# Estuaries

## THE PHYSICAL ENVIRONMENT



## BIOLOGICAL FEATURES



## ECOLOGY



## ESTUARIES AND US



## THE PHYSICAL ENVIRONMENT

### Formation

Estuaries are formed where rivers meet the ocean. There are no two identical estuaries. Some are small, others cover a very large area.

The actual formation of some estuaries is believed to have occurred during the last ice age, when glaciers carved out river beds along the coast.

### Physical Characteristics

## Currents

In the estuary, river and tidal currents play very important roles in mixing the lower and upper layers of water. This estuarine circulation, as we will see later, is a crucial factor determining the high productivity of estuaries.

When sea-water enters an estuary in the northern hemisphere, it flows clockwise to the 'right,' and freshwater flowing down-river moves also clockwise, thus flowing to the other side. Due to this coriolis force, one side in the estuary is often saltier than the other side.

## Ice

Some of our more northern estuaries have ice cover for up to four months of the year. Ice cover helps provide a constant temperature in the mud, which is beneficial for many marine organisms. Once the ice melts, there is a very sudden increase in freshwater content, contributing to the variability in salinity.

## Salt

Salinity constantly changes in estuaries. When freshwater mixes with saltwater it is called brackish water. The water of estuaries and salt marshes can be brackish.

*see activities 11, 37*

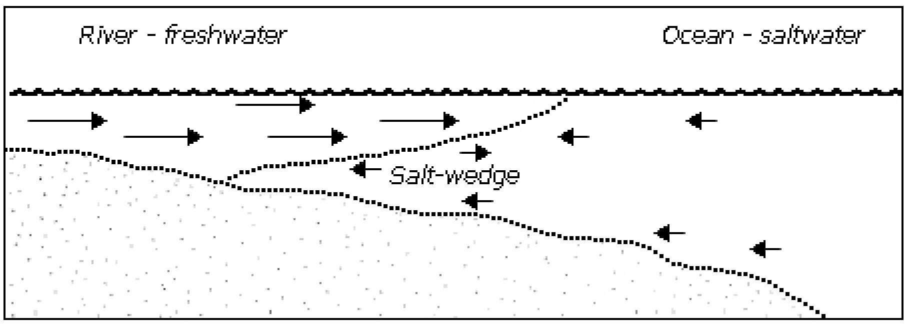
### Salinity

Salinity is an important feature of estuaries. Estuary water is a mixture of freshwater and saltwater in proportions that vary according to the location in the estuary. An out-going tide can reduce salinity slightly.

The degree of salinity can also be influenced by factors such as the level and intensity of the tides, the melting of snow in the spring, heavy precipitation, and dry periods during the summer season.

The salinity can be weak upstream in the estuary, about 0.5 ppt, and very high downstream, up to 30 ppt. In the sea, the average salinity is 35 ppt. The zone where freshwater changes to saltwater is called a pycnodine.

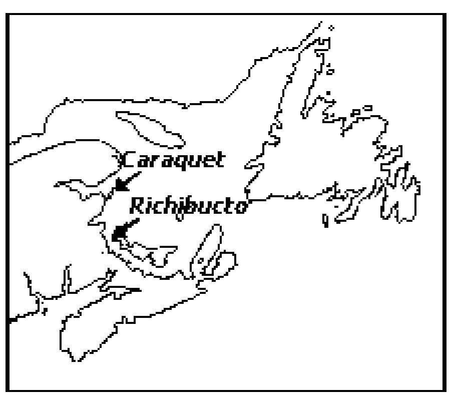
The freshwater from rivers is lighter than saltwater, so it has a tendency to stay on top of the saltwater. If the estuary is deep enough, the saltwater from the sea will travel up the estuary by passing under the freshwater while the freshwater going down the river will stay above the saltwater layer and enter the sea. This is called a salt-wedge estuary. This kind of estuary tends to form in situations with low turbulences; therefore, little mixing occurs. It often happens in certain places that there is virtually no salt content at the water's surface, but the salinity is very high at the bottom. If the estuary is shallow or where water turbulence is great, the salt and freshwater will mix and the salinity change is gradual.




There are a few organisms, such as salmon, that undergo physiological changes so that they can move from saltwater to freshwater environments and vice versa.

By following the saltwater wedge, some marine organisms can advance farther into the estuary. By following the freshwater, some aquatic organisms can move farther down the estuary. Thus some marine species can be found very far upstream in an estuary.

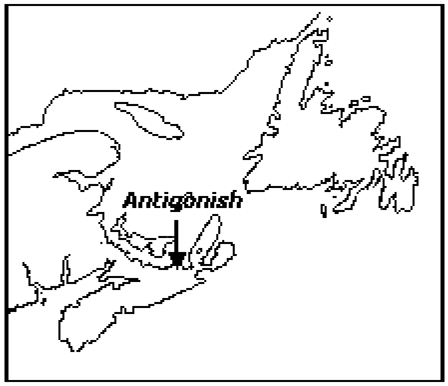
At the mouth of the Caraquet River, New Brunswick, salinity of 4 ppt has been observed at low tide in the spring. Melting snow and ice, spring rains and run-off contribute to the low salinity levels. During the summer the salinity can vary between 20 and 25 ppt at the same place.




In the Richibucto River, it's possible to collect American Oysters as far up as the Nicolas River, located 25 km from the coast.

## Sediment

An estuary is constantly changing and tends to accumulate sediments. Sediments come from rivers, streams and brackish marshes located inland, and salt marshes and sand dunes located near the mouth of the estuary. Sediments can be composed of animal and plant matter, as well as inorganic material, such as mud or sand.




In the 1930s, boats ventured up the Antigonish estuary in Nova Scotia some 12 to 15 kilometres inland. Due to large amounts of sediment deposited over the years from three rivers into the estuary, it is now only possible for a canoe to navigate where once ships travelled.

## Temperature

Most of the estuaries in Atlantic Canada are warmer in the summer than the ocean and in the winter estuaries tend to be slightly colder. In Newfoundland however, when the offshore is below zero degree celsius in winter, the estuaries are warmer than the ocean.

Temperature is one of the main elements influencing reproduction of invertebrates and fish. Since estuaries are shallow and semi-enclosed, temperatures can be slightly higher than in open areas, providing the levels required for some species to lay their eggs. Cold temperatures can negatively affect fish in their planktonic stages, slowing down the hatching and growth of the young.

## Tides

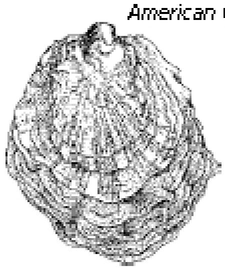
With the rise and fall of tides, nutrients are brought into the estuary. The movement of tides also causes turbulence, resulting in an upwelling of water, which brings nutrients from the bottom of the estuary to the surface.

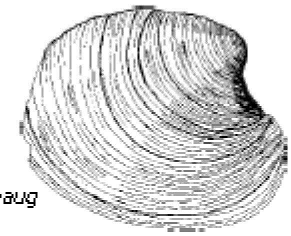
*see activity 4*

The further up the estuary you go, the more delayed the tide becomes. Since estuaries are usually funnel-shaped, incoming tides at the mouth tend to increase in amplitude as the channel narrows. The frictional contact from the shore and bottom act against the tide and tend to lower the height of the tide. With these counteracting forces, it can be difficult to predict whether the tidal range will be smaller or greater at the head of the estuary. The rise and fall of tides can be felt far up-river, especially in bigger estuaries.

### Temperature

The American Oyster requires a temperature of 20° C, while the Bay Quahaug requires 23° C to breed. It is not surprising that the distribution boundary for the Bay Quahaug is more to the south than the one for the American Oyster. In fact, oysters are found as far north as Caraquet Bay, New Brunswick, while the Bay Quahaug is only found as far north as the Miramichi estuary, New Brunswick.


American Oyster

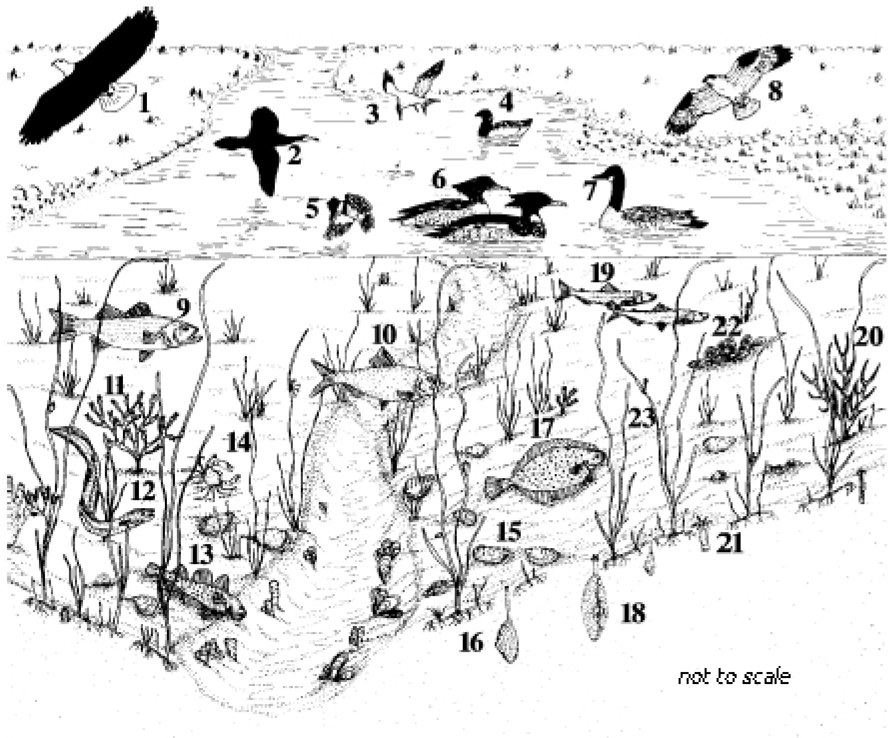

Bay Quahaug

## BIOLOGICAL FEATURES

In the summer there is an abundance of biological activity in the estuary. The tides, currents, and wind bring nutrients to the water's surface (upwelling). Plentiful nutrients combined with warm shallow waters set the stage for a profusion of activities. Some invertebrate animals, birds, and fish are able to take advantage of these factors. Estuaries and other coastal ecosystems tend to be in areas of high productivity and therefore have high-quality habitats for many species of wildlife.

