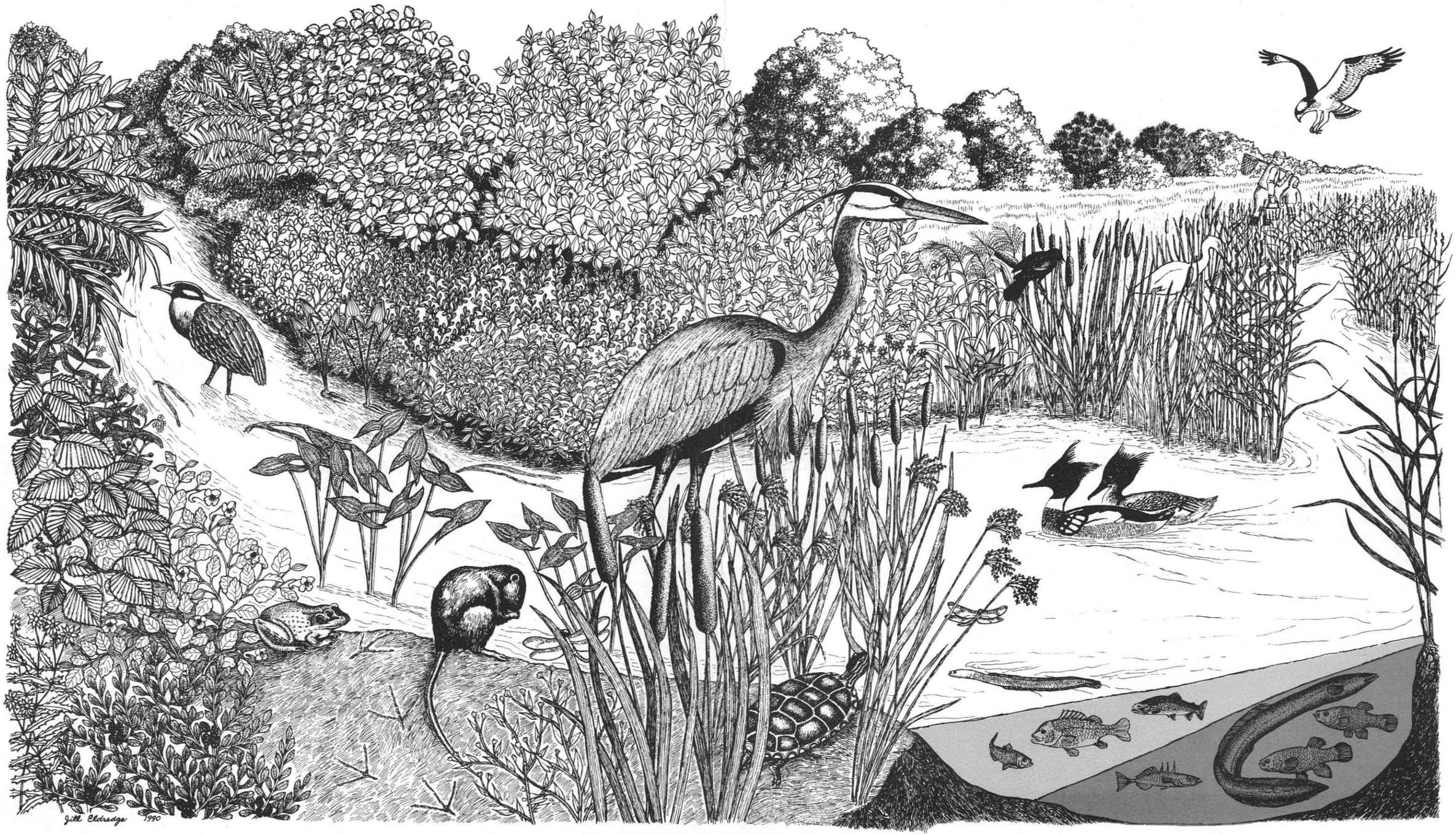
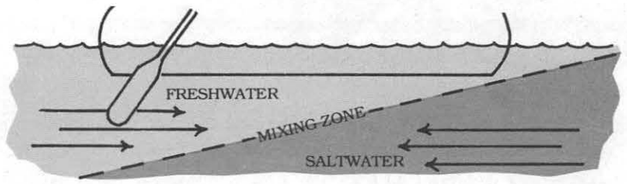
Over the Wedge - *Where Fresh and Saltwater Meet*



A JOURNEY THROUGH THE WEDGE

A canoeist glides along with the flowing water of the freshwater stream. Many kinds of trees, bushes and flowers crowd and overhang the banks on each side. The canoe passes over wide and ripple blade grasses growing on the stream bottom and floating in the direction of the current. Small fish flash in and out of sight. The canoe slips around small islands of colorful blue **Forget-Me-Nots** and **Arrowhead** flowers. There are fragile **Jewelweeds** and pink-flowered **Smartweeds** lining the banks. Further on are **Bullrushes** and **Cattails** intermingled with tall, stiff **Spartina** grasses.

