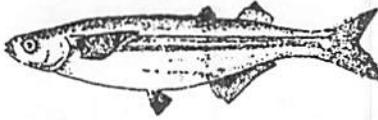


OVERVIEW OF SAN FRANCISCO BAY ECOSYSTEMS AT THE VISITOR CENTER

An ecosystem is defined as a "community of plants and animals and the physical environment with which it interacts." Most of the south bay region is comprised of wetland ecosystems - open bay water, mudflats, sloughs, salt marshes, and salt ponds. These ecosystems will be described along with their associated animals and plant life. The spatial arrangement of these ecosystems is shown on page 47.



Topsmelt

PLANTS & ANIMALS OF THE OPEN BAY

Plants

Phytoplankton
(e.g. Diatoms)

Invertebrates

Ghost Shrimp
Zooplankton
(e.g. Copepods)

Fish

Leopard Shark
Northern Anchovy
Striped Bass
Topsmelt

Birds

Brown Pelican
Diving Ducks (e.g.
Canvasback, Scaup)
Cormorants
Gulls

Mammals

Harbor Seals

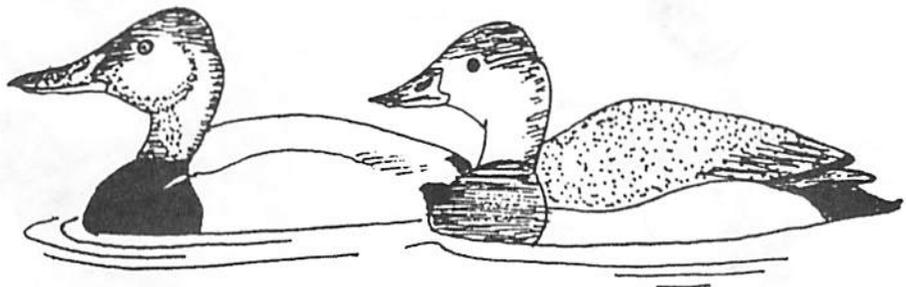
OPEN BAY ECOSYSTEM

Rather than being a true bay, San Francisco Bay and Delta is actually California's largest and best-known estuary. An estuary is a unique ecological system where fresh and salt water come together and mix. The salt water from the Pacific Ocean and the fresh water from rivers are mixed by winds and tidal currents. The Bay provides the only outlet to the sea for the 60,000 square mile Central Valley and its rivers. Of the sixteen rivers that flow into San Francisco Bay, the principal ones are the Sacramento and the San Joaquin Rivers.

Marshlands, tidal shallows and deep-water areas produce a variety and abundance of fish and wildlife. At low tide, 70% of the bay is less than 18 feet deep. However, there is a deep-water channel approximately one mile wide and forty feet deep; this central channel, at lesser depths, extends almost to the town of Alviso.

The Bay originally covered 720 square miles, but filling operations reduced its cover to 480 square miles. The shallow areas of the bay have been filled to create freeways, airports, and housing developments. Much of the original South Bay was diked off to create a huge system of salt ponds.

The open waters of the Bay are a necessity to wildlife as they provide a resting and feeding place for the millions of waterfowl and shorebirds that pass through this area on their spring and fall migrations. Seventy percent (70%) of the birds that use the Pacific Coast as a migration corridor stop at San Francisco Bay every year; many birds spend the entire winter here. The bay also serves as a home to many species of aquatic animals as well, including shrimp, fish, and harbor seals.



Canvasbacks

MUDFLAT AND TIDAL SLOUGH ECOSYSTEM

The slough is a natural waterway, a "finger of the Bay" that allows the tidal bay water to flow in and out of the salt marsh. Water from the open bay enters the slough and floods the marsh as the tide comes in. As the tide goes out, the water from the marsh returns to the slough and flows back into the bay. Mudflats are exposed when the tide is out. This regular tidal action makes the slough and mudflats a valuable habitat for many plants and animals.

