Goldeneye (*Bucephala clangula*)

Rare summer; *very common* winter.

Occurrence: The Common Goldeneye is the more abundant of the two goldeneye species in the Fraser River delta. It occurs in small scattered groups along shorelines, river channels (Table 10), ditches, sloughs and ponds. Spring migration occurs mostly in March, and few birds remain by mid-April. The summer population usually consists of individuals scattered throughout the delta. The main autumn influx of migrants commences in late October and carries over into November. By late November and early December, winter populations are established. The winter population for Goldeneye spp. (Table 8) has been estimated at 1600 birds, most of which are Common Goldeneyes. Christmas counts: Ladner — maximum 450 in 1980, average 199; White Rock — maximum 452 in 1978, average 151.

Remarks: The food of Common Goldeneye in the delta is mostly crustaceans (Vermeer and Levings 1977).

Barrow's Goldeneye (*Bucephala islandica*)

Rare summer; *common* winter.

Occurrence: Barrow's Goldeneye prefers rocky sections of the delta, including breakwaters, jetties and local pebble beaches (e.g., Tsawwassen). As rocky habitats are local and restricted, populations are much lower here than immediately north along the shores of North and West Vancouver, where the Christmas count in 1970 of 3388 birds was the highest reported for North America. Spring migration occurs mostly in the latter half of March, and very few birds are left by mid-April. Only single birds are found throughout the summer. Autumn migrants may appear in late September, but the main influx occurs in October and builds during November, sometimes into early December. The winter population is probably less than 150 birds. Christmas counts: Ladner — maximum 87 in 1961, average 19; White Rock — maximum 44 in 1980, average 24.

Bufflehead (*Bucephala albeola*)

Rare summer; *very common* winter.

Occurrence: The Bufflehead is widely distributed in all aquatic habitats. Preferred habitats include rivers (see Table 10), sheltered Iona Island and Boundary Bay. Most birds depart during the latter half of March, and few birds remain by mid-April. Flock sizes in spring may reach 100 birds (e.g., 21 March 1972, Iona Island). In summer, scattered individuals are seen, usually on large sloughs and sewage lagoons. Autumn migrants return in late October (mean date 25 October for nearby Vancouver; Erskine 1971). Numbers increase through November and frequently into early December. In winter, groups of up to 40 birds are scattered throughout the delta; the total population is calculated to be 5900 birds (Table 8). Christmas counts: Ladner — maximum 1143 in 1980, average 424; White Rock — maximum 481 in 1974, average 231.

Remarks: Food of Bufflehead on saltwater areas of British Columbia is mainly composed of crustaceans and molluscs (Munro 1942). The Fraser River delta may support nearly one-quarter (23%) of the estimated winter population of Buffleheads in British Columbia (Erskine 1971).

Hooded Merganser (*Mergus cucullatus*)

Rare summer; *uncommon* winter. Breeds.

Occurrence: The Hooded Merganser prefers brackish and freshwater sloughs, ponds, river channels and large irrigation ditches, but also frequents sheltered saltwater areas. Numbers are small. Spring migration probably occurs in early April, although it is not as pronounced as with other waterfowl. This species is a late-fall migrant, arriving in numbers on the delta in early November. In winter, there are probably fewer than 60 birds in the delta. Christmas counts: Ladner — maximum 31 in 1981, average 6; White Rock — maximum 33 in 1978, average 8.

Breeding habits: One record exists: a nest with 10 eggs in a wooden nest box at GRMBS on 17 May 1978.

Common Merganser (*Mergus merganser*)

Rare summer; *common* to *very common* winter. Breeds.

Occurrence: The Common Merganser frequents river channels (e.g., South Arm; Table 10), large sloughs and often marine waters protected by breakwaters and jetties. Spring and autumn migration periods are not well defined; rather, there appears to be a gradual departure from the area in April and a return in mid-October, with numbers increasing through November. Most flocks contain fewer than 40 birds, except when inland lakes freeze, forcing birds to aggregate in flocks of up to 100 birds on the sea, river channels and larger sloughs (e.g., Deas Slough). Christmas counts: Ladner — maximum 177 in 1980, average 39; White Rock — maximum 205 in 1984, average 57.

Breeding habits: A female with three young (Class II), recorded from Deas Slough on 2 August 1981, is the only breeding record.

Red-breasted Merganser (*Mergus serrator*)

Very rare summer; *very common* winter.

Occurrence: The Red-breasted Merganser prefers more marine waters and forms larger aggregations (100+ birds) than the other two species of mergansers; it also frequents more open littoral waters and is often found off Westham, Sea and Iona islands. Spring migration commences in late March, but occurs mainly during April. One or two birds are infrequently recorded during summer. Fall migration is evident in late September, but occurs mainly in October and early November. In winter, the largest flocks are found off Westham Island. The estimated winter population for the delta of 1000 mergansers (Table 8) is probably mostly composed of this species. Christmas counts: Ladner — maximum 249 in 1972, average 113; White Rock — maximum 134 in 1979, average 71.

Ruddy Duck (*Oxyura jamaicensis*)

Uncommon summer; *very common* to *very abundant* winter. Breeds.

Occurrence: The Ruddy Duck frequents shallow, fresh and brackish waters, sloughs and sewage lagoons, and is seen infrequently on shallow, near-shore saltwater areas. Ruddy Ducks concentrate in large flocks in Boundary Bay near White Rock, where they roost with scaup. Numbers build up in February and March, with most birds departing in April. In summer, flocks are rarely larger than 20 birds, although a flock of 56 birds was counted at Iona Island on 26 June 1971 (Campbell *et al.* 1974). Autumn migration may commence in late September, but most birds begin arriving in mid-October. Numbers build up during November and December. The mean winter population in the delta has been estimated at 9200 birds (Table 8), but numbers vary considerably depending on weather and availability of ice-free lakes inland. Christmas counts: Ladner — maximum 3838 in 1965, average 265; White Rock — maximum 11 280 in 1978, average 2278. These averages are much higher than the "few hundred" Bellrose (1976) estimated for coastal British Columbia.

Breeding habits: A female with two young (Class I) was found on the Ladner sewage lagoon on 3 August 1973 by K.C. Boyce. This represents the third record for coastal British Columbia; the others are also from the lower reaches of the Fraser River (Campbell 1968*a*).

CATHARTIDAE: American Vultures

Turkey Vulture (*Cathartes aura*)

Rare summer; *casual* winter.

Occurrence: The Turkey Vulture is most often seen soaring over fields and exposed mud flats. Spring migrants appear from mid-March to early April, the earliest date being 14 March (GRMBS). In summer, birds are seen infrequently, and in flocks only when a carcass is found (e.g., six feeding on dead horse at Boundary Bay, 12 June 1971). Autumn migration occurs mostly in mid-September, and birds are rarely seen in October. There are several winter records. Christmas counts: Ladner — 1 in 1978, 3 in 1979; White Rock — 1 in 1974.

ACCIPITRIDAE: Eagles and Hawks

Osprey (*Pandion haliaetus*)

Rare summer; *casual* winter. Breeds.

Occurrence: The Osprey frequents water habitats, including bays, sloughs and rivers. There is no pronounced spring or autumn migration, and most sightings are infrequent and usually of single birds. In spring, arriving birds are reported mainly from mid-April to early May. In autumn, most birds depart by early September. There are three winter records. Christmas counts: White Rock — 1 in 1982.

Breeding habits: Only one record exists — a pair raised two young in the summer of 1962 in a nest in a cottonwood tree along the South Arm of the Fraser River near Lafarge concrete plant.

Bald Eagle (*Haliaeetus leucocephalus*)

Uncommon summer; *fairly common* winter. Breeds.

Occurrence: The Bald Eagle frequents a wide variety of habitats, but mostly intertidal areas. There is no pronounced spring movement on the delta. In summer, small numbers of immatures frequent intertidal areas. There is a small influx of immatures in September, followed by an increase in adults in October and November (Campbell *et al.* 1974). The winter population varies annually, probably averaging from 20 to 30 birds, although up to 40 eagles may be seen in some winters on the mud flats of Boundary Bay. Christmas counts: Ladner — maximum 96 in 1983, average 13; White Rock — maximum 16 in 1982, average 5.

Breeding habits: There are three known nests in the study area, one on the ANWA and two along the South Arm of the Fraser River. All are in large black cottonwood (*Populus trichocarpa*) trees bordering rivers and sloughs. Eggs are laid during March. By late July, young have fledged.

Remarks: At GRMBS, Bald Eagles have been observed feeding on Red-necked Grebe, Great Blue Heron (frozen carcass), Trumpeter Swan carcass, Canada Goose, Snow Goose (crippled), Green-winged Teal, Mallard, American Wigeon, Greater Scaup, Surf Scoter, Short-eared Owl, Ring-necked Pheasant, American Coot, Mew Gull and California Gull. Mammals identified included muskrat (*Ondatra zibethicus*) and river otter (*Lutra canadensis*) caught in traps, and dead domestic stock.

Northern Harrier (*Circus cyaneus*)

Uncommon summer; *common* winter. Breeds.

Occurrence: The Northern Harrier frequents open habitats, including all types of marshes, grass fields, sloughs, upper beaches along drift logs and even mud flats. Spring migration is evident in late March, but occurs mostly during April, the month when most males are reported (Campbell *et al.* 1974). Few nonbreeding birds are present in summer. Autumn migration is protracted. First birds arrive in late September and slowly build up to winter populations by mid-December. Lowlands along the lower Fraser River support the largest wintering populations of harriers in Canada, and the marshes and grass fields of the delta have the highest numbers, so that the Northern Harrier is the most abundant raptor in the delta. Christmas counts: Ladner — maximum 135 in 1984, average 61; White Rock — maximum 34 in 1979, average 20.

Breeding habits: Most breed east of the Coast Mountains (Thompson and McDermond 1985). In the delta, they breed in cattail marshes off Sea, Reifel and Westham islands and among hardhack-filled fields adjacent to

Boundary Bay. Eggs are laid in late April and early May. Clutch size for seven nests ranged from three to five eggs. Most eggs hatch in June.

Sharp-shinned Hawk (*Accipiter striatus*)

Rare summer; *uncommon* winter.

Occurrence: The Sharp-shinned Hawk frequents all terrestrial habitats and marshes and hunts along the edges of waterways — the widest range of all accipiters. Spring migration, not well pronounced, occurs mostly during the latter half of April. Very few are seen each summer. Autumn migration may commence in late August with the passage of passerine migrants, but is more evident in late September and October. In winter, most records are of birds hunting along brush and tree hedgerows. Christmas counts: Ladner — maximum 13 in 1980, average 5; White Rock — maximum 8 in 1973, average 5.

Remarks: Eighteen species of birds (2 nonpasserine and 16 passerine) and two species of mammals (both rodents) have been recorded as prey of Sharp-shinned Hawks at GRMBS. Song Sparrows, Dark-eyed Juncos and starlings were most often captured.

Cooper's Hawk (*Accipiter cooperi*)

Rare summer; *uncommon* winter. Breeds.

Occurrence: The Cooper's Hawk frequents wooded areas along dikes (e.g., ANWA, Boundary Bay), hedgerows on agricultural lands and wooded bogs. Much of the population may be resident. There appears to be a small spring movement of birds during the latter half of April and an autumn movement from late August to early October, with peak numbers in September. In winter, most birds frequent ANWA and Burns Bog. Christmas counts: Ladner — maximum 11 in 1981, average 4; White Rock — maximum 10 in 1980, average 4.

Breeding habits: At least three pairs nest in Burns Bog and one on the ANWA. All nests are in conifers. Eggs are laid in the second and third weeks of May. Young usually fledge by late July. Clutch sizes for four nests were three eggs (N = 1), four eggs (N = 2) and five eggs (N = 1).

Remarks: The Cooper's Hawk is considered a "rare" species in Canada (Cook and Muir 1984).

Northern Goshawk (*Accipiter gentilis*)

Casual summer; *rare* winter.

Occurrence: The Northern Goshawk is usually recorded near wooded sloughs, hedgerows and woodlands, along river banks with tall shrubs and infrequently over open cattail marshes. There is no pronounced spring movement; wintering birds gradually disperse from the delta by mid-April. There are four summer records, all of immatures. Autumn migrants return from the third week of September through October. Nearly 97% of 113 records during autumn were of immature birds, most of them at GRMBS and ANWA. Christmas counts: Ladner — maximum 2 in 1974 and 1977, average <1; White Rock — maximum 2 in 1984, average <1.

Red-tailed Hawk (*Buteo jamaicensis*)

Fairly common summer; *common* winter. Breeds.

Occurrence: The Red-tailed Hawk prefers open and semi-open habitats bordered by trees and tall shrubs. It was the second most numerous raptor recorded during an annual census in the Lower Mainland in 1971, with peak numbers occurring in February (Campbell *et al.* 1972*a*). Spring migration is not pronounced and consists largely of birds dispersing from wintering areas in late February and early March. Most of the autumn migration occurs in September. In winter, this common hawk is widely distributed throughout the delta. Largest numbers are found in the vicinity of Reifel and Westham islands and east Delta (e.g., Boundary Bay airport). The total population in the delta is estimated at 200 birds. Christmas counts: Ladner — maximum 130 in 1984, average 42; White Rock — maximum 63 in 1980, average 34. The figures in 1984 for Ladner are an all-time Canadian high count.

Breeding habits: The Red-tailed Hawk breeds in deciduous or mixed woodlands, usually close to open areas such as agricultural fields and pastures. Hedgerows, especially those with cottonwoods, are also favourite nesting areas. Nesting density in the delta is the highest in British Columbia. Most nest in the eastern portion of Lulu Island (C. Runyan, pers. commun.), partly because of an abundant supply of voles (*Microtus* sp.). Most nests are built in black cottonwood trees (N = 44) 10.6–16.8 m above the ground. Egg-laying takes place mostly in April. Clutch sizes for 22 nests ranged from two to four eggs. Most young fledge in July.

Remarks: Beebe (1974) discussed foods and opportunistic feeding, and Campbell (1977*a*) gave specific evidence of the latter. On 12 May 1976, Campbell observed an adult Red-tailed Hawk pick up and carry off an American Robin, recently killed by a car, from the side of a paved highway near Tsawwassen.

Rough-legged Hawk (*Buteo lagopus*)

Fairly common winter.

Occurrence: The Rough-legged Hawk inhabits open, treeless areas, especially farmland, and less frequently upper, dry beaches with permanent short vegetation. The Fraser River delta supports the largest wintering populations of Rough-legged Hawks in Canada, partly because of the abundance of its principal food, the Townsend's vole (*Microtus townsendii*), and the lack of snow. This is the third most common bird of prey in the delta each winter. Most birds leave in March, but a few stragglers can be found in late April. Returning birds may appear in early September, but the main influx occurs in October and November. East Delta, the vicinity of Boundary Bay and Sea and Iona islands are preferred wintering areas. Christmas counts: Ladner — maximum 72 in 1984, average 19; White Rock — maximum 32 in 1977, average 9.

Remarks: The occurrence of the "dark phase" is extremely rare in the delta. Of 213 observations, only 8 (4%) were classified as dark-plumaged birds. The Rough-legged Hawk feeds almost exclusively on the Townsend's vole. An analysis of stomachs (N = 4) and pellets collected near Boundary Bay (N = 26) showed frequency of occurrence as follows: *M. townsendii* 94%, *M. oregoni* 3%, *Sorex* sp. 2% and *Peromyscus maniculatus* <1%.

Golden Eagle (*Aquila chrysaetos*)

Rare winter.

Occurrence: This rare eagle has been recorded in the Fraser River delta in most months, but most often from late November to April, usually where puddle ducks and geese are numerous. Most records are from the vicinity of GRMBS. All records have been of single birds, mostly immatures. Christmas counts: Ladner — 1 in 1974; White Rock — 2 in 1977 and 1978, average <1 per count.

Remarks: Golden Eagles prey on many species of waterfowl (Sharp 1951; Brown and Watson 1964): Davies (1972) added Snow Goose to the list of prey items.

FALCONIDAE: Falcons

American Kestrel (*Falco sparverius*)
Uncommon transient; *rare* summer; *rare* winter. Breeds.

Occurrence: The American Kestrel frequents farmland and suburban/industrial areas, mainly in the vicinity of Sea Island. Most sightings are of single birds, except during migration periods, when flocks of up to six are found. Birds pass through during the second and third weeks of April and in the first half of September. In winter, birds are more widely scattered. Christmas counts: Ladner — maximum 12 in 1979, average 3; White Rock — maximum 8 in 1976, average 2.

Breeding habits: There are two breeding records. One nest was in a black cottonwood cavity near the Ladner sewage lagoon and contained four eggs on 5 May 1981. The other, also with four eggs, was found in a Wood Duck nest box at GRMBS on 15 May 1973.

Merlin (*Falco columbarius*)
Very rare summer; *uncommon* winter.

Occurrence: The Merlin is widely distributed and frequents more habitats than other falcons. All records are of one or two birds. Small numbers pass through the delta in early April, and few remain by the end of the month. Summer birds were reported, on average, every second year, mostly from GRMBS. Autumn migration occurs from mid-August to mid-November, with most arriving in late September and early October. In winter, Merlin are reported mainly from suburban areas where they hunt near bird feeders. Christmas counts: Ladner — maximum 9 in 1984, average 3; White Rock — maximum 3 in 1977 and 1981, average 1.

Peregrine Falcon (*Falco peregrinus*)
Rare summer; *uncommon* winter.

Occurrence: The Peregrine Falcon frequents habitats where shorebirds and waterbirds are concentrated, including all marshes, tidal flats, flooded farmlands and airports close to the Fraser River foreshore. Most birds depart in March and are rarely present after mid-April. Reports in summer (mostly of adults) may be of foraging birds from nest sites in the Gulf Islands (B. Davies, pers. commun.). Autumn migration commences in late August and continues until early November, with most birds arriving in late September and October. Early arrivals are all immatures. Adults are first noticed by mid-September (Campbell *et al.* 1974). There are few records of adult males. Christmas counts: Ladner — maximum 7 in 1982, average 2; White Rock — six occurrences of single birds from 1974 to 1983.

Remarks: Thirty-eight prey items captured on the Fraser River delta included shorebirds (five species), waterfowl (three species), gulls (two species) and passerines (two species). Most captures (86%) were by direct pursuit. European Starlings were captured on two occasions by underflying flocks and isolating a single bird (Campbell 1975*a*). There were six observations of starlings that avoided hunting peregrines by flying in tight flocks between the legs of domestic stock (Campbell 1976*b*), flying into barns or hiding in grass. The coastal race of Peregrine Falcon, *F. p. pealei*, is "rare" in Canada (Cook and Muir 1984).

Gyrfalcon (*Falco rusticolus*)
Rare winter.

Occurrence: The Gyrfalcon prefers marshes, tidal mud flats and farmlands, especially where waterbirds are concentrated. One or two birds, mostly females, are present in the delta each winter. Records are from 7 October to 20 April, most from December through February. Christmas counts: Ladner — maximum 2 in 1968, 1981 and 1982.

PHASIANIDAE: Pheasants, Grouse and Quail

Ring-necked Pheasant (*Phasianus colchicus*)
Introduced. *Fairly common* resident. Breeds.

Occurrence: The Ring-necked Pheasant frequents open country, such as cultivated fields, shrub rows, wet and dry brackish and freshwater marshes, drift-log beaches and, infrequently, open woodlands. This pheasant was first introduced into the delta, at Ladner and Delta, in 1890 and 1891, with further annual introductions from about 1934 to 1949 (Taylor 1950). In 1948 and 1949, the average numbers of crowing males per square kilometre in Delta Municipality were calculated to be 4.75 and 5.5, respectively, the average territory sizes being 22.1 and 18.2 ha. This species remains widespread and numerous throughout the study area, except in heavily forested habitats. It is not unusual to see flocks of 50–60 birds (mostly at Westham Island) in autumn (September) and from December to February. Winter numbers in the Ladner CBC are often the highest in British Columbia. Christmas counts: Ladner — maximum 256 in 1979, average 133; White Rock — maximum 79 in 1983, average 46.

Breeding habits: The Ring-necked Pheasant nests mainly in fields where there is sufficient cover of grass and low shrubs. Egg-laying commences in early or mid-April and peaks in mid- to late May. Clutch size (Delta and Westham Island) in 1948–49 ranged from 4 to 22 eggs, the average being 8.5 (Taylor 1950). Hatching begins in mid- to late May and peaks a month later. Brood size decreases as season progresses; in 1949, brood size was 7.1 in June and 3.8 in August (Taylor 1950).

Remarks: Food habits have been studied in the lower Fraser River valley by Taylor (1948). Grains were the major food in the autumn, whereas weed seeds (*Polygonum persicaria* and *P. convolvulus*) constituted most of the winter diet. Green plant material increased in importance during the winter, and *Equisetum* sp. was especially significant in January and February. Grit peaked in importance in December.

Gray Partridge (*Perdix perdix*)
Extirpated.

Occurrence: Small numbers were introduced to the delta area in 1905 (Taverner 1926) and infrequently thereafter during the next 50 years or so. Populations remained small. The Gray Partridge was last reported in the early 1960s from the vicinity of Ladner. Christmas counts: Ladner — recorded only from 1959 (maximum of 14) to 1961.

Ruffed Grouse (*Bonasa umbellus*)
Rare local resident. Breeds.

Occurrence: Anderson (1884) reported grouse (presumably this species) to be abundant a century ago. Today only small numbers are locally distributed, mostly in stands of pure deciduous woodlands in Delta and White Rock. Those habitats are disappearing and, therefore, the future status of this species, especially in the lower delta,

is uncertain. Christmas counts also support this trend. Christmas counts: Ladner — maximum 12 in 1975, average 2; White Rock — maximum 11 in 1972, average 5.

Breeding habits: All records (five) are of broods from Ladner and White Rock as follows: 3–27 June — three, four, six, seven and eight young.

Northern Bobwhite (*Colinus virginianus*)
Introduced. Extirpated.

Occurrence: The Northern Bobwhite was introduced unsuccessfully into the Lower Mainland near Huntingdon about 50 km east of the Fraser River delta after the turn of the century (Taverner 1926). Small numbers have been infrequently introduced into the Fraser River delta by sportsmen near Ladner and on Reifel and Westham islands during the 1960s and early 1970s. The latest release was of nine birds in mid-April 1971 at GRMBS: none was seen after 18 July (Campbell *et al.* 1972*a*).