### Who Lives Where?

| | |
|---|---|
| *1 Bald Eagle* | *2 Double-crested Cormorant* |
| *3 Common Tern* | *4 Brant* |
| *5 Belted Kingfisher* | *6 Red-breasted Merganser* |
| *7 Canada Goose* | *8 Osprey* |
| *9 Striped Bass* | *10 Gaspereau* |
| *11 Rockweed* | *12 American Eel* |
| *13 Atlantic Tomcod* | *14 Green Crab* |
| *15 American Oyster* | *16 Soft-shelled Clam* |
| *17 Winter Flounder* | *18 Bay Quahaug* |
| *19 Atlantic Silverside* | *20 Hollow green weed* |
| *21 Terebellid worm* | *22 Blue Mussel* |
| *23 Eelgrass* | |




## Plankton

Phytoplankton are minute plants such as dinoflagellates. Phytoplankton, along with bacteria and fungi, are the basis of life in the estuary and are carried by the currents. In order to survive, they must remain in a place where the salinity fits their needs. They use the sun and the nutrients from rivers and salt marshes to feed themselves.

Zooplankton are the tiny animal part of plankton. In estuaries, zooplankton benefit from an abundant food supply: phytoplankton, microscopic algae, bacteria, and detritus coming from dead plants and animals.

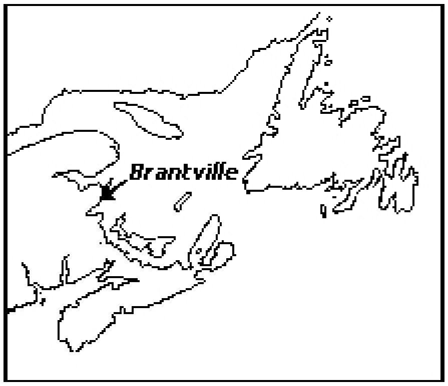
## Plants

Plants modify coastal ecosystems by trapping sediments, slowing down currents, producing food, and giving shelter to organisms.

Eelgrass is a major source of food for a whole community of animals and plants. Small fish such as the Mummichog, Sticklebacks, and the fry of the Striped Bass and Gaspereau shelter and feed in Eelgrass beds. This plant helps to stabilize the bottom with its roots, allowing organisms such as Crabs and Lobsters to move around on it. Accumulations of dead Eelgrass are often found along beaches, enriching other ecosystems.

In the early 1930s an epidemic destroyed close to 90 per cent of Eelgrass beds along the Atlantic coast, seriously affecting the organisms that were associated with them. Brant (a type of goose) rely on Eelgrass as food during migration, and were greatly reduced in numbers. Brant and Eelgrass are still recovering to this day.

The formation of an Eelgrass bed can actually be an early successional step in the development of a salt marsh.




A small community north of Newcastle, New Brunswick, is called Brantville. It was named after the once abundant Brant feeding on the Eelgrass. Today Brant are still found in small numbers, particularly along the Northumberland Coast of New Brunswick and Nova Scotia, where Eelgrass occurs.

**Eelgrass facts**

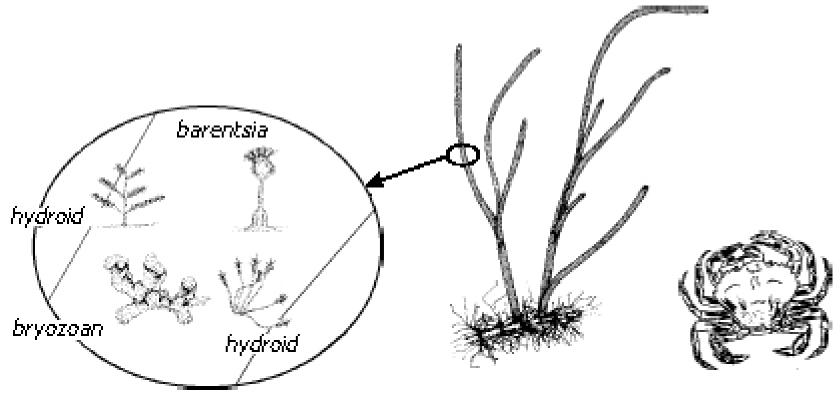
Eelgrass is one of the few plants that flower in the water. It's found in practically all shallow expanses of water, with a sedimentary bottom in Atlantic Canada. In estuaries, it's found just below the low tide line to where the salinity is lower than 14 ppt. It grows best in water temperatures from 10°C to 20°C, reproduces best between 15°C and 20°C, but can tolerate temperatures between -1.5°C and 30°C. Like other sea grasses, it has salt glands on its leaves to remove sodium and chlorine ions from its cells.

When conditions are suitable for growth, Eelgrass beds can be one of the most productive systems in the world. They grow as fast as cultivated wheat or corn and the biomass of plants living on Eelgrass can sometimes be as great as the biomass of Eelgrass itself.

*see activities 31, 32*

The roots of Eelgrass may become so thick that they tightly bind sediments to the extent that they can withstand severe storms with little erosion. The leaves of Eelgrass slow down currents, allowing the water to deposit their sediment loads.

Apart from Black Ducks, Canada Geese, and Brant, few animals actually feed on Eelgrass. Snails feed on epiphyte vegetation on the surface of the leaves, amphipods and small shrimp on detritus, encrusting bryozoans on suspended food particles, and hydroids on small organisms in the water.




Eelgrass beds were decimated in the 1930s by a protozoan (one-celled organism) called Labryinthula. Fortunately this organism does not survive in areas of high salinity, so pockets of Eelgrass survived in the affected regions. If Eelgrass becomes widespread the protozoan might again trim back the Eelgrass beds.

An over-abundance of Eelgrass can be an environmental indicator. Too much Eelgrass can be due to an over-abundance of nutrients, often coming from human's sources. When Eelgrass becomes over-abundant, it can slow the flow of water and allow sediment to accumulate in great amounts, making the area more and more shallow.

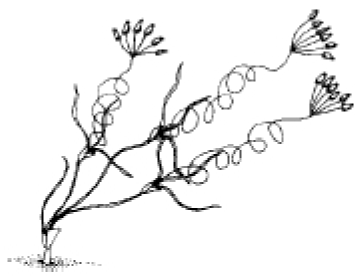
Eelgrass

Eelgrass has long blades that can be seen floating in the water or washed ashore in large heaps.

Graceful Red Weed

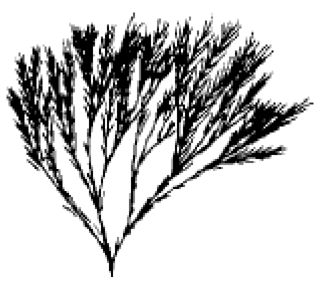
The Graceful Red Weed is a red seaweed that grows in association with Eelgrass.

Ditch-grass/Widgeon-grass



Ditch-grass is another one of the few flowering plants that grows here. It is a favourite of ducks. More delicate than Eelgrass, it is easily crowded out by it.

Tubed Weed

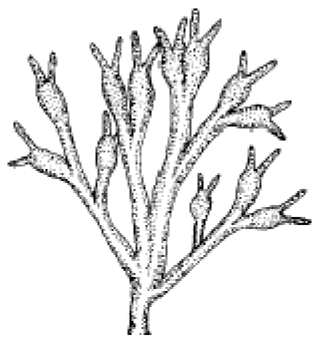


The Tubed Weed is an epiphyte on Eelgrass that can build up a substantial biomass.

Sea Lettuce

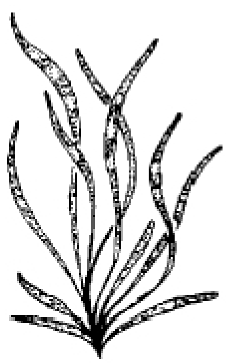
Sea Lettuce is a green seaweed with thin leaves that does look like lettuce.

Bladder Wrack



Bladder Wrack is a brown seaweed that grows in Eelgrass beds where it finds a hold in the substrate.