The mudflats support an abundance of life; an estimated 40,000 organisms live in a double handful of mud. While, most of the 40,000 organisms are microscopic (not visible to the naked eye), some are visible without a microscope, including ostracods, copepods, and a variety of worms. Larger, more easily visible animals also live in the mudflats, including snails, mussels, crabs, and clams. Many of the animals in the mudflats are burrowers. Burrowing protects the animals from wave action, enemies, and from drying out.

The aquatic habitat of the slough also supports a wide variety of life. Detritus and plankton form the base of the food chain in the slough. Detritus forms as bacteria decomposes marsh plants, such as cordgrass, into small floating bits. Plankton are the small plants (phytoplankton) and animals (zooplankton) that drift in the water. Zooplankton include copepods and the eggs or larvae of aquatic animals. Larger aquatic animals found in the slough near high tide include fish and harbor seals.

The feeding regime of many animals is governed by the tidal rhythms of the slough. The mud-probing shorebirds and dabbling ducks wait for the tide to go out then flock to the exposed mudflats looking for mudflat organisms. When the tide is in, the diving ducks and fish-eating birds search the slough waters for swimming crustaceans and fish.



PLANTS & ANIMALS OF THE MUDFLATS & SLOUGHS

Plants

Phytoplankton
(e.g. Diatoms)
Cordgrass
Detritus (decomposing plants and animals)

Invertebrates

Zooplankton
(e.g. Copepods)
Amphipods
Mussels
Snails
Clams
Crabs
Shrimp
Worms

Fish

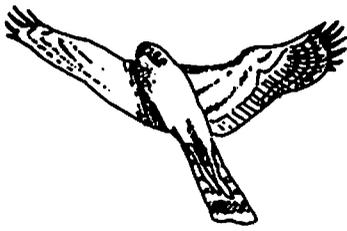
Top Smelt
Bat Ray
Leopard Shark
Bay Goby

Birds

Shorebirds
(e.g. Sandpipers,
Avocet, Willet,
Dowitcher, Godwit)
Forster's Tern
Dabbling Ducks
(e.g. Mallard,
Northern Shoveler)
Diving Ducks (e.g.
Canvasback, Scaup)
Grebes
Great Egret
Snowy Egret
Great Blue Heron
Canada Geese

Mammals

Harbor Seal



Northern Harrier

PLANTS & ANIMALS OF THE SALT MARSH

Plants

Alkali Heath
Australian Saltbush
Cordgrass
Dodder
Pickleweed
Salt Grass
Sea Lavender
Gum Plant

Invertebrates

Pygmy Blue Butterfly

Birds

Northern Harrier
California Clapper Rail
(endangered)
Shorebirds (e.g.
willetts, sandpipers)

Mammals

Norway Rat
Salt Marsh Harvest
Mouse (endangered)
Vagrant Shrew
Vole



Gum Plant

TIDAL SALT MARSH ECOSYSTEM

Salt marshes serve as a transition zone between the aquatic habitats of the bay and the dry upland. They are noted for the abundant plant life that grows in their salty, waterlogged soil. Salt marshes are subject to flooding by the high tides that occur twice every day. Salt marshes usually form in the zone between the highest high tide and the mean tide levels. Eighty to eighty-five percent (80-85%) of the salt marshes around the San Francisco Bay have been destroyed. Salt ponds, housing developments, roads, landfills, airports, etc. have been built on top of salt marshes, resulting in a loss of habitat for salt marsh plants and animals.

