# T6.4 ESTUARIES

Estuaries occur at the mouths of rivers where seawater becomes diluted by fresh water draining from the land. They are among the most productive ecosystems—comparable to rainforests and coral reefs—partly because they tend to be shallow, receive a continuing supply of nutrients from the river and are mixed by the tidal movements of the sea.[1] They are not easy environments for organisms to inhabit, due to variations in salinity and temperature, periodic exposure to the atmosphere and the great influences exerted by human beings (see T12).

Nova Scotia has many estuaries (almost as many as there are rivers) and they vary regionally.

## PHYSICAL FEATURES

Important physical features which determine estuarine conditions include the morphology of the river mouth and availability of soft sediments (both related to the geology of the area), and the relative strengths of tidal movements and river outflow.

Tides vary over several different time scales (see T6.1). The sea level is also influenced by wind and changes in barometric pressure; these may either increase or decrease the natural tidal movement near a coastline. River flow, in turn, tends to be seasonal—higher following major storms or snow melt in spring, and lower during mid-winter and in dry periods such as commonly occur in summer.

The relative rate of sea-level rise can also contribute to estuarine conditions. Studies in Chezzetcook Inlet indicate that rapid sea-level rise (3.8 mm per year between 1920 and 1970) has resulted in widespread coastal erosion and subsequent infilling of the estuary.[2]

## FRESHWATER INFLUENCE

When river flow is much greater than tidal movements, the fresh water tends to remain on top of the seawater because it is less dense, forming a freshwater layer above a distinct salt wedge. Such an estuary is said to be stratified (see Figure T6.4.1). Under these circumstances, many of the dissolved and particulate materials brought by the river move seaward in the estuary and may in fact be flushed right through it if the flow is very high. As the water travels further into the estuary, its velocity usually decreases, allowing heavier particles to settle toward the bottom and resulting in an accumulation of sediments and other detritus in deeper water. The outward flow of the river also mixes with and carries along some of the underlying seawater. This phenomenon has the effect of causing water in the deeper seawater layer to move upstream as a reaction current or countercurrent (see T6.1). The reaction current can carry free-floating objects in the water just above the bottom (suspended sediments, planktonic larvae, fragments of detritus, etc.), bringing them upstream toward the head of tidal influence. Because of a relative lack of mixing in the salt wedge, water remains at about the same salinity as that of the nearby sea. It can be inhabited by marine plants and animals that in some cases move from the ocean all the way to the head of the salt wedge. The surface layer, being fresh, may be inhabited by plankton and fish originating in fresh water.

Few of Nova Scotia's rivers have such a dominating flow all year, but during periods of snow melt or following heavy rainstorms, many estuaries may become temporarily stratified. Where the



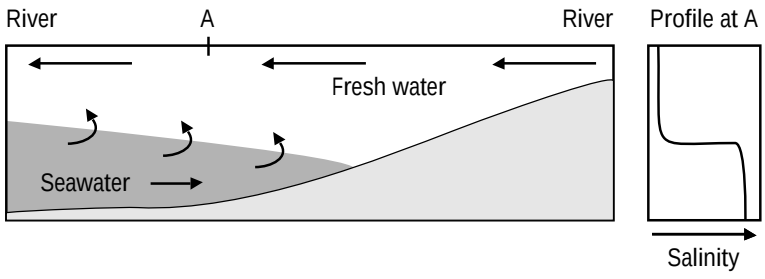


**Figure T6.4.1:** Diagramatic longitudinal section and profile of a stratified estuary.

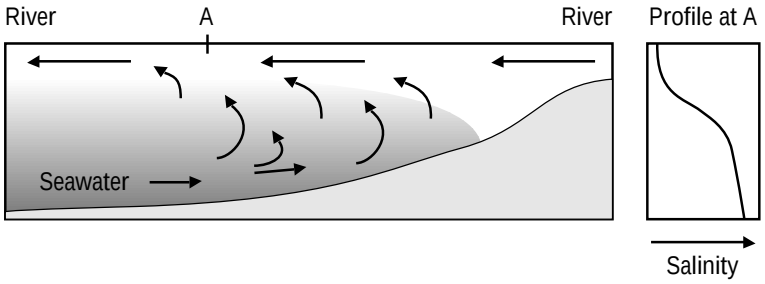


**Figure T6.4.2:** Diagramatic longitudinal section and profile of a vertically mixed estuary.

influence of the tide has been reduced by building of dams or causeways (e.g., the Annapolis River at Annapolis Royal, District 610), such stratification may become a permanent feature.

### TIDAL INFLUENCE

Many Nova Scotia estuaries are more strongly influenced by tidal and wind-generated movements of the sea than by the river flow. The strong bottom currents tend to mix the fresh water and seawater together, so that the salinity at any point in the estuary is approximately the same from the surface to the bottom of the water column. Such an estuary is said to be vertically mixed (see Figure T6.4.2).

In these estuaries, salinity declines progressively as one moves upstream. In vertically mixed estuaries, materials brought down the river from the watershed are also mixed from top to bottom. They may accumulate in the upper part of the estuary, forming a zone of distinctly turbid water, known as the turbidity maximum. Marine organisms, having little tolerance for reduced salinity, will be confined to the outer parts of the estuary. Freshwater species will be restricted to the end where the river enters. Most parts of such estuaries are inhabited by species that have relatively wide tolerance of salinity and temperature. Furthermore, animals living attached to the bottom or in bottom sediments may be subjected to widely varying salinity as the tide ebbs and floods.