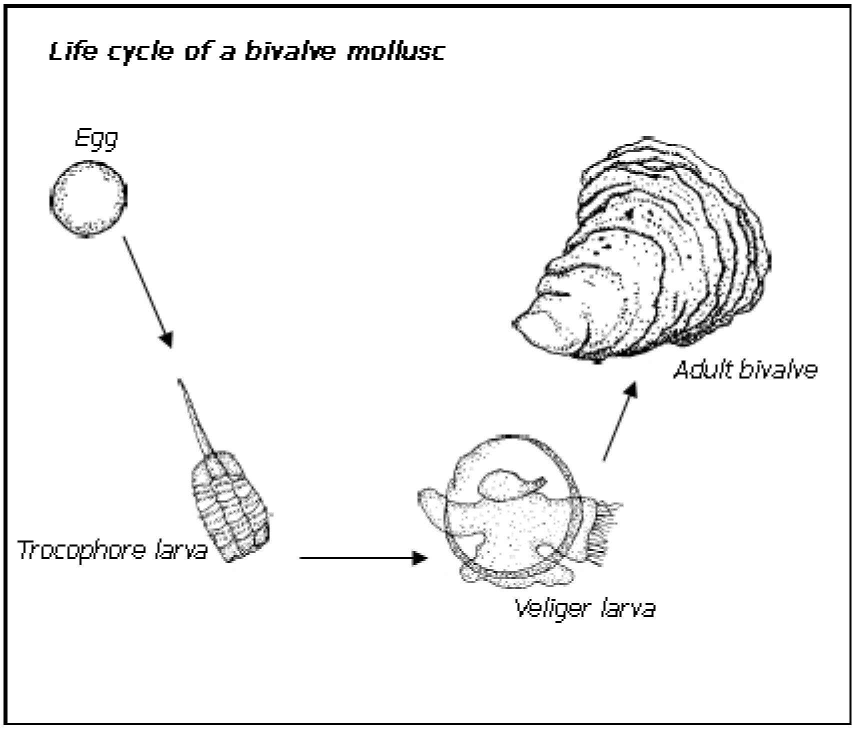
hollow greenweed



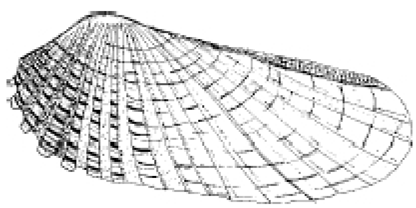
Hollow green weed is a very common green seaweed and is a major primary producer in the estuary.

## Molluscs

Molluscs are plentiful in estuaries. Some hide in the sediment while others live on sediments or plants. Molluscs can be carnivores or can feed by filtering water. Some graze on microscopic algae that live on the estuary bottom and on the vegetation. Others feed on detritus from dead animals and plants. Molluscs are an important source of food for other animals that live or stay in the estuary such as the Winter Flounder, Mud Crab, Ducks (such as Scaup), and Raccoon.

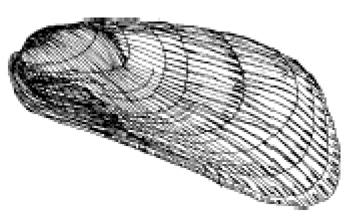



False Angel Wing



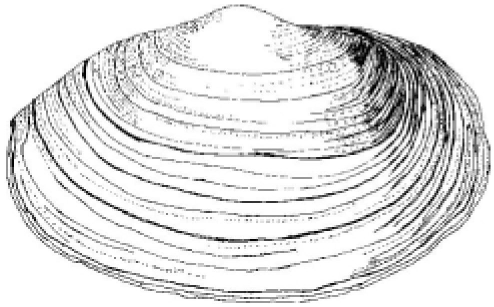
The False Angel Wing has very sharp rays that allow it to bury itself in the clay. 5 cm.

Ribbed Mussel



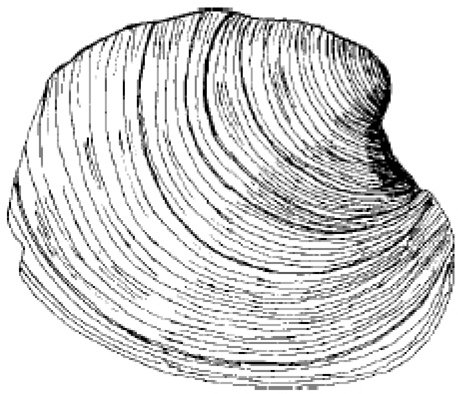
Ribbed Mussels are found mainly in salt marshes at the low tide line. They prefer brackish waters. 10 cm.

Soft-shelled Clam



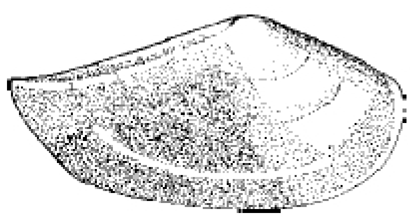
The exterior of the Soft-shelled Clam is greyish white and chalky. This is the clam that squirts from the mud. 10 cm.

Bay Quahaug



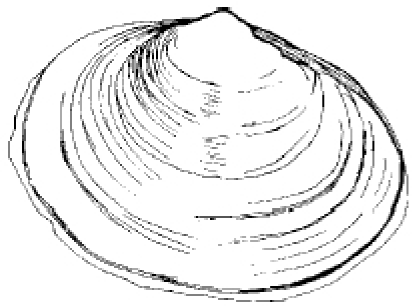
The Bay Quahaug is a mollusc of muddy sediments. It is thick-shelled and greyish yellow and is also known as hard-shelled clam. 10 cm.

Short Yoldia



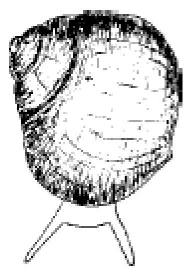
The Short Yoldia is a very slender mollusc. It lives mainly in muddy bottoms. 2.5 cm.

Baltic Macoma



The Baltic Macoma can feed on plankton when the tide is high and on detritus when the tide is low. 5 cm.

Common Periwinkle

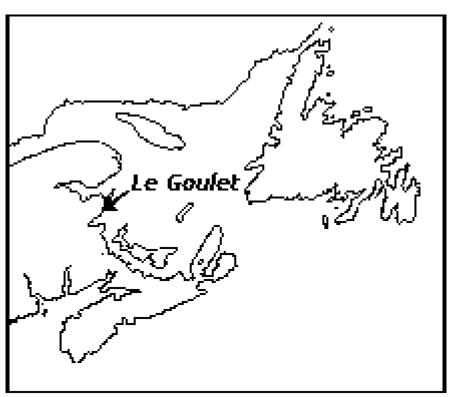


The periwinkles are gastropod molluscs. They are very common in the estuary and also abundant along wharves. 3.1 cm.

## Crustaceans

Lobster, Crabs, Sand Shrimp, and Amphipods (a type of small shrimp) are found in estuaries. They can serve as food for birds, fish, and mammals.

At low tide, if you take a sample of Eelgrass and examine it carefully, you will see that it contains a lot of amphipods and even some isopods. In a sample collected at Le Goulet, New Brunswick, 98 amphipods were found in two cups of Eelgrass.




**Crab and lobster**

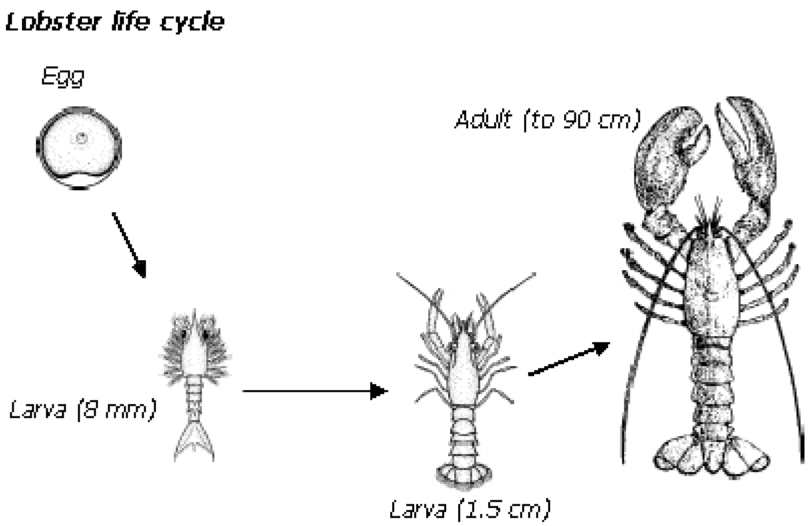
Crabs and lobsters feed on molluscs and other living or dead organisms. They use their claws to break shells. Lobsters can eat mussels, crabs, oysters, sea stars, and worms.

Crabs eat mussels. When mussels are cultivated using 'collectors' they are the size of a grain of pepper when first installed. Crabs are often found on these collectors.

A lobster of 8 cm can eat six oysters of 15 to 25 mm in length per day. A Mud Crab of 2 cm can eat one.

