



Estuaries in British Columbia

Estuaries are naturally rare, comprising only 2.3 percent of British Columbia's rugged coastline





What are Estuaries?

Estuaries, formed where rivers enter the ocean and fresh water mixes with the saltwater environment, are among the most productive ecosystems on earth. They develop on deltas, where fine soil materials (sediment), are carried hundreds of miles downstream by the rivers and deposited on gentle shoreline slopes. These materials accumulate faster than they can be carried away by ocean currents, wave, and tidal action. Estuaries are most well developed where they are protected from oceanic forces by offshore islands and spits, or at the end of long fjords.

Estuarine plants and animals occupy different zones depending on their ability to tolerate salt concentration (salinity), wave action, river flow, tidal changes, and sedimentation levels.

The upper intertidal zone occurs closest to the river mouth. It is the least salty environment in the estuary, with more fresh water influence and only brief tidal flooding during the highest tides. The vegetation tends to be relatively diverse, forming dense meadows that include grasses such as tufted hairgrass and meadow barley and non-grass plants such as Alaska plantain and Douglas' aster.

Closer to the marine environment, the middle intertidal zone is flooded by tides more often and for longer periods of time, which excludes all but those plant species that are both salt- and flood-tolerant. These salty marshes are often dominated by just one or two species, such as Lyngbye's sedge, widgeon-grass, seashore salt-grass, or American glasswort.

The lower intertidal zone, flooded most of the time and exposed only

during the lowest tides, is essentially a marine environment. As a result, there is almost no plant life, but the rich muddy river sediments are prime habitat for bottom-dwelling worms and mud-algae, important food sources for estuarine wildlife.

Below the low tide line are three ecologically important zones: shallow subtidal, deep subtidal, and benthic (bottom zone). The shallow subtidal zone extends to a few metres in depth, where light can still reach the bottom, and eelgrass, the most common seagrass in British Columbia estuaries, forms extensive underwater meadows that provide food, cover, and nurseries for estuarine fish and invertebrate animals.

The deeper subtidal waters are similar to the coastal ocean, with a food chain founded on tiny, free-floating algae called phytoplankton. However, a specialized group of marine creatures

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that can tolerate the low salinity of an estuary make this zone distinct from marine systems.

The most distinct feature of an estuary is the rich and vibrant benthic ecosystem. It is home to microor-

ganisms and tiny animals that live between grains of sand, large burrowing worms and scavengers such as crabs and snails, and sandy areas with filter-feeders like clams. On harder surfaces, such as rocky headlands or artificial structures, you will find reef-forming shellfish like oysters and mussels, and strange, colourful animals like sponges and feathery hydroids.

What is their history?

Along the coast of British Columbia, delta formation started about 10 000 years ago, at the end of the last glaciation, making deltas and estuaries very young in the geological

timeframe. Before deglaciation, more water was frozen in the polar ice caps, sea level was lower, and river mouths were located on steep continental slopes where estuaries could not form. During deglaciation, glacial ice melted and transported sediments from their glacial source to the sea. Flowing waters from steep uplands slowed as they approached the gentler slopes closer to sea level and began to deposit their sediment. The coarse sediments were the first to be deposited while fine sediments travelled for long distances out to sea. Gradually these sediments accumulated to form a gently sloping surface that starts above sea level and continues under water, below the high tide line.

Deltas expand gradually over time and British Columbia's largest estuaries are formed where our largest and oldest rivers meet the sea.

Because of the gentle slopes and low relief of deltas, islands, lagoons, spits, tidal flats, and bars are common shoreline features related to deltas. The seaward edge of the delta, known as the delta front, is a steep slope (scarp) that can be found a few metres (e.g., small streams) to several kilometres (e.g., the Fraser River Delta) from the shoreline. This scarp separates the shallow surface of the delta from deeper oceanic waters.