As the canoe passes the tall grasses, the paddler feels a change in the movement of water. Clear freshwater is flowing downstream, but below the surface, dark, muddied water is flowing in the opposite direction. The ocean tide is rising, bringing in saltwater from the bay. As the two kinds of water meet, they form a **WEDGE;** the incoming tide is pushing the heavier, denser saltwater against and under the lighter, less dense freshwater.



The stream widens and the canoeist paddles ahead and waves to a man and child walking in the low expanse of saltmarsh grasses. The sun flecks on a wide, shallow bay. Beyond the bay is the edge of a long, barrier beach that helps to protect the quiet estuary from the steady pounding waves of the ocean.

Now the canoeist leaves the freshwater behind and enters an ever changing natural system, the most biologically productive on earth - **THE ESTUARY.**

WHAT IS AN ESTUARY?

The plant and animal life in the freshwater portion of a watershed changes at the WEDGE. It is here, **OVER THE WEDGE,** that an estuary begins, where a river meets the ocean and the pulsing tide is forever mixing freshwater from land with saltwater of the ocean. Beyond the WEDGE, bays, inlets, lagoons, tidal marshes, sandy beaches or rocky shores are formed. The lowland area surrounding the estuary is known as an estuarine zone.

It is Not an Easy Life

Animals and plants living in an estuarine zone find a harsh environment. There are rapid changes in temperature, salinity, currents and water level changing daily and seasonally. The change depends on the amount of freshwater flowing in from the watershed, the shape and depth of the bay, and the difference between high and low tides. Salinity in an estuary varies with the tidal cycle. High saline water pours into an estuary on a flood tide resulting in the highest salinities. The extent of salinity also depends on the season. During a spring freshwater runoff, the wedge of saltwater is pushed down the river. During low river flows in the summer and winter, the salinity wedge extends for greater distances upriver. High and low tides also depend on the lunar cycle with highest tides (spring) occurring during the full and new moons. Direction and strength of wind also influence the movement of tidal saltwater in an estuary and up its inflowing rivers.

Temperature, as well as tide, varies daily and seasonally. In summer and fall, the freshwater inflow is warmer than the ocean; therefore, the temperature is warmest in the upper estuary and coldest in the low estuary with the temperature varying with the tidal cycle. In winter and spring, the freshwater inflow is usually colder than the ocean -- making the winter temperatures opposite to those of summer.

A Nutrient Trap and Marsh Maker

In contrast to the many kinds of vegetation growing along the freshwater stream, only a few types of plants can survive in the border between sea and land. Marsh grasses are able to grow in oxygen-poor mud and peat, ever changing temperatures, and tidal seawater flooding twice every 24 hours. They have adapted to this ever changing environment, with specialized glands to take in saltwater and get rid of the excess salt. A system of tubes in the marsh grasses carries air to the parts of the plant that grow underground and under water.

Another significant characteristic of the estuary is its role as a "nutrient trap." The balance of forces between river flow and tides tends to slow the passage of materials and prevent total flushing through the river mouth and out to sea. A "trap" is formed between the two opposing water forces where a large collection of dead plants and animals, as well as suspended materials, is built up. The materials eventually settle and create large shoals that become the foundation for formation of salt marshes and tidal flat communities.

Many Meadows of the Estuary

The marsh grasses and tidal flat eel grasses grow and catch or "trap" more sediments and detritus. Animals and bacteria feed upon these materials, breaking down organic matter to nutrients in a form that fertilizes the plants of the estuary -- nature's perfect recycling system.

The most important but often overlooked plants are the single-celled algae (often called microscopic plant plankton). Large familiar algae growing in shallow coastal water, sometimes attached to rocks and pilings, are called seaweeds. At times the combination of warm water, dissolved nutrients coming down from the watershed, and sunlight promote explosive growth of all kinds of algae – the water becomes dark green with single cells of plant plankton (phytoplankton) and choked with massive drifting beds of the larger seaweeds. Too much growth, too fast, creates great stress on all life in the estuary, resulting in unwanted changes in the natural system. Short term stress can mean sudden "kills" of oxygen-dependent swimming animals such as fish, crabs and shrimp; and long term stress is signaled by loss of diversity of species in the system.