**Movement**

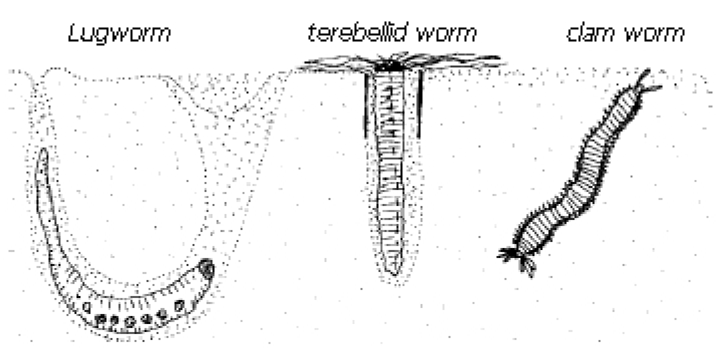
Lobsters move foreward. When they're hurried, they often swim backwards. Sand Shrimp move in the same manner. Crabs move sideways.



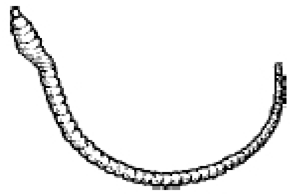

## Worms

Worms are prey for a great variety of animals, such as crustaceans, fish, and birds. Some are carnivores, others eat seaweed or detritus (non-living materials). Some worms, like the clam worm, move freely through the mud, while others build permanent tubes through which they filter particles from the water.

***Examples of worms feeding and their burrows***

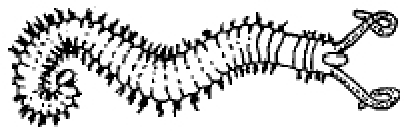



capitellid thread worm



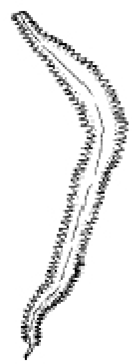
The capitellid thread worm digs a burrow with two holes. It sucks in its food by creating a current of water. 10 cm.

mud worm



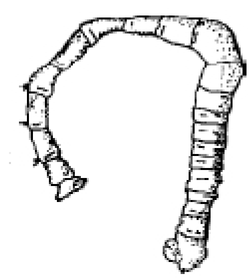
The mud worm has lashes on its two tentacles. It captures food from the bottom and transports it to its mouth. 10 cm.

red-lined worm



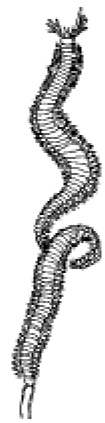
The red-lined worm is a very voracious predator with a trunk (proboscis). It resembles the clam worm but the tentacles on its head are poorly developed. 30 cm.

bamboo worm



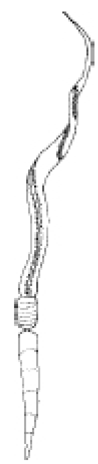
The segments of the bamboo worm are longer than they are wide. The head is flat and has no tentacles. 15 cm.

clam worm



The clam worm has several well-developed antennae on its head, and a trunk armed with two hooks that it uses to capture its prey. 20 cm.

Acorn Worm



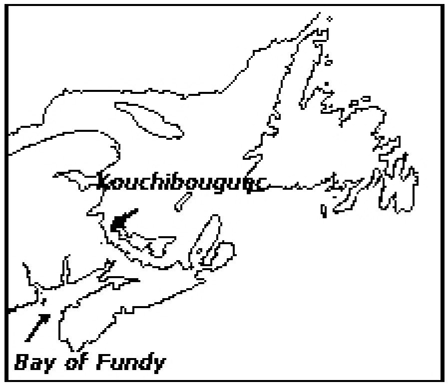
This worm-like creature is not a worm at all but belongs to the Hemichordata. It is found in muddy bottoms and is whitish-coloured. 15 cm.

## Fish

Fish use the estuary for spawning, the development of fry (very small fish), and as nursery areas for juveniles. Many species have migratory patterns that take advantage of the plankton. Food, as well as shelter, is abundant in an estuary. The estuary is a transition zone for marine species travelling from the sea to rivers, and for freshwater species travelling from rivers to the ocean.

*see activity 39*

From the Bay of Fundy, New Brunswick, a Winter Flounder was reported to have 315 Soft-shelled Clams in its stomach. In Kouchibouguac National Park, New Brunswick, Soft-shelled Clams, Macomas, Mussels, and other Invertebrates were found in the stomach of a Winter Flounder.



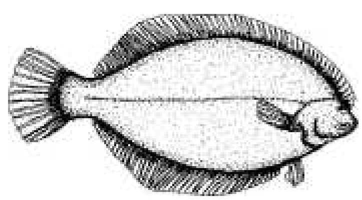

**Catadromous and anadromous**

The American Eel spends the major part of its life in fresh or brackish water, returning to the ocean to spawn in the Sargasso Sea, near the Bahamas. It's called a catadromous fish because it returns to the sea to breed. The Atlantic Salmon, the Striped Bass, the Gaspereau, and the Smelt are anadromous species-they spend the major part of their life in the sea or in brackish waters, returning to freshwater to reproduce.

Flounder

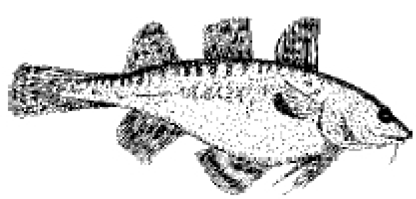
As it grows, the Winter Flounder undergoes a metamorphosis. The larval or young stages of the Winter Flounder resemble a 'typical' fish. As this fish grows, it will settle on its side on the bottom and the right eye will move gradually to the left side (or the other way around). The mouth seems to be askew. The Flounder's pigmentation follows the same evolution as if it always tanned on the same side.

The Flounder is especially tolerant of low salinity and temperature, and thus is frequently found in estuaries both as adult and young. Young Flounder bury themselves in the mud when the tide is low or when there is danger. They are almost completely camouflaged. With the incoming tide, they rise and let the water carry them into tidal creeks where food is plentiful.



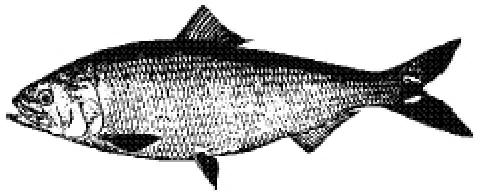
Atlantic Tomcod

The Atlantic Tomcod is a miniature cod that lays its eggs on gravel or sand at the outer edges of the estuary. To 30 cm.



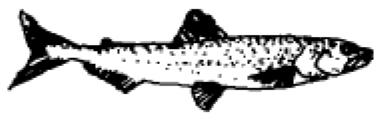
American Shad

The American Shad strongly resembles the Gaspereau, however the migration to spawning grounds occurs later. 50 cm.



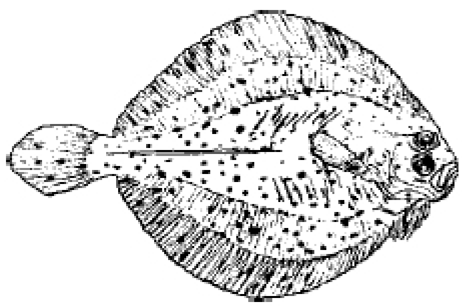
Smelt

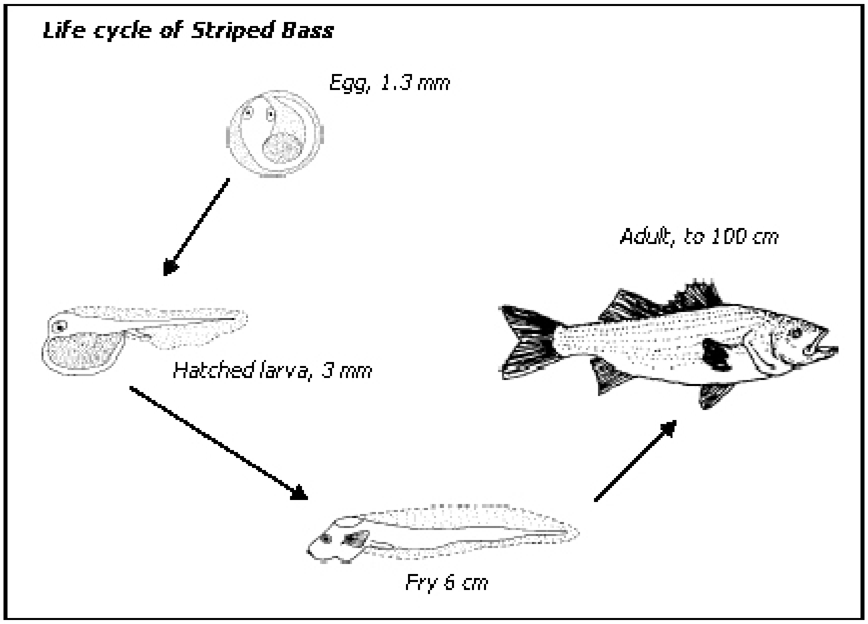
The Smelt is a member of the Capelin family. It generally moves in groups and feeds on small zooplankton. To 35 cm.



