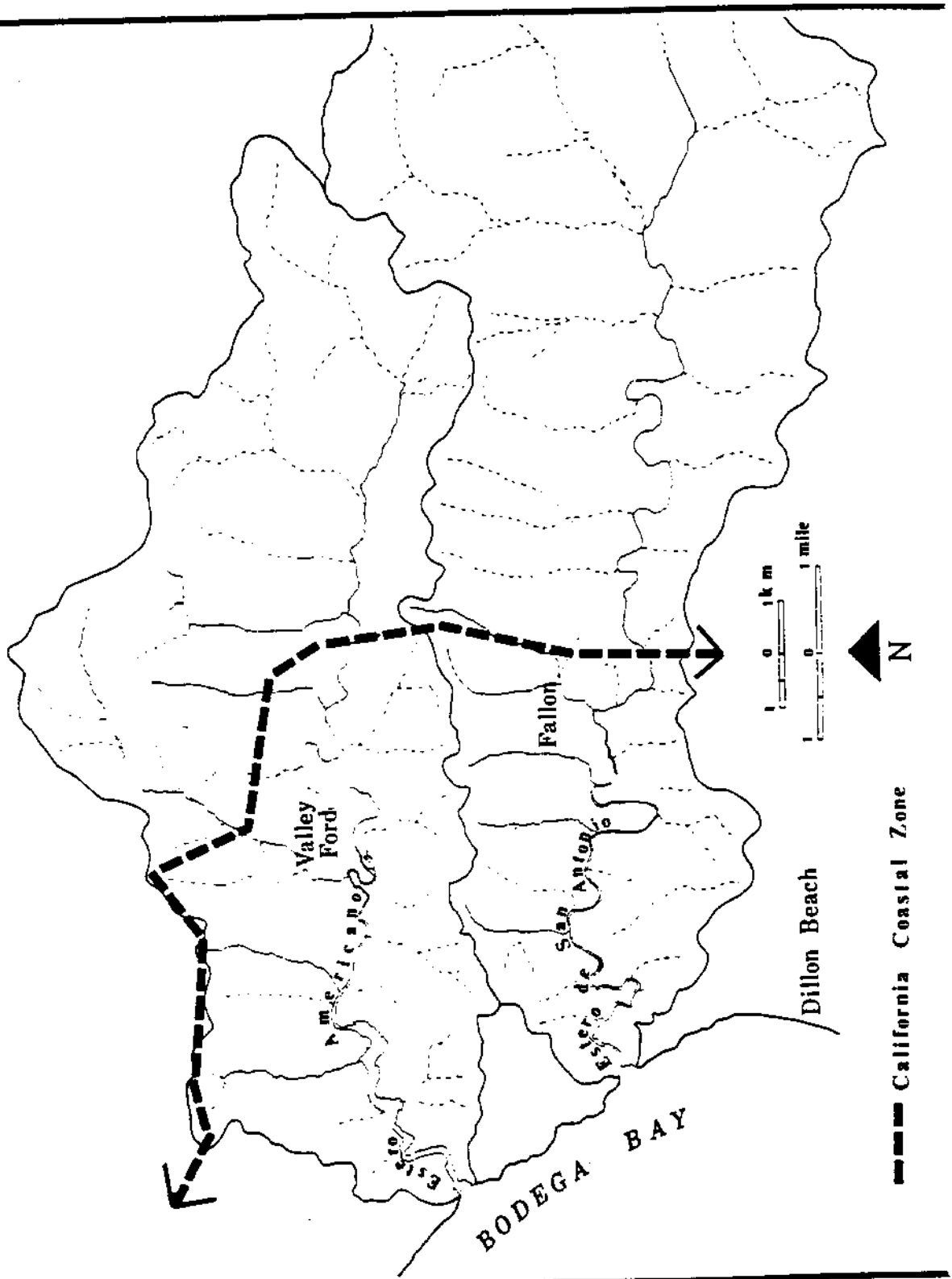


PLATE #2: **Esteros Americano & De San Antonio Watersheds**

Pacific. The 93 acres of open water reach a depth of approximately 20 feet and may vary in width from 20 feet to 10 times that amount. The wetlands of Estero de San Antonio encompass about 228 acres of the watershed (Plate 3).

Bottom sediments of both esteros vary from coarse sand near the mouths to silt and mud further upstream. Due to the relative shallowness of both esteros there is no significant water thermocline and surface and bottom water temperatures vary only one to two degrees. Water and air temperatures also remain relatively close. Salinities throughout the year may vary extremely with the alternating effects of the tidal marine waters, freshwater runoff from Americano and Stemple Creeks during winter and spring rains, and intense evaporation rates of summer. Salinities peak at higher levels and salinity variation is greater than variations found in most estuaries throughout the year. Hypersaline conditions result when sand bar formation closes the esteros' mouths and fresh water flows dimish. Salinities have been recorded up to 67 parts of salt per 1000 parts of water in Estero Americano in late August (Kjeldsen, C., pers. comm., 1976). Ocean salinity is, for comparative purposes, about 34 ppt. No data exist pertaining to the specific causes of sand bar formation across the mouths of the esteros. Bar formation appears to be a function of the prevailing northwest winds and to result from littoral currents carrying tidal sediment loads from local beaches and possibly from Doran Spit. The diurnal tidal cycle and the fresh water inflow to the esteros with its associated fluvial sediment load also influence the bar building process to an unknown degree. This process is an unpredictable phenomenon (Kjeldsen, C., pers. comm., 1976). Although the increased winter fresh water flows gradually open the sand bar, some flooding of lands adjacent to the esteros has been experienced after initial winter rains. Local residents have in the past assisted the natural process with shovels and/or dynamite by manually digging and/or blowing a channel through each bar and releasing the trapped fresh water (Connors and Chimes, 1975). In the fall of 1976, both esteros had been closed by sand bars for approximately 15 months,