California Quail (*Callipepla californica*)
Introduced. *Rare* resident. Breeds.

Occurrence: The California Quail is locally distributed in small coveys in brushy and weedy areas in the vicinity of Deas Slough and Ladner. More stable populations are found at Point Roberts, Washington. Populations reached peak numbers in the delta in the late 1950s and early 1960s but have declined since, presumably as shrubby areas were turned into farmland. It is not known when, how often or how many birds were introduced into the area. Christmas counts: Ladner — maximum 81 in 1961, average 13.

Breeding habits: Broods have been found from late June through July; two consisted of 9 and 11 young.

RALLIDAE: Rails and Coots

Virginia Rail (*Rallus limicola*)
Rare summer; *fairly common* winter. Breeds.

Occurrence: The Virginia Rail frequents all wetland habitats where emergent vegetation provides some cover. In winter, birds are found mostly in estuarine marshes. Most depart in April and return in October. Winter populations are largest, up to 40 birds having been recorded. Christmas counts: Ladner — maximum 7 in 1984, average 1; White Rock — 2 in 1975, 1 in 1977.

Breeding habits: The Virginia Rail breeds in freshwater and brackish marshes (on Westham and Iona islands) and sloughs at GRMBS. Most eggs are laid from late April to mid-May. Clutch sizes for four nests ranged from six to nine eggs. First young have been reported on 3 June, and two juveniles were observed on 16 July on Iona Island.

Sora (*Porzana carolina*)
Rare summer; *casual* winter. Breeds.

Occurrence: Most records are from the sewage lagoons at Iona Island, Ladner and sloughs at Sea Island and GRMBS for the period mid-March through August. Most records are of one or two birds. Four responded to broadcast tape recordings of their calls at a cattail slough on the northwest tip of Sea Island on 12 June 1985. Winter records are from brackish marshes. Christmas counts: Ladner — 2 in 1974, 1 in 1976.

Breeding habits: Two records exist: a nest containing nine eggs among cattail marsh in Ladner on 7 June 1979, and two small young at Iona Island on 20 July 1974.

American Coot (*Fulica americana*)
Uncommon summer; *abundant* winter. Breeds.

Occurrence: The American Coot prefers sloughs, shallow, brackish and freshwater marshes and exposed tidal river banks (Table 9). Largest numbers are found along foreshore marshes, especially in the vicinity of ANWA. Spring movement occurs mainly in early to mid-April, most migrants having departed by May, leaving a small number of breeders. Autumn migration commences in mid- to late September but occurs mostly in October, continuing into November. Largest flocks are reported in late winter, mostly February, in the vicinity of Westham Island. Christmas counts: Ladner — maximum 760 in 1976, average 280; White Rock — maximum 89 in 1976, average 26.

Breeding habits: The American Coot prefers nontidal marshes bordering sloughs, ponds and sewage lagoons. The breeding population is small. Egg-laying occurs in June. Sizes of 13 completed clutches ranged from six to nine eggs. Rarely do more than one or two young reach fledging age.

GRUIDAE: Cranes

Sandhill Crane (*Grus canadensis*)
Rare summer; *casual* winter. Breeds.

Occurrence: The Sandhill Crane frequents farmlands in the vicinity of Burns Bog and Boundary Bay; it is seen infrequently on beaches and mud flats. Birds may return in very late March, but most come back in early April. Autumn departure occurs in early September, but small numbers winter infrequently. Christmas counts: Ladner — 4 in 1980, 2 in 1984.

Breeding habits: The present breeding status in the Fraser River delta is uncertain. Small numbers nested at Ladner and on Lulu Island at the turn of the century. The last breeding record was in July 1946 on Lulu Island (Munro and Cowan 1947), but rumours persist that several pairs nested in Burns Bog to the southeast. An adult with a large, flightless young was found in the bog in August 1963, apparently the last certain record for the delta. An aerial survey of the area on 9 June 1970 recorded only one adult. One or two pairs may still breed in the area, as birds are still recorded in the vicinity each summer.

CHARADRIDAE: Plovers

Black-bellied Plover (*Pluvialis squatarola*)
Abundant to *very abundant* transient; *rare* summer; *very common* winter.

Occurrence: The Black-bellied Plover frequents mud flats, flooded and dry farm fields and upper beaches, especially in the vicinity of Boundary Bay. During high tides, and with strong offshore winds, flocks roost in upland habitats as well as on jetties and breakwaters. Spring migration occurs in April and May, with peak movements during late April through early May. Aggregations may total over 2000 birds (e.g., 2010 at Boundary Bay, 29 April 1978). Small numbers summer in the delta. Autumn migration may commence in late July and carry through into November. First migrants are mainly moulting adults, followed in September and October by waves of juveniles. Peak numbers from surveys in Boundary Bay in 1978 were 800 on 2 August and 595 on 22 October, but in some years have reached 7000 birds. In winter, the highest numbers in Canada occur in the delta. Christmas counts: Ladner —

maximum 727 in 1981, average 136; White Rock — maximum 75 in 1977, average 13.

Lesser Golden-Plover (*Pluvialis dominica*)

Uncommon to *fairly common* transient; *casual* winter.

Occurrence: The Lesser Golden-Plover prefers sandy intertidal areas and short-grass farmlands bordering coastal areas. Spring migration occurs mainly through the interior of North America (American Ornithologists' Union 1983), but small numbers are regularly seen in the delta from late April through mid-May. Autumn migration commences in late August and carries on into early November. Peak movement occurs during mid- to late September. Flocks of over 100 birds are rare. The average number of birds recorded (N = 76) on Sea Island in the falls of 1963–66 was 12 birds (range 1–74). There are only three winter records. Christmas counts: Ladner — 2 in 1965.

Semipalmated Plover (*Charadrius semipalmatus*)

Fairly common transient; *rare* summer; *casual* winter. Breeds.

Occurrence: The Semipalmated Plover frequents intertidal areas throughout the delta, having a preference for sandy sites. Highest numbers (rarely more than 100 birds) are from Boundary Bay in autumn. Most records, however, are from Iona Island. Spring migration occurs from late April to about mid-May. The autumn movement starts in late July and is usually over by mid-September, but in some years plovers may linger until a month later. Maximum numbers during a survey of Boundary Bay in 1978 were 30 on 22 July and 24 on 29 July. There are several winter records. Christmas counts: Ladner — 1 in 1976.

Breeding habits: In July 1967, the first evidence of breeding (small young) was documented at Iona Island (Campbell and Luscher 1972), the most southern breeding site in North America (American Ornithologists' Union 1983). Up to three pairs now nest each year in the vicinity of sewage lagoons and the jetty at Iona Island.

Killdeer (*Charadrius vociferus*)

Common transient; *fairly common* summer; *common* winter. Breeds.

Occurrence: Widely distributed throughout the delta, the Killdeer prefers agricultural lands (wet and dry fields and pastures), mud flats and shores of rivers and sloughs. Numbers build up in February and peak in March and April. Concentrations are rarely more than 50 birds. An influx occurs in late August and another from about mid-September to mid-October, after which numbers decrease rapidly. Fall concentrations may approach 200 birds. In winter, largest numbers in British Columbia are reported from the vicinity of Westham, Sea and Iona islands and Boundary Bay. Christmas counts: Ladner — maximum 411 in 1962, average 116; White Rock — maximum 140 in 1976, average 39.

Breeding habits: The Killdeer breeds throughout the entire delta in open, dry (often gravelly) locations, including dikes, fields and roads. Complete clutches have been found from 6 March to 24 July. Clutch sizes (N = 32) ranged from two to seven eggs, with 88% having four eggs.

SCOLOPACIDAE: Sandpipers, Phalaropes and Allies

Greater Yellowlegs (*Tringa melanoleuca*)

Fairly common transient; *rare* summer; *rare* winter.

Occurrence: The Greater Yellowlegs prefers marshes, wet farmlands and edges of shallow sloughs and ponds. Migrants pass through mainly from mid-March to mid-May, with peak movement from mid- to late April. They occur singly or in loose aggregations of usually fewer than 30 birds. Small numbers are present in summer, mostly in the vicinity of GRMBS and ANWA. Autumn migration commences about mid-July and carries on into late October (e.g., 11 at Boundary Bay, 14 October 1978). Peak passage, however, occurs in mid-September. Small numbers are reported most winters. Christmas counts: Ladner — maximum 16 in 1979, average 2; White Rock — maximum 9 in 1981, average 1.

Lesser Yellowlegs (*Tringa flavipes*)

Fairly common spring; *rare* summer; *common* autumn transient; *casual* winter.

Occurrence: The Lesser Yellowlegs more often frequents tidal areas than the Greater Yellowlegs, but also prefers shallow marshes, sloughs, sewage ponds and wet agricultural fields. Spring migration is later and autumn migration earlier than for Greater Yellowlegs; both occur mostly east of the Pacific coast (American Ornithologists' Union 1983). In spring, most movement occurs from mid-April to mid-May, at which time flocks of more than 20 birds are unusual. A few stragglers remain in summer. The autumn movement commences in early to mid-July and carries on into October. Peak movement, at which time 100 or more birds may be concentrated, occurs during the latter half of August. There are four winter records for the delta, but no birds have been recorded on Christmas counts.

Solitary Sandpiper (*Tringa solitaria*)

Rare transient.

Occurrence: Small (< 10) numbers pass through the delta, mostly in autumn. They are most often seen alone or with Lesser Yellowlegs along ditches, sloughs and ponds. Spring migrants are seen throughout May, autumn migrants from late July through mid-September. There are no winter records.

Willet (*Catoptrophorus semipalmatus*)

Rare summer; *casual* winter.

Occurrence: Records exist of one to three birds for all months except February, March and November. Most records are from April through October from Iona Island, Blackie Spit and Boundary Bay. There are two winter records. Christmas counts: White Rock — 2 in 1973.

Spotted Sandpiper (*Actitis macularia*)

Fairly common summer; *very rare* winter. Breeds.

Occurrence: The Spotted Sandpiper prefers a wide variety of freshwater habitats, frequently brackish areas and rarely intertidal areas. Most records are from the vicinity of sewage lagoons, usually of one or two birds. Breeding birds arrive during the last week of April and first week of May. Most birds depart in September, although some linger into October. Very few winter in the delta. Christmas counts: Ladner — 1 in 1976; White Rock — 1 in 1975.

Breeding habits: The Spotted Sandpiper nests near fresh water, including dikes along the Fraser River (ANWA), sewage ponds, ditches, stream banks and sloughs. Eggs are laid in mid- to late June. All nests (N = 31) contained four eggs. The latest brood (recently hatched young) was 29 July.

Whimbrel (*Numenius phaeopus*)

Fairly common spring; *rare* summer; *uncommon* autumn; *casual* winter.

Occurrence: The Whimbrel frequents sand and mud flats, agricultural and airport fields and freshwater sloughs and ponds. Spring migration is pronounced and occurs from mid-April through May. Peak movement, when flocks of up to 80 or so birds are seen, occurs in early May. Occasionally some birds remain during the summer. The small autumn movement occurs during early September. There are three winter records.

Long-billed Curlew (*Numenius americanus*)

Rare spring; *very rare* summer; *casual* winter.

Occurrence: The Long-billed Curlew frequents grassy fields, beaches and mud flats. Coastal records for British Columbia through 1970 have been summarized by Campbell (1972*b*). Spring migrants have been recorded from 8 April to 28 May, mostly from the vicinity of Iona and Sea islands. Single birds are infrequently seen in summer (e.g., 1 on Sea Island, 15 August 1966, BCPM 11635). Fall migrants have occurred throughout October. There are two winter records. Christmas count: Ladner — 1 in 1979.

Remarks: The stomach of a bird shot on Sea Island on 7 May 1970 (UBC 13463) contained remains of 31 earthworms and 17 beetles (Campbell 1972*b*).

Marbled Godwit (*Limosa fedoa*)

Rare transient.

Occurrence: The Marbled Godwit has been recorded about 25 times from 18 April to 26 October, in every month. Most records are from April to May (44%) and July to August (28%), of one or two birds. The Marbled Godwit frequents mud flats and beaches, mostly at Blackie Spit and Iona Island.

Ruddy Turnstone (*Arenaria interpres*)

Rare transient; *very rare* winter.

Occurrence: The Ruddy Turnstone associates with flocks of Black Turnstone wherever pebble beaches, rocky shores and rock breakwaters and jetties occur. It has recently been seen on mud flats at Boundary Bay. Most records are of single birds in May and August. Christmas counts: Ladner — 1 in 1964, 1980 and 1984; White Rock — 1 in 1981.

Black Turnstone (*Arenaria melanocephala*)

Fairly common winter.

Occurrence: The Black Turnstone frequents any habitat with rocky components, including beaches and man-made breakwaters. It occurs less frequently on sand and mud flats. In spring, most depart in March. Fall migrants may arrive in late July, but most arrive in September. Numbers build up during October and November. Flocks usually number fewer than 80 birds. Christmas counts: Ladner — maximum 92 in 1968, average 30; White Rock — maximum 18 in 1979, average 5.

Red Knot (*Calidris canutus*)

Rare transient.

Occurrence: The Red Knot is frequently seen in fields near sewage lagoons, on upper beaches and on mud flats (e.g., Boundary Bay) with Black-bellied Plovers. In spring, movement occurs mostly in mid- to late April. In autumn, it occurs from late July through September. Most observations are of single birds.

Sanderling (*Calidris alba*)

Rare summer; *very common* fall; *very common* winter.

Occurrence: The Sanderling prefers sandy habitats, especially in Boundary Bay, but also other intertidal flats. Spring migration is probably mostly offshore, as it is not well pronounced in the delta. There is some movement evident in late April and early May, but those aggregations (up to 150 birds) may be departing birds. Small numbers remain in summer, mostly along beaches. Autumn migration occurs from late July through October. Most adults arrive from late July to mid-August, juveniles in late August and September. Flocks of more than 100 birds are the exception. In winter, largest numbers are found in the vicinity of Iona and Sea islands. Christmas counts: Ladner — maximum 436 in 1979, average 124; White Rock — maximum 28 in 1978, average 4.

Semipalmated Sandpiper (*Calidris pusilla*)

Rare spring; *uncommon* summer; *uncommon* autumn.

Occurrence: The Semipalmated Sandpiper migrates chiefly inland and through eastern North America (Harrington and Morrison 1979). It frequents mud and sand flats in Boundary Bay and Roberts and Sturgeon banks, sloughs and sewage lagoons, and frequently roosts with other "peeps" on runways at the Vancouver Airport. In spring, only small numbers are present, mostly in early to mid-May. Small numbers have recently been observed in summer in Boundary Bay and off Sea Island. Autumn migration is evident from early July through mid-October, with peak movement from the third week of July to the third week of August. Exceptionally large numbers during autumn were 94 birds on 31 July 1985 and 200 birds on 18 July 1986 at Iona Island. There are no confirmed winter records.

Western Sandpiper (*Calidris mauri*)

Very abundant spring, summer, fall; *rare* winter.

Occurrence: The Western Sandpiper occurs in large flocks in Boundary Bay, Roberts Bank and near Iona Island. Sturgeon Bank has not been surveyed. They feed on the mud flats and roost along the upper beach in Boundary Bay and in the Iona Island sewage ponds. Spring migration occurs from mid-April through mid-May. Fall migration takes place from late June through mid-October. The maximum count in spring was 62 000 on 27–29 April 1978 (G. Kaiser, unpubl. data). The maximum count in fall was 22 500 on 17–21 August 1978 (G. Kaiser, unpubl. data). As the length of stay is only 2–3 days for a given individual (Butler *et al.* 1987), the total numbers passing through might reach 500 000 in spring and 1.2 million in autumn. Adult males migrate ahead of females in spring but after them in autumn (Butler *et al.* 1987). Juvenile males and females migrate together mostly in July and August after the adults.

Conservation of this species hinges on the protection of mud flats for feeding and uplands for roosting sites. No other site in British Columbia supports the number reported for Boundary Bay. Christmas counts: Ladner —

2 in 1980, 11 in 1982, 1 in 1984; White Rock — maximum 33 in 1978, average 7.

Remarks: Adults are significantly heavier in spring than in autumn, and females are significantly heavier than males (Butler *et al.* 1987). Similarly, juvenile females are significantly heavier than juvenile males.

Least Sandpiper (*Calidris minutilla*)

Fairly common spring; *uncommon* summer; *common* to *very common* fall; *very rare* winter.

Occurrence: The Least Sandpiper frequents sand and mud flats, shores of ponds and sloughs and flooded fields. Intertidal areas off Sea and Iona islands are preferred locations. Spring migration occurs mainly from mid-April to mid-May. The movement is not spectacular, and groups of more than 50 birds are rarely seen. One or two birds are seen most summers. Autumn migration occurs from early July through late October (some years). Adults arrive in July, followed by juveniles in August. Peak numbers have been recorded at Iona Island in late August (700 on 20 August 1972) and early September (2000 on 2 September 1972). From 1963 to 1966, average numbers in autumn (N = 33 flocks) at Sea Island were 29 birds. Most depart by November. Christmas counts: Ladner — 8 in 1961; White Rock — 6 in 1980.

Baird's Sandpiper (*Calidris bairdii*)

Very rare spring; *uncommon* autumn.

Occurrence: The Baird's Sandpiper migrates chiefly through the interior of North America (American Ornithologists' Union 1983). Spring records for the delta are few, mostly of one or two birds in early to mid-May. During autumn migration, birds have been recorded from early July through late October. According to Jehl (1979), adults arrive first in early July (females earlier than males) and move rapidly through the interior of the continent over a narrow route. In late July, they are followed by juveniles, which move south over a broad front. Peak numbers in the delta (75+ birds) occur from mid- to late August. Most records are from Iona and Sea islands.

Pectoral Sandpiper (*Calidris melanotos*)

Very rare spring; *uncommon* autumn.

Occurrence: The Pectoral Sandpiper migrates chiefly through interior North America (American Ornithologists' Union 1983). It prefers wet and damp fields (e.g., Sea Island), sand and mud flats and shores of sloughs and ponds. Spring migration occurs mainly from late April to late May. Numbers are small, rarely 20 birds in a flock. The autumn movement may commence in late June and carry on through October. Most birds depart by mid-October, although some may linger for another month. Peak numbers (200+ birds) occur in late September and early October. According to Hayman *et al.* (1986), adults begin their southward movement from arctic breeding grounds in late June. Juveniles first appear in southern locations in early August. Presumably most birds in the delta are juveniles. There are no winter records for the delta.

Sharp-tailed Sandpiper (*Calidris acuminata*)

Rare autumn.

Occurrence: The Sharp-tailed Sandpiper frequents drier parts of shallow ponds, marshes and sewage lagoons; it infrequently occurs in damp fields, with the Pectoral Sandpiper. Up to 14 birds have been recorded from 7 September to 30 October, with peak numbers in October. Most reports are from GRMBS and Iona and Sea islands.

Dunlin (*Calidris alpina*)

Very abundant fall, winter, spring.

Occurrence: The Dunlin prefers mud and sand flats, but is also found on wet agricultural fields, upper beaches (roosting), jetties and airports. The maximum number counted in November 1979 was 109 000 birds (Fry 1980), whereas the winter average was estimated at 40 000 birds (McEwan and Whitehead 1984). Winter populations depart in early May. Birds begin returning in late July; most arrive in late October. Christmas counts: Ladner — maximum 45 575 in 1976, average 19 220; White Rock — maximum 22 391 in 1977, average 7684.

Remarks: McEwan and his co-workers investigated the winter ecology of Dunlin in the Fraser River delta since 1979. Dunlin forage by pecking and probing for invertebrates in the mud and sand flats of Boundary Bay. McEwan and Farr (1986*a*) found that small crustaceans were pecked from the surface of the substrate, whereas large polychaetes, particularly *Eteone* sp., were caught by probing the bill into the sand. The maximum diversity of invertebrates in Boundary Bay occurred in an area covered by marine algae (algal-mat zone) next to a salt marsh (McEwan and Gordon 1985). The density of invertebrates was greatest in the algal-mat zone ($1.5 \times 10^4/m^2$) and lowest in the sand ($8.2 \times 10^3/m^2$) and eelgrass ($3.1 \times 10^3/m^2$) zones. The Dunlin spent significantly more time feeding while in the sand and eelgrass zones than while in the algal-mat zone (McEwan and Farr 1986*b*). In winter, daytime foraging was confined to the algal-mat and sand zones, as high tides precluded feeding lower on the beach. Weight changes occurred in overwintering Dunlin in response to reduced prey densities and cold weather (McEwan and Whitehead 1984). Mean body weights of males (61 g) and females (56 g) peaked in December, but decreased 11–15% over the next two months. Much (61–67%) of the weight loss was due to a decrease in body fat, but other factors were also involved. In April, during northward migration, Dunlin body weights were similar to those of birds caught in November the previous year.

Stilt Sandpiper (*Calidris himantopus*)

Uncommon autumn.

Occurrence: The Stilt Sandpiper frequents shallow, freshwater ponds, marshes and sewage lagoons. Most records are from Iona and Sea islands. Birds were recorded from 2 July to 14 October, with a maximum of 12 birds on 9 July. Birds in July are adults, whereas juveniles occur mostly from late August onwards.

Short-billed Dowitcher (*Limnodromus griseus*)

Common spring; *rare* summer; *common* autumn; *casual* winter.

Occurrence: The Short-billed Dowitcher frequents mud flats, shallow, brackish marshes, Iona and Ladner sewage lagoons and shores of ponds and sloughs, as well as beaches. Spring migration occurs mainly from mid-April to mid-May. Campbell *et al.* (1972*a*) suggested that this species is more common in spring than the Long-billed Dowitcher. A few scattered birds (occasionally small flocks) are present in summer, especially in the vicinity of shallow, brackish marshes. Autumn migration occurs from late July through mid-October, with the main movement in August and September. First migrants are adults (females first), followed by juveniles (Hayman *et al.* 1986). There are uncertainties concerning the relative status of the two *Limnodromus* species on the delta. Christmas counts: Ladner — 12 in 1965.

Long-billed Dowitcher (*Limnodromus scolopaceus*)
Fairly common spring; *uncommon* summer; *very common* autumn; *very rare* winter.