Deltas are dynamic landforms that are continually formed, eroded, and modified by stream, wave action, and tidal processes. Offshore winds, shoreline shape, stream flow, sediment load, bank erosion, flooding, and other factors influence the size and shape of the constantly changing delta landform.

What is their ecology?

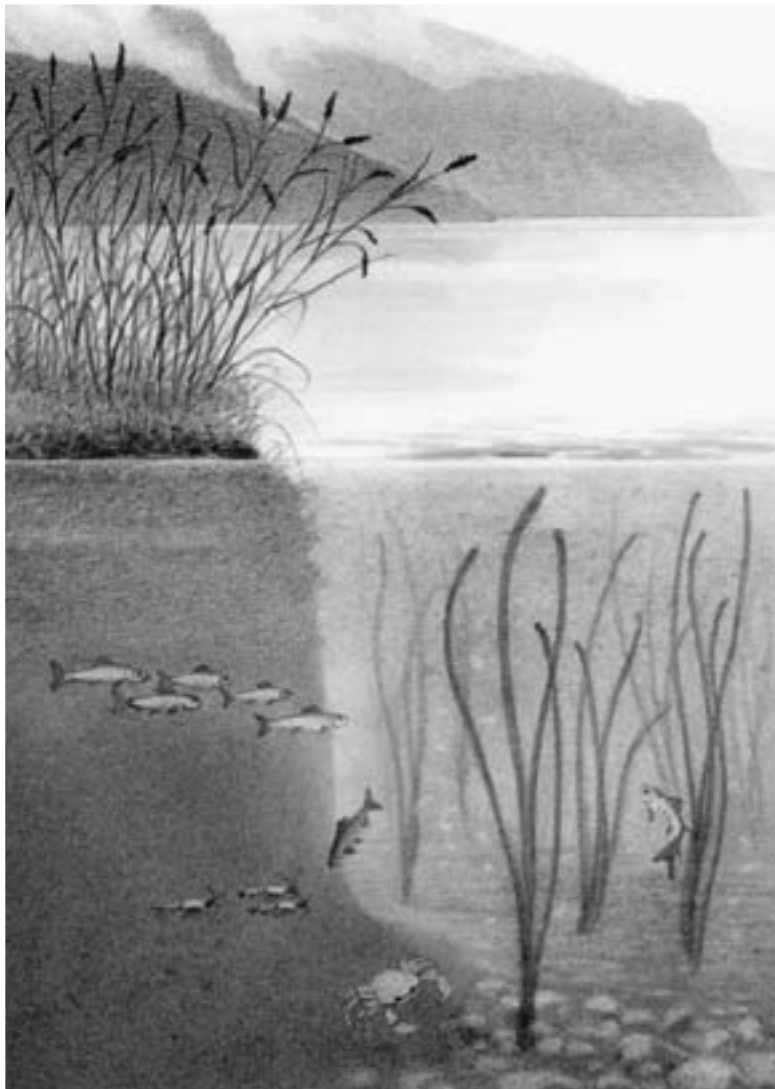
Estuary ecology is complex and dynamic because of the interaction of three very different environments – freshwater aquatic, terrestrial, and marine. The unusual conditions create many challenges for estuarine plants and animals, and relatively few species

can survive in an estuary. Those that do survive have few competitors and predators, and so are able to grow and reproduce quickly, making estuaries among the most productive ecosystems on earth.

There are several reasons for this exceptionally high productivity. Estuaries are constantly being fertilized by river sediment. Estuary vegetation, and the barrier islands or sandbars protecting it, combine to trap and hold sediments. The constantly moving tides and currents carry in oxygen, nutrients, and plankton, and take away excess wastes. Plant foods are available in a variety of forms – phytoplankton, algae, sea-grasses, wetland plants – which support a variety of animal consumers.

Most importantly, estuaries are extremely efficient at extracting, recycling, and conserving nutrients. Most of this activity takes place in the top 50 centimetres of estuary sediment, where a dense network of micro-organisms lives, recycling waste, and regulating or modifying most of the ecological processes in the estuary. This phenomenon is known as the “benthic effect.”

