NATURAL RESOURCES OF THE MATTOLE RIVER ESTUARY, CALIFORNIA

Natural Resources and Habitat Inventory Summary Report

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PREFACE

This report summarizes 1987 biological and physical data for the Mattole River estuary and compares results to previous years. Most of the available information on the estuary has been generated from a cooperative research effort between the United States Bureau of Land Management (BLM) and Humboldt State University which began in 1984. Findings of this research have been reported by Barnhart and Young (1985), Barnhart and Busby (1986), and Young (1987). The purpose of this report is not to duplicate these documents but to provide an expandable information base which can be supplemented as more data are collected and used as a tool for resource planning and management.

A focal point of this report is the implementation of the U.S. Fish and Wildlife Service's wetland and deepwater habitat classification system (Cowardin et al. 1979) to the Mattole estuary. Designations in this system may be used to identify sensitive areas or specific management units which require special attention or provisions such as activity or use restrictions and/or restoration efforts. This report also identifies information gaps and areas where research has not yet been conducted or additional study is needed.

INTRODUCTION

The Mattole River estuary is located in southern Humboldt County 60 km south of the city of Eureka, California (Figure 1). Because of the area's remoteness, very little development has occurred. Petrolia, the nearest town, which is located approximately 8 km upriver from the estuary, has a population of 400. Three other unincorporated towns are located higher in the drainage which have populations about equal to that of Petrolia. Most of the land surrounding the estuary is used for grazing, light farming and recreation. The estuary itself is used solely for recreation and receives light to moderate use. Recreational use is expected to increase as population growth in northern California continues. The estuary is located on BLM land and is managed as a recreation/conservation area. A small campground is maintained by the BLM just south of the estuary.

Although remote and sparsely populated, evidence of negative human impact exists throughout the drainage and extends into the estuary in the form of river channel aggradation and the presence of stray cattle grazing in riparian areas. Most of the erosion and resulting sediment deposition can be attributed to deforestation, overgrazing, and other poor land use practices such as improper road building techniques and drainage culvert placement (California Department of Water Resources 1974; Peterson 1985, pers. comm.; Barnhart and Young 1985; Barnhart and Busby 1986; Young 1987). This report summarizes the physical and biological characteristics of the Mattole estuary and presents management recommendations. Problems associated with human activities and their related impacts are identified and discussed as are areas needing preliminary or additional investigation.

HISTORY OF LAND USE

The first white settlers arrived as early as 1854 and established the township of Mattole in 1859 (Carkeet 1967; Roscoe 1977). Farmers from the Marysville, California area settled from 1868 to 1876 and began to develop agriculture and livestock for commercial and domestic use (Carkeet 1967; Roscoe 1977). During the area's first 35 years, agriculture was the most important economic resource. Oil was discovered near the confluence of the North Fork of the Mattole and the main river in 1861 and the first oil well in California was drilled (Lyttel 1966; Carkeet 1967; Roscoe 1977). The name Petrolia was subsequently given to the Mattole township. An oil boom occurred which lasted until 1866 and the population of Petrolia and the entire Mattole valley doubled quickly (Carkeet 1967; Roscoe 1977). The inaccessibility of the region made transportation of the oil and drilling equipment too costly so extraction of the small volume available became economically infeasible and the boom died (Carkeet 1967; Roscoe 1977). Additional short-lived oil booms occurred in 1889, 1900, 1907, 1921 and 1953 (Carkeet 1967; Roscoe 1977).

The tan oak _(Quercus densiflora)_ bark and fruit industries flourished at several times in the Mattole valley. A tannin extracting plant was built just south of Ettersburg in 1902 (Roscoe 1977). A wharf was built in the estuary in 1908 to deliver apples and tan oak bark from Ettersburg to ships (Roscoe 1977). A narrow gauge railroad was built from the wharf to a flat 1.5 miles upriver where pack mules could unload goods (Roscoe 1977). Remnants from this railway are still present along the banks of the estuary today. The wharf, however, failed and was damaged by a storm before the first ship ever landed (Roscoe 1977). Subsequent attempts to repair the wharf failed and it was permanently destroyed in 1914 (Roscoe 1977). Truck service to the area began in 1915 (Roscoe 1977).

Fruit and dairy production were major sources of income in the 1860's. A creamery existed in Petrolia during this period (Roscoe 1977). Around 1900 livestock production passed crops as the principal income source of the region and remains so today (Carkeet 1967). A decline in the valley's population began after the collapse of the oil boom. Several economic and natural disasters which led to this decline are discussed by Carkeet (1967).

Logging in the basin has occurred for many years. Between 1950-1960 most of the harvestable timber in the lower basin was removed (Barnhart and Young 1985; Young 1987). Logged areas were not reforested and grazing land was often created in its place (Barnhart and Young 1985). Today sheep and cattle ranching are the principal land uses and sources of income, in the area with timber harvesting and recreation (fishing and hunting) also contributing significantly to the economic base (Carkeet 1967).

PHYSICAL CHARACTERISTICS

The available data on estuary basin morphology, estuary water level, tidal influence, water chemistry and physical properties indicate that the Mattole estuary is a highly dynamic system with changes, often extreme, occurring on an annual, seasonal, monthly or even daily basis. An overview^ of the physical characteristics of the estuary is presented in this section.

Drainage Basin

The Mattole River originates on the eastern side of the Kings Peak range in Mendocino County within three miles of the Pacific Ocean. It flows generally north, bounded on the east by the South Fork Eel River drainage. At Honeydew, the river turns west for its' final approximate 32 km before entering the Pacific Ocean 60 km south of the city of Eureka (Figure 1). Approximately seventy-four tributaries join the Mattole along its 100 km