Most of the estuaries along Nova Scotia's coast (Atlantic Coast and Gulf of St. Lawrence) have tidal ranges of about 1 to 2 metres. The smallest tidal range (less than 20 cm) is found in Bras d'Or Lake (Unit 916). In the Bay of Fundy (Units 912, 913), on the other hand, average tidal range increases from about 4 m near Yarmouth to almost 12 m in Minas Basin. Estuaries with tidal ranges smaller than 2 m are classed as microtidal, those from 2 to 4 m as mesotidal and those above 4 m as macrotidal.

Estuaries with large tidal ranges naturally have extensive areas of tidal flats that are successively covered and exposed as the tide floods and ebbs (see H2.4 and H2.5). This is a difficult environment for many organisms to inhabit, owing to the interaction of physical and chemical factors: salinity and temperature variations, the nature of the substrate, alternations in wetting and drying, and so on. Consequently, the diversity of species is often rather limited, certainly by comparison with rivers, streams and rocky shores. Where there are few species, however, those present may be extremely abundant.

### SEDIMENTS

Many estuaries have extensive areas of soft sediments, such as deposits of sand, silt or clay, which are exposed at low tide. Their distribution is determined by the strength of tidal and river currents, or exposure to waves, but they each represent significantly different habitats for organisms.

Sands occur where water movements are quite strong. They are coarse in texture and drain quickly as the tide ebbs. The larger clams, polychaetes that construct tubes from sand grains, burrowing isopods and other crustaceans are common inhabitants of this zone. In nutrient-rich sand flats, common in estuaries, the sand may also be colonized by benthic diatoms, which provide the base of the sand-flat food chain. This food source is often augmented with detritus from surrounding salt marshes and submerged Eel Grass beds, or by organic matter brought down the river. Silts tend to be richer in organic matter, do not drain as readily at low tide and are more likely to become anaerobic. These are also inhabited by polychaetes, species of clams, mud snails and small crustaceans. Clay-dominated "mud flats" occur in relatively calm water, appear "sticky," tend to retain the water at low tide and are often anaerobic just below the surface because of the high content of plant-derived material. The surface of a mud flat may sometimes be held together by carbohydrates exuded by microscopic diatoms living in

the upper millimetre of sediments and migrating to the surface to photosynthesize as the tide ebbs. Each type of deposit has its characteristic fauna and flora and exhibits very strong interactions between the physical and biological world.[3]

## PRODUCTIVITY

Estuaries and other coastal environments are important for biological organisms in a variety of ways. They tend to act as traps for sediment and nutrients brought down the river. The nutrients support phytoplankton growth and extensive development of tidal marshes and frequently Eelgrass beds, which are important to the Brant and Canada Goose. The stems and leaves of Eelgrass decay in coastal waters and form detritus. Several estuarine species, including crustaceans, molluscs and worms, consume detritus either for its inherent food value or for the rich microflora of bacteria and fungi that may be decomposing it. Many Nova Scotia estuaries, particularly in the inner Bay of Fundy (Unit 913a), support ecosystems which are almost entirely based on detritus.

The estuary is open to the sea, allowing mobile species, such as fish and crustaceans, to migrate into the estuary for feeding, as well as to find appropriate spawning grounds. Estuarine circulation, and the nutrients it provides, offers an added benefit to marine organisms over the already-important coastal regimes where upwelling, light and temperature are favourable to growth. Estuaries have high productivity by organisms in the water column and in suspension-feeding marine organisms (such as mussels) that feed on them, because of the physical interaction of the fresh and salt water and the nutrient supply it provides. In estuaries in which the surface freshwater layer is well defined, a tongue of salt water can extend significant distances upriver and provide habitat for marine organisms.

The warm temperatures, rich food supply and relative absence of predators make estuaries important nursery grounds (areas where young stages are able to feed, find shelter and grow rapidly). A number of fish species (e.g., salmon, flounder, herring, shad and Striped Bass) are linked closely to estuarine environments at important stages in their life cycle. The fertile estuarine regions of the Bay of Fundy also attract migratory fish (e.g., pollock, dogfish), seabirds, shorebirds and marine mammals, which sometimes come from great distances. These estuaries are therefore important for Nova Scotia and much of the Northern Hemisphere.

## CULTURAL FACTORS

There is a long tradition of use related to estuaries in Nova Scotia. Most recently, aquaculture has focused attention on maintaining the quality of estuarine environments (see T12.7 and T12.11).

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***Associated Topics***

T6.1 Ocean Currents, T6.2 Oceanic Environments, T6.3 Coastal Aquatic Environments, T8.2 Freshwater Environments, T10.5 Seed-bearing Plants, T10.6 Trees, T11.6 Shorebirds and Other Birds of Coastal Wetlands, T11.7 Seabirds and Birds of Marine Habitats, T11.12 Marine Mammals, T11.13 Freshwater Fishes, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T12.7 The Coast and Resources, T12.11 Animals and Resources

***Associated Habitats***

H2 Coastal

***References***

1 Mann, K.H. (1982) *Ecology of Coastal Waters. A Systems Approach*. Blackwell Scientific Publications, Oxford. (*Studies in Ecology* 8).

2 Carter, R.W.G., J.D. Orford, S.C. Jennings, J. Shaw and J.P. Smith (1992) "Recent evolution of a paraglacial estuary under conditions of rapid sea-level rise: Chezzetcook Inlet, Nova Scotia." *Proc. Geologists' Association* 103.

3. Postma, H. (1967) "Sediment transport and sedimentation in the estuarine environment." In *Estuaries*, edited by G.H. Lauff. American Association for the Advancement of Science, Washington, D.C. *(Publication* 83).