



Fraser River Delta: Southern British Columbia (Canada)

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Anne Murray

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Abstract

The Fraser River Delta is the largest on the west coast of Canada. Its upland, riverine, marine and bog environments are highly significant wildlife habitats, increasingly threatened by industrial and urban developments.

Keywords

Fraser river · Fraser estuary · Fraser delta · Boundary bay · Burns bog

A. Murray (✉)
Nature Guides BC, Delta, BC, Canada
e-mail: sanderling@uniserve.com; info@natureguidesbc.com

Introduction

The Fraser delta, in the Strait of Georgia, is a globally important ecosystem, essential habitat for wintering and migrating birds and many aquatic species, including salmonids. Birds migrating through the delta use three continents and 20 countries on the Pacific flyway (Butler and Campbell 1987). The agricultural soils and growing conditions of the delta are among the best in Canada (Klohn Leonoff et al. 1992). The Fraser River is called Stò:lo by the indigenous Halq'eméylem-speaking people that bear the same name (Carlson 2001).

The Fraser delta is located in the southwest of the province of British Columbia (BC), Canada, at 49° 10'N, 123° 05'W. The delta covers approximately 700 km² immediately south of the city of Vancouver and is the largest estuary on Canada's Pacific coast (Butler and Campbell 1987). It extends 30 km west from the community of New Westminster to the Strait of Georgia (part of the Salish Sea) and 22 km from the north arm of the Fraser River south to the US border at Point Roberts (Fig. 1).



Fig. 1 The Fraser River delta, British Columbia, Canada (July 20, 2000 Landsat 7 image downloaded from Geogratis.cgdi.gc.ca. Contains information licensed under the Open Government License)

The Fraser River and Formation of the Delta

The Fraser was designated a Canadian Heritage River in 1998 (http://www.chrs.ca/Rivers/Fraser/Fraser_e.php), for its ecological and cultural importance. It is the longest river in BC, flowing for 1,378 km from its headwaters in the Canadian Rockies. During its journey through mountain ranges and plateaus, it is joined by many tributaries and drains a total area of 234,000 km² (Fig. 2), one quarter of the province (Bocking 1997).

Following the melting of the Pleistocene ice sheets between 16 and 11,000 years BP, ocean levels adjusted, approaching their current level about 6,000 years BP. The formation of the Fraser delta began with sediment deposition near the confluence of the Pitt and Fraser rivers and aggraded southwest (Neu 1966). The river braided into channels as it flowed across the low-lying marshy landscape, and the original mouth lay to the south, discharging into the current area of Boundary Bay (Thomson 1981).