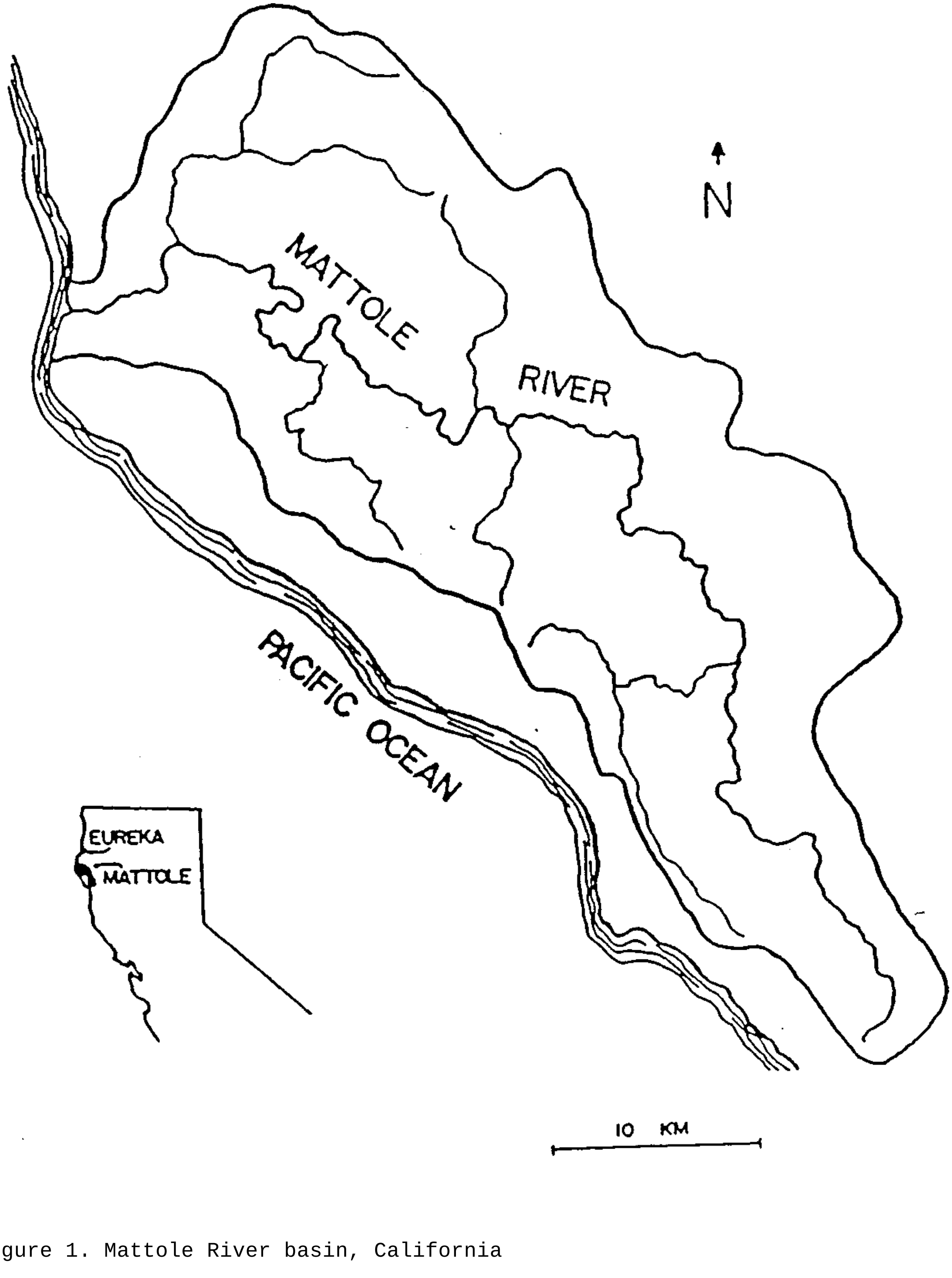

Figure 1. Mattole River basin, California

mainstem (Barnhart and Young 1985). Most of the drainage lies in southwestern Humboldt County. The drainage covers 785 km^2 (Young 1987).

Geology

The dominant components of the area are graywacke sandstone and shale of the Franciscan formation. Beds are generally 0.30 to 3.0 m thick but range up to 9.1 m (Decker 1983; Jim Decker, pers. comm.). The sand grains are angular, medium in size and poorly sorted (Decker 1983). Shale beds in this area have undergone much deformation which is locally acute (Jim Decker pers. comm.). Surrounding areas consist mostly of Quaternary undifferentiated non-marine terrace deposits (Pleistocene), sand, gravel and clay (Carkeet 1967). Most of the soils in the area are classified as Hugo (Carkeet 1967; Decker 1983).

Surface deposits of the area consist of local stream alluvia (recent and old) and stream terrace deposits (Carkeet 1967; Jim Decker, pers. comm.). Many of the streams are full of alluvial debris in an unstable condition. These deposits arise from the movement of weathered rock fragments assisted by gravity and running water (Jim Decker, pers. comm.).

Several active fault systems exist in the immediate area (Carkeet 1967). Tectonic uplifting of a middle Wisconsin marine platform near the Mendocino triple junction is raising the area at a rate of at least 1.0 m/1,000 years (McLaughlin et al. 1983).

Sediment

A comprehensive analysis of particle size distribution in the estuary has never been conducted. All that is known about substrate composition has been determined by observation and from samples of benthic macrofauna collected in 1986 and 1987.

The substrate in the lower lagoon is composed predominantly of sand with larger rocks and boulders along the eastern shore (Young 1987; Present study). Strong wind mixing, characteristic of this area, causes the bottom to be fairly flat and homogenous (Young 1987). Alternating scouring and deposition cause large boulders to become exposed and then covered with sediment. Substrate in the upper lagoon is composed predominantly of gravel with frequent cobble and occasional stones and boulders (Barnhart and Busby 1986; Present study), more characteristic of riverine systems (Cowardin et al. 1979; Bottom et al. 1979). Because of the relationship between substrate types and biota, further discussion of sediments is presented in the biological characteristics section where applicable to habitat types.

Climate

The climate of this coastal region is described as humid mesothermal; heavy winter rains with coastal fog in summer (California Department of Water Resources 1973). Mean annual precipitation at Petrolia is 62.2 inches (158 cm) (Carkeet 1967). Two thirds of this rain falls in November, December, January, and April (Carkeet 1967). Higher in the drainage, mean annual precipitation exceeds 100 inches (254 cm) (G. Peterson, pers. comm.). Mean annual precipitation for the entire drainage is 73.0 inches (185.4 cm) (Carkeet 1967). Strong northwesterly ocean winds are characteristic of the estuary and surrounding coastal region. Average daily temperatures range from 75 to 95 °F (23.8-35.0 °C) in the summer and from 40 to 60 °F (4.4-15.5 °C) in the winter. Temperature extremes range from 25 to 106 °F (13.8-41.1 °C) (Jim Decker, pers. comm.).

River Discharge

Mattole River flow is extremely variable through the year, ranging historically from 0.6-2560.0 cms at the Petrolia gaging station (California Department of Water Resources 1973). The Petrolia gaging station measures river flow from 621 km^2 of the 785 km^2 Mattole drainage. This is approximately 80% of the basin. Mean monthly discharges for the 1984-86 water years are given in Table 1.

Coastal Processes

The Mattole estuary is classified as a bar built estuary (Pritchard 1967) but is only seasonal in nature (California Department of Water Resources 1973; Barnhart and Young 1985; Barnhart and Busby 1986; Young 1987). In early summer, a combination of sediment deposition from coastal longshore ocean currents, constructive wave action, and decreased river flows causes a sandbar to build up which closes the river mouth (Barnhart and Young 1985; Barnhart and Busby 1986; Young 1987). This process is described in more detail by Barnes (1980). Similar processes have been documented in other systems in Humboldt County such as Big Lagoon (Joseph 1958) and Redwood Creek (Hofstra 1983).