Occurrence: The Long-billed Dowitcher frequents habitats similar to those of the Short-billed Dowitcher, but prefers those with more fresh water (e.g., flooded fields). It is most common during autumn migration (Campbell *et al.* 1972*a*). Spring migration occurs from early April to early May. The Long-billed Dowitcher is more commonly seen in summer than the Short-billed Dowitcher, but only in small numbers and locally distributed. Autumn migration occurs from early July to late October, with greater numbers in August and September, when flocks of several hundred birds are not uncommon. Small numbers (< 100 birds) may spend the winter in the delta. During very mild winters, larger numbers winter. Christmas counts: Ladner — maximum 683 in 1975, average 31; White Rock — maximum 113 in 1976, average 14.

Common Snipe (*Gallinago gallinago*)
Common to *very common* transient; *uncommon* summer; *fairly common* winter: Breeds.

Occurrence: The Common Snipe frequents freshwater grassy areas, including pastures, fields, shallow marshes, sloughs and ditches, and occurs less frequently in brackish areas. There are short but pronounced spring and autumn movements through the delta, when numbers may approach 200 birds. The spring movement occurs from late March to early May, with peak numbers in early April. The autumn movement occurs from about mid-September to mid-November. Largest numbers have been observed in late September and late October. In winter, birds are widely distributed in most wetland habitats. Christmas counts: Ladner — maximum 127 in 1962, average 22; White Rock — maximum 48 in 1976, average 9.

Breeding habits: The Common Snipe breeds in wet to damp grassy areas, often along fence rows on the edge of agricultural fields. Displaying males (winnowing) have been heard from 22 March to 28 May. Most eggs are laid mid- to late May. Earliest chicks were reported on 21 May.

Wilson's Phalarope (*Phalaropus tricolor*)
Uncommon summer. Breeds.

Occurrence: The Wilson's Phalarope prefers shallow, freshwater habitats, including marshes, sloughs and the Iona Island sewage lagoon. It is occasionally seen on mud flats. It has been recorded in the delta from 25 April to 29 September. Peak numbers (13) occur in mid-May. Most birds depart by mid-August. Iona Island and GRMBS account for over 90% of all records.

Breeding habits: Breeding was first documented in the delta at Iona Island in 1965 (Campbell 1969). Egg-laying occurs during the latter half of May and first week of June. The average clutch size for nine nests was four eggs. Small numbers breed at Iona Island, Sea Island, Ladner sewage lagoon and Reifel Island: the nesting population is probably fewer than 10 pairs.

Red-necked Phalarope (*Phalaropus lobatus*)
Rare spring; *uncommon* autumn.

Occurrence: All records are from sewage lagoons and brackish sloughs. One or two birds are regularly reported in May; in autumn, birds are observed from 4 July to 24 September. Peak numbers have been recorded in mid-August (19) and early September (32). Most records are from Iona and Reifel islands.

LARIDAE: Jaegers, Gulls and Terns

Parasitic Jaeger (*Stercorarius parasiticus*)
Very rare spring; *uncommon* autumn; *casual* winter.

Occurrence: The Parasitic Jaeger is most often seen off Tsawwassen and Point Roberts (Washington) and less frequently offshore throughout the rest of the delta. Occasionally it visits lower reaches of the North and South arms of the Fraser River. Up to four birds have been seen during late May. The autumn migration is far more pronounced and occurs from late August through mid-November, with most birds reported in September. The largest group was nine birds off the Tsawwassen jetty on 25 September 1981. There are two winter records. Christmas counts: White Rock — 1 in 1977.

Franklin's Gull (*Larus pipixcan*)
Very rare spring; *very rare* summer; *uncommon* autumn.

Occurrence: Campbell and Foottit (1971) summarized records for British Columbia for the period 1938–70 and showed that this gull had become a regular autumn migrant, in small numbers, in the Fraser River delta. That trend has continued over the past 15 years. There is a small spring movement, most noticeable at Iona Island, from mid-April to mid-May. Up to three birds are seen infrequently at sewage lagoons in summer. The autumn movement occurs from late July (some years) to early November, but mostly in late August and September. Flocks of up to 19 birds have been reported. Nearly 71% of all records are from the vicinity of Iona Island.

Bonaparte's Gull (*Larus philadelphia*)
Very abundant transient; *very common* summer; *uncommon* winter.

Occurrence: The Bonaparte's Gull frequents bays, estuarine marshes, rivers, mud and sand flats, sewage ponds and flooded agricultural fields. Spring migration commences during late March and continues into mid-May. Peak numbers (low thousands) occur during the last week of April and first week of May. Commencement and duration of autumn migration are uncertain. During the latter half of June, flocks of 2000 or more birds occur in the delta and may be early migrants. Most of the movement, however, occurs from mid-July to mid-November, after which numbers decrease rapidly. The main influx occurs during September. In winter, small numbers, usually fewer than 20 birds, are widely scattered. At times there are far larger and very impressive gatherings of 1000 or more birds. Christmas counts: Ladner — maximum 1052 in 1962, average 46; White Rock — maximum 205 in 1972, average 15.

Mew Gull (*Larus canus*)
Fairly common summer; *very abundant* winter.

Occurrence: Found in a wide variety of aquatic and terrestrial habitats, depending on food (e.g., spawning eulachons, invertebrates in freshly turned fields), weather and season, the Mew Gull prefers flooded agricultural fields, mud and sand flats, sewage outlets and river channels (Table 10). Spring migration occurs from mid-March to mid-May, with peak numbers (5000+ birds) in late April and early May. Small numbers, mostly immatures, are present along coastal areas in summer. Fall migration occurs from late July through November. In winter, flocks of up to 7000 birds (e.g., 12 January 1966) may frequent

the North Arm of the Fraser River near Sea Island. Christmas counts: Ladner — maximum 7243 in 1972, average 1916; White Rock — maximum 1564 in 1972, average 488.

Ring-billed Gull (*Larus delawarensis*)

Uncommon spring; *common* to *very common* summer; *fairly common* winter.

Occurrence: The Ring-billed Gull is widespread, occurring along beaches, in agricultural fields, garbage dumps, sewage lagoons and bays and on banks of river channels. The seasonal cycle, especially of different age-classes, is uncertain. There appears to be a small spring movement from late March to mid-May. In June and July, there is an influx of birds from the Canadian Prairies (Vermeer 1970), when small flocks arrive and begin to moult. An increase occurs from August to late October, after which numbers decrease to wintering populations. Peak numbers of 3000–4000 gulls have occurred in mid-September and late October. In winter, this species readily mixes with flocks of other gulls. Christmas counts: Ladner — maximum 178 in 1974, average 23; White Rock — maximum 254 in 1980, average 43.

California Gull (*Larus californicus*)

Very common transient; *fairly common* summer; *uncommon* winter.

Occurrence: Habitat preferences are similar to those of the Ring-billed Gull, but the California Gull also favours mud bays and sand flats. Spring migration occurs from about mid-March through May. Peak numbers (flocks of 200+) occur during mid- and late April. In summer and autumn, birds are present in late June, reach peak numbers in early September and decrease in numbers through October (Oldaker 1961). Small numbers winter. Christmas counts: Ladner — maximum 16 in 1981, average 1; White Rock — 2 in 1980, 1 in 1983.

Remarks: Houston (1977) showed that California Gulls reared in Saskatchewan travel 1200 km to the southwest mainland coast of British Columbia within six weeks of fledging. In addition, subadults remain on the coast until they reach breeding age.

Herring Gull (*Larus argentatus*)

Uncommon winter.

Occurrence: The Herring Gull frequents mud flats, beaches, garbage dumps, banks of river channels (Table 10) and offshore waters. It occurs primarily from mid-August to late April. Most birds arrive in September and depart in April. During October and November, several hundred may be found among other roosting gulls. Moderate numbers winter on the delta. Averages for Christmas counts are misleading, as Thayer's Gull was not formally distinguished from Herring Gull (American Ornithologists' Union 1973), so that records of the two species were not kept separately before 1973.

Thayer's Gull (*Larus thayeri*)

Common winter.

Occurrence: Thayer's Gull associates with other gulls in all habitats, but is more terrestrial than the Herring Gull (e.g., greater use of garbage dumps, beaches, fields). It arrives in September and October. Numbers increase during November and December, peak in January and February and decline during March. Few remain after mid-April. In late winter, peak numbers include groups of several hundred. Averages for Christmas counts are available only since 1973 (see Herring Gull). Christmas counts: Ladner — maximum 924 in 1984, average 365; White Rock — maximum 462 in 1980, average 61.

Remarks: Thayer's Gull was formerly considered a race of Herring Gull (Smith 1966). Its status on the delta is known in general, but specific details of numbers, habitat preference and movements are lacking. The delta could be an important wintering area on the Pacific coast. Mattocks *et al.* (1976) suggested that Thayer's Gull outnumbers Herring Gull by "a wide margin" along the coast of Washington.

Western Gull (*Larus occidentalis*)

Very rare summer; *rare* winter.

Occurrence: Along the coast, the Western Gull prefers open sea, sandy beaches and rocky shores; inland it is seen mainly at garbage dumps. It occurs chiefly from mid-October to mid-March, in small numbers. One or two immatures are infrequently seen during summer. Christmas counts: Ladner — maximum 6 in 1981, average 1; White Rock — maximum 2 in 1980, average <1.

Glaucous-winged Gull (*Larus glaucescens*)

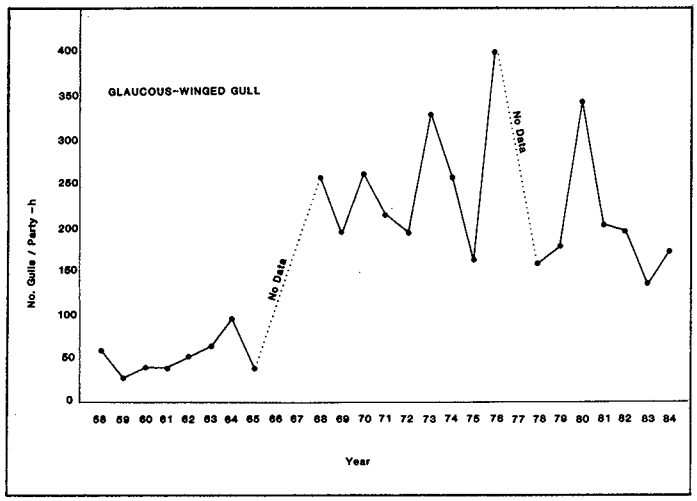
Abundant winter; *common* summer. Breeds.

Occurrence: The Glaucous-winged Gull is widespread and frequents all aquatic and terrestrial habitats. Large numbers roost on mud and sand flats, fields, jetties and open offshore waters. Many of the birds' daily activities are associated with feeding flights to local garbage dumps. Maximum counts during nonbreeding season were 38 000 in February 1984 (McKelvey *et al.* 1985). Maximum counts during breeding season were 30 400 in June 1983 (McKelvey *et al.* 1985). Christmas counts: Ladner — maximum 44 832 in 1980, average 17 872; White Rock — maximum 13 387 in 1981, average 2854.

Breeding habits: One colony was observed at Tsawwassen Ferry Terminal breakwater (238 nests in 1985); isolated nests are widespread. Eggs are laid in mid-May to late July. Young fledge in late June to late August. Glaucous-winged Gulls at Tsawwassen had poor fledging success relative to the colony on Mandarte Island (Vermeer 1963; Ward 1973; Verbeek 1979, 1986). In August 1985, there were 8 nests with single unhatched eggs, 1 nest each with two and three unhatched eggs, 68 nests with one chick, 6 nests with two chicks and 2 nests with three chicks at Tsawwassen. There were 86 fledged chicks on the water. If we assume that all chicks survived to fledging, then 172 chicks were produced from 238 nests, or 0.72 chicks per nest. Vermeer (1963) found 1.0–1.7 chicks fledged per nest on Mandarte Island.

Remarks: There are over 33 000 nesting pairs of Glaucous-winged Gulls around Vancouver Island (Campbell 1976*a*) which mostly disperse southward after breeding to feed around garbage dumps and beaches (Butler *et al.* 1980). Many gulls from the largest colony in the Strait of Georgia, on Mandarte Island, winter in Vancouver (Drent and Ward 1970). The large summer population noted by McKelvey *et al.* (1985) probably included breeding gulls from Mandarte Island that fed in the Vancouver garbage dump (Vermeer 1963), nonbreeding subadults and a small, locally breeding population. Undigested food remains at the Tsawwassen colony in June and July 1985 included human refuse (bones, glass and chicken tags) and naturally occurring food such as herring, ling cod (*Ophidon elongatus*), shiner sea-perch (*Cymatogaster aggregata*), crescent gunnels (*Pholis laeta*), starfish (*Pisaster ochraceous*) and basket cockles (*Clinocardium nuttallii*). The basket cockle might be important in the summer diet of adult gulls at Tsawwas-

Figure 4
Number of Glaucous-winged Gulls counted per party-hour on Christmas Bird Counts in Ladner, British Columbia. The Burns Bog garbage dump opened in 1965.



sen. On 6 June 1985, 51 cockles were broken by 33 gulls during 70 min of observation. On 17 June 1985, 20 cockles dropped by gulls were measured; the mean of the greatest shell diameter was 5.7 mm (SD = 1.0).

Glaucous-winged Gulls have tripled their numbers in southwestern British Columbia since 1928 (Butler *et al.* 1980), presumably as a result of abundant food at the garbage dumps in southwestern British Columbia. A garbage dump on the edge of Burns Bog opened in 1965 and received most of the refuse from Vancouver and surrounding municipalities. Shortly after 1965, the number of Glaucous-winged Gulls counted on CBCs in Ladner increased more than fourfold (Fig. 4). The gulls began breeding in isolated sites about 1972, when three pairs nested at the GRMBS and "about 10 pairs" nested at Tsawwassen (Campbell *et al.* 1972*a*). The Tsawwassen colony has continued to grow: 115 pairs in 1974 (Campbell 1976*b*), 160 in 1977, 150 in 1978, 191 in 1980, 223 in 1981 (BCWRS) and 238 in 1985. Colonies have also been established nearby in Vancouver (Campbell 1975*b*; K. Vermeer and co-workers, unpubl. data).

The Fraser River delta is a major wintering area for the Glaucous-winged Gull, which has become a pest in some areas, such as at the garbage dump in Burns Bog and on buildings in Vancouver. On the other hand, it also scavenges beaches throughout the delta. Whether its numbers will continue to increase following the planned incineration of garbage at the Burns Bog garbage dump is uncertain.

Glaucous Gull (*Larus hyperboreus*)
Rare winter.
Occurrence: The Glaucous Gull is most often found at garbage dumps or with other gulls along beaches and mud flats. Records are of one to six birds, mostly immatures, from early November to mid-April. Christmas counts: Ladner — maximum 6 in 1970, 1977, 1982 and 1984, average 2; White Rock — maximum 2 in 1984, average <1.

Caspian Tern (*Sterna caspia*)
Fairly common summer.
Occurrence: The Caspian Tern frequents coastal areas, including bays, sand flats, estuaries and sewage lagoons, as well as man-made jetties and breakwaters for roosting. It arrives in early May and departs by early October, but most records are in June and July when flocks of nearly 100 birds may be seen. Average flock size (N = 48) in the 1980s is 14 birds. Most sightings are from Iona Island, Boundary Bay and Tsawwassen jetty.
Remarks: This species has increased greatly in abundance since the turn of the century. Records for British Columbia, through 1970, have been summarized by Campbell (1971). In 1985, many individuals were seen per day per locality. The Caspian Tern is extending its breeding range northward (Penland 1982) and, in time, may breed in isolated sandy areas in the vicinity of Iona and Sea islands. Flying juveniles are often seen being fed by adults in late summer at Boundary Bay. The Caspian Tern is considered a "rare" species in Canada (Cook and Muir 1984).

Common Tern (*Sterna hirundo*)
Fairly common spring; *rare* summer; *common* autumn.
Occurrence: The Common Tern frequents offshore areas, but is often found around bays, off jetties and resting with gulls on beaches. Spring migration occurs from mid-April to late May, with peak movement in mid-May, when flocks of 1800 birds may be seen, although flocks usually number fewer than 50 birds. Small numbers are present along the coast each summer, but largest numbers generally occur in fall. Autumn migration begins in early August. Peak movement occurs in early September. Numbers decrease through October, and late stragglers may occur in early November.

Arctic Tern (*Sterna paradisaea*)
Rare transient.
Occurrence: The Arctic Tern prefers offshore waters; hence migration periods and numbers in the delta are unclear. The spring movement probably occurs from mid-May through early June. The autumn migration probably occurs mainly from mid-August through mid-September. Numbers are probably greater in autumn than in spring.

Black Tern (*Chlidonias niger*)
Rare summer. Breeds.
Occurrence: Records of one to four birds are mostly from Iona Island, Westham Island and Ladner (sewage ponds). Extreme dates are 26 May to 5 September.
Breeding habits: Campbell (1970*b*) summarized earlier occurrences for the delta and documented the first breeding record for coastal British Columbia at Pitt Meadows, 30 km to the northeast of the study area. Since then there has been one breeding record for the delta, the second for the coast: on 12 July 1974, two young were found in a cattail marsh near the Ladner sewage lagoon.

ALCIDAE: Auks and Murres

Common Murre (*Uria aalge*)
Rare summer; *fairly common* winter.
Occurrence: Most records are from marine habitats near Point Roberts, but the Common Murre also occurs off Tsawwassen, Roberts Bank and Iona Island throughout the year. In spring, largest numbers are found in May. A few move into the delta in September and early October, but the main autumn influx occurs later in October and through November. Winter numbers fluctuate greatly. Christmas counts: Ladner — maximum 313 in 1972, average 141; White Rock — 2 in 1975, 1 in 1982.

Pigeon Guillemot (*Cepphus columba*)
Uncommon summer; *fairly common* winter. Breeds.
Occurrence: The Pigeon Guillemot frequents marine littoral waters. Small numbers are present throughout the year, but winter numbers are largest. Strong winds force them into sheltered areas. Christmas counts: Ladner — maximum 38 in 1982, average 12; White Rock — maximum 11 in 1974, average 1.
Breeding habits: At least one pair has nested among pier structures at the Tsawwassen ferry terminal since 1979. This is an uncommon habitat for this species in British Columbia (Campbell 1977*b*). Eggs are laid in June and hatch in July. Young fledge in late July and August.

Marbled Murrelet (*Brachyramphus marmoratus*)
Fairly common resident. Breeding not determined.
Occurrence: The Marbled Murrelet prefers marine waters, but also frequents estuarine and brackish waters. Most records are from Point Roberts and Tsawwassen. Numbers are largest in winter, with occasional large aggregations. Christmas counts: Ladner — maximum 2125 in 1976 (highest reported for British Columbia), average 107; White Rock — maximum 45 in 1974, average 5.

Ancient Murrelet (*Synthliboramphus antiquus*)
Uncommon winter.
Occurrence: The Ancient Murrelet prefers offshore waters; it occurs casually in waters off Westham and Iona islands. Most records are from the vicinity of Point Roberts from mid-October to March. Numbers fluctuate greatly from year to year. Christmas counts: Ladner — maximum 77 in 1979, average 6.

Rhinoceros Auklet (*Cerorhinca monocerata*)
Rare summer; *very rare* winter.
Occurrence: Most records are of small numbers in marine waters off Point Roberts and Tsawwassen jetty. Birds in summer are probably from a breeding colony on Protection Island, Washington. Christmas counts: Ladner — 1 in 1973.

COLUMBIDAE: Pigeons and Doves

Rock Dove (*Columba livia*)
Introduced. Common resident. Breeds.
Occurrence: The Rock Dove frequents urban and suburban areas, farmlands, industrial areas and, infrequently, beaches. Other than Christmas counts, there is no information on distribution and numbers. Concentrations have been reported at Iona Island (200 on 12 March 1972) and Boundary Bay (300 in cultivated fields, 18 March 1982). Christmas counts: Ladner — maximum 2119 in 1979, average 1049; White Rock — maximum 935 in 1977, average 501.
Breeding habits: The Rock Dove prefers man-made structures such as barns, silos, old houses and industrial buildings. A small colony of about 30 pairs breeds among pier structures and on a breakwater at the Tsawwassen ferry terminal. Eggs have been found in every month of the year. Most egg-laying, however, occurs from April to June.

Band-tailed Pigeon (*Columba fasciata*)
Fairly common summer; *uncommon* winter. Breeds.
Occurrence: Although primarily a species of the mixed woodland, in the delta the Band-tailed Pigeon frequents cultivated farmlands, urban/residential areas and woodland edges. In some years there appears to be a spring movement of birds (150+ in flocks) from late March to mid-May. Summer aggregations some years approach 90 birds. In autumn, a "migration" occurs in September and October, with flocks of over 50 birds being the exception. Small numbers are widely scattered throughout the delta in winter. Christmas counts: Ladner — maximum 15 in 1983, average 1; White Rock — maximum 13 in 1981, average 3.
Breeding habits: This species is very elusive around its nest, but small numbers probably breed throughout the delta where stands of undisturbed woodlands and tall shrubs occur. There are two breeding records: White Rock, 29 May 1962 — nest with two eggs; Ladner, 28 June 1965 — one young fell from nest in tall shrubs next to a house.

Mourning Dove (*Zenaida macroura*)
Uncommon summer; *fairly common* winter. Breeds.
Occurrence: The Mourning Dove prefers bare or grassy areas in agricultural and residential areas, including parks, and also the edges of woodlands and tall patches of shrubs. Mourning Doves are present throughout the year. There is probably an influx of birds in April and a general departure in September and October. Winter populations in the Fraser River delta are the largest on the British Columbia coast. Christmas counts: Ladner — maximum 145 in 1973, average 23; White Rock — maximum 54 in 1974, average 12.
Breeding habits: The Mourning Dove breeds in a wide variety of habitats except marshes and heavily wooded areas. Preferred sites are patches of tall shrubs (*Salix*) bordering sloughs. The breeding season is long. Egg dates for 19 nests ranged from 19 March to 7 August. Five nests were in ornamental trees and shrubs in private yards.

TYTONIDAE: Barn-Owls

Common Barn-Owl (*Tyto alba*)

Uncommon resident. Breeds.