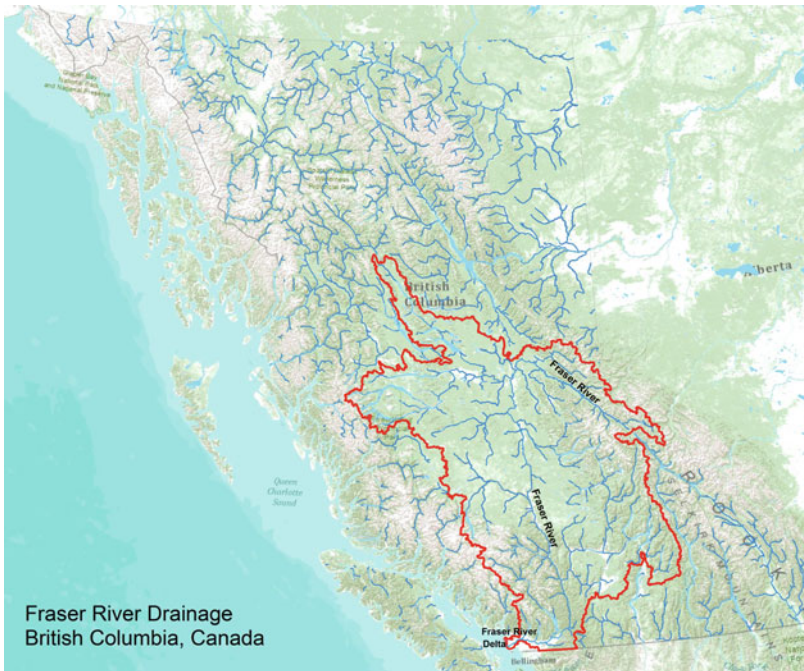


Fig. 2 Map of the Fraser River drainage, British Columbia, Canada. Basemap created using ArcGIS[®] software by Esri. ArcGIS[®] and ArcMap[™] are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved. For more information about Esri[®] software, please visit www.esri.com. Watershed from Freshwater Atlas downloaded from DataBC (www.data.gov.bc.ca). Contains information licensed under the Open Government License – British Columbia

The higher ground of the Point Roberts peninsula was an island until 2,500 years ago (Clague et al. 1998). About 6,000 years ago, the river changed direction to flow west, and Burns Bog began to develop in the center of the delta, from an accumulation of organic debris (Hebda et al. 2000). Boundary Bay was cut off from the Fraser River's flow and reformed as a shallow marine bay, bordered by salt marshes. Prior to dyking, the position of the main channel of the Fraser varied up to 3 km north or south of its current position (Church et al. 1987).

The Fraser River now has four branches as it enters the Strait of Georgia: the North Arm, Middle Arm, South (or Main) Arm, and Canoe Pass. The South Arm carries 85% of the river volume (Port Metro Vancouver 2005), with an average flow of 1.85 m/s. This increases to 2.83 m/s during the freshet in May and June, when snow melt from the interior mountains enters the river system (Ward 1980).

Larger deltaic islands formed from alluvial deposits include Lulu Island, the location of the City of Richmond; Sea Island, home to the Vancouver International Airport; and Westham Island in Delta, known for its farms and national wildlife reserve. Smaller islands line the shore of the South Arm.

The Fraser River delivers 17 million tonnes of sediment annually to the Strait of Georgia, much of which accumulates on the delta slope (City of Richmond 2016a). Two to four million tonnes of sediment are dredged from the main river channels every year, to keep shipping lanes open (Cannings and Cannings 2015). Many back sloughs and channels are silting up. On the active front, the delta progrades at a rate of 3 m per year (Kennett and McPhee 1988). However, it is thought that sand deposition may no longer be occurring through normal deltaic processes (McClaren and Ren 1995), and the expansion of marshes has slowed (Church and Hales 2007).

Areas of the delta lying below sea level are potentially at risk from storm surges and flooding. The delta is located in a seismically active part of the coast and is at risk for earthquake-induced ground liquefaction. The risk of a tsunami is considered to be low (City of Richmond 2016b).

Ecological Importance

The Fraser delta has a temperate climate and lies within the sheltered Strait of Georgia, ensuring year-round use of wildlife habitats. The delta is a critically important habitat for migratory and wintering shorebirds, waterfowl, and raptors (Butler and Campbell 1987). Several million birds stop over on migration, including tens of thousands of waterfowl – swans, geese, ducks, loons, and grebes – and up to a million shorebirds. 250,000 waterfowl spend the winter offshore and in the agricultural uplands (www.ramsar.org). The uplands around Boundary Bay and Roberts Bank host the largest density of wintering birds of prey in Canada (Butler and Campbell 1987), including falcons that follow the migrant shorebirds (Butler et al. 2003) and hawks, harriers, and owls that feed on grassland rodents, such as the abundant Townsend's vole *Microtus townsendii*. Bald eagles *Haliaeetus leucocephalus* are very common resident and wintering species. There are several colonies of the coastal race of great blue heron *Ardea herodias fannini*, a federal

species of concern. The Fraser delta (Ladner) Christmas bird count regularly has the highest species count in Canada (<http://netapp.audubon.org/cbcobservation/>).