If adequate flows persist, lagoon formation occurs on the Mattole from mid to late June as was the case in 1986. During extremely dry years, closure will take place earlier; in wet years it may never close as was the case in the summer of 1983, but this is extremely uncommon (G. Peterson, pers. comm.). Erosion of the sandbar by increasing river flow and wave action cause it to be breached in the fall, usually in October.

Table 1. Mean monthly discharges and yearly extremes, means and total discharges in cubic meters per second 1984-86 water years at the Petrolia gaging station, Mattole River, California (Sources USGS 1986, 1987,1988).

Water Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Min	Max	Mean	Total (m^3x 10^9)
84-85	3.0	140.8	45.4	14.0	41.4	29.5	16.3	5.1	2.8	1.3	0.9	0.9	0.7	747	24.8	0.78
85-86	4.4	5.4	35.0	95.0	241.4	85.7	10.5	12.1	3.6	1.7	1.0	5.4	0.6	991	40.5	1.28
86-87	5.7	7.0	25.6	75.0	80.0	93.2	11.0	5.6	2.5	1.3	0.9	0.7	0.6	354	24.8	0.80

Surface Area and Depth

When the river mouth is closed by the sandbar, river water backs up and floods an area of approximately 3.0 hectares (Figure 2). The main channel of the river forms the deepest areas. Depth and surface area of the lagoon fluctuate (Figure 3). In late summer, surface area and depth decrease as a result of diminishing river flow, increased evaporation and seepage through the berm. Table 2 gives minimum and maximum depths recorded at each of the four water quality stations shown in Figure 2.

Table 2. Minimum and maximum depths in meters at four water quality stations, Mattole River estuary/lagoon, California 1986-1987.

	1986				1987			
Stn.	Minimum depth	Date	Maximum depth	Date	Minimum depth	Date	Maximum depth	Date
1	0.5	09/13	1.5	10/22	0.1	07/29	1.5	11/13
2	1.3	09/13	2.5	10/22	1.0	08/28	2.0	11/13
3	1.5	08/08	3.0	10/22	1.5	06/18	2.0	11/13
4	2.5	07/31	3.5	06/27	2.3	07/29	4.0	05/26

Figure 3 and Table 2 indicate that the lagoon was approximately the same size at formation and breaching in 1986 and 1987. In 1987, the lagoon was deeper soon after closure in May but surface level subsided at a faster rate so that during mid and late summer it was smaller and shallower than in 1986. Although the data are not available at this time, we believe that river flow was considerably lower in summer 1987 and that this was the primary factor responsible for the lagoon's reduced size in mid summer.

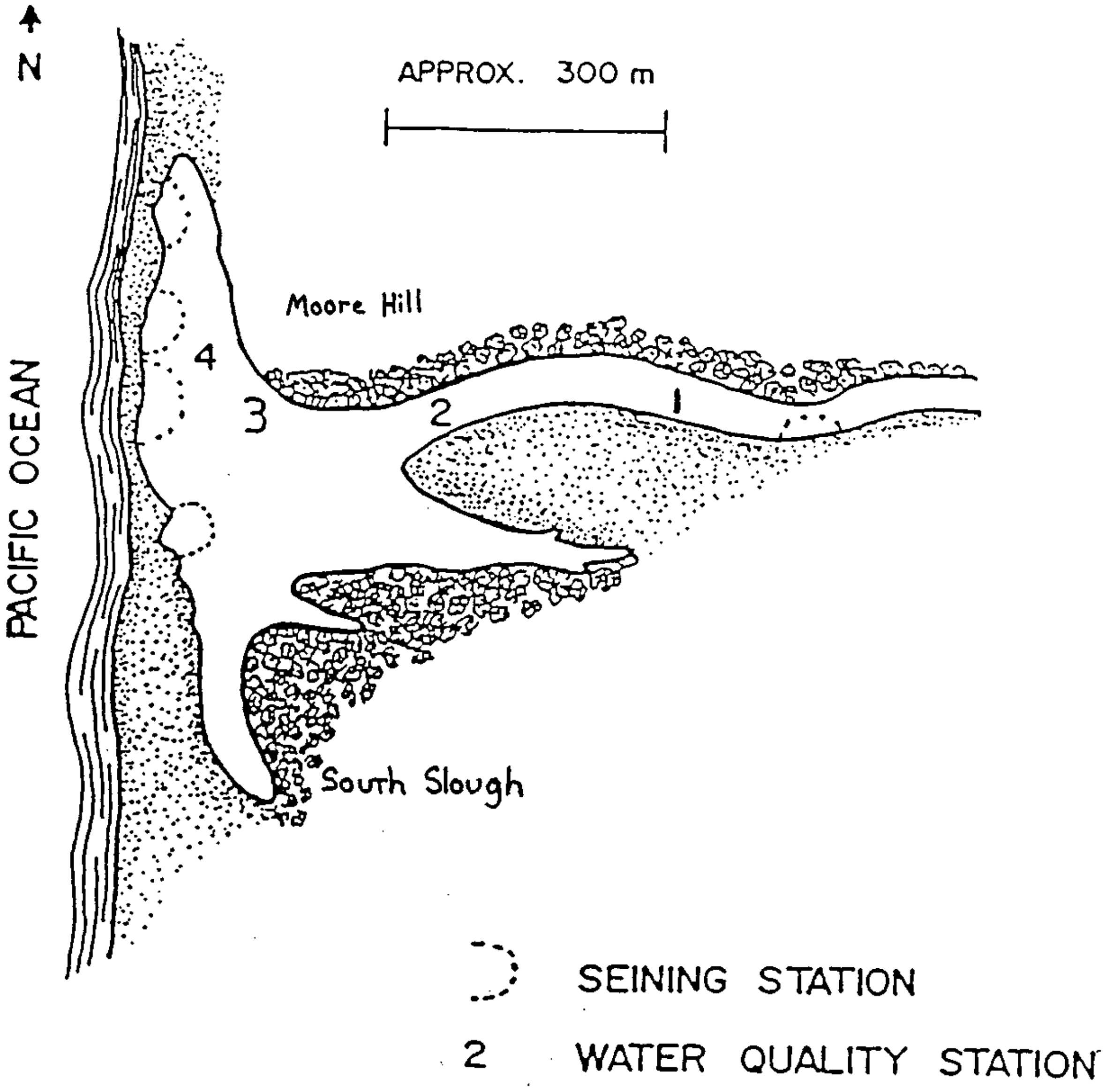

Figure 2. Mattole River lagoon showing beach seining and water quality stations.