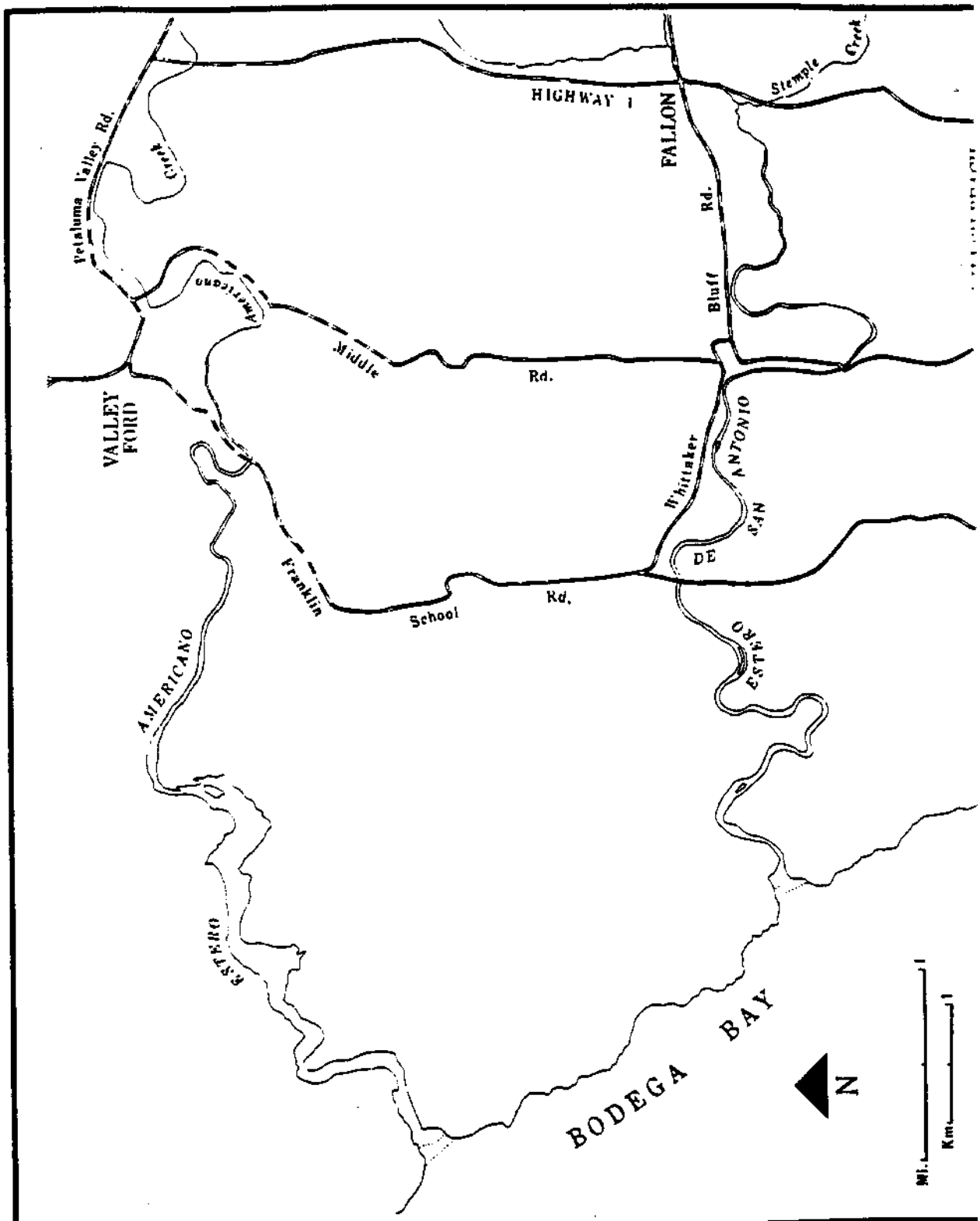


PLATE #3: Esteros Americano & De San Antonio

Periodic breaching of the sand bars at the Estero mouths relieves flooding of upland areas and allows juvenile fish and crabs to escape. (Calif. Dept. of Fish & Game photos by Hilton Taylor)

creating habitats in some areas which more closely resemble lagoons than estuaries. However, 1976 was the driest year of record in the last half century and in years of average precipitation the sand bar breaks after winter rains.

Although each estero drains an area of rolling hills and grazed grassland, the terrain of each watershed differs somewhat; slopes are steeper at Estero Americano and transition to the uplands from open water is more abrupt. Elevations throughout the watersheds range from 0 to 600 feet above mean sea level and the coastline between the esteros' mouths is moderately steep and rocky.

These esteros illustrate the extreme environments which are characteristic of estuaries. The flora and fauna of such areas must be able to tolerate a wide range of salinity, water temperature, pH, dissolved oxygen, turbidity and other physical factors. Many species which are especially adapted to such extremes actually require this variation. Environmental and seasonal fluctuations which are usually present in estuarine ecosystems are amplified in Esteros Americano and de San Antonio due to their small size.

Estero Americano was the subject of various studies by Sonoma State College and Bodega Marine Laboratory students from 1968 to 1972 and recently by California Department of Fish and Game personnel in 1976. Estero de San Antonio has been the subject of a single invertebrate investigation in the summer of 1973 (Hare and Ho, 1973) and another in 1976 (Studley, 1976). The latter was conducted concurrently for California Department of Fish and Game and Sonoma State College.

DRAINAGE

The Estero Americano watershed includes approximately 49 square miles with Americano Creek as its sole tributary. The estero and creek extend approximately 11 miles from the headwaters in the Coast Range to the point of discharge into Bodega Bay. Americano Creek

has an overall slope of less than one percent. No flow data exist for Americano Creek. Based on the size and location of the watershed, and the flow regime for nearby streams for which recorded discharges are available, Americano Creek may be considered an intermittent stream.

Similarly, the Estero de San Antonio drains an area of 59 square miles via its single tributary, Stemple Creek. Stemple Creek and Estero de San Antonio have a total length of 15.5 miles from headwaters to mouth and an overall slope of less than one percent. Flow data for Stemple Creek are scarce. The California Department of Fish and Game reported no surface flow in a July 1976 stream survey, indicating that for the year of record, at least, Estero de San Anotnio also is an intermittent stream. The natural flow diversions for stock watering place the stream in the regulated waterway category. The two esteros and their tributary watersheds are shown in Plate 2.

Mean annual runoff varies within the Estero Americano watershed from 9 to 12 inches while within the Estero de San Antonio watershed it ranges from 7 to 10 inches (Rantz, 1974).

GEOLOGY

The esteros area is underlain by two main geologic units--the Franciscan melange formation, a matrix of crushed shale, sandstone, chert, greenstone, and schist; and the overlying Merced formation, a relatively young, fine-grained marine sandstone (Rice and Strand, 1971). Franciscan formation rocks generally occur in lower elevation areas along steep-sided streambeds or rugged coastline and are inherently weak. This weak matrix affects the stability of any slope it underlies and as a result landslides are common in this region. The Merced formation occupies higher elevation areas capping the Franciscan materials. It is a massive, weakly cemented unit which often contains fossils and is highly erosive where it

is exposed and unprotected (Miller, 1972). A thin alluvium layer is found along the streams and further inland in small valleys.

Deep incised stream valleys and other geologic evidence indicate that the esteros' area has undergone general uplift throughout Quaternary time. Esteros Americano and de San Antonio, as well as other streams of northern California, have drowned mouths, indicating a relative rise of sea level. The San Andreas fault zone passes within one mile offshore from both esteros. This fault system is the boundary between the Pacific and the North American continental plates. Historically, the San Andreas fault itself is the most important break of this plate boundary. In the Bodega Bay area, the area of the zone which has experienced repeated slippage averages about 1.5 miles in width.

Northwest of the San Francisco Bay area, the San Andreas fault is considered to be "locked", that is, little of the fault's strain is relieved by frequent small or moderate magnitude earthquakes, as is the case southeast of the Bay Area. Instead, the fault segment northwest of the Bay Area is thought to be subject to infrequent major events, such as the 1906 earthquake. The frequency of these major earthquakes cannot be reliably predicted at present, but known rates of strain accumulation suggest that perhaps one earthquake per hundred years should be anticipated (Rice and Strand, 1971).

SOILS

Generally speaking, two major soil differentiations can be made in the esteros area. The surrounding uplands consist of well-drained, moderately deep loams and clays. They are typically acid, and the risk of erosion is moderate to high, depending on the slope. Grasses and forbs are well adapted to this substrate. The majority of these upland areas belong to the Kneeland, Los Osos and Steinbeck soil series.

The estero bottomlands differ from the upland areas in that they are poorly drained and are composed of sand, gravel, silt, and peat,

as well as clay. Some of the lowest areas are highly saline. The Blucher soil series, a fine sandy loam, is also found in the bottomlands. Erosion has not been a major problem in these bottomland areas. Soils of the esteros area are most suited to use as dryland pasture for dairy cattle and for growing hay.

CLIMATE

The northern California coast has a Mediterranean climate with dry summers and mild, wet winters. Prevailing winds are westerly. The meeting of warm, moist ocean air and colder ocean nearshore currents results in frequent coastal fogs (60 to 80 days yearly) and generally cool coastal weather year-round.

The esteros' microclimate is typical of the north coast. Winds are usually from the northwest from March through November then reversing to blow from the southeast during the winter months. Air temperature in the esteros is presumed similar to that of Tomales Bay, varying from the low thirty's in winter to as high as the low ninety's.

Recent total annual precipitation has varied from 41.44 inches in rainfall year 1973 to 1974 (June to July) to 14.64 inches in 1975 to 1976. The California drought of 1976 showed a low rainfall of 11.69 inches for the first ten months of the 1976 to 1977 rainfall year. Rantz (1971) reports a mean annual precipitation varying from 30 to 38 inches within the esteros' watersheds, with rainfall increasing from the inland toward the coast. Precipitation is seasonal with nearly 90% occurring in the period from November through April.

ARCHAEOLOGICAL RESOURCES AND HISTORY

Archaeological sites in the area of Esteros Americano and de San Anotnio were first recorded in the early 1900's by investigators from U.C. Berkeley and Santa Rosa Junior College. The reports referred to habitation sites near the mouth of Estero Americano,

primarily indicated by mussel shells. There are probably more sites to the north and south and between both esteros, especially along the coast where small drainages empty into the ocean; however, substantiating surveys are lacking. A survey in 1974, in connection with the then proposed Bodega Bay sewage disposal system, recorded 13 sites north of the esteros that had previously been reported as well as four newly discovered ones (Frederickson, 1974).