Occurrence: This nocturnal species is adapted for open-country living and prefers agricultural lands with brush fence rows for hunting. In the delta, airports, parks and beaches are also used. Numbers fluctuate from year to year and seasonally, depending on food supply and weather. During severe winters, barn-owls (mostly juveniles) hunt along roads, and many are killed by traffic. Some of the birds are picked up and taken to the BC Wildlife Branch for taxidermy permits. During 1982 and 1983, 53 and 24 carcasses were received, respectively. Barn-owls accounted for 54 and 40% of all raptors received in 1982 and 1983, respectively (D. Wilson, pers. commun.).

The barn-owl was first recorded in British Columbia near the mouth of the Fraser River in 1909 (Brooks 1909). During the next 40 years or so, the bird expanded its range and now occupies suitable habitat throughout the extreme southwestern portion of British Columbia.

During the 1970s, the entire lower Fraser River valley (Vancouver to Hope) was surveyed, and the population was estimated at 1000 birds, of which 750+ were non-breeders (Campbell and Campbell 1983). The highest density was in the Fraser River delta, specifically on Reifel and Westham islands.

Birds in the delta are probably residents and show site tenacity to foraging and breeding areas. In 1965, an adult banded on Sea Island on 3 June was released in Surrey, 40 km to the east. On 22 June, the bird was retrapped on Sea Island. The following year, a bird released in the same area was retrapped within two months. Local dispersal probably occurs among immatures. Of 122 owls banded on the southwest coast from 1962 to 1975, 19 (15.6%) were recaptured within 80 km of the banding site (Campbell and Campbell 1983).

Christmas counts: Ladner — maximum 16 in 1982, average 5; White Rock — maximum 8 in 1974, average 3.

Breeding habits: Thirty-two years after the barn-owl was first seen in British Columbia, it was found breeding in the same general area (Cowan 1942). Preferred nest sites are associated with agricultural activities; in the delta, 98% are in man-made structures such as barns and silos, the remainder in natural tree cavities. In northern parts of the barn-owl's range, the use of man-made structures appears to be important. W.D. Johnson (1974) suggested that barns and silos may "supplement plumage in heat retention and decrease the requirement for greater energy expenditures strictly for thermogenesis." Abandoned or unused unlit buildings are preferred nesting sites.

Common Barn-Owls breed at less than 1 year of age (Schneider 1937) and have been reported breeding throughout the year in the Fraser River delta. In most years, the reproductive season lasts from mid-April through July. Clutch size ranges from 1 to 10 eggs, with 4 eggs being most common. Average brood size (N = 16) is 2.2 young. On three occasions, pairs were double-brooded, all in years when populations of small mammals were high. Nest-site tenacity is strong; one pair, recognized by plumage, used the same nest site on Westham Island for 18 years.

Remarks: The annual and seasonal food habits have been studied extensively (Campbell 1987*b*). Small mammals (rodents and insectivores) constitute 98% of the diet. The most important mammal was the Townsend's vole (*Microtus townsendii*), which accounted for nearly 75% of all prey as well as 84.3% of mammalian prey biomass. In the Fraser River delta, 14 species of mammal were utilized as food (97.2% of total diet), of which *M. townsendii* accounted for 80% of prey items.

Over 13 years, small mammals (mostly *M. townsendii*) composed between 65.3 and 84.5% of all prey items, further emphasizing the importance of those grassland mammals to establishing and maintaining populations of barn-owls in the delta (Campbell 1983). The Common Barn-Owl has recently been declared a "rare" species in Canada by the Committee on the Status of Endangered Wildlife in Canada.

The Fraser River delta has the highest population of the Common Barn-Owl in Canada, where the species is considered rare. Survival of the owl in the delta depends on maintaining barns and old fields as habitat.

STRIGIDAE: Typical Owls

Western Screech-Owl (*Otus kennicottii*)

Rare resident. Breeds.

Occurrence: The Western Screech-Owl frequents all woodland habitats, with a preference for mixed coniferous and deciduous woods. Most records are from woodlands along the Serpentine and Nicomekl rivers and in White Rock and Ladner. Numbers are very small and show little seasonal variation, although up to four birds have been seen in November and December. Individuals roost infrequently in wooden nest boxes at GRMBS. Christmas counts: Ladner — 1 in 1970; White Rock — 1 in 1982, 2 in 1983.

Breeding habits: The Western Screech-Owl prefers riparian habitats or open woodlands. Only two records exist: a nest with four eggs near White Rock on 21 April 1969, and two young in a nest box at GRMBS on 6 June 1969.

Great Horned Owl (*Bubo virginianus*)

Uncommon resident. Breeds.

Occurrence: A versatile, solitary species, the Great Horned Owl has a preference for woodlands and is frequently seen along treed windrows, edges of sloughs and marshes, residential areas, farmlands, bogs and rivers. Although widely distributed, populations are small and local. During severe winters, small numbers may disperse to coastal marshes to hunt (e.g., 7 on Reifel Island, 29 December 1973). Christmas counts: Ladner — maximum 8 in 1984, average 1; White Rock — maximum 3 in 1976 and 1977, average 1.

Breeding habits: The Great Horned Owl prefers woodlands with tall trees close to water and treed fence rows. Egg-laying occurs from mid-February through April, with most from late February to early March. Clutch sizes range from one to three eggs; most have two eggs. One pair nested in an abandoned barn near Ladner in 1964.

Snowy Owl (*Nyctea scandiaca*)

Uncommon winter.

Occurrence: The Snowy Owl frequents open, treeless country, including farmlands, airports, log-strewn beaches, jetties and breakwaters. Snowy Owls are found in the delta each winter, mostly near Boundary Bay. Numbers are small, except during years of incursions. During the past 25 years, those incursions have occurred during the winters of 1966–67, 1973–74, 1975–76, 1977-78, 1978–79 and 1984–85 (based upon Christmas counts). The largest influx was in 1973–74, when an estimated 150–175 birds were scattered throughout the delta. Extreme dates are 13 September (Vancouver Natural History Society, unpubl. data) to 12 May (Campbell *et al.* 1974). Most birds, however, arrive in late October and November and depart by mid-April. Christmas counts: Ladner — maximum 107 in 1973, average 10; White Rock — maximum 14 in 1973, average 1.

Remarks: In coastal areas of North America such as Alaska (Williams and Frank 1979) and British Columbia (Campbell and MacCall 1978), Snowy Owls were thought to shift their diet from small mammals to birds, mostly waterfowl, when small mammals became scarce. However, Kennedy *et al.* (1982) found that Snowy Owls in Boundary Bay preferred waterfowl, despite the availability of mammals. They suggested that the visibility and larger concentrations of waterbirds may have influenced the diet shift.

Burrowing Owl (*Athene cunicularis*)

Formerly *rare* resident and breeder; currently *very rare* winter.

Occurrence: The Burrowing Owl frequents open areas, especially dikes, log-littered beaches and sand-dune areas. Most records are for Sea and Iona islands, although single birds have been seen in dry coastal habitats throughout the delta. Most spring records are in March and April, autumn records in October and November. There are several winter records; no Burrowing Owls have been seen in Christmas counts.

Breeding habits: At least one or two pairs nested in most years, in the vicinity of Lulu Island, from 1939 through 1976. The last record was in late June 1976, when four young were reported on the dike near the nest site.

Remarks: Single birds were trapped and banded on Sea Island on 23 October and 5 and 6 November 1964. Two were apparently birds of the year. The Burrowing Owl is considered extirpated in the delta (Table 5).

Long-eared Owl (*Asio otus*)

Rare resident. Breeds.

Occurrence: The Long-eared Owl prefers riparian woodlands, especially those associated with sloughs, and wooded windbreaks bordering agricultural fields. Most records are from mid-October to mid-April from the vicinity of GRMBS and ANWA. Small numbers (up to 6 birds) infrequently roost together on Westham Island in December and January. Christmas counts: Ladner — maximum 4 in 1970 (recorded four times from 1970 to 1980); White Rock — 1 in 1975.

Breeding habits: The Long-eared Owl breeds in dense patches of tall shrubs, usually near water, in the vicinity of ANWA and GRMBS, Iona and Sea islands, Burns Bog and Boundary Bay. Breeding numbers are small, and nests are difficult to locate. Voles are the major prey of Long-eared Owls, and, in years when populations of small mammals are low, birds may not nest. Eggs and/or young have been recorded in abandoned nests of Northwestern Crow and Black-billed Magpie. Eggs are laid mostly in April and May.

Short-eared Owl (*Asio flammeus*)

Uncommon summer; *fairly common* winter. Breeds.

Occurrence: The Short-eared Owl prefers open grasslands, airports, agricultural areas, wet marshes, open brush fields and upper beaches. It often roosts in dry cattail stands and the landward side of dikes. Wintering birds depart mostly in April. Birds return in October and increase in numbers through November and early December. In winter, numbers fluctuate greatly; in some years the delta supports the largest reported numbers in North America (see Campbell *et al.* 1972*a*). From December to February, roosting aggregations on Sea and Iona islands may at times approach 120 birds. Christmas counts: Ladner — maximum 56 in 1980, average 29; White Rock — maximum 34 in 1973, average 10.

Breeding habits: Populations have decreased through the delta because of loss of habitat from urbanization. Numbers are now small and locally distributed, centred in the vicinity of Boundary Bay, Ladner, Westham Island and Sea Island. Nests are situated in open habitats with vegetative cover for incubating birds, such as grassy fields, dry marshes and, occasionally, open low-shrub fields. Eggs are laid in late March and the first two weeks of April. In years when small mammals are numerous, eggs may be found in early June. Clutches (N = 12) ranged in size from

3 to 10 eggs, with 6 eggs being the average size. Brood size (N = 9) ranged from two to six young.

Remarks: As part of a bird control program at the Vancouver International Airport from January 1964 to October 1966, raptors were trapped, banded and released at distant locations. The Short-eared Owl was the most numerous of 11 species of raptors trapped: in total, 426 birds, or 78% of all raptors caught. The trapped owls were released at sites between California and Alaska. Few (8%) returned to the airport; of those that returned, the farthest release sites were at Victoria and Bellingham, Washington, about 64 km away.

Northern Saw-whet Owl (*Ageolius acadicus*)

Uncommon resident. Breeds.

Occurrence: The Northern Saw-whet Owl frequents shrub thickets, especially bordering sloughs and marshes, thick groves and woodlands, and ornamental shrubs and trees in parks and residential areas. This species, because of its nocturnal habits, generally goes unnoticed in the delta, and its status needs clarification. Most information on migration periods comes from banding and recorded kills by traffic along main highways. The spring movement is uncertain. In autumn, there appears to be a movement from mid-October to early November. Few remain in winter. Christmas counts: Ladner — single birds recorded four times; White Rock — maximum 10 in 1977, average 1.

Breeding habits: Only two records exist: a clutch of four eggs in an apple tree on Sea Island on 15 April 1965, and three eggs in a nest box near Serpentine River on 3 April 1978.

CAPRIMULGIDAE: Goatsuckers

Common Nighthawk (*Chordeiles minor*)

Uncommon summer. Breeds.

Occurrence: The Common Nighthawk is widely distributed throughout the delta and found roosting on fence posts, beach logs, buildings at Iona Island, jetties and dead trees. Most birds arrive in early June and depart in early September. Extreme dates are 25 May and 7 October.

Breeding habits: Sand dunes, cultivated fields, gravel roads in dikes and jetties are preferred nesting sites. Nests with eggs have been found from 18 June to 14 July. Seven of eight nests contained two eggs, the other, one.

APODIDAE: Swifts

Black Swift (*Cypseloides niger*)

Fairly common summer.

Occurrence: The Black Swift is widely distributed. On fair-weather days, Black Swifts fly high in the air and are hard to detect. They are seen at much lower heights during dull or rainy weather. Movements and aggregations correspond with cyclone passage (Udvardy 1954). Spring arrival occurs in mid-May, autumn departure in mid- to late September. Extreme dates are 8 May and 26 September. Flocks of approximately 200 birds are occasionally seen during the second and third weeks of June. Most aggregations are from the vicinity of Sea and Iona islands.

Vaux's Swift (*Chaetura vauxi*)

Fairly common summer.

Occurrence: Widespread over most habitats, the Vaux's Swift shows a preference for large sloughs, rivers, open woodlands and shrubby fields. In spring, flocks are often large (400+ birds) and most evident during cloudy weather. Most birds arrive from late April to mid-May. Small numbers of swifts are present each summer. Autumn migration occurs mostly in September, when flocks are seldom larger than 20 birds. Extreme dates are 30 April and 29 September.

TROCHILIDAE: Hummingbirds

Anna's Hummingbird (*Calypte anna*)

Rare summer; *uncommon* winter.

Occurrence: During the past 15 years or so, this hummingbird has extended its range along the Pacific coast from California to southwestern British Columbia (Zimmerman 1973). It became established in the Fraser River valley in the early 1970s (Campbell *et al.* 1972*a*, 1974) and spread throughout the delta during the next decade. It has now been recorded in every month, mostly in the vicinity of gardens and houses with hummingbird feeders. Breeding has not been confirmed. Most records are from November to January in Tsawwassen, White Rock and Ladner. Christmas counts: White Rock — maximum 11 in 1982, average 4.

Rufous Hummingbird (*Selasphorus rufus*)

Fairly common spring; *uncommon* summer. Breeds.

Occurrence: The Rufous Hummingbird frequents any habitat that has nectar-bearing plants, especially during spring migration. First spring migrants arrive in late March; the peak movement occurs in mid-April. Males arrive ahead of females, usually by two weeks. The autumn migration is not as well pronounced and probably occurs mostly during the first half of September. Extreme dates are 23 March and 3 October.

Breeding habits: The Rufous Hummingbird breeds throughout the area in shrubs and bushes and edges of coniferous woodlands. Nests with eggs have been found from 25 April to 26 June; peak egg-laying occurs in early June.

ALCEDINIDAE: Kingfishers

Belted Kingfisher (*Ceryle alcyon*)

Uncommon resident. Breeds.

Occurrence: The Belted Kingfisher is widespread, usually singly, in a variety of freshwater, brackish water or marine habitats, including sloughs, rivers, estuaries, sheltered bays and even large ditches where small fish are available. There is no information available on seasonal occurrence. Christmas counts: Ladner — maximum 10 in 1978, average 5; White Rock — maximum 16 in 1974, average 8.

Breeding habits: One record exists: Nicomekl River, 7 June 1958 — eggs.

PICIDAE: Woodpeckers

Red-breasted Sapsucker (*Sphyrapicus ruber*)
Rare resident. Breeds.
Occurrence: The Red-breasted Sapsucker frequents all woodland habitats, but prefers stands of alder and cottonwood. It is seen primarily during winter, when up to four birds may be sighted at one time. Most records are from the eastern end of the study area near White Rock. Christmas counts: Ladner — maximum 10 in 1983, average 1; White Rock — maximum 14 in 1978, average 2.
Breeding habits: One record exists: Tsawwassen, 24 June 1966 —young in nest.

Downy Woodpecker (*Picoides pubescens*)
Fairly common resident. Breeds.
Occurrence: The Downy Woodpecker prefers riparian woodlands, especially along sloughs and rivers, but is widespread wherever tall shrubs and trees are found. In winter, most records are from feeders in residential areas. Christmas counts: Ladner — maximum 37 in 1970, average 17; White Rock — maximum 49 in 1977, average 24.
Breeding habits: The Downy Woodpecker prefers open woodlands or areas with scattered deciduous trees, such as dikes, orchards, parks and residential areas. On ANWA, breeding birds were calculated at 0.6 per kilometre (Table 11). Nest excavation begins in late March and early April. Most egg-laying occurs in late May. Clutches (N = 16) range from four to five eggs. The date for the latest brood (in nest cavity) was 7 August 1962.

Hairy Woodpecker (*Picoides villosus*)
Rare resident. Breeds.
Occurrence: The Hairy Woodpecker is widespread in small numbers in mature, open woodlands, tall conifers and deciduous trees along dikes and sloughs. In winter, it uses a variety of trees in residential areas. No information on seasonal migration or dispersal patterns is available. Christmas counts: Ladner — maximum 4 in 1968, average 1; White Rock — maximum 14 in 1984, average 6.
Breeding habits: The Hairy Woodpecker prefers open mature woodlands — deciduous, conifers or mixed. Adults have been seen excavating nest holes in late April. There are only two breeding records, both from nests containing an unknown number of young: Westham Island, 11 June 1962, and White Rock, 18 June 1965. One nest was in a red alder, the other in a black cottonwood.

Northern Flicker (*Colaptes auratus*)
Uncommon summer; *fairly common* winter. Breeds.
Occurrence: The Northern Flicker prefers any habitat with trees, as well as open areas such as cultivated fields and log beaches. The seasonal pattern is not well understood. There appears to be a spring movement in April, when aggregations of up to 12 birds are seen towards the eastern edge of the delta. Autumn migration is not pronounced. In winter, flickers are more widely distributed and frequent a greater variety of habitats than in summer. Christmas counts: Ladner — maximum 155 in 1975, average 76; White Rock — maximum 125 in 1974, average 78.
Breeding habits: The Northern Flicker prefers sparsely wooded areas, often bordering dikes, sloughs and farmlands. Bird boxes are frequently used. Eggs have been found from 6 May to 13 July. Most clutches are laid during the last week of May and first week of June. Clutch sizes (N = 31) ranged from one to nine eggs; most had three to six eggs. Latest fledged young was in late August.

Remarks: Both forms are most evident during the winter months. The ratio of "red-shafted" to "yellow-shafted" to "hybrid" flickers for the greater Vancouver area (including the Fraser River delta) was 431:10:20 in 1971 and 409:10:39 in 1972 (Campbell *et al.* 1972*a*, 1974). Most yellow-shafts are probably *C. a. borealis*; some winter red-shafts are likely *C. a. collins* (R.J. Cannings, pers. commun.).

Pileated Woodpecker (*Dryocopus pileatus*)
Rare local resident. Breeds.
Occurrence: The Pileated Woodpecker frequents woodlands, mostly in the vicinity of White Rock. It casually visits the lower areas of the delta in spring and winter. There is no information on seasonal movements and population size, although annual Christmas counts suggest stable populations. Christmas counts: Ladner — maximum 6 in 1960, average 1; White Rock — maximum 12 in 1979, average 7.
Breeding habits: The only evidence of breeding is from White Rock in early July 1966, when adults were observed feeding at least two young in a nest hole high in a big-leaf maple tree. There have been other reports of adults at nest holes near the Nicomekl River, Ladner and Tsawwassen from early May through July, but nest contents were unknown.

TYRANNIDAE: Tyrant Flycatchers

Olive-sided Flycatcher (*Contopus borealis*)
Rare transient.
Occurrence: On the southwest mainland coast of British Columbia, this species frequents mountainous areas and is only rarely encountered in the Fraser River delta. There is, however, a noticeable migratory movement. In spring, the Olive-sided Flycatcher is seen, usually singly, from late April through May, and in autumn, in late August and early September. Extreme dates are 30 April and 16 September.

Western Wood-Pewee (*Contopus sordidulus*)
Uncommon transient; *rare* summer. Breeds.
Occurrence: During migrations, this species frequents almost any habitat with trees. The GRMBS and ANWA are preferred locations. Spring migrants arrive in mid-May; autumn departure occurs in early September. Extreme dates are 24 April and 19 September.
Breeding habits: The Western Wood-Pewee breeds in riparian woodland habitats through the delta. At ANWA, the number of breeders per kilometre was calculated to be 1.1 birds (Table 12), highest of the tyrannids. Eggs are laid in late June and early July.

Willow Flycatcher (*Empidonax traillii*)
Uncommon summer. Breeds.
Occurrence: Migrants frequent all habitats with trees and tall shrubs, but prefer those bordering waterways and open fields or marshes. Spring migrants arrive during the last week of May and first week of June, when up to 10 birds may be seen in appropriate habitat. In autumn, most birds depart in late August and early September. Extreme dates are 7 May and 8 September.
Breeding habits: The Willow Flycatcher breeds in shrubs and small trees in riparian locations and less frequently in fence rows bordering farmlands. Most eggs are laid in the latter half of June.

Hammond's Flycatcher (*Empidonax hammondii*)
Probably *fairly common* transient; *rare* summer. Probably breeds.

Occurrence: The status of this flycatcher remains uncertain. There are usually fewer than 10 reports each year. It is found mostly in coniferous and mixed coniferous/deciduous woodlands. Most spring records are for early to mid-May. In autumn, departure probably occurs in late August and early September. In summer, there are records from widespread areas, but breeding has not been confirmed. Extreme dates are 29 April and 15 September.

Western Flycatcher (*Empidonax difficilis*)
Fairly common migrant; *uncommon* summer. Breeds.

Occurrence: The Western Flycatcher frequents coniferous and deciduous woodlands, especially near sloughs, backwaters and rivers. Most birds arrive in late April and depart in late August. Extreme dates are 17 April and 7 October.

Breeding habits: The Western Flycatcher probably breeds in sizeable woodlands throughout the delta, but only one record exists: a nest containing four eggs was found in Ladner on 18 June 1949.

Say's Phoebe (*Sayornis says*)
Rare spring transient.

Occurrence: The Say's Phoebe frequents open spaces throughout the delta where bushes, buildings, fence posts and small trees provide hunting perches. Single birds are most often seen along log-littered beaches. Extreme dates are 9 March and 18 May.

Eastern Kingbird (*Tyrannus tyrannus*)
Rare summer. Breeding suspected.

Occurrence: The Eastern Kingbird has been recorded in shrubs bordering agricultural fields, sloughs, ponds and, infrequently, parks. Most birds are reported in late May to early June and in early September. Extreme dates are 30 May and 6 September.

ALAUDIDAE: Larks

Horned Lark (*Eremophila alpestris*)
Uncommon transient; *rare* winter. Local breeder.

Occurrence: The Horned Lark is found on bare ground, especially in disturbed areas, including cultivated fields, sand dunes, beaches and short-grass fields. It is most often seen on Sea Island, Westham Island and Boundary Bay. It has been recorded in every month, but numbers and occurrence fluctuate greatly each year, so that migration periods are not well known. Largest numbers are reported from mid-February to mid-March, July, September and December. Christmas counts: Ladner — maximum 108 in 1964, average 35.

Breeding habits: Nesting populations in the delta are the subspecies *E. a. strigata* (Henshaw). Numbers are small and local, being restricted to short-grass fields of Sea Island, formerly Lulu Island, and probably in the vicinity of the Boundary Bay Airport. The last nest with eggs reported was on Sea Island on 25 May 1970 (Campbell *et al.* 1972*a*). Two fledged young were seen on Sea Island in late July 1978, and nesting was suspected in 1981 when an adult flushed from a field on 11 June. However, there have been no reports of adults or young during the past 5 years. Preservation of dry, short-grassed fields appears crucial for retaining breeding larks.