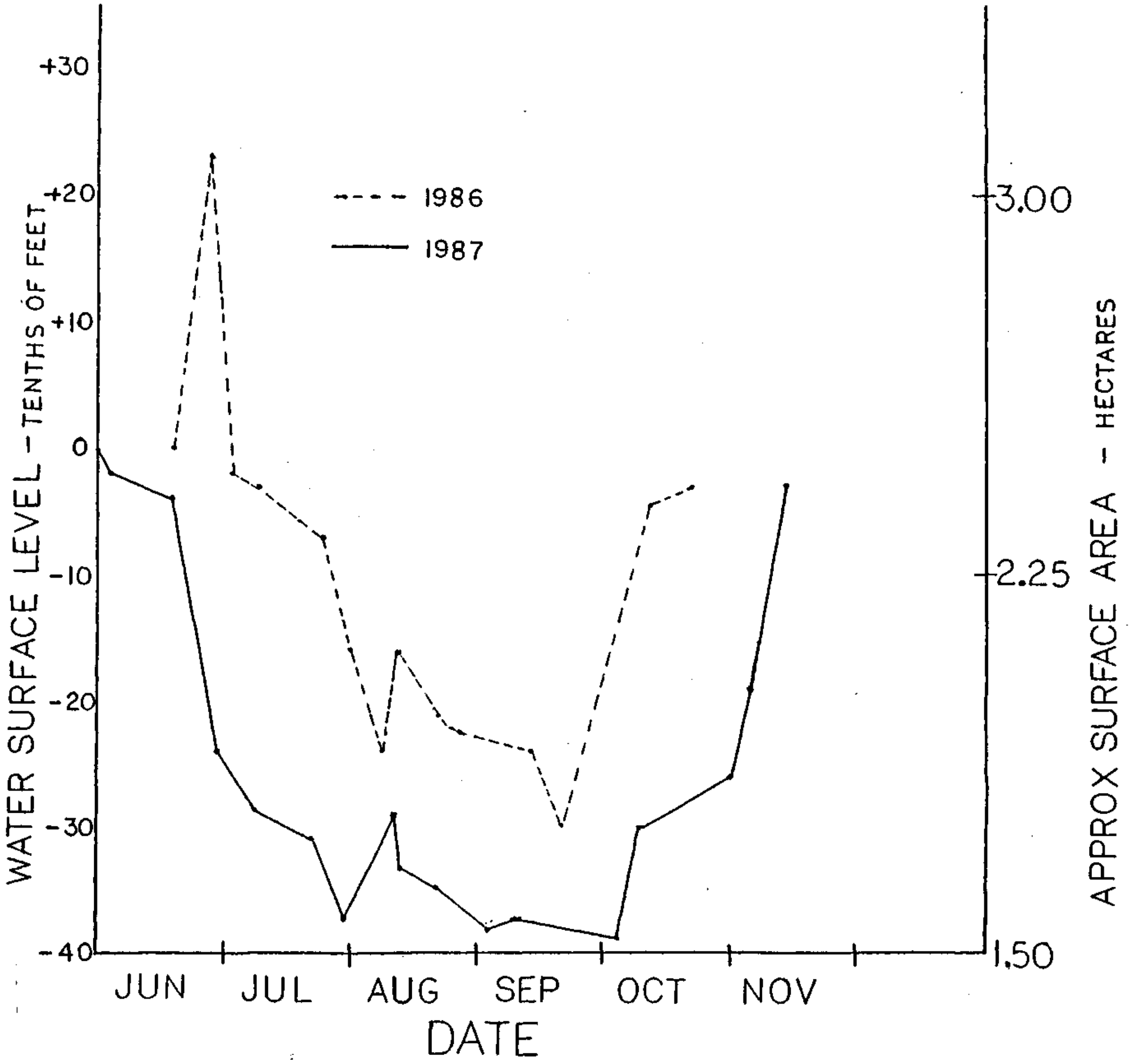

Figure 3. Water surface level fluctuation in relation to surface area in the Mattole River Lagoon, California, 1986 and 1987.

Annual variations in depth are also caused by scouring (deepening) in some areas of the lagoon and sediment deposition (shallowing) in others. Station 3 elevated approximately 0.5 m between 1986 and 1987 due to sediment deposition. We have no information regarding surface area and depths during the estuary (open) phase. Personal observations indicate that the surface area of the estuary at high water (monthly spring tide) is approximately equal to that of the lagoon at maximum volume.

Tides

Little information exists on tidal heights, hydraulics, prism or flushing for the Mattole estuary. Mean tide levels at Cape Mendocino, California, which is the nearest recording station, probably best approximate those at the Mattole (U.S. Department of Commerce 1987). Mean tide level is 3.1 feet with a mean fluctuation range of 4.0 feet. Diurnal range is 5.7 feet (1987). Tides have a minimal effect on water level in the lagoon; the extent has not been quantified. Seawater overwash caused surface level in the lagoon to rise 0.85 feet between October 5 and 8, 1987 (Figure 3). We believe that outflowing seepage through the sandbar is reduced at high tide.

Salinity and Mixing

Most of the information on salinity and mixing has been collected during the summer months when the river mouth is closed; as a result, little is known about these parameters in the estuary. California Department of Water Resources (1973) describes the Mattole estuary as abbreviated; seawater intrusion may only extend 300 m above the river's mouth. Shortly after closure of the sandbar, incoming river water and wind driven mixing cause the system to become essentially freshwater (Barnhart and Young 1985; Barnhart and Busby 1986; Young 1987). Because of the intense and persistent winds characteristic of the area, mixing is vigorous throughout the entire water column.

Occasionally seawater washes over the berm at high tides during the summer (California Department of Water Resources 1973; Barnhart and Busby 1986; Young 1987). This seawater is usually visible as plumes of lighter colored water which are pushed southeast by the wind as they sink and form a layer about 0.5 to 2.0 m thick in isolated deep pockets of the lagoon. This layer of cold, saline water is quickly diluted by incoming river water and mixed into the water column, rarely persisting over 24 hours except at station 2 which is protected from the wind by Moore Hill (Barnhart and Busby 1986; Young 1987) (Figure 2). The seawater layer at times is pushed into the upper lagoon several hundred meters (between stations 1 and 2). Figure 4 shows the upriver intrusion distance of a seawater layer at high tide after overwash on November 13, 1987.

Salinity values ranged from 4.0 to 27.0 ppt in 1985 (Young 1987), 0.0 to 14.5 ppt in 1986 (Barnhart and Busby 1986), and 0.1 to 20.5 ppt in 1987. When present, saline water was concentrated in a layer up to 2.0 m thick on the bottom and was frequently isolated in deep areas in the flooded river channel. Table 1 (Appendix) gives salinity profile measurements for 1987. Data could not be collected at station 1 from July 27 to November 1, 1987 due to inadequate depth. Salinity profiles for earlier years are reported in Barnhart and Busby (1986) and in Young (1987).