The estuary plays a key role in the life history of seven salmon species – chinook *Oncorhynchus tshawytscha*, coho *O. kisutch*, sockeye *O. nerka*, pink *O. gorbuscha*, chum *O. keta*, coastal cutthroat trout *O. clarkii clarkii*, and steelhead *O. mykiss* – and hundreds of genetically unique stocks. It has been estimated that the Fraser averages 800 million out-migrating juvenile salmonids a year (Environment Canada 1992), of which pink smolts average 450 million (Fraser River Aboriginal Fisheries Secretariat 2015). Federally listed species of concern include eulachon *Thaleichthys pacificus*, white sturgeon *Acipenser transmontanus*, and green sturgeon *A. medirostris*. Marine mammals, including endangered orcas or killer whales *Orcinus orca*, humpback *Megaptera novaeangliae*, gray whale *Eschrichtius robustus*, minke whale *Balaenoptera acutorostrata*, harbor seal *Phoca vitulina*, two species of porpoise, and two species of sea lion, occur in adjacent waters.

Wetland Diversity

Intertidal

Beneath the 25,700 ha sand and mudflats on Sturgeon Bank, Roberts Bank and Boundary Bay are myriads of microscopic plant eaters and filter feeders such as lugworms *Arenicola marina*, burrowing shrimp *Callinassa* sp., snails, clams, and cockles *Mollusca* sp. (Butler and Campbell 1987). Nonnative crustaceans are common. They were introduced in ballast water and by former oyster-growing operations. Biofilm occurs on muddy substrate where freshwater mingles with ocean saltwater at the mouth of the Fraser, particularly on Roberts Bank. This mucous-like mix of microbes and organic detritus is a key dietary component for small shorebirds, such as the western sandpiper *Calidris mauri* (Kuwae et al. 2008; Kuwae et al. 2012).

The tidal flats are covered by extensive growths of the native eelgrass, *Zostera marina*, and a nonnative species, *Zostera japonica*. The eelgrass meadows of Boundary Bay and Roberts Bank are the most extensive in the Strait of Georgia, covering thousands of hectares and supporting numerous species of invertebrates, algae, and vertebrate species (Short et al. 2004). Many of the local, commercially taken fish and shellfish spend at least part of their lives in eelgrass meadows.

Estuarine Marshes

Characteristic vegetation of the estuarine marshes, on the active front of the delta, includes sedge *Carex lyngbyei*, bulrush *Scirpus paludosus*, and cattail *Typha latifolia* (Butler and Campbell 1987). This marsh is important feeding habitat for wintering trumpeter swans *Cygnus buccinator* and lesser snow geese *Chen caerulescens*

caerulescens. Near the dykes, the marsh is only covered by the highest winter tides. Plants such as dunegrass *Elymus mollis*, Douglas' aster *Aster douglasii*, Canada goldenrod *Solidago canadensis*, sea-watch *Angelica lucida*, and cow parsnip *Heracleum lanatum* are typical of this backshore vegetation. Populations of Townsend's vole provide prey for resident northern harriers *Circus cyaneus*, wintering rough-legged hawks *Buteo lagopus*, and short-eared owls *Asio flammeus*.

Salt Marshes and Boundary Bay

Most of the Fraser delta salt marsh was lost when dyking occurred (Butler 2003). A remnant fringe occurs at Boundary Bay. Characteristic plants are sea asparagus *Salicornia virginica*, sea arrow-grass *Triglochin maritimum*, entire-leaved gumweed *Grindelia integrifolia*, and saltmarsh dodder *Cuscuta salina*. Hundreds of thousands of black-bellied plover *Pluvialis squatarola*, dunlin *Calidris alpina*, and other shorebirds gather to feed in Boundary Bay in season. Up to a hundred thousand dabbling ducks winter here, primarily northern pintail *Anas acuta*, mallard *A. platyrhynchos*, American wigeon *A. americana*, and green-winged teal *A. crecca* (Badzinski et al. 2008). Flocks of brant *Branta bernicla* gather offshore. The backshore habitat is similar to that described for estuarine marshes, with high populations of voles, nesting northern harriers, savannah sparrows *Passerculus sandwichensis*, and wintering hawks and owls. Other species characteristic of this marsh include short-tailed weasel *Mustela erminea* and anise swallowtail butterfly *Papilio zelicaon*.

