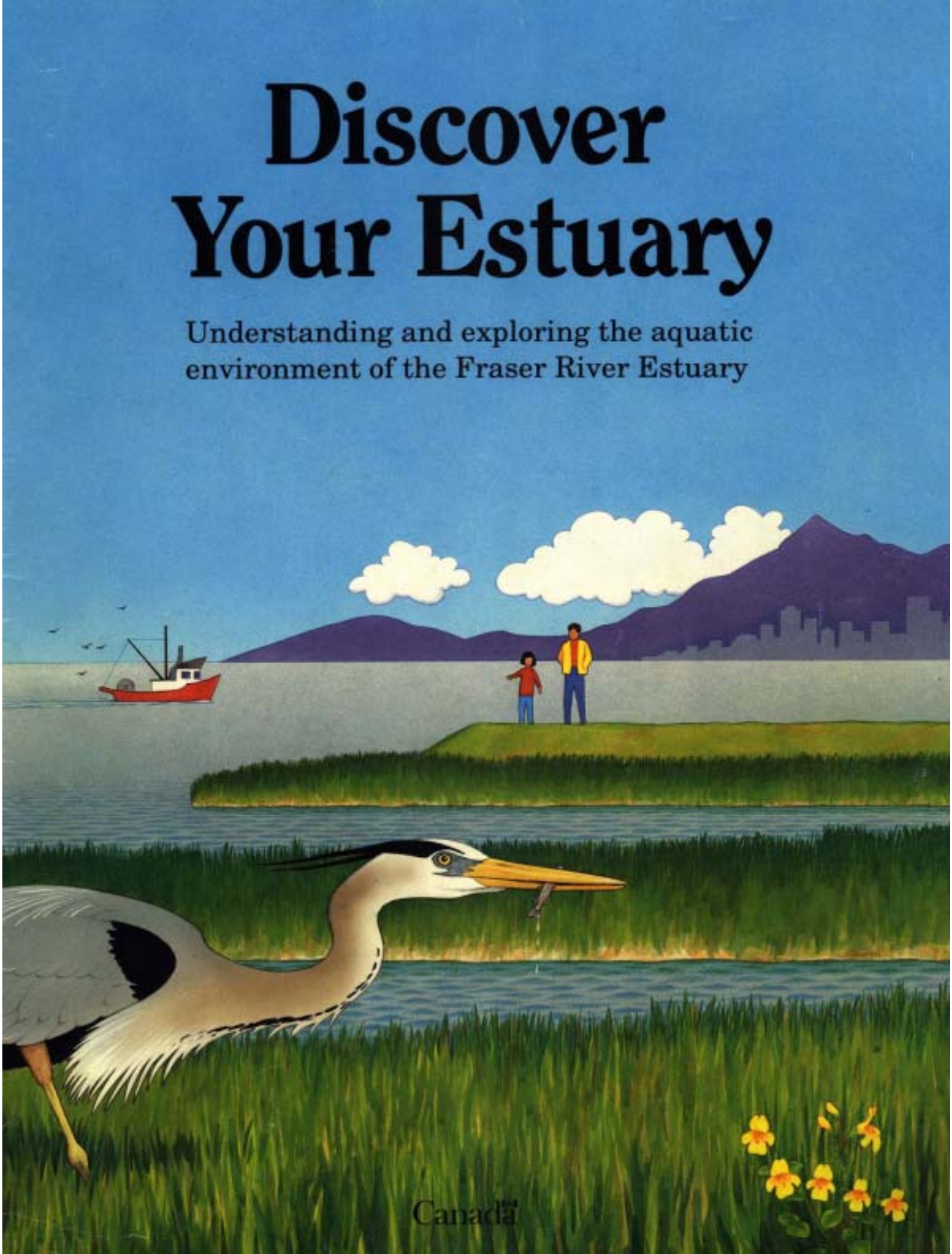
# Discover Your Estuary

Understanding and exploring the aquatic environment of the Fraser River Estuary



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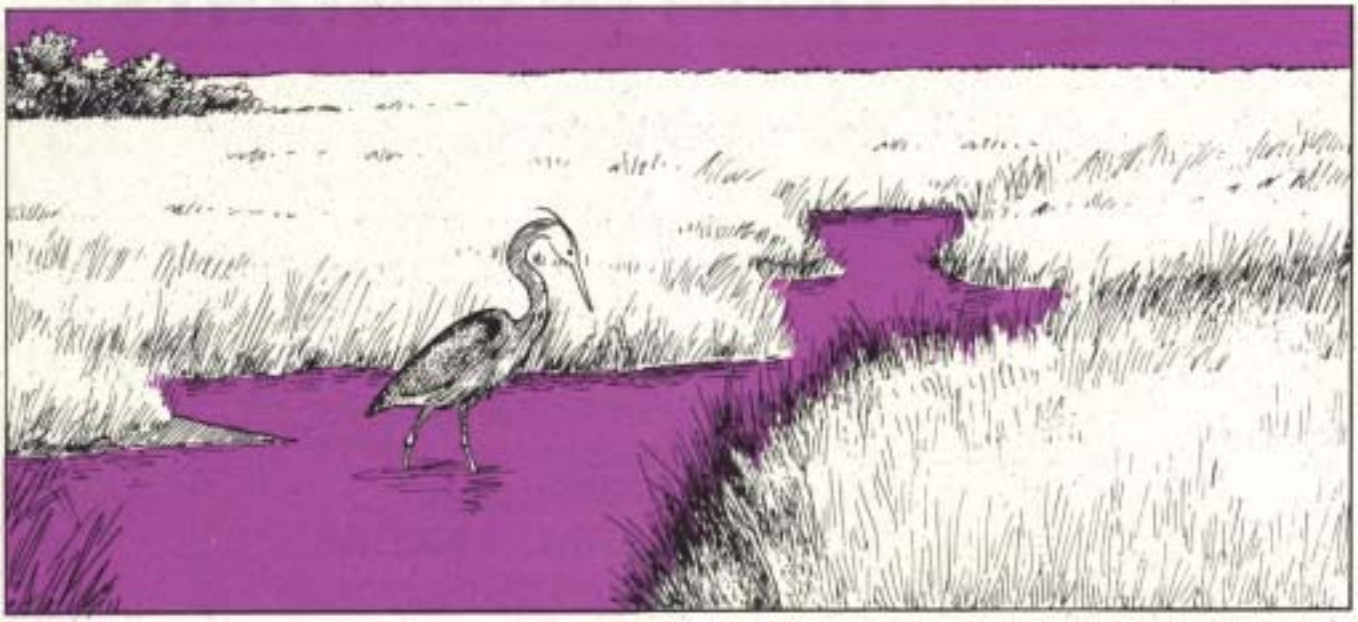

# Discover Your Estuary

## UNDERSTANDING AND EXPLORING THE AQUATIC ENVIRONMENT OF THE FRASER RIVER ESTUARY


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Coordinator

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Illustrator



LE PLAN VERT DU CANADA
CANADA'S GREEN PLAN

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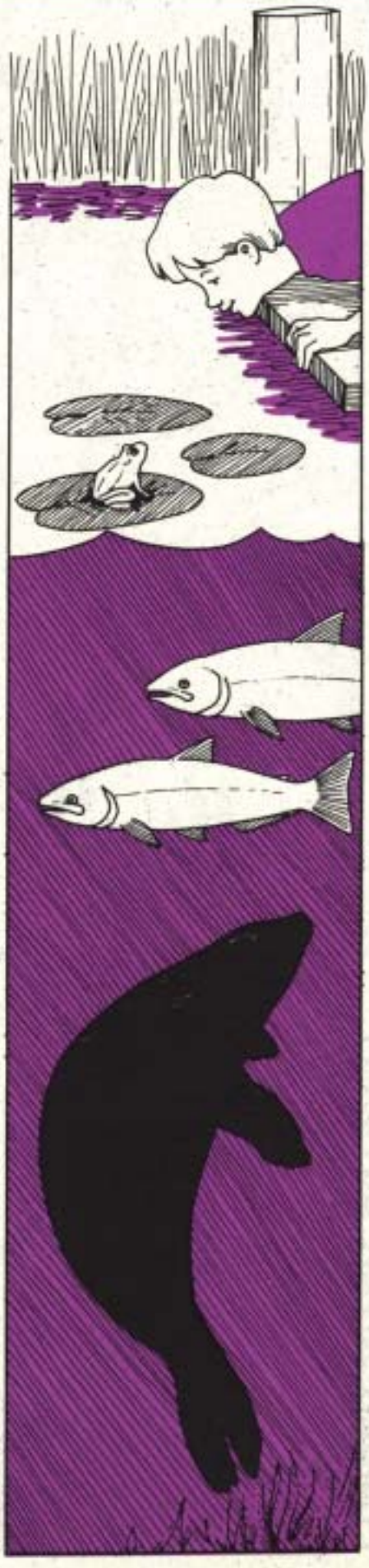
# INTRODUCTION



This book is a journey into one of the most rich and diverse places on earth — the estuary, where freshwater meets the sea. It's a place where plants, animals and people are vitally linked with each other.

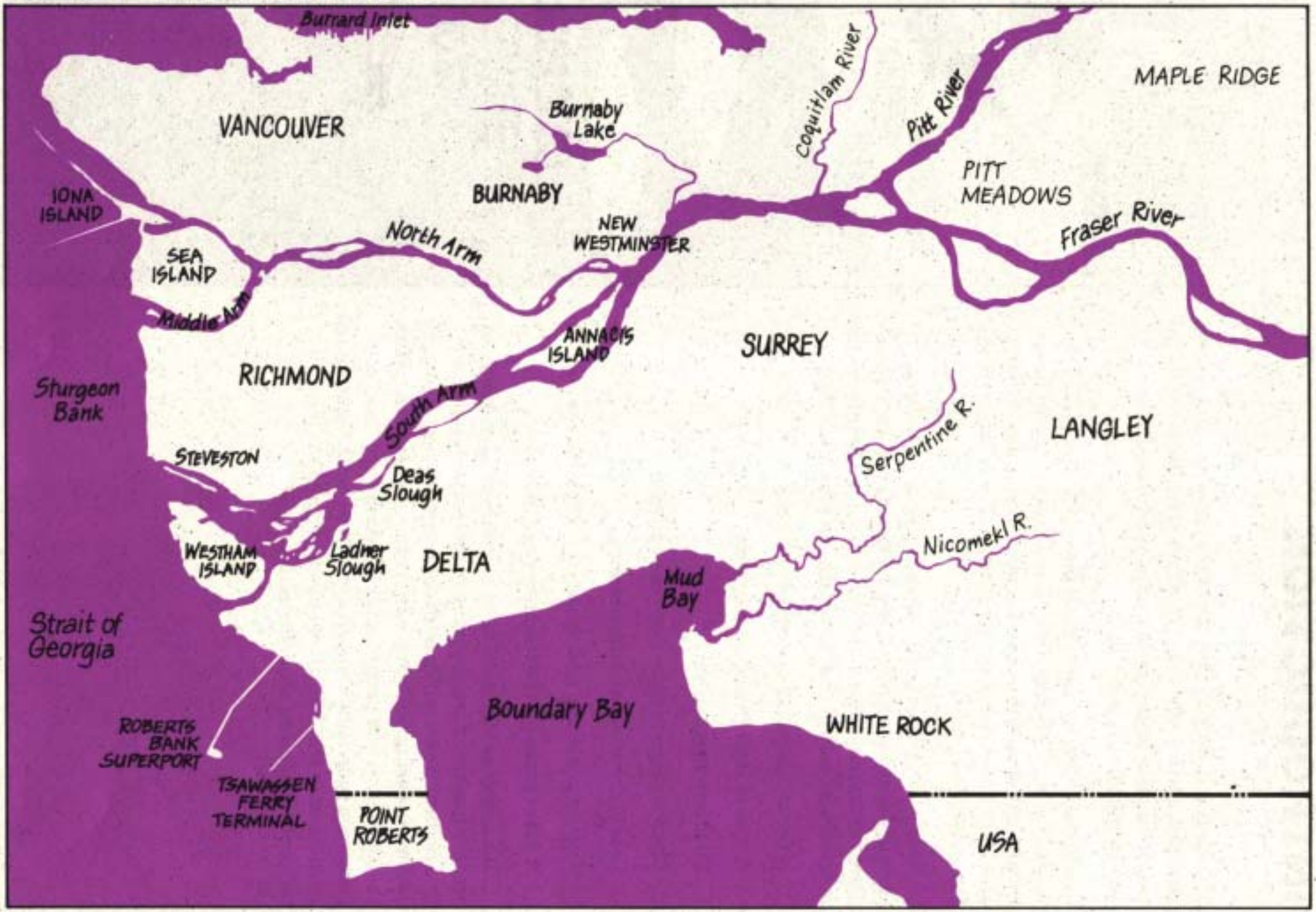
On the pages to follow, you'll discover a fascinating world of unique life forms which you probably didn't know existed in the muddy environment of the estuary. You'll also learn about one of the greatest estuaries on earth, the Fraser River.

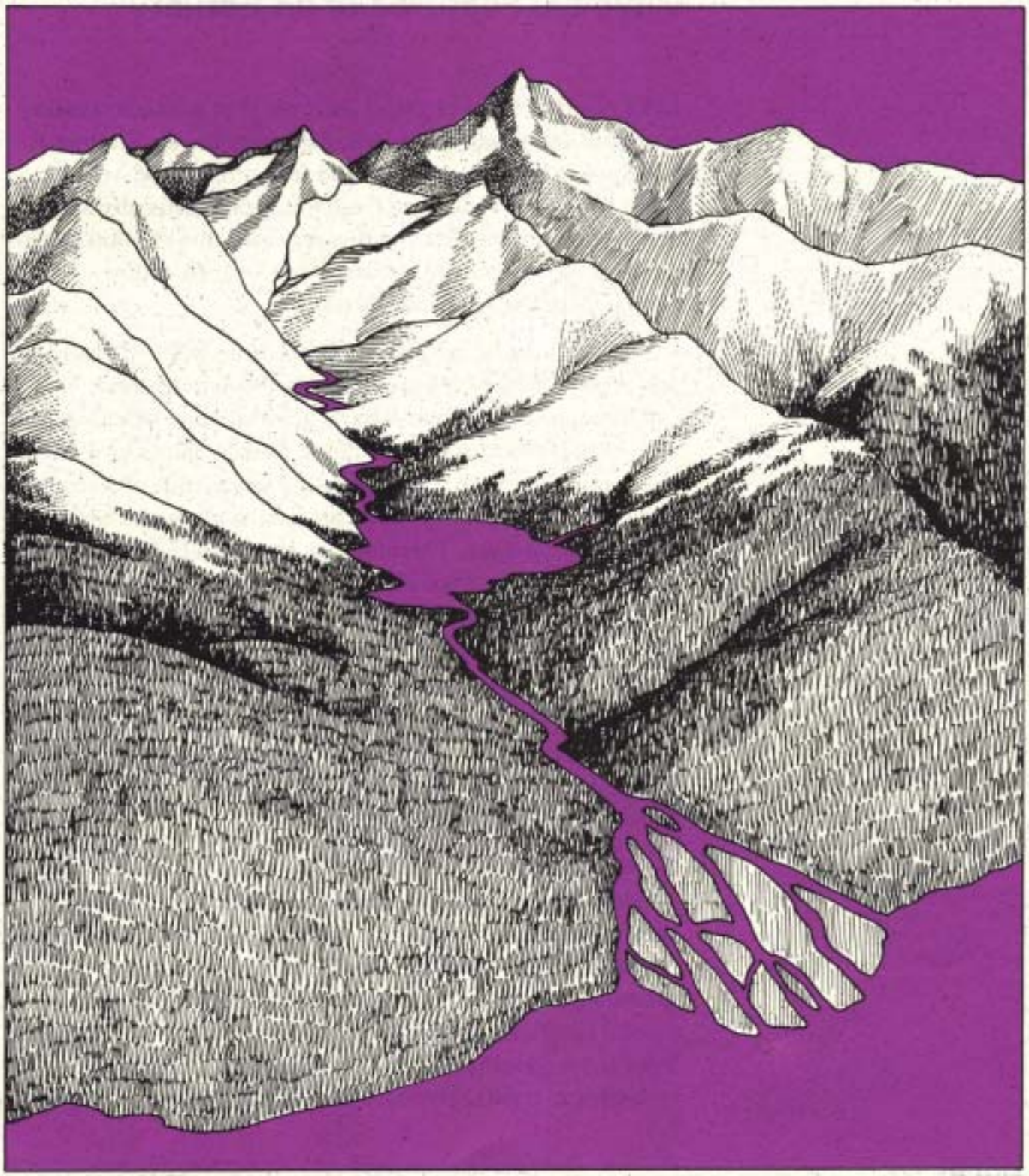
This book is intended for anyone who has a natural curiosity about the estuary. It's written clearly enough for older children to understand and enjoy, but the information is equally interesting for adults. In the book you'll find:

- ☐ Information on the ecology of estuaries
- ☐ A look at their history and culture
- ☐ Field trip suggestions
- ☐ Challenging activities everyone can enjoy
- ☐ Lots of drawings and illustrations
- ☐ Tips on protecting and conserving a healthy estuary
- ☐ A great guide for the classroom and at home

It's important for all of us to be aware of what keeps an estuary healthy, if we are going to protect and conserve this natural treasure. Many of our estuaries continue to be under increasing pressure from human development. With the knowledge and understanding gained from this book, concerned individuals and groups will be better equipped to participate in the difficult choices and decisions that influence the future of our estuaries.

# FRASER RIVER ESTUARY





# 1. WHAT IS AN ESTUARY ?

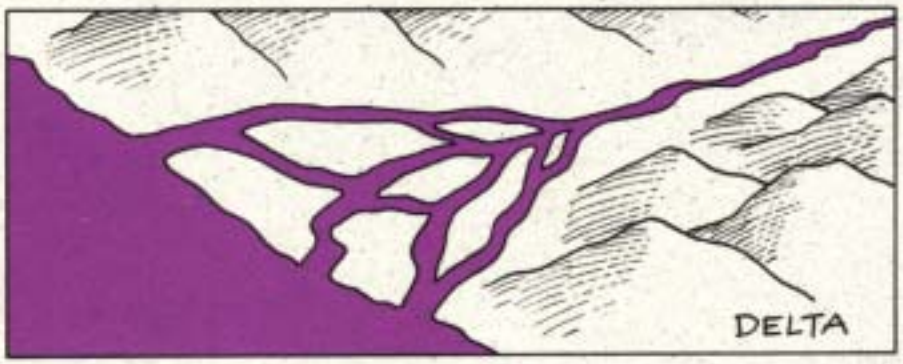
An estuary is a special place with some unique and important physical and ecological features. This book focuses on the Fraser River Estuary, one of the largest and most important estuaries on the coast of British Columbia. To begin with, though, let's look at some of the basic physical and ecological features of estuaries.

# Physical Features of an Estuary

Let's start with the physical features that make an estuary a unique and important place. Estuaries have a distinct geographic location, unique land formations, and are a place where seawater and freshwater mix. This physical setting supports a rich and diverse collection of plants and animals — the estuary's ecosystem — which will be described in the following section.

Geographically, an estuary is the area where a river (or any other freshwater source) meets the sea. In some estuaries, sand and gravel bars, mudflats and islands make up a land formation called a delta. Fertile deltas have been the cradle of human civilizations for thousands of years, and to this day continue to be attractive places for human use and settlement. Therefore, as shown in Figure 1-1, an estuary is usually identified and defined by its delta.

**FIGURE 1-1**




However, estuaries include more than just a delta, because any open water area where freshwater mixes with seawater is also considered to be part of an estuary. For example, estuaries include areas inside the steep-sided coastal basins or fiords of our province (Figure 1-2), such as Bute Inlet, Rivers Inlet and Howe Sound. Other major estuaries of coastal British Columbia are shown in Figure 1.3.

**FIGURE 1-2**

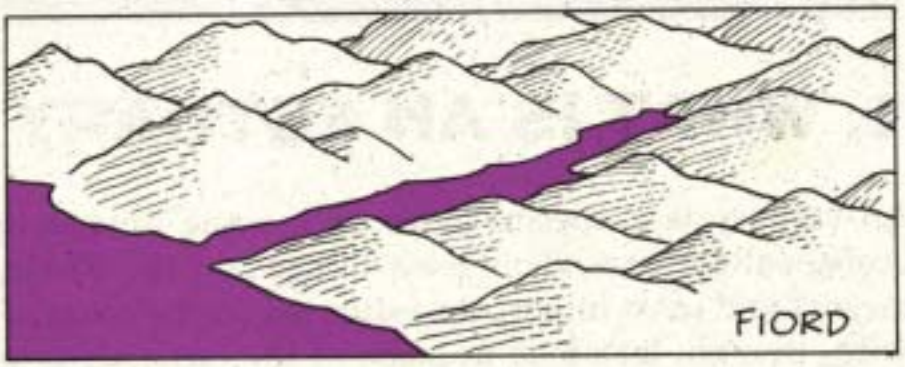
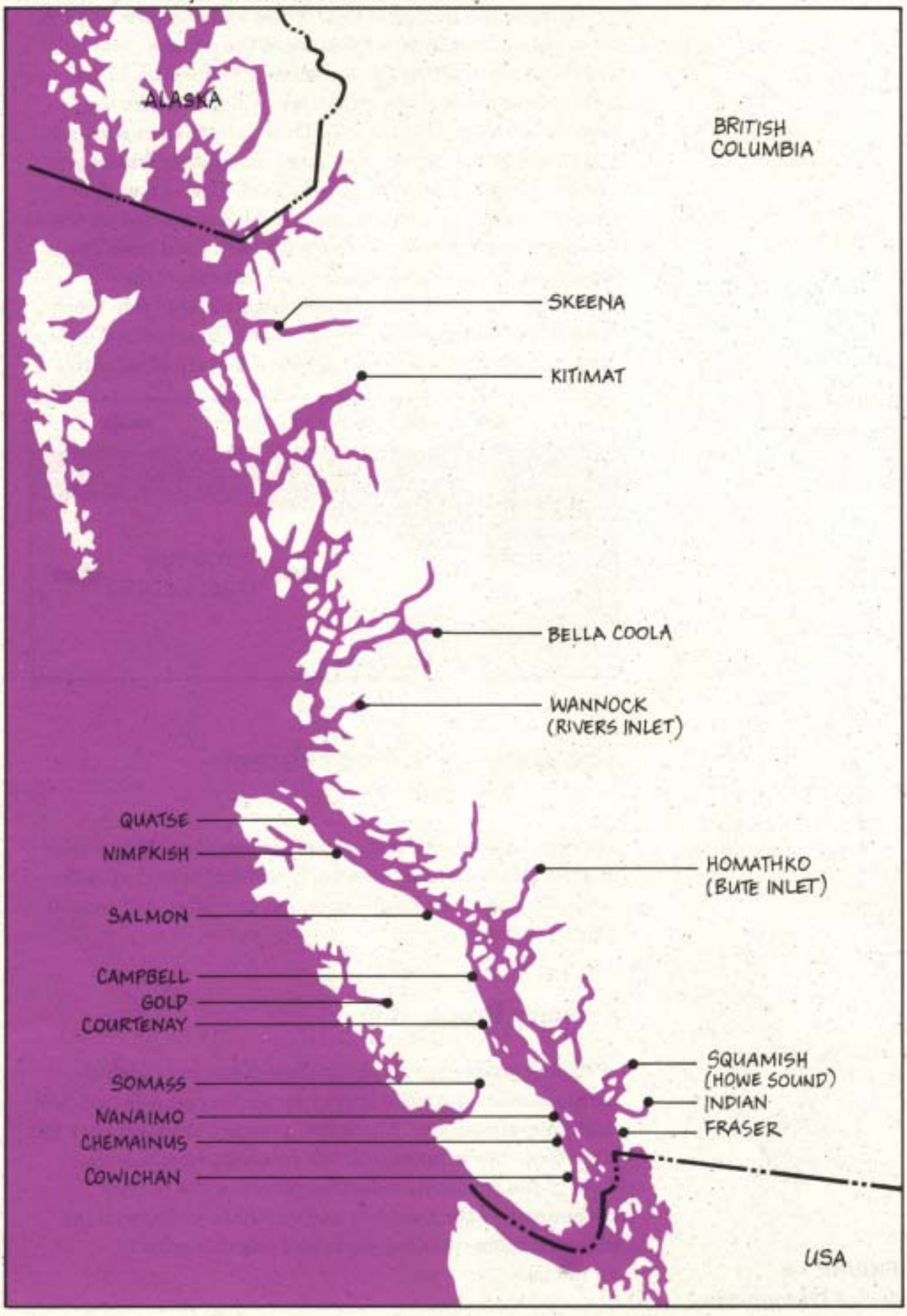


**FIGURE 1-3** Major Estuaries of British Columbia



Because the mixing of freshwater and seawater is such an important and distinct feature of the estuary, it is worthy of some further explanation. Freshwater, being lighter (less dense) than saltwater, will flow above the heavier seawater (Figure 1-4). Thus, in estuaries such as the Fraser River, where very large amounts of freshwater are discharged, a salt wedge is formed. This is a wedge-shaped, bottom layer of seawater, which is pushed up the estuary along the river bottom with each flood tide. The separation between freshwater and saltwater (the interface) can break down on an outgoing (ebb) tide. Such conditions of mixing will create zones of brackish, or diluted seawater, a common physical feature of estuaries.

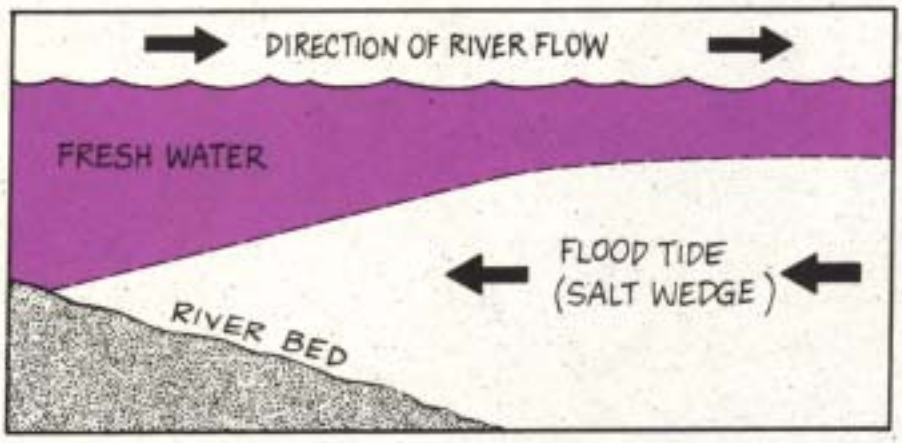



**FIGURE 1-4**
Salt Wedge

## The Estuary's Ecosystem

There are some basic ecological features that all estuaries have in common. It is these ecological features that make estuaries one of the most important ecosystems of coastal British Columbia.

### Primary Production

"Primary production" is the biological process in which plants convert the sun's energy by photosynthesis into food that animals can use. Therefore, primary producers are the basic food source for animal life on earth. In estuaries, most of the primary production occurs in the bottom community — the marshes and mudflats where wetland plants, bottom-dwelling algae and eelgrass grow in abundance.

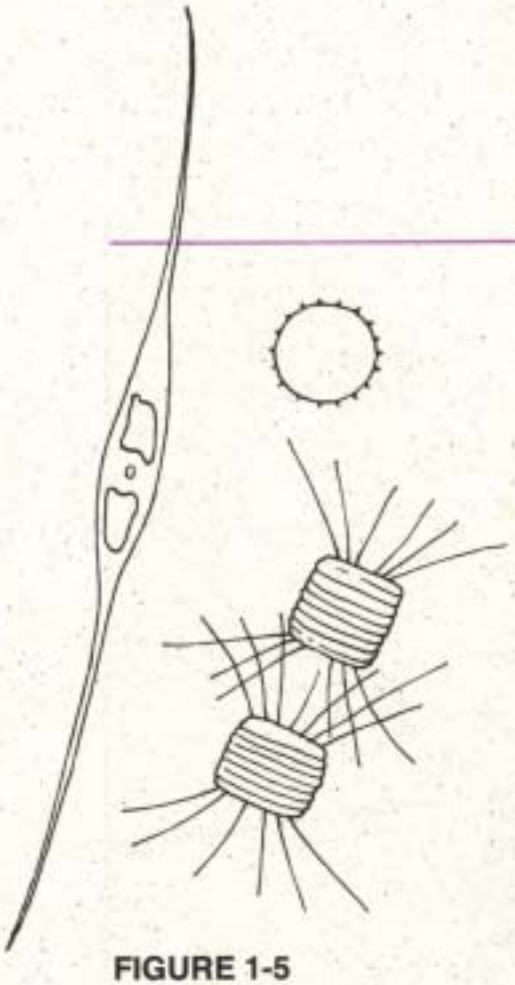
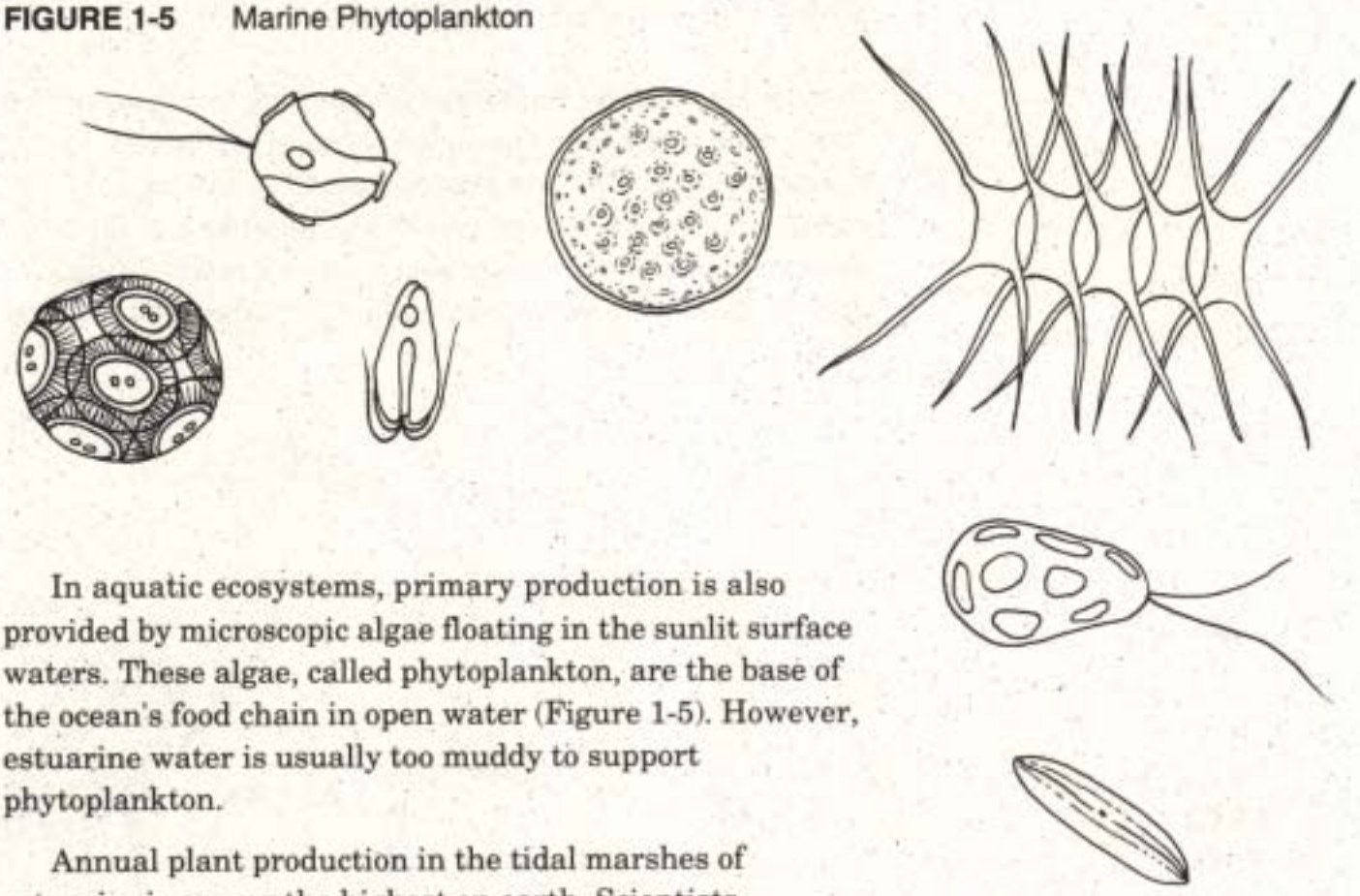


**FIGURE 1-5**
Marine Phytoplankton

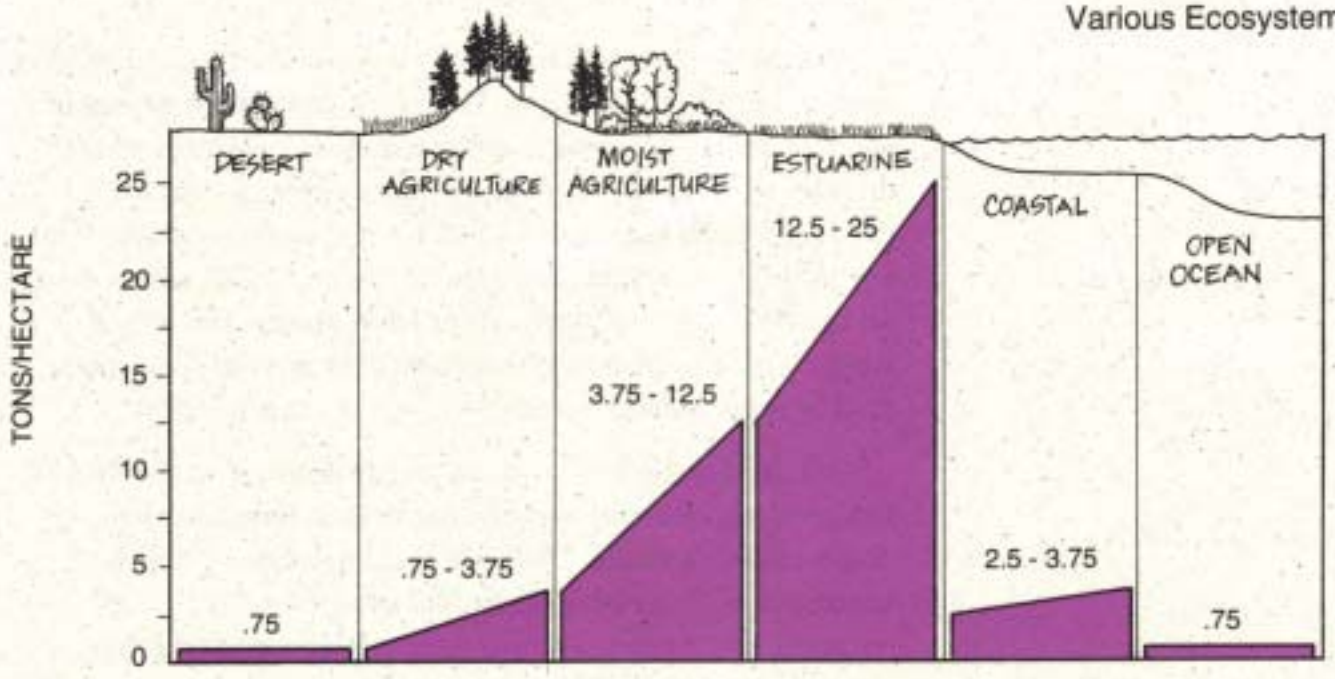
**FIGURE 1-5** Marine Phytoplankton



In aquatic ecosystems, primary production is also provided by microscopic algae floating in the sunlit surface waters. These algae, called phytoplankton, are the base of the ocean's food chain in open water (Figure 1-5). However, estuarine water is usually too muddy to support phytoplankton.

Annual plant production in the tidal marshes of estuaries is among the highest on earth. Scientists measure annual plant production according to the total amount of leaves and stems produced in a unit area (square metre or hectare) of marsh per year. Estuaries, with annual production rates that range from 12.5 to 25 tons/ha, exceed even that which can be produced by the most intensive agriculture (Figure 1-6).

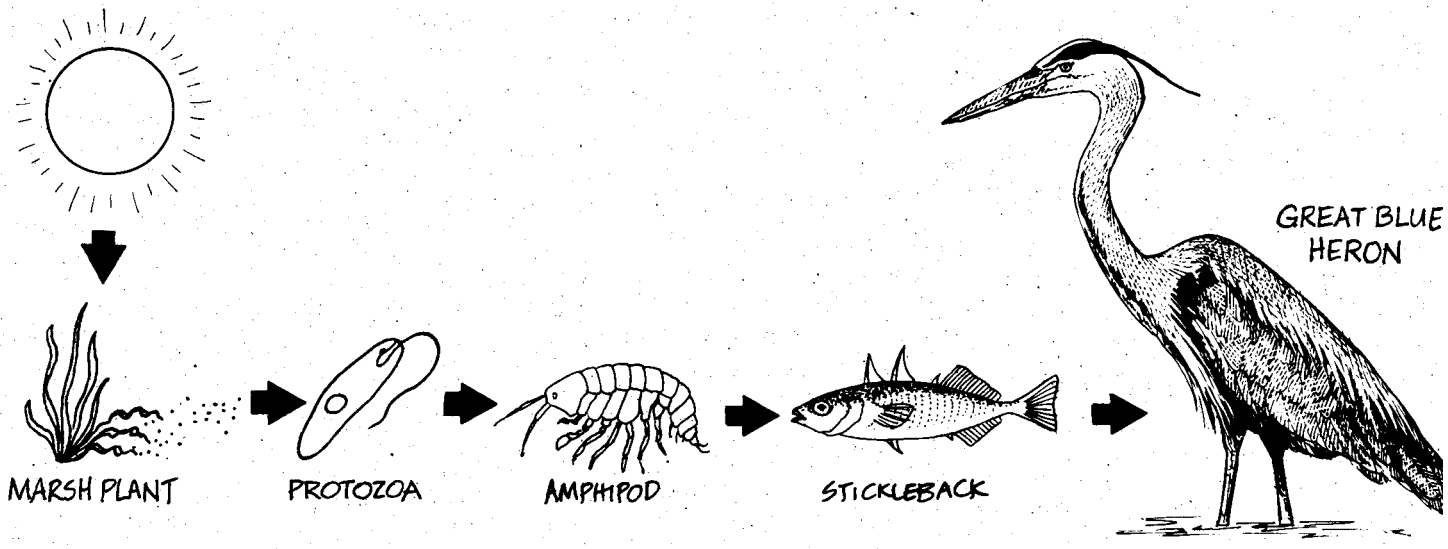
**FIGURE 1-6**
Primary Production of Various Ecosystems



## Food Chains and Food Webs

Food chains are the transfer of food energy from plants (the base of the food chain) through a series of organisms, by the process of eating and being eaten, to some top consumer. One link in the food chain might be a plant-eating animal (herbivore) being eaten by a meat-eating animal (predator). An example of an estuarine food chain is as follows:

**FIGURE 1-7**
Estuarine Food Chain




In the food chain above, the transfer of food energy between each organism is shown by an arrow pointing from the food source to the consumer. The arrows represent the links of the food chain. Food chains are based on what biologists observe in the field about the feeding habits of animals, or what they analyze in the laboratory from the animals' stomach contents.

You will notice in the above example that the amphipod does not eat the live plant. This is an important aspect of the food chain, since only a few estuarine animals graze directly on the vast amount of living plant material produced each season. The few herbivores of our estuaries are mainly waterfowl, such as the Snow Goose which feeds on the belowground parts of bulrush plants, the Black Brant which depends on eelgrass, and certain species of dabbling ducks which eat the seeds of marsh plants.

All the dead plant material accumulating at the end of the growing season forms an important base of the food chain called detritus. Detritus consists of dead plants combined with a rich assortment of microscopic fungi, bacteria, protozoa (as in our example above) and other

microorganisms. Small invertebrates such as worms, snails, and crustaceans (e.g. amphipods) thrive on this detritus. Anyone who has ever poked around in the compost pile of their garden, in a pile of rotten leaves, or in a rotten log will recall the teeming invertebrate life in these detritus-rich habitats.

The millions of small invertebrates living in the estuary are eaten by fish, birds, and amphibians. Small fish and amphibians are in turn eaten by larger fish, birds and mammals. Much of the estuary's food chain is therefore supported by the rich organic detritus of the marshes, shallow sloughs and tidal channels.

## ACTIVITY 1: ESTUARINE FOOD CHAIN

1. Design a food chain that illustrates the following short story (adapted from: *Discover Wetlands, A Curriculum Guide*, Washington Department of Ecology, 1988). Remember to connect each link in the chain with arrows pointing from what is being eaten to what is doing the eating.

A clam that filtered microscopic detritus particles from the estuary's water was caught by a Glaucous-winged Gull, dropped on the rocky beach, and cracked open. The clam meat was then fed to the gull's hungry chick. Soon, a Bald Eagle searching for food captured and ate the chick. The food energy the clam first obtained from the detritus was transferred to the gull chick and finally to the eagle.

2. To the base of the food chain add two more links to illustrate how the detritus was derived. The third paragraph under the heading **Food Chains and Food Webs** will give you a clue. Finally, don't forget the ultimate energy source -- the sun.

Answer provided in Appendix 1, page 109.

In reality, the estuary consists of an interconnection of different food chains. This pattern of interconnecting food chains is called a food web. To better understand the significance of food webs, do the following activity.

## ACTIVITY 2:
## ESTUARINE FOOD WEB

Complete the simplified food web for an estuarine marsh habitat shown in Figure 1-8 by using the words below to fill in the correct numbered circles (adapted from: *Discover Wetlands, A Curriculum Guide, Washington Department of Ecology*, 1988). Read the numbered clues to help you. To show the flow of energy, the arrows point away from a food source and toward the organism that eats it. The answers to the food web diagram are given in Appendix 1, page 109.