Water Temperature

Daily maximum surface temperatures in the upper lagoon ranged from 17 to 23°C during the 1987 survey period (Table 2, Appendix). Maximum daily temperatures of 20°C or greater occurred throughout July and August except on 2 occasions (Table 2, Appendix). Diurnal fluctuations up to 5°C (18-23°C)

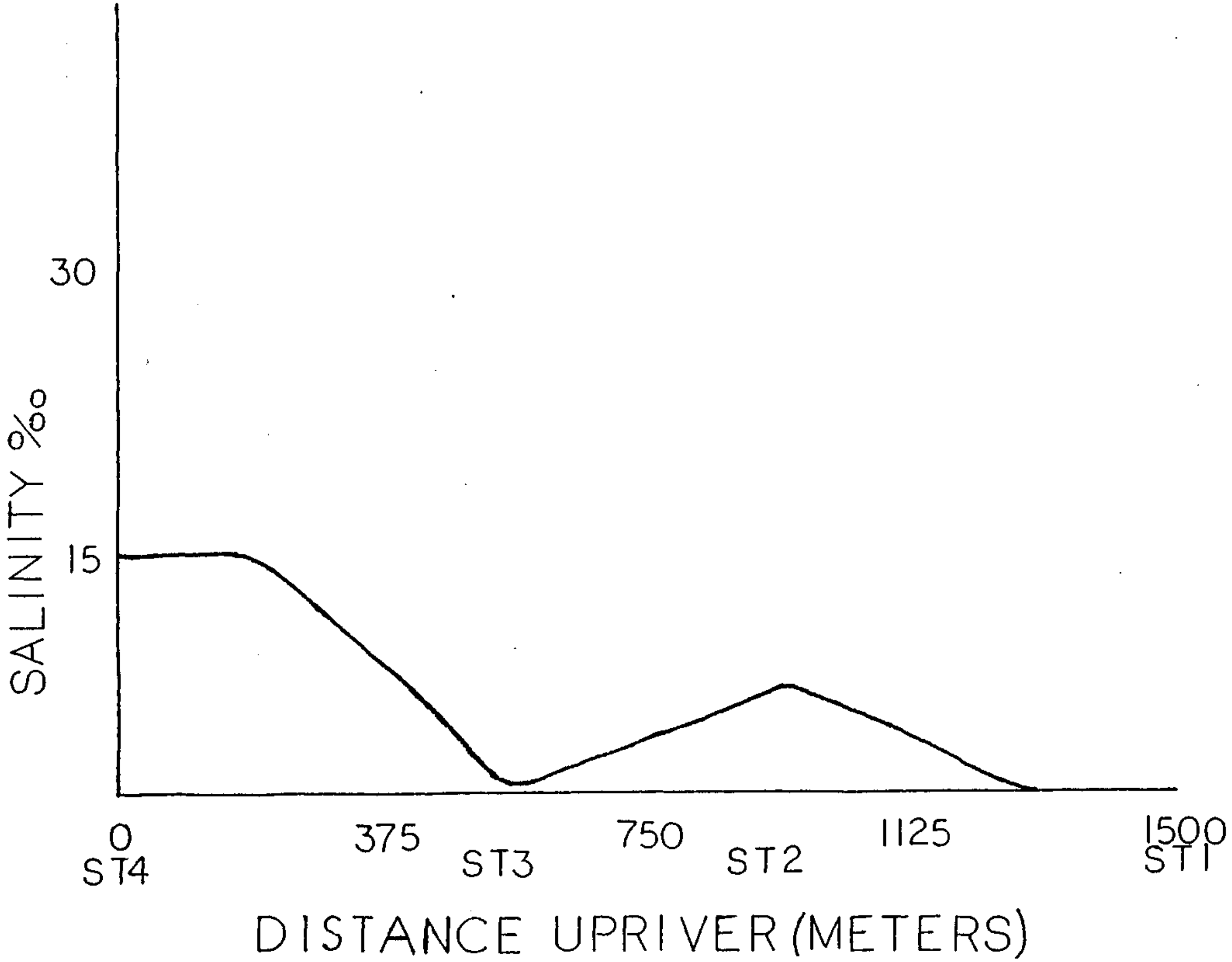

Figure 4. Distance upriver of seawater layer intrusion at high tide November 13, 1987.

were experienced during this period. Maximum temperatures generally occurred around 2:00 p.m. and persisted until about 10:00 p.m. Maximum daily temperatures fell to 20°C or below in September. Barnhart and Busby (1986) reported maximum daily temperatures ranging from 15 to 26°C in the upper lagoon during 1986.

Maximum daily surface temperatures in the lower lagoon ranged from 16 to 21°C in 1987. Daily maximum temperatures of 20 and 21°C occurred frequently in July only. Diurnal fluctuations up to 3°C were experienced during this period. Similar temperature regimes in the lower lagoon were reported by Barnhart and Busby (1986). Because of its exposure to prevailing northwesterly winds, the lower lagoon is usually 1 to 4°C cooler than the upper lagoon (Table 2, Appendix).

Temperature profiles seldom exhibited well defined thermoclines in 1987 (Table 3, Appendix). A thermocline developed at station 3 between 1.0 and 2.0 m depth on June 5, 1987 (Table 3, Appendix). A thermocline was also measured at stations 2, 3 and 4 on the night of October 7, 1987 (Table 3, Appendix). On October 7, windless and calm conditions probably promoted thermal stratification. Fall thermoclines in the Mattole lagoon are probably more a result of colder, recently overwashed seawater lying on the bottom than actual differential heating of the surface layer. Young (1987) reported temperature regimes in 1985 similar to those of 1986 and 1987.

Inverse stratification due to meromixis, reported by Barnhart and Busby (1986), was never measured in 1987. Meromixis occurs when a lens of dense, saline water on the bottom is heated by solar radiation refracted through the overlying freshwater to higher temperatures than water above it (Lichatowich and Nicholas 1985). Temperature data were not collected in the estuary prior to lagoon formation.

Dissolved Oxygen

Dissolved oxygen concentrations in the upper lagoon ranged from 2.8 to 14.5 ppm in 1987 (Table 4, Appendix). The low end of this range is considerably lower than the 7.3 to 14.4 ppm range reported by Barnhart and Busby (1986). Lower lagoon concentrations ranged from 7.0 to 15.4 ppm in 1986 and from 5.0-11.8 ppm in 1987 (Barnhart and Busby 1986, Present study).

Low dissolved oxygen levels (2.8, 4.7 ppm) were noted on one night and one day water quality analyses. These occurred on the night of September 9 and on the day of November 13, 1987. In both cases the low oxygen concentration was limited to the bottom 0.5 meters at station 2 (Table 4, Appendix). This was probably caused by respiration of large quantities of green algae and the lack of mixing at station 2 which is often sheltered from prevailing northwest winds. These oxygen depletions may occur on a nightly basis in the late summer-early fall. The effects of night time oxygen depletions on the aquatic biota of the lagoon is not clearly understood at this time. Throughout the 1985, 1986 and the remaining 1987 study periods, measured dissolved oxygen levels remained above the minimum acceptable level of 5.0 ppm set by the United States Environmental Protection Agency (1976).