History

The Coast Miwok who inhabited the esteros' area were emigrants from the interior Miwok tribe of the Sierra Nevada foothills (Frederickson, 1962). These Indians lived in villages of either semi-subterranean or tule-thatched huts near the beach, in populations of 30 or more adults. Hunting tools included stone-tipped arrows, snares for catching small animals, and fishing nets. Their watertight, decorated baskets resembled those of the Pomo tribe with whom they had frequent interchange due to the local occurrence of clam shells in Bodega Bay. The Pomo Indians used the traded clam shells to manufacture shell disc beads which were used for ornamentation. The local Coast Miwok population is estimated to have been between 1,500 and 3,000 at the time of the first European contact; it dwindled to 250 by 1850. Upper Tomales Bay is the only place where Miwok occupation is known to have continued past 1860.

The first recorded sighting of Bodega Bay was in 1603 during the age of the Spanish ship, "Tres Reyes", to Tomales Bay. It was not until 1775 that Bodega Bay was rediscovered by Juan Francisco de la Bodega y Oyadra from whom the bay's name may have come. The late 1700's saw domination of the area by the Spanish.

In 1793, the Russians first came to Bodega Bay from colonies in the Aleutians and began to hunt sea otter. Drakes, Tomales and Bodega bays were hideout anchorages used by two or three Russian ships a year, which were illegally poaching in Spanish preserves. From 1811 to 1841, the Russians occupied the north coastal area,

building colonies at Fort Ross and at Romanov. Their settlements included activities such as hunting, fishing, dairying, fodder and food crop agriculture; the raising of cattle and sheep; and the industries of shipbuilding, tanning, and metal work. But the poor soil, fog, rain, political hostility, and an unending battle with gophers contributed to the Russians' decision to leave (Frederickson, 1962).

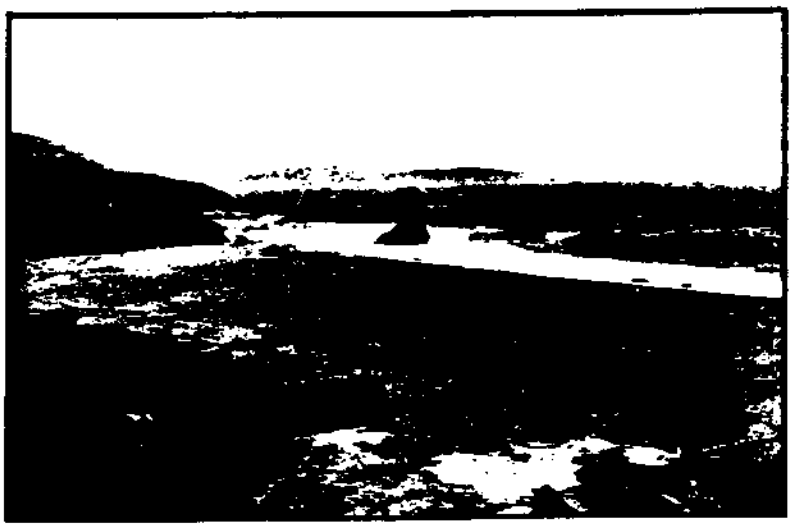
In 1841, Stephen Smith, an enterprising captain from Massachusetts, enlisted the support of the Mexican governor and established the first steam plant in California. It was at Salmon Creek Valley and powered a saw mill and flour mill. Smith's Bodega land grant included "all west of a line beginning at the Estero Americano to the Russian River to the Pacific Ocean--37,787 acres" (Oakland Tribune, 1956). California was admitted to the United States in 1850. By 1854, Smith had established the first settlement in Sonoma County and from his flagpole were flown the first four U.S. flags.

With Smith's economic impetus, people began to move to the Bodega Bay and esteros' area, and occupied themselves with potato raising, dairying, sheep grazing, and fishing, depending on the esteros for irrigation and adjacent uplands for grazing land.

Within 20 years after Smith's original settlement, the British Isles and Northern Europe were well-represented in the Bodega Bay area. Swiss settlers operated dairies and Italians made a living by catching and drying fish. By the 1880's the railroad boosted the area's economy.

During the middle to late 1880's the estero lands were used for growing a wider variety of crops than now exists. Farming over the last 50 years has evolved to primarily dairying and grazing of sheep and replacement heifers.

As the Esteros flow coastward, the fjord-like qualities of steep and twisting uplands become the dominating character of the scene. (Calif. Dept. of Fish & Game photos by Tom Studley)



NATURAL RESOURCES

HABITAT TYPES

The wide range of physical characteristics possessed by the esteros is exemplified by the adaptations of plant and animal life in the 14 different habitat types existing in this area. These habitats include representatives from all three main kinds of biological communities, i.e., marine, freshwater, and terrestrial (Plates 4 and 5).

The habitat types described in this report are based on characteristics of plant communities set forth by Munz and Keck (1973) but revised to fit more exactly the presently existing communities in Esteros Americano and de San Antonio. Some, such as coastal prairie, coastal scrub, and rocky coastal bluffs, are unique to the California coastline areas. Others, such as seasonal brackish marsh, vernal pools, and freshwater marshes remain in few areas as compared to a century ago. And still others, such as ponds and windbreaks, are man's additions to the esteros environment.

Each habitat is characterized by an assemblage of plants and animals. These may be peculiar to a single habitat, as are eel grass or the staghorn sculpin to the open water-mudflat community, or they may occur in several communities, as do the bull thistle or the great blue heron. Although the 14 habitat types are applicable to the environments of both esteros, detailed differences within each habitat indicate that the esteros are independent ecological systems.

Lists of vascular plant species and accompanying distribution data were developed for each habitat category from field surveys by California Department Fish and Game seasonal aid Craig Thomsen (Appendix A). Habitats were mapped using aerial photographs and were field checked. These field surveys made it clear that plant communities are rarely of one type, such as coastal scrub or annual

grassland, but are usually combinations of several habitat types. For instance, a hillside might be primarily coastal scrub, but contain some coastal prairie and some annual grassland. Because of size and the number of mapping categories which would be required, delineation of these differences on a map reproducible in this report is impossible. Hence, only primary habitat types are indicated on the habitat maps (Plates 4 and 5) and boundaries of the mapped categories are approximate. Vegetation mapping corridor boundaries were established using peak elevations of adjacent grasslands. Planimetric estimates of habitat acreages (Table 1) were calculated from mapped habitat boundaries.

Open Water

The open water habitat is the heart of the estuarine wetlands of the Esteros Americano and de San Antonio. Here one finds a meeting of marine waters from the ocean and fresh water from inland drainages. During the winter when fresh water enters the esteros and the sand bars are breached, plants and animals are submerged or exposed twice daily with the ebb and flood of the tides.

A few plants are able to root in the muddy bottom areas of the channel. These include pondweed and eel grass. Pondweed grows wholly submerged, arising from thick, matted rhizomes and is a very important food for many water-associated birds. Eel grass (*Zostera marina*)[1/] is a flowering plant, not a true grass, with long slender green leaves, that inhabits the muddy bottoms in shallow subtidal and intertidal areas. It provides substrate for many non-burrowing invertebrate species, such as hermit crabs and micro-algae (diatoms), that provide food for larger invertebrates, fish, and birds. Extensive eel grass beds are present near the mouth of Estero de San Antonio in late winter and spring but seasonally die down by late summer.

[1/] Scientific names of all plants and animals will be found in the Appendix.

