Chapter 8

Ecology of Upper Newport Bay

PURPOSE

The purpose of this exercise is provide an opportunity for you to perform the following:

- Recognize seven different biological communities, and draw their locations on a map.
- Identify the special combinations of physical factors which limit the locations of the different biological communities.
- Discriminate between the processes of photosynthesis and growth.
- Explain how the bay is an optimal setting for photosynthesis and growth.
- Recognize the dominant plants in each community. Identify key anatomical and physiological characteristics.
- Identify some of the many different species of birds which inhabit the bay - some are endangered.
- Describe the special adaptations possessed by plants and animals that enable them to thrive in their respective communities.
- Identify and describe instances of competition between organisms in the bay.
- Identify and describe instances where alien species have been introduced into the bay.
- Recognize evidence of eutrophication. Explain how eutrophication could be harmful to the bay.
- Prepare a food web diagram showing the energetic relationships between the saltmarsh community and migrating birds.

WHAT IS AN ESTUARY?

An estuary is an embayment along the coast of an ocean, with a generally steady supply of freshwater washed down from rivers. An estuary is a sort of mixing zone where water from the sea and water from the land meet each other. For example, San Francisco Bay is a large estuary, receiving sea water from the Pacific Ocean, and freshwater from the Sacramento River. Upper Newport Bay is an estuary too. It receives sea water input on one end, and freshwater mainly from San Diego Creek on the other.

The water environments in Upper Newport Bay are always changing. For example, during a flood tide (when the tide is coming in), sea water pushes into the bay, raises the water level and salinity, and changes the water temperature. During ebb tide, sea water retreats, the water level and salinity are lowered, and water temperature changes again. Tides strongly influence activity in the estuary. Each day, the bay experiences two high tides and two low tides. While sea water is continually moving in and out of the bay, freshwater flow plays an important role too.

During the ebb and flow of tides, freshwater is steadily being added to the bay from San Diego Creek. At low tides, open channels of the estuary are more heavily influenced by freshwater than by sea water, and vice versa during high tide. In addition, there can be periods of high freshwater flow (usually as a result of winter storms), which can exert even stronger freshwater influences. The zone where these two water resources meet and mix is called the Null Zone. It consists of brackish water — less salty than sea water, and more salty than freshwater. The ocean and San Diego Creek contribute more than just water to the bay. Nutrients and sediments are added too.

Nutrients are imported by flood tides and freshwater flow. In the bay rapid plant growth is made possible because new supplies of nutrients are imported everyday. However, too many nutrients can be unhealthy for the bay's ecology (to be discussed below).

Sediments from upland areas are eroded during storms, and are carried to and deposited in the bay by San Diego Creek. Over the years, sediment deposition has steadily filled-in the bay resulting in broad, shallow mudflats and marsh areas. It is normal for estuaries to gradually fill-in with sediments, but recent human activity around Upper Newport Bay has rapidly accelerated sediment in-flow.

HOW DID UPPER NEWPORT BAY FORM?

Geologists suggest that the formation of Newport Bay started about 300,000 years ago, in the middle of the Pleistocene Epoch. At that time, a river eroded a canyon whose walls now surround the bay. This canyon was subsequently inundated and covered by rising seas. In fact, the bay's canyon walls are composed of ancient seabed, and fossils of marine organisms can be found in many locations. The bay remained under sea water until about 15,000 to 25,000 years ago when the seabed was pushed up from underneath and lifted above sea level. During this uplift event, the bay canyon was further eroded by creeks and rivers. Gradually, this canyon began to fill-in with sediments forming shallow mudflats and grassy marshes.

BIOLOGICAL COMMUNITIES FOUND IN AND AROUND UPPER NEWPORT BAY

A biological community can be defined as: *an easily recognizable geographic area that has a somewhat unique assemblage of plants and animals*. Basically, it looks different from its surroundings. The bay is painted with a multi-colored, checkerboard of biological communities. As we walk along, we will pass through several different communities. Why are there different communities?