Turbidity

During 1987 turbidity measurements ranged from 0.25 to 2.00 NTU and were lowest in early June and late September (Table 5, Appendix). Turbidity ranged from 0.60 to 2.80 NTU in 1985 and from 0.37 to 1.20 NTU in 1986. Turbidity is nearly always higher in the lower lagoon because vigorous winds mix the entire water column and suspend bottom sediments. Seawater overwash and subsequent sandbar erosion increase turbidity in the lagoon as does increased surface runoff from precipitation. Although not measured, turbidity of dilute seawater layers on the bottom may exceed that of the overlying freshwater by a magnitude of 100 or more (G. Bryant, pers. comm.).

pH

Measurements of pH remained 8.5 throughout the entire 1987 study period at all stations. Young (1987) reported a range of 8.5 to 9.0 for 1985 and a range of 7.0 to 8.5 was reported by Barnhart and Busby (1986). In all cases, pH fell within the 6.5 to 9.0 range specified as suitable for freshwater aquatic life (United States Environmental Protection Agency 1976).

BIOLOGICAL CHARACTERISTICS

After closure of the sandbar, the lagoon deepens and expands, flooding large boulders and riparian vegetation which creates habitat for aquatic plants, benthic and planktonic macrofauna, insects, reptiles, amphibians, fish, birds, and mammals. Physical and chemical characteristics play an important role in the quality and quantity of this habitat. For example, rapidly dropping water levels in mid-late summer can greatly reduce the quantity and quality of available habitat. As depths are reduced, temperature generally rises which excludes salmonids from certain habitats or restricts their migrations within the lagoon. Dissolved oxygen levels can become greatly reduced, especially at night, as a result of increased plant and animal respiration and lowered oxygen production. Receding water levels separate the south slough (Figure 2) from the Mattole lagoon's main embayment resulting in isolated pools with stranded fish. It is understandable why Barnes (1980) wrote, "Lagoons, especially the smaller ones, are rapidly changing, highly dynamic systems and their biology cannot be understood except within the framework of their formation, evolution and subsequent decline".

Most of the available biological information concerns residency of juvenile salmonids in the lagoon (Barnhart and Young 1985; Barnhart and Busby 1986; Young 1987; Busby in prep.). Little biological data have been collected during the systems' open (estuary) phase. This section provides an overview of the information available on productivity, plants, habitat types, benthic and planktonic macrofauna, amphibians, reptiles, fish, birds, and mammals in the Mattole River lagoon. Some research in progress is previewed.

Primary Productivity

Primary productivity in the Mattole estuary/lagoon has not been assessed. Simenstad (1983) summarizes the production of plant biomass through the photosynthetic fixation of carbon at several phylogenetic levels characteristic of estuarine channels of the Pacific northwest. These levels include benthic microflora, macroalgae, angiosperms and phytoplankton.

Benthic microflora typically include benthic microalgae such as diatoms (Bacillariophyceae) which occur in the upper 1 cm of bottom sediments (Simenstad 1983). Macroalgae generally include various bluegreen algae and species of *Enteromorpha* spp. and *Fucus* spp. Less dominant forms include species of *Monostroma* spp., *Ulva* spp., *Rhizoclonium* sp., and others. Eelgrass (*Zostera* spp.) is the angiosperm common to Pacific Northwest estuaries (Simenstad 1983). Dominant phytoplankton taxa vary on a seasonal basis in estuaries. Although dinoflagellates are occasionally abundant, nannoplanktonic diatoms appear to be the most abundant forms during the summer and fall periods of peak phytoplankton production (Simenstad 1983).

Detritus Processing

The formation of barriers which partially or completely close estuaries and lagoons acts as a trap for allochthonous and autochthonous materials including dissolved, fine and large particulate organic carbon (DOC, FPOC, LPOC) and detritus (Sibert et al. 1977; Reimers 1978; Odum et al. 1979; Barnes 1980). Darnel1 (1967) has defined organic detritus as "all types of biogenic material in various stages of microbial decomposition which represent potential energy sources". This includes a wide size range of material from dissolved organic carbon molecular aggregates to whole tree trunks from marine, estuarine, riverine and terrestrial sources. Since much of this material has originated from much larger organic particles which were mechanically or biochemically reduced to FPOC, this definition should include any free (non-attached) particles of organic matter which no longer, if ever, produce carbon through photosynthesis (Simenstad 1983). Figure 5 shows some of the potential sources and pathways of organic detritus in estuaries of the Pacific Northwest.

A pool of detritus and DOC accumulates in estuaries and lagoons which can be utilized by the biotic community (Odum 1970; Sibert et al. 1977; Reimers et al. 1978; Tenore 1977; Odum et al. 1979; Barnes 1980; McLusky 1981; Simenstad 1983). Recent evidence suggests that directly through detrivory or heterotrophic processes, detritus may constitute the dominant pathway of trophic carbon into estuarine food webs (Odum 1970; Tenore 1977; Odum et al. 1979; McLusky 1981; Simenstad 1983). The estuarine/lagoonal pool of detritus and DOC is not limited to benthic production as wind driven circulation often penetrates to the bottom and resuspends sediment, detrital components and microorganisms, thus making them available to the planktonic community (Tenore 1977; Barnes 1980; Simenstad 1983). A possible food web diagram for the Mattole River estuary/lagoon is presented in Figure 6. The amount of available detritus based carbon (carbon from detrital origins) and its