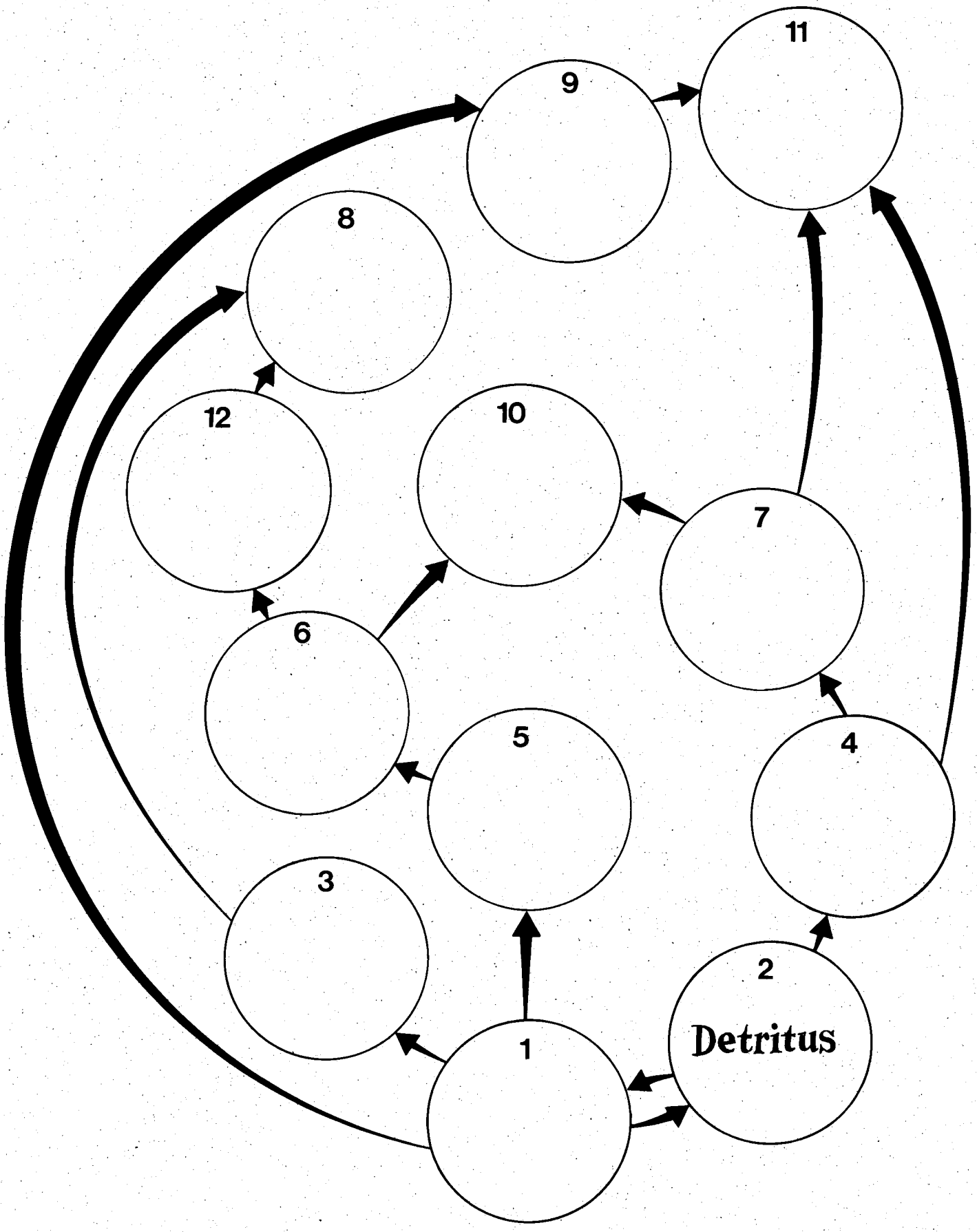
**WORDS TO FILL INTO CIRCLES:**

| | | | |
|---|---|---|---|
| Clam | Heron | Mayfly | Owl |
| Humans | Plants | Snake | Frog |
| Flounder | Detritus | Vole | Beaver |

**CLUES FOR NUMBERED CIRCLES:**

1. These organisms use energy from the sun to make food.
2. This is dead plant material enriched with bacteria and fungi. It returns plant nutrients back to the marsh.
3. This small rodent eats mainly plants and sometimes insects.
4. These shelled animals live in the mud and sand and filter small particles of organic matter.
5. The larva of this flying insect feeds on organic matter.
6. This amphibian eats any small moving invertebrate.
7. This flat-looking animal lives underwater and feeds on small bottom-dwelling invertebrates.
8. This animal hunts at night for snakes and voles.
9. This small mammal was hunted in the past for its fur and it eats mainly plants.
10. This long-legged animal can be seen patiently standing in shallow water for a fish or frog to eat.
11. If it wants to, this creature can find and eat almost anything in the estuary. Nothing in the estuary can kill and eat this animal.
12. This reptile slithers around to hunt for frogs.

**FIGURE 1-8** Estuarine Food Web



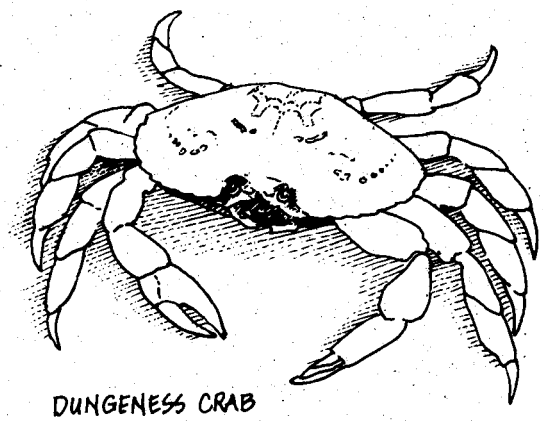
## Important Life-History Stages

The estuary plays an essential role in the life history of many fish and wildlife species. For example, our estuaries provide important rearing and feeding habitats for juvenile Chum and Chinook salmon. The brackish water of the estuary gives juvenile salmon time to gradually adjust to saltwater conditions before they migrate into the ocean.

Especially in larger estuaries such as the Fraser River and Skeena River, juvenile salmon spend several weeks feeding in sloughs and tidal channels as they slowly migrate out into the ocean in early spring. This feeding and rearing period represents an important life-history stage for juvenile salmon. Other fish species such as smelt and Starry Flounder spawn in the estuary and also use its protected backwaters for the nursing and rearing of juvenile stages.

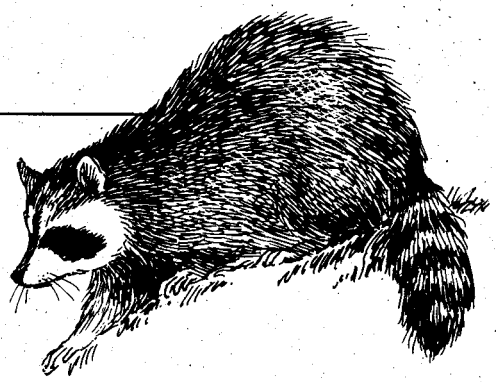
Dungeness crab move into shallow subtidal areas of the estuary to burrow into soft bottom areas, seeking protection from predators while the crab's shell is soft during its moulting and mating stage. Juvenile Dungeness Crab will use the shelter and food provided by the estuary to go through various stages of development before moving offshore as adults.

All of our coastal estuaries provide essential resting and feeding habitat for waterfowl migrating from their northern breeding ranges along the Pacific Flyway to their southern wintering habitats. Without the critical resting and feeding habitats provided by estuaries, some species of migrating birds would probably disappear.



DUNGENESS CRAB

# The Fraser River Estuary



The Fraser River Estuary is one of the largest, most interesting, and perhaps most important estuaries on the coast of British Columbia. We will begin our introduction to the Fraser Estuary by describing some of its physical features. Chapter 2 will then describe the aquatic habitats of the estuary and its abundance of plants and animals.

At the point where the Fraser River exits the mountains at Hope, it has drained over 200 000 square kilometres of very diverse terrain (Figure 1-9). At this point, the river is rich in sediments eroded from across southern and central British Columbia.

As the river enters the Fraser Valley lowland, its speed is checked by the change in slope of the river bed, and great volumes of sediment drop out of suspension to form gravel and sand bars, islands, sloughs and mudflats. The finer and lighter the sediment, the further it will be transported out into the estuary, eventually settling out onto Sturgeon and Roberts Banks.

During the spring and early summer snowmelt, the Fraser River surges, and this pushes back the tidal inflow of salt water to the lower reaches of the delta. During this peak flow period in May, June or July, river flows at Hope are from 10 000 up to 15 000 cubic metres per second. This is equivalent to about 50 000 to 75 000 full bathtubs of water per second. In winter, when the river flow is at its lowest, the tide has less opposing force from the river and will therefore push salt water inland as far as New Westminster. Normal winter flows are approximately 700 cubic metres per second.

Freshwater flows far into the Strait of Georgia and is clearly visible from an airplane or space satellite as a distinct light colored plume against the darker marine waters of the Strait. This is because the sediment-laden freshwater plume reflects more light than the clearer marine water. The influence of the Fraser River plume reaches across the Strait of Georgia, all the way to the Gulf Islands (Figure 1-10).

**FIGURE 1-9** Fraser River Drainage Basin

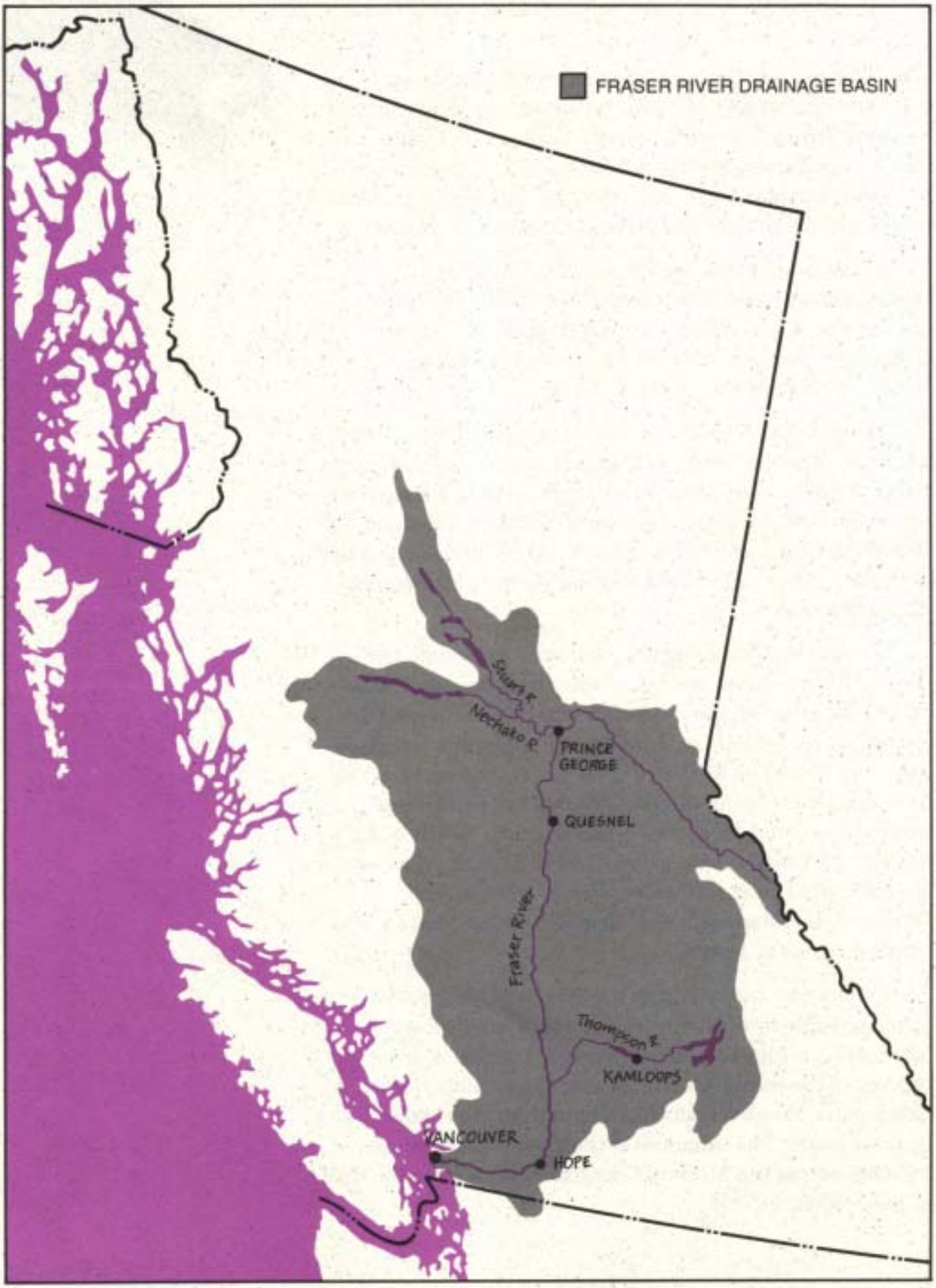
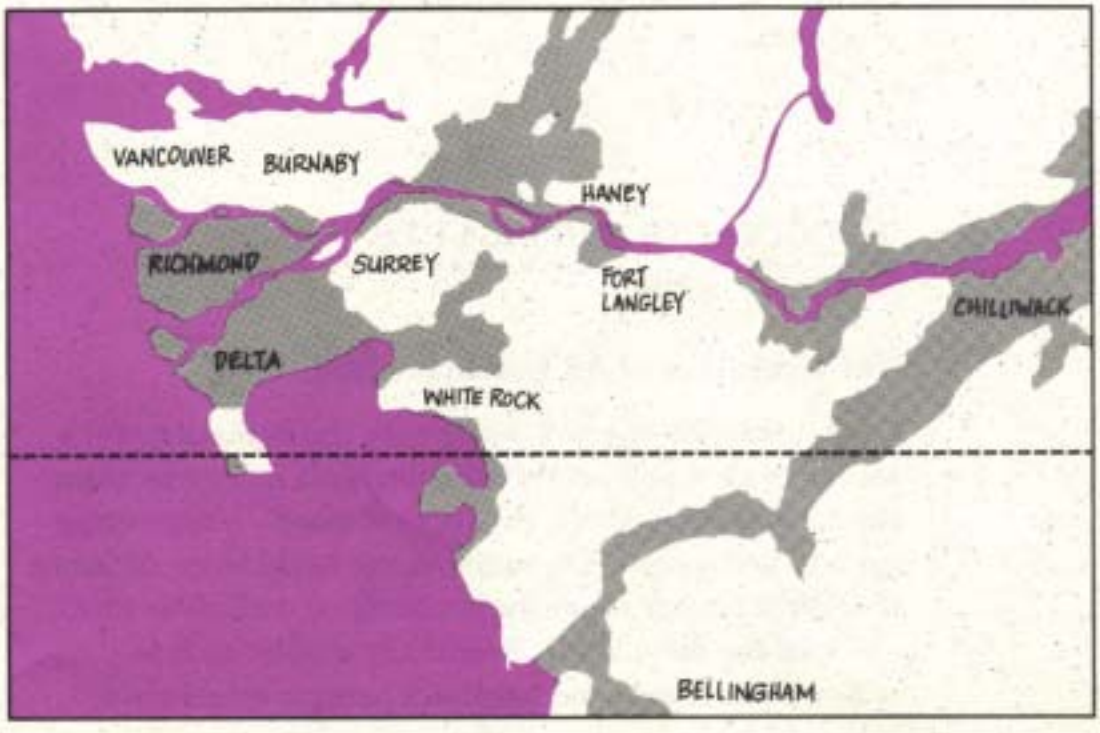



**FIGURE 1-10**
Fraser River Plume

The present-day physical setting of the Fraser Estuary is the result of sediments accumulating over thousands of years. The Fraser River has been building and expanding its delta at the rate of 13 million cubic metres per year, resulting in sediment deposits which are now 100 to 230 metres deep.

The terrestrial and intertidal portion of the estuary includes the delta created from river sediments since the last ice age. As you can see in Figure 1-11 and on the map of page 6, this includes all of South Delta, Ladner, Tsawwassen, Richmond, including Sea Island, as well as the smaller mid-river islands downstream from New Westminster. Sturgeon and Roberts Banks, and Boundary Bay make up the outer areas of the delta.

**FIGURE 1-11**
Present-Day Delta Formations



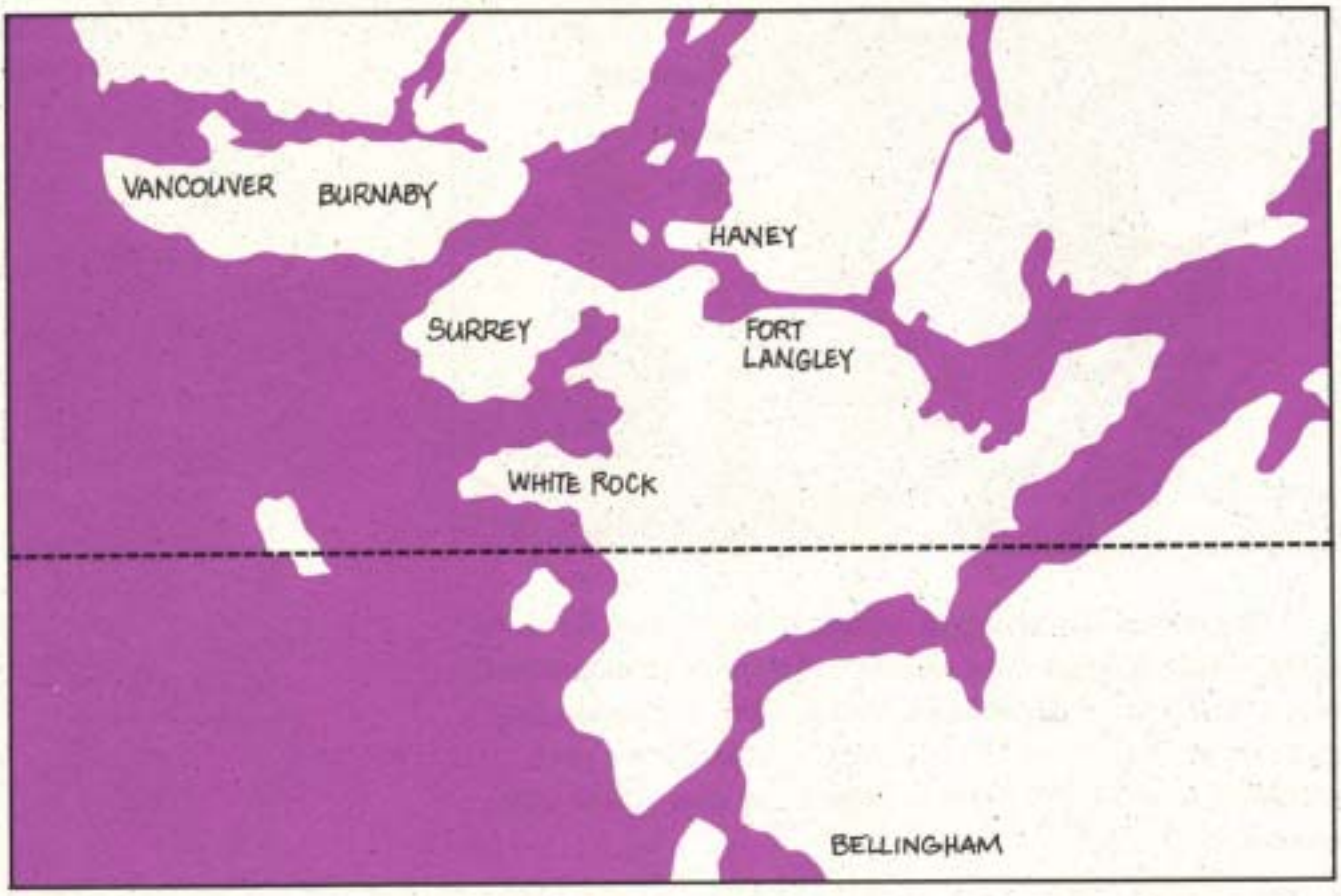



**FIGURE 1-12**
Delta Formations
11 000 Years Ago

Terrestrial areas of the Fraser River Estuary looked much different just after the last ice age, some 10 000 years ago (Figure 1-12). At that time, the estuary extended up into Pitt Lake, up Bellingham Bay, and into the eastern Fraser Lowland — an area that had previously been occupied by ice, but was replaced by water. There was an open-water connection between Chilliwack and Bellingham Bay, as well as perhaps one coming down past New Westminster.

## OTHER FACTS AND FIGURES

### The Evolution of An Estuarine Bog

Over thousands of years, along with the formation of the estuary's sand and gravel bars, mudflats and delta, came the development of vast expanses of marshes supporting grasses and sedges. The marshes produced large amounts of organic matter which, in combination with river silts, elevated the delta lands. Eventually shrubs such as willows, sweet gale and hardhack became established.

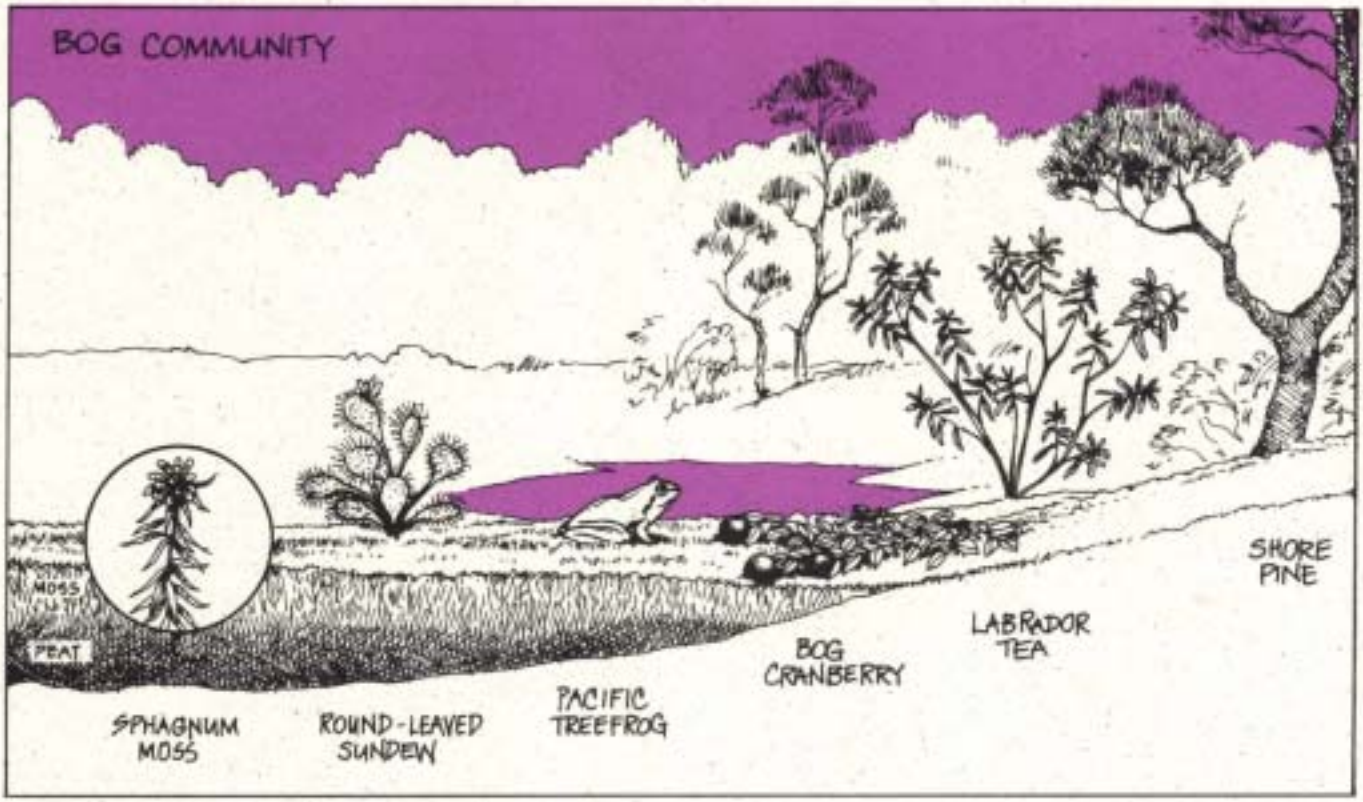
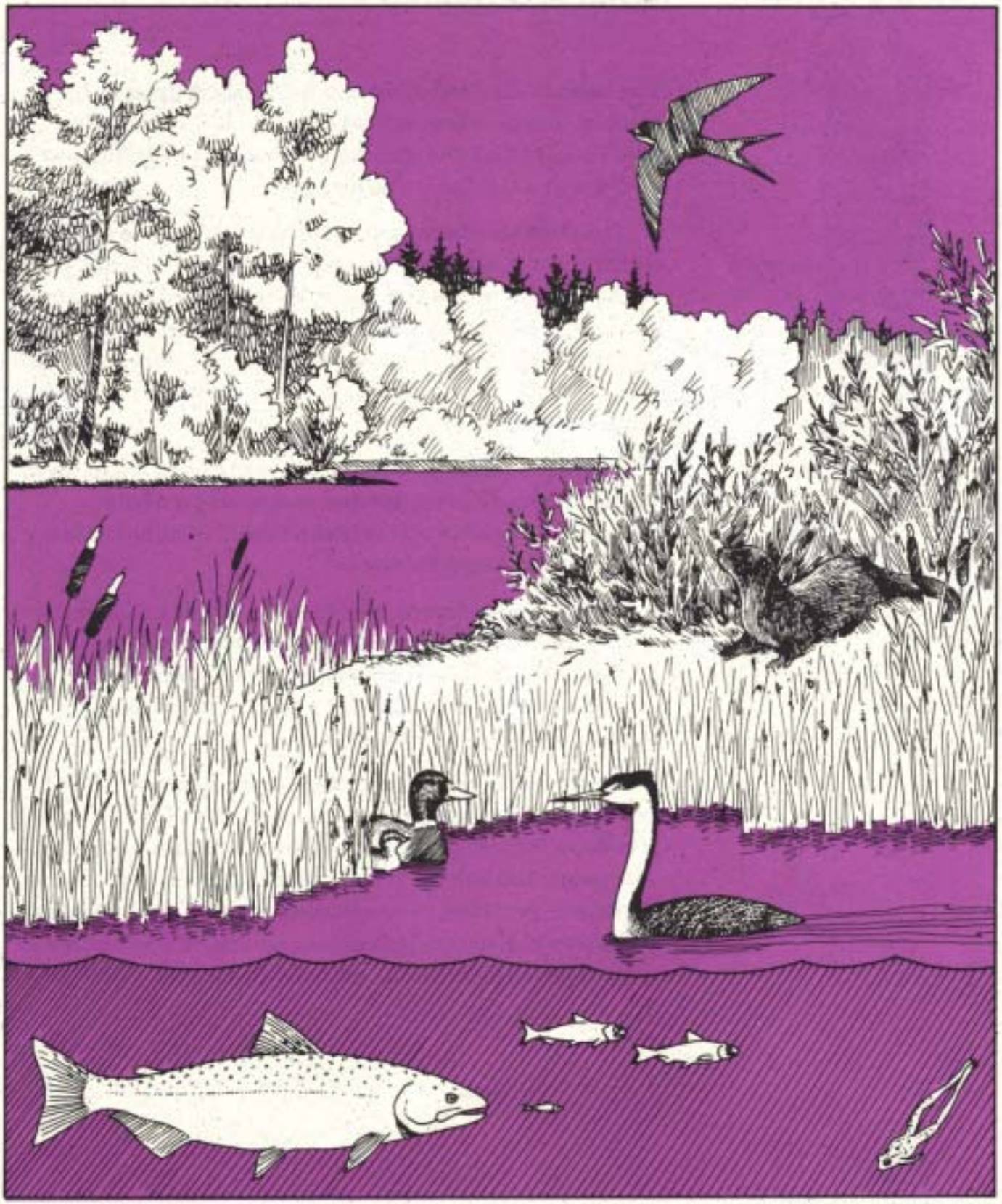



**FIGURE 1-13**
Bog Community

In certain poorly drained areas of the estuary, the accumulating organic matter formed large deposits of peat. These areas were cut off from river flooding and therefore did not receive their annual supply of nutrient-rich floodwater. However, heavy winter rains kept these areas saturated with water. Soon, these wet, nutrient-poor, peat-dominated areas developed into bogs. Burns Bog and Surrey Bend are two areas where bogs have survived to the present day. The presence of large peat bogs is a unique feature of the Fraser River Estuary.



# 2. AQUATIC HABITAT

We know that estuaries like the Fraser support a rich and diverse assemblage of habitats. Exactly what do we mean when we use the word "habitat"?

# What Is a Habitat ?

The habitat of an organism can be simply defined as the place or "home" where it lives or where it is expected to live. Thus, to find and observe a shorebird like Dunlin, we would visit a tideflat in the estuary.

The physical characteristics of habitats include sediment texture, water salinity (saltiness) and light. The living parts of the habitat consist of many different organisms, from bacteria to bulrushes and birds. Habitats therefore provide everything that a plant or animal needs to live and reproduce: food, nesting sites, protection for offspring, and resting and shelter sites for adults.

There is usually sufficient local variation in a habitat to support many different species, and indeed a whole community of plants and animals. Small, local habitats are referred to as micro-habitats.

Habitats also change over time. As plants and animals modify their physical environment, new and different plants and animals will gradually replace them. For example, new trees will modify a habitat by gradually shading out the sun-loving plants.

This natural process of change in the habitat is called succession. Once the habitat has changed as far as it can, it is called a mature or climax habitat. At this final stage of succession, the habitat can exist for hundreds or thousands of years — provided, of course, that humans don't damage or destroy it. Eventually, a climax habitat will be altered by natural forces such as fire, extreme flooding or drought.

# Habitat Types

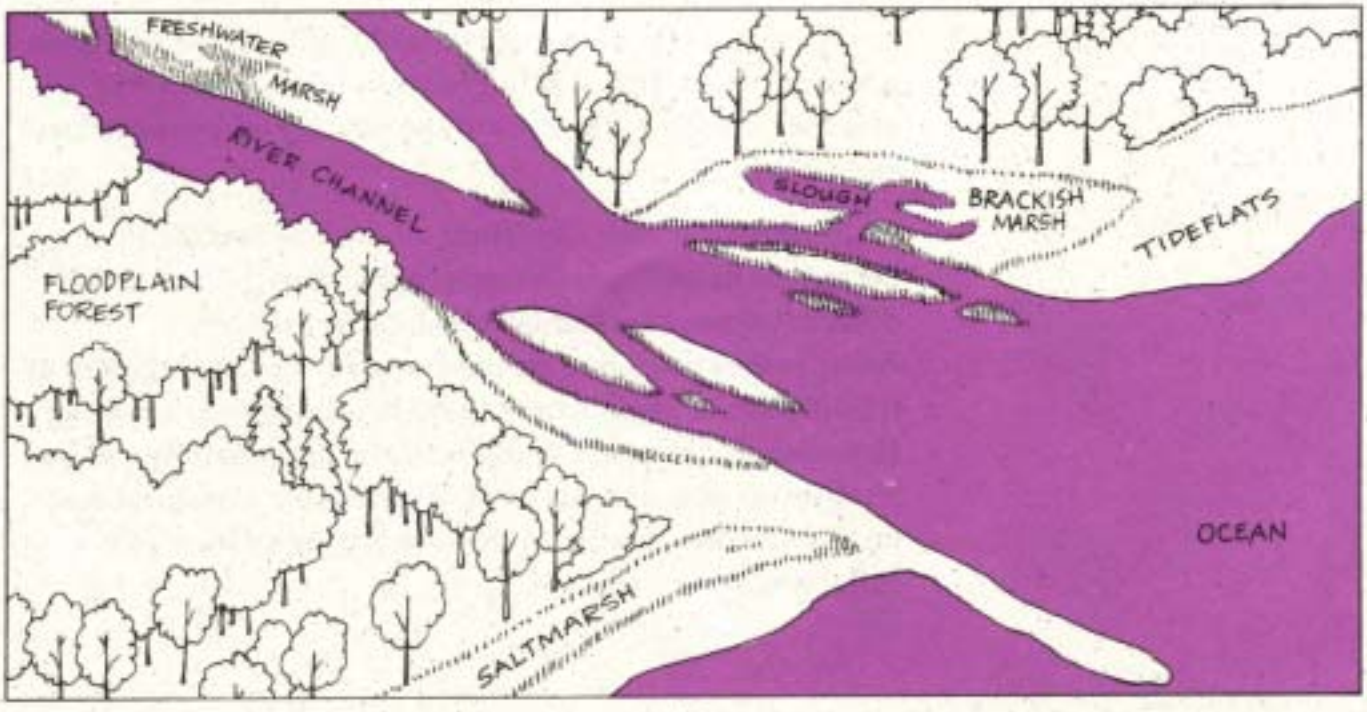
Habitats are generally classified according to the type of vegetation growing in an area. Animals are not usually used to classify habitats since birds, fish and other animals move from place to place, and are often inconspicuous and difficult to observe.

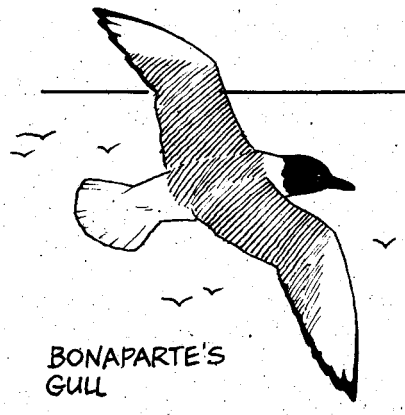
In this section, we'll describe four habitat types common to the Fraser River Estuary. We'll also describe where you can visit them, and suggest some appropriate field activities. The four habitats are:

- ☐ Brackish and Freshwater Marsh
- ☐ Saltmarsh and Tideflat
- ☐ Active Floodplain Forest
- ☐ Sloughs and River Channels

The first three habitat types can be easily recognized in the field by their distinct vegetation community. What is perhaps less obvious are the environmental factors that create just the right conditions for certain species of plants to grow and propagate. Environmental factors can be physical (light, temperature) or chemical (nutrients, salinity). The relationship between plants and environmental factors is one of the most important aspects of the estuary's habitat ecology.

**FIGURE 2-1**
Major Habitats of the Estuary






# Physical Influences on Habitats

Although there are many different environmental factors influencing the growth and distribution of plants in the estuary, we shall discuss only two of the most important factors: salinity and flooding.

## Salinity

Two of the habitat classifications listed above (brackish and freshwater marsh, and saltmarsh) are based on salinity. Plants are very sensitive to salinity, which is the amount of salt in their environment. Salt can make it difficult for some plants to nourish themselves and to maintain a balanced water level in their tissue.

Only certain kinds of plants can tolerate high levels of salt. Such salt-tolerant plants are present in saltmarshes. Many saltmarsh plants get rid of the salt they take up by releasing it through special salt pores on their leaf surfaces.

In Chapter 1, an estuary was defined as the place where the freshwater of the river mixes with the saltwater of the ocean. This mixing of fresh and saltwater creates a condition called brackish water, which contains some salt, but much less than seawater. Plants adapted to these brackish conditions are found in brackish marshes.

Plants that grow in freshwater usually do not like even a moderate amount of salt. Plants in these freshwater marshes are found in areas of the estuary where seawater cannot reach.

Salinity is a very important environmental factor because it determines the geographic distribution of the different types of marshes found in the estuary. Saltmarshes are found farthest away from the influence of freshwater, in areas where there is usually only seawater. Brackish marshes are found near the outer estuary where freshwater and seawater mix. Freshwater marshes occur only in the upper parts of the estuary, away from any influence of seawater.

## Flooding

Plants are also very sensitive to flooding. The longer and deeper an area is flooded, the less oxygen is available in the soil. Plant roots need oxygen to grow and survive. To overcome the shortage of oxygen in flooded soils, some species of plants have special oxygen storage cells and are able to bring this oxygen from their leaves and stems to their roots. However, when flooding is too deep or too long in duration, most rooted plants can no longer survive.

The degree of flooding depends on the elevation at which a plant is located. On higher areas of the outer delta, near the estuary's dikes, a plant would be flooded for a relatively short time, and perhaps only during the highest tides. Farther down the delta slope toward the lower intertidal zone, tidal flooding is longer in duration and greater in depth.

The outer delta certainly looks flat when viewed from the dikes. This is because the slope is very slight. Nevertheless, five or ten centimetres of rise or fall on the delta slope can begin to make a difference as to what type of plant can grow. Tidal marshes consist of distinct patterns of different types of plants, since their growth and distribution is easily influenced by small changes in soil elevation and flooding.

### ACTIVITY 3: CRITICAL TIDAL ELEVATIONS

Tides are an important feature of the estuary. The purpose of this activity is to become familiar with tides and to learn how to read tide tables. Figure 2-2 is based on data obtained from ecological studies of marshes in the outer Fraser River Estuary. The figure represents a profile view of a tidal marsh showing tidal elevations from the dike to the outer edge of the marsh.

**Procedure:**

1. Align a ruler with the bottom of Figure 2-2. Keeping the ruler horizontally aligned, move it upwards and read the numbers on the vertical scale labeled "Tidal Elevation - Point Atkinson Datum".

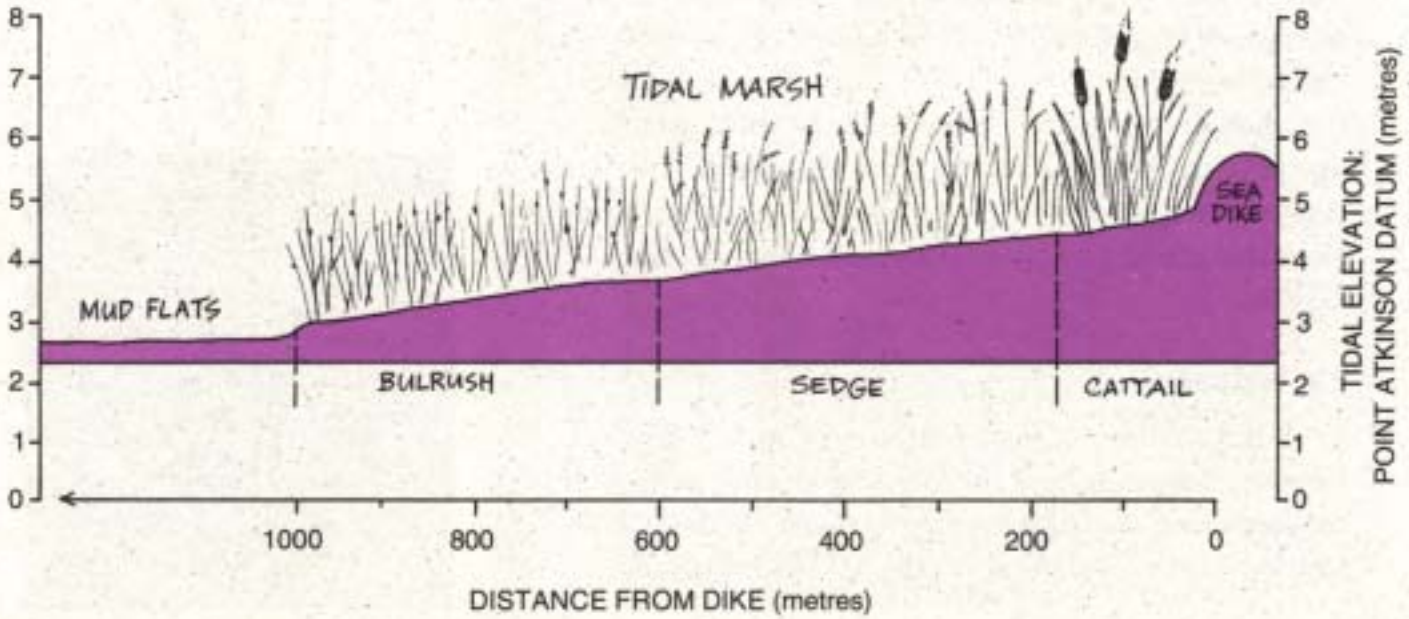
2. Note the tidal elevations of the following locations in the marsh:

- Start of the mudflat and end of the marsh
- Beginning and end of bulrush growth
- Beginning and end of sedge growth
- Beginning and end of cat-tail growth
- Top of the dike

3. Obtain a copy of the *Canadian Tide and Current Tables, Vol. 5.*, Fisheries & Oceans Canada, available at marine supply centres. Refer to the tide table for Point Atkinson. In the table find today's date. Mark the three or four tidal elevations for this date on the figure. Now you will know today's locations of the low and high tides in the delta marsh. Helpful hints for using the Tides and Currents Tables are provided in Appendix 1, page 110.

4. Refer again to the same tide table and date and make a note of the time for each tide. If you had wanted to walk into the marsh today to sample bulrush plants, when would you have been able to do so? How much time would you have had for your work? If it had not been possible today, when would be the next possible date for your sampling? Scan through the tide table and determine the best time of year to see the intertidal zone in daylight. Is there a pattern (daily, monthly, seasonal) to the tides?

**FIGURE 2-2**
Elevation Profile of a Tidal Marsh



# A Primer for Field Trips

The best way to learn about the aquatic habitats of the Fraser River Estuary is to visit and explore them. However, to make the field trip successful and enjoyable, it is well worth taking time to make some basic preparations. This is especially true of group field trips with children.

## Selecting Your Destination

In selecting your destination, the following may be helpful:

1. Prior to the field trip, decide on your objectives and learning outcomes, although you should also leave some room for open-ended discoveries. You might also want to study the activities in this book which are specifically intended for field trips.
2. For suggestions and descriptions of field trip destinations, refer to Table 2-3 and Figure 2-3 which provide additional information.
3. If you're planning to explore intertidal areas, you'll need to find out when low tide occurs, if the area to be visited will be exposed, and for how long. Some areas are relatively inaccessible even at low tide, due to muddy conditions or other hazards. It is important to find this out before a trip is undertaken.

WARNING

Watch out for narrow and deeply cut tidal channels which are sometimes covered by vegetation. It is best to stay away from densely vegetated tideflats where the ground is hidden from view.

**FIGURE 2-3** Location of Suggested Field Trip Destinations

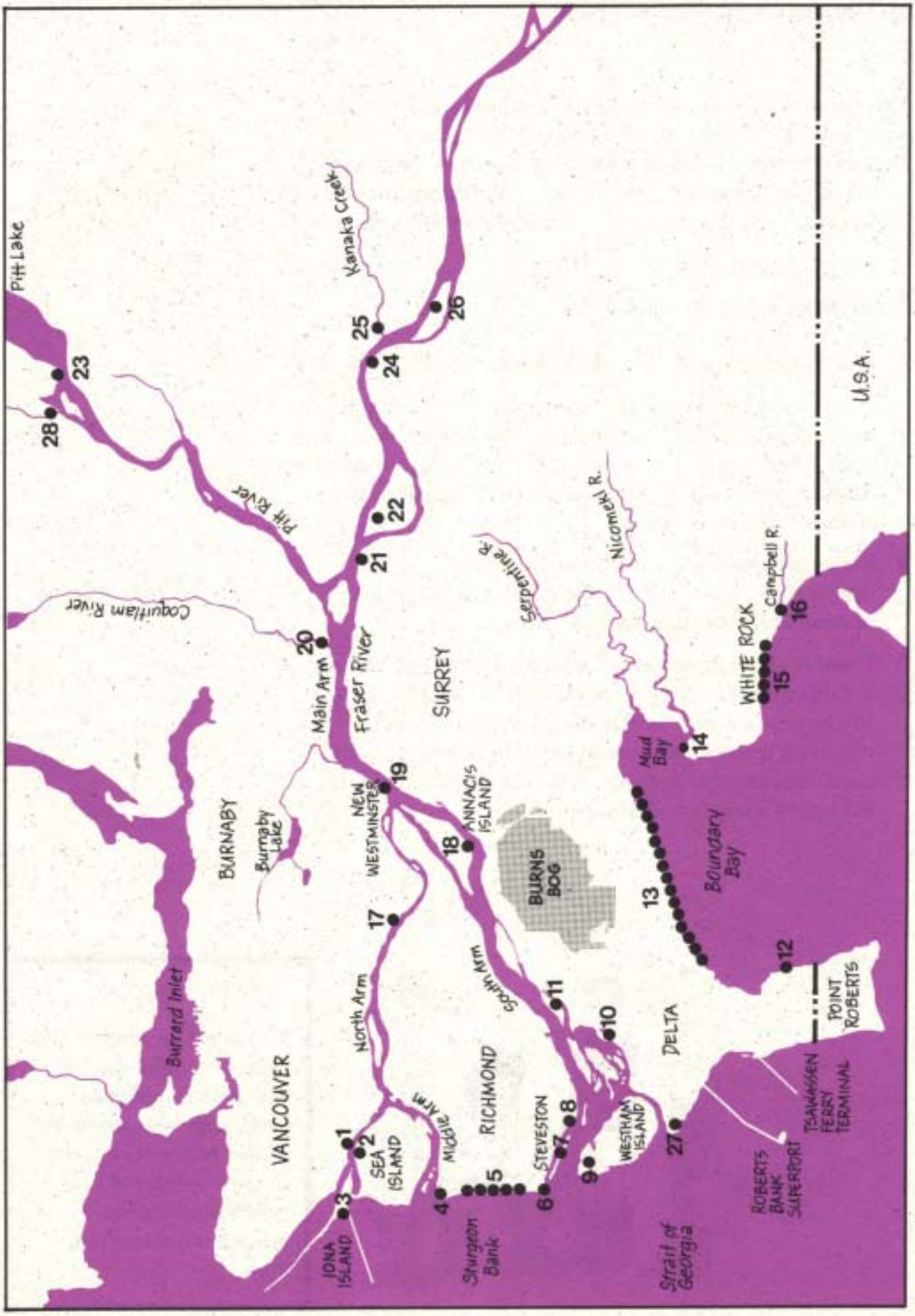


**TABLE 2-3** List of Suggested Field Trip Destinations

| # | FIELD TRIP DESTINATION | A | B | C | D | NOTES |
|---|---|---|---|---|---|---|
| 1 | Fraser River Park | X | | | X | Marsh restoration site |
| 2 | McDonald Beach Park | X | | | X | Boat launch & picnic area |
| 3 | Iona Beach Park | X | | | | Pond restoration site; excellent birding |
| 4 | Terra Nova | X | | | X | Described in this book on page 41 |
| 5 | Richmond Dikes | X | | | | Described in this book on page 37 |
| 6 | Garry Point Park | X | | | X | Marsh restoration site |
| 7 | Steveston Island | X | | X | X | Difficult access, and only at low tide |
| 8 | Gilbert Beach | X | | | X | Easily reached from dike |
| 9 | Reifel Island Bird Sanctuary | X | | | | Excellent birding |
| 10 | Ladner Harbour Park | X | | X | | Described in this book on page 59 |
| 11 | Deas Island Regional Park | X | | X | X | Described in this book on page 71 |
| 12 | Centennial Beach | | X | | | Great for exploring the tideflats |
| 13 | Boundary Bay (64th to 112th St.) | | X | | | Described in this book on page 47 |
| 14 | Blackie's Spit Park | | X | | | Close to large eelgrass beds |
| 15 | White Rock Beach | | X | | | Great for exploring tideflats |
| 16 | Semiahmoo Park | | X | | | Explore the Campbell R. Estuary |
| 17 | Fraser Foreshore Park | X | | X | X | Described in this book on page 59 |
| 18 | South Annacis Island Park | X | | X | X | Good reptile and amphibian habitat |
| 19 | Westminster Quay | | | | X | Great place to watch boat traffic |
| 20 | Coquitlam River Estuary | X | | X | X | Explore the Coquitlam River Estuary |
| 21 | Surrey Bend | X | | X | X | The largest undiked floodplain |
| 22 | Barnston Island | X | | X | X | Access via ferry, great biking route |
| 23 | Grant Narrows Regional Park | X | | | X | Nearby elevated observation platform |
| 24 | Derby Reach Park | X | | X | X | Popular bar fishing location |
| 25 | Kanaka Creek Regional Park | X | | X | X | Explore Kanaka Creek Estuary |
| 26 | McMillan Island | X | | X | X | Camping and nearby floodplain forest |
| 27 | Brunswick Point | X | X | | | Brackish - Saltmarsh transition zone |
| 28 | Widgeon Marsh Park Reserve | X | | X | X | Access with permission from GVRD |

A = Brackish & Freshwater
B = Saltmarsh & Tideflat
C = Active Flooplain Forest
D = Slough & River Channel

4. Intertidal plants and animals are sensitive to trampling, and considerable damage can be done by a large group of people. Some valuable and sensitive intertidal habitat areas, or habitat sites which have been restored, should not be walked into at all. It is always a good idea to check these things out first.