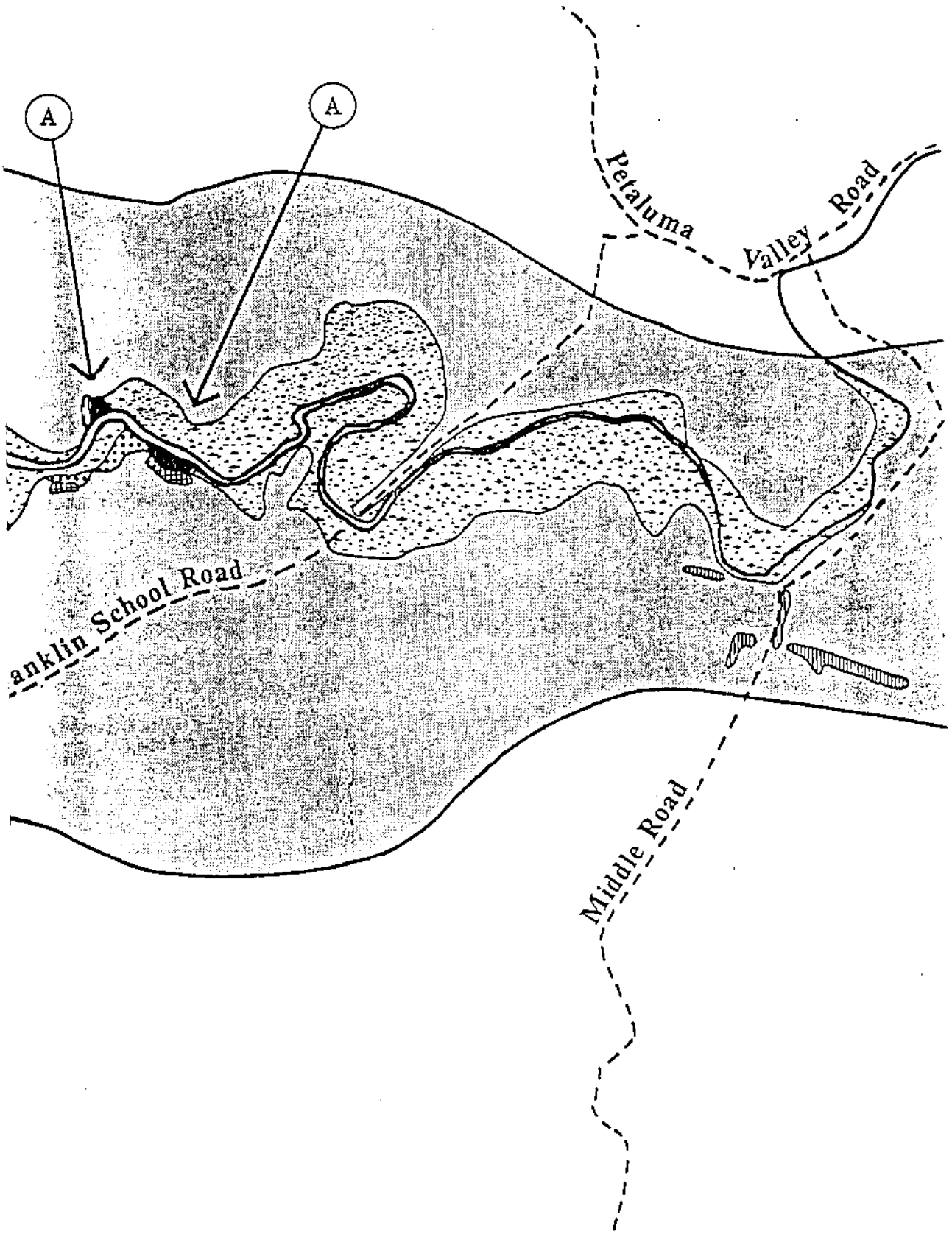
TABLE 1

ESTEROS AMERICANO AND DE SAN ANTONIO

AREA BY HABITAT TYPE

	HABITAT APPROXIMATE AREA	
	Estero Americano	Estero de San Antonio
	acres	acres
Estuarine and Rocky Coastal Bluffs	0	2
Rocky Shore	*	*
Open Water	301	93
Mudflats	4	13
Coastal Strand	13	18
Coastal Scrub	237	150
Coastal Prairie	17	303
California Annual Grassland	3,379	1,872
Seasonal Brackish Marsh	391	213
Freshwater Marshes, Ponds and Seeps	17	2
Riparian Ravines	49	62
Vernal Pools	*	*
Bay Groves	6	2
Windbreaks	16	10
Total	4,430 acres	2,740 acres

*Area not calculated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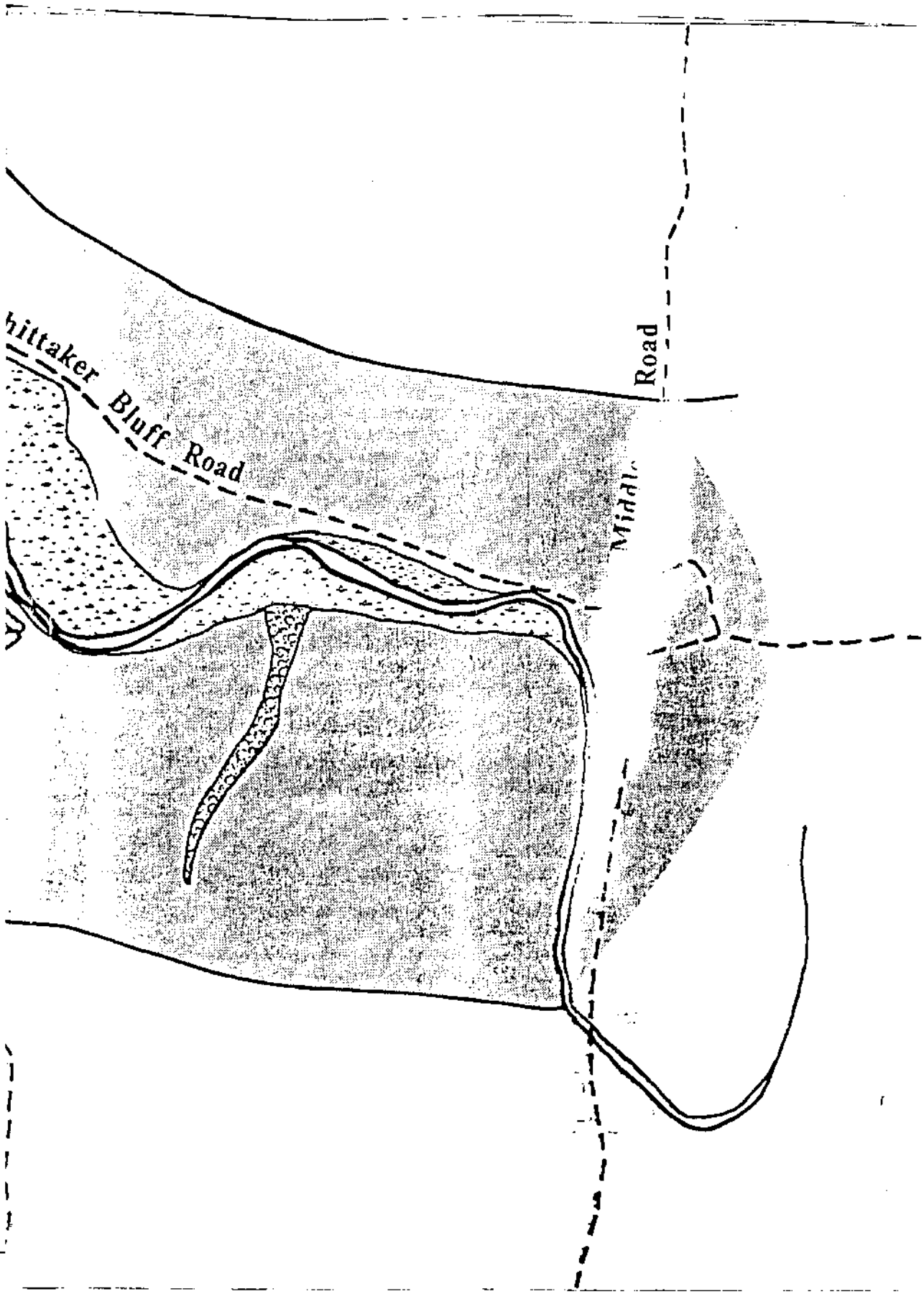
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Road

The open water habitat flora also includes non-flowering plants commonly known as algae or kelp. The algal populations of the esteros are one of the strongest indicators of the differences between the two areas. Of the 64 algal species presently collected from the esteros, 38 species are from Americano and 26 are from de San Antonio (Appendix B) and only 1 species, a red algae, has been collected from both. A major difference in algal community species composition is the lack of fresher water green and blue-green algae in Estero de San Antonio. This absence may indicate a difference in salinities between the esteros or may just indicate seasonal differences in collecting times for each estero. Additional surveys and investigations are needed to pinpoint the reason for differences in the algal communities of the two areas.