HIRUNDINIDAE: Swallows

Tree Swallow (*Tachycineta bicolor*)
Abundant spring; *fairly common* summer. Breeds.

Occurrence: The Tree Swallow frequents a variety of habitats associated with fresh and brackish waters, such as marshes, lagoons, rivers and sewage lagoons. Most spring migrants arrive in March, with peak numbers occurring late in the month. For example, at ANWA in 1985, 199 Tree Swallows were counted on 17 days between 21 February and 6 April. The percentages present in each week were: 21–28 February, 1.8%; 1–7 March, 4.5%; 8–14 March, 24.1%; 15–21 March, 33.9%; 22–30 March, 17.9%; 1–6 April, 17.9%. A peak (50 birds) occurred on 17 March. Autumn departure occurs mostly in August. Extreme dates are 17 February and 24 September.

Breeding habits: In 1986, eggs were laid in 30 nest boxes on ANWA from 10 May to 8 June. The mean clutch size was 4.5 eggs (SD = 0.9, N = 30). Holes in trees are also used.

Violet-green Swallow (*Tachycineta thalassina*)
Abundant spring; *fairly common* summer. Breeds.

Occurrence: In spring, it can be found over most habitats, but large aggregations are associated with water and usually with cloudy weather. Early migrants may appear in late February, but most pass through in late March and early April. For example, at ANWA in 1986, 1128 Violet-green Swallows were counted from 21 February to 6 April. The percentages present in each week were: 21–28 February, 0.3%; 1–7 March, 3.3%; 8–14 March, 6.6%; 15–21 March, 9.2%; 22–30 March, 51.6%; 1–7 April, 29.0%. The largest number (N = 400 birds) occurred on 30 March. Migration often extends into mid-April (e.g., 340 seen at ANWA, 10 April 1966). Most depart in late August. Extreme dates are 26 February and 2 October. The GRMBS and ANWA are major staging areas in spring.

Breeding habits: The Violet-green Swallow prefers man-made structures, including under eaves in buildings, nest boxes and lamp standards, but also nests in snags. Extreme egg dates (N = 12) are 29 May and 26 June.

Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)
Uncommon summer. Breeds.

Occurrence: The Northern Rough-winged Swallow is widespread in small numbers (e.g., 6 on Iona Island, 8 April 1969). It is mostly seen with other spring flocks of swallows. Migrants arrive usually in late March and early April, and most depart by late August. Extreme dates are 26 March and 28 September.

Breeding habits: Small numbers breed locally along the North and South arms of the Fraser River, near the Serpentine River and in drainage pipes on bridge structures throughout the delta. Extreme egg dates (N = 3) are 16 and 27 May.

Bank Swallow (*Riparia riparia*)
Rare transient.

Occurrence: All records are of birds seen with concentrations of other migrating swallows. Spring numbers seldom exceed 3 or 4 birds; in autumn up to 40 may be seen. The few spring records occurred mostly in May and June (Poynter 1965, 1966). In autumn, a small movement is evident in late August through mid-September. Extreme dates are 8 May and 23 November (Campbell 1966).

Cliff Swallow (*Hirundo pyrrhonota*)

Locally *common* to *very common* summer. Breeds.

Occurrence: Widespread, the Cliff Swallow associates with other flocks of swallows during migrations, but often forages over cultivated fields and farmlands and along beaches and marshes. Most birds arrive in mid-April and depart in August. Extreme dates are 20 March and 23 October.

Breeding habits: All breeding sites are associated with man-made structures, including barns, silos, small bridges, houses and concrete industrial buildings. The largest known colony is 160 pairs on a barn at the ANWA. The season lasts from late April through early August. Mud-gathering commences in late April and early May. Egg-laying occurs mostly in late May and early June.

Barn Swallow (*Hirundo rustica*)

Very common summer; *very abundant* autumn; *casual* winter. Breeds.

Occurrence: The Barn Swallow occurs widely in all open situations. In spring, it shows a preference for brackish waters; in autumn, thousands roost in cattail marshes along dikes. Most spring migrants arrive in mid-April, with the peak influx occurring during the second and third weeks. Most have left by October, with the peak departure occurring from late August through early September (e.g., 3500+ resting in cattails, Ladner sewage pond, 2 September 1965; Poynter 1965). Extreme dates are 30 March and 22 November. Since 1970, up to four birds have infrequently wintered at GRMBS and ANWA. Christmas counts: Ladner — 4 in 1969, 1 in 1974.

Breeding habits: The Barn Swallow breeds in a wide variety of man-made structures that provide shelter from weather. It usually nests singly, but loose colonies of 20 or more pairs are found in some old large barns. Most nest-building commences about 7 May. Egg-laying occurs mainly from late May through early July (second broods), although complete clutches have been found from 6 May to 16 August. (The latter date probably represents deserted nests.) Clutch sizes (N = 171) ranged from three to eight eggs, with 62% having four or five eggs. The chronology of one double-brooded pair is of interest: 18 May, pair arrived; 20 May, nest completed; 28 May, first egg; 31 May, fourth egg; 14 June, first egg hatched; 17 June, three young; 5 July, three young fledge; 6 July, first egg of second brood laid in same nest; 31 July, four young now hatched; 20 August, young fledged; 30 August, all swallows gone.

CORVIDAE: Jays, Magpies, Crows and Ravens

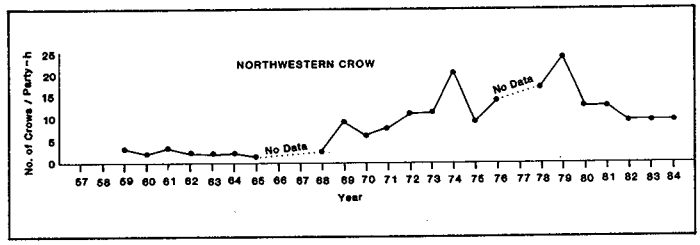
Steller's Jay (*Cyanocitta stelleri*)

Rare resident. Breeds.

Occurrence: The Steller's Jay prefers coniferous woodlands or mixed woodlands interspersed with large conifers. It has been recorded in all months, but numbers are small and populations localized. White Rock and Tsawwassen are centres of populations. There is no noticeable seasonal variation, although there is a slight dispersal to lower reaches of the delta in autumn. Christmas counts: Ladner — maximum 31 in 1971 and 1984, average 7; White Rock — maximum 138 in 1983, average 38.

Breeding habits: Only three records exist, all from the vicinity of Tsawwassen: 30 April 1954, four eggs; 12 May 1959, four eggs; 22 June 1966, three young.

Figure 5
Number of Northwestern Crows counted per party-hour on Christmas Bird Counts in Ladner, British Columbia. The Burns Bog garbage dump opened in 1965.



Northwestern Crow (*Corvus caurinus*)

Very common resident. Breeds.

Occurrence: Large numbers (2000+) frequent the garbage dump in Burns Bog and roost nearby in late summer. Small numbers feed in family groups in parks and along marine beaches, especially near White Rock, Boundary Bay and Tsawwassen. Winter roosts break down in February. Christmas counts: Ladner — maximum 3672 in 1979, average 1011; White Rock — maximum 7380 in 1978, average 3480.

Breeding habits: The Northwestern Crow nests mainly in tall shrubs and trees near residential areas, parks and beaches. Egg-laying in first attempts on Mandarte Island, about 40 km south of the Fraser River delta, began on 16 April and ended on 9 May; second attempts extended to 31 May (Butler *et al.* 1984). The mean clutch size on Mandarte Island was 4.0 eggs (N = 67), from which a mean of 1.6 young successfully fledged. However, clutches on islands are often smaller than those of mainland populations, and clutches of up to six eggs have been reported from the Fraser River delta (BCWRS). Young leave the nest in June, and large postbreeding flocks begin to form by late July.

Remarks: With the opening of the garbage dump in Burns Bog in 1965, the number of crows counted on CBCs increased about fivefold (Fig. 5). In summer, crows forage on beaches near White Rock, Centennial Beach and Tsawwassen; few feed along Roberts and Sturgeon banks. In spring, flocks follow ploughs in farm fields.

Each summer the raucous calls of begging juvenile crows disturb the early-morning sleep of residents in and around the Fraser River delta, which prompts letters to editors of local newspapers calling for eradication of crows. Once the juveniles are independent and the postbreeding flocks become less visible in September, the complaints subside.

Common Raven (*Corvus corax*)

Uncommon resident. Breeds.

Occurrence: The Common Raven is widespread and frequents woodlands, Burns Bog, garbage dumps, beaches, mud and sand flats and farmlands. One or two birds are usually seen throughout the year, except in the vicinity of garbage dumps. There are no apparent seasonal fluctuations in numbers or habitat used. A noteworthy flock of soaring birds was reported at Burns Bog (30 on 16 May 1971). Christmas counts: Ladner — maximum 27 in 1980, average 6; White Rock — maximum 14 in 1978 and 1980, average 5.

Breeding habits: No nests have been located, but fledged young being fed by adults have been reported from Delta (12 June 1944), Tsawwassen (June 1958), White Rock (31 May 1979) and on Arthur Laing bridge (Sea Island; May 1981).

PARIDAE: Chickadees

Black-capped Chickadee (*Parus atricapillus*)
Fairly common resident. Breeds.
Occurrence: Widespread, the Black-capped Chickadee frequents all types of woodlands, tall thickets of willow and alder and fence rows in wet and dry locations. It prefers edges along waterways. Trees and shrubs in residential areas are used more in winter. Foraging flocks are noticeable in late summer and early autumn, when they mix with kinglets, nuthatches, warblers and creepers. In winter, flocks are largest (e.g., 20+ birds) and composed mainly of chickadees. Christmas counts: Ladner — maximum 467 in 1974, average 238; White Rock — maximum 788 in 1980, average 567.
Breeding habits: The Black-capped Chickadee breeds in almost any type of woodland, but prefers more open areas with scattered trees. Nest boxes are used. Nest-building commences in April, and most eggs are laid in May. Extreme egg dates (N = 11) are 18 April and 29 June. Clutch sizes ranged from 5 to 10 eggs, with 52% having 6 to 8 eggs.

Chestnut-backed Chickadee (*Parus rufescens*)
Fairly common resident. Breeds.
Occurrence: The Chestnut-backed Chickadee prefers coniferous woodlands and drier locations than does the Black-capped Chickadee. Most records are from the vicinity of Ladner and Point Roberts. Flocks of up to 30 birds occur in August and September, when they flock with other songbirds. In winter, foraging flocks are slightly larger and usually species-specific. Christmas counts: Ladner — maximum 126 in 1980 and 1984, average 27; White Rock — maximum 218 in 1980, average 95.
Breeding habits: All nests have been located in mixed woodlands, but with a predominance of conifers. Most egg-laying occurs in May. Extreme egg dates (N = 4) are 2 May and 14 June.

AEGITHALIDAE: Bushtit

Bushtit (*Psaltriparus minimus*)
Common resident. Breeds.
Occurrence: The Bushtit frequents a wide variety of habitats throughout the delta, including riparian woodlands and thickets, residential areas, parks and shrub fence rows. Winter flocks disband by early March, and post-breeding flocks are noticeable again in mid-July. During the nonbreeding season they forage in flocks of about 15-40 individuals. Christmas counts: Ladner — maximum 459 in 1980, average 134; White Rock — maximum 534 in 1980, average 213.
Breeding habits: The Bushtit nests in open deciduous woodlands with tall understory, patches of willows and young alders and in residential areas. Nests are built in March and early April. Most egg-laying occurs in April. Extreme egg dates (N = 23) are 22 March and 13 May.
Remarks: During the past 80 years or so, the Bushtit has extended its range northward along the Pacific coast into southern British Columbia. It is currently widespread and resident in the lower Fraser River valley. Butler (1981*a*) suggested that the range extension and increase may be due to increased availability of open woodlands and a general warming trend along the Pacific coast that allowed populations to become established.

SITTIDAE: Nuthatches

Red-breasted Nuthatch (*Sitta canadensis*)
Rare resident; *uncommon* autumn. Breeds.
Occurrence: The Red-breasted Nuthatch prefers woodlands with coniferous trees in parks, residential areas, along dikes and in large tracts of forest. Nuthatches are scarce most years in January and February, but small numbers of 8-10 individuals flock together throughout the delta in September and early October. By mid-October these flocks have disbanded. Christmas counts: Ladner — maximum 16 in 1982, average 6; White Rock — maximum 9 in 1971, 1977 and 1983, average 4.
Breeding habits: One record exists: Ladner, 25 May 1949 — adult carrying food to nest hole.

CERTHIDAE: Creepers

Brown Creeper (*Certhia americana*)
Rare resident. Breeds.
Occurrence: The Brown Creeper has been recorded in every month, especially in denser woodlands where large trees such as Douglas firs have loose or deep-pitted bark. Patterns of occurrence and abundance are unknown. Birds may gather in coastal areas in winter (e.g., 13 on Westham Island, 19 December 1959). They are frequently found in foraging flocks of mixed songbird species in early autumn (e.g., 7 in White Rock, 11 September 1978). Christmas counts: Ladner — maximum 21 in 1984, average 8; White Rock — maximum 28 in 1979, average 13.
Breeding habits: Two records exist: GRMBS, 10 April 1969 — eggs present; Ladner, 3 May 1976 — four young in nest.

TROGLODYTIDAE: Wrens

Bewick's Wren (*Thyromanes bewickii*)
Uncommon resident. Breeds.
Occurrence: The Bewick's Wren is widespread, but prefers edges of riparian woodlands, hedgerows, parks and patches of shrubs bordering agricultural fields. Small numbers live in residential areas where dense hedges are found. There appears to be no seasonal pattern, and groups of four to six birds can be seen in every month. Christmas counts: Ladner — maximum 90 in 1984, average 43; White Rock — maximum 89 in 1979, average 54.
Breeding habits: The Bewick's Wren prefers hedges, thickets and brushy places bordering open spaces. It also uses nest boxes and old buildings. Most egg-laying occurs in April. Extreme egg dates (N = 14) are 28 March and 7 June. Clutch sizes range from four to eight eggs.
Remarks: Bewick's Wrens appear to be susceptible to prolonged freezing temperatures.

Winter Wren (*Troglodytes troglodytes*)
Fairly common resident. Breeds.
Occurrence: The Winter Wren prefers dense coniferous forests, but frequents a variety of riparian woodlands, wooded dikes and residential areas. Concentrations occur only from mid-September to mid-October, when flocks of 10-12 individuals may be seen. Tsawwassen and White Rock are centres of abundance. Christmas counts: Ladner — maximum 94 in 1982, average 41; White Rock — maximum 116 in 1978, average 51.
Breeding habits: Nests have been found in dense coniferous and mixed woodlands. Nests are situated among roots of upturned trees and in moss on stumps. Most egg-

laying occurs in April. Extreme egg dates (N = 18) are 2 April and 18 May. Clutch size ranges from four to eight eggs.

Marsh Wren (*Cistothorus palustris*)

Common summer; *uncommon* winter. Breeds.

Occurrence: The Marsh Wren prefers foreshore and riverine marshes and wet upland fields. It is most often seen in brackish marshes near the mouth of the Fraser River. Christmas counts: Ladner — maximum 73 in 1976, average 23; White Rock — maximum 13 in 1980, average 4.3.

Breeding habits: Large numbers nest in cattail and *Scirpus* marshes in the upper foreshore marshes. Eggs are laid in early April through early August (Picman 1980*a*). Nestlings appear from mid-April through late August.

Picman (1977, 1980*a*, 1980*b*, 1980*c*) studied the interaction of Marsh Wrens and Red-winged Blackbirds in the foreshore marshes at the GRMBS. There were 16 territories on about 14 ha in 1976 and 17 males on about 16 ha in 1977. The pooled data for the 2 years revealed that males defended territories averaging 9080 m^2 (nearly 1 ha) in size (SD = 4080, N = 30) and 4.6 females (SD = 1.9, N = 34) in their harems. They built 399 nests, of which 94 (23.5%) successfully fledged nestlings. In 1976, predation was highest in April (82.6%, N = 23 nests) followed by May (69.6%, N = 56) and June (59.6%, N = 47). In 1977, 53.2, 75.4 and 54.5% of 47, 69 and 33 nests were destroyed by predators.

Picman (1980*a*) believed that interference between wrens and blackbirds has evolved to reduce competition in cattail marshes. He found that Marsh Wrens were most disruptive to blackbirds in dense cattails, whereas Red-winged Blackbirds were most disruptive to wrens in more sparsely vegetated areas of the marsh.

Breeding populations of Marsh Wrens and Red-winged Blackbirds in the Fraser River delta are the largest known concentrations in coastal British Columbia.

MUSCICAPIDAE: Kinglets, Thrushes and Allies

Golden-crowned Kinglet (*Regulus satrapa*)

Common resident. Breeds.

Occurrence: Golden-crowned Kinglets are most widespread in winter, when they are frequently found in flocks of 50 or more individuals in mixed coniferous and deciduous woodlands. Riparian shrub and tree habitats, parks and residential areas are also visited. Christmas counts: Ladner — maximum 547 in 1980, average 189; White Rock — maximum 611 in 1974, average 340.

Breeding habits: Two records exist of adults feeding recently fledged young: White Rock, 30 May 1977, and Ladner, 5 June 1968.

Ruby-crowned Kinglet (*Regulus calendula*)

Fairly common transient; *rare* summer; *uncommon* winter.

Occurrence: The Ruby-crowned Kinglet frequents all woodland habitats in both wet and dry locations. It is most numerous in riparian habitats, especially willows and alders bordering sloughs, ditches and marshes. Spring migration occurs from mid-March to mid-May, with peak movement in April. In summer, very small numbers are widely scattered, mostly in open woodlands. Autumn migration is evident from early September through early November, with peak passage in October. Groups are rarely larger than 20 individuals. It is scarce in January and February. Christmas counts: Ladner — maximum 117 in 1984, average 35; White Rock — maximum 125 in 1978, average 40.

Townsend's Solitaire (*Myadestes townsendi*)

Rare resident.

Occurrence: The Townsend's Solitaire has been recorded in the delta in every month of the year, but summer occurrences are infrequent. Most records are of single birds from scrubby and open woodlands adjacent to open country. It is frequently sighted along wooded portions of dikes and beaches. Christmas counts: Ladner — 1 in 1974.

Mountain Bluebird (*Sialia currucoides*)

Rare spring; *very rare* autumn; *very rare* winter.

Occurrence: The Mountain Bluebird frequents open country, including agricultural fields, beaches and dikes. Very small numbers are seen in the delta each spring, mostly in April. Extreme dates are 20 March and 30 April. In autumn, birds are reported infrequently in late October and early November. During mild winters, small numbers remain in the delta. For example, during the winter of 1982–83, two females and one male were found at Boundary Bay from 5 December to 17 March (Weber *et al.* 1983).

Swainson's Thrush (*Catharus ustulatus*)

Fairly common summer; *very rare* winter. Breeds.

Occurrence: During migration, the Swainson's Thrush frequents almost any habitat with dense undergrowth, including woodlands, edges of sloughs, parks and residential areas. Spring arrival occurs from late April through late May, the main arrival period being the second and third weeks of May. In autumn, most birds depart by mid-September. Extreme dates are 24 April and 2 October. Single birds are infrequently reported from scattered areas in winter. Christmas counts: White Rock — 1 in 1975.

Breeding habits: The Swainson's Thrush prefers riparian woodlands. Most egg-laying occurs in June. Extreme egg dates (N = 14) are 28 May and 1 July. Clutch sizes range from three to five eggs.

Hermit Thrush (*Catharus guttatus*)

Uncommon summer; *very rare* winter. Breeds.

Occurrence: The Hermit Thrush prefers mixed coniferous/deciduous woodlands with dense plant cover (e.g., understory). It is most often seen along edges. It also frequents riparian woodlands, parks and residential shrubbery. Spring migration may occur from mid-March through late May, but is most noticeable in mid- to late April. The autumn departure occurs from mid-September through early November. Extreme dates are 13 March and 16 November. One or two birds are reported most winters. Christmas counts: Ladner — 1 on five occasions from 1964 to 1984; White Rock — 1 in 1974, 2 in 1982 and 1984.

Breeding habits: There is one confirmed record, although small numbers probably breed wherever mixed deciduous/coniferous or pure coniferous woodlands are found. On 30 June 1964, a nest with four young was located in a small conifer near Crescent Beach.

American Robin (*Turdus migratorius*)

Abundant summer; *common* winter. Breeds.

Occurrence: In migration, the American Robin prefers agricultural areas, residential areas, parks and riparian habitats. In winter, it roosts in alder and willow woodlands and vacant lots. Numbers fluctuate greatly each year, but it is mainly a summer bird (Campbell *et al.* 1972*a*). Spring migration usually occurs from mid-February through mid-April. In some years, flocks of over 1000 individuals are not uncommon. In autumn, flocks are in the low hundreds and are seen mostly from late September to early October. The American Robin is widespread in winter but collects in large nighttime roosts (e.g., 508 on Sea Island, 20 January 1972). Christmas counts: Ladner — maximum 1416 in 1961, average 827; White Rock — maximum 1153 in 1975, average 533.

Breeding habits: The American Robin prefers open riparian deciduous woodlands, fence rows, scrub and thickets, residential areas and parks. It is the most abundant nesting songbird on the ANWA (Table 11). Eggs may be found from late March to late July, but most egg-laying occurs in April and May. Extreme egg dates (N = 264) are 26 March and 30 July. Clutch sizes ranged from one to seven eggs, with 62% having three to five eggs. Of 11 known cases of predation of robin nests on the University of British Columbia campus, adjacent to the Fraser River delta, 7 were by Northwestern Crows, 2 by raccoons (*Procyon lotor*) and 1 each by Common Raven and Douglas squirrel (*Tamiasciurus douglasii*) (McLean *et al.* 1986).

Varied Thrush (*Ixoreus naevius*)

Uncommon summer; *fairly common* winter. Breeds.