5. A half-day field trip will probably be sufficient, especially for children in elementary grades. Therefore, no more than one or two different types of habitat should be visited and studied. It is essential that children bring rubber boots and are dressed appropriately for what could be a wet, cold and muddy field trip.

6. Parent or other adult volunteers will be needed to accompany children on the field trip. It is best to select only those volunteers who are not squeamish about mud, insects, snakes, frogs, and anything else that the children will present and ask questions about. A minimum of 1 adult for every 8 children is recommended.

7. Parent volunteers should be given a Parent Information Sheet which indicates the objectives of the field trip and describes their responsibilities. Before the trip, the class or group should be divided into teams of 8 children (or fewer, depending on the number of adult supervisors). The parent volunteer will be attached to one of the groups as an adult supervisor. A list of names should be provided so the parents can get to know the children.

## Pre-Trip Activities

If you prepare your group before the trip, the whole experience will be more interesting and rewarding, and there will be fewer demands on you and your volunteer supervisors. If the children already have some vocabulary and knowledge, they will look forward to discovering and finding interesting things. If children know where to look, they will find more on their own. What they find on their own, they register as discoveries — and what they discover, they will remember.

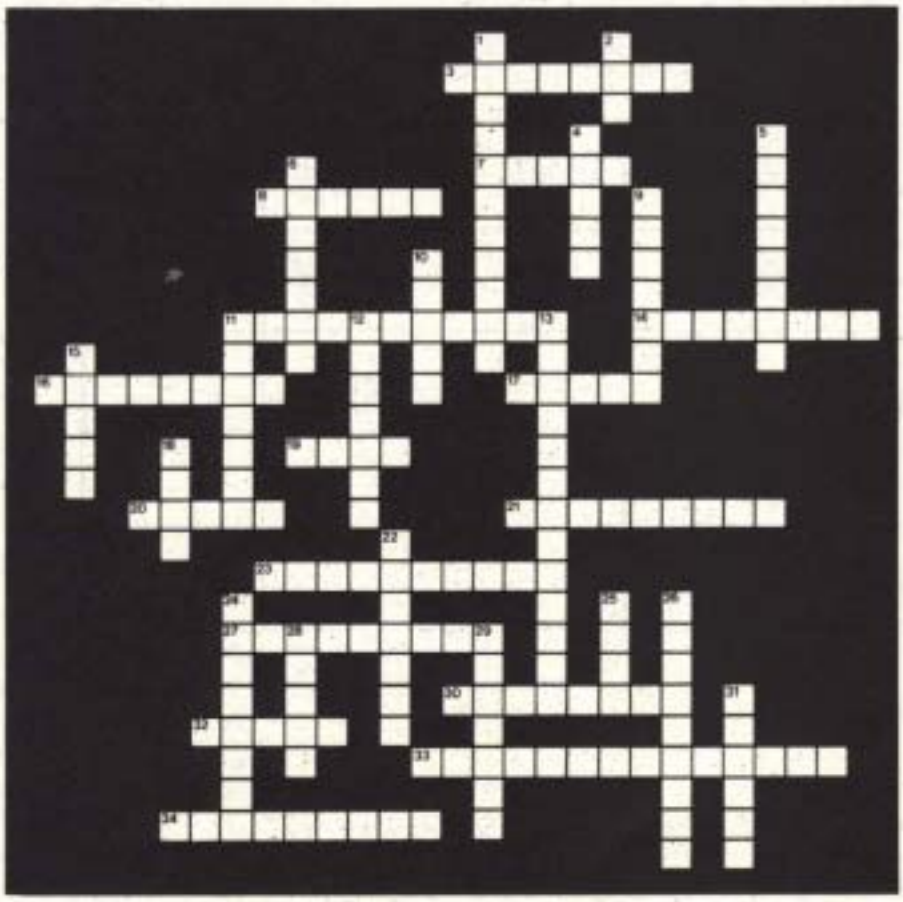
The following pre-trip activities can help you prepare for your trip to the estuary:

## ACTIVITY 4: PRE-TRIP FUN

1. Give everyone a vocabulary list and the **Estuary Crossword Puzzle** provided in Figure 2-4. The crossword establishes basic vocabulary in an enjoyable way. As a supplementary activity, have everyone make up their own simple 7-word crossword. They can select their own words from the vocabulary list.

For answers see Appendix 1, page 111

**FIGURE 2-4**
Estuary Crossword Puzzle



### ACROSS:

3. Eroded material which is deposited in an estuary
7. Large flowing body of water
8. Salt water environment
11. Biggest river in British Columbia
14. Human activity related to work
16. Small floating or swimming organisms
17. Simple organisms which contain chlorophyll
19. Two shelled animal living in marine sediments
20. An investigation
21. Waste substances which interfere with life
23. Animals which will consume anything which is edible
27. In-coming water in the daily changes in sea level (2 words)
30. Organisms which must eat other things for food
32. Organism which is the major pollutor on earth
33. The process used by plants to make their food
34. Birds which inhabit water environments

### DOWN:

1. Forces which break down the natural relationships between organisms
2. Salt water marine environment
4. Islands and other land built in an estuary
5. Living thing
6. Place where an organism lives
9. Out-going water in the daily changes in sea level (2 words)
10. First in time
11. The relationship between food organisms in a natural community (2 words)
12. Area where fresh water from a river meets the salt water of the sea
13. The connections between organisms
15. An environment which is not polluted
18. Place where ships dock to take on or put off cargo
22. Organisms which inhabit the bottom sediments
24. Liquid by-products of industry
25. Unit of weight
26. Movement of organisms from one place to another
28. Enormous body of salt water
29. The study of relationships between living things and their environment
31. Needed for the ability to move and to grow or produce materials

### WORDS TO SELECT FROM:

| | | | | |
|---|---|---|---|---|
| waterfowl | migration | clean | destructive | organism |
| consumer | flood tide | ocean | algae | river |
| industry | early | ebb tide | clam | Fraser River |
| sediment | scavengers | human | relationships | benthic |
| habitat | effluent | plankton | energy | probe |
| marine | port | ecology | estuary | pollution |
| photosynthesis | sea | delta | food web | gram |

2. **Estuary Word Challenge** (adapted from the Federation of B.C. Naturalists booklet, *From Sidewalk to Seashore* ) is another good game for building vocabulary skills. Each player is given a chart such as in the example of Figure 2-5.

Any word can be chosen to make up the letters in the rows. The word is revealed by the group leader at the start of the game. Children then fill the chart with acceptable estuarine vocabulary. If a group is doing this you might want to assign scores to the right answer and create a time limit for completing the answers. The winner is the one who can fill the chart first or who can score the highest. Two points are given to a word that only one person used; one point is given to words used by more than one person.

**FIGURE 2-5**
Estuary Word Challenge

| | PLANTS | ANIMALS | HUMAN ACTIVITIES | THINK OF YOUR OWN CATEGORIES! |
|---|---|---|---|---|
| S | Saltwort | Seal | Sailing | |
| A | Algae | Amphipod | Angling | |
| L | | | | |
| T | | | | |

# Brackish and Freshwater Marsh

## Where is this habitat located?

Because the Fraser is such a large river, the huge amount of freshwater it discharges creates a vast area of brackish water along the outer delta. Figure 2-6 shows that large areas of the brackish tidal marsh occur along Sturgeon Bank, Roberts Bank and the islands in the lower estuary. Freshwater tidal marshes are found upstream of New Westminster, where saltwater does not occur. Some of the most extensive freshwater tidal marshes are along the banks of the Pitt River.

In the smaller estuaries along the east coast of Vancouver Island, brackish and freshwater marshes occupy intertidal areas in the inner estuary. These estuaries do not have the extensive delta formations of the Fraser Estuary.

**FIGURE 2-6**
Location of major Brackish and Freshwater Marshes

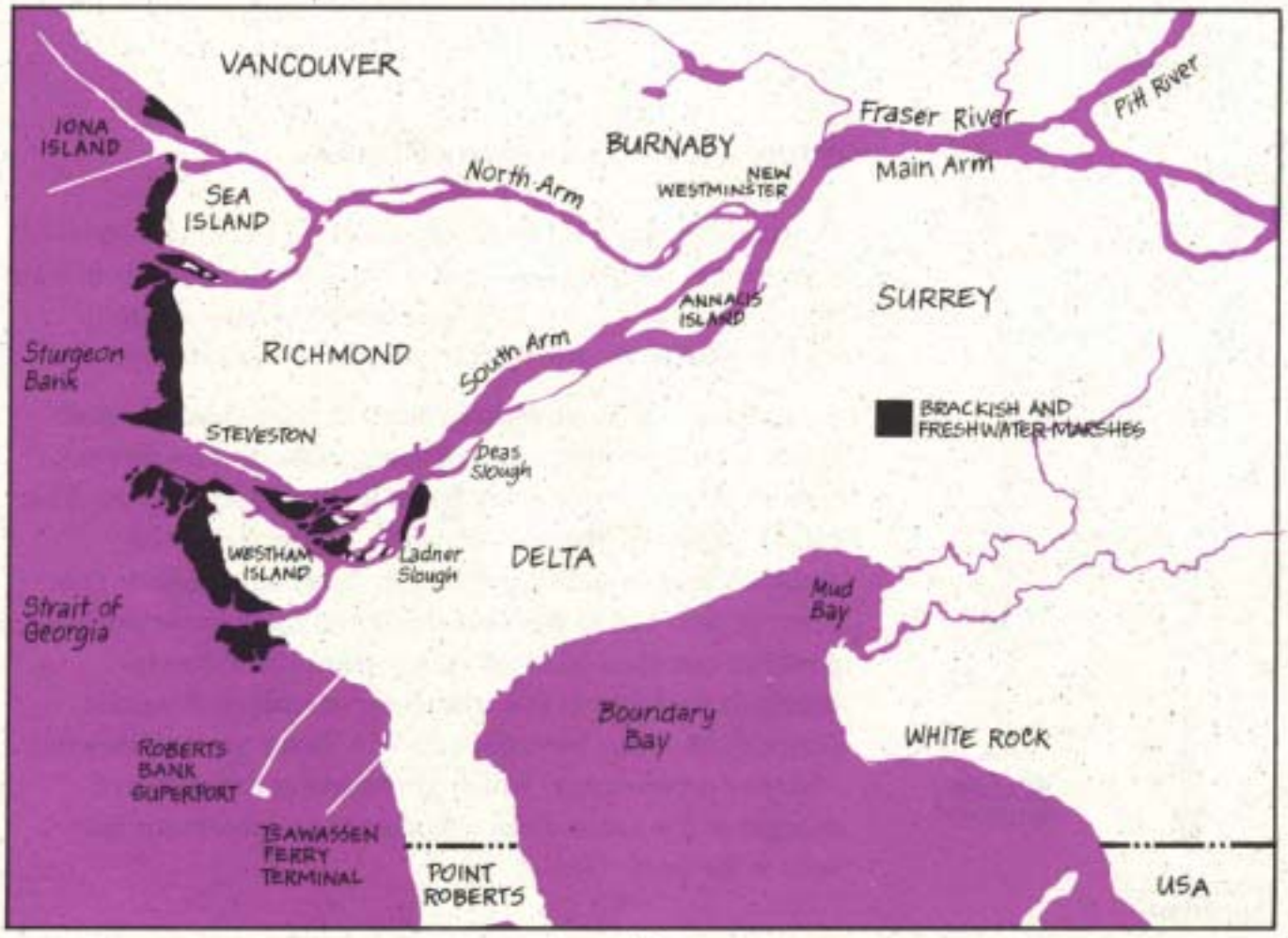
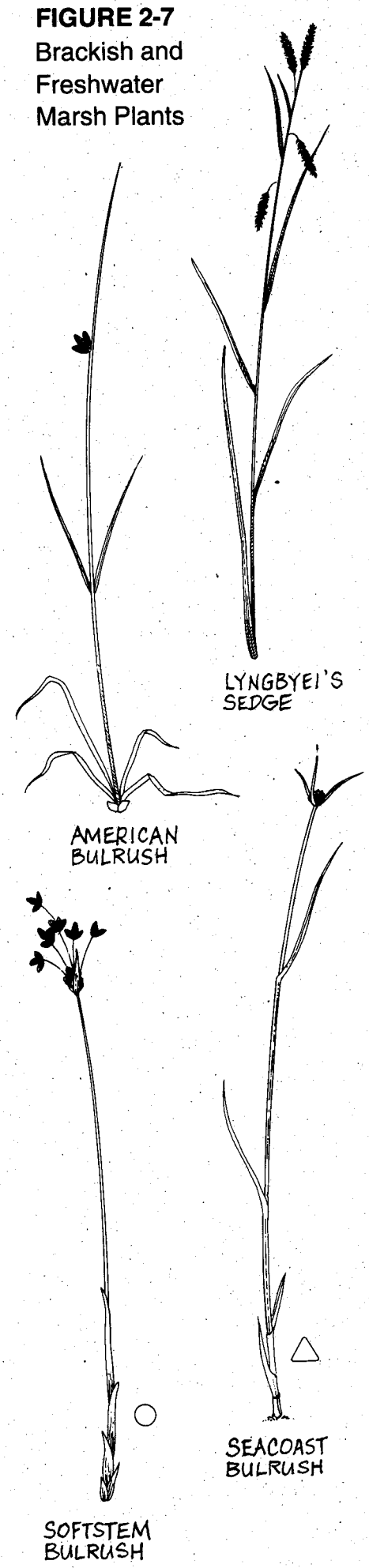


**FIGURE 2-7**
Brackish and Freshwater Marsh Plants




## What are the features of this marsh?

Brackish and freshwater marshes are being discussed under the same heading because they are difficult to distinguish unless you are a biologist or experienced naturalist. Brackish marsh plants can tolerate freshwater for some periods of the year. As a result, there is considerable overlap between brackish and freshwater plant species.

Not only are these the most extensive marshes in the estuary, but they are also the most productive. Each year, our brackish and freshwater marshes produce an average of five metric tons of plant material per hectare. This amount of plant production is three times greater than that produced in saltmarshes.

At the end of the growing season, this plant production creates a huge supply of organic detritus, much of which is flushed out of the marshes with each tide. The organic detritus provides a nutritious food source which sustains life in tidal channels, sloughs and throughout the estuary.

## Some of the Dominant Plants

Bulrush, Lyngbyei's Sedge, cat-tail, and Pacific Silverweed are some of the dominant plant types found in the brackish marsh. Figure 2-7 will help you identify these common marsh plants on your field trip to the lower estuary.

Bulrush can have either round or triangular shaped stems which are filled with a spongy tissue. The flowers consist of brown spikes with small overlapping scales. The round-stemmed bulrush shown in Figure 2-7 is the common tule or softstem bulrush (*Scirpus validus*). This plant is common to both brackish and freshwater marshes. Another common bulrush visible from the dykes in brackish marshes is the triangular-stemmed Seacoast Bulrush (*Scirpus maritimus*). The Three-square Bulrush (*Scirpus americanus*) which grows along the seaward margin of the outer delta marshes is an important food source for Snow Geese.

The most common sedge in the brackish environment is Lyngbyei's Sedge (*Carex lyngbyei*). Sedges tend to look much like grasses; however, there is a simple way to tell them apart. Sedges have stems with three sharp edges and soft joints (nodes), whereas grasses have round hollow stems with hard joints. Remember, "sedges have edges."

Cat-tails (*Typha latifolia*) are conspicuous tall plants with brown velvety heads. These plants are found near the dike, in ditches, and just about anywhere where there is fresh or brackish stagnant water. What you can't see are the massive root stocks, containing a core of almost pure starch, as much as corn but with less fat.

Pacific Silverweed (*Potentilla pacifica*) is often visible from a distance because of its feathery, silver leaves. This is a plant that can be found in brackish marshes, but it can also tolerate the higher salinities found in saltmarshes.



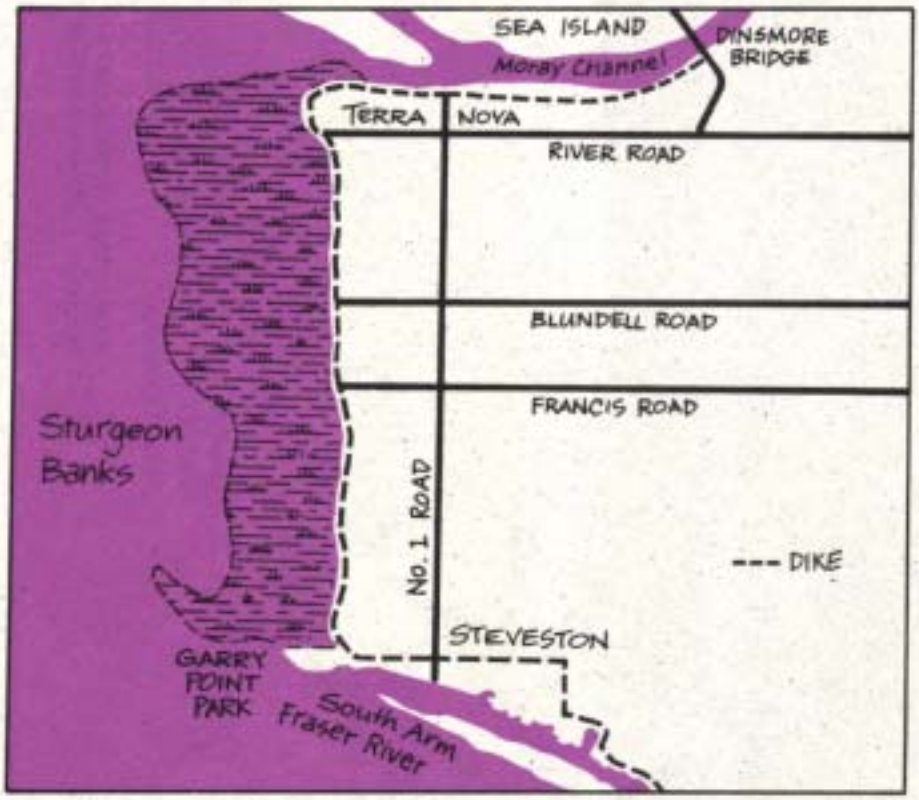
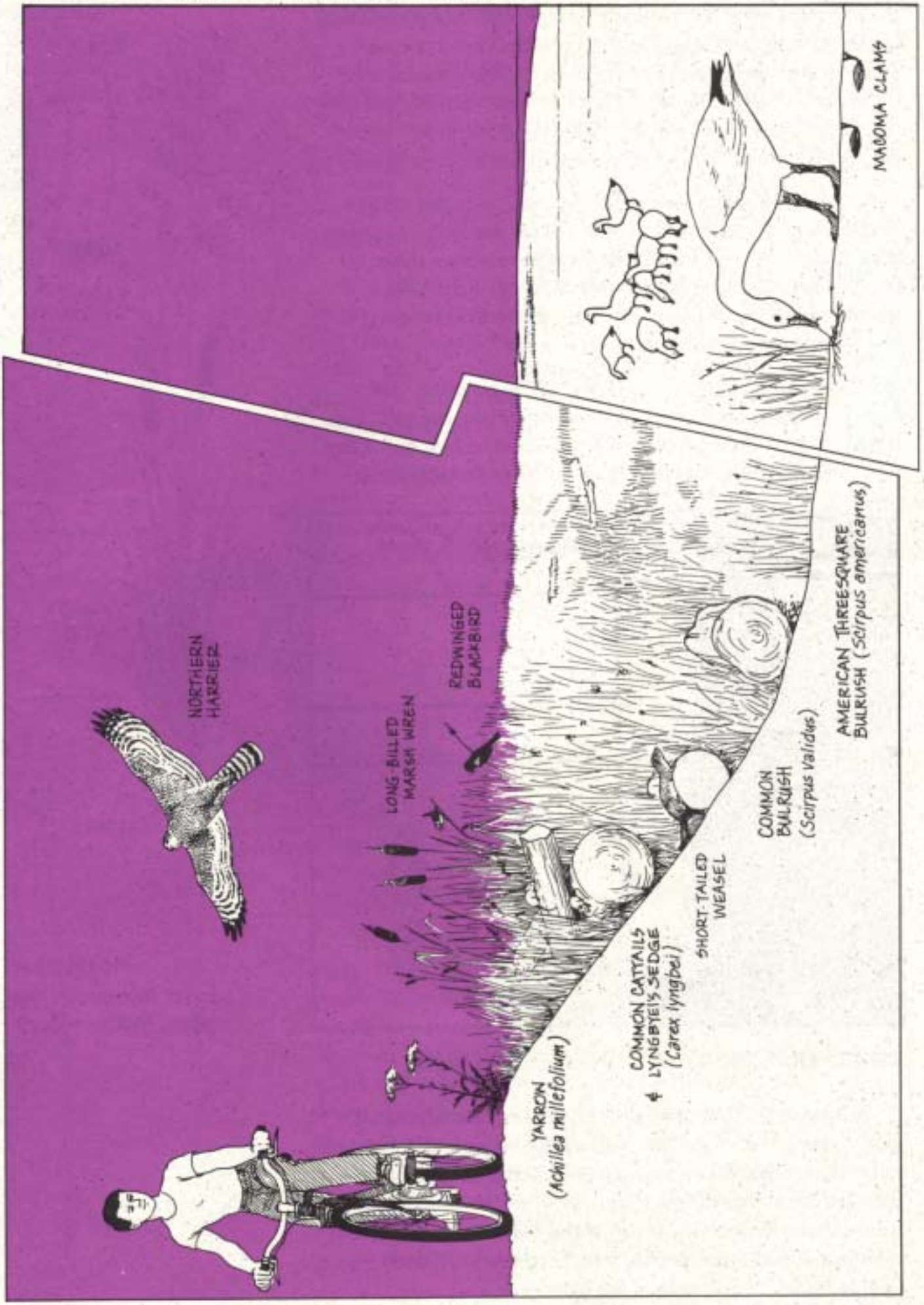



**FIGURE 2-8**
Location of Richmond Dike along Sturgeon Bank

## FIELD TRIP DESTINATION: Sturgeon Bank

Sturgeon Bank foreshore is one of the best and most easily reached areas in the estuary for viewing the brackish marsh habitat. This area can be enjoyed from Richmond's western dike system (see Figure 2-8), which affords an unobstructed vista over much of the delta. Adjacent to the dike is a one-kilometre-wide foreshore marsh. Barely visible beyond the marsh is the extensive

**FIGURE 2-9** Life Along Sturgeon Bank Foreshore



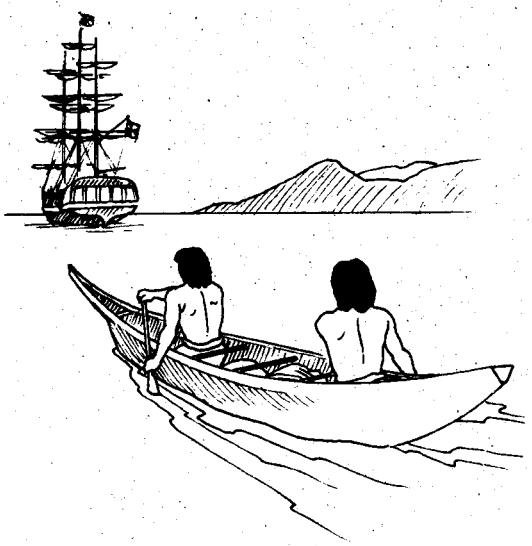
tideflat area of the delta. These tidal flats extend another five kilometres to the outer foreslope of the delta in the Strait of Georgia. Figure 2-9 is a combined depiction of a typical inner and outer foreshore community.

Richmond dikes can be accessed from a number of road-ends including Westminster Highway, Blundell Road and Francis Road. The dike connects with Garry Point Park in Steveston (Figure 2-8). This park is a good access point particularly suited for large groups because of its ample parking space.

The dikes are well suited for travel by bicycle. A trip can begin at the Middle Arm near the Dinsmore Bridge, continue on to Terra Nova, and south towards Garry Point.


**What to Look For**

- ☐ Figure 2-7 shows some of the common marsh plants seen from the dike. Try to find Lyngbyei's Sedge. Compare this to one of the grasses growing near the dike to see the obvious difference between a sedge and grass.
- ☐ The small amount of salt in brackish water can become concentrated in some areas as stagnant water evaporates over the summer. Evidence for this is the presence of saltgrass, a saltmarsh plant described on page 47. See if you can discover one of these sites adjacent to the dike.
- ☐ Mice and voles find homes under drift logs, while mink and Short-tailed Weasel prey on these small mammals. You will be really lucky if you spot one of these small mammals.
- ☐ You will probably see and hear many Red-winged Blackbirds, especially in the spring, as they feed and nest in the vegetation of the upper marsh. The red-shouldered males are easily recognized.
- ☐ In spring, winter and fall, Snow Geese are distinctly heard in outer reaches of the marsh. It is a spectacular sight when hundreds of these geese suddenly take off from the marsh.



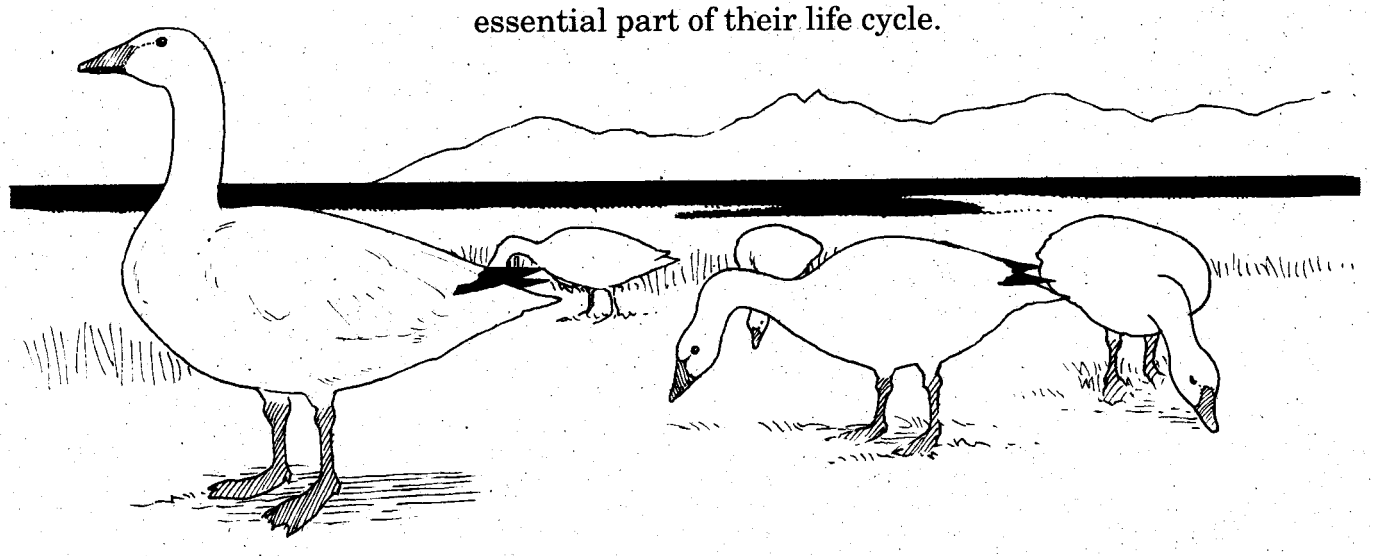
## OTHER FACTS AND FIGURES

### How Sturgeon Bank Got Its Name

In the early 1790s, Captain George Vancouver was commissioned by the British Admiralty to chart the west coast of North America. While searching for the mouth of the Fraser River, he and his crew purchased some "fine sturgeon, of from fourteen to two hundred pounds each" from the Aboriginal people who proceeded across the banks towards their larger ships. Henceforth the shallow area between Point Roberts and Point Grey appeared on nautical charts as Sturgeon Bank. It may not have occurred to Captain Vancouver that sturgeon frequent the mouth of large rivers, so he left the area not knowing he had found the mouth of the great Fraser River.

### Snow Geese - A Wonderful Spectacle of White

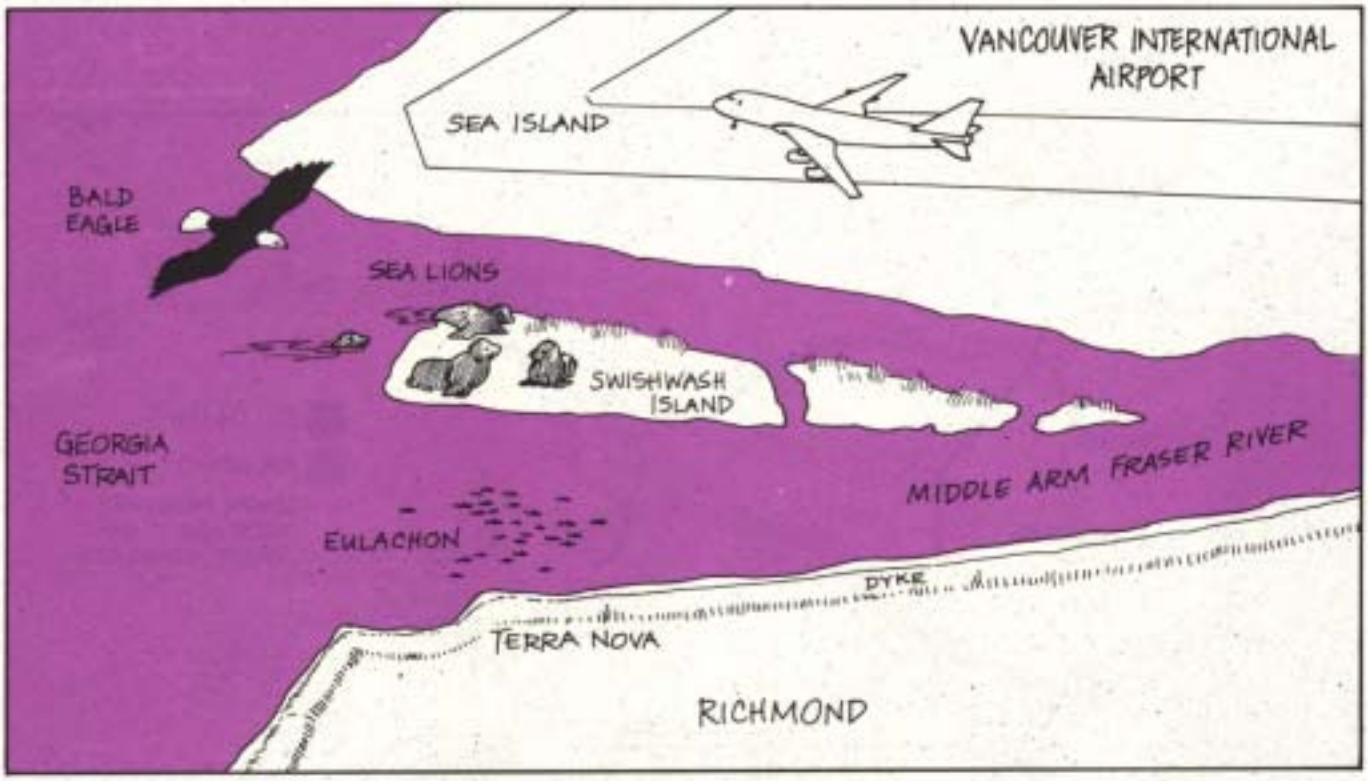
Snow Geese from Siberia travel along the British Columbia coast to winter in the Fraser River Estuary and the Skagit River estuary in Washington State. As many as 40 000 birds gather on the Fraser delta foreshore, where they feed extensively on the below-ground parts of marsh plants (especially bulrush). Flocks also travel a short distance inland to graze on the agricultural land in the upland portion of the estuary's delta. A few agricultural fields on Reifel and Westham Islands are managed by Environment Canada's Canadian Wildlife Service specifically to provide food for Snow Geese and other waterfowl. The Snow Geese are active in the estuary for up to seven months each year, and this winter residence in the Fraser River Estuary is an essential part of their life cycle.



**Terra Nova - A Productive Corner of the Estuary**

The Middle Arm of the Fraser River flows into the Strait of Georgia past Terra Nova, which is situated in the northwest corner of Lulu Island (Richmond). The dike which curves around this area offers an excellent view of the rich and varied life associated with the estuary's marshes. In the spring, millions of Eulachon fish migrate up the estuary to spawn. One of the predators, the sea lion, can be seen hauled out on Swishwash Island. Bald Eagle and terns also feast on the Eulachon as they become trapped in tidal channels at low tide. Tidal channels and fringe marshes along the Middle Arm are attractive habitat for Mallard and Widgeon ducks as well as Coots. Winter concentrations of Western Grebes, often seen in large, tight flocks are part of the largest flock in Canada. These elegant, long-necked birds dive for small fish.

**FIGURE 2-10** Terra Nova



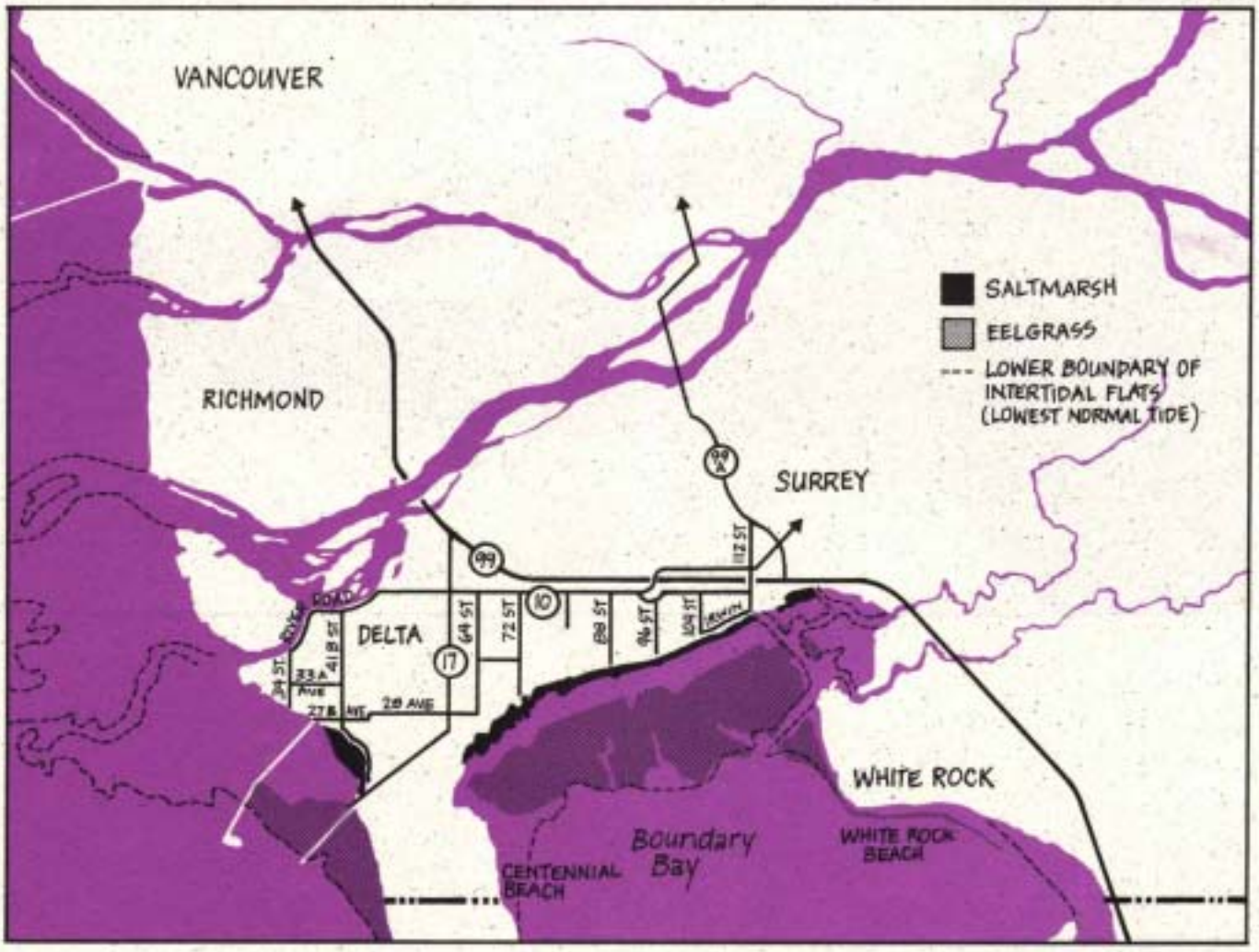
LONG-BILLED DOWITCHER

## Where is this habitat located ?

Saltmarsh habitat is located in areas of the outer estuary, away from the freshwater influence of the Fraser River discharge. The most extensive saltmarshes occur along the Boundary Bay foreshore. There is also a saltmarsh on the foreshore of the Tsawwassen Indian Reserve, between the coal port jetty and the jetty leading to the ferry terminal (Figure 2-11).

Smaller estuaries along coastal British Columbia are almost entirely dominated by saltmarsh and tideflat habitat. This is because the volume of freshwater flooding in these smaller estuaries is much less than in the Fraser River. As a result, only saltmarsh vegetation can grow on the estuarine tideflats.

**FIGURE 2-11**
Location of Saltmarshes and Eelgrass Beds



## What are the features of the saltmarsh ?

As with the brackish and freshwater marshes in the Fraser River Estuary, a large unvegetated tideflat extends seaward from where the saltmarsh ends. The tideflat at Boundary Bay is within easy reach, and in most places provides a firm surface to walk on. By contrast, the tideflats off Sturgeon Bank are located far from the dike and are very soft and muddy due to the fine silts originating from the Fraser River. Caution should be exercised wherever a tideflat is explored on foot. In this discussion, the tideflat habitat has been included with the saltmarsh habitat, because both can be easily explored and studied at the same time.

After visiting the brackish/freshwater marshes of Sturgeon Bank, the different appearance of the saltmarsh habitat will be quite obvious. Much of this difference is because the saltmarsh is constantly exposed to the salty effects of seawater. The salt tolerant plants growing in the saltmarsh are smaller and less productive than the plants of brackish/freshwater marshes. Also, the saltmarsh does not extend as far seaward from the dike as do the marshes of Sturgeon Bank.


## What lives on the extensive tideflats ?

The tideflats beyond the saltmarsh habitat support large beds of eelgrass. Because these submerged aquatic plants can tolerate only brief exposure to the air, they occur near and below the lowest tide level. The eelgrass beds are too far away from the dike to be seen; but in winter, large piles of dead eelgrass leaves are washed inshore. In summer, eelgrass is easily seen after a short walk across the tideflat at, for example, Centennial Beach or White Rock Beach. Eelgrass beds are an important habitat for many small marine invertebrates as well as feeding Black Brant, flounder, Dungeness Crab and spawning Pacific Herring.

Large numbers of small marine invertebrates also live in the surface sediments of the tideflats. These invertebrates consist of marine worms such as Ragworms and Lugworms, burrowing shrimp and mollusks. So, although the tideflats look rather lifeless, there are actually hundreds of small invertebrates living below each square metre of sediment surface.

ROUGH-LEGGED HAWK

## Why are there so many birds ?

All of this invertebrate food supply doesn't go unnoticed by birds. The tideflats are used by the largest numbers of shorebirds on the British Columbia coast. The most commonly occurring shorebirds are sandpipers (Western and Least) and Dunlin. More information on shorebirds is provided later in this chapter.

About one million birds use Boundary Bay each year because it is located on a major bird migration route, the Pacific Flyway (Figure 2-12). These birds, many of them ducks and shorebirds, arrive in late summer and autumn from northern breeding grounds and remain throughout the winter.

Farmlands in the Fraser River Estuary are also an important resting and feeding habitat for birds. Overwintering swan and geese populations grub for remnant root crops in agricultural fields. In uncultivated farmland, commonly known as old fields, birds of prey such as hawks and owls are more abundant than anywhere else along the British Columbia coast.

Uncultivated farmland supports large populations of small rodents such as the Townsend Vole. These voles make up the majority of the prey caught by Common Barn-Owls, Short-eared Owls, and Roughlegged Hawks. In winter, even Great Blue Herons feed on these voles when fish are hard to catch. Few of these so-called "old field" habitats remain, since many have already been lost to urban and industrial developments.

**FIGURE 2-12**
The Pacific Flyway


TOWNSEND'S VOLE

## ACTIVITY 5: LIFE BENEATH THE TIDEFLAT

It is well worth exploring the sand and mud of the tideflat because it is a habitat that most people are completely unfamiliar with. It is also a habitat that should be appreciated for its abundance of invertebrate life and activity. You will be surprised at what the tideflat has to reveal.

**Objectives:**

The objective of this activity is to closely inspect the surface of the tideflat and to dig up a small square area (quadrat) so as to observe and examine the bottom dwelling invertebrates (Figure 2-13)

**Equipment:**

To do this activity you will need a small shovel or trowel, and a flat tray and magnifying glass for studying the collected invertebrate specimens. A kitchen colander and coarse sieve will be needed to separate the smaller specimens from the sediment. To do this, you will need a source of water to wash the sediments, revealing the invertebrates which are too large to go through the holes of the colander or sieve.

**FIGURE 2-13**
Sampling on the Tideflat

**Procedure:**

1. Find an open area in the saltmarsh or walk to the open tideflat. Examine the mud surface very closely — find and identify the following:

**FIGURE 2-14**
Tideflat Invertebrates


ALGAL MATS: Blue-green algae form rubbery mats on the tideflat. On the mud surface you may also see brownish layers of diatoms (a microscopic alga).

GRAZING TRAILS: A grazing trail is a linear mark made in the mud by small snails (gastropods) as they graze on diatoms living on the mud surface. You may even find one of these small snails as it is grazing or resting on the tideflat.