Benthic fungi and bacteria consume dead organic material (“detritus”) – most of which comes from intertidal wetland plants – and are in turn consumed by other organisms. Other microbes also convert animal wastes into forms that plankton, eelgrass, and



algae can use. What is remarkable is that most of this takes place in the low-oxygen benthic environment. Sub-surface micro-organisms are forced to use sulphur in place of oxygen, which is what gives stirred up estuary sediments their characteristic “rotten egg” smell. Benthic animals introduce more oxygen, increase activity by micro-organisms, and clean the water, allowing more light to enter and stimulate seagrass and plankton growth. Benthic animals, a vital link in the estuarine food

chain, consume benthic micro-organisms and in turn become food for small, bottom-feeding fish, which in turn become food for higher predators such as salmon, osprey, and humans.

Where do they occur?

Estuaries occur sporadically along British Columbia’s coastline, wherever the topography is gentle enough to allow river sediments to accumulate. The most extensive estuaries are found where the coastline is relatively flat and the sediments brought by the river build up slowly over a wide area and a long period of time. British Columbia’s greatest estuary is that of the Fraser River, the largest riv-

er in British Columbia, and the largest estuary on the Pacific coast of North America (21 703 hectares).

The Fraser River estuary has been recognized as a globally important centre of biodiversity. The intertidal wetlands alone cover roughly 17 000 hectares. The freshwater flows from the river are so great that, technically, the entire southern Strait of Georgia is an estuary. The Fraser estuary supports the highest concentration of migratory birds in Canada, up to 1.4 million during peak migration times. More than 300 species of birds and 80 species of fish and shellfish spend at least part of their life cycles here along with 300 species of invertebrate animals. More than two *billion* juvenile salmon spend weeks or months in the estuary before

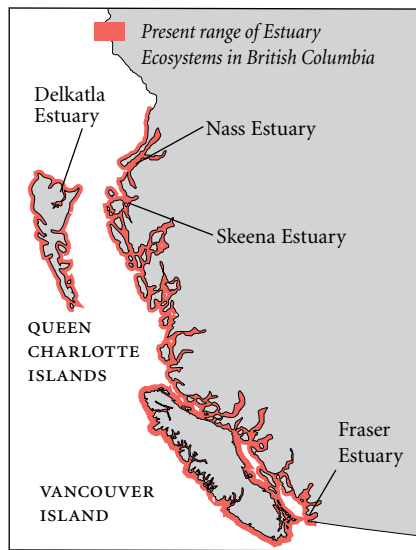
beginning their ocean migration, making the Fraser the greatest salmon-producing river on earth.

On the central and northern mainland coasts most estuaries are located at the heads of glacier-carved fjords. Two notable exceptions to this are the great Nass (6490 hectares) and Skeena (12 576 hectares) river estuaries, both of which include about 2500 hectares of wetlands. Estuaries on the Queen Charlotte Islands are located mainly where rivers empty into large inlets, such as the Delkatla estuary in Masset Inlet. Vancouver Island's estuaries are best developed along the south-eastern coastal plain. The largest of these is the Nanaimo River estuary, but others, such as the Cowichan, Chemainus, and Comox estuaries are also significant.

What makes them special?

Estuaries could be called super-habitats because they provide a diversity of food sources and habitats, and support large populations of fish and wildlife in a concentrated area. About 80 percent of coastal wildlife species use estuaries at one time or another. One of the most spectacular of these is the Grizzly Bear, which can spend large amounts of time in estuaries grazing on wetland plants and gorging on salmon during the autumn runs. About 50 other species at risk use estuaries as well, including migratory birds, and Eulachon, a culturally important fish.