The lives of all species of organisms are ultimately controlled by the state of their surrounding physical environment. For example, some plants need to have their roots in water all year long, a condition that would suffocate the roots of most other plants. A few other species of plants can survive nicely with just a few inches of intermittent rainfall, while most other species would quickly dry out. Soil too dry and salty for most plants proves suitable for certain salt-tolerant grasses. You will quickly observe that the physical environment of Upper Newport Bay is not homogeneous. There are areas of wet soils and dry soils, salty and unsalty soils, tidal flats and hillsides. Taken together, the physical factors of the bay's environment lay the foundation for the establishment of different assemblages of organisms who find particular parts of the bay to their liking. And it is largely the special adaptations that these creatures successfully employ which continue to enchant inquisitive biologists.

There are at least seven major community types in, and surrounding the bay. They include the following:

1) <u>Coastal Sage Scrub</u> - A dry, drought-tolerant upland community which consists of short grasses, and low-lying shrubs. This community generally is found along the bluffs and hillsides which surround the bay. This community has many plants which are drought-deciduous (they lose their leaves after prolonged periods without rain).
2) <u>Riparian</u> - Streamside community; freshwater. Possesses open freshwater channels. Soils are moist all year long. Dominant plants are deep-rooted trees, and tall, bushy shrubs. Many plants in this community are seasonally-deciduous, an lose their leaves in fall and winter - regardless of rainfall patterns.
3) <u>Freshwater/Brackish Water Marsh</u> - Marshy, flat area, saturated soils (not just moist) or intermittently submerged with freshwater or brackish water. Soils are muddy from freshwater. Vegetation consists mainly of tall (3-6 ft.) grasses. These grasses will turn brown in winter.
4) <u>Salt Barren</u> - very infrequently submerged by salty tidal waters. Little flushing by freshwater. These areas might be flooded by sea water a few times in winter. During the remainder of the year, the sea water evaporates, leaving the salts behind. Therefore, the soils here are extremely salty. In fact, you usually can see white salt deposits on the ground. This community is dominated by succulents and short, salt-tolerant grasses.

5) <u>Saltmarsh</u> - Marshy, flat area very frequently (daily) submerged by salty tidal waters. Soil is muddy from salt water. Salt doesn't build up because of frequent tidal flushing. At low tide the salt marsh is seen to border the mudflat and deeper, water-filled channels. This community consists mainly of medium-height (1-3 ft.) grasses. These grasses will turn brown in winter.

6) <u>Open Channel</u> - These are deep (3-8') channels through which tidal water and freshwater flow. They are nearly always filled with water (even at low tide), and possess a mud bottom covered with organic debris and green algae.

7) <u>Mudflat</u> - Broad, flat, muddy areas completely covered during high tide, and exposed during low tide. A slimy green alga sometimes covers the mudflat.

SPECIAL ADAPTATIONS BY ORGANISMS AT THE BAY

<u>DEALING WITH PERIODIC SUBMERGENCE</u> - Many of the living areas of the estuary are continually changing, and the creatures which live there have developed special adaptations to deal with these changes. For example, the bay experiences alternating flooding and draining twice each day. This means, many mudflat and saltmarsh organisms are under water only part of the day. Being submerged in water is desirable for most of the mudflat animals which feed during this time. But, during low tide, the flat is directly exposed to the sun and atmosphere and these creatures must be able to: 1) stay cool; 2) keep from drying out (avoid desiccation); 3) continue to respire; 4) tolerate changes in salinity, pH and other chemical factors; and 5) avoid being eaten. In the lower saltmarsh, grasses are submerged during high tide - a dangerous experience for most types of grasses, because it is very difficult for them to obtain needed gaseous carbon dioxide while under water. However, some types of estuarine grasses have special adaptations which allow them to survive submergence.