Mudflat

The formation of mud and sandflats takes place when upstream and ocean-born sediments are deposited in the shallow areas of an estuary. In the esteros, this intertidal community is characterized by soft substrate invertebrates and algal populations. Invertebrate fauna living on or in this habitat type in the esteros include: bivalves--the common softshell clam, the sand clam, and the bent-nosed clam; snails--limpets and sea slugs; polychaete worms--*Glycera* and *Streblospio;* and various crustaceans--the oppossum shrimp, rock lice, amphipods, bay crabs, ghost shrimp, and the Dungeness crab (Appendix I).

Mud-sandflats are the most important feeding areas within an estuarine system; at low tide for shorebirds and at high tide for waterfowl (Small, 1974). However, in the esteros tidal ebb and flood of this habitat type is limited to periods when the sand bars are open. This may affect the extent of use of these areas for feeding by shorebirds.

The border of the esteros, on the edge between the mudflats and upland habitats, are frequently colonized by the emergent three square sedge, *Scirpus americanus*.

Seasonal Brackish Marsh

The periodic interruption of tidal activity in the esteros is responsible for the development of a plant community which is similar to coastal salt marsh but seasonally receives more fresh water. This unique set of conditions has resulted in the establishment of a community which has adapted to seasonal variations in the range of inundation, salinity of flooding waters, and the degree of dessication to which the marsh plants and animals are subject. Because this habitat fits a description of neither coastal salt marsh nor freshwater marsh, but contains elements of both plant communities, it is referred to as "seasonal brackish marsh".

These marshlands form at the edge of the estero uplands in low elevations and are maintained by yearly tidal flooding and by winter and spring heavy rainfall runoff. After the spring rains cease and a sand bar forms across the mouth of each estero, soils become saline as water evaporates from the marsh.

Vegetation which is common to the higher elevations of coastal salt marshes typifies this habitat. Pickleweed, *Jaumea*, and saltgrass are the dominant species bordering the esteros, with saltbush and *Frankenia* occupying some better drained areas. The inland edges of this habitat receiver more fresh water, thus plants which are less salt tolerant, such as wild oats, soft chess, and velvetgrass, invade these areas.

During the winter and spring, when standing water often covers much of this habitat, birds congregate by the hundreds. Northern phalarope, willets, yellowlegs, dowitchers, ducks, gulls, herons, and egrets feed or rest here. Marsh hawks and white-tailed kites regularly patrol the area.

Estuarine and Coastal Rocky Bluffs

This habitat type occurs only at Estero de San Antonio. Areas described as rocky bluffs are characterized by steep, unstable slopes with little or no soil. Vegetation here is exposed to the extremes of high winds and salt spray. Plants in this habitat type are adapted to these special conditions and include slender hairgrass, coffee fern, goldback fern, licorice fern, and the native herbs--Henderson's angelica, native chickweed, live-forever, seaside daisy, coast plantain, and stonecrop.

In some small areas of micro-climatic extremes in this habitat, lichens are dominant, particularly where steepness and lack of soil prevent colonization of vascular plants. A preliminary list of lichens observed on rocks and dead tree branches in Estero de San Antonio is included in Appendix C. Some portions of the rocky bluff habitat in Estero de San Antonio are formed from water-retaining sandstones. Here, less drought-resistant plants, such as ferns, miner's lettuce, cow parsnip, California poppy, and ice plant may thrive. The native herb, coast rock cress *(Arabis blepharophylla)* survives on the cliffs between the esteros and is currently designated as rare and endangered by the California Native Plant Society (Thomsen, 1976).

Coastal rocky bluffs provide important habitat for shorebirds. Also, bank swallows commonly breed in the cliffs. Reptiles and amphibians known to frequent the rocky bluff habitat include the gopher snake, western fence lizard, southern alligator lizard, and western toad (Brown, C.W., per. comm., 1976; Cline and Katoski, undated).

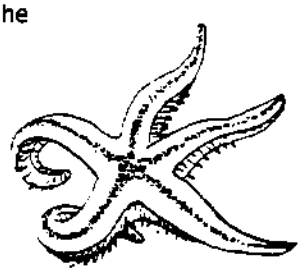
Rocky Shore

Within the esteros proper, rocky shore habitat is found only at the northern edge of the mouth of Estero de San Antonio.[1/] Here the

1/ Because of the small size of the rocky shore community in Estero de San Antonio, its area has not been calculated from the map.

rock outcrops exist as a normal rocky shore community only periodically. During periods when little fresh water flows from inland sources and the estero mouth is blocked by a sand bar, tidal cycles which commonly influence rocky shore environments are no longer present in this habitat.

When tidal entrance to the estero is blocked and summer air temperatures increase, evaporation reduces the depth of the water surrounding the rocks until they are entirely exposed. This, of course, produces physical extremes of temperature and dessication which are most often fatal to the species, such as barnacles, purple shore crabs, and starfish which inhabit the area during tidal influence. However, when the estero is again opened to tidal action and ocean waters, the rocks are once more colonized by rocky shore species.



Coastal Strand

A rather fragile plant community immediately adjacent to sandy beaches is the coastal strand. Here, plants grow on and stabilize sand dunes, sandy flats, and sometimes the beach itself. These plants have to contend with rooting in a saline substrate that is low in nutrients, drains rapidly, is subject to extreme daily temperature fluctuations, and is constantly being shifted by the wind. Leaves are often succulent, and the plant form is generally low as a result of wind pruning.

Bare sandy areas are inhabited by a small succulent annual, sea rocket, and by the introduced European beachgrass. In nearby areas, such as Bodega Bay and Dillon Beach, European beachgrass has been planted for dune stabilization purposes. Vegetation of more stable strand areas includes introduced herbs, such as ice plants, bur clover, and bristly ox-tongue, as well as native bush lupine, silver beach weed, the California poppy, and paintbrush. In shelterd spots further inland, such species as poison oak, miner's lettuce, wild cucumber, and plantain join the plant community.

At Estero de San Antonio the coastal strand habitat is well developed. Forty-seven plant species have been recorded there in a preliminary investigation by Fish and Game personnel (Thomsen, 1976). In front of the sand dunes, where exposure to the coast is not pronounced, species diversity is limited, allowing only a few plants such as sea rocket, silver beach weed, and sand verbena to exist. Further inland, with the stabilizing and protective effect of European beachgrass, dunes develop and allow for greater diversity; the strand indicators species, beach morning glory and dune sun cup, are impressive in their display. Behind the dunes, where protection is maximum, a flat and slightly depressed area exists. The protection and increased water of this area have allowed many more species to exploit the sandy soil. Here the native small dune bluegrass has colonized along with other natives and a contingent of introduced "weedy" herbs and grasses.

The coastal strand area at Estero Americano, in contrast, has low species diversity and density. Present are silver beach weed, sea rockets, and European beachgrass.

The food and shelter of the low, vegetative mat of the coastal strand are utilized by wildlife species, such as the California quail, white-crowned sparrow, house finches, mice, and many insect species.

Coastal Scrub

The coastal scrub community has often been termed the "soft chaparral" of the California coastline, because the growth form closely resembles the true chaparral found on drier, inland slopes. High winds and accompanying salt spray usually keep the shrubs of this habitat type low in stature, but in protected canyons they can attain a height of six feet. This habitat includes a diverse and rich mixture of hearty, wind-blown shrubs which often form a thick and impenetrable barrier. Twenty-four different shrubs occur in this plant community in the esteros (Thomsen, 1976).

Establishment of some plant species in this habitat depends partially on environmental factors, which include proximity to the ocean, steepness of terrmain, direction of the slope, soil types, textures and depths, and grazing or browsing pressures. The coastal scrub habitat of the esteros is dominated by locally common native herbs and shrubs, such as snowberry, ocean spray, ninebark, silk tassel, blue blossom, and coyote brush. Primary colonizers of this habitat, i.e., coyote brush, California sagebrush, and bracken fern, are arid-tolerant plants. Their establishment is soon followed by that of poison oak, native blackberry, and native herbs, such as yerba buena, *Potentilla*, and honeysuckle. In areas of the esteros where the coastal scrub plant community is fully developed, other more moisture-loving species occur, such as ninebark, thimbleberry, salmon berry, coffee berry, and hazelnut.

Elimination of this native vegetation can result from overgrazing. In the esteros this has resulted in the dominance of a very thorny introduced rosebush, *Rosa eglanteria*. Dominance by this opportunistic species restricts the growth of other plants with greater habitat value, and limits future land use options.