The soil in a salt marsh is very salty. Most plants cannot grow in salty soils because the salt will literally suck fresh water right out of the plants. However, some plants have adapted to a salt life; these plants are called halophytes, meaning salt-loving. They either excrete the salt through special cells or are able to keep salt out of their root systems. In the marsh, these plants are also adapted to being submerged by tidal waters part of the time. Salt marsh plants grow in distinct zones. Each zone is dominated by a particular plant species. The distribution of each species is primarily determined by the amount of time they can be submerged. The amount of salt in the soil and in the water also determines plant distribution. The three zones in tidal salt marshes are dominated by the following plants:

Cordgrass is one of the two most abundant plants in the marsh. It grows closest to the bay waters that come in and go out with the tide; this is the boundary between the mudflats and the salt marsh. Cordgrass forms the first link in many food chains involving hundreds of animals that live in the bay. By fall, cordgrass has grown to a height of four feet and resembles a small corn plant. When cordgrass dies, it is decomposed by bacteria and becomes detritus, an important food for filter-feeding animals which are eaten by larger forms of life. Cordgrass produces five to ten times as much nutrient materials and oxygen per acre as wheat.

Pickleweed is the other dominant marsh plant; it grows in the middle marsh, a higher and drier zone. This grey-green succulent plant begins growing where the cordgrass stops. The compressed leaves look like a series of slender pickles attached end to end. Pickleweed tolerates having its "feet" wet by high tides but grows above the average low tideline. The stored salt builds up in the "pickles" until fall, when the end "pickle" turns yellow or red, dries up and breaks off. During the summer months you may see a conspicuous, bright orange hair growing on the pickleweed. These hairs are actually the stems of a parasitic plant called **dodder**. It attaches itself to the pickleweed by inserting small knobs into the pickleweed which bring food from the pickleweed to the dodder.

Salt grass, Australian saltbush, sea lavender, gum plant, and alkali heath grow in the high marsh, a zone which is at a higher elevation than the pickleweed. Like cordgrass, they excrete salt from their leaves by means of special glands.

Various animals are found throughout the salt marsh habitat. There are two endangered species that live only in the salt marshes of San Francisco Bay: the salt marsh harvest mouse and the California clapper rail. The clapper rail, a secretive marsh bird, hides and nests in the pickleweed and cordgrass. The harvest mouse makes a nest of dry pickleweed, feeds on pickleweed, and can drink salt water. Voles, shrews, and other mice inhabit the marsh also. These small marsh rodents are a major source of food for the northern harrier, a hawk.

LaRIVIERE MARSH AT THE VISITOR CENTER IN FREMONT

LaRiviere Marsh is an example of a restored salt marsh. Historically it was a tidal salt marsh, but the area has gone through many changes resulting in what we see today, with the most recent changes caused by humans.

Prior to the 1860s, all of the present salt ponds that surround San Francisco Bay were actually tidal salt marshes or tidal mudflats. In the late 1800s, Arden Salt Company, the first salt manufacturing company in the Bay area, smoothed the ground and created the salt ponds by building levees around portions of the marsh and flooding the marsh with Bay water. LaRiviere Marsh was converted from salt marsh to salt ponds during this period of time. In the early 1920s Leslie Salt (now owned by Cargill) purchased the land from Arden. The ponds in LaRiviere Marsh were the crystallizing ponds - the ponds from which salt was harvested.

In the salt manufacturing process, water is pumped from the Bay into a sequence of evaporating ponds. Over time, water evaporates and the salt concentration becomes so high that the salt crystallizes out of the water and can be harvested. After about 5 years, the salt is harvested from the crystallizing ponds in late summer and is processed for sale to the public and to industries.

The crystallizing ponds in LaRiviere Marsh were abandoned in the early 1960s. The Refuge purchased this land in 1979 from Leslie Salt and restored Avocet Marsh to tidal action in the early 1980s by breaking the levees at two points. Tidal waters entered the area, softening the soil, leaching out the excess salt, and bringing in the seeds of salt marsh plants. Marsh plants, such as pickleweed and cordgrass, are now growing in Avocet Marsh and the area is used by migratory shorebirds and ducks, and by the endangered California clapper rail and salt marsh harvest mouse.