Windowpane

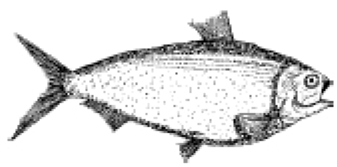
The Windowpane has a very round shape in comparison to other Flounders found in the estuary. To 43 cm.





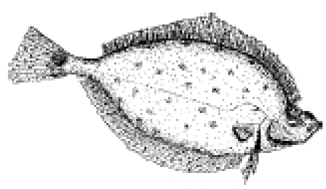

Blueback Herring

The Blueback Herring enters rivers to spawn at the beginning of June. The young descend to the sea towards the end of summer. Around 27 cm.



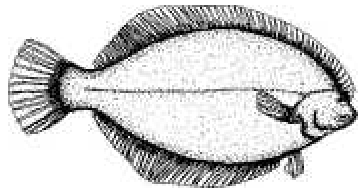
Smooth Flounder

The Smooth Flounder has smooth skin between its eyes. Its right side can change colour according to its environment. To 32.3 cm.



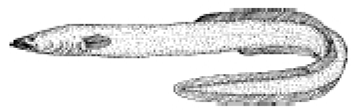
Winter Flounder

The left side of the Winter Flounder can change colour according to its environment. It has rough skin between its eyes and feeds on crustaceans, molluscs, and marine worms that live on or in the bottom of the estuary. 50 cm.



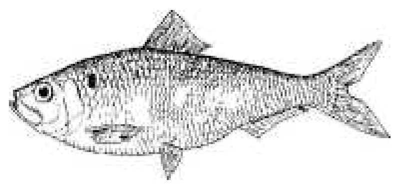
American Eel

Young Eels enter estuaries in July as elvers. They stay in rivers and estuaries for five to 15 years before returning to the sea to spawn. They feed at night on practically everything they capture. Around 100 cm.



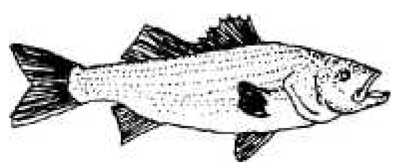
Gaspereau

The silvery body of the Gaspereau is compressed sideways. It can measure up to 30 cm.



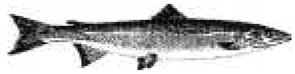
Striped Bass

Striped Bass come from the ocean to reproduce in estuaries. The young stay there for a year, feeding on small invertebrates before descending to the sea. Can grow over 100 cm.



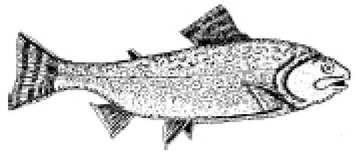
Atlantic Salmon

When they move into saltwater, small salmon take on a silvery appearance, which they will keep until they return to their native river to spawn. During their migration to their spawning grounds, Atlantic Salmon stay in estuaries to become accustomed to the weak salinity. During their migration to the sea, the smolt, or young salmon, spend several weeks in estuaries, feeding on small fish and invertebrates.



Brook Trout

Brook Trout ascend rivers in the spring. Some populations use the estuary during the winter. Up to 39 cm.



## Birds

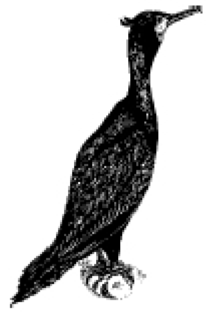
Birds are very mobile and their rhythm is associated with that of the tides, their food, and the movement of the water. Some birds, such as the Canada Goose, feed in the intertidal zone at low tide. Some, such as the Black Duck, feed in shallow waters. Cormorants, mergansers, and scaups feed in deeper water by diving from the surface. Terns, Osprey, and Kingfishers dive from above the surface.

**Some birds' habitat and food**

| Bird | Habitat | Food |
|---|---|---|
| Double-crested Cormorant | coastal ecosystems | Rock Gunnel, sculpins, Sand Lances, Herring, Flounder, Atlantic Tomcod, American Eel, Sea Perch, American Shad |
| Osprey | ecosystem near estuaries | Gaspereau, Herring, Flounder, Perch, Atlantic Salmon, Small Birds and Rodents |
| Bald Eagle | ecosystem near estuaries | Crippled waterfowl, Dead fish, Steals fish from Osprey, Muskrat |
| Canada Goose | salt marshes, estuaries | Glasswort, Grasses, Eelgrass, Widgeon-grass, Sea Lettuce, Molluscs, Small Crustaceans |
| Kingfisher | ecosystem near water | Mainly Fish, Crabs, Mussels, Insects, Clams, Oysters |
| Herring Gull,<br>Great Black-backed Gull,<br>Ring-billed Gull | coastal ecosystems | Dead Fish, Molluscs, Crustaceans, Marine Worms, Sea Stars, Crabs, Young Birds, Marine Algae, garbage |

Double-crested Cormorant

This cormorant is a goose-sized bird that has a snake-like neck. One of the few birds that have no oil gland for waterproofing. Look for it perched with its wings spread out to dry. 81 cm.

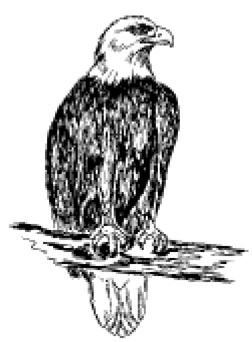


Osprey

The Osprey is a large bird and is sometimes called a fish hawk. It hovers in place and dives from great heights into the water for fish. To 64 cm.

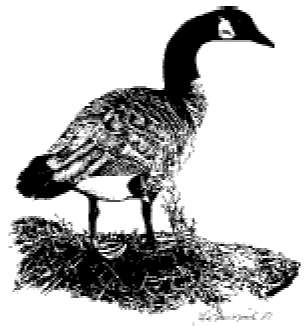
Bald Eagle

Adult Bald Eagles have whitish (bald) heads and tails. Young birds are brownish until they are mature, at four to five years. To 94 cm.



Canada Goose

The Canada Goose has a white cheek patch. Listen for the familiar honking. To 114 cm.



Brant

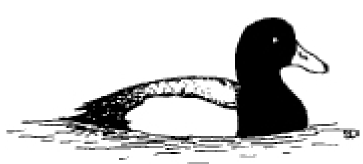
Brant are smaller than Canada Geese and very fond of Eelgrass. Before the 1930s they were very numerous, until a disease nearly wiped out the Eelgrass. 64 cm.

Red-breasted Merganser

The Red-breasted Merganser has a greenish plume on the head. The whitish neck and wings are good field marks. It is sometimes called sawbill because of the tooth-like projections on the bill used for catching fish. 58 cm.

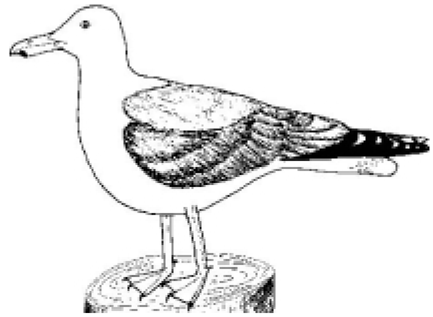
Greater Scaup

The Greater Scaup is one of several species of ducks that use the estuary for resting and feeding during migration. Look for its blackish green head and white flank especially in early spring. 46 cm.



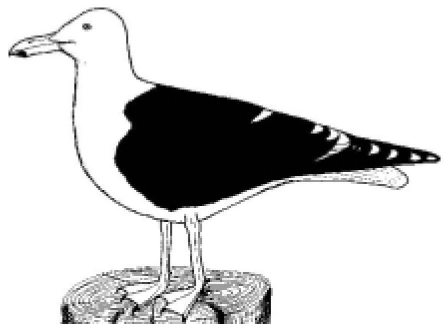
Herring Gull

The Herring Gull is smaller than the Great Black-backed Gull, and has black wings tips. Gull numbers have increased drastically due to human wastes. 64 cm.



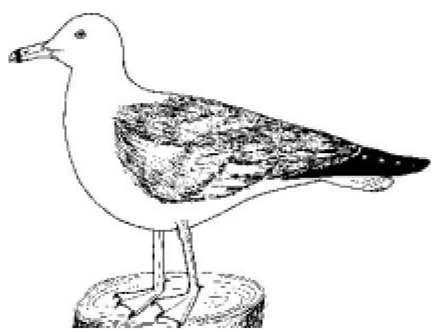
Great Black-backed Gull

The Great Black-backed Gull is the largest of our gulls, with all black wings and back. The young gulls are brown. 76 cm.



Ring-billed Gull

The Ring-billed Gull is slightly smaller than the Herring Gull. It has a black ring around its bill and is a newcomer to the east coast, attracted by human wastes. 45 cm.



## ECOLOGY

### Stress and Survival

Organisms that live in the estuary face two major challenges: variable salinity and how to stay put.

Most solutions are behavioural adaptations, such as burrowing or simply closing shop when there isn't enough water. Some organisms, such as fish, can move around and find an appropriate spot, while other organisms excrete the excess salt that enters their bodies.

#### Behavioural adaptations

The Blue Mussel closes its valves when the level of salinity becomes too low or the tide is out.

Some marine worms and amphipods bury themselves in sediments until conditions become adequate.