<u>DEALING WITH CHANGES IN SALINITY</u> - The salinity (saltiness) of the water can change drastically. During high tide, the salt content in the water is about 34 parts per thousand (equivalent to 3.4%). During low tide in channel areas, the salinity can drop to as low as 0.5 parts per thousand (equivalent to 0.05%) because of the influence of freshwater in these areas. Only certain organisms can tolerate such wide salinity fluctuations — they are considered euryhaline. In the Salt Barren, sea water slowly evaporates from the exposed and wet soil, leaving its salts behind. The salinity of the remaining ground water can soar to 50 parts per thousand and more. Green plants adapted to tolerate high salinity are called halophytes.

<u>FEEDING STYLES</u> - Feeding mechanisms by animals in the bay are diverse and bizarre. Some graze in the grass (grazers), many filter the water for edible treats (filter feeders), there are things which actually eat the mud and process it for its rich nutrient supply (deposit feeders), a few types kill others for food (predators), some feed on animals already dead (scavengers/decomposers), and some that don't feed at all (stupid/skinny/dead). There's lots to eat in estuaries, which are considered to be one of the most biologically productive wildlife habitats in the world.

THE ESTUARY AS A FUNCTIONING ECOSYSTEM

<u>PHOTOSYNTHESIS AND PRIMARY PRODUCTIVITY</u>: Estuaries are highly productive. The magnitude of biological growth in estuaries can equal or exceed that in the tropical rain forest or an intensely managed, fertilized and manicured wheat field. *Primary Productivity* is a term used to describe the total amount of production of biological products by photosynthesizing organisms (usually green plants and algae) in a given area, and in a given unit time. The biological products generally considered include energy (measured in kilo-calories) or biomass (measured in kilograms). We are going to concentrate on energetics here. Thus, the primary productivity of estuaries can range from 10,000 to 40,000 kcal/sq. meter * year., significantly higher than the open ocean, grasslands and temperate forests which range from 1,000 kcal./sq. meter * year.

The energy we are discussing is developed by photosynthesis, the process in which sunlight energy is captured, transformed and stored as high energy sugar molecules. Photosynthesis can be simply expressed in the following equation:

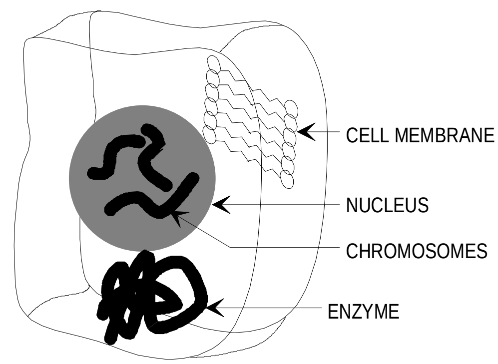
carbon dioxide + water + sunlight———>>> sugar + oxygen

GROWTH AND THE ROLE OF PLANT NUTRIENTS:

Living things are constantly engaged in the process of cell division, whether they are single-celled organisms like bacteria or larger creatures like trees. Each new cell requires materials in order to grow and operate. Let's think about some of the major components of eukaryotic cells, what they're used for, and what they're made up of. Refer to the simple drawing of the cell below.

Cells need certain mineral nutrients in order to make more of the parts that make up the cell. For example, each new cell must have a new nucleus, new cell membrane and new enzymes. Why? Let's look at what these parts do for the cell.

CELL MEMBRANE Security. The cell membrane totally surrounds the cell and defines its boundaries. It keeps all of the cell's valuable parts together into one cohesive unit and it also protects the cell's contents from intruders. Raw materials coming into the cell and products leaving the cell must pass through the cell membrane, which separates "inside" from "outside". It is made up of funny-looking molecules (phospholipids) which have a long, zig-zaggy tail attached to a phosphate group (the head). The tails are made up of carbon, hydrogen, and oxygen. The heads are made up of phosphorous, which is sometimes in short supply. So, in order to make new cells, new membranes must be made, and phosphorous must be found somewhere. No phosphorous, no membrane, no new cell.