Many small, seed-eating birds, rodents, and other small mammals feed and nest in this habitat. Larger predatory mammals, such as the raccoon, striped skunk, gray fox, and long-tailed weasel, hunt and feed there as well.

Coastal Prairie

The coastal prairie is characterized by a rich mixture of perennial grasses and various native herbs, growing in an open situation in association with shrubby plants of the coastal scrub formation. Human activity, resulting in the introduction of non-native plant species, has eliminated the coastal prairie throughout much of its original distribution in California. Relatively intact portions of this rare plant community exist in the vicinity of the esteros where the largest continuous expanse extends roughly 0.6

miles inland from the shore, on the south side of Estero de San Antonio. Smaller patches of prairie are found on slopes and hilltops on the south side of both esteros.

Unlike the often impenetrable coastal scrub community, coastal prairie is more open; the shrubs there, including coffee berry, hazelnut, ocean spray, and poison oak, generally take on a prostrate or stunted growth form that reflects the influence of harsh westerly winds, salt spray, and repeated fires. California fescue and Pacific reedgrass are the dominant native grasses of the association in the esteros; other plants found there include tufted hairgrass, needlegrass, California bromegrass, iris, and lupine. A species of gentian, rare in the surrounding area and approaching the southern limit of its distribution, is fairly common in the coastal prairies associated with the esteros.

Wildlife found in the coastal prairie includes brush rabbits, grey foxes, and mule deer; common birds are goldfinches, meadowlarks, house finches, and several types of sparrows. Raptorial birds that hunt from the air above the prairie include American kestrels, red-tailed hawks, and white-tailed kites.

California Annual Grassland

In terms of actual area, the California annual grassland community dominates the landscape surrounding the esteros. This grassland is composed largely of alien plant species, many of which were introduced to California from the Mediterranean region. Clearing, grazing, and other human-induced disturbance has allowed this annual grassland community to become established in areas formerly covered by coastal prairie, coastal scrub, or other native vegetation.

Grasslands surrounding the esteros are for the most part heavily grazed, and plants that are common there include wild oats, soft chess, Italian ryegrass, filaree, cheese weed, and pineapple weed. Areas that are more lightly grazed also support a variety of native and introduced wildflowers, some of which are found only in open grasslands. Coast fiddleneck, brodiaea, coast tarweed, goldfields, owl's clover, sorrel, checkerbloom, mustard, yarrow, and California poppy are often seen along the esteros.

Raptorial birds that hunt during the daytime seek their prey in this open grassland environment. Red-tailed hawks, white-tailed kites, American kestrels, and an occasional golden eagle can be found at both esteros. Rough-legged and ferruginous hawks have been sighted at Estero Americano. Other birds, such as meadowlarks, killdeer, white-crowned sparrows, goldfinches, house finches, and blackbirds are common. When wet years cause standing water in the grasslands, shorebirds and wading birds use the area as an extension of their regular mudflat habitat. Jackrabbits, deer, voles, and pocket gophers favor the grassland habitat, and mammals like the badger and grey fox can occasionally be seen. Burrowing owls live here in close association with the more conspicuous California ground squirrels.

Freshwater Marshes, Ponds, and Seeps

In an area of predominantly salt water, freshwater features are particularly attractive to many species of wildlife and domesticated animals. In addition to the herons, kingfishers, and other birds commonly associated with fresh water, raccoons, deer, skunks, and other mammals migrate daily to these spots. Various salamanders, snakes, toads, and frogs depend on a freshwater habitat during some part of their life cycle, and feed in part on the abundant array of insects, snails, and slugs that are found in wet places.

Two small (1 acre) freshwater marshes lie adjacent to both sides of Estero Americano, roughly 3.5 miles from the mouth of the

estuary. These marshes are floristically well-developed with such native plants as rushes, duckweed, water plantain, loosestrife, cattails, and bur-reed. Great horned owls frequent these two marshes; redwinged blackbirds, black phoebes, and song sparrows are particularly common. These and numerous other animals are attracted to the relatively unique marsh habitat.

Estero de San Antonio has no freshwater marshes, but a small freshwater pond has been constructed in a sandy are on the north bank of the estero, less than 0.5 miles from the ocean. This pond is used as a watering hole by livestock as well as by many native animals.

Seeps are found where the side of a hill or face of a bluff intercepts strata containing underground water. Different plant associations develop in seeps, depending on the surrounding plant communities, aspect of slope, and so on. Seeps are found along the hillsides flanking both esteros. Plants that are found in the seeps include the aptly-named seep thistle, a locally rare plant, and well-developed stands of western chain fern and coast hedge nettle. Other common species are arroyo willow, wax myrtle, loosestrife, yellow monkey-flower, fireweed, poison hemlock, pearlwort, and western lilaeopsis.

Riparian Ravines

Intermittent streams drain the hillsides surrounding both esteros through a number of riparian ravines. The vegetation and wildlife associated with these ravines varies from area to area as the ravines traverse several plant and animal communities, primarily annual grassland and coastal scrub. Ravines along the south side of Estero de San Antonio are most numerous and most diverse.

Some of the plants growing near the esteros that are generally common in the riparian ravines are Coulter's and red willows, dogwood, gooseberry, hedge mustard, stinging nettle, honeysuckle, hill lotus, and a variety of soft rush. Buckeye trees, salmonberry,

The Esteros have a rich diversity of wildlife habitats, including freshwater, marine and upland habitats. (Calif. Dept. of Fish & Game photos)

poison oak, wax myrtle, yellow monkey flower, blackberry, and arroyo willow grow there as well.

Thickets line the wettest part of the ravines, providing bedding areas for deer, escape cover and food for birds, nesting site for woodrats, hunting grounds for bobcats, and attractive habitat for many other mammals, reptiles, and amphibians. Black-crowned night herons roost seasonally in the willow thickets that grow where the ravines widen as they reach the esteros. Kingfishers, scrub jays, goldfinches, towhees, song, golden-crowned and white-crowned sparrows, and yellow-rumped warblers frequent the trees and bushy growth of the ravines. Other animals attracted by this riparian environment include Trowbridge shrews, raccoons, striped skunks, Pacific treefrogs, common garter snakes, and California newts.

Vernal Pools[1/]

Vernal pools are ephemeral bodies of standing water which, during the rainy season, collect in low, poorly drained areas in the grasslands, and which gradually dry up with the onset of the summer. Typically, vernal pools are characterized by an assemblage of annual wildflowers and grasses that are unique to such pools. While vernal pools do occur at the esteros, they have not been studied in detail, nor have they been mapped.

Common herbs found at the vernal pools, but nowhere else at the esteros, include Howell's bentgrass, white broadiaea, a species of cudweed, everlasting *Psilocarphus*, (a typical vernal pool species), and white hedge nettle. Other plants, such as spikerush, bracted allocarya, marsh lasthenia, loosestrife, and pennyroyal, that prefer a moist or wet habitat, are also found in the pools.

While mammals and birds of the surrounding grassland frequent the vernal pools, the most obvious inhabitants are the noisy male

1/ Vernal pools have not been mapped or area calculated due to drought during the year of plant community study of the esteros.

Pacific tree frogs, which use the pools as breeding areas. Garter snakes also use the pools, and tiger salamanders, which are relatively uncommon, are often found in this type of habitat and may occur in the vernal pools in the area of the esteros.

Bay Groves

Bay groves have developed near the esteros in spots that enjoy some protection from the prevailing winds. Along Estero de San Antonio, two small groves covering less than one acre are found on the south-facing hillsides, less than one mile from the estuarine mouth. Four small but well-developed groves occur on the north-facing hills and bluffs of Estero Americano, roughly four miles inland.

California bay trees form the dominant overstory in these groves mixed with some of the deciduous California buckeye. Along Estero Americano, the bays are very large and stately, with gnarled and weathered trunks. A rich assortment of plants makes up the understory, including a variety of western choke-cherry and, near Estero Americano, bitter cherry; while these two species have a wide general distribution, in Marin County they are found in only a few, scattered localities. Douglas hawthorne, approaching its southern limit of distribution in the area of the esteros, is found in the bay groves and at one other spot in Marin county. More common shrubs growing under the bays are blue elderberry, poison oak, coyote bush, hazelnut, snowberry, and arroyo willow. With the exception of a few species like hedge nettle and shield fern, herbaceous plants are absent from the understory.