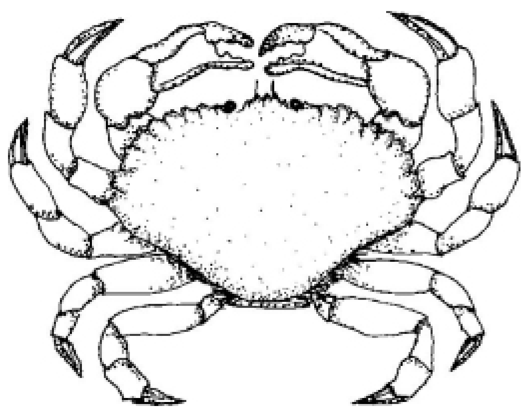
Some fish move about in the estuary to find the desired level of salinity.

Oyster larvae are incapable of swimming against a current, so they maintain their location in the estuary by dropping to the bottom when the tide is ebbing and rising to the top with the incoming tide.

The quahaug is well adapted to sedimentation problems. When its gills are obstructed by mud, it cleans them by expelling a great quantity of water.

#### Physiological adaptations (changes relating to their own bodies)

The majority of organisms living on or in the sediments, such as crustaceans, excrete the salt as rapidly as it's absorbed. Birds possess salt glands that excrete excess salt. Some other organisms (especially marine worms) contract their bodies to reduce the surface area that's in contact with the water and thus decrease the absorption of salt. The last option is to have an impermeable surface - but only birds, reptiles, and mammals have this. A clam or mussel can only make itself temporarily watertight. Organisms without any of these features are absent from estuaries.



## Productivity

The estuary is full of life, especially during the summer season. In the winter, activity slows down.

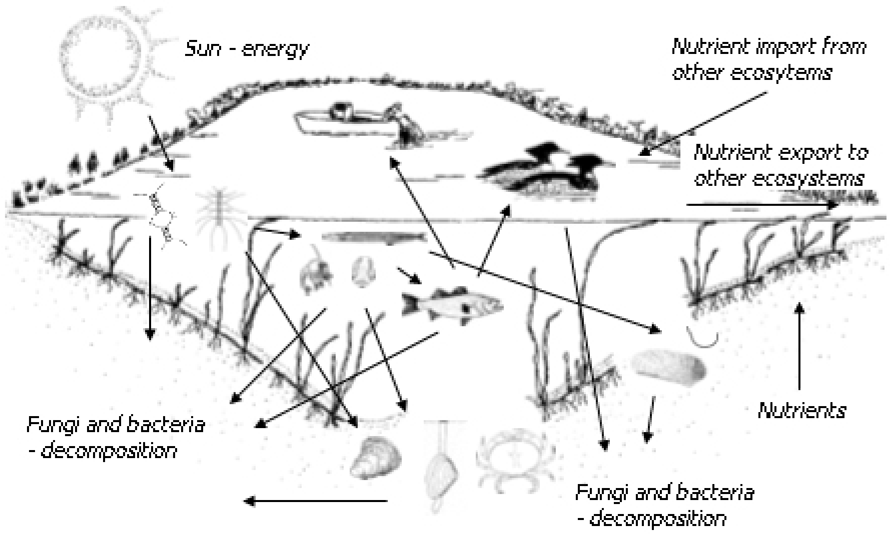
The sizable supply of nutrients from rivers, rocky shores, and salt marshes, combined with their warm temperatures and good penetration of sunlight, make estuaries very productive areas.

## Food Web

Eelgrass and other plant matter from the estuary or from adjacent ecosystems enter the food chain in the form of detritus. Bacteria and fungi are found in the estuary bottom, on Eelgrass, and on seaweed. They're responsible for the decomposition of dead plants and animals. The bacteria and fungi are in turn eaten by worms. Fish feed on the worms and are in turn food for birds.

***Food web***

*Arrow: indicates direction of food/energy*




## ESTUARIES AND US

Estuaries have significant economic importance. Some estuaries support substantial commercial fisheries, in addition to recreational fishing activities, wildlife activities, and aquaculture. Estuaries are also used as navigation routes.

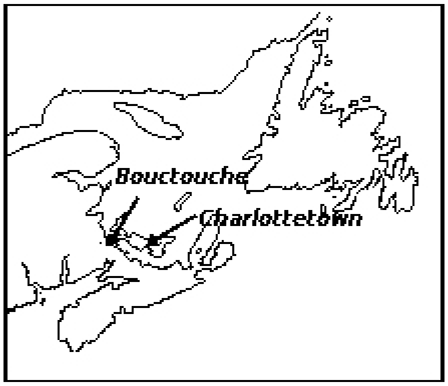
## Commercial Fishing

Fishing is a very ancient practice that was an important activity for the Mi'kmaq nation. In the past and today they fish for Atlantic Salmon, trout, and American Eel, among other species. They also collected Molluscs, such as Oysters and Soft-shelled Clams.

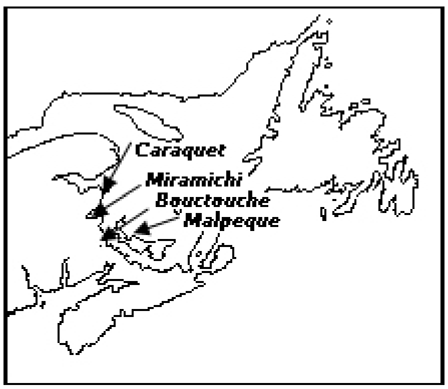
| ***English*** | ***Mi'kmaq*** |
|---|---|
| *Atlantic Salmon* | *Plamu* |
| *Brook Trout* | *Atoqwa'su* |
| *American Eel* | *Ka'tew* |
| *Flounder* | *Anakwe'j* |
| *Lobster* | *Jakej* |
| *American Oyster* | *Mntmu'k* |
| *Mussel* | *Nkata'laq* |
| *Bay Quahaug* | *Pukanamowe's* |
| *Soft-shelled Clam* | *E's* |

Smelt, American Eel, Gaspereau, and American Shad are fished commercially in the different estuaries of the region.

Molluscs such as American Oysters, Soft-shelled Clams, Bay Quahaugs, and Blue Mussels are fished commercially in the estuaries of Atlantic Canada.




The Bay Quahaug is fished commercially in the region of Bouctouche, New Brunswick and Charlottetown, Prince Edward Island. This Clam lives in muddy bottoms. Barefoot fishermen can feel Bay Quahaugs underfoot.

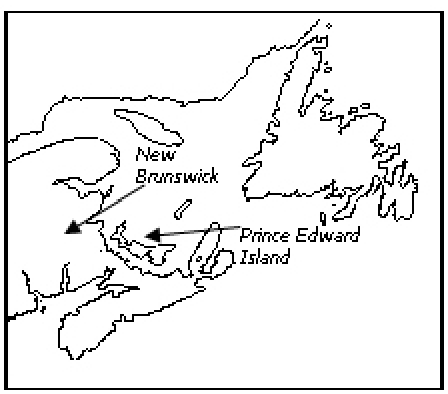



The main areas for oyster fishing are located in the Bay of Caraquet, New Brunswick, the Miramichi estuary, New Brunswick, and Bedeque Bay, Prince Edward Island. Rakes are used to collect oysters.

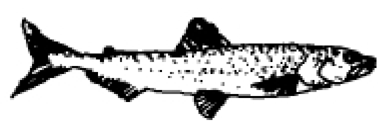
In the Bouctouche, New Brunswick, region, Blue Mussels and Oysters are fished during the winter. To do this, fishermen make a hole in the ice and use a large rake to scratch the estuary bottom.

## Recreational Fishing

Smelt, Striped Bass, Atlantic Tomcod, American Eel, and Mackerel can be fished in estuaries.

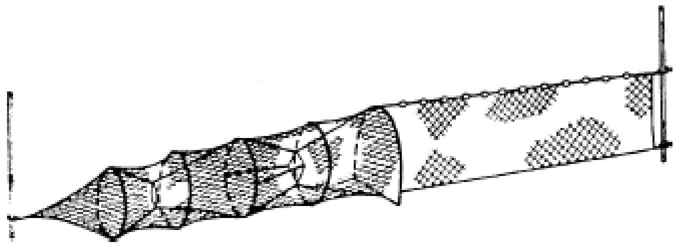


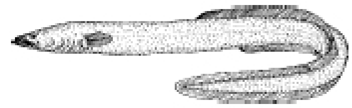

Smelt fishing under the ice is very popular all along the coasts of New Brunswick, Prince Edward Island, and Quebec.



### Fishing techniques

The shape and dimensions of the type of trap used by fishermen vary according to the species they intend to catch. The trap is divided into two parts: the first part is called the leader and serves to direct the catch towards the second part, the net cage. Eels are fished this way.





## Aquaculture

Aquaculture or cultivation of marine animals is an increasingly important activity in Atlantic Canada. Currently, Oyster, Blue Mussel, and Atlantic Salmon aquaculture are practised on a commercial basis.

*see activity 46*

### Salmon aquaculture

Salmon aquaculture is commercially important in the Bay of Fundy, Cape Breton, and along the eastern shore of Nova Scotia. The value of the industry in the Bay of Fundy was estimated at $100 million in 1993.