SOME COMPONENTS OF A LIVING CELL

NUCLEUS Administration. The nucleus is a centralized region of the cell that contains the chromosomes. It acts as the cell's boss, telling it what to do, what to make, how fast to work and so on. The chromosomes contain very large, coiled molecules called DNA. The DNA contains the coded instructions (program) needed by the cell in order to make the molecules it needs. Without these instructions, the cell will die. The DNA is made up of atoms of nitrogen, phosphorous, carbon, hydrogen and oxygen. The nitrogen and phosphorous generally are in short supply in the environment. No nitrogen or phosphorous, no DNA, no instructions, no new cell, no new growth.

ENZYMES Workers. Enzymes are huge proteins inside the cell. They are made inside the cell by following instructions provided by the DNA. There are thousands of different types of enzymes in each of our cells, and they are the real workers of the cell. Enzymes are catalysts. That is, they speed up chemical reactions inside the cell by thousands of times. Without enzymes, cell activity would be too slow for even simple maintenance, and the cell would slowly break apart. Enzymes are the assemblers on the cell's shop floor. With them, the cell is able to make its particular product or provide its particular service. Without them, the cell is powerless. Enzymes are made up of atoms of nitrogen, carbon, hydrogen, oxygen, and others. Again, nitrogen is in short supply in the environment. No nitrogen, no enzymes, no reactions, no production.

WHAT PLANT NUTRIENTS ARE WE CONCERNED ABOUT FOR THIS EXERCISE? We are worried about only two major plant nutrients for this exercise: Nitrogen, taken in by plants as nitrates, nitrites, or ammonia; and Phosphorous, consumed by plants in the form of phosphates.

WHY IS NITROGEN IN SHORT SUPPLY? Nitrogen really isn't in short supply in the environment. After all, the atmosphere is 78% nitrogen. But atmospheric nitrogen cannot be directly used by plants. They can't pull it out of the air like they do with carbon dioxide. Instead, gaseous nitrogen first must be converted to a solid, something that can be carried along by water and absorbed by the roots. Most plants can't do this conversion themselves, but rely on soil bacteria to do it for them. Soil bacteria convert gaseous nitrogen in the atmosphere to ammonia and later, salts called nitrates. These are deposited into the soil. While searching for water, plant roots also seek out ammonia and nitrates.

WHY ARE PHOSPHATES IN SHORT SUPPLY? Unlike nitrogen, which must be pulled out of the atmosphere, phosphorous is found naturally in the soil. It exists in a form of salt called phosphate. Although it is found in the soil, it can be used up by many thousands of years of plant growth - especially if phosphates from generations of dead plants are not efficiently recycled back into the soil. In any case, the availability of phosphates in the soil frequently isn't enough for unlimited plant growth. As such, phosphates are a desirable yet limited resource which, in turn, limits plant growth.

Some of the most important nutrients (macronutrients) include Nitrogen (in the forms of nitrates or ammonia), Potassium, Calcium, and Phosphorous (in the form of phosphates). Nutrients which are required in lesser amounts (micronutrients) include Iron, Chlorine, and Manganese. In ecosystems, the rate of plant growth often is limited, at least in part, by the availability of nutrients. The functions of certain of these nutrients are listed below:

MACRONUTRIENT

- Nitrogen — amino acids, proteins, DNA, chlorophyll
- Potassium — amino acids, enzymes
- Calcium — cell walls, helps regulate cell permeability
- Phosphorous — ATP (energy molecule), DNA, phospholipids for cell membranes

MICRONUTRIENT

- Iron — chlorophyll synthesis
- Chlorine — osmosis and ionic balance
- Manganese — activator of some enzymes

The estuary provides a desirable physical setting for the promotion of plant growth and primary productivity. New supplies of nutrients are imported each day from San Diego Creek and the Pacific Ocean. There is usually plenty of sunlight, even at the bottom of shallow channels. And the whole system is mixed by tidal action, which widely distributes oxygen, carbon dioxide and nutrients, and which removes wastes.