A total of five million waterfowl and shorebirds use British Columbia estuaries every year as "refuelling stations" along their migration routes, as wintering grounds, or as year-round habitat. These massive flocks are mirrored by the large numbers of fish and shellfish that use estuaries as either



temporary or permanent habitat. All salmon species and Eulachon use estuaries as nurseries in which juveniles can grow and develop before heading into the more dangerous open ocean. Without these nurseries it is likely that both coastal and off-shore fisheries would be a fraction of their current size. Studies have shown that the size of a fishery is partly determined by the size of the intertidal wetlands in the nearby estuaries, demonstrating the interconnectedness of land, river, and ocean health.

Estuaries have benefited human beings greatly, from ancient times to today. Not only are estuaries a rich source of food, they recycle nutrients, clean our water, and provide endless opportunities for ecotourism and research. They also form natural hubs linking marine and river trade routes. We know that people have lived in or near estuaries for tens of thousands of years, and it may be no coincidence that the first great human civilizations arose near river mouths at the same time that sea level stabilized and large estuaries started to develop. The use-

fulness of estuaries also means that few of the world's estuaries have not been modified by human activity and British Columbia is no exception.

Why are estuaries at risk?

Estuaries are naturally rare, comprising only 2.3 percent of British Columbia's rugged coastline. Despite their high productivity, the difficult conditions under which they develop make them very vulnerable to disturbances.

Seventy percent of the Fraser River estuary wetlands have been diked, drained, and filled to reclaim land for development (the greatest cause of estuary loss in the past), and this has likely had an impact on the size of the Fraser River fisheries. Similarly, on Vancouver Island, about half of both the Nanaimo and Cowichan estuary wetlands have been lost.

The usefulness of estuaries as transportation hubs often means that channels get dredged to allow large ships to pass through. Not only does this affect shallow water habitats, including eelgrass meadows and shellfish beds, it alters the currents that are needed to maintain estuary productivity. Forest companies sometimes use estuaries as convenient access points; logging camps, roads, and landings can all negatively affect an estuary. Log booms can be damaging because of the wood debris that falls to the estuary bottom. When this debris decomposes it uses up precious oxygen, which in turn reduces estuary productivity and impairs fish survival. Log booms also restrict the natural flow of currents in the estuary.

Pollution from urban and agricultural areas, and from offshore oil spills, is a serious problem made worse by the tendency of estuary species to keep material in the estuary. Wetlands and eelgrass beds trap

toxic sediments, and filter-feeding organisms like clams concentrate toxic chemicals in their bodies.

Invasive alien plants and animals are another threat to British Columbia's estuaries. Eurasian wetland plants such as creeping bentgrass, English cordgrass, and purple loosestrife are becoming more prevalent and efforts are underway to prevent them

from growing out of control and displacing native wetland species. Exotic marine animals, such as the green crab, are also being introduced, often through the release of ballast water from ocean-going ships. This is such a serious problem that the Port of Vancouver now requires all ships to exchange their ballast water in the open ocean in an attempt to prevent any more invasive species from reaching our shores.

The long-term stability of British Columbia's estuaries can be affected by the damming of rivers and by climate change. Dams can cut off the supply of nutrient-rich sediment to the estuary, significantly reducing productivity, and they can interfere with the river's natural flooding cycle. Some migratory species of birds and fish time their arrival at an estuary to coincide with the river's peak flows, which are also times of peak estuary productivity. Disrupting these flows may disrupt the timing of these migrations, with unpredictable consequences.

Global climate change has been assessed as a moderate risk to a rise in sea level along British Columbia's coastline. For estuaries that are sandwiched between the ocean and development or a steep shoreline, a



OFFSHORE ISLAND PROTECTS KWATNA RIVER ESTUARY FROM OCEANIC FORCES. W.M. Mackenzie photo

rising sea could mean complete disappearance for an estuary and its wildlife.

What is their conservation status?

It is estimated that there are 434 estuaries, large and small, occupying approximately 75 000 hectares on British Columbia's coastline, and there is a need for greater protection.