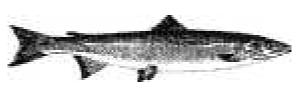
Aquaculture sites are mostly located close to or in estuaries.

### Aquaculture concerns

There are a number of concerns about the effects of aquaculture on wild salmon species and the environment.

Aquaculture is in general done within natural ecosystems, although experiments are underway to develop land-based aquaculture sites. The escape of pen-raised salmon has the potential not only to spread diseases, but also to change the genetic make-up of wild salmon. The escaped salmon not only compete with the wild salmon for food, they will also interbreed if they are not sterilized.

Increased waste from aquaculture sites changes the bottom habitat below the cage and antibiotics used in aquaculture are released into the environment.



### Mollusc aquaculture

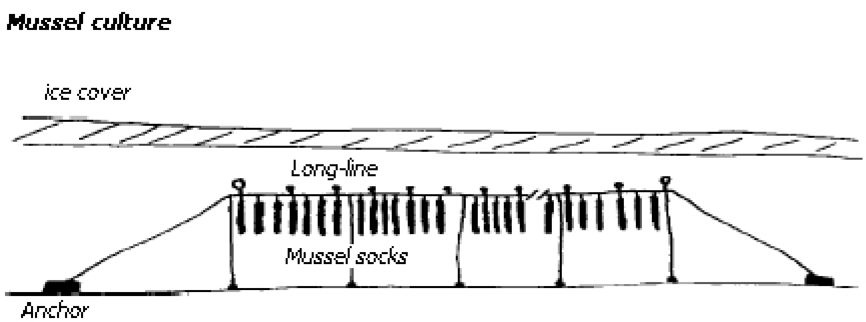
In 1993, 6 million kg of molluscs were produced on Prince Edward Island. Blue Mussel culture is carried out in Nova Scotia and New Brunswick, and scallop culture in Newfoundland.

In New Brunswick, an oyster seed production industry has been established in various locations, particularly in Bouctouche Bay, using Chinese hat collectors. Some collectors can accommodate up to 50,000 seed oysters.

In New Brunswick and Prince Edward Island, oyster culture is done by either spreading spat (oyster seed) on the bottom, or by suspending it in cages or nets off the bottom. The seed comes from a natural harvest in the Malpeque region.

*see activity 46*

Blue Mussel culture is practised in bays that are generally well sheltered, having a depth of at least 5 metres of water. Mussels are raised suspended on long-line systems. In the summer, installations can be near the surface, while in the autumn they must be lowered to a metre below the surface to avoid the ice. Between 16 and 20 months are needed to produce a 65 mm Blue Mussel.

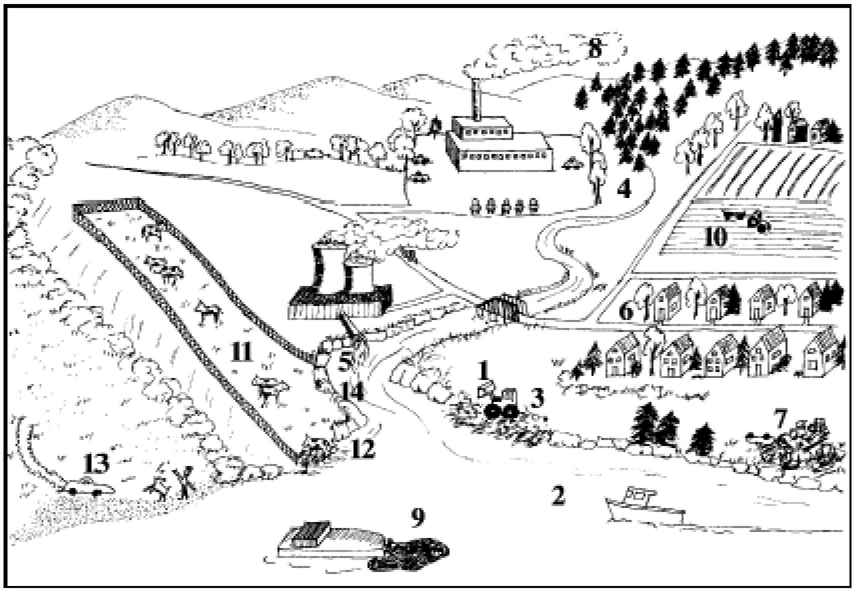



Mussels secrete numerous anchoring threads with one of the few naturally produced glues that work in water. This allows them to attach themselves to each other or to anything else they find. Mussel breeders have taken advantage of this aspect of the mussel's biology and, to reduce the density of breeding mussels and to accelerate their growth, they put the mussels in long net bags. Looking for a good place to feed, the mussels leave the stocking and attach themselves to the exterior.

## Problems in the Ecosystem

Coastal ecosystems are heavily used by people and often abused. Estuaries usually bear the brunt of human waste and contamination because they were and are the first areas of human settlement.

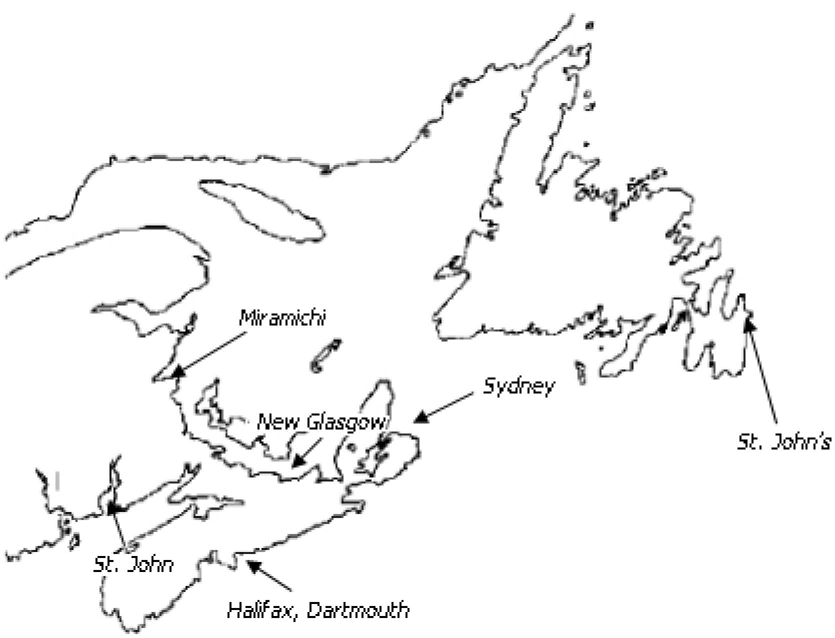
***Some of the more measurable and visible human impacts***




*(1) infilling of marshes and thus elimination of habitat and other wetland functions, (2) dredging carried out in the water, (3) development along the shoreline, (4) waste from pulp and paper mills, (5) discharge from electrical generating stations, (6) untreated sewage from towns, (7) garbage and toxic wastes, (8) airborne toxins, (9) discharge of oil, (10) pesticides from agricultural run-off, (11) nitrate run-off from animal farming and excessive fertilizer usage, (12) shoreline erosion due to grazing by cattle, (13) vehicles driving through habitat and (14) soil erosion from agriculture and road building activity results in silt deposition. Improper installation of aquaculture stations also has negative impacts on estuaries.*

We can see the effects of these human impacts in destroyed habitats as a result of development, poisoned shellfish made unfit for human consumption by bacterial contamination, industrially polluted fish nursery areas, and oiled birds washing up along the shore.

***Some of the most polluted estuaries***



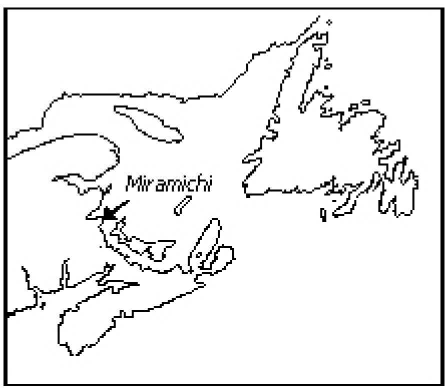
People originally chose estuaries to settle because they provided sheltered sea ports, a good source of food, and rich pasture land for farming. Towns subsequently developed cities such as St. John's, Halifax, Dartmouth, Sydney, New Glasgow, Miramichi, and St. John are all located on estuaries and are very polluted.

Because estuaries receive water from rivers, all the pollution that is transported by those waters eventually reaches the estuary. Estuaries are affected by human activity of various types, whether domestic, manufacturing, or commercial.

Industrial and domestic wastes, agricultural activities, and the forest and transportation industries pollute our estuarine ecosystems. Many areas are closed to mollusc harvesting because of chemical and bacteriological contamination.

## Chemical Contamination

In the estuary, sediments tend to settle. The chemical contaminants transported by rivers likewise settle to the bottom. Fish and crustaceans that feed on plants and molluscs can accumulate great quantities of toxic products. These hazardous chemicals can be lethal to marine life and cause abnormalities in organisms.




The harvesting of molluscs is banned in the Napan region, in the Miramichi estuary, New Brunswick, due to chemical contamination from industrial activities. Sources of identified contamination are situated 20 km upstream from Newcastle. Domestic wastes from municipalities also constitute a significant share of the pollution.