Let's briefly discuss only one simple food chain in the bay. Most primary productivity occurs in the s*alt marsh and is* performed by cord grass (*Spartina foliosa*), the dominant inhabitant there. It is mainly the growing and decaying cord grass which forms the trophic base upon which most other estuary organisms depend. Parts of old growth from cord grass break off and are deposited on the mudflat by the ebbing tide. Once there, the grass begins to decay and break apart. This decaying organic matter (detritus) provides food for an enormous community of filter-feeders, and deposit feeders (detritovores, collectively) which live in and on the mud (mostly clams, snails, and worms). Invertebrate predators in the mudflat feed on these detritovores, and the whole bunch provide food for fish and migrating shorebirds.

Following the movement of energy and food supplies in the bay helps to explain the often clumped distribution of birds found there.

LIFE FORMS FOUND IN THE BAY ECOSYSTEM

Because of the frequently changing physical conditions in the bay, only certain types of plants and animals can live there. They have developed specialized ways of dealing with this type of environment as the result of millions of years of evolution. In fact, many have become so specialized, that they can live only in an estuary habitat. This is particularly true for many of the grasses, and mudflat creatures.

The bay is an important habitat for several rare and endangered species, including: Light-footed Clapper Rail; Belding's Savannah Sparrow; American Osprey; California Brown Pelican; and California Least Tern.

Over 150 species of birds use the bay for a place to live and feed. It is especially important to ducks and shorebirds as an over-wintering home and stopover during their annual migrations. The bay supports as many as 50,000 birds during the winter.

Seventy-eight species of fish have been found in Newport Bay. The estuary provides an important feeding ground for coastal fish. In addition, the quiet, and food-filled waters of the bay support a valuable breeding ground and nursery of oceanic and estuarine fish.

Human animals have been known to visit the bay and enjoy its high biological diversity, quiet, and beauty. And, certain human activities in and around the estuary have degraded it.

HUMAN IMPACTS ON ESTUARIES

The following is a list of ways humans have caused degradation on estuaries.

1) Siltation - sediment-laden runoff from upstream land development. This causes the estuary to fill in with sediment, forming islands, reducing tidal influence, and losing valuable marshes and mudflats.
2) Damming or Diverting Freshwater Sources - This removes input of nutrients and disrupts estuary ecosystem. For example, the Colorado River is so heavily dammed (to provide water for agriculture, drinking and hydroelectricity) that in dry years no water reaches the Gulf of California. Another classic example is the diversion of water from the Sacramento / San Joaquin Delta (which flows into San Francisco Bay) into the California Aqueduct in order to provide water to Central and Southern California. This diversion threatens the ecology of San Francisco Bay, and the reduction in high winter flows also reduces flushing of the south bay — needed to prevent that part of San Francisco Bay from becoming a stagnant cesspool.
3) Encroachment - Invasion by humans to adjacent areas. This can disrupt the estuarine ecosystem which extends beyond the visible boundaries of the bay. Hint: follow the flight path of jet aircraft leaving John Wayne Airport.
4) Industrial and Agricultural Pollutants - Adding toxic industrial substances like heavy metals (chromium, lead, mercury) and synthetic organic compounds. Upstream agriculture contributes its share of synthetic pesticides. These toxins are absorbed and concentrated by most estuary animals (biomagnification).
   Fertilizers from upstream agriculture drain into estuaries and supply an over-abundance of nutrients. This can result in overgrowth of certain plants. Their ultimate decay depletes the dissolved oxygen, killing aquatic animals and creating an unhealthy, smelly mess. This process is called eutrophication.
5) Commercial Development - Turning estuaries into harbors, luxury marinas, garbage dumps, airports, housing tracts, and business parks. In the State of California, about 75% of the original estuary acreage has been lost. The problem is more severe in Southern California where 90% has been filled-in otherwise developed.

MATERIALS YOU WILL NEED

On your field visit to Upper Newport Bay, you should have the following materials:

- Field Notebook
- Binoculars (if you have some around the house, bring 'em)
- Bird Identification Guide (we will provide)
- Drinking Water
- Comfortable Walking Shoes
- Sunglasses, Visor, Hat

MEETING AT THE BAY

With your Instructor as your guide, meet at Upper Newport Bay and investigate its remarkable ecology (See Figure 1, for map on how to get there).