FECAL CASTS: Many of the small tideflat invertebrates live in tubes or burrows. To keep their burrow clean, anything that is excreted (fecal matter) is pushed into a small pile around the tube entrance. These small piles are called fecal casts. You will notice many small conspicuous-looking piles all over the tideflat.

2. From your inspections of the tideflat surface, find a location with a lot of evidence of invertebrate activity. Dig up a small area to a depth of 10 - 20 cm and examine the sediments for large invertebrates such as clams or mussels. Sift through the remaining mud and sand (using your colander and sieve) to find smaller invertebrates such as burrowing shrimp and marine worms.

3. If you dig up an exact area of mud (e.g. 25 x 25 cm) and count the total number of different animals collected, you can calculate the density of animals. See if you can figure out how many invertebrates would occupy a square metre, or the entire tidal flats of Boundary Bay (6 000 hectares).

4. Use the illustrations in Figure 2-14 to help you identify the invertebrates you have collected. If you find something not shown in Figure 2-14, measure the animal's size and make a clear drawing. Later you can contact a biologist or naturalist to help you identify your drawing. Also, refer to suggested identification guides given on page 119.

## Some of the Dominant Plants

The saltwort *(Salicornia virginica)* is one of the most common saltmarsh plants in the Fraser River Estuary, and in smaller estuaries and protected bays of coastal British Columbia. Commercial harvesting of this plant in the Strait of Georgia amounts to about 20 metric tons a year. It is sold to restaurants where it is served as "Sea Asparagus."

Figure 2-15 shows an illustration of saltwort, along with three other common saltmarsh plants: saltgrass (*Distichlis stricta*), saltbush (*Atriplex patula*), and arrowgrass (*Triglochin maritimum*). These plants possess adaptations typical of the saltmarsh environment: wiry structure and a tough outer covering.

Eelgrass (*Zostera marina*) is a common submerged aquatic plant growing throughout the lower intertidal and shallow subtidal area of Boundary Bay and Roberts Bank. Since eelgrass beds are rooted in a soft and flat bottom, and provide a thick canopy of leaves, these underwater meadows significantly enhance the nearshore marine environment. Eelgrass meadows stabilize sediment and provide good cover for aquatic animals. This results in a much greater diversity of animals within the meadow than in adjacent unvegetated areas.

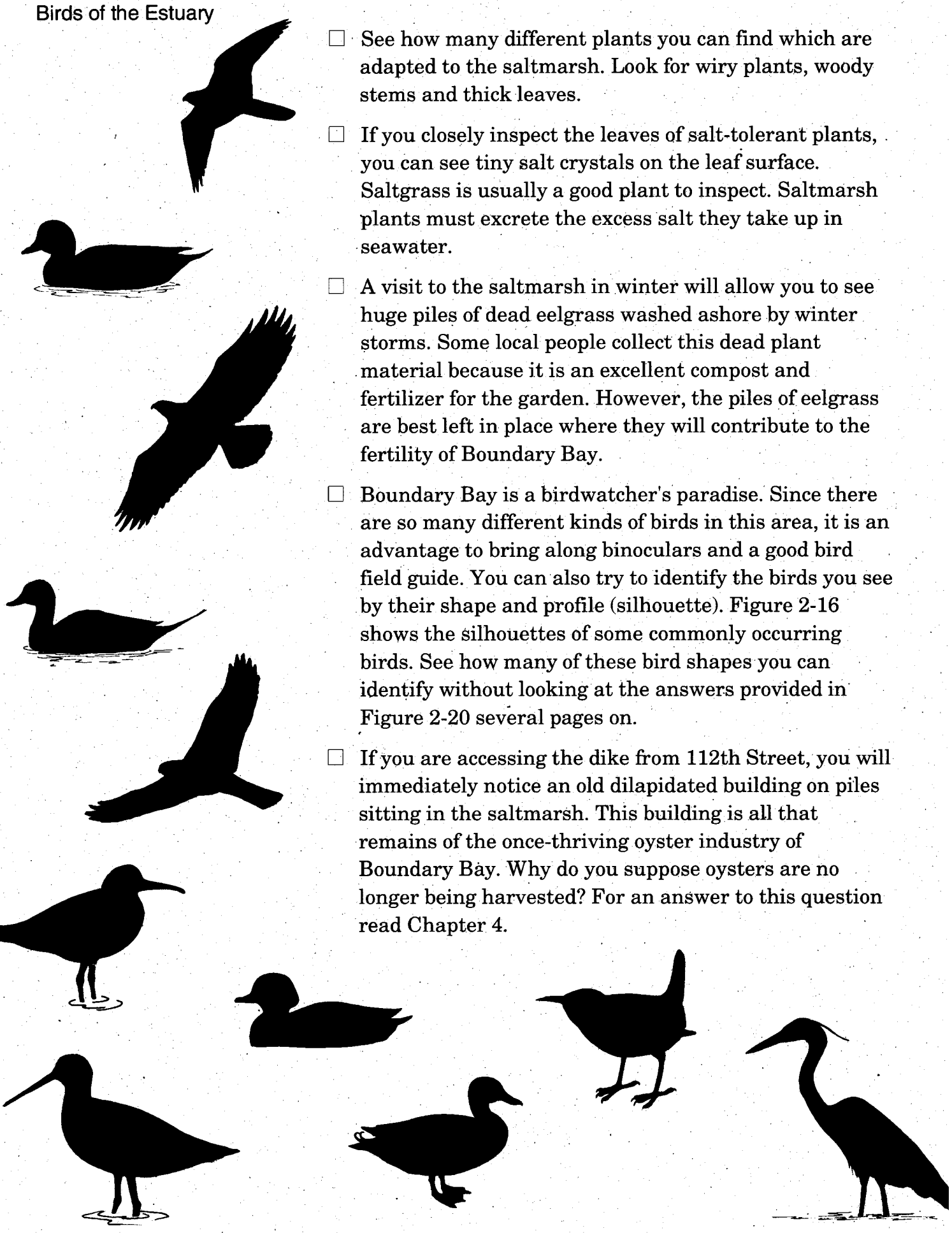

**FIGURE 2-15**
Saltmarsh Plants

## FIELD TRIP DESTINATION: Boundary Bay

Boundary Bay is the best and most accessible location for exploring and studying the saltmarsh and tideflat habitat. Most of the major roads between and including 64th and 112th Streets south of Highway 10 in South Delta end at the dike (Figure 2-11). There is pedestrian access to the dikes and a good view over the saltmarsh.

It is relatively safe and easy to walk into the saltmarsh for a closer look at the vegetation and tideflats. Make sure your field trip coincides with a low tide. Any tide below 3.0 m at Point Atkinson will provide good access to the saltmarsh and tideflat. Daily tide levels are published in the daily newspaper, and in the *Canadian Tide and Current Tables, Volume 5*, which can be purchased at most boating supply stores.

**FIGURE 2-16**
Birds of the Estuary



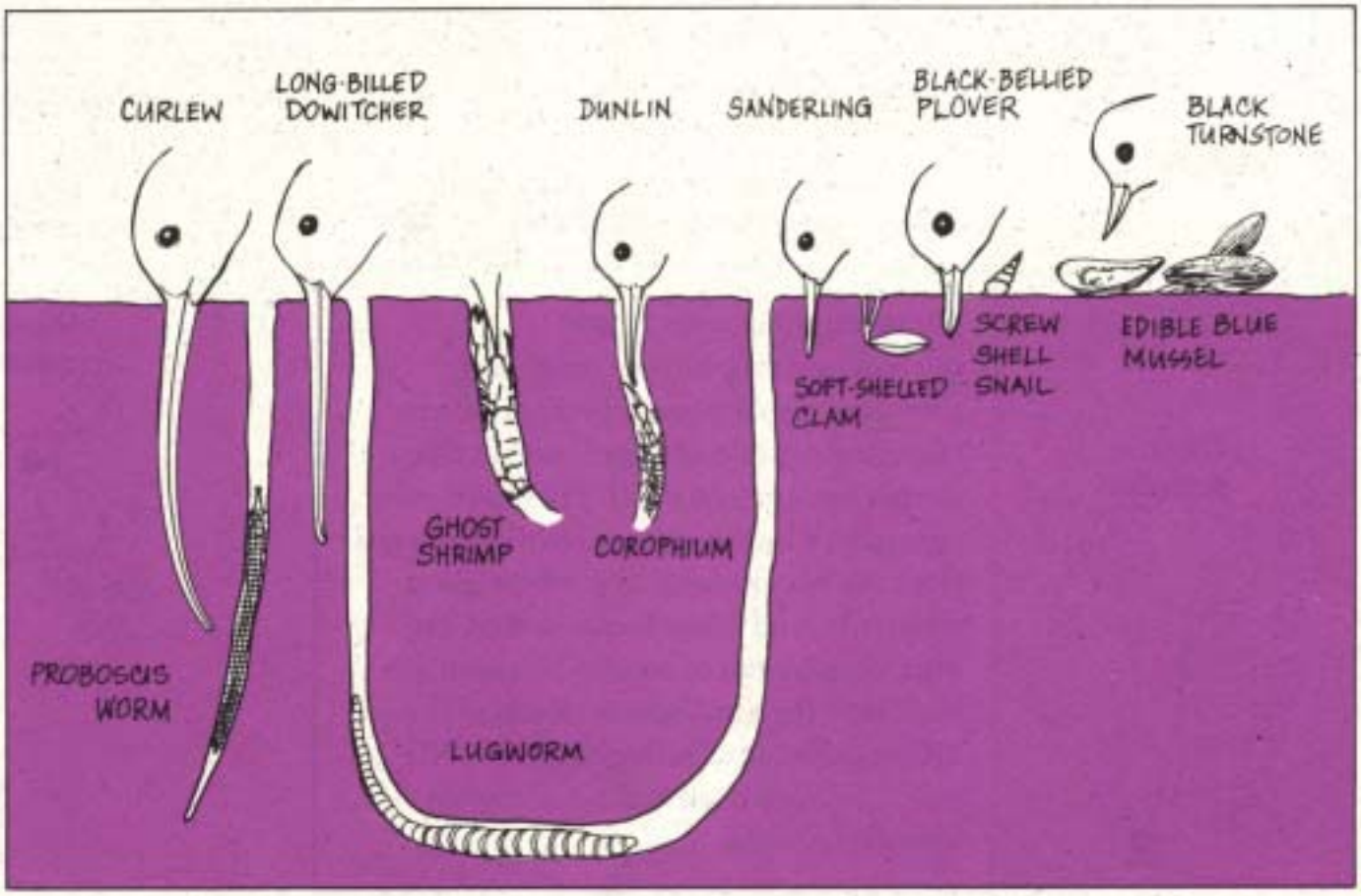
## What to Look For

- ☐ See how many different plants you can find which are adapted to the saltmarsh. Look for wiry plants, woody stems and thick leaves.
- ☐ If you closely inspect the leaves of salt-tolerant plants, you can see tiny salt crystals on the leaf surface. Saltgrass is usually a good plant to inspect. Saltmarsh plants must excrete the excess salt they take up in seawater.
- ☐ A visit to the saltmarsh in winter will allow you to see huge piles of dead eelgrass washed ashore by winter storms. Some local people collect this dead plant material because it is an excellent compost and fertilizer for the garden. However, the piles of eelgrass are best left in place where they will contribute to the fertility of Boundary Bay.
- ☐ Boundary Bay is a birdwatcher's paradise. Since there are so many different kinds of birds in this area, it is an advantage to bring along binoculars and a good bird field guide. You can also try to identify the birds you see by their shape and profile (silhouette). Figure 2-16 shows the silhouettes of some commonly occurring birds. See how many of these bird shapes you can identify without looking at the answers provided in Figure 2-20 several pages on.
- ☐ If you are accessing the dike from 112th Street, you will immediately notice an old dilapidated building on piles sitting in the saltmarsh. This building is all that remains of the once-thriving oyster industry of Boundary Bay. Why do you suppose oysters are no longer being harvested? For an answer to this question read Chapter 4.

### Shorebirds - The Mud Probers of the Tideflat

Several million shorebirds migrate through the Fraser River Estuary, and many remain all winter. These birds feed on the tideflats by probing and searching in the mud with their beaks. There are many different kinds of bottom-dwelling invertebrates to choose from; some live on the surface while others live at different depths in the mud. Shorebirds have evolved a variety of different beak shapes and lengths, each specialized to probe for and handle a particular kind of invertebrate (Figure 2-17).

**FIGURE 2-17**
Feeding Habits of Shorebirds

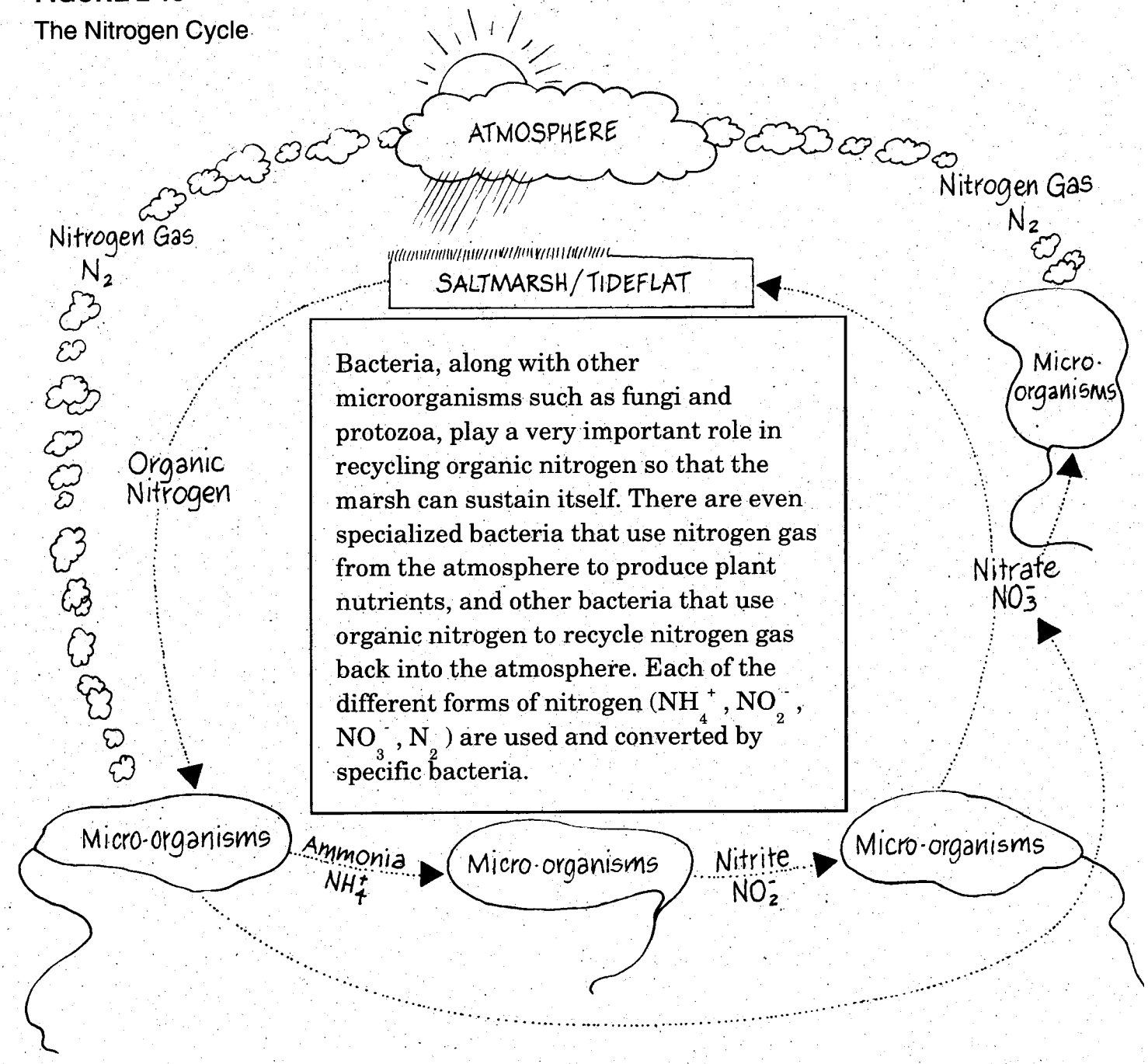



Medium-sized sandpipers, like Dunlin, are very abundant in the fall, winter and spring. Look for them probing for invertebrates that make comparatively shallow burrows, such as the burrowing shrimp (*Corophium*). Long-billed Dowitchers can probe for deeper organisms in muddy brackish areas and along the shores of shallow ponds and sloughs.

## Bacteria and Algae - The Unnoticed Heroes

Coastal marshes and mudflats are an ideal habitat for many different kinds of bacteria. These are natural and beneficial bacteria, not the types that are harmful to humans. By decomposing the rich supply of organic matter in the saltmarsh and tideflat habitat, bacteria create a nutritious source of the important detritus that supports the estuarine food web. The decomposition of organic matter also recycles important plant nutrients, such as nitrogen, back to the marsh (Figure 2-18).

**FIGURE 2-18**
The Nitrogen Cycle




Bacteria, along with other microorganisms such as fungi and protozoa, play a very important role in recycling organic nitrogen so that the marsh can sustain itself. There are even specialized bacteria that use nitrogen gas from the atmosphere to produce plant nutrients, and other bacteria that use organic nitrogen to recycle nitrogen gas back into the atmosphere. Each of the different forms of nitrogen ($NH_4^+$, $NO_2^-$, $NO_3^-$, $N_2$) are used and converted by specific bacteria.

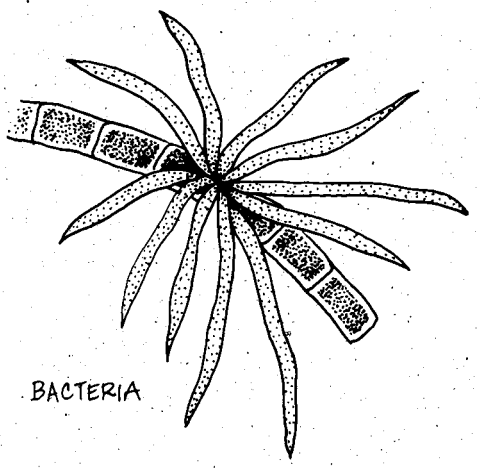
There are many different kinds of specialized bacteria, such as those that create the foul smelling marsh gas you'll probably notice when you walk into a muddy area of the saltmarsh and tideflat habitat. This "rotten egg" smell is due to hydrogen sulfide gas produced by bacteria living in mud where there is no oxygen. Nitrogen gas is produced by another type of bacteria that thrives in oxygen-free zones of the saltmarsh and tideflat habitat (Figure 2-19). These specialized bacteria are extremely important because they help maintain a global chemical balance in the air, water and soil (the biosphere).

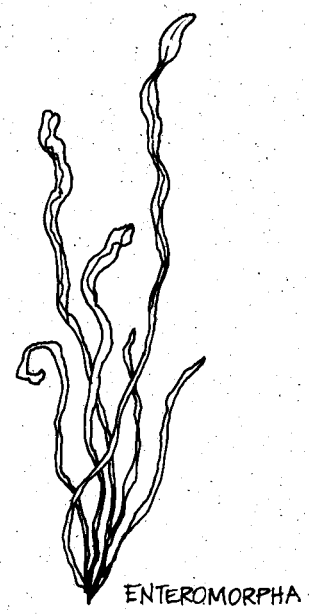
In some locations of the tideflat, you may notice dark-colored mats which have been formed by blue-green algae. These strange-looking mats are generally not recognized as algae because of their odd color and rubbery texture. In fact, scientists think that blue-green algae are in some ways related to bacteria. By trapping sediments, these blue-green algae mats are the first important step in providing stable and nutrient-rich sites for marsh plants to colonize, thus contributing to the development of new saltmarsh habitat.

Other important groups of algae that live on the tideflat habitat are microscopic in size. These algae, called diatoms, can often be detected by the brownish to golden layer they form on the mud surface. Since many different surface-dwelling invertebrates graze on diatoms, these algae are a vital food source on the open tideflat.

Much larger and more visible is the green alga (*Enteromorpha*) which grows in bundles of slender hollow tubes. When this alga is dead, it becomes bleached and can look like animal guts. In fact, a species of this alga is called *Enteromorpha intestinalis*.

**FIGURE 2-19**
Bacteria and Algae of the Estuary



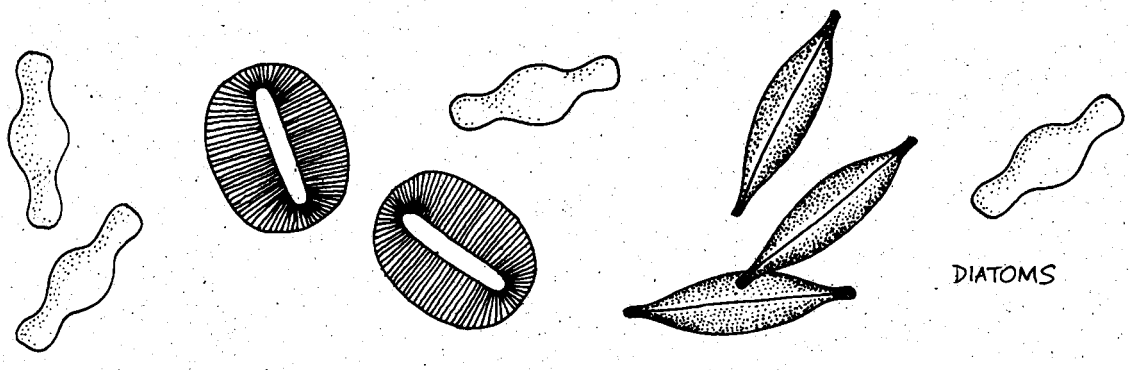
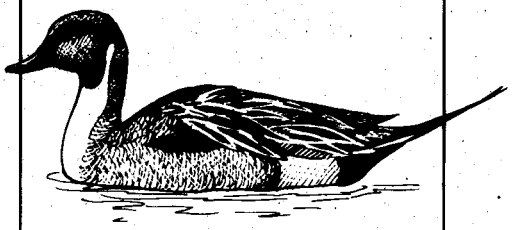



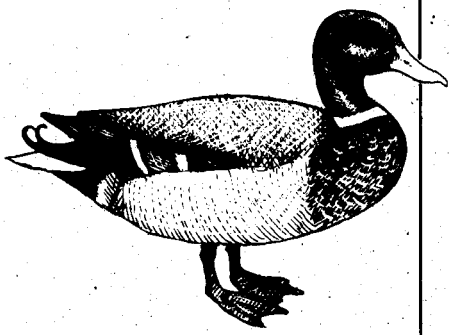
**FIGURE 2-20** Birds of the Estuary (answer to silhouettes)

**BIRDS COMMONLY SEEN**

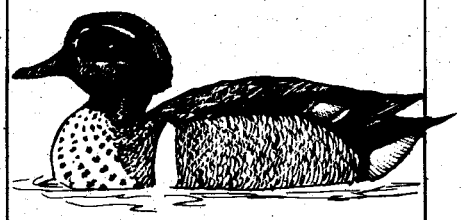
American Widgeon



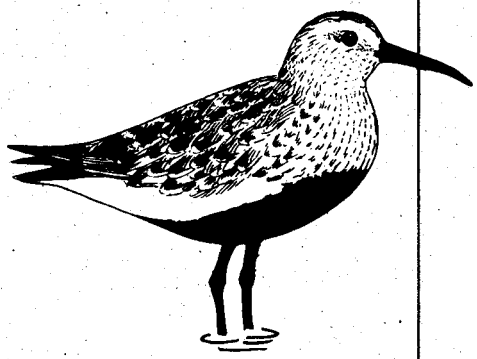
Northern Pintail



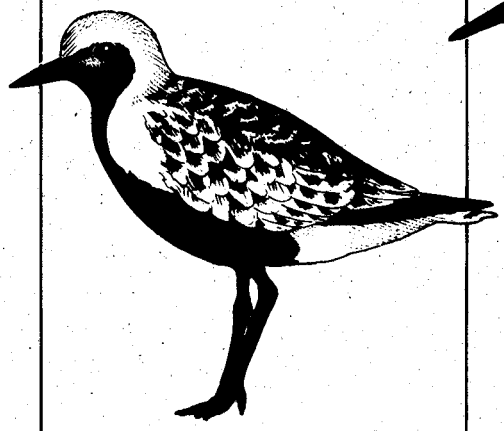
Mallard



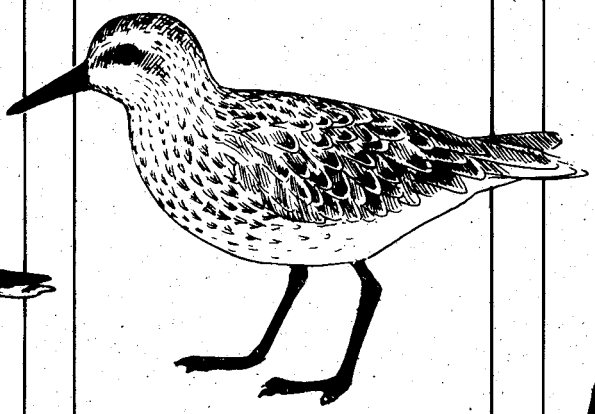
Green-winged Teal



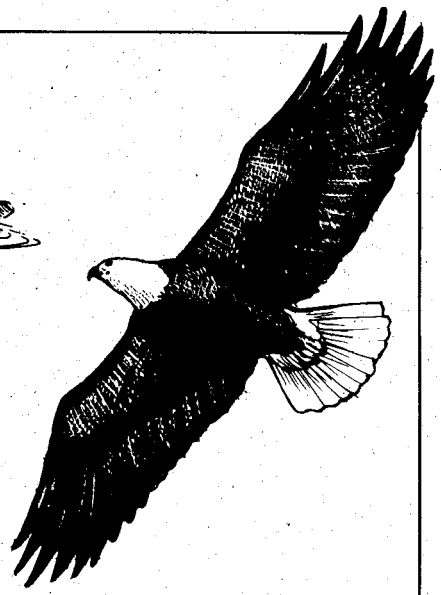
Dunlin



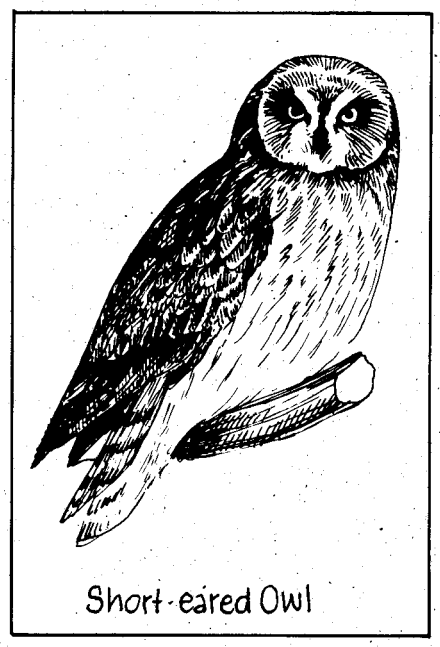
Black-bellied Plover



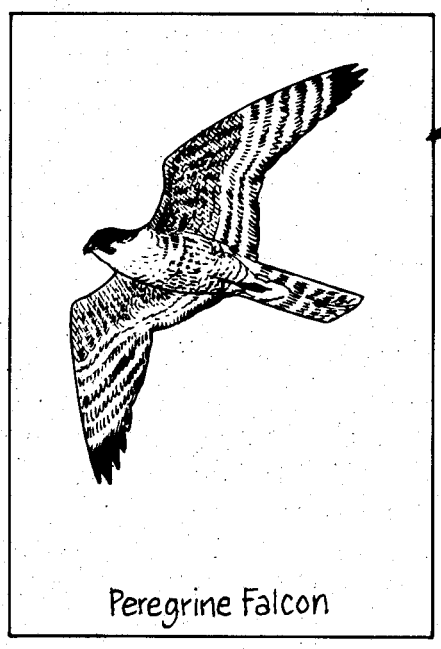
Western Sandpiper



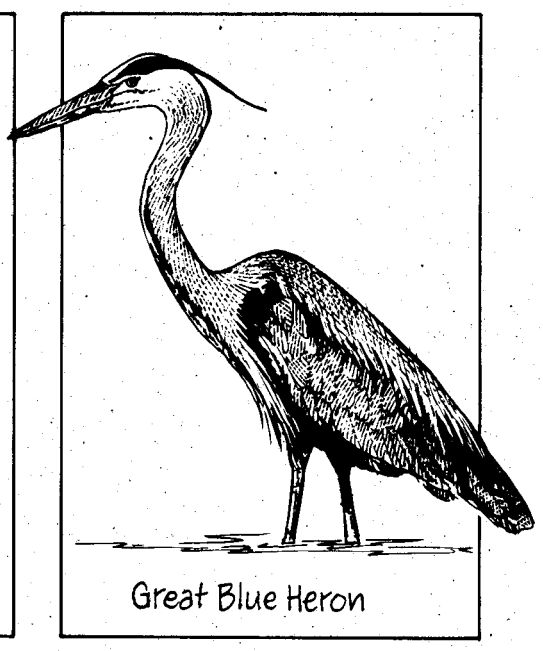
Bald Eagle



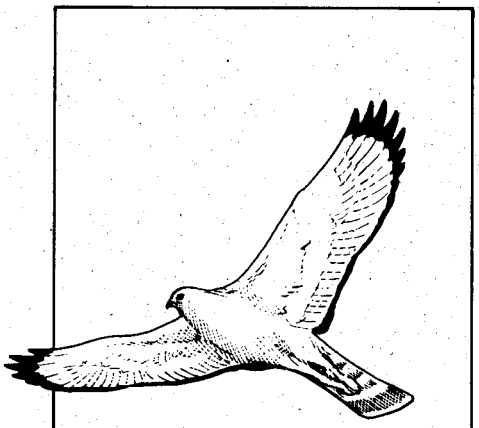
Short-eared Owl



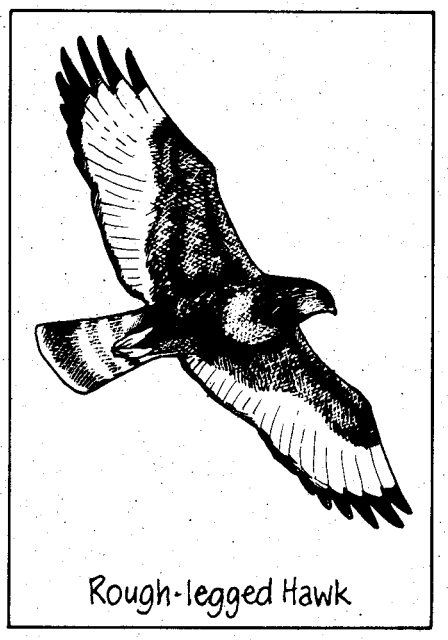
Peregrine Falcon



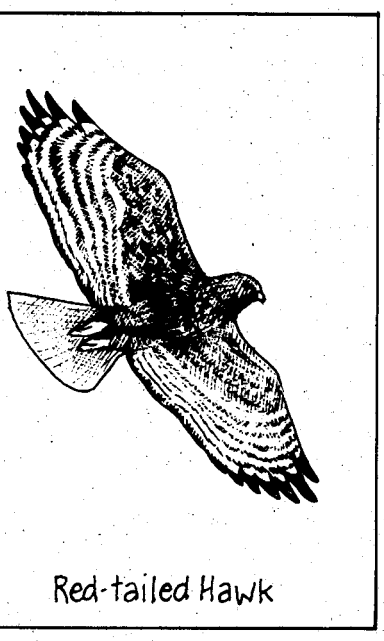
Great Blue Heron



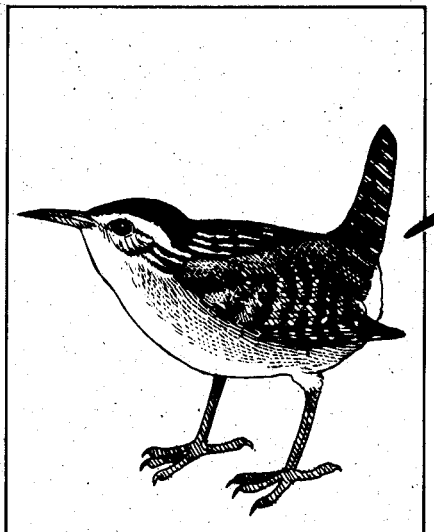
Northern Harrier



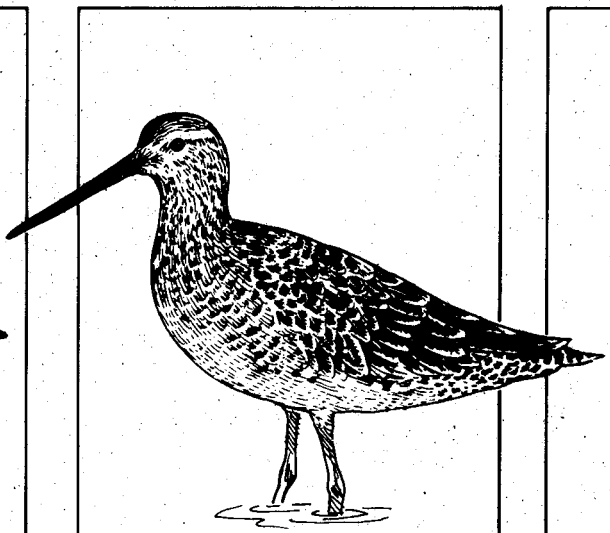
Rough-legged Hawk



Red-tailed Hawk

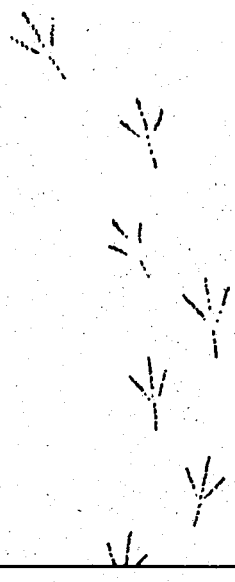


Marsh Wren



Long-billed Dowitcher

Heron tracks



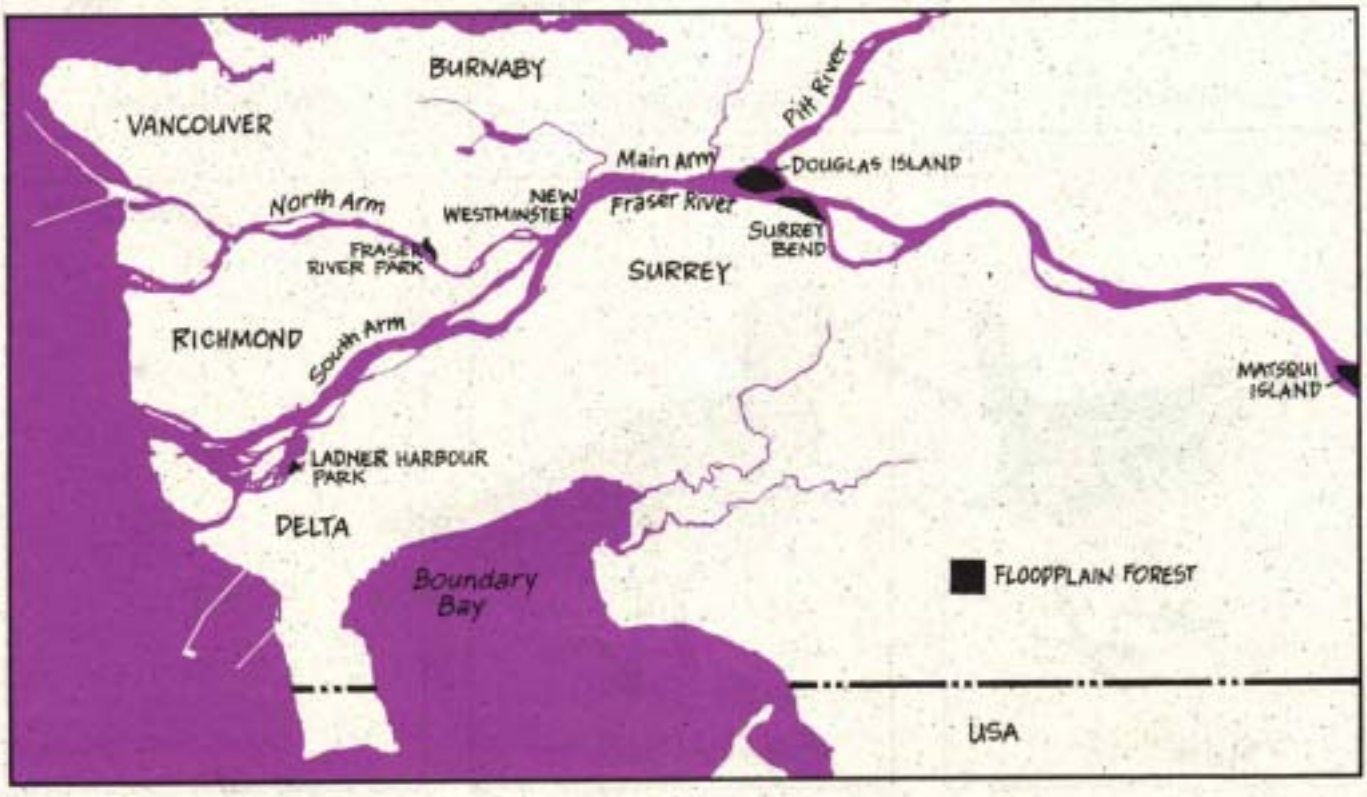
# Active Floodplain Forest

## Where is this habitat located ?

Floodplain forests are located at and above the high tide level, and also exist on the floodplain where rising river levels create seasonally flooded conditions. These forests tend to blend into other forest types. For example, in drier sites, and at higher elevations, floodplain forests merge into coniferous coastal forest, whereas in wet and poorly drained sites, bogs tend to dominate. Thus, undiked and well drained areas in the estuary which are periodically flooded by high tides or high river levels, will likely support some type of floodplain forest.

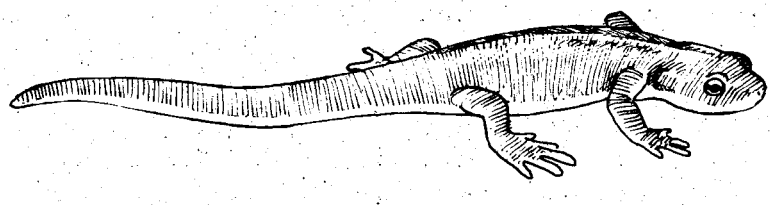
Most of the extensive floodplain forests that once grew in the lower Fraser Valley have long ago been converted to farmland or urban-industrial development. There are only a few remaining pockets of large and active floodplain forest such as Matsqui Island, Surrey Bend, Douglas Island, and a scattering of fringe forests along the riverbanks and sloughs of the estuary. Figure 2-21 shows the location of some of these remnant floodplain forests.

**FIGURE 2-21**
Location of Undiked Floodplain Forest



## What's the difference between a swamp and a marsh ?

It is quite common to hear people refer to any wetland area as swamp, regardless of what type of habitat actually exists there. However, trees and shrubs are the main characteristics that set a swamp apart from other wetland types. Swamps, which represent the wettest locations of the floodplain forest, support trees and shrubs well adapted to water-saturated soils. Marshes, on the other hand, are dominated by grass-like plants (grass, sedge, and rush) because they are adapted to even wetter conditions than are trees.



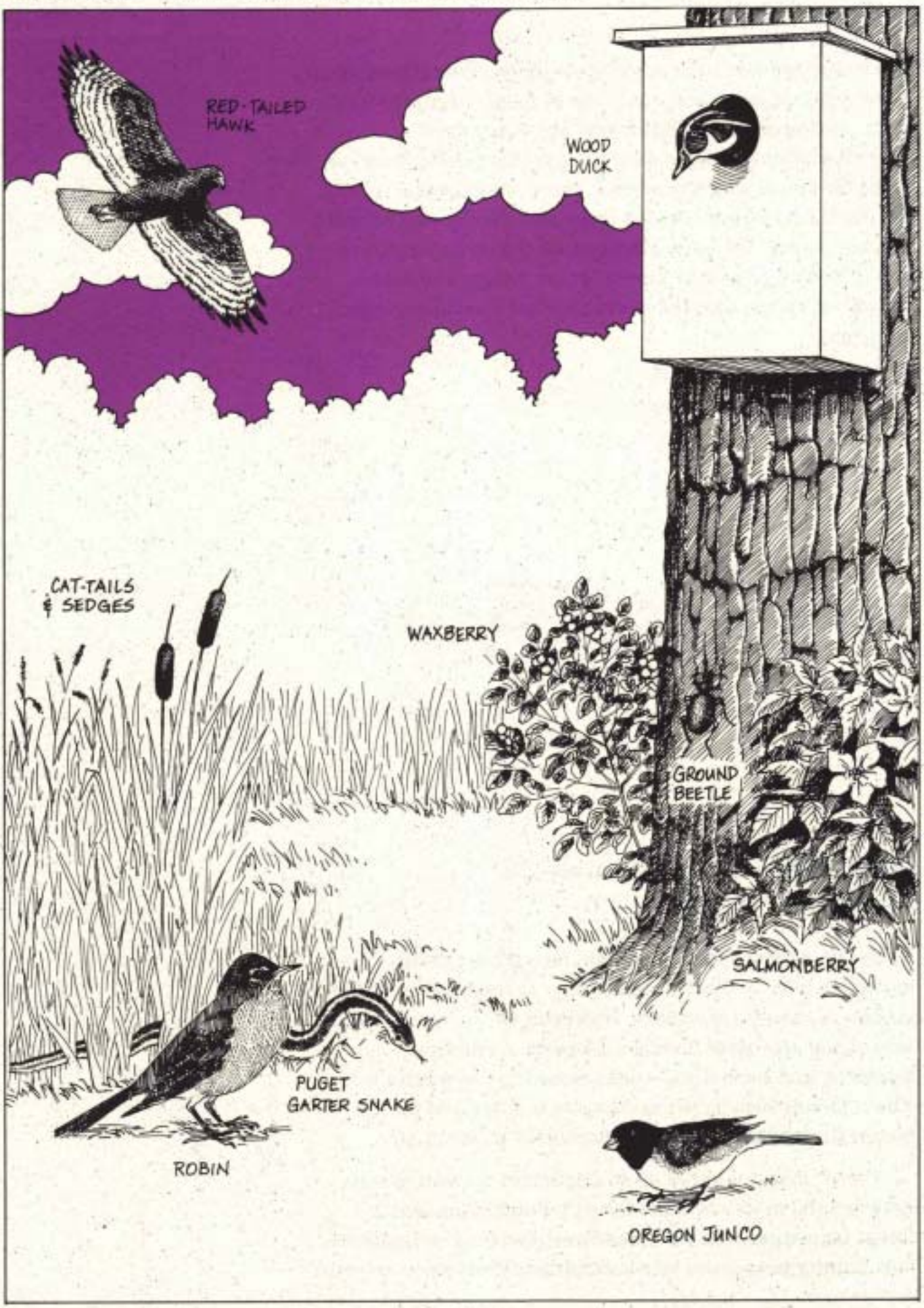
ROUGH-SKINNED NEWT

## What is the ecological value of a floodplain forest ?

There are so few active floodplain forests remaining that biologists have had little opportunity to undertake detailed studies of their local ecology. However, we do know that the vegetation growth in floodplain forests is important in retaining and controlling excess runoff in the watershed. These forests also have the capacity to filter and purify water, thereby improving a watershed's water quality.

Forest margins serve as an important transition zone between the marsh and the forest habitat. This marsh-forest transition zone provides forest-dwelling animals an opportunity to venture into sunnier and more open areas to

**FIGURE 2-22** Wildlife Crossroads in the Floodplain Forest



feed, while marsh creatures can seek food, cover and shelter in the swamp forest. Birds such as Great Blue Herons, owls, hawks, Wood Ducks and songbirds feed in the open marshes and use tall trees in the nearby swamp for nesting or perching. The Puget Garter Snake seeks cover at the forest edge and feeds near marshes on amphibians, earthworms and the occasional small fish. The edge between the marsh and forest is therefore a rich "wildlife crossroad" for marsh and forest creatures (Figure 2-22).