Ocean

Within a few kilometers of the mouth of the Fraser, the Strait of Georgia drops to depths of over 300 m. The deep water is habitat for marine mammals, including endangered southern resident orca, wintering diving ducks, loons, grebes, and alcids. Gray whales often come into the shallower waters of Boundary Bay during spring and summer, and harbor seal colonies occur around the delta shores. The Strait of Georgia has commercial Dungeness crab *Metacarcinus magister* and prawn *Dendrobranchiata* sp. fisheries.

Salt Wedge and Plume

Tides in the Strait of Georgia are mixed, semidiurnal with the difference between high and low tide ranging from 3.1 to 4.8 m (Thomson 1981). At high tide, the saltwater moves up the Fraser River in a wedge that lies below the outflowing freshwater of the river. The salt wedge reaches maximum intrusion during low river discharge in winter and is at a minimum during freshet (spring snowmelt) from mid-May to July. The outgoing freshwater transports suspended sediments and is discernible as a turbid plume, which during freshet can extend across the Strait as

far as Galiano Island, 30 km west of the river mouth (Thomson 1981). With salinity levels half that of the Strait of Georgia (15 psu to 30 psu), the plume is a distinct ecosystem from surrounding waters (Harrison and Yin 1998).

Upland Farmland

Agricultural land in the delta grows crops such as hay, potatoes, beans, corn, and berry fruits. Open-field farmland, together with hedgerows and ditches, provides habitat for diverse wildlife, from beneficial insects to fish, birds, and mammals. It is an essential winter habitat for birds such as trumpeter swan, lesser snow goose, dunlin, black-bellied plover, short-eared owl, and northern harrier. A few industrial-scale glass-houses have associated freshwater ponds that are used by waterfowl and shorebirds.

Bog

Burns Bog is the largest bog in the Fraser delta, and the largest, deltaic, domed bog on the west coast of North America (Environment Canada 2001). Historically covering about 4,800 ha, between the Fraser River and Boundary Bay, it has been encroached on by other land uses, and only about 29% remains relatively undisturbed (Metro Vancouver 2007). The bog formed over the course of several thousand years. Areas of the delta with a high water table and poor drainage gradually became elevated by decaying vegetation and the growth of sphagnum moss *Sphagnum flexuosum*. The domed bog is dependent on rainfall for its moisture, and the nutrient-poor, acidic conditions promote a specialized plant assemblage, uncommon on the southwestern BC coast (Hebda et al. 2000). As well as twelve species of sphagnum moss, characteristic bog plants include: Labrador tea *Ledum groenlandicum*, reindeer lichen *Cladonia rangiferina*, bog laurel *Kalmia microphylla*, cloudberry *Rubus chamaemorus*, and round-leaved sundew *Drosera rotundifolia* (Metro Vancouver 2007). Drier conditions prevail around the bog's outer, transitional region or lagg. Predominant vegetation includes shore pine *Pinus contorta* var. *contorta*, western redcedar *Thuja plicata*, red alder *Alnus rubra*, and sweet gale *Myrica gale*.

Burns Bog is also known for faunal diversity. Two locally rare dragonflies, subarctic damer *Aeshna subarctica* and zigzag damer *A. sitchensis*, have been recorded (Kenner 2000). Pacific water shrew and a rare subspecies of southern red-backed vole *Myodes gapperi occidentalis* also occur (Fraker et al. 1999). Bird species include waterfowl, songbirds, raptors, and greater sandhill crane.