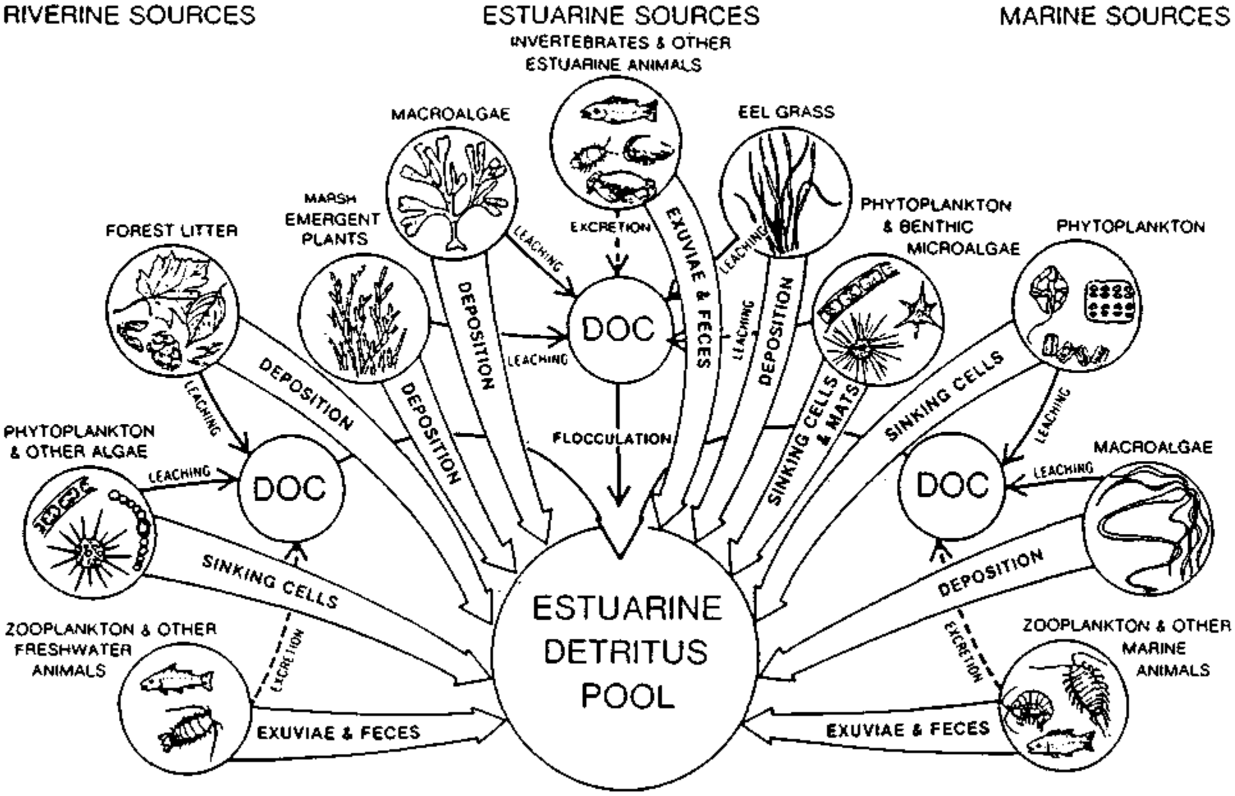

Fig. 5. Potential sources and pathways contributing to detritus in estuarine channel habitats of the Pacific Northwest (from Simenstad 1983).

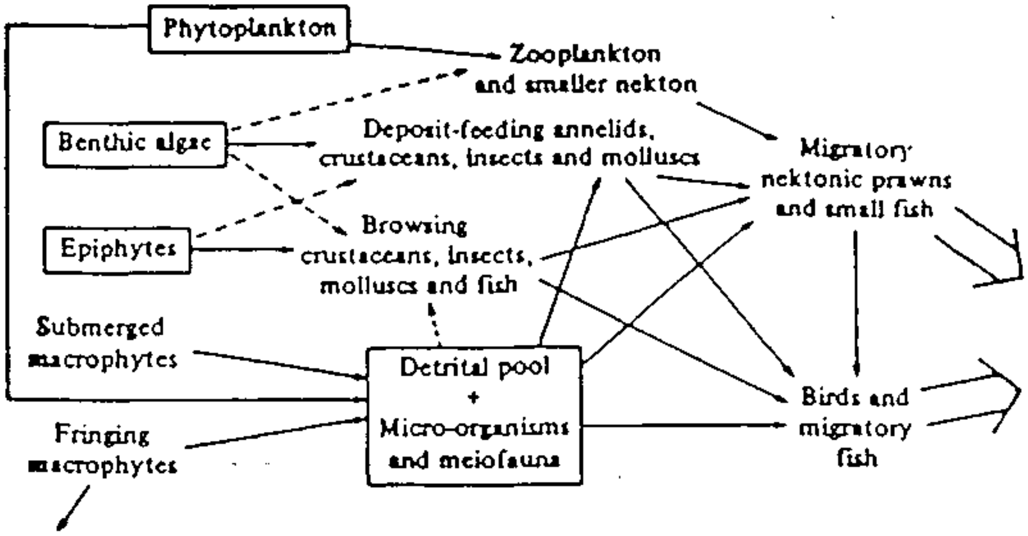

Figure 6. Potential food web diagram of the Mattole River lagoon (Modified from Barnes 1980).

importance in the food web of the Mattole estuary/lagoon has not been determined.

Habitat Types

Habitat types in the Mattole River estuary/lagoon were inventoried using the United States Fish and Wildlife Service's classification system of wetlands and deepwater habitats of the United States (Cowardin et al. 1979). Aerial photographs along with ground observations and measurements were used to construct a map which delineates habitat types (Figure 7). The original of this map is on file at the U.S. Fish and Wildlife Service, California Cooperative Fishery Research Unit, Humboldt State University, Arcata.

The structure of this classification system is hierarchical, progressing from Systems and Subsystems at the most general levels, to Classes, Subclasses and Dominance types based on vegetation and/or substrate composition. Modifiers for water regime, water chemistry and soil types can be applied to classes, subclasses and dominance types to achieve more detail. Special modifiers that describe wetlands and deepwater habitats that have been either created or highly modified by man may also be used (Cowardin et al. 1979). The classification criteria and detailed explanations for the use of this system can be found in the above cited text.

Marine, riverine, palustrine, and estuarine systems are present in the area around the mouth of the Mattole River (Figure 7). The marine system is, however, omitted from this discussion because the estuary is the focus of the present study and the marine system was segregated from the estuarine system by the sand bar during the majority of all study periods.

The estuarine system includes both estuaries and lagoons (Cowardin et al. 1979). Estuarine systems are divided into subtidal and intertidal subsystems and they extend upstream and landward to where ocean-derived salts