Trees and shrubs on the banks of river channels and sloughs provide cover as well as a source of food for organisms living in the water. Juvenile fish, especially salmon, benefit from the cooler water provided by the shade of wooded riverbanks. Dead branches and other snags that have fallen into the water offer excellent hiding places for small fish, which feed on insects that fall from the tree and shrub canopy. Deciduous trees also contribute detritus to the estuary as they shed their leaves each year.

## Some of the Dominant Plants

Identification of trees and shrubs in the floodplain forest is relatively easy if you look at the shape of the leaves. In winter, when there are no leaves present, the shape and structure of branches can be used to identify the trees and shrubs.

The biggest and most majestic tree of the floodplain forest is the Black Cottonwood (*Populus trichocarpa*). It attains heights of up to 38 m (125 ft.) and is the largest broad-leaved tree native to British Columbia. Most of these big trees have been cut down because their logs produce wide boards of knot-free lumber, or more recently, wood pulp for tissue paper.

Other typical and commonly found trees and shrubs are illustrated in Figure 2-24. This figure can be used as a simple summer and winter key to help identify the leaf and branch structures of trees and shrubs.

**FIGURE 2-23**
Black Cottonwood
(*Populus trichocarpa*)

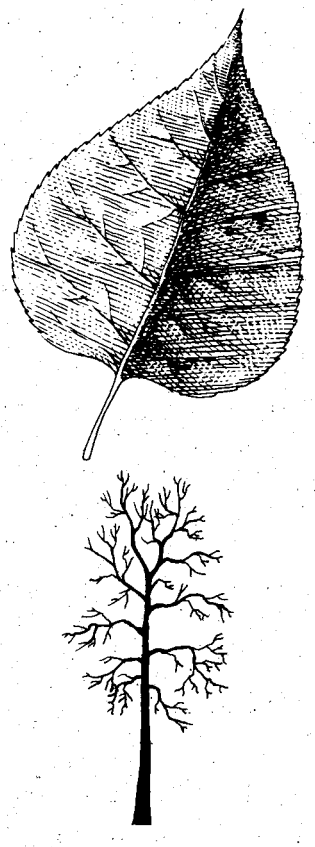
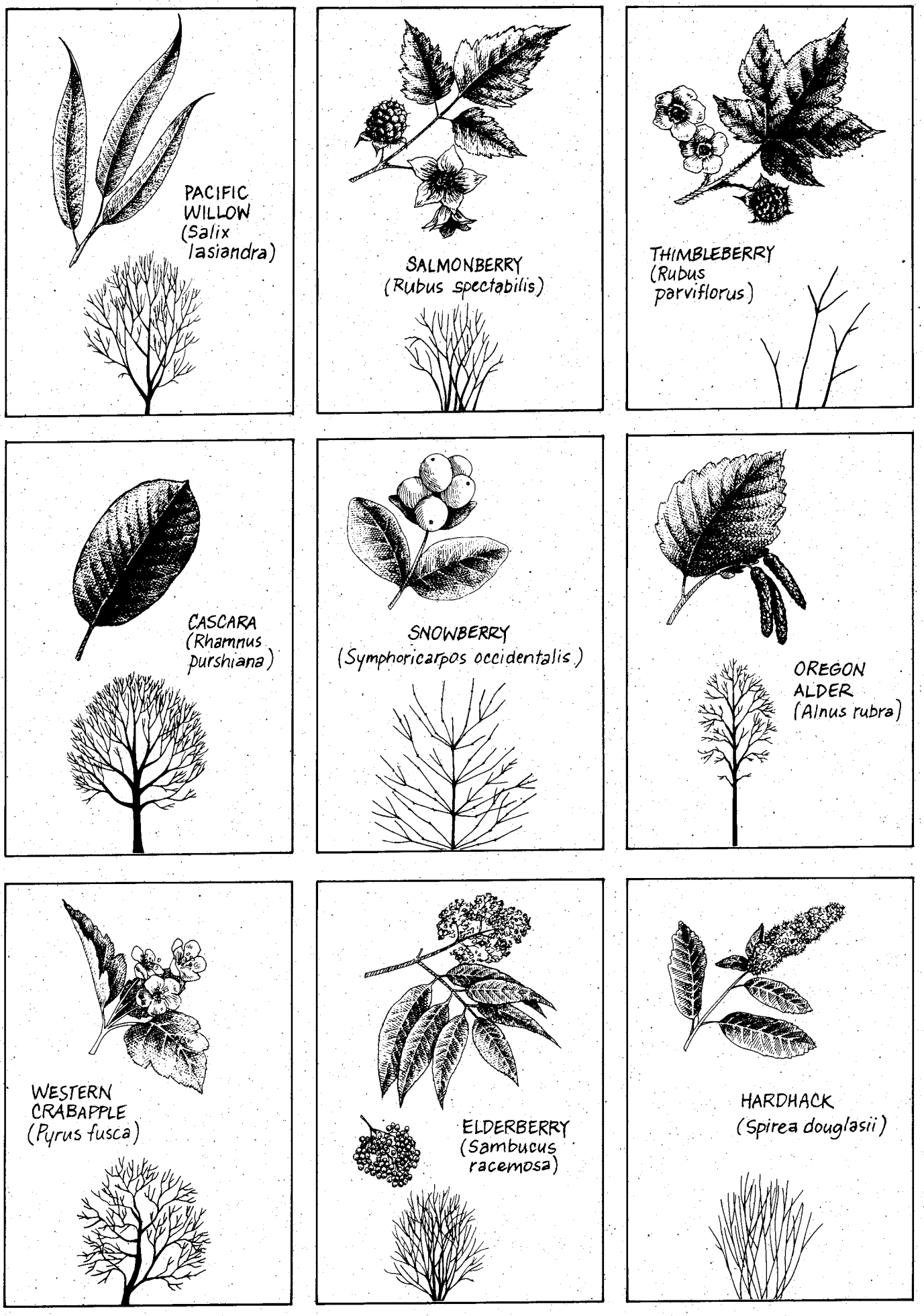


**FIGURE 2-24** Trees and Shrubs of the Floodplain Forest



## FIELD TRIP DESTINATION: Riverside Parks

The most convenient places to study remaining active floodplain forests are two riverside parks: Ladner Harbour Park in Ladner and Fraser Foreshore Park in Burnaby (Figure 2-25 and 2-26).

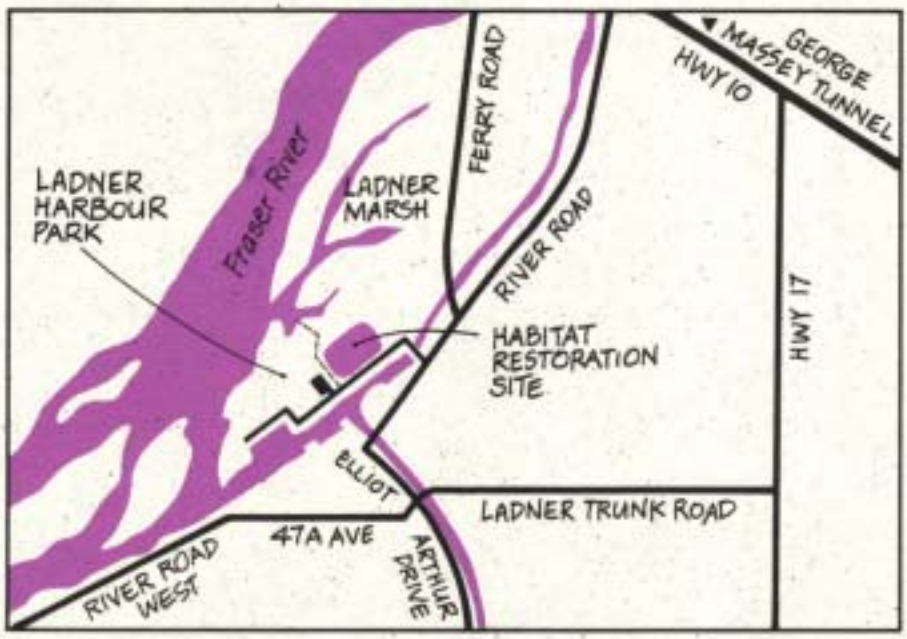



**FIGURE 2-25**
Location of Ladner Harbour Park

Ladner Harbour Park can be reached from River Road in Ladner. It has been developed into a family park, yet it retains a forest, dominated by large cottonwood trees which blend naturally into an extensive tidal marsh. The wet transition zone between the cottonwood forest and the marsh represents the type of forest habitat which once occurred along much of the undiked areas of the estuary.

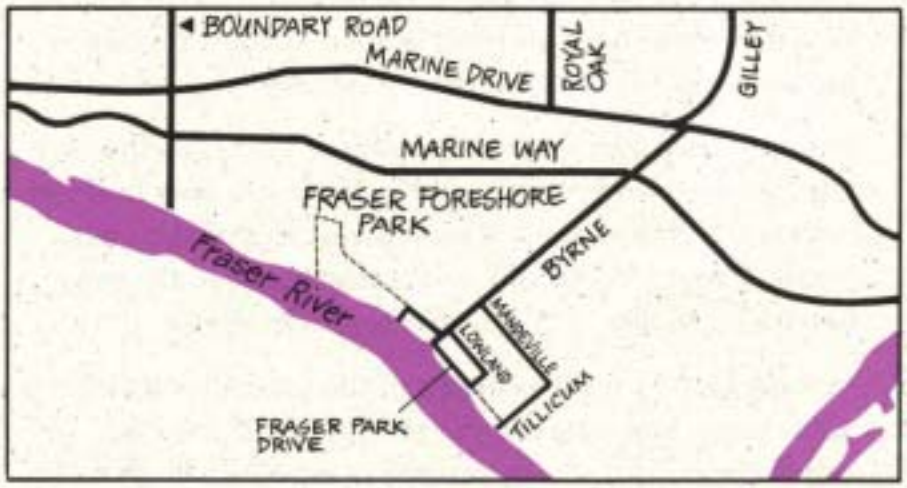



**FIGURE 2-26**
Location of Fraser Foreshore Park

Fraser Foreshore Park is located in Burnaby on the North Arm of the Fraser River (Figure 2-26). It is accessible from the foot of Byrne Road (south of Marine Way) by a trail which heads west, and then north all the way to Marine Way.

PACIFIC TREEFROG

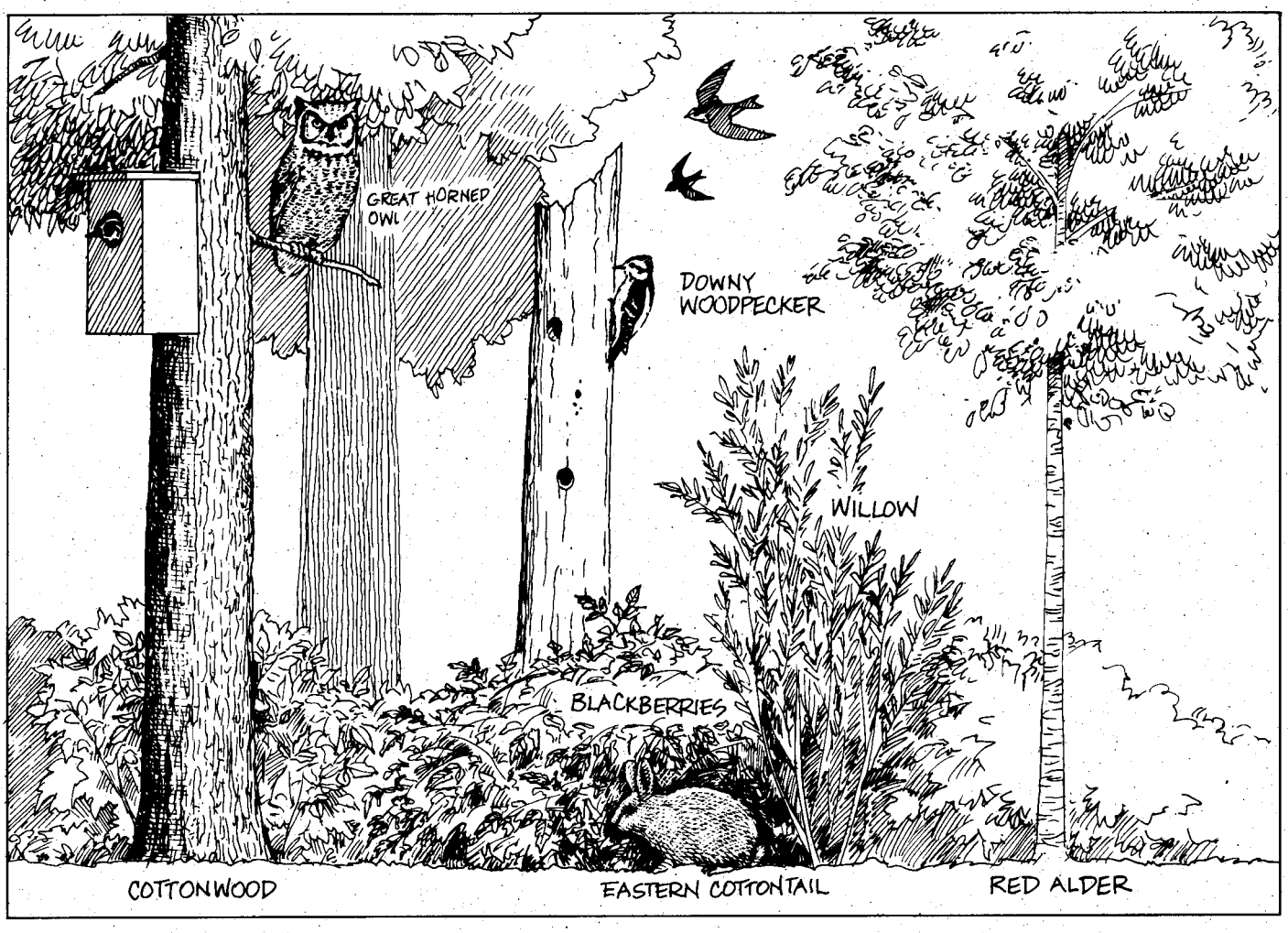



**FIGURE 2-27**
Floodplain Forest Community

## What to Look For

- ☐ The floodplain forest is an excellent habitat for reptiles and amphibians. The Puget Garter Snake and Pacific Tree Frog are two common inhabitants of these forests. Please return these animals to their habitat if you are lucky enough to catch and examine one.
- ☐ Inspect the ground underneath large branches that are likely to be used by resting owls. Here you may find owl pellets which are the undigested remains of the owls' meals. These pellets will reveal tiny bones of the prey eaten — a mouse, a frog or perhaps a snake.
- ☐ If you look up into the canopy of the cottonwood and alder trees, you may see the stick nests of the Red-tailed Hawk. If the nest you see is especially high and gigantic, it could belong to a pair of Bald Eagles. There may also be nesting boxes attached to the tree trunks to provide additional nesting sites for Wood Ducks.

☐ The Eastern Cottontail Rabbit is abundant at Ladner Harbour Park. This rabbit is an arrival from an introduced population in the State of Washington. Their nests are constructed in underground burrows.

**ACTIVITY 6:**
**A FLOODPLAIN FOREST MICRO-HABITAT STUDY**

The floodplain forest contains a diverse variety of plants and animals, mainly because it supports many different micro-habitats. A micro-habitat is a small habitat within a larger habitat where a plant or animal can live. In a floodplain forest, micro-habitats may include a rotting log, the canopy of a tree, a small pool of water, and so on. A scavenger hunt will serve as a good opportunity to increase your awareness about the rich and varied forest environment.

**Objectives:**

Participants in the scavenger hunt will be able to describe some of the many different micro-habitats found in the floodplain forest. They will acquire the ability to collect and record information about the environment.

**Equipment:**

This activity will require: trowels, buckets, shallow trays, plastic jars, plastic spoons, hand lenses, binoculars, clipboards and notepads. To help with your search and record keeping, a sample form, "Micro-habitat Study Sheet", is provided (Figure 2- 28). Consider studying the following micro-habitats: rotting log, small pool of water, tree canopy, pile of fallen leaves. You may also use other examples in the first row of the Study Sheet.

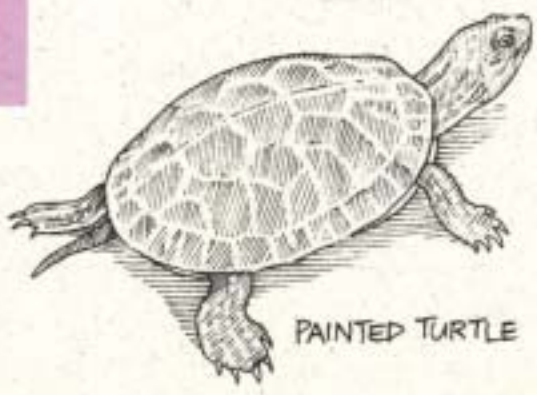
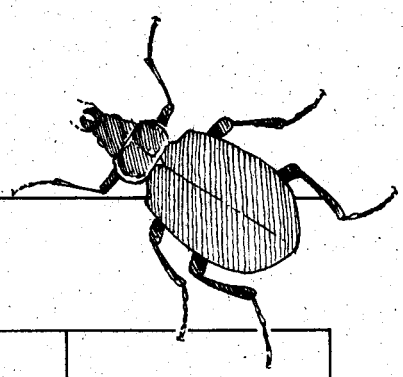


**FIGURE 2-28** Micro-habitat Study Sheet



# MICRO-HABITAT STUDY SHEET

For each micro-habitat answer the following questions

| | | | | |
|---|---|---|---|---|
| 1. What is the name of the micro-habitat? | | | | |
| 2. Describe it. | | | | |
| 3. What animals or their signs do you see there? | | | | |
| 4. What else might live in this habitat? | | | | |
| 5. Why would an animal want to live in this habitat? | | | | |
| 6. Describe the plants you find there? | | | | |
| 7. Draw a plant and an animal you see. | | | | |
| 8. What are the signs of human influence? | | | | |

**Procedure:**

1. Divide the participants into groups of 4-5 and give them any of the equipment listed above that you can acquire. Give each group a clipboard with a copy of the Micro-habitat Study Sheet.

2. Each group should look for four different micro-habitats, and answer the questions for each of these on the Study Sheet. Everyone should also find or describe items indicated on the Sheet.

**IMPORTANT**

This is an excellent time and situation to encourage respect for the outdoors. The following guidelines should be remembered on any outing.

Don't collect any living plants or their parts (bark, flowers, leaves).

Don't collect bird eggs or disturb their nests.

Don't mar the landscape while collecting.

Return anything gathered back to the environment.

Refill all holes dug and return overturned rocks or logs to their original positions.

Treat the area with respect and preserve its beauty for others.

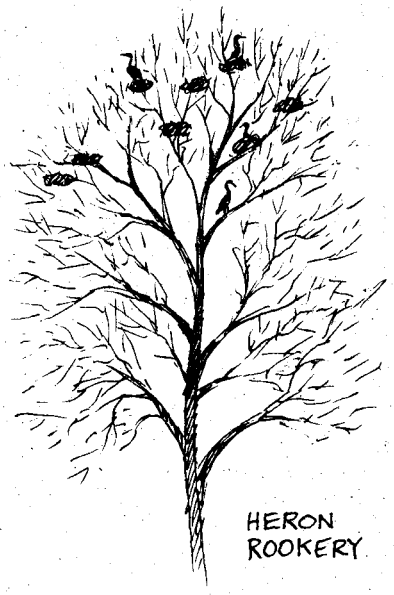
3. After the study, gather together in a group to discuss the following:

Review and compare answers to the questions on the Micro-habitat Study Sheet.

What are some ways that these micro-habitats can be damaged or destroyed by careless people?

Are there any ways to help protect, restore, or enhance these micro-habitats?

Why is this specific habitat in such imminent danger of disappearing?



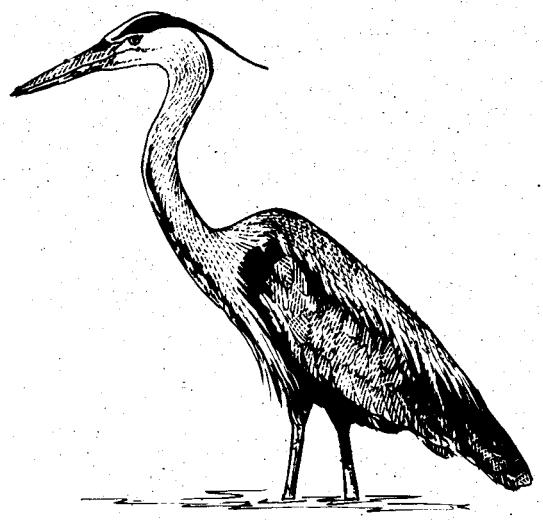

## OTHER FACTS AND FIGURES

### Heron Rookeries - A Vulnerable Micro-habitat

The Fraser River Estuary provides a rich feeding ground for Great Blue Heron. Adult herons have the opportunity to feed on small fish, frogs and rodents in the many wetland habitats of the estuary. However, young nesting herons need to be close to a source of food; otherwise the longer the adults are away from the nests obtaining food for their young, the greater the chance for predators to raid the nest.

Many herons moved to Point Roberts to nest after their colonies were repeatedly destroyed in Tsawwassen — first by logging around 1955 and then by urban development. They have now been in Point Roberts for at least 16 years. There are over 300 nests in the Point Roberts heron rookery, and it may be the largest in the Pacific Northwest. The Creston Colony near the Nicomekl River in south Surrey has also moved numerous times due to disturbances related to development.

Herons need undisturbed stands of large trees close to wetlands. The destruction of these habitats has eliminated or endangered heron populations in local areas of the estuary. Heron rookeries represent a vulnerable habitat for the survival of this famous natural symbol of the estuary.



# River Channels and Sloughs

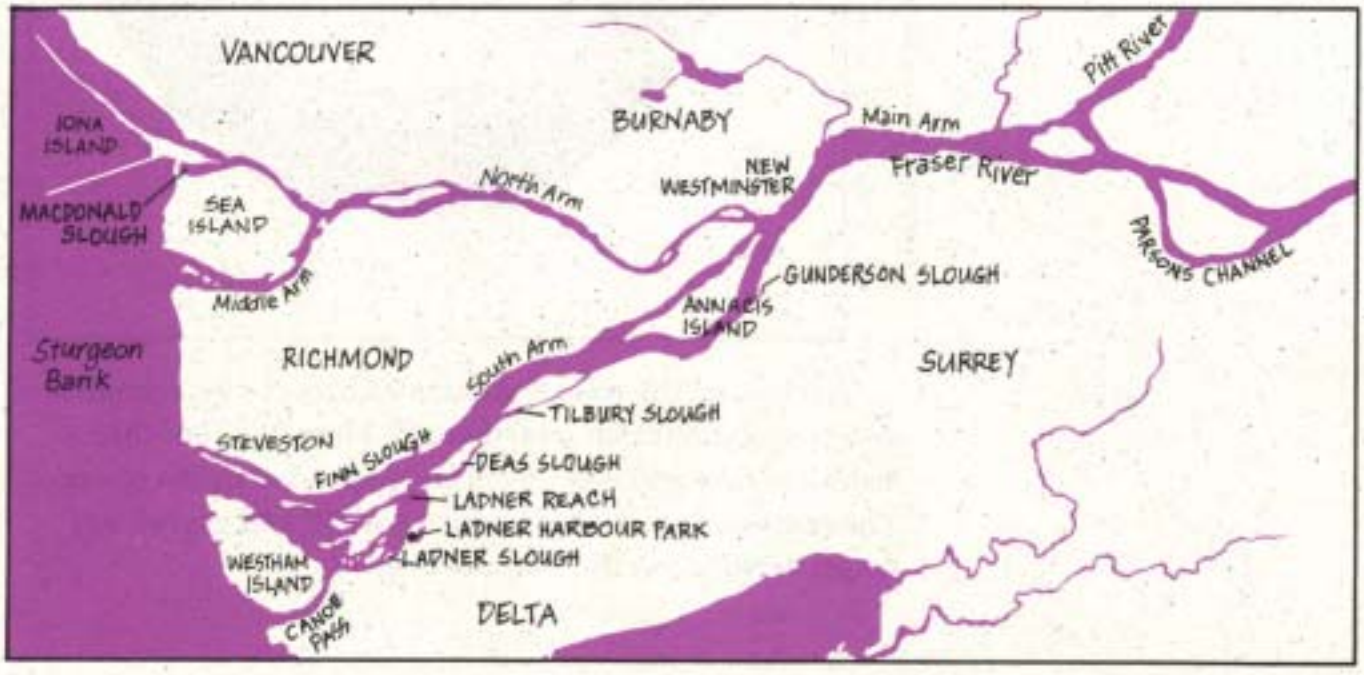
Sloughs are the relatively shallow and quiet backwater channels found in the estuary. River channels are the fast flowing, deeper water areas while marsh, tideflat and floodplain forest habitats are exposed each day as the tide ebbs. The sloughs and river channels of the estuary are an aquatic environment that is almost always submerged.

## Where is this habitat located?

The Main Arm of the Fraser River downstream of New Westminster splits into two channels, the South Arm and the North Arm. Secondary channels include the Middle Arm and Canoe Pass. There are also several minor channels such as Annacis Channel, Ladner Reach and Parsons Channel. These river channels make up a network of secondary channels typical of most estuaries with deltas.

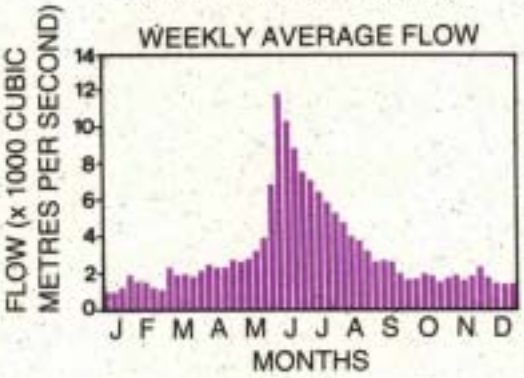
Some of the better known and largest sloughs in the Fraser Estuary are MacDonald Slough, Finn Slough, Deas Slough (adjacent to Deas Island Park), nearby Tilbury Slough and Gunderson Slough, located farther upstream (Figure 2-29). Most of these sloughs were once open to the Fraser River at both ends, but due to diking and filling, the upstream ends of most sloughs are now closed off by a causeway.

**FIGURE 2-29**
Major River Channels and Sloughs



## What are their physical features?

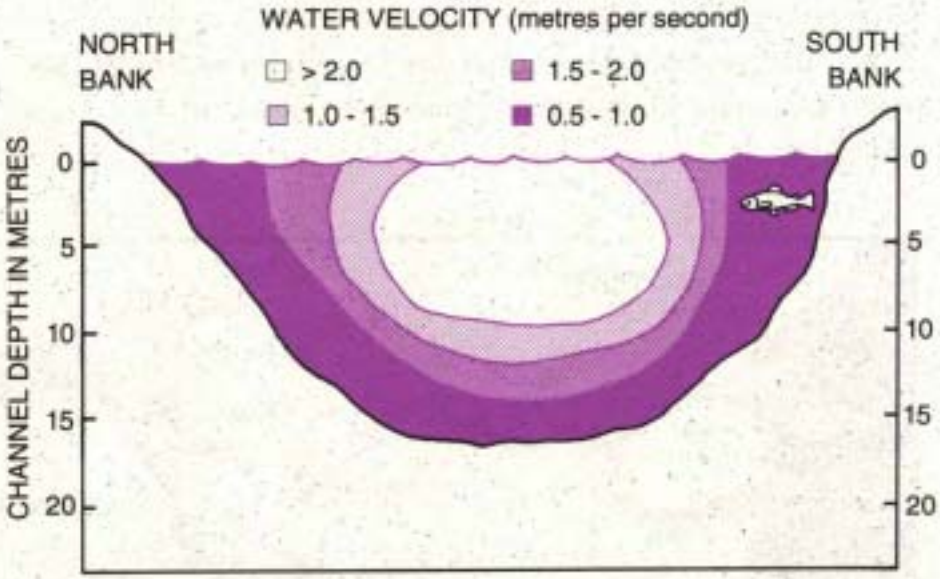
**FIGURE 2-30**
Fraser River Hydrograph




In June, during peak flow (also known as "freshet"), the main river channels of the Fraser carry a huge amount of water — up to 15 000 cubic metres of water per second flows past Hope. Figure 2-30 shows what is called a hydrograph — the seasonal flow of the Fraser River. The South Arm, representing the largest channel (200 - 300 metres wide) and deepest (approximately 12 metres), carries 85% of the flow. The fresh river water flows over top of the saltier and denser seawater, which is pushed up each channel bottom with every flood tide.

Water velocity is of importance since the main river channels are the route used by millions of migrating salmon. The highest water velocities (1.0 - 2.0 metres per second) occur in the centre of the channel. Near the bottom and banks of the channels, velocities decline to less than 1.0 metre per second (Figure 2-31). If you were a fish looking for the easiest migration route up the river, where would you swim?

**FIGURE 2-31**
Cross-section of River Showing Water Velocities




Each year, the river channels transport vast amounts of sediment (25 million metric tons). Most (80%) of this sediment (silt and clay) remains suspended in the water. The remaining heavier sediments (sand and gravel) are transported along the channel bottom.

## Is there any life on the river bottom?

The river channel habitat is a cold, dark environment with fast-flowing water and shifting sediments. Other than floating and drifting algae, there is no plant production in the river channels. However, despite the seemingly harsh conditions on the river bottom, it is home to numerous different invertebrates which feed on the plentiful supply of detritus. These bottom-dwelling organisms are collectively referred to as benthos (Figure 2-32).

Small aquatic worms known as Oligochaetes are found living in the mud throughout most of the estuary's river bottom. These worms are especially abundant (up to 1 000 worms per square metre) in organically polluted parts of the estuary because they can tolerate very low dissolved oxygen levels. Therefore, Oligochaetes are often used as bioindicators to show which regions of the estuary are most polluted.

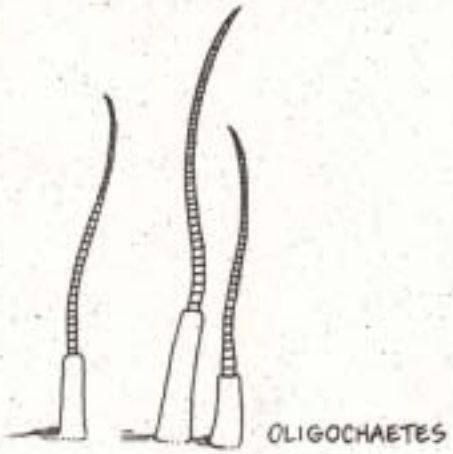
The river bottom is also home to several species of aquatic fly larvae, one of the most common being the midge larva (*Chironomid*). These larvae, which are quite common in the estuary, are a favorite food for juvenile salmon.

Bottom-dwelling organisms living on the surface of the river bottom are known as epibenthos. One of the most common epibenthic invertebrates is the Mysid Shrimp (*Neomysis mercedis*). A fine meshed net towed on the river bottom will yield thousands of these small shrimp.

The water in the river channel is occupied by another group of organisms referred to as plankton. In the Fraser Estuary, much of this plankton fauna consists of tiny invertebrates called zooplankton — the most common types being cladocerans and copepods (small crustaceans, only one or two millimetres in size, Figure 2-33).

Because of this fish's huge size and long life span, White Sturgeon are one of the most interesting dwellers of the river bottom. Earlier in the century, sturgeon over 500 kilograms were common (one weighing 850 kilograms was reported caught near Mission City). Fish up to 71 years old have been caught commercially, and one angler caught a fish that was well over 100 years old.

**FIGURE 2-32** Benthos



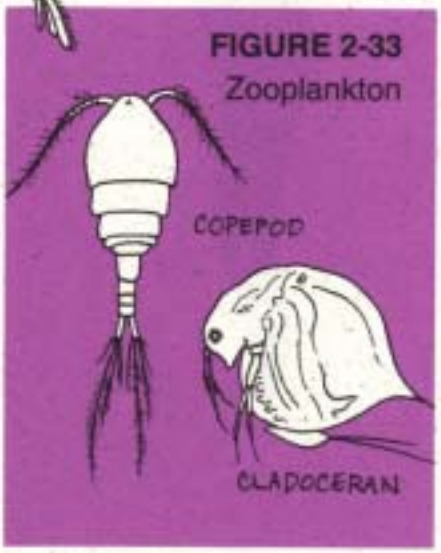




**FIGURE 2-33** Zooplankton

**FIGURE 2-34**
A Self-made Plankton Net

## ACTIVITY 7:
## AN EXAMINATION OF PLANKTON

Sampling and studying zooplankton is an interesting activity because it helps you appreciate the diversity of life that exists in the muddy waters of river channels and sloughs. To capture zooplankton you will need a plankton net, which is conical in shape with a fine meshed net.

**Objective:**

To capture, examine and identify samples of zooplankton which live in the estuary.

**Construction of Plankton Net:**

You can make your own plankton net by using the thin fine-meshed fabric of womens' stockings or panty hose. Cut out the bottom of a plastic ice cream bucket. Slip the top of a large size stocking over the cut end of the ice cream bucket. Fasten the stocking to the bucket using waterproof tape. Fasten a rope or long pole to the handle of the ice cream bucket.

**Procedure**:

Normally a plankton net is dragged through the water on the end of a rope behind a boat. However, the net can also be rigged to a pole and drawn back and forth through the water from a river bank or the end of a dock.

To remove the captured organisms from the net shown in Figure 2- 34, first turn the net inside out. Touch the end of the net to some water in a wide mouthed container. Many of the organisms will swim off the net on their own, while others may need to be gently rinsed free using a spray bottle. Remember that the less water you use in this transfer, the more concentrated will be your plankton sample.

It is best to examine the zooplankton under a microscope while they are still alive. Using an eye dropper to pick up a few organisms, place these on a slide (preferably a well slide), and top it with a cover slip.

# Sloughs

## What is a slough?

Slough is a popular term applied to almost any slow-flowing, muddy, shallow water habitat in the estuary. Thus, any still backwater area connected to a river channel can be designated as slough habitat. The important physical features of sloughs are the absence of any strong currents, relatively shallow water (0 - 3 m depth) and a muddy bottom. The summer water temperature in sloughs is also generally higher than in the adjacent river channels.

Over several hundred years, as river channels shift and change course throughout the estuary, old and abandoned river channels gradually silt in and become sloughs. Sloughs have also been created with the construction of connections (causeways) between the river shoreline and adjacent islands. Deas Slough is an example of such a man-made slough.

## Why are sloughs such a valued habitat?

Sloughs are the most biologically productive habitat in the estuary; nowhere else is there such a rich diversity of aquatic life. It is not surprising, therefore, that ecologists place a special value on the remaining slough habitats of the estuary. Figure 2-36 shows a detritus food web typical of the slough or side channel habitat. For a description of food webs, refer to Chapter 1.

Typically, sloughs are bordered by floodplain forest, brackish and freshwater marsh, and support mudflat habitat along their intertidal margins. Therefore, all the aquatic plants and animals found in these habitats will also be found in the slough habitat. Some sloughs, such as Tilbury Slough, will drain almost completely during a very low tide, whereas others, such as Deas Slough, always retain some water. In either case, there is always a nearby place for small fish and other aquatic organisms to seek refuge between tides without getting swept away by strong currents in the river channels.

**FIGURE 2-35**
Aquatic Insects and Shrimp

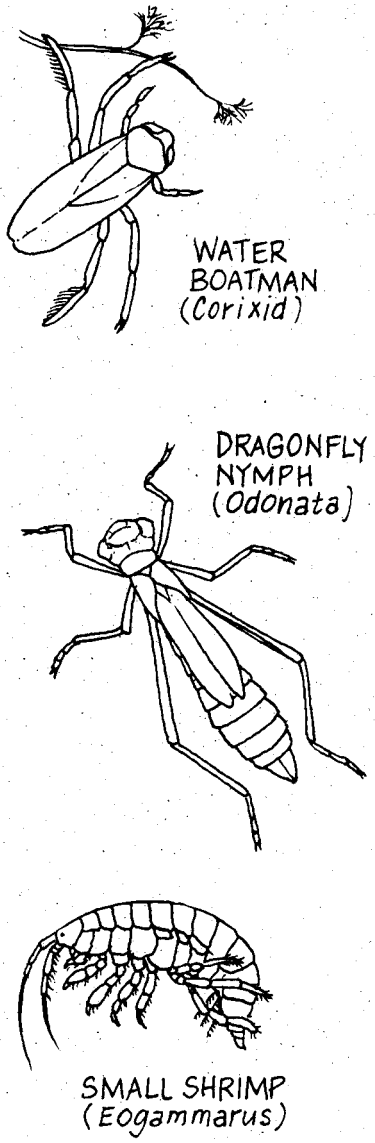
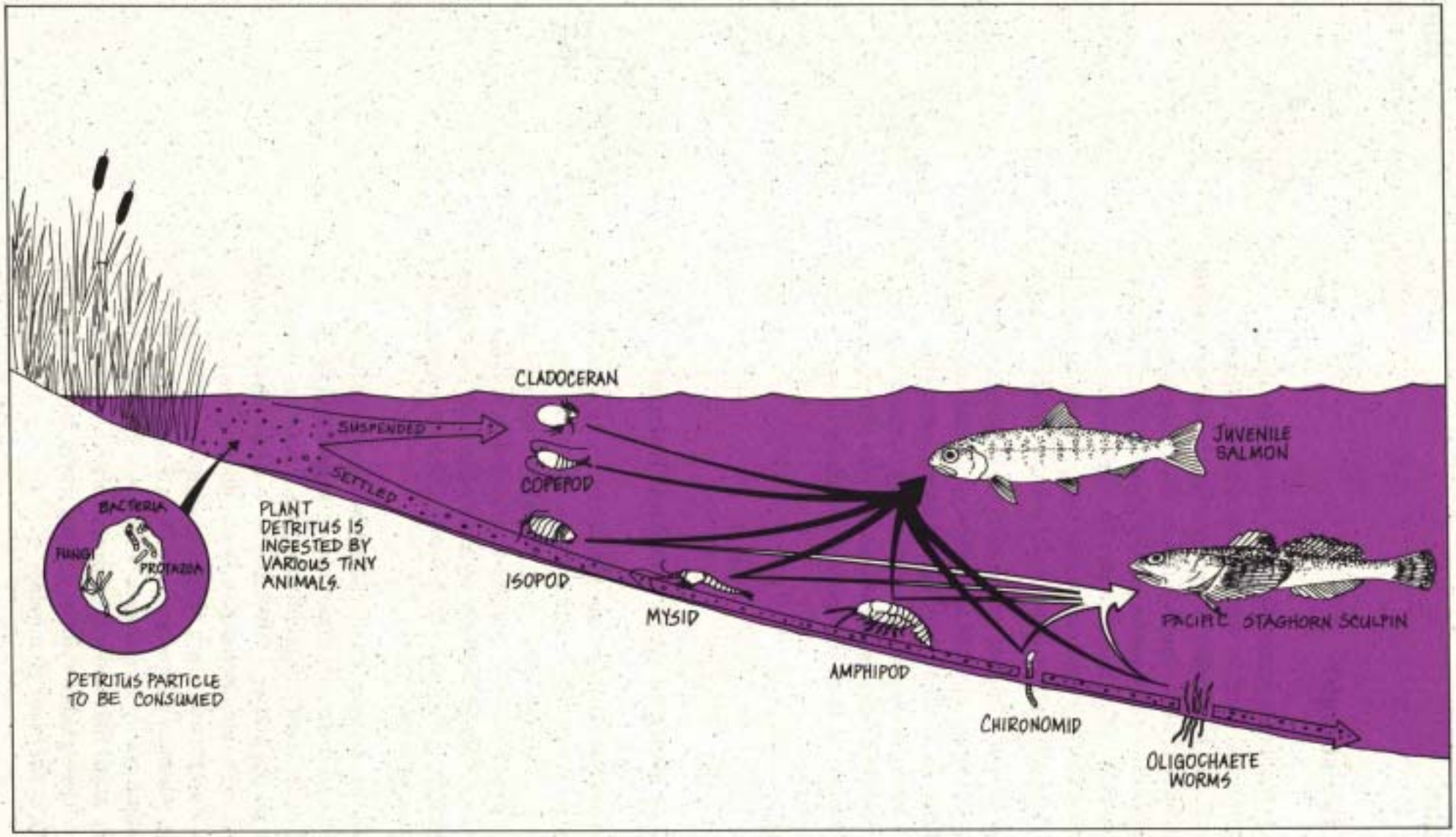


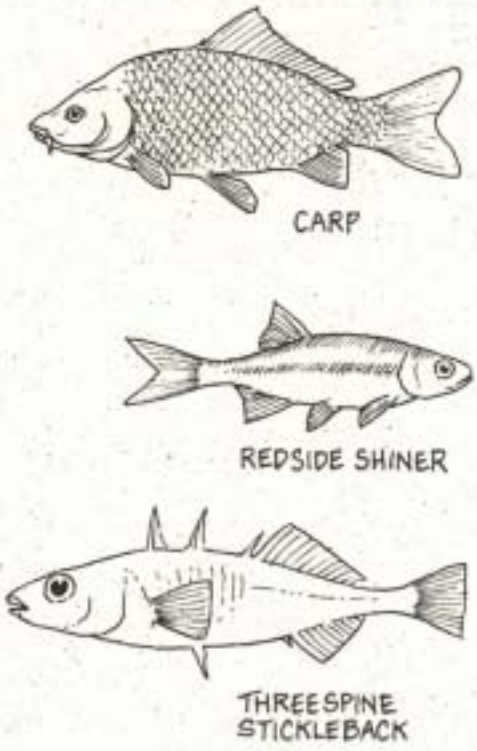
**FIGURE 2-36** Detritus Food Web of Sloughs



In addition to the bottom-dwelling invertebrates previously described for the river channel habitat, the quiet sheltered water of the slough also supports a number of other aquatic invertebrates. There are snails, leeches, aquatic insects such as Water Boatmen (*Corixidae*), dragonfly (*Odonata*) nymphs, and small shrimp (*Eogammerus*), to name only a few (Figure 2-35).

The slough is also the home of small resident fish such as the Three-spine Stickleback (*Gasterosteus aculeatus*) and Redside Shiner (*Richardsonius balteatus*) that could not live in the strong currents of the river channels. Large fish, such as the Common Carp (*Cyprinus carpio*), which can reach nearly five kilograms in weight, will seek out sloughs in summer to spawn (Figure 2-37).

**FIGURE 2-37**
Common Slough Fish




## FIELD TRIP DESTINATION: Deas Island Park

Deas Island Park can be reached by taking the second turnoff from Highway 99 south of George Massey Tunnel and proceeding approximately two kilometres north along River Road to the park entrance (Figure 2-38). This park belongs to the Greater Vancouver Regional District, has plenty of parking, and sponsors several public events -- the most notable of which is the Fraser River Festival, usually held on the first Sunday in June, during national Environment Week.