There are proposals for parks in the Nass and Skeena estuaries, and significant portions of what re-

Invasive alien plants and animals are another threat to British Columbia's estuaries.

mains of the Fraser estuary have been designated as provincial Wildlife Management Areas where human activities must accommodate wildlife habitat requirements. Some regionally important estuaries, such as the Nanaimo and Englishman river estuaries, have partial protection through parks and private conservation land trusts.

Dala-Kildala Rivers Estuaries Provincial Park, near Kitimat, was created specifically to protect estuaries. The Khutzeymateen Grizzly Bear Sanctuary and Kitlope Heritage

Conservancy protect entire watersheds, maximizing protection for the estuary's terrestrial and freshwater component. Fiordland Recreation Area, north of Bella Bella, contains three significant estuaries and two smaller ones. Numerous smaller estuaries are provided protection in conservancy areas such as Hakai Luxvbalis Conservancy Area and British Columbia's system of provincial marine parks.

The *Fisheries Act of Canada* and the *Fish Protection Act of British Columbia* provide strong legal protection for fish habitat, providing additional avenues to protect freshwater flow to estuary ecosystems of fish-bearing streams and rivers.


Despite this variety of protections, past land use practices, global influences on climate, and alien species introductions mean British Columbia's estuaries are at risk. Every estuary wetland vegetation type in British Columbia is red-listed (endangered) or blue-listed (special concern). Naturally rare and subject to multiple threats in both urban and wilderness areas, these tiny jewels in British Columbia's coastline will require both protection and stewardship if they are to last.

How can we protect them?

In 1987, governmental and non-governmental conservation agencies joined together to form the Pacific Estuary Conservation Program (PECP). The goal of the PECP is to protect British Columbia's estuaries by creating parks for estuaries on public lands, buying private land in estuaries, and encouraging stewardship. The program has secured thousands of hectares of shoreline and intertidal

habitats, winning the prestigious international Ramsar Wetland Conservation Award. British Columbians can participate in these efforts by supporting the creation of new estuary parks and by volunteering with or donating to conservation organizations (on the PECP website) that buy estuary land as part of the PECP.

The PECP also works with landowners to enhance stewardship of estuaries on private land. Good stewardship of estuaries includes timing activities so as not to disturb migratory birds, maintaining good water quality while juvenile salmon are in the estuary; leaving the estuary bottom intact as much as possible; and leaving the intertidal wetlands in a natural state as much as possible. These practices can be incorporated in a conservation covenant so that future owners will abide by them and, depending on location, there may be associated tax benefits or other incentives.

The best way to start protecting estuaries, however, is the simplest. Visit a local estuary and get to know the local flora and fauna. Take along this brochure and see if you can spot all the elements of estuary ecology described here. Join a natural history society or take a guided walk with a park naturalist to find out more about the importance of estuaries to both the local ecology and economy. Getting to know and appreciate the contributions estuaries make to British Columbia's biological, cultural, and economic health is the greatest incentive to maintain these precious ecosystems into the future. 



MIGRATING SHOREBIRDS IN FLIGHT OVER BOUNDARY BAY ESTUARY.
R. Butler photo



SKOWQUILTZ ESTUARY SITUATED ON THE NORTH SIDE OF DEAN CHANNEL, A DEEP COASTAL FJORD.
W.M. Mackenzie photo



FLOWERING EELGRASS PROVIDES HABITAT FOR DIATOMS AND BUBBLE SHELL.
Archipelago Marine Research Ltd. photo



ROAD, LOGPILE, AND ABANDONED MATERIALS ARE ARTIFICIAL STRUCTURES COMMONLY FOUND ON ESTUARINE MEADOWS AND MARSHES.
Sensitive Ecosystems Inventory: Sunshine Coast and Adjacent Islands

Pacific Estuary Conservation Program partners:

<http://www.bc.ducks.ca/province/bc/partners/pecp/index.html>

FOR MORE INFORMATION ON SPECIES AND ECOSYSTEMS AT RISK, CONTACT:

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