Conservation Designations

The ecological value of the Fraser delta is well recognized by scientists, yet legal protection of the area is limited. There are several overlapping international conservation designations. The 20,682 ha of intertidal and marsh area in the provincial

Wildlife Management Areas outside the dykes at Boundary Bay and Sturgeon Bank, and at South Arm Marshes and Serpentine, together with the Alaksen National Wildlife Area and the multi-jurisdictional Burns Bog Ecological Conservancy Area, are collectively designated under the Ramsar Conventions as a Wetland of International Importance (Fraser River Delta – site 243: <https://rsis Ramsar.org/ris/243>). Roberts Bank has not yet been designated as a Ramsar Site although it meets the criteria for designation. It is however along with Boundary Bay and Sturgeon Bank designated a hemispheric site under the Western Hemispheric Shorebird Reserve Network, www.whrsn.org. In addition, the whole Fraser delta and estuary, including Boundary Bay, Roberts Bank, Sturgeon Bank, the surrounding uplands, and lower reach of the Fraser River, are designated an Important Bird Area (IBA) under the worldwide BirdLife International program (www.ibacanada.com; www.birdlife.org).

The delta also has a number of Canadian national, provincial, and regional designations which carry legislated conservation protections of varying degrees. These include the federal Alaksen National Wildlife Area that includes the George C. Reifel Migratory Bird Sanctuary; the Sea Island Conservation Area; provincial Wildlife Management Areas at Boundary Bay, Roberts Bank, Sturgeon Bank, South Arm Marshes, and Serpentine; Burns Bog Ecological Conservancy Area that is jointly owned by the federal and provincial governments, Metro Vancouver Parks and the Corporation of Delta; and three Metro Vancouver Regional Parks in the Fraser delta managed for recreation and conservation – Boundary Bay Regional Park and dyke trail, Deas Island Regional Park, and Iona Beach Regional Park.

Threats and Future Challenges

The delta has undergone considerable physical modification since the 1880s, including dyking, dredging, channel stabilization, and jetty construction. A landscape that was originally wet prairie, bog, and marsh (North et al. 1979) is now a mix of urban, industrial, and agricultural land, surrounded by dykes and crossed by numerous transportation and infrastructure networks. The original dykes were built by farmers, in order to permanently settle the land. Following major floods in 1894, the delta was comprehensively dyked and drained, eliminating 70% of the original marshes (North et al. 1979). Dykes stretch for 620 km along the shoreline and the lower reaches of the Fraser River (Bocking 1997). Water levels are regulated by ditches, pump stations, box culverts, and storm sewers, which allow for agricultural irrigation in summer.

Since the early 1960s, the wildlife-rich environment of Roberts Bank has been significantly affected by the construction and ongoing expansion of a port and a ferry terminal and their respective 4-km causeways across the tidal flats. Dominant tidal currents flow northward, parallel to the bathymetry (McClaren and Tuominen 1988). The unculverted causeways have prevented sediments from the Fraser River being deposited on southern Roberts Bank. Geophysical effects of the developments include slumping, channelization, and erosion of the delta

slope (Port Metro Vancouver 2005). Biological impacts range from proliferation of nonnative species, such as *Zostera japonica*, *Spartina* sp., and purple varnish clam *Nuttallia obscurata* (Mills 1999), to bird kills from overhead wires and noise, air, and light pollution. There are additional impacts from jetties in intertidal areas at Sturgeon Bank and constraints on bird use of intertidal and marsh habitat adjacent to the Vancouver International Airport due to safety concerns.

Burns Bog was heavily impacted by twentieth-century peat mining. Today, it is ringed by major highways; the Vancouver landfill is located in the southwest corner. In 2004, 2,042 ha were protected as an Ecological Conservancy Area, under a conservation covenant, jointly owned by three levels of government. It is closed to the public. Other bogs occur in Richmond; many hectares have been converted to farmland or other land uses.

The fertile soils, level terrain, and long growing season make the Fraser delta an excellent area for agriculture. In the last 50 years, competing pressures on the land base have resulted in widespread urban, commercial, industrial, and transportation developments. The establishment of an Agricultural Land Reserve in 1973 slowed, but did not eliminate, the conversion of delta farmland to nonagricultural use. The viability of farming and maintenance of land for agriculture are now under extreme pressure, a situation with the potential to negatively impact wildlife populations.

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