The location of Deas Island Park is ideal for studying the river channel and slough habitat. In addition to Deas

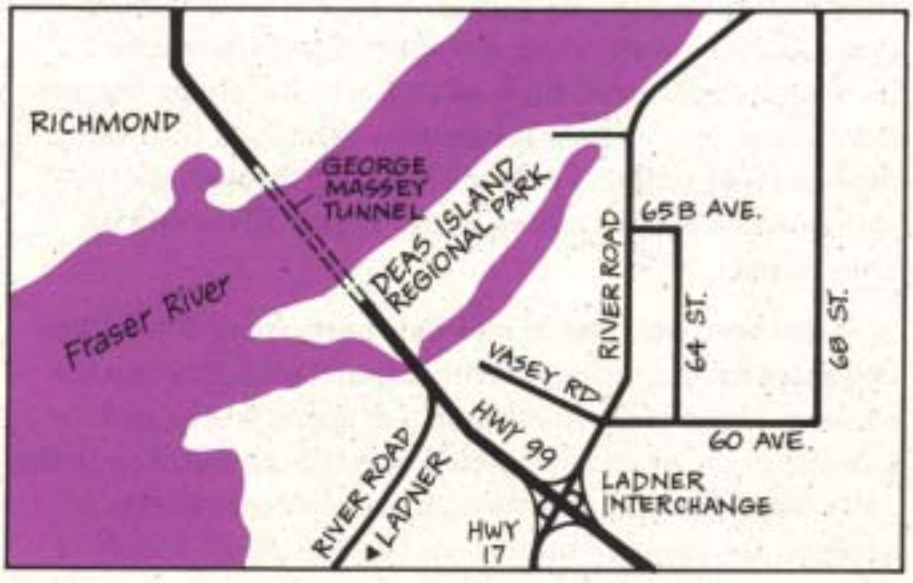
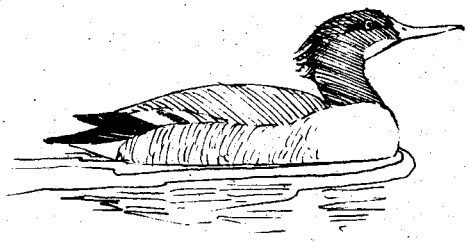



**FIGURE 2-38**
Location of Deas Island Regional Park



Slough itself, which represents a large, man-made slough, there are several smaller, natural sloughs. The South Arm of the Fraser River, a major river channel, can be viewed at several locations in the park as well as from an elevated observation platform.

### What to Look For

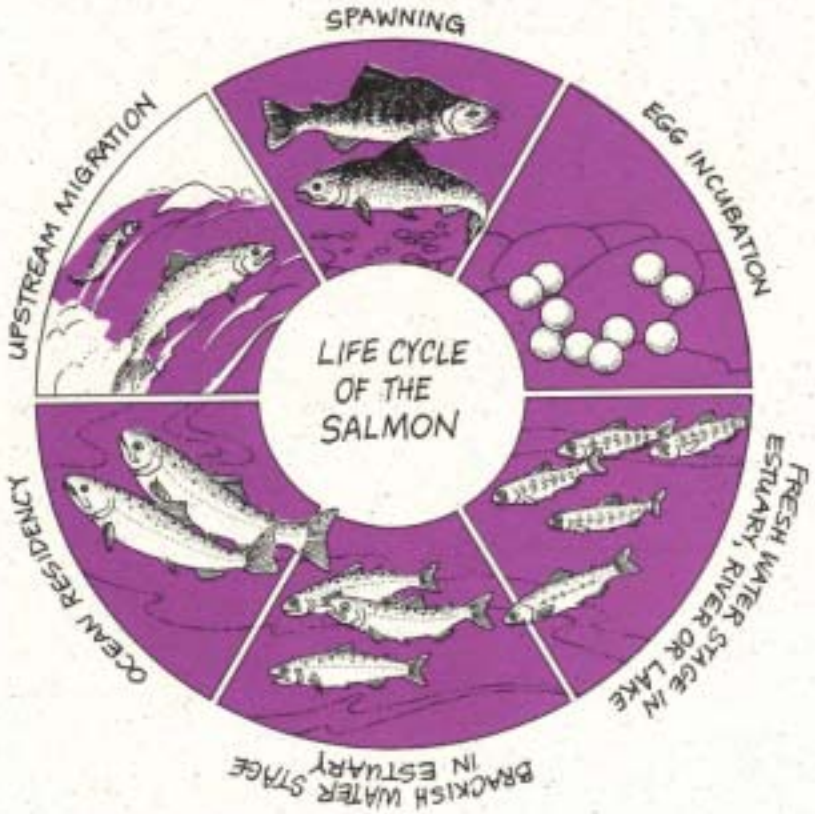
- ☐ Look for evidence of the seasonal movement of fish through the river channel. The presence of fish-eating diving birds such as the Western Grebe and the Common Merganser signal the spawning run of Eulachon from mid-March to mid-May. Gill net boats fishing in July and August indicate the probable presence of thousands of migrating Sockeye Salmon.
- ☐ Migrating salmon must now share the river with deep sea vessels, tugs and barges, log booms, commercial fishboats and recreational boats. It is interesting to watch this vessel traffic and think about their port of origin, cargo and purpose on the river.

## OTHER FACTS AND FIGURES

### Salmon - The King of the Fraser

The Fraser River produces more salmon than any other river system in the world. Five Pacific salmon species (Chinook, Coho, Pink, Sockeye, Chum) as well as sea-run trout (Steelhead) migrate upstream as adults through the river channels of the estuary on their way to spawning grounds in the watershed. Because salmon spawn in freshwater and spend their adult life in the ocean, they are called anadromous fish. It has been estimated that, on average, four million adult salmon pass through the estuary each year to spawn in the Fraser River and its tributaries.

Each year, starting in mid-February, some 800 million downstream migrating juvenile salmon pass through the estuary. Many of these juvenile fish spend weeks and months in the brackish estuary, slowly acclimatizing to the salty ocean. During their temporary residence in the estuary, the juvenile salmon feed on the ample supply of



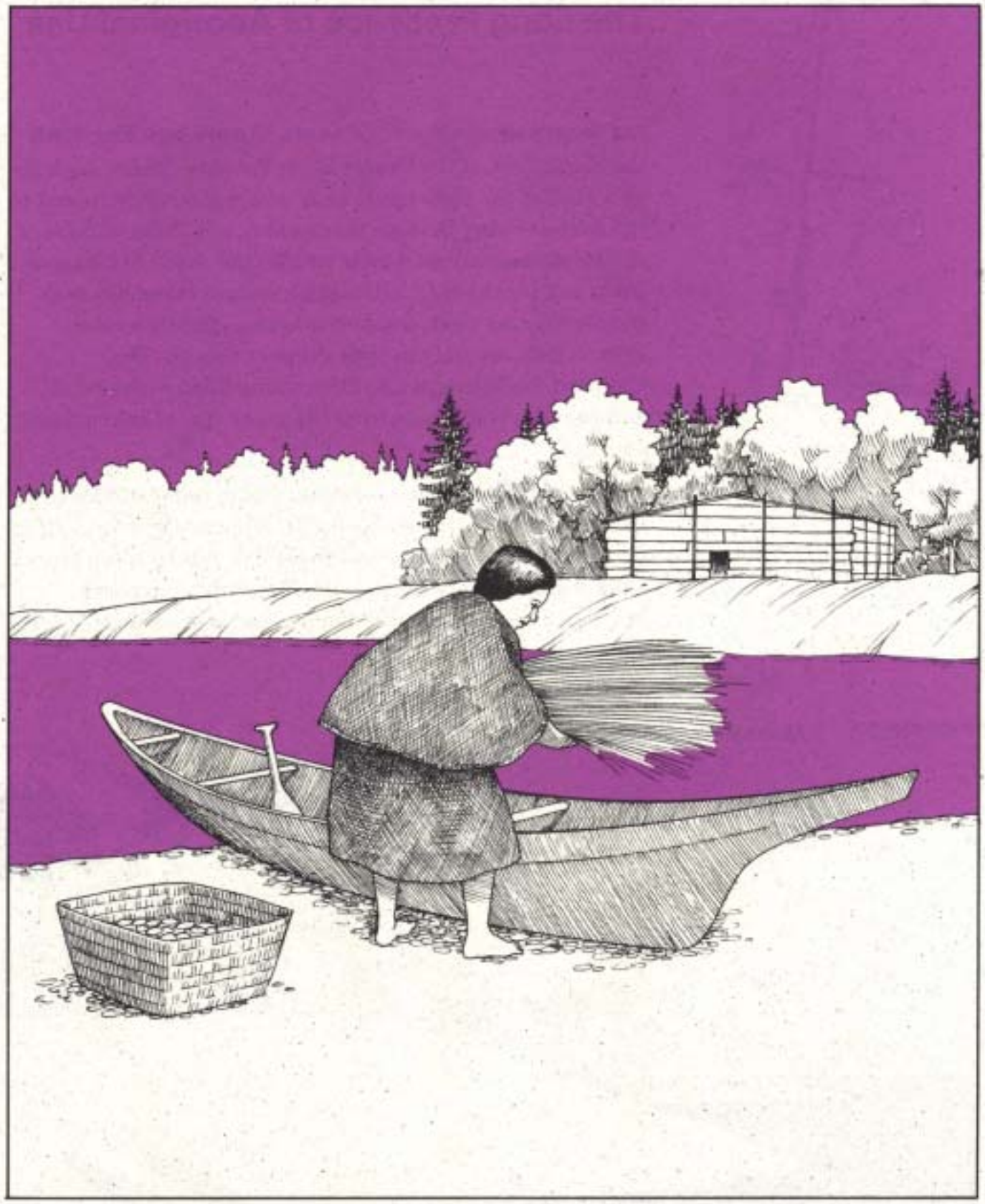

invertebrates provided by the marshes, sloughs and swamps. That is why the salmon's future survival depends on the preservation of a healthy aquatic environment in the estuary.

**Dragonflies - Elegant Helicopters of the Marsh**

The metallic dash of a large dragonfly zipping over the estuarine marsh brings surprise and wonder. Dragonflies can be seen tirelessly hawking after the insects that are their prey.

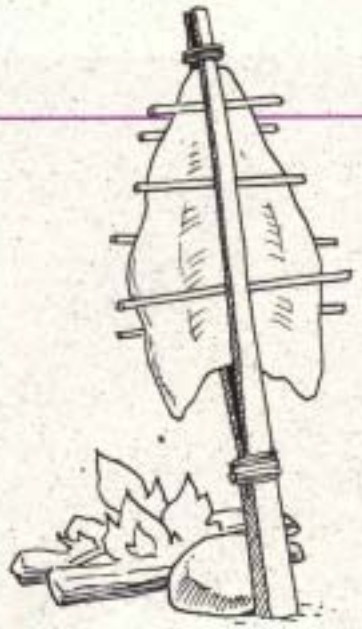
While dragonflies do not sting or bite people, they do have a huge appetite. Using its large compound eye with 30 000 separate lenses to locate prey, and its spiny legs as a basket, the dragonfly hunts, captures and eats its prey in flight. Over several hours, it may consume its own weight in mosquitoes and gnats.

Late in summer, dragonflies mate and lay their eggs. While in flight, the female deposits her eggs under the leaves of aquatic plants by rhythmically dipping her long slender abdomen below the water. The eggs develop into nymphs (*Odonata*, Figure 2-35) that live underwater for one to three years, after which they emerge as flying adults. Look for the outer skin of nymphs left behind on marsh plants by the emerging adults.



# 3. HUMAN HERITAGE

Much of what we see today in the Fraser River Estuary is the result of human activity. In this chapter we look at some of the ways people used the estuary from ancient to modern times.

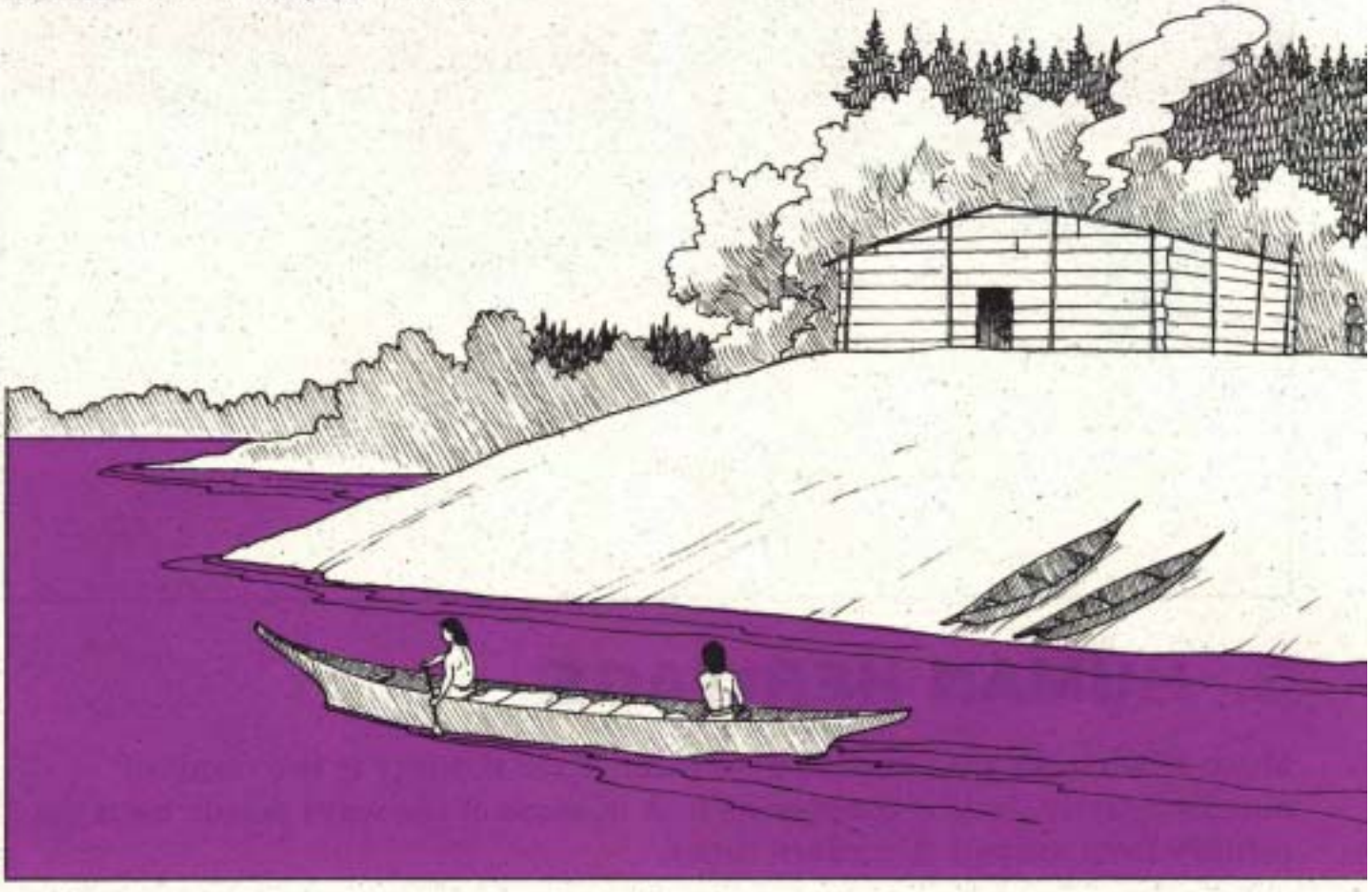


## The Long Presence of Aboriginal Use

Let us go back in time 3 000 years. We are paddling down the North Arm of the Fraser River Estuary. There, high up on a bluff of the right bank, near where the northern end of the Arthur Laing Bridge stands today, are three villages of the Musqueam tribes. Cedar longhouses made of massive posts and planks split with antler wedges stand out over the bluff facing west. Inside the houses, families roast salmon held securely in split skewers over the fire. Children dip fish eggs into clam shells filled with seal oil, and enjoy a relish made from the green tips of salmonberry shoots.

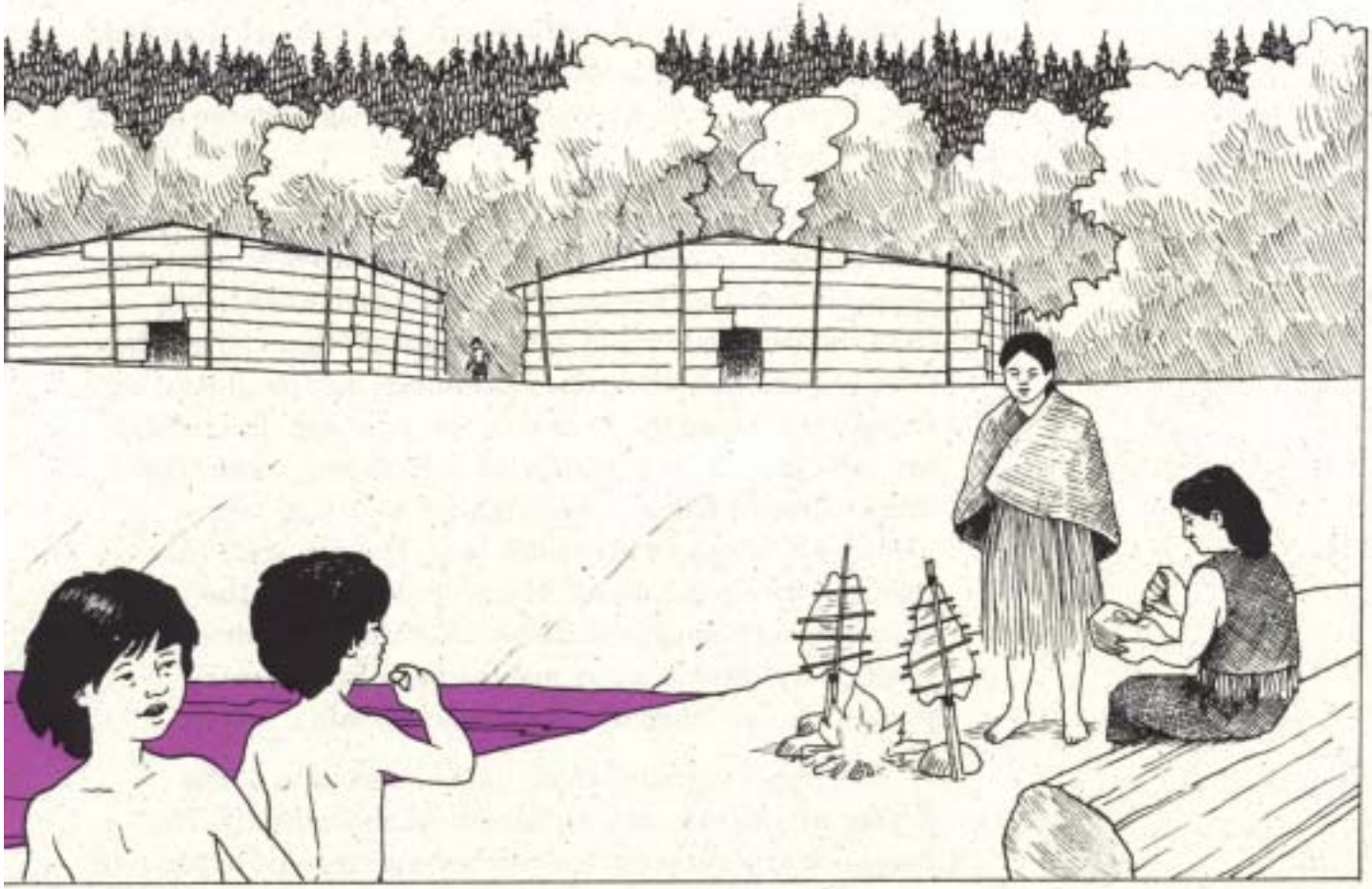
Some members of the tribe set out in cedar canoes to fish the abundant runs of Eulachon that are now migrating up the Fraser River. Some of these fish will be eaten but most will be used to produce oil. Meanwhile, hunters prepare their harpoons for the inevitable seals and

**FIGURE 3-1** Musqueam Village



porpoises that follow the Eulachon into the estuary. Long harpoons are also used to probe the murky river bottom in search of the great sturgeon which can weigh hundreds of kilograms. Others are busy setting stationary traps out on the shallow mudflats. They are taking advantage of the tidal ebb and flow to bring great numbers of flat fish such as Starry Flounder into their traps.

As the summer progresses, the Musqueam paddle their canoes to their summer camps along the river banks. Leaving the North Arm, they set up camp on the Main Arm where Steveston is now, and position themselves for the immense numbers of salmon that will soon come up the river. Other tribes, at the invitation of the host tribe and during an abundant salmon cycle, also derive their food, shelter and clothing from the estuary. Neighbouring tribes from upstream of the Fraser River, from other areas along the lower mainland, from the northern and southern coast, and from Vancouver Island, journey all the way to the Fraser Estuary to set up summer camps for the great congregations of Sockeye Salmon.



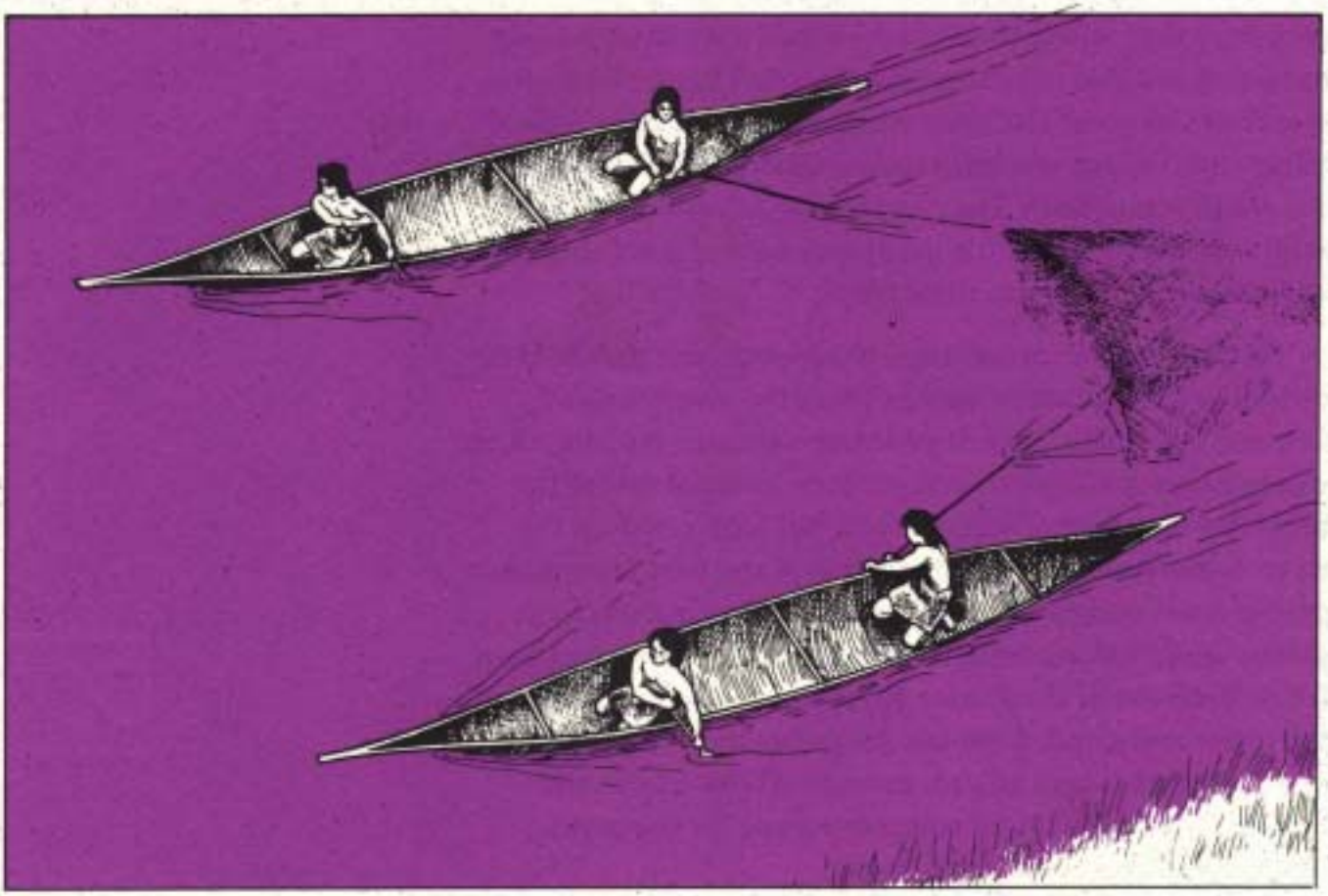


**FIGURE 3-2**
Sockeye fishing in the Fraser River

As the Sockeye enter the Fraser River, the Musqueam paddle out into the Main Arm and, between two canoes, set a gill net made from the shredded bark or root of Red Cedar (Figure 3-2). The Musqueam begin to net their fish, and as they do, they quietly and respectfully chant to the fish, because the Sockeye have spiritual significance as well as food value.

No female salmon or eggs are taken during the first half of the season, to ensure that there will always be a future supply of Sockeye. Yet the Musqueam and other tribes from the lower mainland and Vancouver Island have more than enough fish. Soon the Musqueam and neighbouring tribes are hauling their catch to shore, where the Sockeye are split, gutted, and stretched out on drying racks. The dried salmon will keep the longhouses stocked with a plentiful food supply all winter long. The fish scales are coloured with plant dyes and are used to design the garments and household items. The fish skin is dried and stitched together to make moccasins, bags and small temporary dwellings which are waterproof.

The fringe marshes along the quiet sloughs of the Fraser River are lush with horsetails and cat-tails. The horsetails are gathered and woven into baskets, boiled into

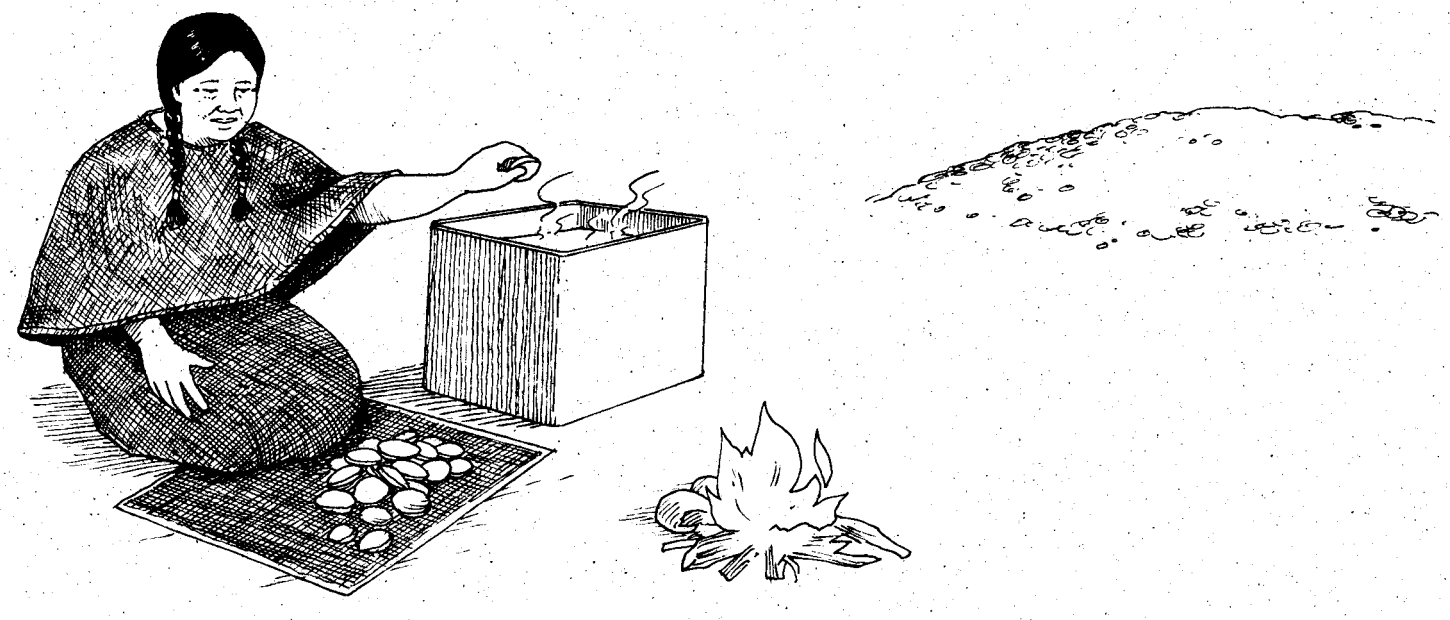
hair wash, and the fluid used as an eyewash. The roots of the cat-tails provide yet another dish for the dinner table while the leaves are woven into mats and hats.

Lulu Island has always been endowed with a variety of berries such as strawberries and salmonberries. Large bog areas supporting cranberries and blueberries are easily reached from the river's edge. Women and other family members gather these berries into their horsetail and cat-tail baskets. Back at camp the berries will be mashed, dried, and kept for a winter food supply.

Beyond the tidal marshes and far out on the tidal mudflats, the Aboriginals use simple sticks to dig up a seemingly unending supply of clams. The shells of leftover clam feasts are piled up around the Musqueam village and have remained buried much as they were left. These ancient kitchen refuse piles, referred to as middens, are now the highly prized discoveries of modern-day archaeologists digging through old soil layers. Human settlements have been uncovered at Beach Grove and Crescent Beach, and the oldest site, located just a kilometre above the Alex Fraser Bridge, dates back 9 000 years.

In spite of harvesting by nearby tribes, and even by the regular summer visitors from Vancouver Island, the renewable resources of the estuary were sustained for thousands of years. The tribes using the Fraser Estuary considered it a highly valuable area because of the large concentration of edible resources, and an active aboriginal food fishery has remained to the present time.

**FIGURE 3-3**
Origin of a midden

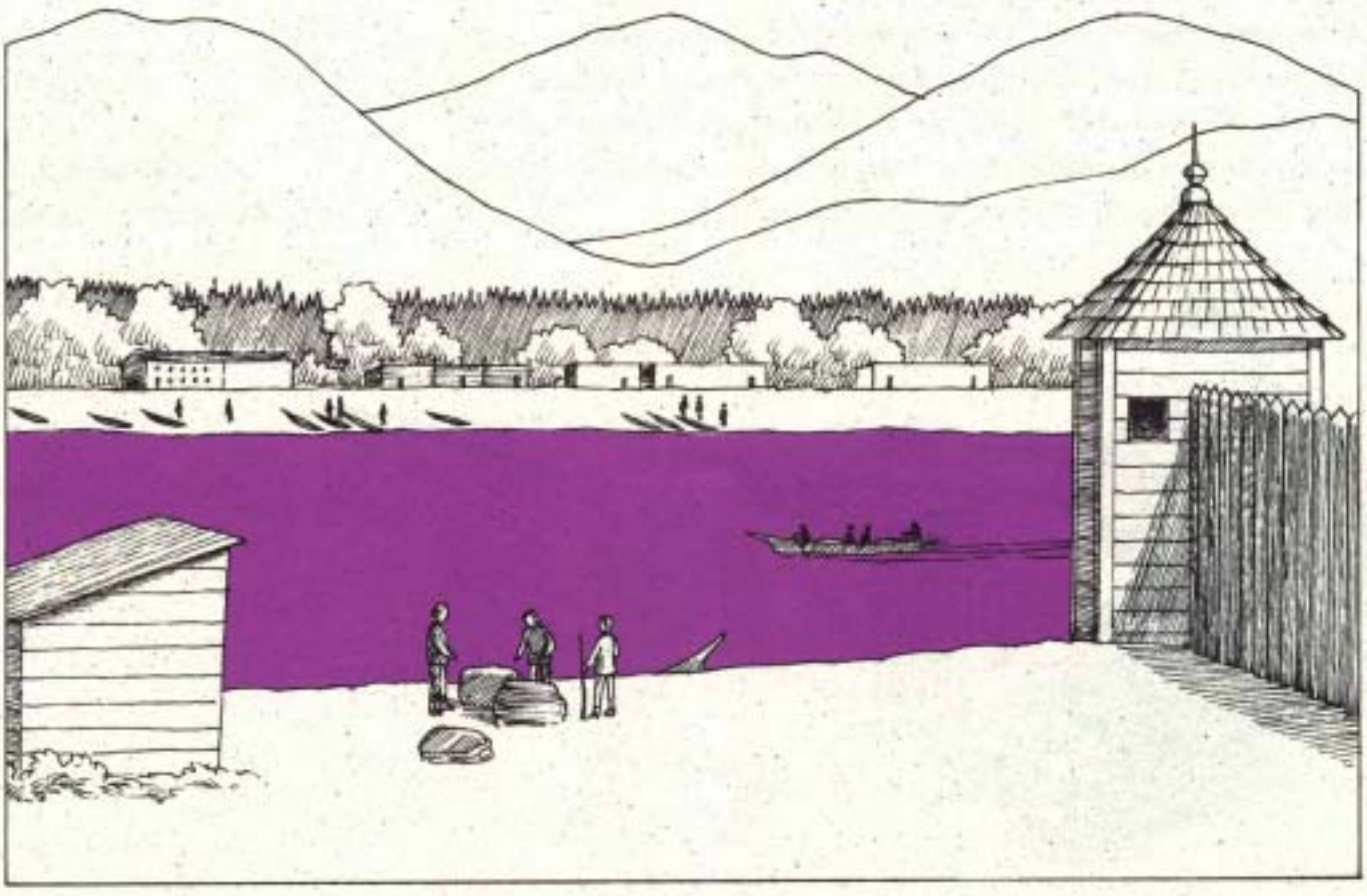


## Settlement by Europeans

The estuary did not appear valuable to the first Europeans who saw it. The Spanish sailors who moved up from their bases in California did not explore the estuary, and Captain Vancouver sailed right past, thinking the estuary was a swamp rather than the delta marsh of a great river. Finally, in 1808 the Northwest Fur Company explorer Simon Fraser navigated the great river — but even he felt a sense of disappointment when he reached the estuary. He had originally hoped to explore down to the Columbia River, and was disappointed to find himself over 300 kilometers to the north.

Fraser's exploration, however, would change the nature of the estuary in ways that he could not have imagined. When settlers in the United States began moving into the Columbia estuary, the Hudson's Bay Company decided to relocate their fur-trading base for coastal shipping from Fort Kamloops in the interior to Fort Langley, near the mouth of the Fraser River. This was achieved after a road was built from Fort Kamloops through the mountains down to Fort Langley, which was established in 1827.

**FIGURE 3-4**
Fort Langley



Soon, furs from the interior were being transported on ships sailing from Fort Langley, through the estuary and out into the Pacific Ocean. When the fur trade began to fail, Fort Langley shipped salted salmon through the estuary to Hawaii and Asia. As an interesting historical footnote, some Hawaiian workers, the "Kanakas," came back with the Company to Fort Langley. Kanaka Creek, which flows into the Fraser River opposite Fort Langley, is named after these Hawaiians.

**FIGURE 3-5**
Panning for Gold

It wasn't many years before another important event affected the Fraser River Estuary. In 1856, a trader at Fort Kamloops learned of an Aborginal miner who had found a gold nugget on the stream bed of a tributary to the Thompson River. The word of gold in the Fraser River system spread like wildfire, and soon thousands of prospectors, many from the United States, made their way through the estuary and on up the Fraser River in search of gold (Figure 3-5). In fact, there were soon so many people from the United States working the Fraser River's gold deposits that Governor Douglas of the Vancouver Island colony felt he must assume jurisdiction over the Fraser River drainage. Canadian prime minister Sir John A. Macdonald knew that the new colony had to be brought quickly into the Canadian Confederation.

Within ten years, British Columbia was drawn into Confederation by the promise of a railroad that would follow the Fraser River through the mountains to the coast. After approximately 9 000 years of Aboriginal settlement, the Fraser River Estuary was about to experience significant alterations, as a result of the large influx of immigrants from other countries.

In the latter half of the 1800s, Europeans began to settle and farm in the valley, starting with a population of only 300 people in 1861. As was typical of many pioneers, the Ladner brothers passed through on their way to the gold fields, and later returned to the estuary to work the rich, black soil. In 1868, they built the first dikes and began to drain and farm the land.

From the farmers' point of view, the dikes were absolutely essential, particularly because the valley was prone to flooding. Farmers also needed protection from winter storms that could push high tides far inland.

**FIGURE 3-6**
The Great Flood of 1894

Diking efforts were stepped up after a catastrophic flood in 1894, which inundated the Fraser Valley right out to sea and flooded all of Richmond and Delta. The flood was so severe that it left Point Roberts once again (as it had been 5 000 years earlier) an island separated from the mainland. After the flood, with government help, dikes were constructed to surround the delta land, and water was drained off the land by drainage ditches and pumps.

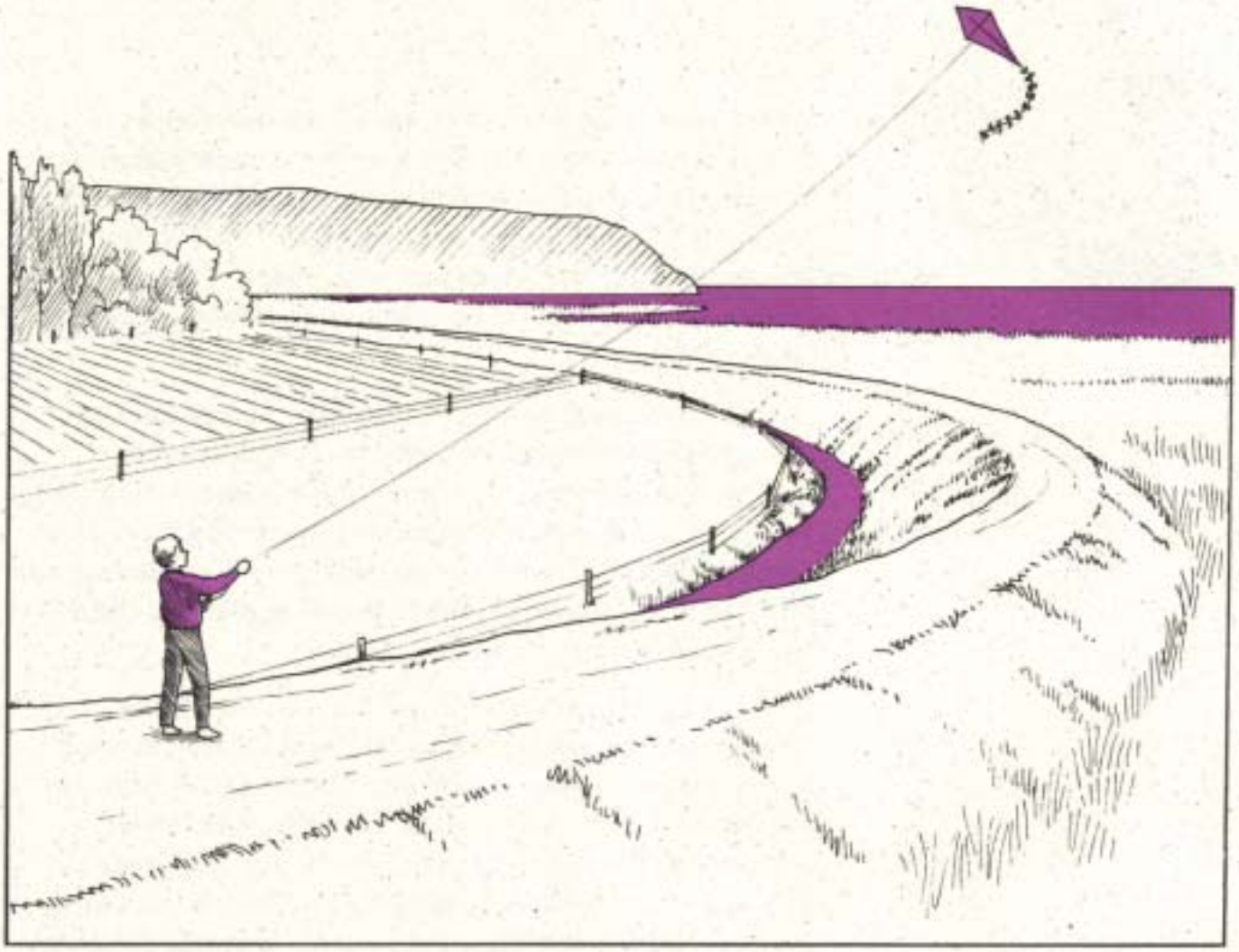


**FIGURE 3-7**
Foreshore Dike

This diking had a dramatic environmental impact. As a result, today we see a very different estuary than the one that existed only one hundred years ago. The size of the delta lands is of course very nearly the same, and the river still delivers a similar sediment load. However, with the barrier of dikes in place to protect the farmlands, the Fraser River and the tides no longer deliver their vital floodwater and sediments to the delta's marshes and wet meadows.

Over the past century, approximately one half of the original wetland habitats have been lost to agriculture, and urban and industrial development. Virtually all of the seasonal wet meadows have disappeared, along with most of the bogs and floodplain forest. Only the outer brackish wetlands which were too difficult to dike and saltmarshes which were too salty to cultivate remain.

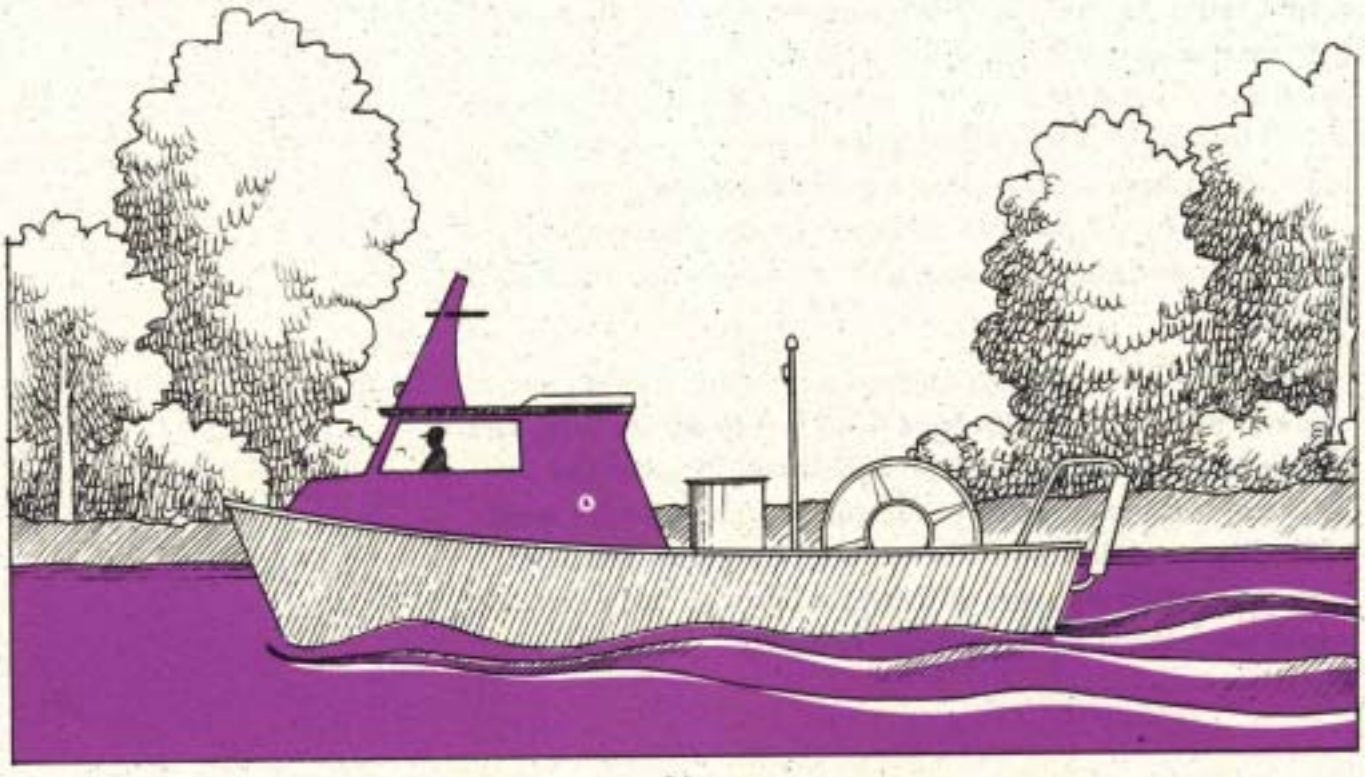
## Present-Day Use

Where once there were wetlands on the delta land of Surrey, Tsawwassen and Delta, there are now highways, airports, industrial areas and agricultural lands. Farmland has spread tremendously since the delta lands were protected from river floods and ocean tides. These delta lands constitute some of the most productive agricultural land in Canada.

The traditional berry picking of the aboriginal has expanded into commercial farms that produce crops of raspberry, blueberry, strawberry and cranberry. However, we do not see new farmland coming into production. The population of the Lower Mainland is quickly expanding and much of this residential growth is taking place on the delta lands of Richmond, Delta and Surrey.

Despite the population growth, the Fraser River Estuary still supports large numbers of salmon, herring and shellfish. Approximately one quarter of the crab harvested in British Columbia come from the Fraser Estuary. At the mouth of the Fraser River, hundreds of gillnetter fish boats work the Sockeye Salmon runs each summer, taking 70% of all the British Columbia Sockeye. Well over 50% of all British Columbia salmon come from the Fraser River.