Occurrence: The Varied Thrush is most numerous in coniferous and mixed coniferous/deciduous woodlands in the vicinity of White Rock and Tsawwassen. Migration periods are not as well pronounced in the delta as on local mountains. In spring, small numbers pass through from mid-March to mid-May, with April the peak month. In autumn, movement is noticeable from about mid-September to mid-October. Birds are widespread in November and December and become scarce in January and February. During years of heavy snowfall in the mountains, thousands of Varied Thrushes invade the delta and are regularly seen in residential areas. Christmas counts: Ladner — maximum 108 in 1983, average 32; White Rock — maximum 222 in 1977, average 75.

Breeding habits: There are only three records for the study area, all of adults feeding young in the vicinity of White Rock: 7 May 1942, three young in nest; 26 May 1975, two young; 2 June 1965, one fledged young.

MOTACILLIDAE: Pipits

Water Pipit (*Anthus spinoletta*)

Common to *very common* transient; *uncommon* winter.

Occurrence: The Water Pipit frequents open country, but prefers agricultural land, beaches, short-grass fields, exposed shores of the Fraser River and adjacent sloughs, and lawns in parks and golf courses. Spring migration occurs from early April through mid-May and peaks during late April and early May. The autumn movement occurs from early September through mid-November and peaks around the third week of September. Flocks during both passages can reach 400 individuals. Small numbers are seen each winter, but many may be overlooked because of their habit of feeding in large agricultural fields. Christmas counts: Ladner — maximum 317 in 1962, average 44; White Rock — maximum 5 in 1976, average 84.

BOMBYCILLIDAE: Waxwings

Cedar Waxwing (*Bombycilla cedrorum*)

Fairly common summer; *uncommon* winter. Breeds.

Occurrence: The Cedar Waxwing frequents a wide variety of open and sparse woodlands along dikes, boulevards, residential areas, riparian locations and edges of farmlands. Waxwings arrive in late May and early June and depart mostly in September. Few are seen after late October, although in some years small numbers remain throughout the winter in the vicinity of berry trees. Christmas counts: Ladner — maximum 29 in 1982, average 5; White Rock — 55 in 1971, also recorded in 1974, 1977 and 1983.

Breeding habits: The Cedar Waxwing prefers deciduous trees and shrubbery, often second growth. Nest-building occurs during the second and third weeks of June. Most egg-laying occurs during the latter half of June. Extreme egg dates (N = 13) are 4 June and 19 July.

LANIIDAE: Shrikes

Northern Shrike (*Lanius excubitor*)

Uncommon winter.

Occurrence: The Northern Shrike is widespread and prefers open areas with scattered trees and bushes for perches, especially close to agricultural land, and beaches. Most records are of single birds from the western edge of the delta. The maximum number recorded from one location is four. Most birds arrive during the first week of October and depart by mid-May. Extreme dates are 30 September and 22 May. Christmas counts: Ladner — maximum 30 in 1973, average 11; White Rock — maximum 14 in 1974, average 8.

Remarks: The ratio of adults to immatures is 1:1.

STURNIDAE: Starlings and Mynas

European Starling (*Sturnus vulgaris*)

Abundant summer; *very abundant* winter. Breeds.

Occurrence: The European Starling is widespread in farmlands, cultivated fields, residential areas including parks and golf courses and, in autumn, deciduous woodlots for roosting. The first postbreeding aggregations, composed mainly of juveniles, appear during the first half of June, at which time flocks may be several thousand birds. Man-made structures are preferred roosting sites in winter, but starlings continue to use autumn woodlot roosts during mild winters (e.g., 1840 birds at Serpentine River, 12 January 1970; Campbell *et al.* 1972*a*). Maximum numbers are noted in the autumn (September and October) when migrants from the interior of British Columbia arrive, although some of them migrate southward (Campbell *et al.* 1972*a*). By early April, large foraging flocks of winter disperse to breed. Christmas counts: Ladner — maximum 56 019 in 1969, average 12 762; White Rock — maximum 12 293 in 1983, average 7313.

Breeding habits: The European Starling breeds in many habitats which provide a cavity nest, including buildings, trees, nest boxes, bridges, drain pipes and lamp posts. Nest-building begins in mid-March, and most eggs are laid during early April. Mean clutch size (for first nestings) was 5.45 ± 0.12 eggs (N = 76) (Johnson and Cowan 1974). Second clutches are laid during mid- to late May.

Mean clutch size for second nestings was 4.73 ± 0.03 eggs (N = 32) (Johnson and Cowan 1974). Hatching and fledging successes for first clutches (N = 76 nests) were 84 and 75%, respectively, and for second clutches (N = 32 nests) were 69 and 71%, respectively (Johnson and Cowan 1974).

Remarks: The invasion of the starling into British Columbia from 1947 to 1957 is discussed by Myres (1958). Once established in southern coastal areas, the starling became sedentary. S.R. Johnson (1974) showed that birds breeding farther north migrate through the Fraser River delta in spring and autumn, supporting earlier statements by Campbell *et al.* (1972*a*) that aggregations build up to 200 000 birds in early fall and large numbers leave the area in October. This migration is most noticeable from Point Roberts.

Crested Myna (*Acridotheres cristatellus*)

Uncommon local resident. Breeds.

Occurrence: The Crested Myna is found mostly in open areas where they forage in cultivated lands and urban and residential habitats. Populations are local and resident, with little spread or dispersal annually (S.R. Johnson 1974). Centres of abundance are situated on the western and extreme eastern ends of Lulu Island. Numbers are declining, because of lack of adaptation in incubation rhythm necessary for high hatching, the low-protein diet fed to nestlings and poor nest attentiveness by adults (Johnson and Cowan 1974). Christmas counts: Ladner — maximum 300 in 1963, average 52.

Breeding habits: The Crested Myna uses cavities in man-made structures (e.g., buildings, nest boxes, pilings), but prefers natural cavities (Mackay and Hughes 1963). Crested Mynas are strongly nest-site tenacious (Johnson and Cowan 1974), and prenesting activity begins about mid-March. First clutches are laid during April, and second clutches are scattered from late May through early August. Mean clutch size for first clutches (N = 31) was 4.85 ± 0.80 eggs, and for second clutches was 3.83 ± 0.47 eggs (Johnson and Cowan 1974). Hatching success for first and second clutches was 61% (32 nests) and 58% (5 nests), respectively, and fledging success was 46 and 35%, respectively.

Remarks: The Crested Myna was introduced into British Columbia in 1897 (Cumming 1925). In the 1920s, populations peaked at an estimated 20 000 birds (Kelly 1927) and remained relatively stable (Scheffer 1931) until the 1930s, when first declines were suggested (Cumming 1932). In 1955, the population was estimated at 4000 birds (Johnson and Cowan 1974) and, by 1962, had decreased to 2000–3000 birds (Mackay and Hughes 1963). However, Johnson and Cowan (1974) estimated numbers of between 5000 and 6000 birds in 1971. During the next 15 years, numbers gradually decreased. In 1980, the greater Vancouver population was estimated to be 1000–2000 birds (Vancouver Natural History Society, unpubl. data).

VIREONIDAE: Vireos

Solitary Vireo (*Vireo solitarius*)

Rare summer. Breeding suspected.

Occurrence: The Solitary Vireo has been recorded from early April through mid-September, but mostly during migration periods. All records, of up to three birds, are from a wide variety of habitats with trees. The main spring movement occurs during the first half of April; autumn departure occurs during the first half of September. Extreme dates are 30 March and 20 September.

Hutton's Vireo (*Vireo huttoni*)

Local *rare* summer. Breeds.

Occurrence: The Hutton's Vireo is seen throughout the year locally in riparian habitats (e.g., sloughs). Most records are from Point Roberts and Westham and Reifel islands. Christmas counts: Ladner — maximum 13 in 1984, average 2; White Rock — maximum 2 in 1972 and 1978, average 1.

Breeding habits: One record exists: Crescent Beach, 18 June 1956 — nest with four eggs.

Warbling Vireo (*Vireo gilvus*)

Fairly common transient; *rare* summer. Breeds.

Occurrence: The Warbling Vireo frequents any habitat with trees or shrubs, but prefers mixed woodlands. Spring migrants arrive in early May and usually depart by early September. Extreme dates are 7 May and 19 September. The maximum number recorded was four at Point Roberts on 10 June 1966. Singing males (0.3/km) reside in summer at the ANWA (Table 11).

Breeding habits: One record exists from Point Roberts: 3 June 1958 — nest with eggs.

Red-eyed Vireo (*Vireo olivaceus*)

Rare summer. Probably breeds.

Occurrence: The Red-eyed Vireo frequents deciduous woodlots and tall-shrub areas throughout the delta, but numbers are very small. Records of one or two birds are mainly from late May to mid-August. Extreme dates are 12 May and 21 September.

EMBERIZIDAE: Wood Warblers, Tanagers, Grosbeaks, Blackbirds and Allies

Orange-crowned Warbler (*Vermivora celata*)

Common transient; *fairly common* summer; *very rare* winter. Breeds.

Occurrence: Migrants pass through all natural woodland habitats, as well as residential areas and along beaches. The main spring movement occurs from mid-April to mid-May, the autumn movement in September. The Orange-crowned Warbler is the fourth commonest spring migrant at the ANWA (Table 12). In spring, groups of 20–30 birds are not uncommon, especially in riparian situations. Extreme dates are 14 March and 14 November. Small numbers winter infrequently in widespread localities in the delta. Christmas counts: Ladner — maximum 2 in 1974 and 1979, recorded 5 times.

Breeding habits: Two records exist, both from Ladner in a cottonwood woodland: 17 May 1953 — eggs; 7 June 1978 — five eggs.

Yellow Warbler (*Dendroica petechia*)

Fairly common summer. Breeds.

Occurrence: The Yellow Warbler prefers riparian habitats, especially willows and alders bordering sloughs, large irrigation ditches, rivers and marshes. In migration, it is frequently seen in shrubs in residential areas. Migrants arrive in early May and usually depart by mid-September. The Yellow Warbler is the sixth commonest migrant songbird at the ANWA (Table 12). Extreme dates are 28 April and 27 September.

Breeding habits: The Yellow Warbler breeds in riparian woodlands, mostly in willows. Peak egg-laying occurs in late May and early June. Extreme egg dates (N = 9) are 17 May and 27 June.

Yellow-rumped Warbler (*Dendroica coronata*)

Abundant transient; *uncommon* summer; *rare* winter. Breeds.

Occurrence: Widespread in migration, the Yellow-rumped Warbler occurs anywhere there are trees or shrubs. It is most abundant in riparian habitats and shrubs adjacent to agricultural areas. Two subspecies occur in the delta — *D. c. coronata* is less numerous than *D. c. auduboni* (Table 12); seldom are groups of more than 50 *D. c. coronata* seen together. Spring migration occurs mostly from mid-April to mid-May, autumn migration from mid- to late September. Extreme dates are 9 April and 19 May. *Dendroica c. auduboni* is the most numerous wood-warbler in the Fraser River delta (Table 12). During migration "waves," groups of more than 500 have been reported. Arrival and departure times vary greatly from year to year. Spring migration can occur from mid-March to mid-May, but usually peaks in late April and early May. Autumn migration occurs from late August to late October, but usually peaks during mid- to late September. Extreme dates are 12 March and 7 November. Small numbers winter most years. Most winter records are from the vicinity of GRMBS and ANWA. Christmas counts: Ladner — maximum 34 in 1978, average 4; White Rock — maximum 8 in 1978, average 2.

Breeding habits: Four records exist of fledged young in Douglas fir trees at ANWA: 31 May 1968 — 1+ young being fed; 14 June 1979 — 1 young begging; June 1981 and 1986 — young being fed.

Black-throated Gray Warbler (*Dendroica nigrescens*)

Uncommon summer. Breeds.

Occurrence: The Black-throated Gray Warbler prefers open mixed woodlands with shrub understory, as well as riparian woodlands. It is widely distributed in small numbers (Table 12). Most migrants arrive during the latter half of April and depart during the first half of September. Extreme dates are 16 April and 26 September.

Breeding habits: The only record is of two recently fledged young at GRMBS on 15 July 1969.

Townsend's Warbler (*Dendroica townsendi*)

Uncommon summer; *very rare* winter. Probably breeds.

Occurrence: The Townsend's Warbler frequents a wide variety of woodlands during migration, but prefers stands with a predominance of conifers. Most migrants arrive in late April and early May and depart by mid-September. Extreme dates are 18 April and 9 October. Single birds are occasionally located in winter. Christmas counts: White Rock — 1 in 1978.

Remarks: There have been several reports of fledged young in the delta, none with supporting details.

MacGillivray's Warbler (*Oporornis tolmiei*)

Rare summer. Probably breeds.

Occurrence: The MacGillivray's Warbler frequents bushy areas bordering agricultural fields and mixed woodlands, thickets along sloughs and marshes and other areas with low vegetation. Most migrants arrive during early May and depart in early September. Extreme dates are 28 April and 25 September.

Remarks: Although there are convincing reports of adults with large fledged young, it is not known if they breed in the delta.

Common Yellowthroat (*Geothypis trichas*)

Fairly common summer; *casual* winter. Breeds.

Occurrence: The Common Yellowthroat prefers freshwater and brackish marshes, as well as riparian thickets. Most birds arrive during the latter half of April and depart during the first half of September. Extreme dates are 10 April and 30 September. There are four winter records. Christmas counts: Ladner — 1 in 1982.

Breeding habits: The Common Yellowthroat nests in clumps of grasses, cattails and hardhack under both wet and dry conditions. Most egg-laying occurs in May. Extreme egg dates (N = 5) are 16 May and 15 June.

Wilson's Warbler (*Wilsonia pusilla*)

Uncommon summer; *casual* winter. Breeds.

Occurrence: The Wilson's Warbler is widespread. It frequents a variety of habitats with trees or large shrubs and shows a preference, in the Fraser River delta, for riparian locations. This species is the second most abundant songbird migrant at the ANWA (Table 12). Spring migration is most noticeable in early May, when groups of 50 or more birds may be seen (e.g., 55 on Westham Island, 9 May 1973). Autumn migration is less pronounced. Most birds depart by early September. Extreme dates are 14 April and 7 November (both Point Roberts; Campbell *et al.* 1972*a*). There are four winter records. Christmas counts: Ladner — recorded in 1969 and 1979.

Breeding habits: Fledged young have been reported from Crescent Beach (July 1962), Ladner (late June 1966) and ANWA (30 June 1979).

Western Tanager (*Piranga ludoviciana*)

Uncommon summer.

Occurrence: Nearly all records are from migration periods in open, mixed woodlands. Most migrants arrive during mid-May and depart by early September. Extreme dates are 30 April and 20 September. Small numbers are present throughout the summer, but breeding has not been documented.

Black-headed Grosbeak (*Pheucticus melanocephalus*)

Fairly common summer. Breeds.

Occurrence: The Black-headed Grosbeak is widespread, but mostly in open second-growth deciduous (e.g., alder, maple) or mixed deciduous/coniferous woodlands, frequently near water. Most migrants arrive during mid-

to late May and leave in late August. Extreme dates are 8 May and 4 September.

Breeding habits: The Black-headed Grosbeak prefers alder and maple woodlands interspersed with conifers. Most egg-laying occurs in June. Extreme egg dates (N = 7) are 31 May and 10 July.

Rufous-sided Towhee (*Pipilo erythrophthalmus*)

Common resident. Breeds.

Occurrence: The population in the delta may contain both residents and migrants. In winter, woodland edges are preferred, as well as residential gardens with shrubs and feeders. At the ANWA, towhees are abundant in winter, but few remain to breed. In other seasons, brushy areas, riparian thickets, open woodlands and willow-alder associations, all with leaf litter, are utilized. Population size is unknown, but lowland areas of the Fraser River delta are the centre of abundance for this species in southwestern mainland British Columbia. Christmas counts: Ladner — maximum 286 in 1984, average 115; White Rock — maximum 286 in 1977, average 146.

Breeding habits: The Rufous-sided Towhee breeds in a variety of dry, open second-growth and brushy woodlands with some undergrowth. Most egg-laying occurs in May. Extreme egg dates (N = 11) are 29 April and 14 June.

American Tree Sparrow (*Spizella arborea*)

Rare winter.

Occurrence: The American Tree Sparrow frequents open areas where patches of scrub vegetation (e.g., dikes), weed plants, tall grasses and forbs are prevalent. It is infrequently found along beaches, especially on Iona and Sea islands and at Boundary Bay. It has been recorded from 20 October to 11 April. Christmas counts: Ladner — maximum 10 in 1979 and 1982, average 2; White Rock — maximum 3 in 1978, average 0.4.

Savannah Sparrow (*Passerculus sandwichensis*)

Abundant transient; *fairly common* summer; *rare* winter. Breeds.

Occurrence: The Savannah Sparrow frequents almost any open areas, but prefers agricultural fields, beaches, weedy areas, shores of sloughs and marshes and sewage lagoons. Spring migration is evident from mid-March to mid-May, but peaks from late April to early May, when flock size approaches 500 individuals. Autumn migration occurs from mid-September through October, with peak movement from late September to early October. Extreme dates are 13 March and 5 November. Small numbers are present most winters. Christmas counts: Ladner — maximum 8 in 1960, average 2; White Rock — maximum 3 in 1979, average 1.

Breeding habits: Nests are in open areas with grass or short vegetation. Most records are from Sea Island. Most egg-laying occurs in May. Extreme egg dates (N = 12) are 11 May and 17 June.

Remarks: The Fraser River delta is at the northern end of the breeding range of the race *P. s. brooksi* (American Ornithologists' Union 1957). Undoubtedly other races pass through the delta, but, as Grinnell (1939) mentioned, the taxonomy of western Savannah Sparrows is confusing. Hatler and Campbell (1975) showed a sex-segregated movement in spring for coastal migrants; males appear first in early May, followed by females.

Fox Sparrow (*Passerella iliaca*)

Fairly common winter.

Occurrence: The Fox Sparrow is found mostly along woodland edges where there is dense, low vegetation and plenty of leaf litter. Spring migration occurs mainly from mid-April to mid-May. Few birds linger into late May. Autumn migrants return in September. Extreme dates are 4 September and 10 June. The sparrow is widespread in winter. Christmas counts: Ladner — maximum 281 in 1984, average 79; White Rock — maximum 98 in 1984, average 35. The lower Fraser River delta is the most important wintering area on the southwestern mainland coast of British Columbia for this species.

Song Sparrow (*Melospiza melodia*)

Abundant resident. Breeds.

Occurrence: The Song Sparrow is widespread in dense, low vegetation along riparian woodlands, freshwater and brackish marshes, dikes; sewage lagoons, farmlands, residential areas, parks and drift-log beaches. It is the most abundant bird in these habitats throughout the Fraser River delta. At the ANWA, only the American Robin is more numerous (Table 11). The birds are resident (Knapton 1973), although there may be seasonal shifts. For example, in severe winters, birds may move into the delta from adjoining areas. Highest densities occur in the lower reaches of the study area. Christmas counts: Ladner — maximum 1355 in 1984, average 554; White Rock — maximum 495 in 1984, average 313.

Breeding habits: The Song Sparrow breeds in grassy, brushy and shrubby areas along or close to water courses such as ditches, edges of marshes and ponds, as well as hedgerows in agricultural and residential areas. Most egg-laying occurs from late April through May. Extreme egg dates (N = 18) are 13 April and 26 June.

Remarks: During research on Song Sparrows on Reifel Island, Knapton and Krebs (1976) found that adults were territorial for most of the year and that juveniles that obtained breeding territories were "the dominant individuals in dominance hierarchies established during the prebreeding season." In addition, Knapton and Krebs (1974) showed that the breeding density of Song Sparrows is limited by territorial behaviour. Much work has been done on Song Sparrows on Mandarte Island, about 40 km south of the Fraser River delta (Tompa 1964; Smith and Roff 1980; Smith 1981).

Lincoln's Sparrow (*Melospiza lincolnii*)

Uncommon transient; *casual* summer; *very rare* winter.

Occurrence: The Lincoln's Sparrow occurs in low underbrush in disturbed or edge situations, fence rows, open grass and weed areas interspersed with shrubs and, frequently, riparian patches of low shrubs. Spring migration occurs from late April through May, with peak movement in late April and early May. There are four summer records, all from Sea and Westham islands. Autumn migration is evident from late August through October, with most of the passage occurring in early to mid-September. Extreme dates are 25 March and 10 November. Small numbers winter infrequently. Christmas counts: Ladner — 8 in 1983, recorded eight times from 1957 to 1984; White Rock — 2 in 1981, 1 in 1973.

Golden-crowned Sparrow (*Zonotrichia atricapilla*)
Common transient; *very rare* summer; *fairly common* winter.

Occurrence: Golden-crowned Sparrows are often seen with White-crowned Sparrows, but tend to avoid more open areas, preferring brush along edges of woodlands, dikes, agricultural fields, parks and residential areas. Spring migrants pass through from mid-April to mid-May, with peak movement in very late April and early May, when flocks may number nearly 300 individuals. Occasionally, one or two birds remain in summer. The influx in autumn occurs from early September to about mid-October. Small numbers winter each year. Christmas counts: Ladner — maximum 135 in 1984, average 41; White Rock — maximum 37 in 1984, average 11.

White-crowned Sparrow (*Zonotrichia leucophrys*)
Abundant transient; *fairly common* resident. Breeds.

Occurrence: The White-crowned Sparrow is widespread. It prefers open areas, especially in agricultural and disturbed areas with weeds, patches of short grass or bare ground. It also frequents beaches and edges of woodlands. Spring migration has been reported from late March through mid-May. The peak period is probably during late April and May, when flocks of 200 or more individuals may be seen. Autumn migration occurs in September. The sparrows are widespread in winter, with local populations on Sea, Lulu and Westham islands. Christmas counts: Ladner — maximum 774 in 1975, average 231; White Rock — maximum 138 in 1973, average 52.

Breeding habits: The White-crowned Sparrow prefers open second-growth woodlands, patches of scrub adjacent to farmlands, willow thickets and hedgerows. It often nests in ornamental hedges in urban and residential areas. Egg-laying occurs mostly in May. Extreme egg dates (N = 24) are 30 April and 18 June.

Remarks: Most migrants are probably of the race *Z. l. gambeli*, whereas *Z. l. pugetensis* is the breeding subspecies.

Dark-eyed Junco (*Junco hyemalis*)
Uncommon summer; *abundant* winter. Breeds.