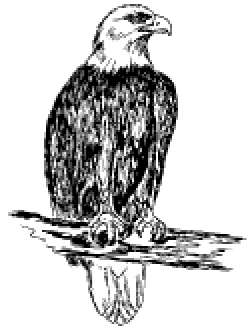
## Bacteriological Contamination

A pathogenic bacterium can be harmful to human health. It can transmit diseases such as hepatitis and polio. These bacteria originate mainly from human waste. Molluscs are the organisms most contaminated by pathogenic bacteria. If people eat these molluscs they will get sick. This type of pollution is connected to the presence of nearby communities with no sewage treatment facilities. Some molluscs feed by filtering plankton and other microscopic animals from the water. If there are bacteria, the molluscs absorb them as well. Crustaceans and fish that feed on molluscs are not affected by the bacteria, but humans consuming the molluscs can get sick.


## Chemical Contamination

In the Atlantic provinces, most of the paper mills are constructed near or upstream of estuaries and are significant polluters. Added to these are oil spills, pesticides, insecticides, and other pollutants coming from forestry, agricultural, and industrial activities.

All organisms are affected by chemical products. Osprey, Bald Eagles, and the Peregrine Falcon, for example, suffered sudden declines in their populations in the '60s due to the common use of DDTs, now prohibited in Canada. Recently their numbers have begun to increase although the Peregrine Falcon is still classified as an endangered species in Atlantic Canada today.



Some of the hazardous chemicals include: PCBs, dioxins, furans, heavy metals, pesticides, oil/hydrocarbons, and radionuclides.

**Bacteriological Contamination**

In many estuaries in Atlantic Canada, the collection of molluscs is closed partially or completely due to contamination with pathogenic bacteria.

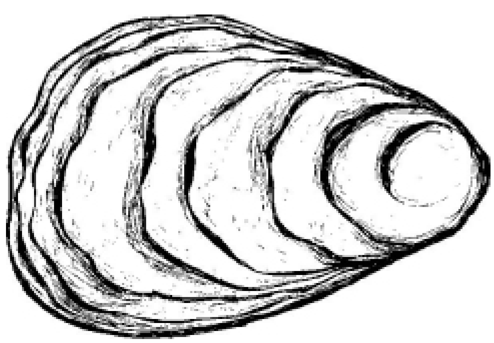
**Domoic Acid**

The diatom *Pseudo-nitzschia multiseries* produces domoic acid, a neurotoxin that can accumulate in molluscan shellfish during their normal feeding process. Consuming such contaminated molluscs can be harmful to humans, causing Amnesic Shellfish Poisoning (ASP). This diatom blooms in many bays and estuaries throughout Atlantic Canada. In 1987, for the first time anywhere, domoic acid was observed as a cause of ASP in the Cardigan estuary of Prince Edward Island.

**Harmful Algal Blooms (Red Tides)**

Certain pigmented microscopic algae (for example, some dinoflagellates) can grow to high concentrations, forming 'blooms' that can sometime colour the water red. This is known as a 'Red Tide'. However, scientists now call this phenomenon a Harmful Algal Bloom (HAB). In Atlantic Canada, the 'red tide' dinoflagellates *Alexandrium tamarense* and *Alexandrium fundyense* produce a neurotoxin that can accumulate in the tissue of molluscan shellfish. Consuming these shellfish may cause Paralytic Shellfish Poisoning (PSP) in humans, which can result in sickness or even death.

A sampling program by the Canadian Food Inspection Agency, with closures implemented by the Department of Fisheries and Oceans, has been put in place to detect these neurotoxins and to protect consumers of molluscan shellfish. Scientists at DFO are studying harmful algal blooms in order to better predict them.



American Oyster *(Crassostrea virginica)*

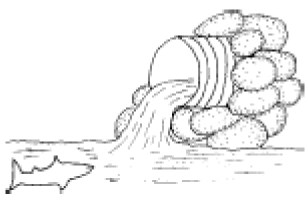
## Habitat Destruction

Aquaculture and fishing can also contribute to the pollution of estuaries. Excess feed from cages and feces alter the benthic habitat below aquaculture sites.

Without tight control, culture cages could cover the whole area of an estuary, altering the beauty of the landscape and limiting accessibility by preventing recreational activities, such as boating, windsurfing or swimming.

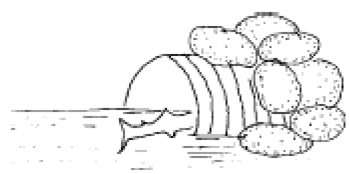
Habitat destruction can also be caused by poorly managed dredging done to create navigable routes, during dam construction, and for developments along the banks of estuaries.

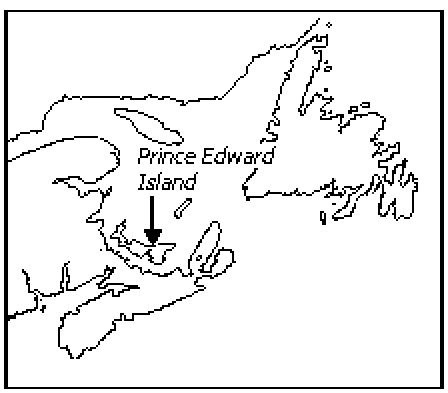
Agricultural activities affect the estuary by causing siltation, which destroys fish spawning habitat and fill in wetlands.



*Fish passage impossible*

*Fish passage possible*





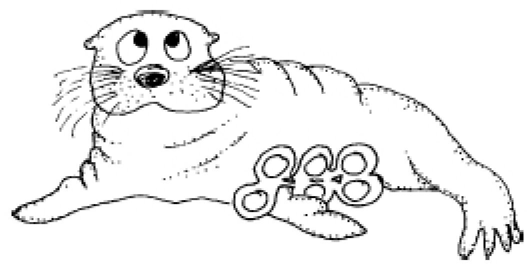

Prince Edward Island has a long history of dam and pond construction initially, from various types of water-powered mills, and later for recreational fishing and waterfowl production. While most have fish ladders, a few have not as yet been fitted with them. The ladders help fish to migrate upstream to their spawning grounds. However some of the older ladders don't work very well. Improvements are ongoing.

## Sediments

Sedimentation is a natural process, but it can be greatly accelerated by human action. Suspended sediments can affect larvae and young fish by interfering with their feeding mechanisms. Fish eggs can be smothered silt, which blocks the passage of oxygenated water into the egg mass. Silt can also erode the gills of fish and prevent them from breathing. Mollusc habitats have been destroyed by the accumulation of loose sediments because they prevent molluscs from feeding and breathing. Oyster spat need to attach to a clean surface in order to grow. Excessive sediment inhibits this process.

## Domestic Wastes

Domestic wastes can also have a serious impact on estuaries. Plastic materials can be eaten by fish or capture them accidentally. Lost fishing gear, i.e. gill nets, results in 'ghost-fishing,' trapping and killing fish years after the gear has been abandoned or lost.



## Nutrient Enrichment

Untreated sewage and detergents can cause increased productivity and algae growth due to the large amount of nutrients. This increased growth can cause eutrophication. Eutrophication is a process by which excessive algae growth and the subsequent death of these plants causes a depletion of oxygen, thus killing marine life or making life in the area impossible. The extent to which the breakdown of dead plant matter takes up oxygen is called the biological oxygen demand or BOD.

Excess nutrient input is a chronic problem in agricultural areas, where fertilizers and faeces from livestock gets washed into the water, causing eutrophication in rivers and estuaries.

### Protection of the Ecosystem

It is important to understand that any change to an estuary can have considerable effects on the associated ecosystems in the coastal zone. Construction must be planned carefully, to ensure it will not cause damage. All modifications must be done in a responsible manner. Permits may be needed. Check with your local Department of Fisheries and Oceans and your local Department of the Environment.

Many people and organizations who live near and work in estuaries think about how their actions might affect fish, wildlife, and plants. To date many things have been done to protect ecosystems in the coastal zone.

The amount of raw sewage entering ecosystems is reduced by the installation of septic tanks and sewage treatment facilities. There is a decrease in the amount of harmful substances entering estuaries because of a reduction in the use of pesticides and fertilizers. Road construction has improved, preventing siltation and blockage of rivers and streams. Oil and empty oil cans are now being recycled. Many federal wharves have collection facilities.

Some things still need to be done. Aquaculture sites need to be continually monitored so that there are no adverse effects on Lobster, Scallop, fish spawning grounds and seabird colonies. Both federal and provincial government are keeping a close eye on developments.

There are also things that you can do to protect the estuaries in your area.

You can begin by exploring their natural beauty. Discover the fascinating interrelationships between the freshwater and the sea. Learn to appreciate the unique role of estuaries in the coastal zone of Atlantic Canada.

Then get proactive. Find out what you can do to protect your local estuaries. Clean-ups are familiar sites in most of the provinces and are mainly organized by local environmental groups. Join an estuary clean-up, or encourage people to use waste receptacles so that they don't dump their garbage in estuaries.

We can all do our part to protect this significant coastal ecosystem. You can begin by simply taking a walk along the shores of an estuary near you.

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