**FIGURE 3-8**
A Gillnet Fishing Boat



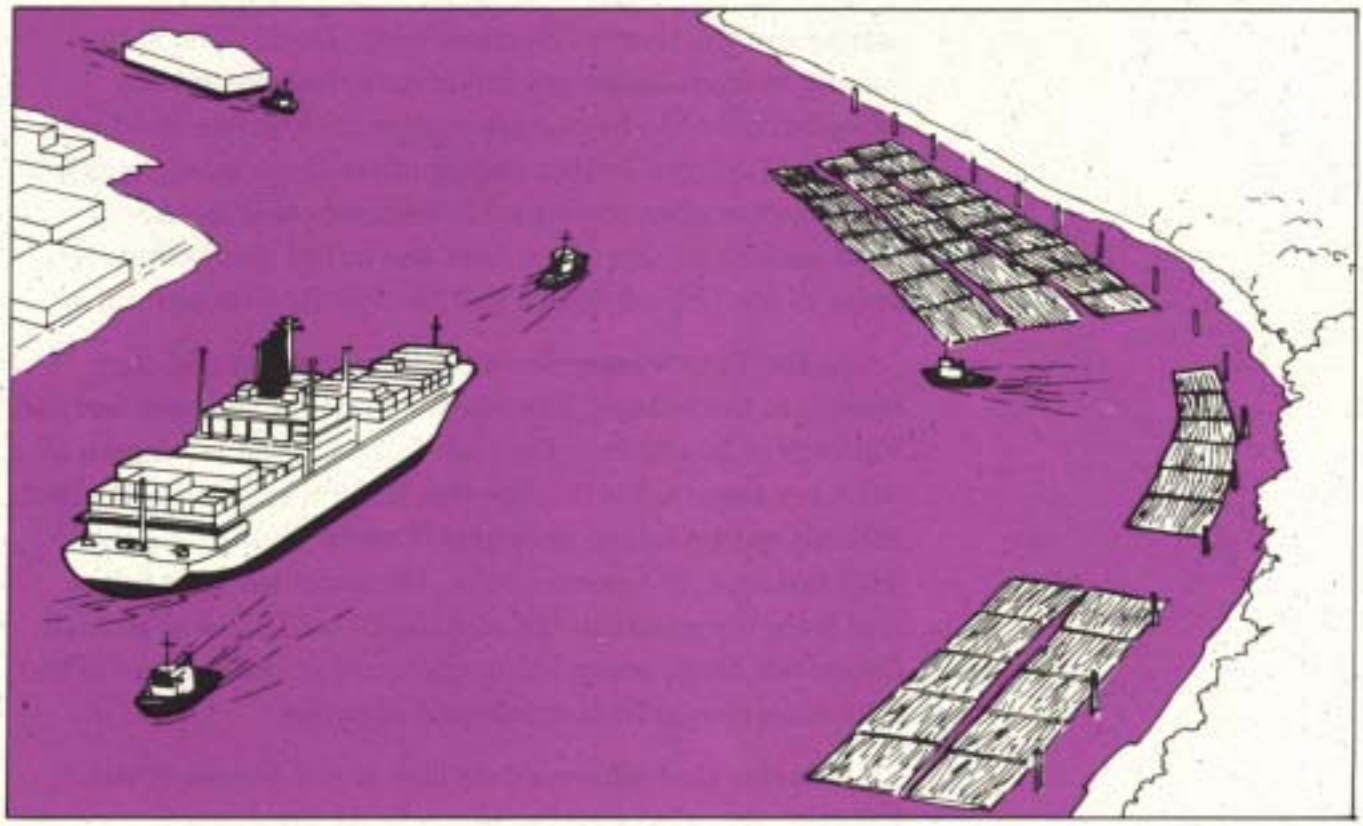


**FIGURE 3-9**
Logbooms, Tugs, Freighter and Barge using the Fraser Estuary

The Fraser Estuary also supports commerce and industry, particularly the forest industry. The traffic on the river is constantly busy with tugs hauling huge log booms and towing barges filled with woodchips. Along the river, saw mills and paper mills produce lumber, shakes, shingles and plywood for building homes, paperboard for packaging, newsprint for newspapers, and even paper to produce this book.

Almost all these mills produce and store wood chips that are then loaded into barges, some of which are towed to pulp and paper mills where the wood chips are transformed into paper. Wood chips are also transferred to ocean vessels for shipping to Japan, where they are used in paper production.

Because of the fiords and the rugged coastline of British Columbia, there are no coastal highways. Logs are therefore taken down to the sea where they are bundled into booms and towed by barge to be stored in the Fraser River Estuary. The estuary protects these log booms from ocean storms and wood boring, marine invertebrates until they are needed by the mills.

Also on the river, huge ocean ships make their way into the estuary upstream to the docks at Annacis Island and

just across the river at Surrey-Fraser Docks. The ships coming in from Japan are full of cars that are quickly offloaded onto the huge parking lots on Annacis and Lulu Island. At Surrey-Fraser Docks, other ships being loaded with cargoes of wood chips, lumber and other products head back down the Main Arm and out to sea, bound for ports in the United States and the Pacific Rim countries.

At the Tsawwassen ferry terminal, trucks and cars cram into the holding lots waiting to board the next ferry to Vancouver Island or to the Gulf Islands. And just north of the ferry terminal is the Roberts Bank Superport jetty that extends out into deep seawater. Trains crawl along the jetty heading for the sea docks. These railcars are full of coal from the mines in the south-east coal block of British Columbia. Huge ocean ships stationed at the sea end of the jetty receive coal from stockpiled supplies.

It seems that wherever we look in the Fraser River Estuary, there is some human activity involving commercial fishing boats, tugs and barges, log booms, dredging operations, police boats, Harbour Commission boats, sailboats and pleasure craft, ocean-going ships from around the world, and coastal ships moving wood products.

River-frontage is also becoming increasingly popular for housing and condominium projects and commercial retail businesses. These new foreshore users are displacing or coexisting with long established facilities such as wood mills, log booms, fishing boat marinas, fish processing plants and barge terminals.

**FIGURE 3-10**

## ACTIVITY 8:
## THE CHANGING ESTUARY

The fertile deltas of estuaries have attracted human use and settlement throughout the ages. Over the centuries, wetlands, floodplain forests, river channels and sloughs have been used by people in many different ways.

The objective of this activity is to match different historical time periods for the Fraser River Estuary with the type of non-leisure human activites that occurred then.

Place the numbers of the human activities listed below into the appropriate historical time period shown in Figure 3-11. You can use an activity in more than one time period.

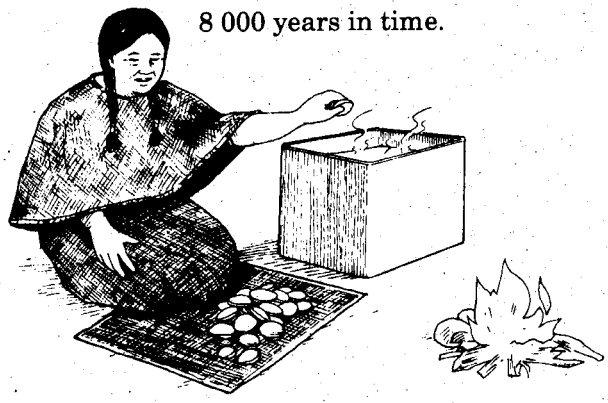
1. Industrial Development
2. Land Clearing
3. Exploring
4. Freighter Traffic
5. Surveying
6. Gillnet Fishing
7. Floodplain Logging
8. Upland Logging
9. Fur Trading
10. Food Gathering
11. Hunting
12. Road Building
13. Diking
14. Fishing
15. Steamboat Travel
16. Dredging
17. Port Development
18. First Railway Development
19. Urban Development
20. Airport Development
21. Farming
22. Fish Canning
23. Gold Rush Traffic
24. Add some more of your own . . .

Answers in Appendix 1, page 111.

**Figure 3-11.** The Changing Estuary

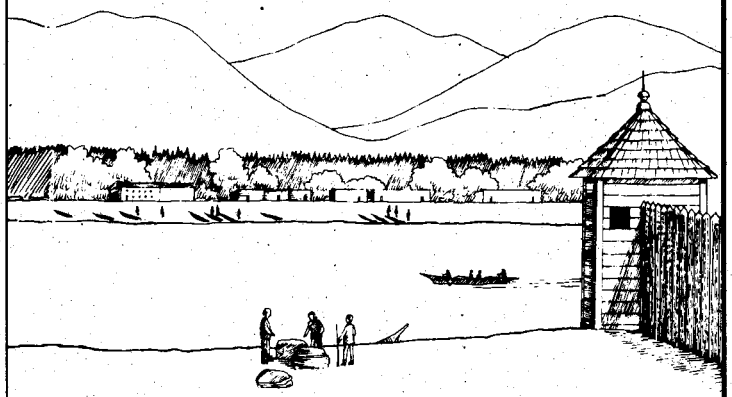
### Period of Pre-white Settlement

Use of the estuary by Coast Salish people goes back 8 000 years in time.



### 1820's to 1830's

In 1827 Fort Langley was established on the banks of the Fraser River.



### 1840's to 1860's

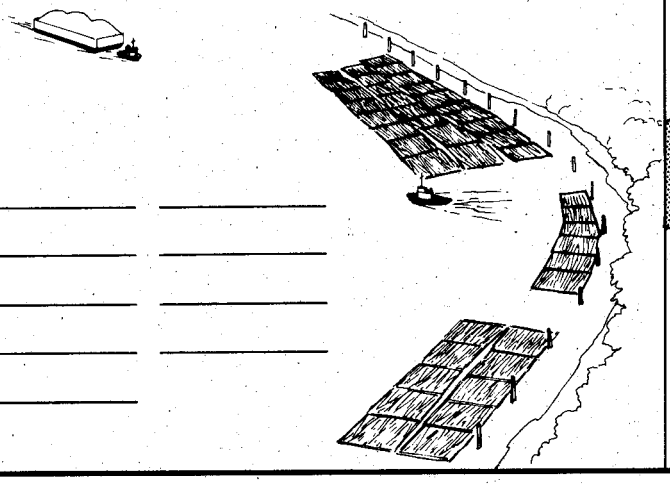
The gold rush of 1858 brought new people into the estuary, some of whom stayed.

### 1870's to 1890's

Pioneers began to farm the rich delta lands and form small communities.

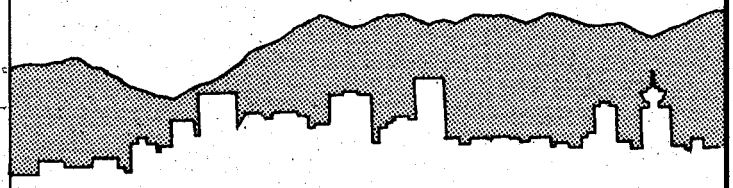
### 1900's to 1940's

The estuary became an important area for agriculture and sawmills.



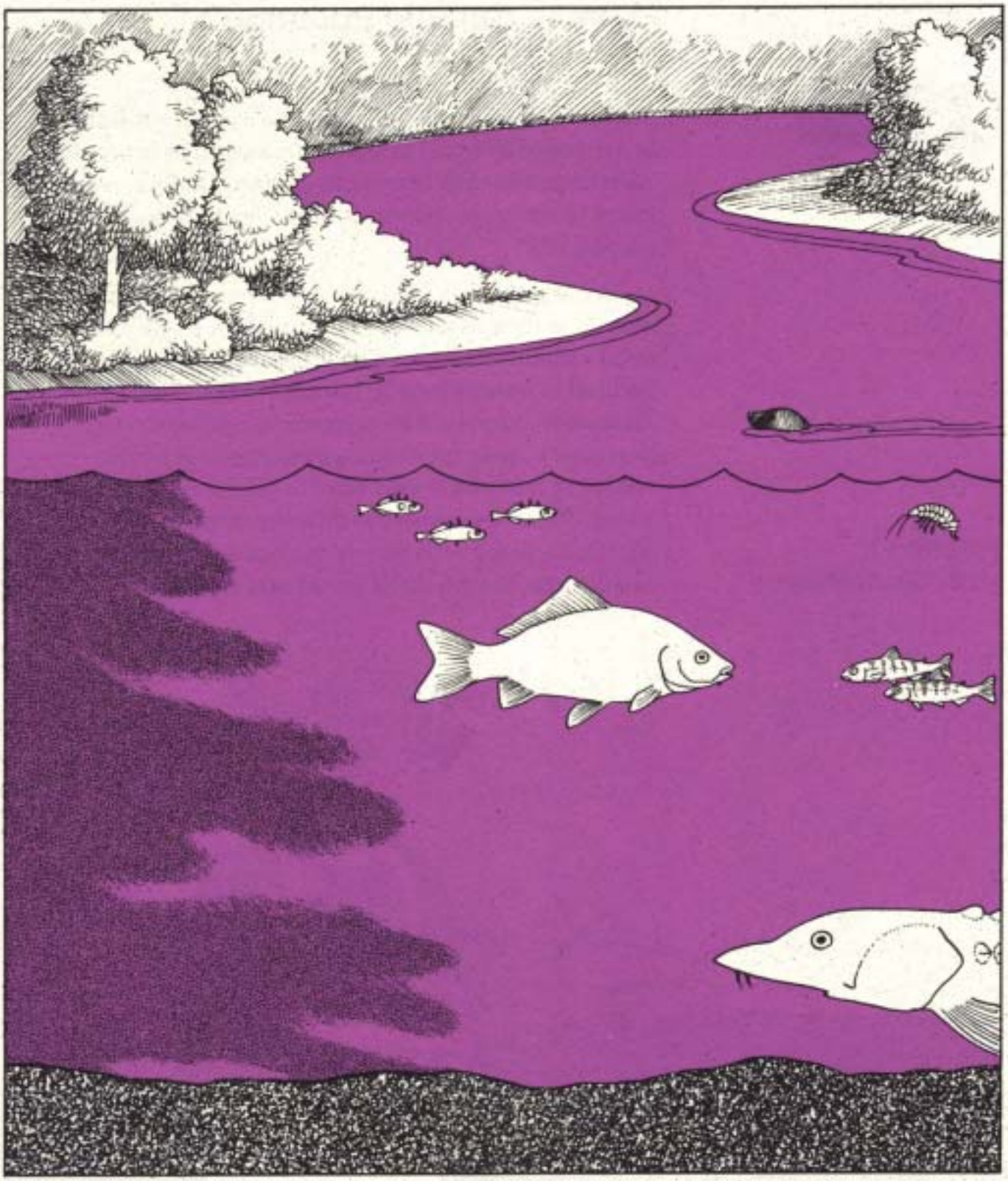
### 1950's to Present

The growing population of the Lower Mainland expanded onto the delta lands.



Once you have matched the human activities with the correct historical periods, think about the following important questions:

1. How have these human activities affected the estuary?
2. What type of habitats do you think were most affected?
3. What has been the benefit of these activities to humans?
4. What do you think people did about protecting and conserving fish, wildlife and habitat in each of the historical periods?
5. Which present-day human activities do you think are, and which are not, a problem in the estuary?



# 4. AQUATIC POLLUTION

Water is essential to aquatic habitats in estuaries because it provides many of the life-sustaining chemicals required by aquatic plants and animals. So we should be concerned about the potential effects of pollution on the estuary's aquatic habitat. This chapter describes some of the characteristics of pollutants.

## What is Aquatic Pollution?

When we talk about a pollutant, we mean a substance that is not normally found in the environment, or is present in such large amounts that it can do harm. Pollution can be found in water, in sediments, and even in fish and other aquatic life.

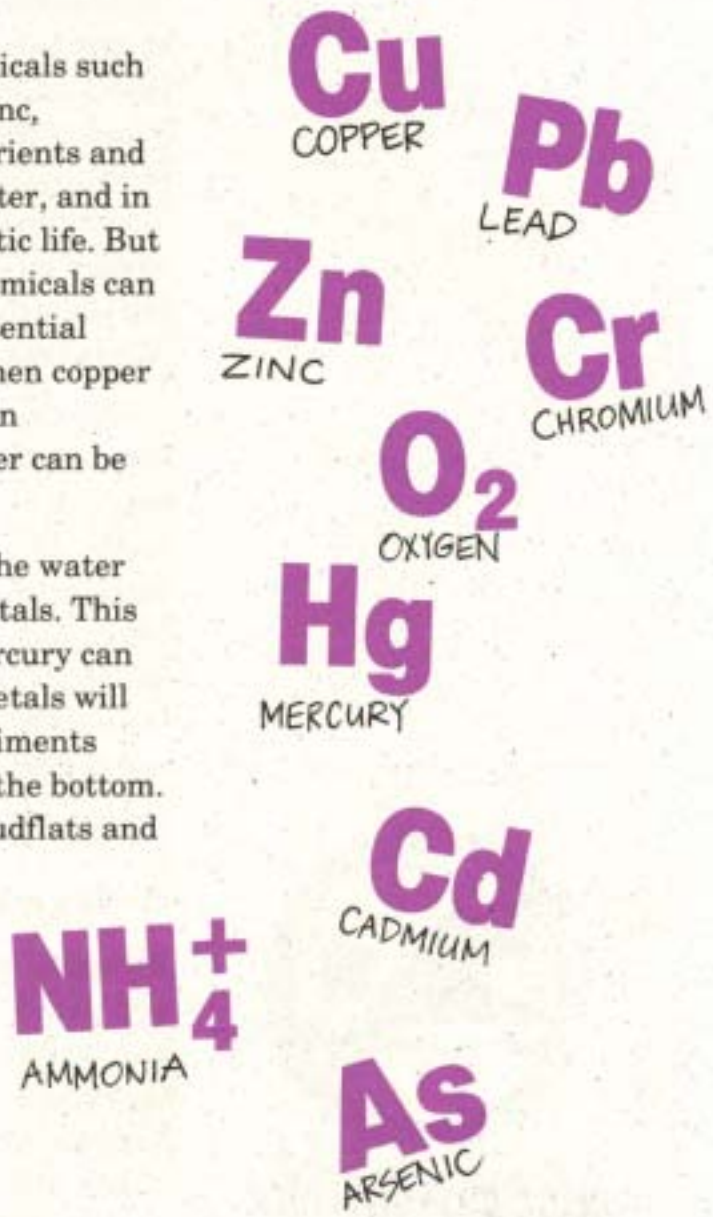
Some pollutants in an estuary are toxic to aquatic life even in minute amounts. For example, a single salt-grain-sized amount of copper (a toxic metal) dissolved in a bathtub of water would be harmful to fish. The same tiny amount of dioxin (a toxic organic contaminant often produced by pulp mills) in a swimming pool would endanger humans, if they were to take a drink of this water. There are numerous different inorganic and organic chemicals, along with various biological substances, that can degrade the quality of an estuary's water.

**FIGURE 4-1**
Water Quality Sampling

## Inorganic Pollutants

Inorganic pollutants may include nutrient chemicals such as ammonia, and metals such as copper, lead, zinc, chromium, cadmium, arsenic and mercury. Nutrients and even metals occur naturally in fresh and sea water, and in proper and small amounts are essential to aquatic life. But when concentrations become too high, these chemicals can be harmful to life. Copper, for example, is an essential element in the blood of crabs and shrimp; yet when copper levels are elevated, it can kill the animal. Certain concentrations of ammonia dissolved in the water can be deadly to fish under certain conditions.

Sediment particles which are suspended in the water can serve as "attachment sites" for dissolved metals. This means that metal pollutants such as lead or mercury can become concentrated on suspended particles. Metals will then accumulate where these contaminated sediments settle out of the river flow and are deposited on the bottom. In this way, water pollution can contaminate mudflats and other places where sediment settles.




## Organic Pollutants

Naturally occurring organic matter exists in particulate or dissolved form, and comes from living and dead plants and animals. This natural organic matter does not normally become a problem, because it is quickly recycled in the estuary by microorganisms and small detritus-eating invertebrates (see Food Chains and Food Webs in Chapter 1). However, even organic matter can cause pollution when too much accumulates and the estuary's natural recycling capacity is overloaded.

Too much organic matter stimulates the growth and activity of large numbers of bacteria and other microorganisms. As the bacteria "feed" on the organic matter, they use up much of the available oxygen in the water. This oxygen depletion can make it difficult for fish to breathe, and will often lead to their death.

Some organic pollutants are human-made, and these are of particular concern when they do not easily break down in the environment. PCBs (Polychlorinated biphenols, found in the cooling oil of large transformers); some pesticides (used to kill agricultural and garden pests); and dioxins and furans (chemical byproducts of industries such as pulp mills) are toxic organic pollutants that, once introduced into the environment, do not easily break down into harmless components.

Dioxins are an environmental hazard not only because they are very toxic, but also because they can be long-lasting in the environment. Natural recycling processes do not work very well with dioxins. Rather than being broken down into harmless products after they enter the estuary, they are often taken up and concentrated in aquatic organisms. This concentration of toxic substances in aquatic plants and animals is called "bioaccumulation," and is a potentially serious problem in any ecosystem.


## Biological Pollutants

Biological pollutants consist of harmful bacteria, viruses and parasites that come from disease-carrying human and animal wastes. When these pollutants enter the estuary, they can be dangerous to people who come into contact with the water. Biological pollutants can cause a number of health problems in humans, including intestinal disorders (e.g., gastroenteritis), blood diseases (e.g., hepatitis) and parasitic infections (e.g., tape worms). To avoid the spread of human disease organisms, sewage is chlorinated (a disinfection process) before being discharged into the estuary during the summer months.

Those of us who like to eat oysters, clams and mussels must also be concerned about biological pollutants. This is because these animals feed by filtering large amounts of estuarine water through their gills. If the water is contaminated with biological pollutants, these animals will concentrate the pollutants in their body and pass them on to the person who eats them. This is precisely the reason why Boundary Bay, along with all other areas of the estuary, has long been closed to the harvesting of molluscan shellfish.

## Bioaccumulation

As discussed in the section on dioxins, "bioaccumulation" is the term used to describe the uptake and retention of chemical contaminants which aquatic plants and animals obtain from food, water or sediments. Bottom-dwelling organisms such as worms, clams and groundfish that feed off the river bed can easily take up pollutants that have settled out with the sediment. Toxic organic pollutants which are not easily degraded by natural means tend to remain inside the bodies of these bottom-dwelling organisms.

Consider the case of a toxic chemical that is discharged into the estuary. It may enter the estuary in a number of ways: from a discharge pipe, from a ditch, from surface or groundwater, or even from the air. Once the chemical enters the water, it is usually diluted to a concentration that is too low to measure with even the most sensitive instruments. However, by providing numerous attachment sites on its surface (Figure 4-2), an organic sediment particle can concentrate the toxic chemical.

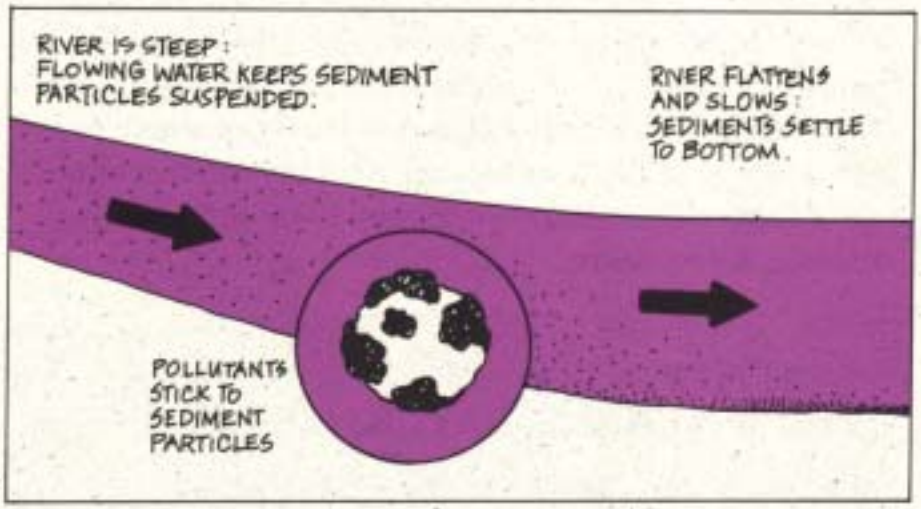
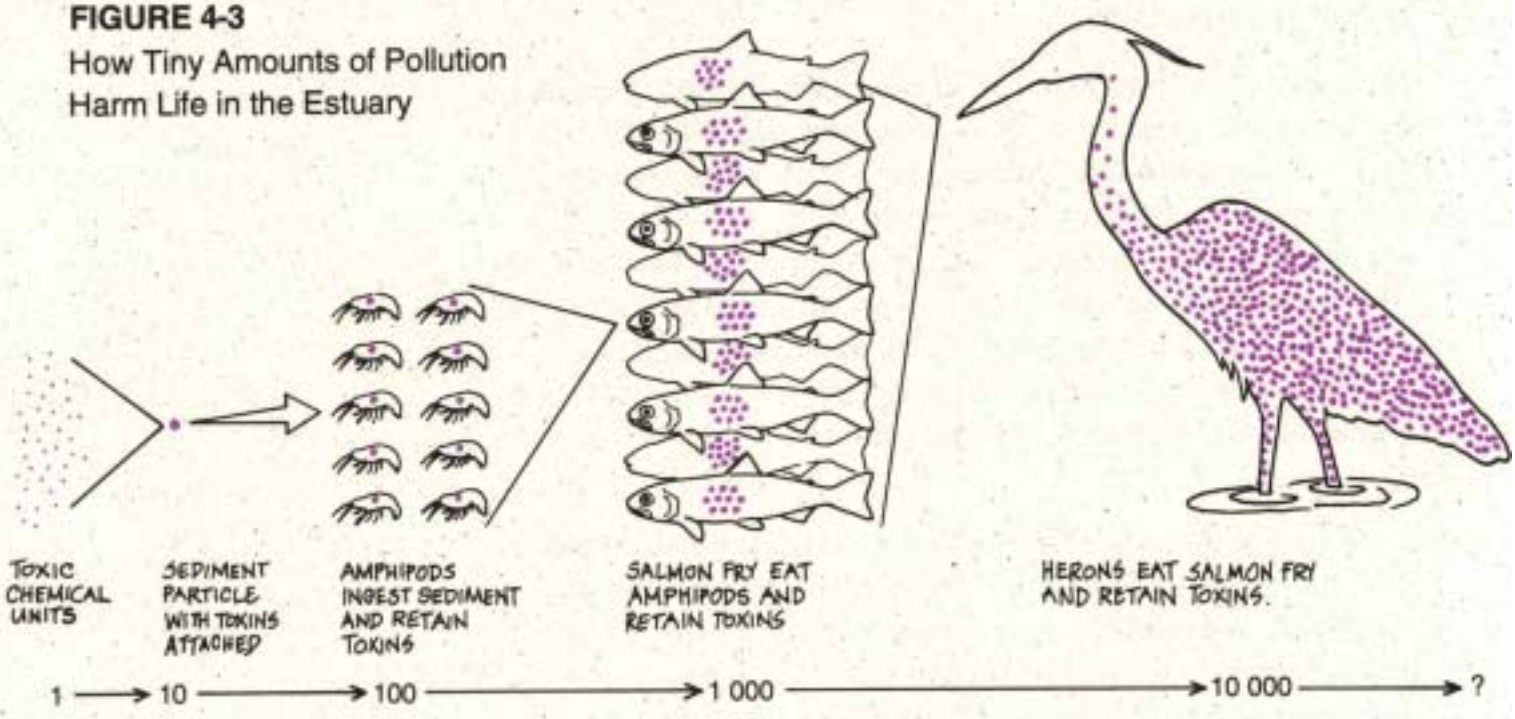



**FIGURE 4-2**
Pollution of Sediment Particles and River Bottom

The process of bioaccumulation is illustrated on the following page, Figure 4-3. In this example, a dissolved toxic chemical is concentrated ten-fold as it is attached to organic sediment particles which eventually settle to the bottom. There, bottom-dwelling amphipods are shown to consume ten of these contaminated particles. A small fish feeds on ten of these contaminated amphipods, and a Great Blue Heron then feeds on ten of the contaminated fish.

**FIGURE 4-3**
How Tiny Amounts of Pollution Harm Life in the Estuary




At each step of the food chain, the toxic contaminant is bioconcentrated ten-fold. By the time the toxic chemical reaches the Great Blue Heron, it has been biomagnified ten thousand times from its original minute (unmeasurable) concentration in the water. The unfortunate animal (perhaps a Bald Eagle, crow, seagull or coyote) that eats one of these sick or dead herons may have its life threatened as a result.

## ACTIVITY 9: THE ESTUARY'S NATURAL FILTER

(adapted from: *Discover Wetlands, A Curriculum Guide*, Washington Department of Ecology, 1988)

Estuaries are the final receiving water for a wide variety of pollutants. Marshes help to keep the estuary's water clean and healthy by filtering and removing these harmful pollutants. This natural filter has the following properties:

1. As water currents are reduced in marshes, suspended sediments, along with any attached contaminants, settle to the bottom. Water flowing out of the marsh is therefore cleaner and purer.

2. Marsh plants can absorb most dissolved toxic contaminants. Some of these pollutants can actually be turned into harmless products inside the plants. Other pollutants end up below the soil in the plant roots. Here the pollutants are incorporated into the soil or are rendered harmless by bacteria.

**Objective:**

You can study the powerful ability of plants to absorb dissolved substances by doing the following experiment which simulates how pollutants can be absorbed into a living organism.

**Procedure:**

Step 1 and 2 of this experiment should be prepared one day ahead.

1. Prepare a coloured solution in a glass container by adding several drops of food coloring (red is a good color) to water. Think of the food coloring as representing pollution by a toxic substance.

2. Cut a small piece off the bottom of a celery stalk and place it in the water overnight (Figure 4-4). Over time, the colored water will visibly travel (by a process called osmosis) up the stalk. This shows how plants can absorb pollutants with the water they "drink." If the colored water is not visible on the outside of the stalk, break it open to reveal the color inside.

3. Imagine that the celery stalk represents a marsh plant, and that millions of these plants growing in a tidal marsh are absorbing pollutants from water in the estuary.

There is, of course, a limit! Plants can store and degrade only a limited amount of pollutants. Some of these stored pollutants can be released back into the aquatic environment as the plants die and decompose. Too much pollution, especially toxic chemicals which are persistent in the environment, will eventually harm and destroy life in the estuary. The best solution is to reduce pollution — or better yet, to eliminate it.

FIGURE 4-4

### Down the Drain!

Many common household products contain substances that are toxic to aquatic life. Household chemicals such as toilet and oven cleaners, bleaches, household paints and thinners, insecticides, camping fuels and antifreeze all contain toxic chemicals.

Many people don't realize that these products are toxic to aquatic life and most of us don't know how to properly dispose of these hazardous materials once we are finished with them. As you can see in Figure 4-5, the worst way to get rid of left-over products is to flush them down the toilet, pour them into the kitchen sink, or dump them into a curbside stormdrain. If we do this, these toxic chemicals will eventually end up in our estuary where they can harm the aquatic life.

If you do not want toxic chemicals in household products to harm your estuary, dispose of them properly. Contact your local municipal hall or the Recycling Hotline (see Appendix 3) to find out the best way to dispose of your household chemicals.

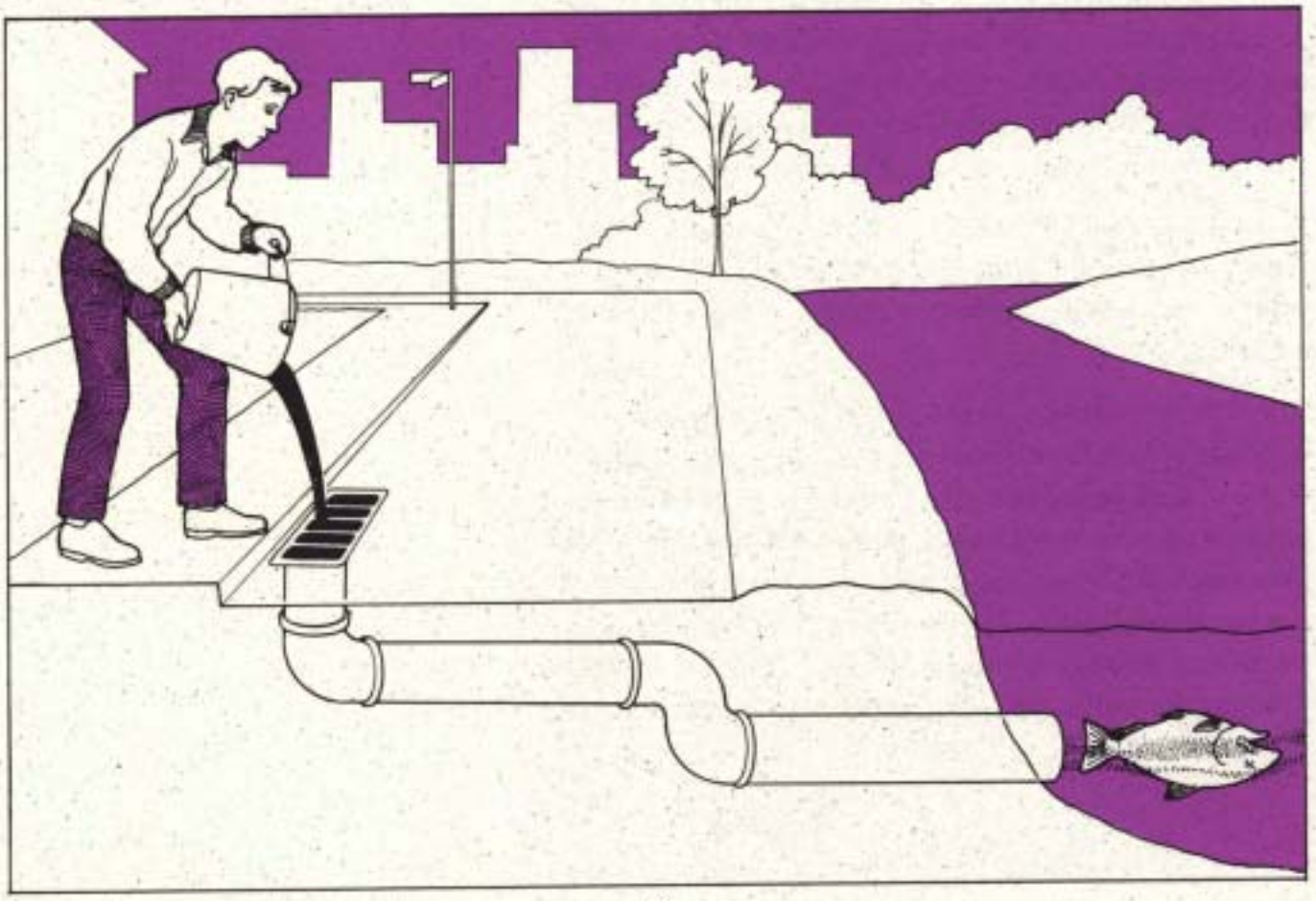


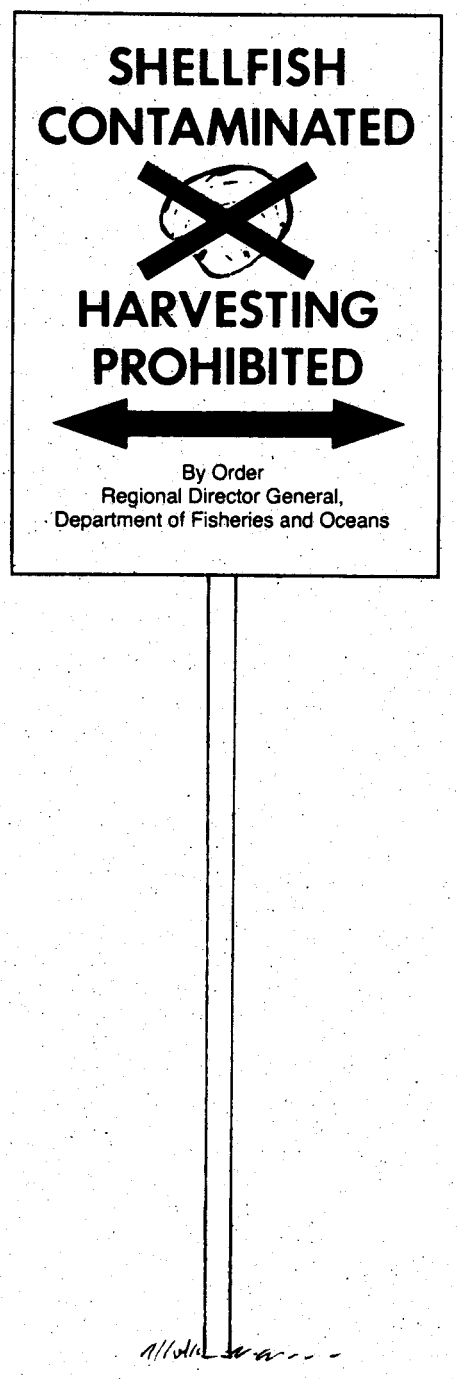
**FIGURE 4-5**
Never Use a Storm Drain for Disposing Waste Materials!

## Too Much of a Good Thing!

It is a well known fact that animal manure serves as an excellent soil fertilizer by providing plant nutrients to enhance the growth of crops. However, too much nutrient supply in aquatic ecosystems will often result in problems. This was the case during the 1980's, when heavy rainfall flushed large amounts of nutrients (animal manure and other agricultural fertilizers) into drainage canals and sloughs that eventually fed into the Nicomekl and Serpentine Rivers. These nutrients stimulated excessive growths of algae. When the algae died off in the fall, there was a large biological oxygen demand which rapidly depleted the dissolved oxygen levels in the river water. This sequence of events resulted in major fish kills in the Serpentine and Nicomekl Rivers.

When animal manure is flushed into local drainages, it can introduce high numbers of coliform bacteria into adjacent parts of the estuary. Both the Serpentine and Nicomekl Rivers drain into Boundary Bay. The continuous high levels of coliform bacteria discharged each year into Boundary Bay have resulted in chronic bacterial contamination of molluscan shellfish. As a result, shellfish harvesting has been banned since 1962, eliminating one of the most important oyster production areas in British Columbia.

**FIGURE 4-6**



## ACTIVITY 10: MATCHING POLLUTANTS AND SOURCES

The various types of pollution described in this chapter can originate from many different sources in the estuary. The nature of the pollutant usually provides some clues to its source. Identifying pollution sources is an important step towards protecting the water quality of the estuary.

The objective of this activity is to match the various pollutants with their potential sources, as shown in Table 4-7. Place a mark (X) in any box of the table where a pollutant matches a potential pollution source. Once you have filled in the table, think about the following questions.

How do these pollutants get from the source to the estuary?

Do you think this pollution could be prevented or reduced?

Can you think of any other potential pollution sources?

What type of pollutants could originate from these other sources?

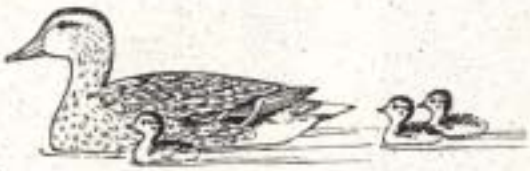
Answers in Appendix 1, page 112.

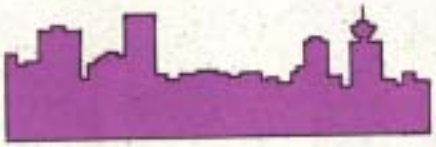
**TABLE 4-7**
Chart for Matching Pollutants and Their Sources

| POLLUTANTS | POLLUTION SOURCES | | | |
|---|---|---|---|---|
| | Household | Pulp Mill | Farm Field | Automobile |
| Bacteria | | | | |
| Copper | | | | |
| Dioxins | | | | |
| Herbicides | | | | |
| Lead | | | | |
| Oil | | | | |

# 5. GETTING INVOLVED

This chapter includes ideas and suggestions on what each individual or citizen group can do to become actively involved in the protection, conservation and management of their estuary.





## Public Awareness

We should all be seriously concerned about the overall health of the estuary, especially if one considers the following:

1. We are part of the earth's biosphere. We need clean soil, water and air to sustain ourselves. The health of our estuary is a good indication of how well we are protecting and managing the environment and, in the long run, how well we are protecting our own health and that of future generations.
2. The Fraser River Estuary supports a valuable salmon fishery worth several hundred million dollars annually from commercial, recreational, and aboriginal food catches. Indeed, the Fraser River is the largest salmon producing river in the world.
3. The wetlands of the estuary are vital to the survival of millions of migrating waterfowl. Again, the Fraser River Estuary has world class status with respect to its bird habitat and its important position on the Pacific Flyway.
4. On a global perspective, we are exceptionally privileged to have such a rich natural heritage as the Fraser River Estuary adjacent to an urban population (Greater Vancouver Regional District) of more than 1.5 million.

What can we, as individuals, do to help protect, conserve and possibly improve the aquatic environment of the Fraser River Estuary? Much of the pollution entering the estuary originates from our own actions. So, to begin with, we can make some changes in our personal habits which, collectively, will make a big difference in the amount of pollution entering the environment.

Secondly, as organized groups, we can take political action to help improve the government rules and regulations that protect and manage the ecosystem of the estuary.

## Individual Actions

Hundreds of good ideas on what individuals can do for their environment are available from government publications such as the federal Department of the Environment's *What We Can Do For Our Environment*. Contact your local federal and provincial environment office, or your local municipal hall to receive these free publications. These, and a continuing supply of new publications, provide ideas on simple things that can be done by anyone, right now:

- ☐ how to conserve water
- ☐ how to conserve energy
- ☐ how to dispose of household hazardous wastes
- ☐ how to find safe alternatives to hazardous substances
- ☐ how to prevent and reduce air pollution
- ☐ how to reuse, repair, recycle, and reject waste material
- ☐ how to shop for environmentally friendly products
- ☐ how to read and learn more about the above topics

**FIGURE 5-1**
Recycyling is Now Everyones' Business

# Group Actions

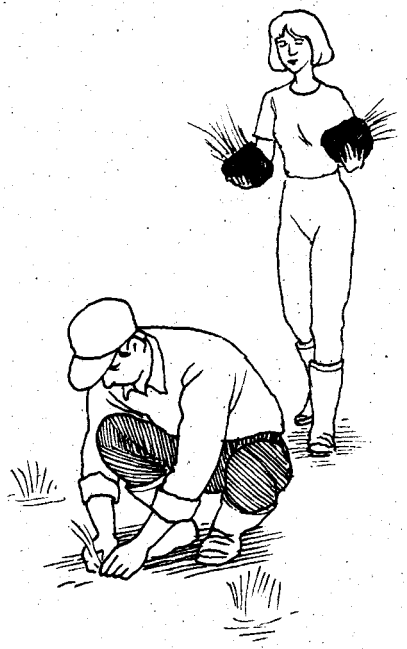
Public groups and organizations are an increasingly effective force in helping to protect and conserve the natural resources of the Fraser River Estuary. Public groups can consist of youth groups, business groups, civic organizations, faith groups, union organizations, women's groups, neighborhood or community associations, and special interest organizations.

One of the first steps for an individual would be to join, support, or if necessary form a public group which is interested in group projects or actions directed at protecting and conserving the natural resources of the estuary.

The following are some ideas on group projects and activities:

1. There are many opportunities for undertaking clean-up projects along the river banks of the estuary. Garbage and other refuse continues to be illicitly dumped and then washed up on the estuary's shorelines. This refuse is not only an eyesore but can be damaging to marsh and mudflat habitats. Choose your favorite location(s) in the estuary and organize a clean-up.

2. Degraded marsh habitats are now being restored by government and industry. These are interesting projects which typically involve the transplanting of marsh vegetation to unvegetated sites. With technical assistance from the Department of Fisheries and Oceans (DFO) or an environmental consultant, a school or other public group could provide the much-needed manual help required for a marsh restoration project. Monitoring the marsh growth could provide a valuable project activity.