HINTS ON WHAT TO RECORD IN YOUR FIELD NOTEBOOK

Record the following pertinent information in your Field Notebook:

- Date, Time of Day, Location
- Name of Group you are with (Class name, Instructor, College)
- Purpose of field trip
- Prepare sketches whenever possible
- show general outline of bay (the portion you
- observed)
- show your route and location of stops along it
- make rough sketches of plants, leaves, flowers,
- seeds
- draw rough sketches of birds, noting special
- adaptations for feeding
- Note the location of the various major communities
- Note each community's physical characteristics
- Note the dominant plants in each community
- Note the birds and other animals you observed in each community
- Keep careful lecture notes

TASKS YOU WILL BE PERFORMING, AND WORK YOU WILL BE TURNING IN

1) **PREPARE A SITE MAP** of Upper Newport Bay, based upon your observations (just the portion you saw).
   NOTE: See example drawing at the front of this lab manual for guidance on how to label drawing.

- Title your Drawing
- Provide an Estimated Scale
- Label:
- NORTH
- Land Uses
- Roads
- Airport (or flight path)
- Water Resources
- Seven different biological communities
- provide notation on physical characteristics
- note *dominant* plants, and animals observed
- Sources of the following:
  - Freshwater (include seepage and springs)
  - Sea water
  - Sediments
  - Nutrients
  - Agricultural and industrial pollutants
- Recent dredging activities
- New island growth as a result of siltation
- Show the origin and flow of detritus in the bay

2) **MAKE A TABLE THAT SUMMARIZES YOUR OBSERVATIONS** for each of the seven biological communities. Make seven copies of this page and bring them with you on the day of the trip. Based on your observations, neatly fill in the table for each of the categories shown. Consult Exhibits A and B (at the back of this exercise) for help in identifying plants and birds at the bay.

Plant Community:

OBSERVATION CATEGORY	**FIELD OBSERVATIONS** (Note: these don't have to be in complete sentences. But they should provide enough detail to be informative.)
General Description	
Elevation and Topography	
Exposure to Tidal Influence	
Soil Moisture Content	
Main Source of Soil Moisture	
Salt Content of Soil	
Dominant Plants	
Observed Birds and other Animals	

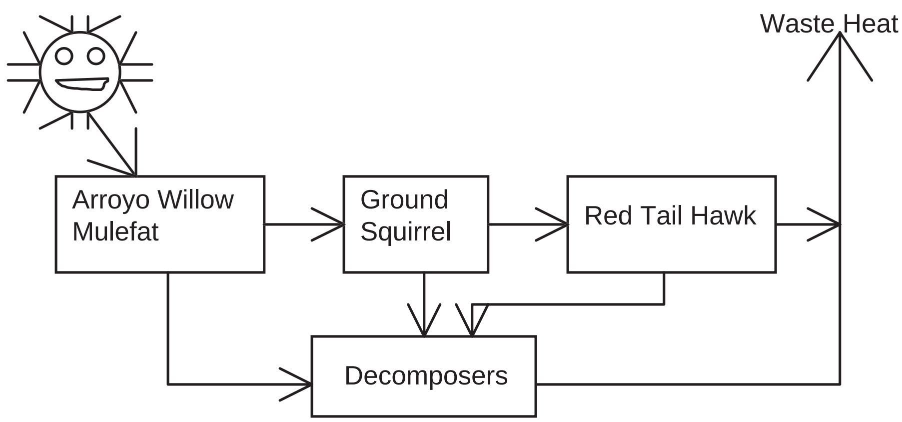
3) Identify and describe three instances of **COMPETITION BETWEEN SPECIES** in the bay ecosystem. The best opportunities for observing potential for competition are in the following areas:

- Animals - Feeding behaviors; diet, prey species.
- Plants - competition for water, soil nutrients, growing space, access to sunlight.