Animals Must Adapt to Life in Fresh and Saltwater

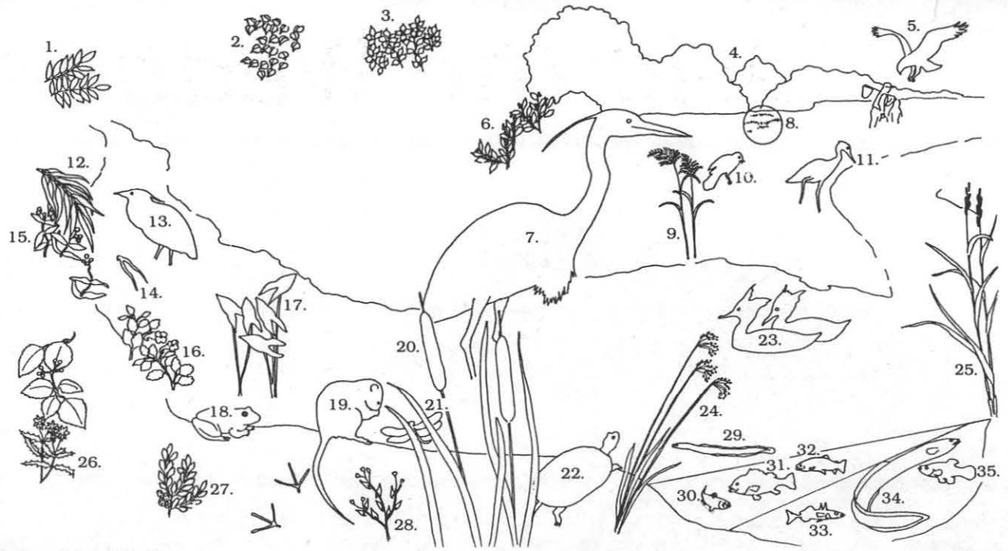
The open ocean animals have salt concentrations within their bodies that are similar to surrounding seawater. These animals do not normally experience conditions that would produce water balance problems. But estuary animals, who also have salty fluids in their bodies, must adjust to the alternating high and low salinities of the estuary. Otherwise, their body cells would take in a great amount of water when they encounter water low in salt. If an animal cannot control its water balance, it will die; the tissues and cells swell up and fail.

Estuarine animals have an extraordinary capacity to adjust to wide ranges in salinity. For example, sea run trout, herring and shad are anadramous fish that are able to withstand the transition from seawater to freshwater. Each animal spends the early stages of its life cycle in freshwater streams and most of its adult life in saltwater. A reverse example is the catadramous **American Eel** which hatches in the tropical waters of the Sargasso Sea and then migrates to estuaries. In the fall of its third year, the willow leaf-shaped larvae metamorphoses into a transparent **Elver** and "smells" (by chemoreception) its way to freshwater streams, where it completes its development into an adult eel.

Impacts of Us on an Estuary

Many forces can change the structure and change the environment of an estuary. Hurricanes or a harsh winter are among the natural events to which the estuary system has always adapted. But in the last 300 years the agricultural, social and industrial activities of humans have created unnatural conditions that could destroy the diversity and productivity of our estuaries. We have introduced new substances into the estuary system through the rivers from the land and directly into the ocean. Some of the substances, or pollutants, are trapped in the muds and estuary wetlands; others are transported into the open ocean. Life in a polluted estuary is under stress; the most sensitive species of animals and plants die first. These creatures are the "canaries" of an estuary. Their death is a signal that the natural system is changing.

Scientists are recording and studying the way pollutants come into and circulate through estuary systems. These records are of great use to those responsible for the management of estuaries as a resource. Records of present-day and past pollution allow us to estimate the future and take steps to make the choices and changes required to keep all estuaries places we will want to live and visit.



IDENTIFICATION KEY

THE WEDGE

Where Salt and Freshwater Meet

1. Black Cherry - *Prunus serotina*
2. Arrowwood or Roughtoothed Viburnum - *Viburnum dentatum*
3. Tupelo Tree - *Nyssa sylvatica*
4. Pitch Pine and Red Maple - *Pinus rigida* and *Acer rubrum*
5. Osprey - *Pandion haliaetus*
6. Black Alder or Winterberry - *Ilex verticillata* (only deciduous holly)
7. Great Blue Heron - *Ardea herodias*
8. Saltmeadow grass - *Spartina patens*
9. Wild Rice - *Zizania aquatica*
10. Redwing Blackbird - *Agelaius phoeniceus*
11. American or Common Egret - *Casmerodius albus*
12. Black Willow - *Salix nigra*
13. Blackcrowned Night Heron - *Nycticorax nycticorax*
14. Water or Tape Grass - *Potamogeton* sp.
15. Water Forget-Me-Not - *Myosotis* sp.
16. Yellow Jewelweed - *Impatiens capensis*
17. Arrowhead - *Sagittaria latifolia*
18. Bullfrog - *Rana catesbeiana*
19. Muskrat - *Ondatra zibethica*
20. Cattails - *Typha latifolia*
21. Dragonfly - *Plathemis lydia*
22. Eastern Painted Turtle - *Chrysemys picta picta*
23. Red-breasted Merganser Duck - *Mergus serrator*
24. Bullrush - *Scirpus atrovirens*
25. Smooth Cordgrass, Saltwater Grass - *Spartina alterniflora*
26. Begger Tick - *Bidens frondosa*
27. Sweet Gale - *Myrica gale*
28. Smartweed - *Polygonum* sp.
29. Elver or Glass Eel (Juvenile American or Freshwater Eel)
30. Alewife - *Pomolobus pseudoharengus*
31. White Perch - *Morone americana*
32. Sea Run Brown Trout "Salter" - *Salvelinus fontinalis*
33. Three-spined stickleback - *Gasterosteus aculeatus*
34. American or Freshwater Eel - *Anguilla rostrata*
35. Common Mummichog - *Fundulus heteroclitus*

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