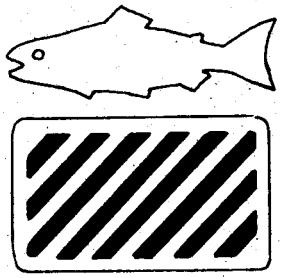


3. The federal Environmental Partners Fund program makes funds available to groups on a 50-50 cost-sharing basis for approved environmental clean-up and restoration projects. The Public Conservation Assistance Fund is a similar program sponsored by British Columbia Environment, Lands & Parks (ELP).

4. Environmental groups are always in need of financial support. Your group can hold a fund-raising event and donate the money to a local environmental organization which is involved in a particular cause for the estuary.

5. Enhance the environmental education and awareness of your group by organizing presentations by environmental experts from government, universities, consultants or other environmental groups. Obtain free publications and videos from government offices. Project Wild, an education program which emphasizes awareness, appreciation and understanding of wildlife and natural resources, can be tapped by your group (contact ELP). Arrange tours of industries located in the estuary, bird sanctuaries, and municipal and regional parks which support estuarine habitats.

6. Use your increased knowledge and awareness of the estuary's ecology, its pollution problems, and how the public can help, to involve other, uninformed people in your community. The Storm Drain Marking Program sponsored by the British Columbia Conservation Foundation, DFO and ELP is a good way to increase your community's awareness about pollution in the estuary. Storm drains have been marked to prevent people from disposing of hazardous waste which could harm fish and other aquatic life.



If you require some technical information about a particular commercial, industrial or household harzardous material, contact the Canadian Chemical Producers Association (**1-800-267-6666**).

7. Your group can start a pollution watch program. Any suspicious looking effluent discharges, illegal dumping, vandalism and fish kills can be reported to local enforcement authorities. The following telephone numbers may be useful in case you observe a problem or environmental emergency:

   **Provincial Emergency Program**
   Report on oil or chemical spills and advice on the disposal of hazardous materials.

   **1-800-663-3456.**

   **B.C. Environment Hotline**
   Observe, record, and report any violation of fish and wildlife regulations.

   **1-800-663-9453**

8. Businesses and industries which are environmentally irresponsible can be approached directly. Use the influence of your group's name and membership numbers to address letters to the president of the offending companies. Most corporations hate bad publicity and are usually understanding and cooperative if approached in a polite and objective manner.

9. Get your group involved in environmental issues which may be of concern. All large and most small development proposals are subject to an environmental review process. Government agency reviews of development proposals on the foreshore and in the river are now coordinated by the Fraser River Estuary Management Program (FREMP) office. FREMP will also facilitate public input in these environmental reviews. The best time to voice a concern is before the proposed project is granted approval. Issues related to the land side of the dike can usually be pursued most effectively through your local city council.

The Fraser River Basin Management Program, which is supported by Federal, Provincial and local governments, encourages and provides the opportunity for the public and other interested groups to participate in management of the Fraser River basin. If you require more information on this program, please contact:

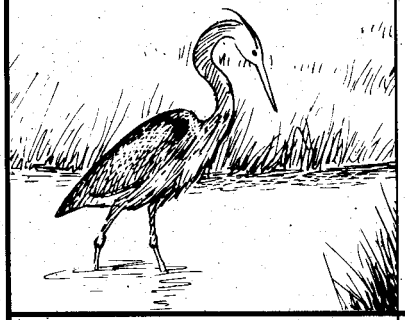
Environment Canada
Communications
224 West Esplanade
North Vancouver, B.C.
Canada V7M 3H7

Tel: (604) 666-5900

# ACTIVITY 11: FRASER RIVER ESTUARY WHIZ QUIZ !

My name is: _____ (adapted from: *The Estuary Program - Level II*)

1. Where a river meets the sea is an _____.



2. _____water and

_____ water

mix in an estuary to form

_____ water.

3. Zooplankton 

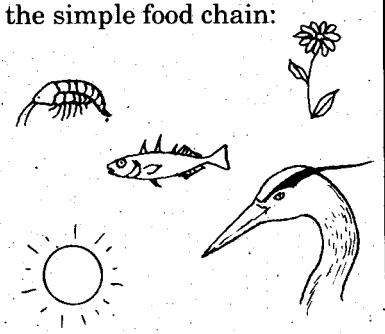
are tiny _____

& 

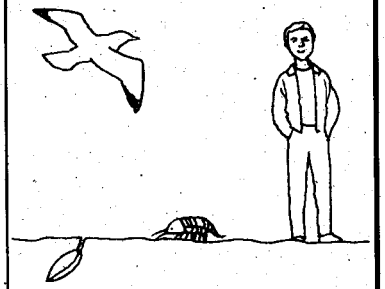
_____plankton

are tiny plants.

4. Draw connecting lines for the simple food chain:



5. Circle those that eat detritus.



6. How many estuarine organisms starting with the letter **S** can you think of?

_____ _____

_____ _____

_____ _____

7. Which plants grow in an estuary?

____ spinach
_____ algae
_____roses
____ cat-tails
_____ eelgrass
_____ papaya
_____ saltgrass

8. Which one of the following plants are trees or shrubs?

___ Bulrush
___ Snowberry
___ Hardhack
___ Sedge
___ Black Cottonwood

9. CONNECT:

| Animal | Habitat |
|---|---|
| Plankton | eelgrass |
| Crab | slough |
| Salmon | tidal flat |
| Snail | channel |
| Sandpiper | marsh |

10. What's wrong with this picture?

_____

_____

11. True or False?

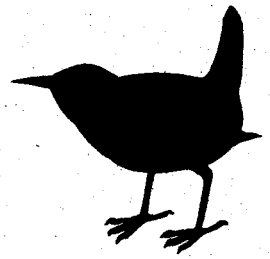
A freshwater plume is a type of marsh flower _____.

Detritus is the base of the food web in estuaries _____.

Ghost shrimp live in mudflat burrows _____.

Bacteria found in estuaries are always harmful _____.

12. Can you identify this estuarine bird?

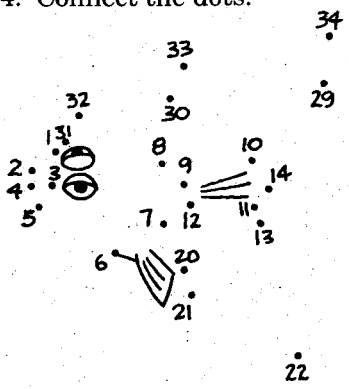


Answer: _____

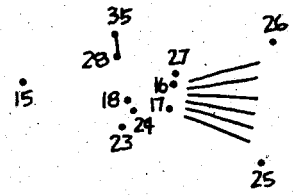
13. Unscramble the following words:

TTIAAHB
ONTIULLOP
RAMSH
KRABSCHI
NOMALS

14. Connect the dots.



What is it?



_____

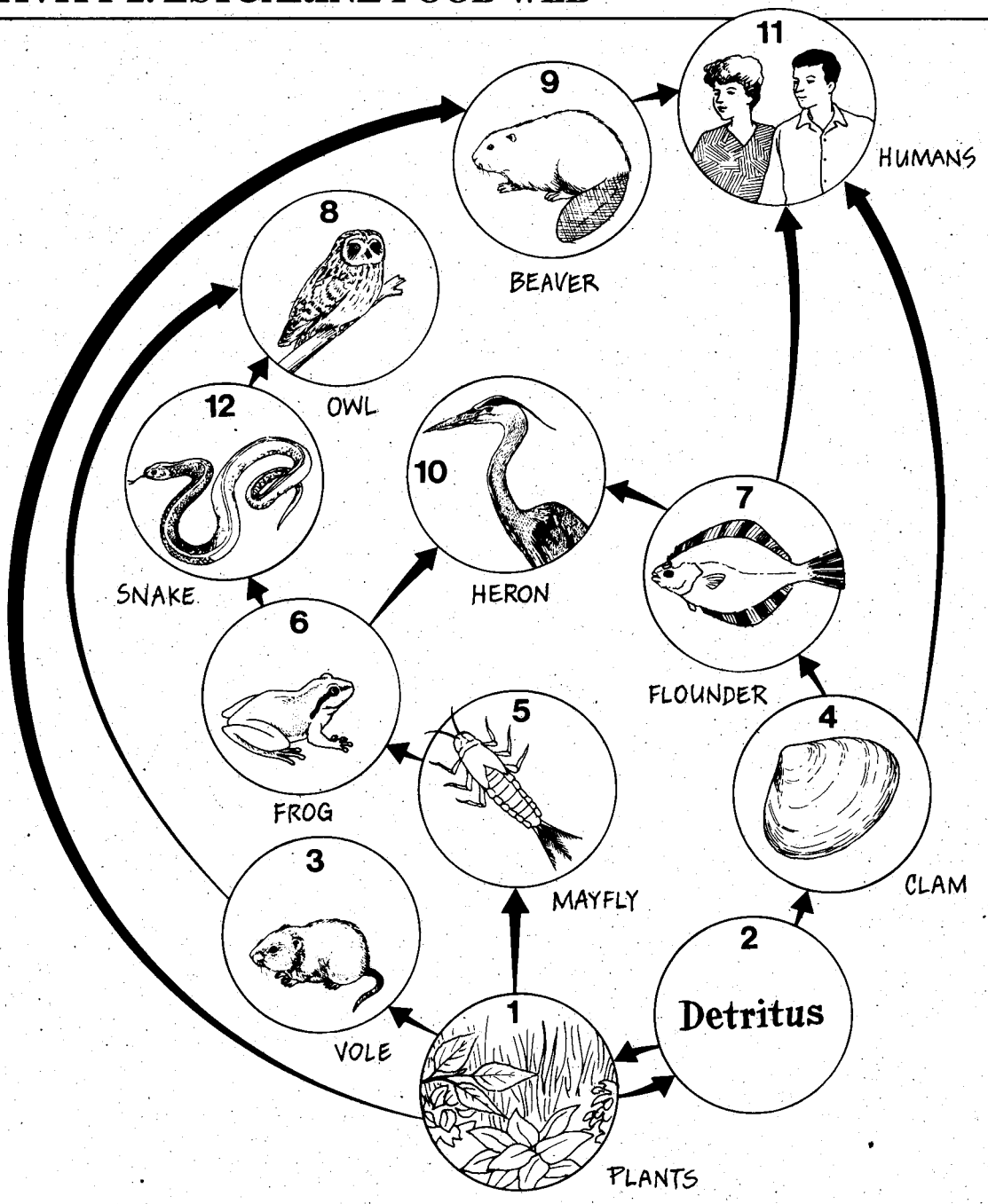
# APPENDIX 1:

## ANSWERS

### ACTIVITY 1: ESTUARINE FOOD CHAIN

SUN ⇒ PLANT ⇒ DETRITUS ⇒ CLAM ⇒ SEAGULL CHICK ⇒ BALD EAGLE

### ACTIVITY 2: ESTUARINE FOOD WEB



## ACTIVITY 3: CRITICAL TIDAL ELEVATIONS

| | |
|---|---|
| Start of mudflat and end of the marsh | 2.8 m |
| Beginning and end of bulrush zone | 2.8 m and 3.7 m |
| Beginning and end of sedge zone | 3.7 m and 4.5 m |
| Beginning and end of cat-tail zone | 4.5 m and 4.8 m |
| Top of dike | 5.8 m |

The following is a brief explanation on how to predict tides using the *Canadian Tide and Current Tables, Volume 5*. You should also take the time to carefully read the instructions provided with these tide tables.

Turn to the section in the tide tables with the heading "POINT ATKINSON". This set of tide tables predicts tide levels for the **outer** Fraser River Estuary (i.e. Sturgeon Bank, Roberts Bank, and Boundary Bay). Next, select the appropriate month and day shown in the table columns. For the purpose of this explanation, we shall use Wednesday, August 26, 1992, which is shown below exactly as it appears in the tide table.

| DATE | TIME | FEET | METRES |
|---|---|---|---|
| 26 | 0230 | 13.4 | 4.1 |
| | 0940 | 2.1 | .6 |
| WE | 1650 | 14.8 | 4.5 |
| ME | 2225 | 9.3 | 2.8 |

In this example, the predicted times and heights of the high and low tides are as follows:

At 0330 hours, the Lower High Water will be 4.1 m

At 1040 hours, the Lower Low Water will be 0.6 m

At 1750 hours, the Higher High Water will be 4.5 m

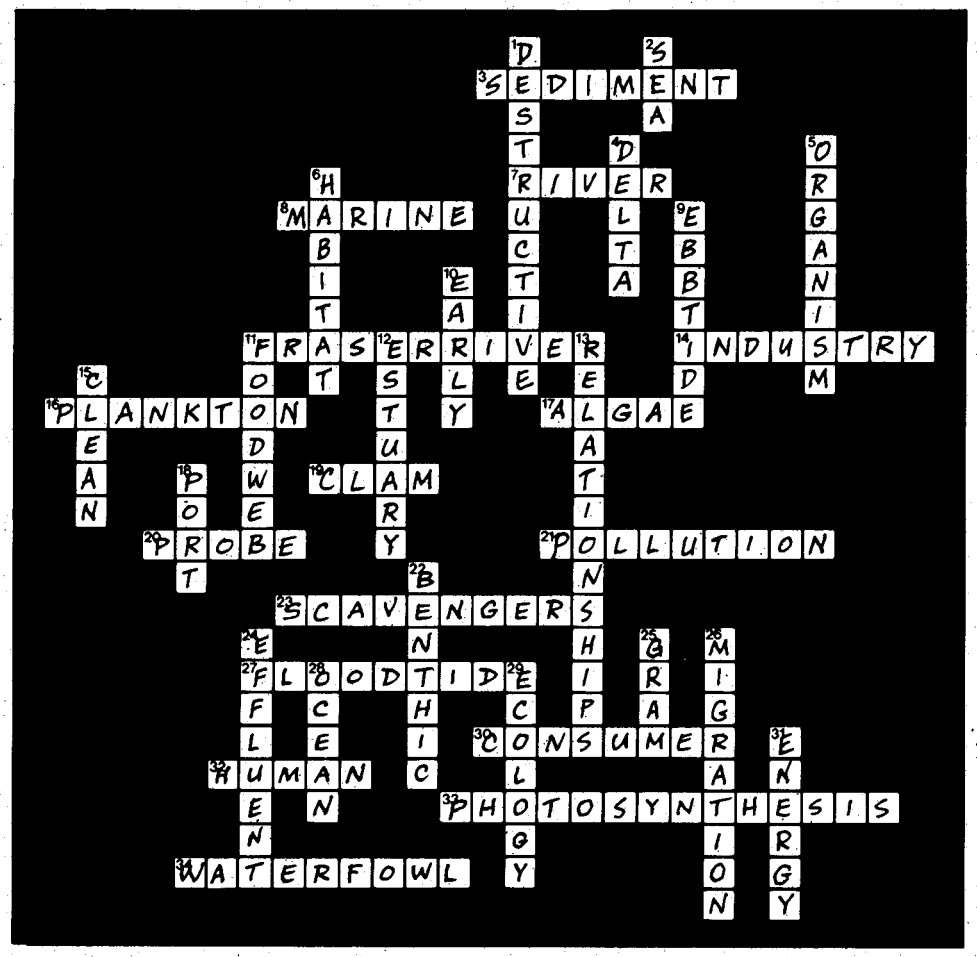
At 2325 hours, the Higher Low Water will be 2.8 m

Note that the times in the tide tables are given in Pacific Standard Time (PST). In the above example, one hour has been added to PST, to convert it into Daylight Savings Time. Daylight Savings Time is when we turn our clocks ahead one hour, and this occurs between the first Sunday in April and the last Sunday in October.

If you are interested in predicting the tide for locations **inside** the Fraser River Estuary (i.e. upstream of Steveston), you'll need to use the "FRASER RIVER" table, usually located near the front of the *Canadian Tide and Current Tables*. The Fraser River tide table takes into consideration the river discharge (flow of water) and location (Steveston, Deas Island, New Westminster). Instructions on how to use this table are provided with the table.

## ACTIVITY 4: PRE-TRIP FUN

Answers to Crossword Puzzle




## ACTIVITY 8: THE CHANGING ESTUARY

**Period of Pre-white Settlement**
Food Gathering, Fishing, Hunting

**1820's to 1830's**
Fur Trading, Food Gathering, Hunting, Fishing, Exploring

**1840's to 1860's**
Surveying, Hunting, Gold Rush Traffic,

**1870's to 1890's**
Land Clearing, Gillnet Fishing, Floodplain Logging, Road Building, Diking, Steamboat Travel, Farming, Fish Canning

**1900's to 1940's**
Industrial Development, Land Clearing, Gillnet Fishing, Upland Logging, Road Building, Diking, Dredging, Port Development, Farming

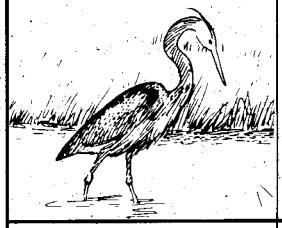
**1950's to Present**
Industrial Development, Land Clearing, Freighter Traffic, Road Building, Diking, Dredging, Port Development, Urban Development

# ACTIVITY 10: MATCHING POLLUTANTS AND SOURCES

| POLLUTANTS | POLLUTION SOURCES | | | |
|---|---|---|---|---|
| | Household | Pulp Mill | Farm Field | Automobile |
| Bacteria | X | | X | |
| Copper | X | | | |
| Dioxins | | X | | |
| Herbicides | X | | X | |
| Lead | | | | X |
| Oil | | | | X |

# ACTIVITY 11: FRASER RIVER WHIZ QUIZ

1. Where a river meets the sea is an ESTUARY.



2. FRESH water and

SALT water

mix in an estuary to form

BRACKISH water.

3. Zooplankton

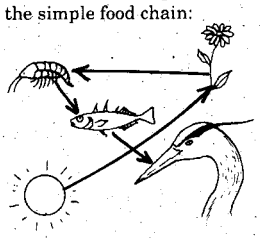
are tiny ANIMALS

&

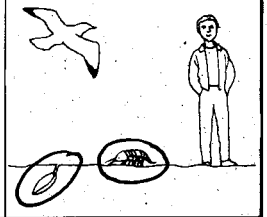
PHYTO plankton

are tiny plants.

4. Draw connecting lines for the simple food chain:



5. Circle those that eat detritus.



6. How many estuarine organisms starting with the letter **S** can you think of?

SALMON SNOWGOOSE

SALTGRASS SEDGE

SHRIMP SANDPIPER

7. Which plants grow in an estuary?

____ spinach
__✔__ algae
__✔____roses
_✔__ cat-tails
__✔__ eelgrass
_____ papaya
__✔__ saltgrass

8. Which one of the following plants are trees or shrubs?

____ Bulrush
_✔_ Snowberry
_✔_ Hardhack
____ Sedge
_✔_ Black Cottonwood

9. CONNECT:

| Animal | Habitat |
|---|---|
| Plankton | eelgrass |
| Crab | slough |
| Salmon | tidal flat |
| Snail | channel |
| Sandpiper | marsh |

10. What's wrong with this picture?

_____

_____

11. True or False?

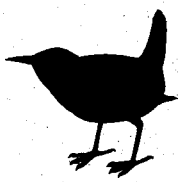
A freshwater plume is a type of marsh flower ___F_____.

Detritus is the base of the food web in estuaries _T___.

Ghost shrimp live in mudflat burrows ___T__.

Bacteria found in estuaries are always harmful ____F__.

12. Can you identify this estuarine bird?

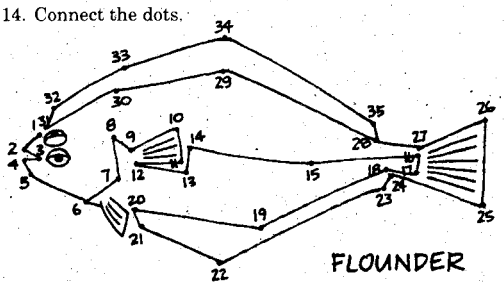


Answer: MARSH WREN

13. Unscramble the following words:

HABITAT
POLLUTION
MARSH
BRACKISH
SALMON

14. Connect the dots.



# APPENDIX 2:

# ACTIVITIES & FIELD TRIP DESTINATIONS

# APPENDIX 3:

# RELEVANT CONTACTS

| Organization | Telephone |
|---|---|
| ***Federal Government*** | |
| Department of Fisheries and Oceans | 666-6098 |
| Canadian Coast Guard | 631-3702 |
| Canadian Wildlife Service | 666-0143 |
| Environmental Protection Service | 666-6711 |
| Inland Waters Directorate | 666-6711 |
| ***Provincial Government*** | |
| B.C. Environment | 584-8822 |
| Recycling Hotline | 1-800 667-4321 |
| ***Municipal Government*** | |
| Richmond | 276-4000 |
| Burnaby | 294-7944 |
| New Westminster | 521-3711 |
| Delta | 946-4141 |
| Coquitlam | 526-3611 |
| Port Coquitlam | 941-5411 |
| Pitt Meadows | 465-5454 |
| Surrey | 591-4011 |
| Langley | 534-3211 |
| Maple Ridge | 463-5221 |
| Greater Vancouver Regional District | 432-6200 |
| ***Other Governmental Organizations*** | |
| Fraser River Estuary Management Program | 525-1047 |
| Fraser River Harbour Commission | 524-6655 |
| North Fraser Harbour Commission | 273-1866 |
| ***Environmental Non-Government Organizations*** | |
| B.C. Environmental Network | 733-2400 |

# GLOSSARY

| | |
|---|---|
| *anadromous:* | a type of fish life cycle in which maturity is reached in saltwater, and the adults enter freshwater to spawn. |
| *algae*: | term applied to small, one-celled or colonial plants without vascular systems. |
| *bacteria*: | microscopic organisms living in soil, water, sediments and the bodies of plants and animals (including man). |
| *benthic*: | organisms living in or on the bottom sediments of a body of water. |
| *bioaccumulation*: | the process whereby pollutants are taken up, retained and concentrated by aquatic plants or animals. |
| *bioindicator*: | an organism which is sensitive to pollution and can therefore be used to measure the degree of pollution in its environment. |
| *biosphere:* | the region around the earth that can support life including the atmosphere, the soil and the water. |
| *brackish*: | describes water having a salinity between freshwater (0.5 parts per thousand) and seawater (17 parts per thousand). |
| *climax:* | a kind of natural community which can continue and sustain itself for as long as the local climate remains the same. |
| *crustacean*: | any of the large class of mostly aquatic animals having an outer skeleton; includes shrimps, crabs, barnacles, etc. |
| *decomposition*: | the biochemical process where biological materials are broken down into smaller particles and eventually into basic chemical compounds and elements. |
| *delta*: | a deposit of sediment (e.g., island, sand bar, mudflat) at the mouth of a river emptying into the sea. |
| *detritus*: | dead organic matter, both plant or animal. |
| *diatoms:* | small, microscopic algae with plate-like, brown structures composed of silica. |
| *dioxin:* | a toxic chemical produced when chlorine interacts with organic materials as in the pulpmill bleaching process, in garbage incinerators, and as a byproduct of other industrial chemicals. |
| *dike:* | an elevated ridge of material constructed to prevent water in a river from overflowing its banks during flooding conditions. |

| | |
|---|---|
| *ecosystem:* | a community of organisms that can be identified and described on the basis of specific and unique physical, chemical and biological properties (e.g., a lake, stream, marsh, forest, desert, etc.). |
| *effluent*: | liquid waste material (e.g., sewage) discharged into the environment. |
| *Eulachon:* | a member of the smelt family of fishes, with elongated body, about 20 cm in length, and high in oil content. |
| *estuary*: | a semi-enclosed body of water, which has a free connection with the open sea, and within which seawater is measurably diluted with freshwater derived from land drainage. |
| *floodplain*: | the area of land adjacent to a river channel which is subjected to flooding when floodwater levels reach a predetermined height. |
| *foreshore*: | with respect to land use in British Columbia, the land between mean high tide and mean low tide. |
| *freshet:* | a sudden increased flow period in a river as a result of spring snowmelt or heavy rainfall. |
| *fungi*: | a non-vascular plant that sustains itself without the use of chlorophyll and sunlight (e.g. mushrooms). |
| *gillnet*: | a net set upright in the water to catch fish by entangling their gills in the mesh of the net. |
| *habitat:* | a place or "home" in the environment where an organism lives or is expected to live in order to fulfill an important function such as feeding or rearing. |
| *herbivores*: | animals that consume plant material as their main source of nourishment. |
| *invertebrate*: | animals without backbones (e.g., insects, worms, snails), which includes most of the animal kingdom. |
| *larva*: | an animal at some pre-adult stage of development. |
| *micro-habitat:* | a small local habitat (e.g., rotton log) within a larger habitat type (e.g., floodplain forest). |
| *midden:* | a refuse heap or pile of discarded garbage which, if old and from a special culture, can have archeological value. |
| *molluscan*: | describing any animal belonging to the molluscs that include most of the shellfish (except for crustaceans). |
| *nutrient chemical:* | a substance containing phosphorus, nitrogen, and potassium, which are essential to the health and for the growth of plants. |
| *nymph*: | an animal at some pre-adult stage of development. |

| | |
|---|---|
| *organic matter*: | biological material or chemicals based on carbon and hydrogen. |
| *Pacific Flyway*: | the migratory path used by birds along the west coast of North America. |
| *photosynthesis*: | the process by which plants use sunlight, in the presence of chlorophyll, to manufacture their food (carbohydrate) from carbon dioxide and water. |
| *phytoplankton*: | floating or drifting microscopic plant life. |
| *plume*: | the volume of water discharged by a river into the sea, and which retains some characteristics of the original river water (e.g., suspended sediments). |
| *pollutant:* | a substance which is harmful to living organisms because it is not normally found in the environment or its concentration is too large. |
| *primary production:* | organic matter produced by plants which serves as the primary source of energy and nutrition for other consumers in the ecosystem (e.g. herbivores). |
| *protozoa*: | microscopic single-celled animal or colony of animals capable of ingesting microscopic food particles. |
| *salinity*: | a measure of the quantity of dissolved salts in seawater, defined as the total amount of dissolved solids in parts per thousand. |
| *saltmarsh:* | a vegetation community where the plants tolerate high levels of salt in the water table or flood waters. |
| *salt wedge:* | a wedge-shaped layer of salty water that is pushed along the bottom into an estuary on every flood tide. |
| *sediment:* | material such as sand, silt, and clay that is suspended in moving water but will settle to the bottom in still water. |
| *slough:* | a shallow, quiet backwater channel connected to some larger body of water such as a river, estuary or lake. |
| *sturgeon:* | a bottom-feeding fish covered with bony plates and a large head with sucking mouth. Sturgeons, highly prized for their eggs (caviar), are the largest freshwater fish of Canada. |
| *succession:* | the replacement of one type of natural community by another through a progressive change in plant and animal life over time. |
| *tideflat:* | a flat expanse of land, usually mud or sand, situated between the high and low tide level, exposed at low tides, and flooded at high tides. |
| *toxic*: | of, relating to, or caused by a toxin or poison which, through chemical action, kills, injures or impairs an organism. |

# SUGGESTED READINGS

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Anon. *Ocean Related Curriculum Activities* (ORCA). (Publisher's Address: Marine Education Project, Pacific Science Centre, 200 Second Avenue North, Seattle, Washington, U.S.A., 98109).

Anon. *The Estuary Program - Level II*. (Publisher's Address: Padilla Bay National Estuarine Research Reserve, 1043 Bay View- Edison Road, Mt. Vernon, Washington, U.S.A., 98273).

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*Pacific Estuaries: Where Rivers Join the Sea*. 1989. 28 minute duration. Available from Ducks Unlimited Canada, 14343 - 44th Avenue, Surrey, B.C. Telephone: 531-1104.

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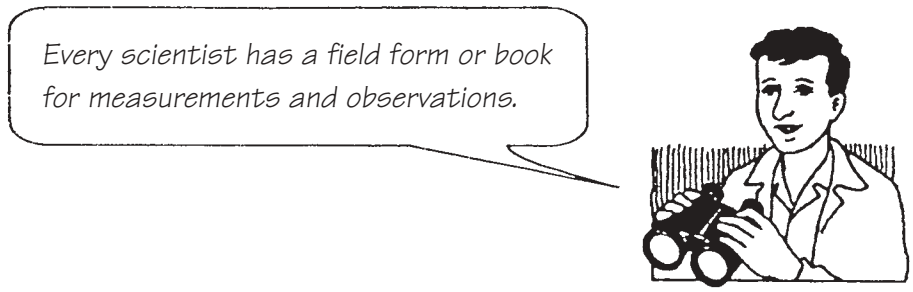
*Wetlands*. 1987. 29 minute duration. Available from Ducks Unlimited Canada. 14343 - 44th Avenue, Surrey, B.C. Telephone: 531- 1104.

# DISCOVER YOUR ESTUARY INVESTIGATION SHEETS: JUST PHOTOCOPY AND GO!

In this section, we have provided a number of ready-to-use Activity Sheets that allow you to just photocopy the quantities you need—one per person or one per group—and go! We recommend that you take a copy of the ***"Discover Your Estuary"*** Book with you for reference. Usually there is helpful background information in the Book to supplement the Activity Sheets.

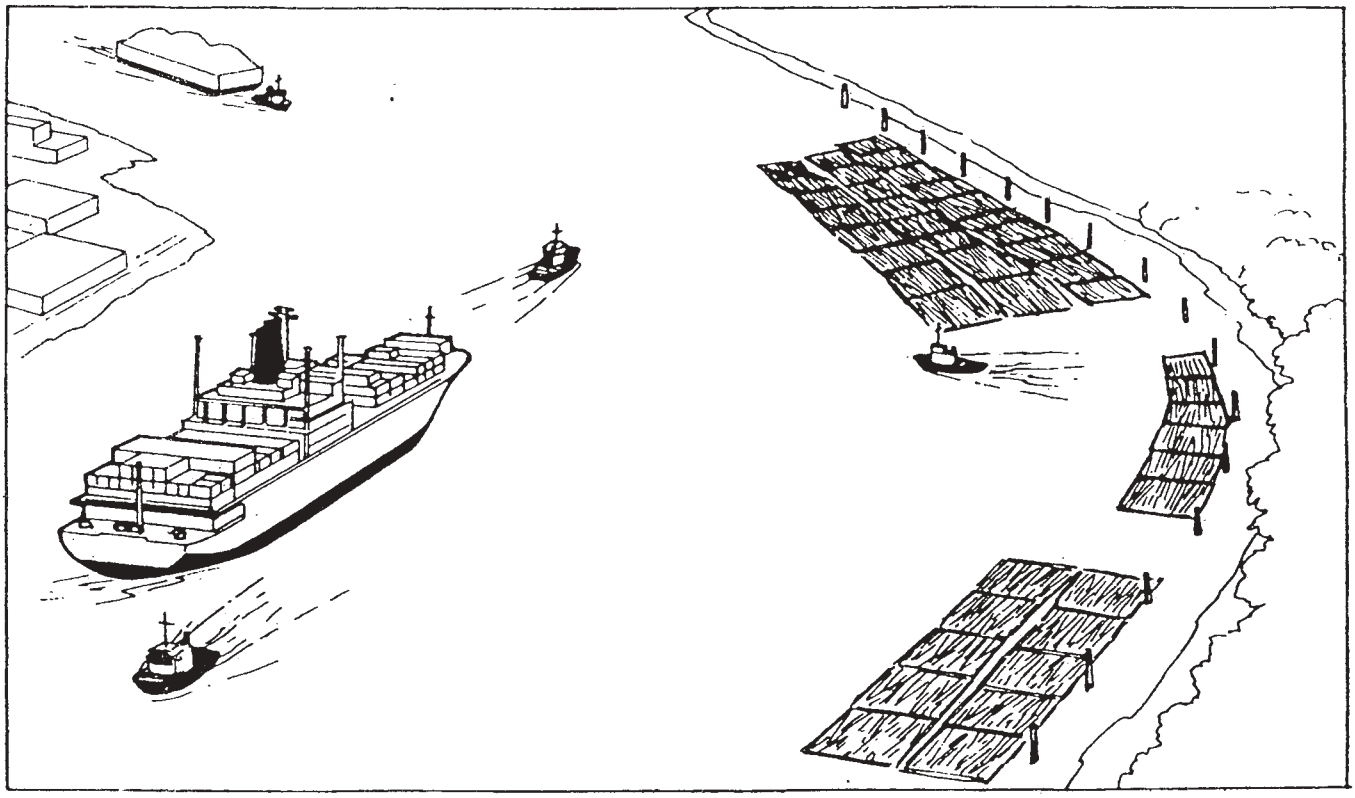


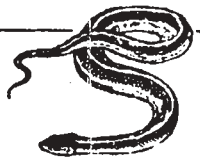

The "Safari" sheets (#'s 2, 4, 5, 6, 7, and 10) are like "treasure hunts": kids of all ages can use them to practise their observation skills and record their observations.

The "Micro-habitat Observation" sheets (#'s 1, 3, and 8) suggest in depth studies that will require patience and perhaps some demonstration and practice. The most elaborate study is found on Investigation Sheet #3, "Tideflat micro-habitat study". You can read more detailed instructions in the Book and in the Salt marsh and Tideflat chapter. There are two "general" observation sheets that can be used for many purposes, and in any area of the estuary, #9 AND #11.

Investigation Sheet #9 encourages free-form exploration; and it is designed to fold into a small square that fits into a kid's pocket easily. On this rainy day each of the students can use a small square of corrugated cardboard as a "clipboard", and keep the sheet dry inside a ziplock baggie.

Investigation Sheet #11 encourages kids to think about how humans are changing the estuary. There are three chapters in the Book that give background information on human effects on the estuary; you may want to use some of this material in preparation for the field trip, and there is a wealth of information in these chapters for students to do their own research, before or after the field trip.





# LIFE IN A BACK-YARD

## Micro-habitat Observation Sheet

Locate a micro-habitat in a back-yard, school-yard or park. This could be a log, a flower-bed, a bush, under a rock, a stump, even a concrete surface.

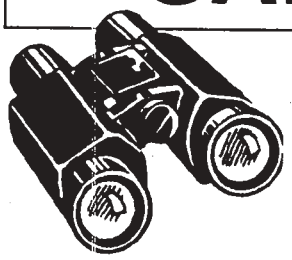
Book pp. 62-63

Where is your micro-habitat? Record the location.

Describe or draw the animals and plants you see here:

Why do they want to live here?

# SALTMARSH SAFARI



Book
pp. 42-53

Keep track of what you find while you're investigating (circle each picture when you find it) ...

Bald Eagle

Saltwort

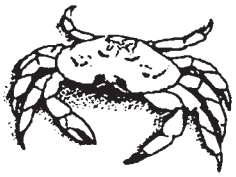
Black Brant

Marsh Wren

Arrowgrass

Rough-legged Hawk

Saltgrass



Dungeness Crab

Saltbush

Dead Eelgrass

Short-eared Owl

Townsend's Vole

...AND draw pictures of, or describe, other organisms you find:

# NOTES FOR PARENT AND TEACHER
## on Investigation Sheet #3

Quadrats are used to sample a known surface area. Digging out the top 2" of the quadrat reveals a living "mud carpet", since Invertebrates are found under the surface of the mud. Illustrations and further instructions can be found on pages 45 and 46 of the Book; and see Suggested Readings, pp. 118-120.

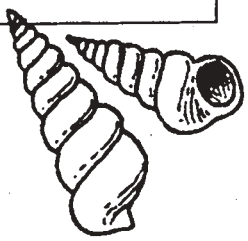
Unless it is a piece of human waste (eg., styrofoam) or nonliving matter (eg., pebbles) everything the treasure hunters find can be categorized as follows:

| | ANIMAL | PLANT |
|---|---|---|
| LIVING THINGS | Molluscs are either<br>• bivalves (pair of hinged shells; looks like a clam)<br>or<br>• gastropods (single shell, usually spiral)<br><br>Crustaceans (insect-like animals with exterior shell and legs)<br><br>Marine Worms (small, usually have bristles) | algae mats<br>(described on page 46 of the Book) |
| ARTIFACTS | dead creatures<br><br>pieces of shell<br><br>fecal casts<br><br>animal body parts<br><br>footprints<br><br>droppings<br><br>other evidence of the presence of animals | plant detritus<br>(e.g., leaves, sticks, stems, decayed matter) |

Classification is an important science skill!

# LIFE BENEATH THE TIDEFLAT
## Observation Sheet for a Tideflat Quadrat

Book
pp. 45-46



As described on pages 45 and 46 of the Book, dig up a "square core" of mud and record your observations here:

Location of quadrat : _____

Dimensions of mud dug up : _____ x _____ x _____
(length) (width) (depth)

Record what you find in this quadrat :

| | ANIMAL | PLANT |
|---|---|---|
| LIVING THINGS | | |
| ARTIFACTS | | |

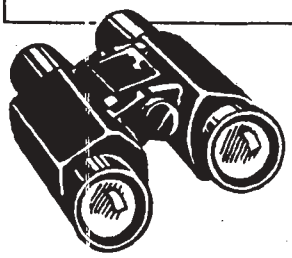
ANIMAL DENSITY CALCULATION :

| Name of invertebrate : | Number of individuals : | Density per square ___ | Estimated density : |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Did you see any plants or animals or artifacts you could not identify? If so, make drawings on the back of this sheet, including measurements, and plan to do further research.

Please Photocopy

# TIDEFLAT SAFARI

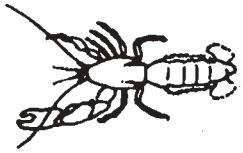


Book
pp. 42-53

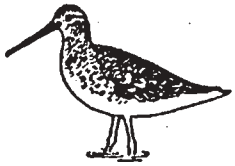
Keep track of what you find while you're investigating (circle each picture when you find it) ...

Lugworm

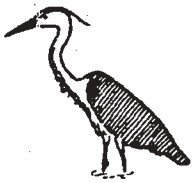
Fecal Casts



Ghost Shrimp



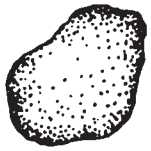
Long-billed Dowitcher



Great Blue Heron

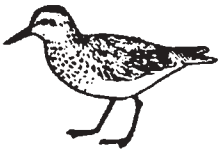
Dunlin

Screw Shell Snail



Algae Mats

Edible Blue Mussel



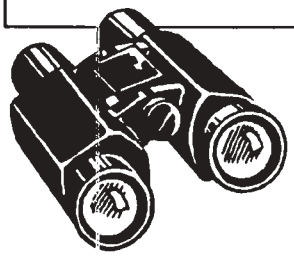
Western Sandpiper

Heron Tracks

Northern Pintail

...AND draw pictures of, or describe, other organisms you find:

# BRACKISH & FRESHWATER MARSH SAFARI



Book
pp. 35-41

Keep track of what you find while you're investigating (circle each picture when you find it) ...

Seacoast Bulrush

Red-winged Blackbird

Lyngbel's Sedge

Northern Harrier

Long-billed Marsh Wren

Cat-tails

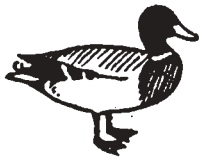
Pacific Silverweed

Yarrow

Snow Geese

American Widgeon

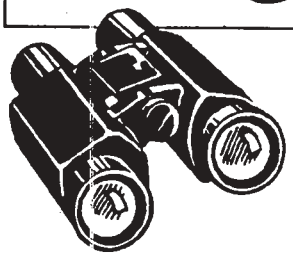
American Bulrush



Mallard

...AND draw pictures of, or describe, other organisms you find:

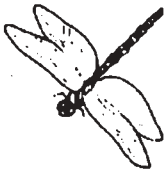
# SLOUGH SAFARI



Book
pp. 65-73

Keep track of what you find while you're investigating (circle each picture when you find it) ...

Water Boatman



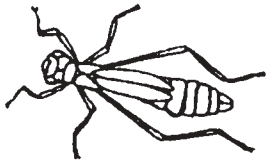
Dragonfly

Detritus

Amphipod

Bald Eagle

Small Shrimp

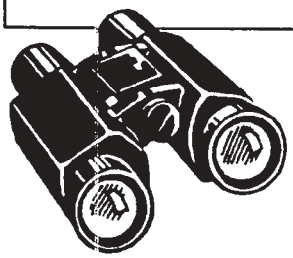


Dragonfly Nymph

Leech

...AND draw pictures of, or describe, other organisms you find.

# FLOODPLAIN FOREST SAFARI



Book
pp. 54-61

Keep track of what you find while you're investigating (circle each picture when you find it) ...

Eastern Cottontail

Downy Woodpecker

Puget Garter Snake

Wood Duck

Red-tailed Hawk

Check each tree or shrub you see...

☐

Elderberry

☐

Oregon Alder

☐

Thimbleberry

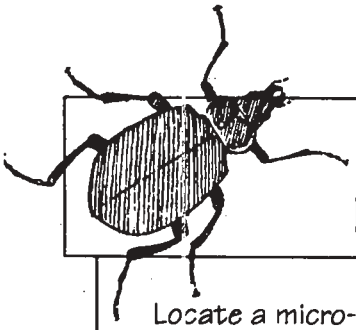
☐

Pacific Willow

☐

Black Cottonwood

...AND draw pictures of, or describe, other organisms you find.



# FOREST FLOOR
## Micro-habitat Observation Sheet

Locate a micro-habitat in the floodplain forest—
a log, or a shrub, or perhaps do a quadrat
(investigate a square area of known dimensions

Book, pp. 61-63

Where is your micro-habitat? Record the location.

Describe the animals and plants you see here:

Why do they want to live here?

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(NAME) (BUDDY'S NAME)

FIELD NOTES FOR

(MONTH) (DAY) (YEAR)

FIELD TRIP TO:

(PLACE)

WEATHER:

SPECIAL INVESTIGATIONS:
(QUESTIONS TO EXPLORE)

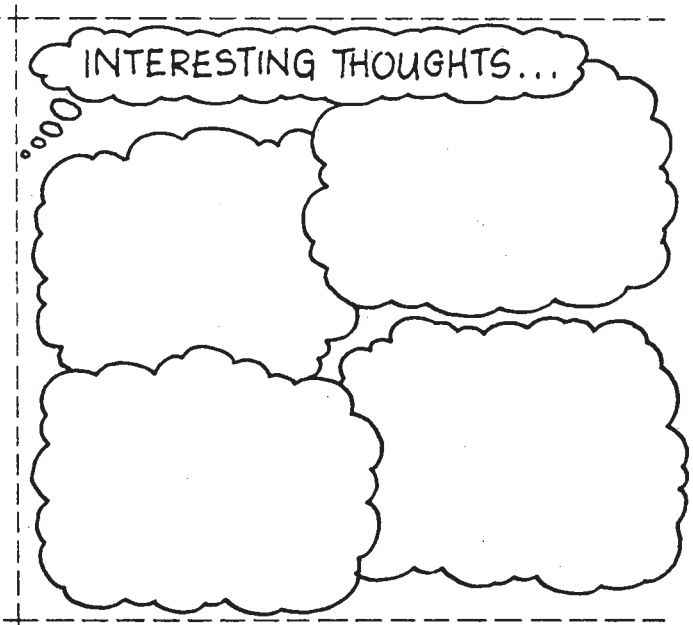
1.

2.

3.

OBSERVATIONS AND MEASURES
(SIGHTS, SOUNDS, SMELLS, TOUCH)

INTERESTING THOUGHTS...



SKETCH: A FAR-AWAY LOOK

SKETCH: A CLOSE-UP LOOK

Please Photocopy

# MINIBEAST SAFARI

Locate a minibeast—a creature small enough for you to capture, examine and release without hurting it. You might want to capture it in a glass jar.

Fill in an observation sheet for each minibeast you examine.

Name of minibeast:

_____

Minibeast #: _____

Location:

_____

_____

_____

Date: _____

Describe how it moves : _____

_____

_____

How does it eat ? _____

_____

_____

Who eats this minibeast ? _____

_____

_____

How does it protect itself ? _____

_____

_____

# HUMAN ACTIVITY IN THE ESTUARY
## Observation Sheet

Book, pp. 80-89: Settlement by Europeans, Present-Day Use

What are some of the indications of humans in the area you are visiting today? (Write or draw your observations.)

How do you think this affects the estuary?