4) Identify on your map any evidence indicating the potential for **EUTROPHIC CONDITIONS**. Briefly describe the processes involved in eutrophication. Why is the Bay now poised to be subjected to agents which could stimulate eutrophication? (related to the upstream sources of nutrients) Explain how eutrophication could be harmful to the bay.

5) **PREPARE A FOOD WEB DIAGRAM** showing the energetic relationship between the saltmarsh community, the mudflat community, and migrating birds. Use the simple web below as an example only. Your food web should look somewhat different from this example. The arrows indicate the direction of resource flow. You should have boxes for the following minimum components:

- Cord Grass
- Decomposers
- Detritus
- Burrowing mudflat animals
- Migrating birds



Example of a food web. **Your food web for Newport Bay will look different from this one.**

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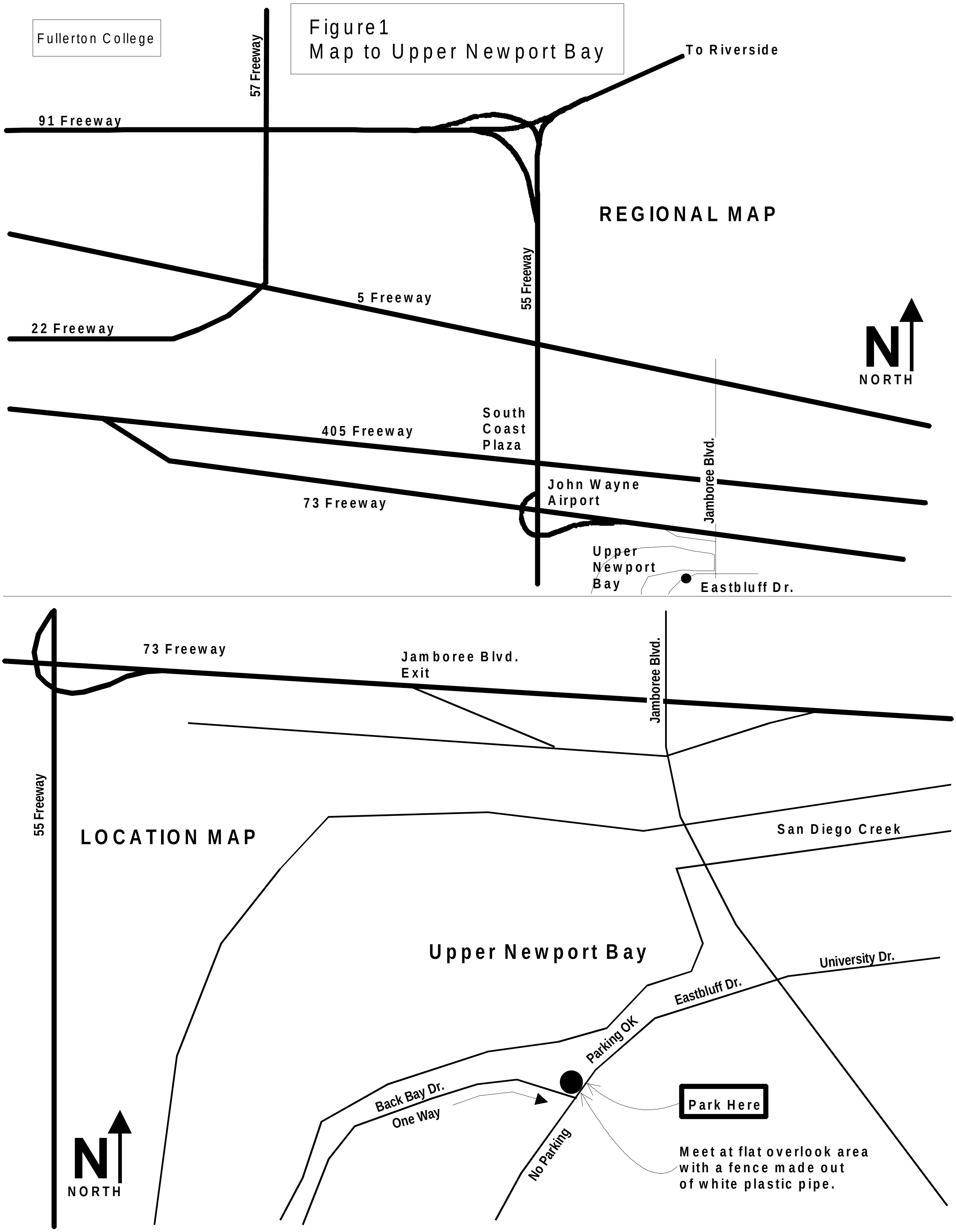