The value of these sheltered bay groves as wildlife habitat is high. Many species of birds, mammals, reptiles, and amphibians find food, cover, nesting and breeding areas, and a suitable place to raise young in the trees and bushes of these groves. Owls,

hawks, and kites, for example, hunt in the surrounding grasslands and return to the protection of the bay groves for roosting and resting.

Windbreaks

Near the eastern limit of both esteros, on hillsides of the southern bank, several small groves of eucalyptus, Monteney cypress, red alder, and willow have been planted, primarily to shelter pasture, crops, and farm buildings from the strong coastal wind.

Raptors, including great horned owls, red-tailed hawks, white-tailed kites, and American kestrels use the tall trees for nest sites and lookout or hunting perches; scrub jays and crows do so as well. Windbreaks provide safe cover and roosting areas for many smaller speices of birds, such as warblers, as they pass by the esteros during migration.

FISH AND WILDLIFE ECOLOGY

ECOLOGY

An estuary or "estero", defined simply, is a semi-enclosed area where fresh water of streams and rivers and marine water from the open ocean meet. Tidal and current action in these areas results in a continuously changing mix of salt and fresh water. The predominance in the estuary of salt or fresh water varies throughout the year with seasonal rainfall and runoff. Typically, estuaries form a gradual transition from an open, marine environment, through mudflats and tidal marshes, to freshwater and upland habitat. The esteros differ from this description, because they are closed to tidal exchange for part of the year by sand bars, and the steep banks and hillsides form an abrupt rather than gradual transition to an upland community.

Plant and animal species of the esteros are adapted to a wide range of changing environments. The species composition of each habitat depends on existing physical and biological features such as the extent of tidal exposure and cover, food and cover resources, sediment or soil type, slope aspect, salinity, temperature, season, and even time of day. Specific adaptation to these conditions by the aquatic fauna include such examples as suspension feeding by clams and mussels, extreme salinity tolerances by limpets and the common sea star, low oxygen demands of polychaetes, and burrowing by the ghost shrimp. Adaptation of species to such physical extremes results in communities with low species diversity and high abundance. This situation is typically a highly productive one.

Estuarine ecosystems have been shown to be communities of high biological productivity (Odum, 1971). In simple terms, this means that estuaries produce more food and nutrients than are consumed by

the plant and animal residents of the ecosystem; the excess is transported to benefit other communities. The nutrients and energy produced are transferred from organism to organism through a variety of food chain relationships.

These food chains begin with energy from the sun being used in the process of photosynthesis by plants on the hillsides, eel grass in the water, and algae on the mudflat. One example of such a food chain in the esteros starts with the consumption of photosynthetic plankton, a "producer", by another microscopic organism, perhaps a larval jellyfish, a "primary consumer". These juvenile jellyfish are in turn fed on by "secondary consumers" like the Pacific herring. A raccoon that snatches one of these herring from the water may live a long life, eventually dying in a riparian thicket. Scavengers (like the turkey vulture) and "decomposers" (such as fungi and bacteria) derive nutrition from the decaying raccoon and release inorganic nutrients; these nutrients eventually wash downstream to the estero where, with additional energy from the sun, they can again be used by the primary producers, perpetuating the cyclic food chain. The nutrient cycle is not unique to estuarine ecosystems, but the particular plants and animals which take part in it are.

The wide diversity of habitat types encompassed by the esteros makes this region highly attractive and valuable to many species of wildlife. Upland habitat, particularly the rolling grasslands and prairies on the hillsides overlooking the esteros, provides hunting grounds for hawks and eagles, burrowing sites for numerous rodents, and suitable conditions for a variety of insects, smaller birds, and other wildlife. Deer, quail, owls, bobcats, mountain lions, and many other species of birds, mammals, reptiles, and amphibians are dependent on the diversity of cover types and food sources provided by the trees, bushes, and thickets of the bay groves, riparian ravines, seeps, and coastal scrub that flank the esteros.

Freshwater features are always attractive to wildlife, particularly in a predominantly saline or brackish setting, such as found around the esteros. In addition to the numerous invertebrates, reptiles, and amphibians which inhabit these wet places, terrestrial birds and mammals are drawn to the ponds, seeps, and freshwater marshes for food and water.

In terms of intensity of use, open water and mudflats may provide the most valuable habitat at the esteros. The esteros are located on the Pacific flyway, a main path of travel for migrating birds. During the winter months, populations of migrant and resident shorebirds and waterfowl reach peak numbers in this area using it as a source of food and resting sites. Open water areas provide habitat for many species of sport and commercial fish, such as striped bass, flounder, steelhead and topsmelt. Abundant populations of crustaceans, including the commercially valuable Dungeness crab, and other invertebrates provide food for the large fish which in turn support the upland local populations of reptiles, amphibians and mammals.

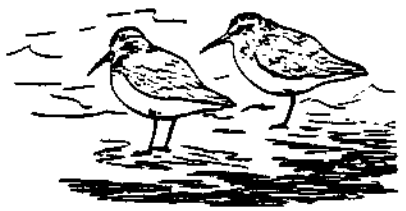
BIRDS

The Esteros Americano and de San Antonio provide essential feeding and resting areas for many species of water-associated birds, both migratory and resident. Preservation of such areas is critical to the survival of many species of shorebirds and waterfowl.

Although specific bird census data which would provide an index to the total numbers of individuals at the esteros are not available, it is estimated that Estero Americano and Estero de San Antonio receive wildlife use which is comparable to other censused areas with similar habitat acreages in Marin County (Smith, 1973). California Department of Fish and Game personnel, conducting bimonthly surveys during 1975 and 1976 (Sample, 1976) listed 71 species of water- and marsh-associated birds and 66 upland species as present in the esteros and the surrounding hillsides (Appendix D).

Additional species occur in nearby areas and are expected in the vicinity of the esteros (Appendix E).

Shorebirds



The migration of shorebirds along the east Pacific Ocean coastline covers thousands of miles as the birds move from their breeding areas in the Arctic to wintering grounds, such as those at the esteros. Of the shorebirds observed in the esteros, 14 species are winter or year-round residents, including the killdeer, common snipe, long-billed curlew, willet, least sandpiper, dunlin, marbled godwit, and sanderling. Black-bellied plovers, snowy plovers, pectoral sandpipers, and western sandpipers are winter residents that have been observed at Estero Americano, and semi-palmated plovers have been seen at Estero de San Antonio. Four migrant species of shorebirds observed are the ruddy turnstone, at both esteros, and the pectoral sandpiper and long- and short-billed dowitchers at Estero Americano (Appendix D).

Detailed four-year studies of the shorebirds using Bolinas Lagoon, an estuary in Marin County located 30 miles south of the esteros, indicate that of the 102 species of water birds using the area annually, 34 species were shorebirds (Page and Stenzel, 1975). The attractiveness of that estuary as a habitat for these 34 species is demonstrated by the fact that in 1973-76, shorebirds accounted for 64% of the total number of individuals present in the fall and 71% of the total number present in the spring. Similar data have been obtained for Limantour Estero, 17 miles from the esteros (Smail and Lenna, 1969).

At least 18 species of shorebirds have been observed in the esteros. Shorebird species composition and abundance change constantly in a given area depending on seasonal migrations, tidal cycles, or disturbances (Jurek, 1974). Presumably, some shore-

birds using the marshes and mudflats of Bolinas Lagoon, Limantour-Drakes Estero, Tomales Bay, and Bodega Harbor also utilize similar habitats at the Esteros Americano and de San Antonio.

The esteros provide abundant food for shorebirds, which are known to feed on small invertebrates living in the intertidal mudflats (Recher, 1964). One of the most common groups of shorebird food species is the Amphipoda, small crustaceans living in the mud or on the mudflat algae. In Bolinas Lagoon, amphipods of the genus *Corophium* were found in 98 to 100% of the stomach-pumped samples of least and western sandpipers feeding in some areas of the lagoon (Page & Stenzel, 1975); *Corophium* was found to be the most common genus of invertebrates collected in Estero de San Antonio in 1973 and 1976 surveys (Appendix I).