Occurrence: The Dark-eyed Junco frequents woodland edges adjacent to open areas, agricultural lands, residential areas, open ground along beaches and dikes and short grass and wide fields. Spring migration and dispersal occur in April, and only a few birds remain by mid-May. The main autumn influx occurs from mid-September to mid-October. Winter populations are probably established by December, when flocks can number 150 individuals. Christmas counts: Ladner — maximum 1191 in 1973, average 624; White Rock — maximum 1848 in 1977, average 1091.

Breeding habits: Nests have been located along the edges of open, mixed woodlands and in open shrub areas. Egg-laying occurs mainly from mid-April to mid-May. Extreme egg dates (N = 8) are 11 April and 14 June.

Remarks: Two races occur in the study area. The regular subspecies is *J. h. oreganus*. The gray race, *J. h. hyemalis*, is rare (0.1% of Dark-eyed Juncos on CBCs) and has been recorded, mostly as single birds, from 2 October to 28 April.

Populations in spring may be partly composed of migrants from wintering areas to the south. A male banded near Trent, Oregon, on 20 December 1969 was recovered in North Vancouver on 21 April 1970 (Campbell *et al.* 1972*a*).

Lapland Longspur (*Calcarius lapponicus*)
Uncommon transient; *rare* winter.

Occurrence: The Lapland Longspur is frequently seen in small numbers with Horned Larks and Snow Buntings in areas of bare soil or short grass. Most records are from Sea, Iona and Westham islands and Point Roberts. Spring migration has not been well defined because it is difficult to separate departing birds from migrants. Most birds depart by late March. One very late record exists: 1 on Iona Island, 31 May 1971 (Campbell *et al.* 1972*a*). In autumn, birds are present from early September to late October, with most records, and largest numbers, occurring from mid-September to mid-October. Small numbers are frequently seen in winter in lower reaches of the delta. Christmas counts: Ladner — 102 in 1963, recorded an additional four times from 1957 to 1984.

Snow Bunting (*Plectrophenax nivalis*)
Uncommon winter.

Occurrence: The Snow Bunting frequents open, often sandy, grassy or disturbed areas with some bare ground and patches of weeds. Most records are from Iona and Sea islands. Most birds depart by early March and arrive from mid- to late October. Numbers fluctuate greatly each year. Small numbers occur most winters somewhere in the delta. Extreme dates are 22 September and 4 May. Christmas counts: Ladner — maximum 44 in 1973, average 8; White Rock — 2 in 1979, also recorded in 1976, 1979 and 1984.

Red-winged Blackbird (*Agelaius phoeniceus*)
Common resident. Breeds.

Occurrence: Large flocks forage on agricultural lands, lawns in residential parks, golf courses, airports and stubble fields. Flocks of 300–600 birds are seen frequently from mid-November through mid-March, often with European Starlings and Brewer's Blackbirds. Winter flocks break up in March and April and build up again in late August and September. Largest flocks are seen on Westham Island, near Tsawwassen and in the vicinity of Boundary Bay. Christmas counts: Ladner — maximum 3075 in 1961, average 563; White Rock — maximum 537 in 1982, average 142.

Breeding habits: The Red-winged Blackbird breeds in freshwater and brackish marshes or in dense vegetation bordering sloughs, ponds and irrigation ditches. Most egg-laying occurs in May. Extreme egg dates (N = 92) are 22 April and 3 July. Picman (1980*b*) reported that nests were built on Westham Island from early April to late June.

Western Meadowlark (*Sturnella neglecta*)
Rare summer; *uncommon* to *fairly common* winter. Breeds.

Occurrence: The Western Meadowlark prefers open grassy areas and agricultural lands, mostly in the vicinity of Sea, Iona and Westham islands and Ladner. The movement of meadowlarks in and out of the delta is not well known. A decrease in numbers occurs gradually from about mid-March to early May. Very few birds remain in summer. Numbers begin to build up again in September and October. Largest numbers are reported in February, when 20–30 individuals may be flushed from grasslands on Sea Island. Christmas counts: Ladner — maximum 153 in 1960, average 50; White Rock — maximum 109 in 1973, average 29.

Breeding: Five nests with two to five eggs were found in dry grass fields on Sea Island, from 26 May to 18 June.

The last record for the delta was in 1968. Several pairs may still breed in the area, but loss of grassland habitat, especially on Sea Island, threatens the future of this colourful bird in the delta.

Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)

Uncommon summer; *casual* winter. Breeds.

Occurrence: The Yellow-headed Blackbird forages with flocks of other blackbirds in agricultural areas and short-grass fields, mainly in the vicinity of Sea, Iona and Westham islands and ANWA. Most birds arrive after mid-April and depart from mid- to late September. Extreme dates are 4 April and 2 October. There are four winter records. Christmas counts: Ladner — 2 in 1980, 1 in 1976.

Breeding habits: The Yellow-headed Blackbird breeds in freshwater marshes and emergents on the northwest tip of Sea Island. During the summer of 1970, a colony of 36 pairs nested on Sea Island. This colony was abandoned the following year because of draining and loss of nesting substrate. On 16 May 1985, six males were displaying at the same pond, and pairs were feeding nestlings on 12 June. Motorcyclists and off-road vehicle enthusiasts destroyed much of the habitat until 1986, when the Ministry of Transport fenced off the area. Egg-laying occurs during late May and early June. Young have fledged by mid-July.

Brewer's Blackbird (*Euphagus cyanocephalus*)

Common summer; *abundant* winter. Breeds.

Occurrence: The Brewer's Blackbird inhabits agricultural areas, residential yards, parks and wet and dry fields and is often found in large flocks on telephone wires along roadsides. Winter flocks begin to break up in mid-April, and only small groups remain by mid-May. Flocks begin to form again in late August and continue building through November and December. Largest flocks, nearly 1000 individuals, occur in January and February on Sea, Lulu and Westham islands and east Delta. In winter, females outnumber males by about 2:1 in the delta; the reverse occurs in the eastern end of the lower Fraser Valley. Christmas counts: Ladner — maximum 6217 in 1980, average 889.

Breeding habits: The Brewer's Blackbird breeds in shrub and blackberry hedgerows bordering farmlands and roads, dense ornamental shrubs in residential and urban areas or, occasionally, man-made structures (Butler 1981*b*), all near open, foraging habitats. Most egg-laying occurs in late April and early May. Extreme egg dates (N = 23) are 15 April and 6 July. Mean clutch size was 5.1 ± 0.7, indistinguishable from 5.0 ± 0.8 reported by Butler (1981*b*) for natural sites throughout British Columbia.

Brown-headed Cowbird (*Molothrus ater*)

Fairly common summer; *uncommon* winter. Breeds.

Occurrence: The Brown-headed Cowbird is widespread in open country in grass and agricultural land and irrigated fields, especially where cattle and horses are found. It often associates with large flocks of blackbirds and starlings. The breeding population arrives from late March to mid-May, but usually in April. Cowbirds remain in large numbers until mid-September. Autumn aggregations are largest (e.g., 100 on Sea Island, 5 September 1971). In winter, a few are found locally throughout the delta, but largest numbers occur in the vicinity of Westham and Sea islands. Christmas counts: Ladner — maximum 200 in 1963, average 32; White Rock — maximum 35 in 1983, average 8.

Breeding habits: Because of their parasitic nesting habits, cowbirds are able to exploit a wide variety of habitats, but prefer riparian locations adjacent to open fields. Most eggs are laid from late May to early June. Extreme egg dates (N = 26) are 14 May and 15 July. Known hosts in the delta include Cliff Swallow, Swainson's Thrush, American Robin, Cedar Waxwing, Yellow Warbler, Common Yellowthroat, Rufous-sided Towhee, Song Sparrow, White-crowned Sparrow, Dark-eyed Junco, Red-winged Blackbird, Yellow-headed Blackbird and House Finch.

Northern Oriole (*Icterus galbula*)

Uncommon summer; *casual* winter. Breeds.

Occurrence: The Northern Oriole prefers open deciduous woodlands along sloughs and marshes. It is occasionally found on open lawns with scattered tall trees in residential areas. Most birds arrive during the second week of May, and postbreeding dispersal begins in late July. Most depart a month later. Extreme dates are 6 May and 4 September. There is one winter record: Ladner, 14–29 January 1978 — one photographed (BCPM Photo 519).

Breeding habits: The Northern Oriole prefers willows, birches, black cottonwood and, occasionally, firs in open areas. Nests are usually situated along the edge of large tracts of woodlands. Breeding populations are established in south Richmond, Ladner and White Rock municipalities. Nest-building begins soon after arrival, and some nests are completed by 17 May. All breeding records are of either adults at nest with food (mostly in June) or recently fledged young (e.g., Ladner, 2 August 1969 — three young; ANWA, July 1986 — three young).

Remarks: The subspecies occurring in the delta is *I. g. bullockii*. This western subspecies has occurred in small numbers in the eastern portion of the Fraser River valley since the 1920s (Munro and Cowan 1947). During the next 40 years, it extended its range towards the delta; by the mid-1960s, it was found breeding at Ladner. The population today remains small (estimated 20 pairs) and local, but is increasing and spreading. In 1986, two nestlings were seen being fed on the ANWA at the extreme western edge of the delta.

FRINGILLIDAE: Finches and Allies

Purple Finch (*Carpodacus purpureus*)

Fairly common resident. Breeds.

Occurrence: The Purple Finch is widespread in open coniferous and mixed woodlands, residential areas with evergreen shrubs and, less frequently, dikes with tall conifers. Many records are from bird feeders in winter. Numbers vary greatly from year to year. Patterns of seasonal occurrence are not known. Christmas counts: Ladner — maximum 92 in 1979, average 34; White Rock — maximum 37 in 1983, average 19.

Breeding habits: Although most are reported from April to August in mixed woodlands, there are very few breeding records. It is probably a very local breeder. Fledged young have been reported from 21 June to 6 July.

House Finch (*Carpodacus mexicanus*)

Common resident. Breeds.

Occurrence: The House Finch is widespread and frequents all terrestrial habitats, but prefers weedy, grassy and agricultural areas for foraging. It is also well established in residential areas with ornamental shrubs. Winter flocks disperse in March and April and form again in early August. Flocks build throughout September and October. From late October through February, flocks of 100–130 birds are frequently encountered on Sea and Westham islands and Ladner. Christmas counts: Ladner — maximum 1383 in 1979, average 576; White Rock — maximum 790 in 1980, average 570.

Breeding habits: The House Finch nests in residential areas in dense ornamental shrubs, along shrubby fence rows bordering agricultural fields and, less frequently, in evergreen hedges along ditches and sloughs. Egg-laying occurs mostly from mid-May to early June. Extreme egg dates (N = 24) are 30 April and 9 July (double-brooded).

Red Crossbill (*Loxia curvirostra*)

Rare resident.

Occurrence: The abundance of this species in the delta is closely associated with the availability of seeds in conifer cones in nearby mountains. During years of poor cone crops (e.g., 1971–74, 1976, 1983), birds wandered into the delta. They have been recorded in every month of the year, but their occurrences are not predictable. Flocks usually number fewer than 20 birds. Christmas counts: Ladner — maximum 35 in 1968, average 5; White Rock — 7 in 1983, also recorded in 1971–74 and 1976.

Pine Siskin (*Carduelis pinus*)

Uncommon summer; *common* winter. Probably breeds.

Occurrence: The Pine Siskin occurs irregularly, and numbers fluctuate greatly from year to year. There appear to be years of invasion (e.g., 1965, 1976) when all types of woodlands are visited, even low shrubs. In winter, siskins are nomadic. They may appear in considerable numbers (e.g., 200 birds), stay for a short time, then disappear. Small numbers are widely scattered in mixed woodlands in the delta each summer, but breeding has not been confirmed. Christmas counts: Ladner — maximum 4141 in 1965, average 513; White Rock — maximum 822 in 1976, average 456.

American Goldfinch (*Carduelis tristis*)

Common summer; *fairly common* winter. Breeds.

Occurrence: American Goldfinches frequent fields, agricultural areas, parks and shrub patches, wherever grasses and weeds are abundant. They arrive during late April and early May, when groups of 50 individuals may be seen. Flocks break up and disperse to breed and form again in September, when numbers may approach 400. By late October, most goldfinches have left the delta. In some winters, very large flocks (e.g., 225 on Lulu Island, 19 January 1979) may be found on Lulu and Sea islands. Christmas counts: Ladner — maximum 400 in 1979, average 87; White Rock — maximum 157 in 1974, average 23.

Breeding habits: The American Goldfinch breeds in open deciduous woods or shrubs, usually along water courses or agricultural fields. Most egg-laying occurs in June. Extreme egg dates (N = 6) are 6 June and 14 July. This species is the third most abundant breeding songbird on the ANWA (Table 11).

Evening Grosbeak (*Coccothraustes vespertinus*)

Rare summer; *uncommon* winter.

Occurrence: Like crossbills and siskins, Evening Grosbeaks are an irregular and irruptive species in the delta. During abundant years (e.g., 1972 and 1983), grosbeaks are widespread in big-leaf maple, cottonwood woodlands and mixed woodlands with a predominance of deciduous trees. They also occur in residential areas, parks and golf courses with tall broadleaf trees. During those years when substantial numbers remained all winter, grosbeaks left the delta by mid-May and usually returned from late August to mid-September. Christmas counts: Ladner — maximum 131 in 1972, average 28; White Rock — maximum 435 in 1983, average 149.

PLOCEIDAE: Weavers

House Sparrow (*Passer domesticus*)

Introduced. *Very common* resident. Breeds.

Occurrence: The House Sparrow associates with human habitation throughout the delta. Preferred habitats include urban, residential and especially agricultural areas. The population is probably resident, although Campbell *et al.* (1972*b*) reported apparent migrants at Point Roberts on 24 October 1971. Largest numbers are from spring and autumn at Sea and Westham islands, when flocks of 125–250 individuals may be seen. Christmas counts: Ladner — maximum 1874 in 1963, average 637; White Rock — maximum 397 in 1976, average 212.

Breeding habits: The House Sparrow breeds in the vicinity of farm buildings and, less frequently, in urban areas. Egg-laying occurs from April to July, mostly in May. There are at least two broods per season.

4. The food web in the delta

Estuaries are biologically productive places because energy and nutrients move through the ecosystem along several parallel routes. Each route has its own specialized producers and consumers in addition to generalists, which exploit several routes (Prater 1981).

The food web in the Fraser River delta is very complex and mostly unquantified, so that only a generalized scheme can be outlined. Primary nutrient sources in the Fraser River delta include ocean- and river-borne detritus, marsh plants and phytoplankton in the aquatic system. On land, primary nutrient sources include plant detritus and man-made fertilizers. About 93% of the energy in the nearby Squamish estuary enters via the detritus cycle (Pomeroy 1977). Figure 3 (page 12) depicts a simplified food web for the Fraser River delta in which several trophic levels can be identified, as follows:

(1) *Producers*
  (*a*) primary
    - brackish marsh plants (e.g., *Carex lyngbei*)
    - eelgrass beds (e.g., *Zostera marina*)
    - phytoplankton
    - salt-marsh plants (e.g., *Salicornia virginica*)

(2) *Consumers*
  (*a*) primary
    (i) grazers
      - herbivorous snails (e.g., *Littorina sitkana*)
      - herbivorous insects (e.g., *Aphididae* spp.)
      - herbivorous birds (e.g., Brant, American Wigeon, Snow Goose)
      - herbivorous mammals (e.g., *Ondatra zibethica*)
    (ii) detritivores
      - bacteria
      - copepods (e.g., *Corophium salmonis*)
      - polychaetes (e.g., *Eteone* spp., *Manayunkia aestuarina*)
      - molluscs (e.g., *Clinocardium nuttalli, Macoma nasuta, Mytilus edulis*)
      - euphasids (e.g., *Crangon francisorum*)
      - echinoderms (e.g., *Anthopleura artemisia*)
  (*b*) secondary
    (i) carnivores
      - fish (e.g., *Platichthys stellatus, Cottus aspey*)
      - crabs (e.g., *Hemigrapsus nudus, Pugettia gracilis, Cancer magister*)
      - snails (e.g., *Thais lamellosa, Pollinices lewisii*)
      - starfish (e.g., *Pisaster ochraceous*)
      - birds (e.g., Surf Scoter, Glaucous-winged Gull, Western Sandpiper)
      - mammals (e.g., *Eschrichtius robustus*)
    (ii) scavengers
      - crabs (e.g., *Cancer productus*)
      - birds (e.g., Bald Eagle, Glaucous-winged Gull, Northwestern Crow)
  (*c*) tertiary
    - birds (e.g., Great Blue Heron, Western Grebe, Bald Eagle)
    - mammals (e.g., *Orcinus orca, Phoca vitulina, Homo sapiens*)

The terrestrial ecosystem has fewer trophic levels than the aquatic ecosystem, and the transfer of energy between levels follows fewer routes than in the aquatic ecosystem. As with the aquatic ecosystem, however, many details of the terrestrial ecosystem have yet to be worked out. A simplified version of trophic levels in the terrestrial ecosystem is as follows:

(1) *Producers*
  (*a*) primary
    - farm crops
    - old-field grasses and herbs
    - bog plants
    - deciduous forest
(2) *Consumers*
  (*a*) primary
    (i) grazers
      - herbivorous insects (e.g., *Malacosoma californicum, Pentatomidae, Aphididae*)
      - herbivorous gastropods (e.g., *Arion ater*)
      - herbivorous mammals (e.g., *Microtus townsendii, Homo sapiens*)
      - herbivorous birds (e.g., Mallard, American Wigeon, Song Sparrow, Ring-necked Pheasant)
    (ii) decomposers
      - bacteria
      - fungi
      - annelids (e.g., *Lumbricus* spp.)
      - isopods (e.g., *Porcellio scaber*)
      - insects (e.g., *Silphidae*)
  (*b*) secondary
    (i) carnivores
      - insects (e.g., *Carabidae*)
      - reptiles (e.g., *Thamnophis sirtalis*)
      - amphibians (e.g., *Rana catesbiana*)
      - birds (e.g., American Robin, Yellow-rumped Warbler, Killdeer)
      - mammals (e.g., *Sorex vagrans, Myotis lucifugus*)
    (ii) scavengers
      - bacteria
      - fungi
      - insects (e.g., *Zootermopsis* spp.)
      - isopods (e.g., *Porcellio scaber*)
      - birds (e.g., Turkey Vulture, Bald Eagle)
      - mammals (e.g., *Canis latrans*)
  (*c*) tertiary
    - birds (e.g., Rough-legged Hawk, Northern Shrike, Great Blue Heron)
    - mammals (e.g., *Mustela frenata*)

Estimates of primary productivity (measured as the above-ground biomass) for the foreshore marshes are 2.6 times greater than for the most productive farm fields in the delta (Yamanaka 1975). The largest primary production in the terrestrial environment is from farm crops. Over 40% of the delta's land is cultivated in crops (Table 3). Most of that production is harvested for human needs and therefore removed from the ecosystem. However, much of the fertilizers and pesticides applied to the soil and crops drain into the aquatic ecosystem. Until energy and nutrient flows are described and quantified in the Fraser River delta, the effects of agricultural chemicals in the ecosystem will not be fully understood.

5. Pollutants in the delta

Most chemicals have the potential to be harmful at some concentration, and the toxicity of each varies depending on conditions. In Canada, toxic chemicals are defined as "those chemical substances which, when released to the environment, or thereafter if chemically transformed through combination or otherwise, could pose a significant threat to natural ecosystems or to human health and well-being. They are generally irretrievable once released into the environment and their effects can, within a time frame meaningful for human society, be effectively irreversible" (Garrett 1982).

Toxic chemicals in the Fraser River delta can be divided into industrial and pesticidal pollutants. The industrial pollutants are mostly waterborne wastes from 5 metal-finishing and metal-fabricating plants; 13 pulp, paper and lumber mills; 20 wood treatment plants; 6 sewage treatment plants; 5 landfill sites; over 100 storm sewers; a coal bulk loading terminal; and many chemical plants. Polychlorinated biphenyls (PCBs) occur in low quantities in the sediment near most industrial sites in the delta and in fish, especially along the industrialized North Arm (Garrett 1982). The arithmetic mean level of PCBs in Great Blue Heron eggs was 3.67 ppm (SD = 0.87, N = 11) at Crescent Beach and 7.28 ppm (SD = 6.93, N = 13) at Point Roberts, Washington, in 1977. However, the highest levels of PCBs (mean = 21.4 ppm, SD = 13.5, N = 12) were found in Great Blue Heron eggs from a colony in the University of British Columbia (UBC) Endowment Lands in 1977. By 1982, PCB levels at UBC had dropped to an arithmetic mean of 15.2 ppm (SD = 10.6, N = 12)

(P. Whitehead, unpubl. data), a significant difference ($t = 4.46$, $df = 22$, $P < 0.01$). Levels in another fish-eating bird, the Double-crested Cormorant, nesting on river pilings at the mouth of the South Arm in 1985 were low (geometric mean = 292 ppm, $N = 5$; Noble and Elliott 1986). Levels of PCBs in 10 Glaucous-winged Gull eggs in 1977 were also low (geometric mean = 1.78 ppm; Noble and Elliott 1986). All other chemicals tested (HCB; p,p′-DDE; mirex; γ-BHC (benzene hexachloride); β-BHC; oxychlordane; *cis*-nonachlor; p,p′-DDT; heptachlorepoxide; dieldrin) occurred at levels below 1.0 ppm. Polychlorinated biphenyls have been detected in wastes from paper recycling plants, the sewage treatment plant at Iona Island and a coal bulk loading facility (Garrett 1982). Those are presumably the sources of heron contamination, as major feeding areas for the UBC and Point Roberts colonies are at Iona Island near the industrialized North Arm (Krebs 1974) and along the south side of the coal-loading facility at Westport Terminals, respectively. Relatively high levels (54 ng/kg) of pentaoctachlorodibenzodioxin, a "dioxin," were found in a pooled sample of heron eggs from the UBC Endowment Lands in 1982 (P. Whitehead, unpubl. data). In 1983, levels of the dioxin HxCDD-123678 reached 104 ng/kg (P. Whitehead, unpubl. data). Studies have commenced to examine the effects of those toxic chemical loads on herons in the Fraser River delta.