Figure1
Map to Upper Newport Bay

Exhibits

PLANT INVENTORY-UPPER NEWPORT BACK BAY

Coastal Sage Scrub Community:

WILD BUCKWHEAT- low growing clumped shrubs; flowers white in ball-like clusters at shrub tops; leaves very small, needle-like.

WILD MUSTARD- erect plant 1-4 ft. tall; flowers yellow with four petals forming a "cross"- in winter the plant dies, leaving upright brown sticks.

BLADDER POD- mid sized shrub; flowers yellow and showy; fruit a swollen pod that hangs downward.

CALIF. SAGEBRUSH- shrub 2-5 ft. tall; flowers inconspicuous and yellow-green in color; leaves are finely cut and have three lobes or teeth at the tip; resinous smell.

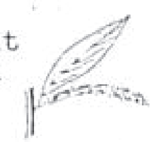
BLUE ELDERBERRY- small trees; flowers white in a flat topped inflorescence berries numerous and blue in color; leaves yellow green in a 5-leaflet arrangement.

TOYON- large evergreen shrub 6-30 feet tall; flowers very small white; leaves 2-4" long and sharply toothed; berries numerous, red.

POISON OAK- spreading shrub 3-6 ft. tall and common in shaded, moist areas; shiny green leaves in three-leaflet arrangement; leaves turning dark red in fall and dropping in winter. DO NOT TOUCH!

Riparian Community:

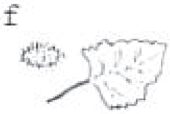
MULE FAT- willow like shrub or small tree; flowers whitish in terminal clusters; leaves elongate and pointed.



ARROYO WILLOW- tall tree with greenish-yellow leaves-somewhat dropping branches; flowers are catkins; leaves often covered with reddish-brown growths called "galls".

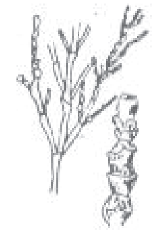
PAMPAS GRASS- reed-like growth; flowers are white plumes at stem tips; leaves long and narrow with serrated edges.

SPINY COCKLEBUR- small annual shrub; fruit an ovoid burr with numerous prickles that attach with the tenacity of velcro; common weed.



PEPPER TREE- evergreen tree; flowers white, small in terminal clusters-fruits ovoid, small and red; leaves dark green in multiple leaflets.

Salt Barren:



PICKLEWEED- low growing succulent plants; leaves absent, but with jointed stems.

SALT GRASS- a coarse, low-growing grass with tendency to form stolons or runners.

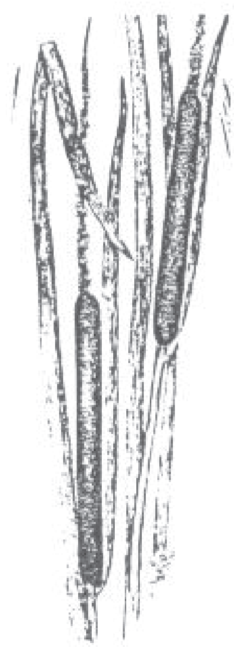
Salt Marsh:

CORD GRASS- medium height grass 1-3 ft. in height turning brown in winter; dominant resident of the highest primary productivity community.

Freshwater/Brackish Water Marsh:

SEDGES- tall three-sided reeds tipped with brownish reproductive structures.

CATTAILS- tall reed-like plants; stalks terminate with a dark brown spike.



BIRDS OF UPPER NEWPORT BACK BAY