PLANTS & ANIMALS OF THE UPLAND

Plants

Native:

California Buckwheat
California Sagebrush
California Poppy
Coast Live Oak
Coyote Brush
Soaproot
Monkey Flower
Gum Plant

Introduced:

Wild Oat
Wild Mustard
Sweet Fennel
Eucalyptus
Acacia

Birds

Anna's Hummingbird
Barn Owl
Northern Harrier
Sparrows
Barn Swallow

Mammals

Jackrabbit
Ground Squirrel
House Mouse

Reptiles

Gopher Snake
Fence Lizard

Butterflies

Cabbage White Butterfly

UPLAND ECOSYSTEM AT THE VISITOR CENTER

Although the land habitats at San Francisco Bay National Wildlife Refuge consist mostly of wetlands, the Visitor Center in Fremont is located on a 200 acre hill. This upland hill is the smallest of the Coyote Hills. It was created about one million years ago, during the Great Ice Age.

The upland habitat is a dry land habitat located adjacent to the marsh but at a higher elevation. Unlike the Coyote Hills, many upland habitats around San Francisco Bay are former salt marshes that have been filled. Salt pond levees are also considered to be part of the upland habitat because they are removed from tidal flow and can support upland plant species, although typical marsh plants may also be found on the levees.

Plants that grow in the upland are generally taller than those living in the salt marsh. The hills bordering the South Bay were once covered with bunch grasses that remained green year round. However, these native grasses have been displaced by annual grasses, like wild oats, that the early settlers brought with them from Europe. These nonnative grasses turn brown in summer after the rain has stopped. Native plant species include buckwheat, coyote brush, California sage brush, California poppies, coast live oak and soap root.

Many animals depend on the upland habitat for nesting and/or feeding. Mammals, like the California ground squirrel and black-tailed jackrabbit, make their homes underground in burrows. Hummingbirds and sparrows build their nests in trees and bushes, and get their nourishment from upland plants. Barn swallows use mud from the slough to secure their nests to the walls of buildings built on the upland. The barn owl nests in the upland and hunts for food in both the upland and marsh.



Western Fence Lizard

SALT POND ECOSYSTEM

The salt ponds are a human-made habitat not connected to the other habitats. The most dominant features of the Refuge landscape are the salt ponds that comprise more than half of the Refuge's total acreage. Although the Refuge acquired the title to this property in 1972, Cargill Salt Company retains a lifetime lease to produce salt using these solar evaporation ponds. Originally the salt pond area was a vast tidal salt marsh, which was diked to form the ponds. The Spanish mission priests started the salt industry and used windmills to pump bay water into the ponds.

Over a five year period, bay water is passed through a series of ponds where solar and wind evaporation concentrates the salt content of the water. This concentrated salt water is transferred to special ponds called crystallizers where the salt settles from the water and forms a six-inch layer on the bottom of the pond. The crystallizers are drained and the salt is scooped into piles which look like huge snow-covered mountains. This salt is harvested at the end of summer before the winter rains begin.

Salt ponds cover about 40 square miles around the Bay. From an airplane, the South Bay resembles a mosaic of different colored tiles. These "tiles" are the salt ponds. Most colors are due to the many varieties of algae and bacteria that thrive in varying concentrations of brine (salty water). Generally, red water indicates a very high level of salinity whereas blue or green ponds indicate lower salinity levels.

The salt ponds, though an artificial habitat, are important areas for many wildlife species. Ponds receiving water directly from the bay often support a variety of fish like topsmelt and mudsuckers, which are in turn, important food sources for fish-eating birds such as terns, pelicans, herons and egrets. Ponds of intermediate salinity teem with tiny brine shrimp, a vital food source for millions of waterfowl and shorebirds that spend the winter at the Refuge.



Black-necked Stilt with chick

PLANTS & ANIMALS OF THE SALT POND

Plants

Green Algae

Invertebrates

Brine Fly

Brine Shrimp

Birds

Shorebirds

(e.g. American Avocet,

Black-necked Stilt,

Willet, Godwit,

Sandpipers, Dow-

itcher, Snowy Plover

(threatened))

Gulls