Elevated levels of metals have been reported in the vicinity of the Iona Island sewage treatment plant and the industrialized North Arm (Garrett 1982). The levels of most metals in some fish are not considered to be a concern for human consumption, except for mercury, which occasionally exceeds Health and Welfare Canada standards (0.5 mg/kg wet wt.) (Garrett 1982). Crabs in the estuary contain high levels of mercury and copper. Vermeer and Peakall (1979) examined the trace metals in seaducks and their foods at Iona Island and Roberts Bank. Greater Scaup had significantly higher levels of silver, copper, lead and zinc than did Surf Scoters, but the latter had higher levels of mercury. Levels of most metals were higher at Iona Island than at Roberts Bank. Lead and mercury are known to be highly toxic to birds, but no levels approached lethal concentrations.

Several duck species feed in farm fields, where pesticides are a threat. These ducks were poisoned by carbofuran and fensulfathion.

Bird kills in the Lower Fraser Valley have been attributed to two pesticides — carbofuran and fensulfathion (P. Whitehead, pers. commun.). Carbofuran is a nematicide introduced in 1970 as a substitute for chlordane, heptachlor and aldrin. It is used on cole (cabbage family) crops in the Fraser River delta and has poisoned from 55 to 1100 Mallard, Northern Pintail, American Wigeon and Green-winged Teal on five occasions between 1973 and 1977. Fensulfathion is an insecticide–nematicide used against root maggots on cole crops. It is also highly toxic to waterfowl. Between December 1979 and March 1980, about 200 ducks were poisoned by fensulfathion, apparently applied seven months earlier to protect seedling cabbage and cauliflower (P. Whitehead, pers.commun.). In 1982, 23 American Robins, 2 European Starlings and 2 House Finches were poisoned by fensulfathion in Richmond, although there was no indication of its misuse. In 1986, over 500 Savannah Sparrows died in a field in Richmond as a result of carbofuran poisoning.

6. Wildlife habitat — its present state

About 1% (6.22 km^2) of the Fraser River delta has been protected by governments for the primary use of wildlife (Table 4). The Canadian Wildlife Service holds 61.2% of that protected land, the British Columbia Wildlife Branch manages 20.7% and the two agencies jointly control 11.3%. In addition, the municipal governments maintain 5.7%, and the Department of Fisheries and Oceans holds 1.1%.

The single largest threat to birds in the Fraser River delta is the loss of a place to live. Most birds can cope with many human activities if provided with suitable resting and feeding areas. In the delta, most habitats have been greatly altered (Table 4), reducing or eliminating some bird species while favouring others. For example, some birds associated with farmlands, such as European Starlings, have fared well, whereas some dependent on wet areas, such as the Sandhill Crane, have suffered. Some habitats can be recreated by simple but costly construction work. For example, seasonally flooded meadows have been artificially built on the Alaksen National Wildlife Area and Serpentine Fen by flooding diked fields. However, other habitats are more difficult or even impossible to recreate. Attempts to plant foreshore marshes in the Fraser River delta have largely been unsuccessful (S. Boyd, pers. commun.). We must protect all habitats, but priority must be given to those that cannot be recreated, especially if their loss threatens specific wildlife populations. Habitats that cannot be recreated with any assurance of success include brackish and salt marshes, bogs, sand flats and mud flats. On the other hand, seasonal wet meadows and tree and shrubby areas can be recreated. Nevertheless, once a piece of land has been zoned for suburban or industrial development, it is highly unlikely that the land will ever become available for restoration. In their present state, niches enhanced by Vancouver urban environments tend to increase the number of adaptable alien species already there, such as the European Starling, House Sparrow and Rock Dove (Lancaster and Rees 1979).

Protecting farmland has more benefits than simply maintaining arable land for cultivation. It provides essential habitats for waterfowl, shorebirds, herons and raptors.

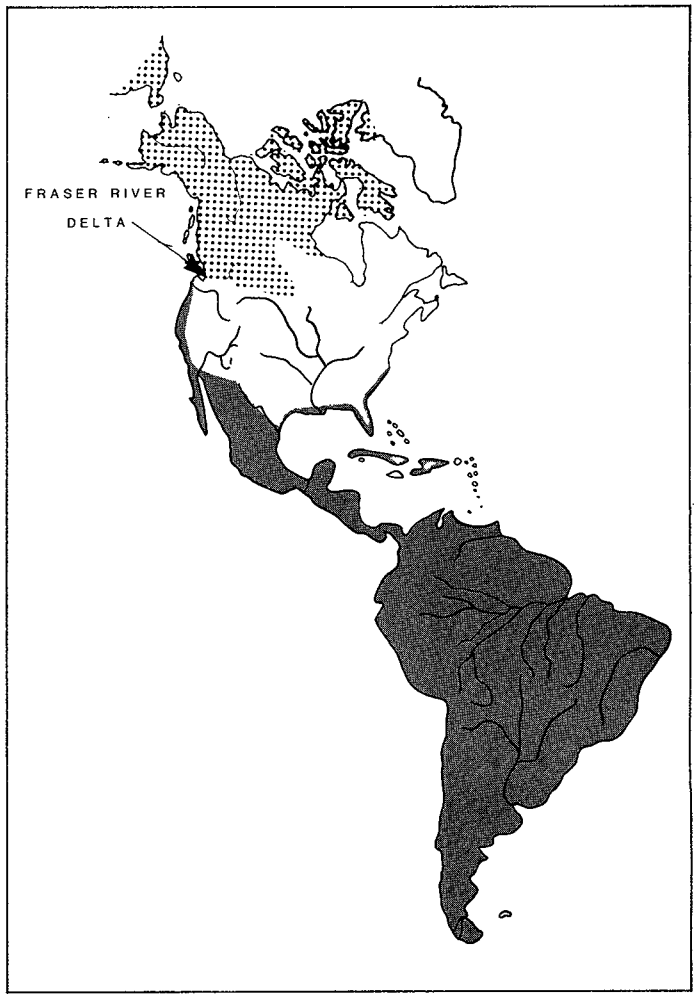
Although farmland is not managed for birds, it is used by a wider assortment of species than the more homogeneous suburban or industrial land. Similarly, land tenure inside the dikes inadvertently provides protection for habitats outside the dikes. For example, the Vancouver International Airport restricts human access to adjacent marshes. Conservation areas have been identified (Government of Canada and Province of British Columbia 1978), but the tiny portion of the delta that is protected for wildlife by legislation (Table 4) will never alone satisfy the needs of the millions of birds that use the delta each year. Nine wildlife species have been extirpated from the delta in the past 140 years, and five others are threatened (Table 5). As farmland and foreshore habitats are degraded or lost, wildlife populations in the delta will decline.

7. The significance of the Fraser River delta

In 1974, the contracting parties to the Convention on Wetlands of International Importance especially as Waterfowl Habitat (the "Ramsar" Convention of 1971) adopted the following criteria for identifying wetlands of international importance:
(1) Quantitative criteria for identifying wetlands of importance to waterfowl. A wetland should be considered internationally important if it:
(*a*) regularly supports 10 000 ducks, geese and swans; or 10 000 coots; or 20 000 waders; or
(*b*) regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl; or
(*c*) regularly supports 1% of the breeding pairs in a population of one species or subspecies of waterfowl.
(2) General criteria for identifying wetlands of importance to plants or animals. A wetland should be considered internationally important if it:
(*a*) supports an appreciable number of rare, vulnerable or endangered species or subspecies of plant or animal; or
(*b*) is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna; or
(*c*) is of special value as the habitat of plants or animals at a critical stage of their biological cycles; or
(*d*) is of special value for its endemic plant or animal species or communities.
(3) Criteria for assessing the value of representative or unique wetlands. A wetland should be considered internationally important if it is a particularly good example of a specific type of wetland characteristic of its region.

The Fraser River delta supports half a million birds each year, based upon monthly averages (Table 7). During the peak of migration, up to 1.4 million birds are estimated to use the delta. Estimates of the maximum number of waterfowl in the delta exceed the criteria for internationally important wetlands for waterfowl established under the Ramsar Convention (point (1) above) by over 30-fold and shorebirds by 60-fold. Under the criteria established for plants or animals (point (2) above), the most important habitats for waterfowl and shorebirds are the estuarine marshes at the mouth of the Fraser River, and the salt marshes, eelgrass beds and beaches in Boundary Bay. There is some evidence that flooded meadows might be important to waterfowl survival in British Columbia coastal estuaries (Eamer 1985). Moreover, nowhere else in Canada are winter populations of Great Blue Heron, Black-bellied Plover, Mew Gull, Rough-legged Hawk, Red-tailed Hawk and Northern Harrier as numerous or as dense as in the Fraser River delta. The significance of the

Figure 6
Summer breeding range (stippled) and winter range (gray tone) of species that pass through the Fraser River delta



delta can be visualized by examining the breeding and wintering ranges of species that use it (Fig. 6). The demise of the Fraser River delta's ecosystems could possibly affect birds in over 20 countries and three continents. No comparable sites exist along the Pacific coast between California and Alaska. There is no other site in Canada that supports the diversity and number of birds found in winter in the Fraser River delta.

Conclusions

The Fraser River delta has seen two major changes since the arrival of European settlers. In the late 1800s, diking and draining of much of the delta began, along with the establishment of farms. In the first 50 years of this century, much of the native vegetation was removed, water flow was altered and tidal flooding was halted.

A second change began about 1955, when bridges first spanned the North Arm of the Fraser River, and continued in the early 1960s, when the George Massey Tunnel crossed the South Arm. These created a direct route between Vancouver and the Fraser River delta. At the same time, a surge of suburban residential developments spread from Vancouver into outlying areas, including the delta. Prime farmland quickly became suburban developments until the mid-1970s, when the provincial government promulgated the Agricultural Land Commission Act.

More recently, a third change has been taking place. Industrial developments have spread into the delta. The North Arm of the Fraser River has long been heavily industrialized. Now the South Arm is quickly becoming industrialized in north Delta near Tilbury Island. About 7% of the delta is now industrialized (Table 3). With continued development of western Canada, the port of Vancouver and those along the Fraser River will become increasingly important.

To protect birds, we must protect their habitats. In the Fraser River delta, a small amount (13%) of the foreshore marshes has been legislated as areas for wildlife. A challenge for the future will be to maintain the quality of those habitats. Human interference, including contamination by toxic substances and nearby development, will continue to affect marsh-dependent birds. Many of the internationally significant species will be maintained only if healthy habitats are preserved. Important areas, such as Roberts Bank and Boundary Bay, must be vigorously protected. Two habitats that require protection or re-establishment are old fields and upland wet meadows. Only paltry fragments of these once-extensive habitats are protected. As the years pass, Great Blue Herons, Short-eared Owls, Common Barn-Owls and several raptors will decline in numbers if those habitats are lost. Large populations of waterfowl still use flooded agricultural areas, a clear indication that the amount of protected land is insufficient to support the delta's wildlife. The challenge for government and industry will be to ensure that development does not jeopardize the quality and quantity of habitats that support the internationally and nationally significant bird populations in the Fraser River delta.

Recommendations

The Fraser River delta supports wildlife populations having international and national significance, to which the highest forms of protection should be afforded. In the Fraser River delta, protection involves securing adequate habitat and maintaining the quality of that habitat. Crucial habitats in need of protection include mud flats, salt marshes, estuarine marshes and old fields (abandoned grassland). Of equal importance is the quality of water in the delta, because it is a major transporter of nutrients between ecosystems. To achieve that protection, the following objectives must be met:

(1) the tidal and subtidal lands of Boundary Bay, including Mud Bay, should be secured for their internationally significant populations of waterbirds and shorebirds;

(2) a belt of farmland on the landward side of the dikes around Boundary Bay and south of Highway 99 should be secured for waterfowl, shorebirds, gulls, herons and raptors to provide:

(*a*) an essential habitat component for wintering waterfowl (see Eamer 1985);

(*b*) important roosting sites for shorebirds; and

(*c*) important upland for herons and raptors;

(3) the foreshore marshes and mud flats near Brunswick Point and south Westham Island should be secured for waterfowl and shorebirds;

(4) the Duck–Barber–Woodward islands complex should be secured for waterfowl;

(5) the quality of water in the Fraser River, its estuary and associated marine environment should not be further degraded;

(6) the precise ecological needs of internationally and nationally significant wildlife species using the Fraser River delta should be determined and those requirements maintained; and

(7) agreements should be reached between appropriate countries and government agencies to maintain internationally and nationally significant populations that use the Fraser River delta.

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Appendices

Appendix 1
Mammals of the Fraser River delta (derived from Cowan and Guiguet 1965)

Common name	Scientific name*
Opossum	*Didelphis marsupialis*[i]
Bendire shrew	*Sorex bendirii*
Cinereus shrew	*S. cinereus*
Wandering shrew	*S. vagrans*
Pacific coast mole	*Scapanus orarius*
Western big-eared bat	*Plecotus townsendii*
Big brown bat	*Eptesicus fuscus*
California myotis	*Myotis californicus*
Little brown myotis	*M. lucifugus*
Yuma myotis	*M. yumanensis*
Big free-tailed bat	*Tadarida molossa*
Snowshoe hare	*Lepus americanus*[e]
Eastern cottontail	*Sylvilagus floridanus*[i]
Douglas squirrel	*Tamiasciurus douglasii*
Northern flying squirrel	*Glaucomys sabrinus*
American beaver	*Castor canadensis*
Deer mouse	*Peromyscus maniculatus*
Western redback vole	*Clethrionomys occidentalis*
Creeping vole	*Microtus oregoni*
Townsend's vole	*M. townsendii*
Muskrat	*Ondatra zibethicus*
Roof rat	*Rattus rattus*
Norway rat	*R. norvegicus*[i]
House mouse	*Mus musculus*[i]
Northwestern jumping mouse	*Zapus trinotatus*
Nutria	*Myocaster coypus*[i]
Killer whale	*Orcinus orca*
Harbour porpoise	*Phocaena phocaena*
Gray whale	*Eschrichtius robustus*
Coyote	*Canis latrans*
Wolf	*C. lupus*[e]
Red fox	*Vulpes vulpes*
American black bear	*Ursus americanus*
Raccoon	*Procyon lotor*
Short-tailed weasel	*Mustela frenata*
Mink	*M. vison*
Spotted skunk	*Spilogale gracilis*
Striped skunk	*Mephitis mephitis*
River otter	*Lutra canadensis*
Cougar	*Felis concolor*[e]
Northern fur seal	*Callorhinus ursinus*
Northern sea lion	*Eumetopias jubata*
California sea lion	*Zalophus californianus*
Harbour seal	*Phoca vitulina*
Elk	*Cervus elaphus roosevelti*[e]
Mule deer	*Odocoileus hemionus columbianus*

* e — extirpated; i — introduced.

Appendix 2
Amphibians and reptiles of the Lower Fraser Valley*

Species	Status				
	Abundant	Common	Rare	Local	Extirpated
Amphibians					
Northwestern salamander (*Ambystoma gracile*)		X			
Long-toed salamander (*Ambystoma macrodactylum*)			X		
Rough-skinned newt (*Taricha granulosa*)		X			
Western red-backed salamander (*Plethodon vehiculum*)			X		
Ensatina (*Ensatina eschscholtzi*)			X		
Western toad (*Bufo boreas*)	X				
Pacific treefrog (*Hyla regilla*)	X				
Red-legged frog (*Rana aurora*)	X				
Bullfrog (*Rana catesbiana*)†		X		X	
Green frog (*Rana clamitans*)†			X	X	
Northern leopard frog (*Rana pipiens*)†			X	X	
Reptiles					
Snapping turtle (*Chelydra serpentina*)†					X
Painted turtle (*Chrysemus picta*)†		X		X	
Western pond turtle (*Clemmys marmorata*)†					X
Northern alligator lizard (*Elgaria coerula*)			X	X	
Western terrestrial garter snake (*Thamnophis elegans*)		X			
Northwestern garter snake (*Thamnophis ordinoides*)		X			
Common garter snake (*Thamnophis sirtalis*)	X				

* Data are from BCWRS from the town of Hope to the mouth of the Fraser River.
† Introduced species.

Appendix 3
List of very rare, casual and accidental species of birds, by season, in the Fraser River delta through 1986

Species	Spring Mar.–May	Summer Jun.–Aug.	Autumn Sep.–Oct.	Winter Nov.–Feb.	References*
Fork-tailed Storm-Petrel			X	X	BCPM Photo 1113†
American White Pelican		X	X		Campbell (1970*c*)
Brown Pelican			X		Cumming 1932
Least Bittern		X			BCPM Photo 352
Great Egret	X	X	X	X	Campbell *et al.* 1972*a*
Snowy Egret	X		X		Campbell *et al.* 1974; Shepard 1977
Ross Goose	X		X	X	Mattocks 1979
Emperor Goose	X			X	Campbell 1968*b*; BCPM Photos 133, 146, 546
Baikal Teal				X	Hatter 1960
Garganey	X	X			Macdonald 1978*a*; BCPM Photos 464, 713
King Eider		X			BCPM Photo 988
Smew	X			X	Weber and Campbell 1978
Rock Ptarmigan				X	BCPM Photos 498, 720
Common Moorhen	X	X			Weber 1982*b*
Snowy Plover	X				BCPM Photo 1055
Black Oystercatcher			X	X	Drent 1970
Black-necked Stilt	X				Campbell and Anderson 1972
American Avocet	X	X	X	X	Campbell 1972*c*; BCPM Photo 714
Spotted Redshank	X		X		Campbell *et al.* 1972*a*; Kautesk 1981
Wandering Tattler			X		BCWRS
Upland Sandpiper		X	X		Campbell *et al.* 1972*a*
Bristle-thighed Curlew	X				BCWRS
Far Eastern Curlew			X		BCPM Photo 1000
Hudsonian Godwit	X	X	X		UBC 75‡; Campbell *et al.* 1972*a*
Bar-tailed Godwit			X		ROM 1957; Munro 1935; Dawe 1973
Surfbird				X	Campbell *et al.* 1972*a*
Rufous-necked Stint		X			BCPM Photos 765, 536
Temminck's Stint			X	X	BCPM Photo 879
White-rumped Sandpiper		X			Crowell and Nehls 1974; Weber 1982*b*
Rock Sandpiper			X	X	Campbell *et al.* 1972*a*
Curlew Sandpiper		X	X		Macdonald 1978*b*
Spoonbill Sandpiper		X			Sauppe *et al.* 1978
Buff-breasted Sandpiper		X	X		Campbell and Gregory 1976
Ruff	X	X	X		Campbell *et al.* 1972*a*
Red Phalarope		X	X	X	Campbell *et al.* 1972*a*, 1974
Pomarine Jaeger	X		X		UBC 2889; Campbell *et al.* 1972*a*

Appendix 3 (continued)
List of very rare, casual and accidental species of birds, by season, in the Fraser River delta through 1986

Species	Spring Mar.–May	Summer Jun.–Aug.	Autumn Sep.–Oct.	Winter Nov.–Feb.	References*
Long-tailed Jaeger		X	X		UBC 2901; Campbell 1968*c*
South Polar Skua			X		Dow and Hesse 1969
Little Gull	X	X	X	X	Campbell *et al.* 1974
Common Black-headed Gull		X	X		Roberson 1980; BCPM Photo 1119
Iceland Gull				X	Shepard 1975
Black-legged Kittiwake	X		X		Campbell *et al.* 1972*a*
Sabine's Gull	X	X	X	X	UBC 1670; Campbell 1970*a*
Elegant Tern		X			BCPM Photo 864
Forster's Tern		X	X		Weber 1982*b*
Northern Hawk-Owl	X			X	BCWRS
Barred Owl			X	X	Campbell *et al.* 1974
Great Gray Owl				X	BCPM 10797
Least Flycatcher		X			BCWRS
Ash-throated Flycatcher			X		Hunn and Mattocks 1981
Western Kingbird		X	X		Campbell *et al.* 1972*a*
European Skylark				X	Weber 1977
Purple Martin	X	X			BCWRS
Gray Jay			X	X	Campbell *et al.* 1972*a*
Blue Jay			X	X	Middleton 1949
Clark's Nutcracker			X	X	BCWRS
Black-billed Magpie	X		X	X	Shepard 1974; BCWRS
Mountain Chickadee			X	X	Campbell *et al.* 1974
House Wren	X	X	X	X	Campbell *et al.* 1972*a*
American Dipper				X	Campbell *et al.* 1972*a*
Western Bluebird			X	X	Weber *et al.* 1983
Gray Catbird		X			BCWRS
Northern Mockingbird		X	X	X	Shepard 1976
Sage Thrasher	X				BCWRS
Bohemian Waxwing	X		X	X	BCPM 1035, 1042, 1046
Loggerhead Shrike	X		X	X	Sirk 1968; Weber 1982*b*
Tennessee Warbler			X		BCWRS
Nashville Warbler	X		X		Campbell *et al.* 1974
Chestnut-sided Warbler			X		Roberson 1980
Black-throated Green Warbler		X			Weber 1984
Palm Warbler			X	X	BCPM Photo 139; Sarles 1965
Black-and-white Warbler	X				Campbell *et al.* 1974
American Redstart			X		Campbell *et al.* 1974
Northern Waterthrush					Campbell *et al.* 1972*a*
Chipping Sparrow	X	X		X	BCWRS
Clay-color Sparrow				X	BCWRS
Brewer's Sparrow	X		X		Kautesk 1982*a*
Vesper Sparrow	X	X	X		Weber 1982*b*
Sage Sparrow			X		BCPM 6913; Cumming 1932
Baird's Sparrow		X			Kautesk 1982*b*
Grasshopper Sparrow		X			BCPM Photo 490
Sharp-tailed Sparrow			X		BCWRS
Swamp Sparrow				X	Weber *et al.* 1980
White-throated Sparrow	X		X	X	BCWRS
Harris' Sparrow	X		X	X	Hughes 1956
Bobolink	X				Shepard 1975; Weber 1982*b*
Rusty Blackbird	X		X	X	BCPM Photo 382
Brambling			X	X	BCPM Photo 192; Campbell 1974
Rosy Finch			X	X	BCPM Photo 249; Shepard 1976
Pine Grosbeak			X	X	Holdom 1953; Campbell *et al.* 1972*a*
White-winged Crossbill				X	Sirk 1968
Common Redpoll			X	X	BCPM 7537; Holdom 1959

* Includes select references (see Campbell *et al.* 1979, 1987*a*) and sources of information. Additional data are in the British Columbia Provincial Wildlife Records Scheme (BCWRS).
† See Campbell and Stirling (1971).
‡ Specimen number housed in specified museum.

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