Marsh Birds

The long-legged wading birds observed in the shallow water of the esteros include the great blue heron, great egret, snowy egret, and black-crowned night heron. Fish, many species of which are present in the esteros (Appendix F) are major food items for the herons and egrets (Kingsley, 1970). In addition, these marsh birds prey upon frogs, lizards, mice, snakes, and insects. Herons and egrets may be seen feeding or resting in the esteros most months of the year. During wet winters, ponded water in nearby fields provides an additional spot to search for food. Windbreaks, willows, and bay groves are used by these birds as roosting sites.

Water-Associated Birds

Differences in the physiography of the two esteros are underscored by differences in their waterfowl use. Pintails, American widgeons, canvasbacks, and ruddy ducks are found in far greater numbers in Estero Americano, where they may be seen on the greater

expanse of open water area. At one time black brant frequented the eel grass beds, also found in this estero. Cinnamon teal, on the other hand have been observed in greater numbers on Estero de San Antonio. These teal as well as mallards nest in the marshy margins of the freshwater pond at Estero de San Antonio.

Other waterbirds using the esteros include loons, grebes, pelicans, cormorants, coots, gulls, and terns. Coastal rock outcroppings between Estero de San Antonio and Estero Americano are used as rookeries and resting places by cormorants, pelicans, and gulls.

Raptors

The esteros and surrounding hillsides provide ideal, varied habitat for owls, hawks, and eagles. Fourteen species of raptors have been observed at the esteros by Department of Fish and Game personnel. Turkey vultures, red-tailed hawks, and golden eagles soar high overhead as they examine the grasslands for their next meal. American kestrels and white-tailed kites hover and dive over open areas. Sharp-shinned and Cooper's hawks prefer the wooded ravines, which also provide a daytime roost for the far-ranging great horned owl. Burrowing owls live in a curious association with ground squirrels; bald eagles, which feed largely on both live and dead fish, have been seen at Estero Americano.

An occasional visitor to the esteros is the osprey, or fish hawk. This bird feeds exclusively on surface-dwelling or shallow water fish, which it can spot from heights of 30 to 100 or 200 feet (Bent, 1961; Pough, 1951). It is a spectacular and unforgettable sight to watch an osprey hover high overhead, then fold its wings and plunge to the water, talons extended to catch its prey. Osprey require clear water for successful hunting and, like the bald eagle, are never found far from extensive aquatic habitats.

Other Birds

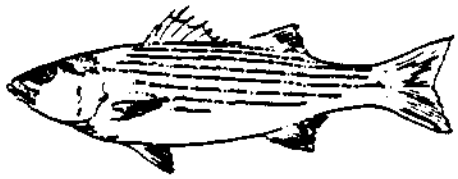
Sixty-six species of upland birds have been observed at the esteros by the Department of Fish and Game. These species are as diverse as the habitats they live in, and include such birds as the California quail, a bird of brush areas; the long-billed marsh wren and belted kingfisher, inhabitants of ponds and marshy spots; horned larks and water pipits, found in treeless grasslands; the wrentit, never found outside coastal scrub or chaparral; and numerous other birds, such as jays, crows, woodpeckers, swallows, and sparrows. During migration, many small birds seek cover in the bushes and trees that line the ravines and moist, sheltered places of the esteros.

FISH

A total of 31 marine and freshwater fish species has been collected in Esteros Americano and de San Antonio by Department of Fish and Game personnel and student investigations; 14 species are common to both, 10 species only identified in de San Antonio, and 7 species only identified in Americano (Appendix F). Information is not available on the developmental life history stages of fish species present in the esteros; however, the value of estuaries as nursery grounds for many marine species has been well-documented and juvenile forms of those species collected in the esteros are likely to occur there as well.

The number of species of fish, as well as the total abundance, is greatest at the mouths of the esteros. Common species include Pacific herring, staghorn sculpins, shiner surfperch, tidewater and arrow gobies, starry flounder, surf smelt, and topsmelt. Surf netting with A-frame nets for surf smelt is common in the early summer when the smelt are spawning in the surf zone at the mouths of the esteros. The Miwok Indians are reported to have used the surf smelt as a source of oil. Monkey-face eels and cabezon are

sometimes fished by "poke poling" near the mouth of Estero de San Antonio.



Striped bass and the threespine stickleback are the anadromous species observed in the esteros. During average years when the mouths of the esteros are open after winter rainfall, the threespine stickleback might be expected to use the esteros for spawning and juvenile development. Striped bass would not be expected to spawn in the area in large numbers but the presence of its primary juvenile food, *Neomysis*, in the esteros makes it possible that the esteros receive some use as nursery grounds. Local residents report that, historically, the esteros supported runs of steelhead and silver salmon. However, these runs have been absent for several recent years, perhaps due in part to the degradation of water quality in the esteros by agricultural wastes.

The difference in the fish species collected in the two esteros may represent variations in collecting times, gear, and persons collecting, and cannot be taken to indicate any specific habitat differences that may exist between the esteros. It is likely that species present in one estero are also at some time present in the other.

MAMMALS

The esteros and areas adjacent to them provide habitat for at least 21 species of aquatic and terrestrial mammals (Appendix G). Scrub and grassland communities adjacent to moist streamsides and marshes are commonly inhabited by raccoons, striped skunks, California voles, black-tailed jack rabbits, deer mice, and black-tailed deer. Pocket gophers, badgers, California ground squirrels, and an occasional spotted skunk are found in the drier upland grasslands.

Many mammals occurring in the area are nocturnal; their presence is indicated by dropping, footprints, burrows, or other signs rather than by actual observation. Steep ravines and crevices and occasional old, deserted farm buildings are good daytime hiding habitats for nocturnal species, such as the bat, raccoon, skunk, and grey fox. The esteros and environs do not necessarily provide suitable habitats for year-round occupancy by all mammals found there. For example, many of the bats are found passing through the area at certain times of the year. The mountain lion has been observed in the area (Arnold, pers. comm., 1976), but probably does not occur there regularly. Coyotes have not been observed in the area since the 1940's. Harbor seals are occasionally seen off the coast near the mouth of the two esteros.

As is commonly true of farmland and residential areas, the domestic cat and dog are two mammals introduced into the esteros area. These two are often detrimental to native wildlife species.

REPTILES AND AMPHIBIANS

Reptiles and amphibians (Appendix H) inhabit the marshes, grassland, wooded area, and drainages and ponds adjacent to the esteros, where the cover and moist environment provided by stream-side litter, logs, rocks, and trees provides the required habitat.

A common inhabitant of Estero de San Antonio and adjacent freshwater ponds is the western pond turtle. Normally seen basking in the sun along the shorelines, it quickly retreats to the safety of the water once disturbed. Other reptiles known to occur in the area include the western fence lizard, gopher snake, western terrestrial garter snake, and aquatic garter snake. One poisonous species, the western rattlesnake, is known to inhabit upland areas adjoining the esteros.

Amphibians known to inhabit the estero environs include the California newt, California slender salamander, western toad, and

the Pacific tree frog. Additional species likely to occur include *Ensatina* in the forested areas; arboreal salamanders in the coastal live-oak areas; and the bullfrog in the marsh and pond areas.

MARINE INVERTEBRATES

Data on marine invertebrate populations of the Estero de San Antonio are more detailed than those available for Estero Americano; however, collections are definitely not complete, and the occurrence of any species listed (Appendix I) is quite possible in both esteros.

Crustaceans

The sandy bottom near the mouth of Estero de San Antonio swarms with mysid crustaceans, such as the opossum shrimp, and a common shrimp, *Heptacarpus paludicola.* This latter shrimp and the bay pipefish are very common along the shores in areas of submerged pickleweed and eel grass. The amphipods *Anisogammarus* and *Corophium* are common in substrate along the shoreline, constructing tubes in the mud and silt. All of these crustaceans provide important links in the estuarine food webs as part of the diet of fish and birds (Green, 1968). Fish food preference studies in the Estero Americano indicate amphipods and some decapod crustaceans are the most common food of small marine fish (Friese, 1969)

A rare freshwater shrimp, *Syncaris pacifica*, has been reported to have existed in Stemple Creek in past years, but habitat of the present creek and drainage is considered "no longer viable [for this species, and] cannot be rehabilitated" (Hedgpeth, 1975).

The mouth areas of Esteros de San Antonio and Americano appear also to be a nursery ground for juvenile Dungeness crabs, *Cancer magister.* Test fishing by the California Department of Fish and Game has shown an abundance of 1975 year class juvenile crabs just