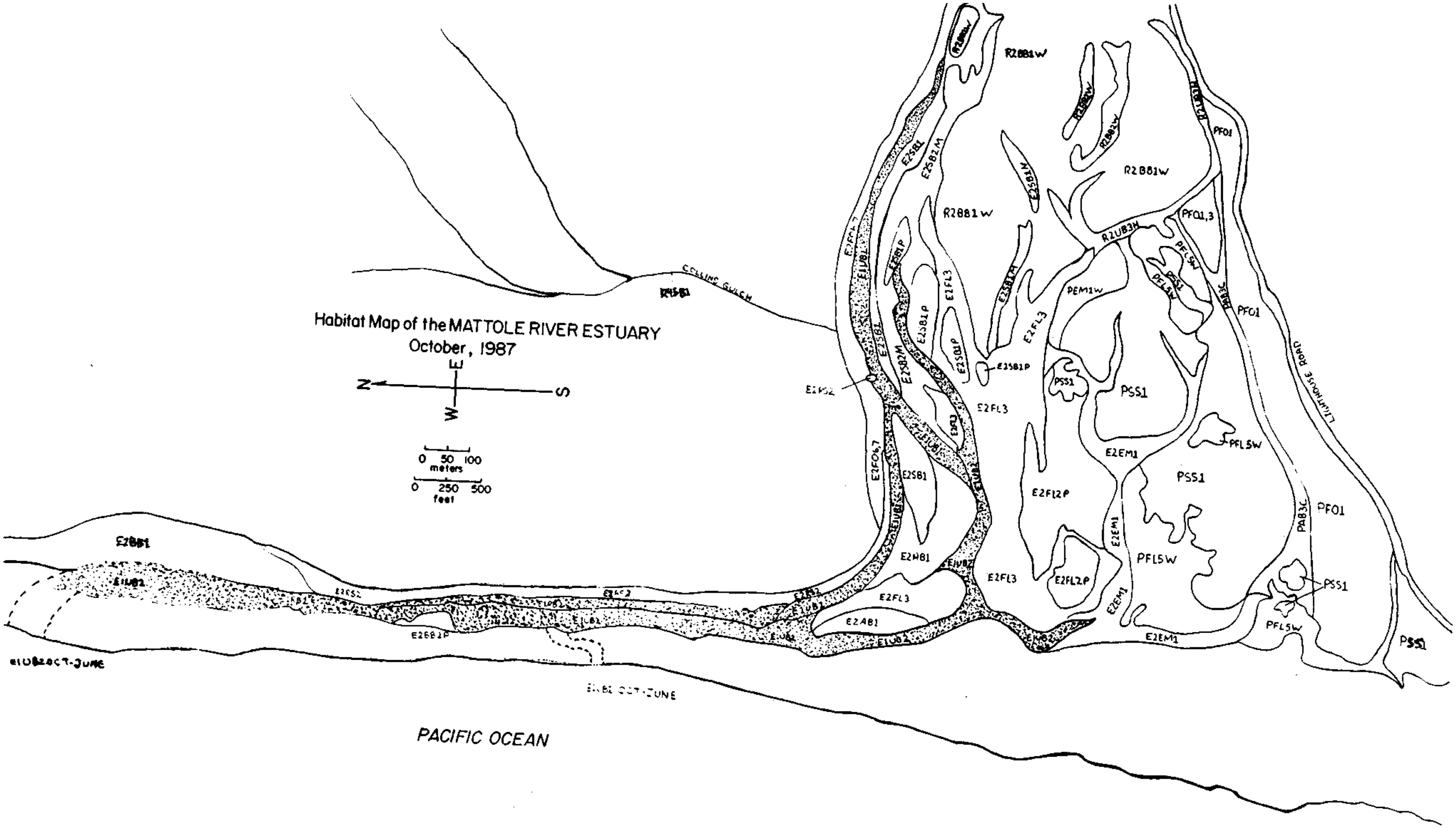

Figure 7. Habitat map of the Mattole Estuary/Lagoon, California, October 1987. Classification System by Cowardin et al. 1979. (Map legend is on the next page).

WETLAND LEGEND

E – ESTUARINE

ECOLOGICAL SYSTEM

Ecological Subsystem

CLASS

Subclass

- **1 – Subtidal**
  - RB ROCK BOTTOM
    - 1 Bedrock
    - 2 Boulder
  - UB UNCONSOLIDATED BOTTOM
    - 1 Cobble/Gravel
    - 2 Sand
    - 3 Mud
    - 4 Organic
  - AB · AQUATIC BED
    - 1 Submergent Algal
    - 2 Submergent Vascular
    - 4 Floating-leaved
    - 5 Floating
    - 6 Unknown Submergent
    - 7 Unknown Surface
  - RF REEF
    - 2 Mollusc
    - 3 Worm
  - OW OPEN WATER/ Unknown Bottom
- **2 – Intertidal**
  - AB AQUATIC BED
    - 1 Submergent Algal
    - 2 Submergent Vascular
    - 6 Unknown Submergent
    - 7 Unknown Surface
  - RF · REEF
    - 2 Mollusc
    - 3 Worm
  - FL – FLAT
    - 1 Cobble/Gravel
    - 2 Sand
    - 3 Mud
    - 4 Organic
    - 5 Vegetated Pioneer
    - 6 Vegetated Non pioneer
  - SB STREAMBED
    - 1 Cobble/Gravel
    - 2 Sand
    - 3 Mud
    - 4 Organic
  - RS ROCKY SHORE
    - 1 Bedrock
    - 2 Boulder
    - 6 Vegetated Non pioneer
  - BB BEACH/BAR
    - 1 Cobble/Gravel
    - 2 Sand
  - EM EMERGENT
    - 1 Persistent
    - 2 Nonpersistent
    - 3 Narrow leaved Nonpersistent
    - 4 Broad leaved Nonpersistent
    - 5 Narrow leaved Persistent
    - 6 Broad leaved Persistent
  - SS SCRUB SHRUB
    - 1 Broad leaved Deciduous
    - 3 Broad leaved Evergreen
    - 4 Needle leaved Evergreen
    - 5 Dead
    - 6 Deciduous
    - 7 Evergreen
  - FO FORESTED
    - 1 Broad leaved Deciduous
    - 3 Broad leaved Evergreen
    - 4 Needle leaved Evergreen
    - 5 Dead
    - 6 Deciduous
    - 7 Evergreen

P – PALUSTRINE

ECOLOGICAL SYSTEM

No Subsystem

CLASS

Subclass

- RB · ROCK BOTTOM
  - 1 Bedrock
  - 2 Boulder
- UB – UNCONSOLIDATED BOTTOM
  - 1 Cobble/Gravel
  - 2 Sand
  - 3 Mud
  - 4 Organic
- AB – AQUATIC BED
  - 1 Submergent Algal
  - 2 Submergent Vascular
  - 3 Submergent Moss
  - 4 Floating-leaved
  - 5 Floating
  - 6 Unknown Submergent
  - 7 Unknown Surface
- FL FLAT
  - 1 Cobble/Gravel
  - 2 Sand
  - 3 Mud
  - 4 Organic
  - 5 Vegetated Pioneer
  - 6 Vegetated Non-pioneer
- ML – MOSS/LICHEN
  - 1 Moss
  - 2 Lichen
- EM – EMERGENT
  - 1 Persistent
  - 2 Nonpersistent
  - 3 Narrow-leaved Nonpersistent
  - 4 Broad leaved Nonpersistent
  - 5 Narrow leaved Persistent
  - 6 Broad-leaved Persistent
- SS SCRUB/SHRUB
  - 1 Broad-leaved Deciduous
  - 2 Needle leaved Deciduous
  - 3 Broad leaved Evergreen
  - 4 Needle leaved Evergreen
  - 5 Dead
  - 6 Deciduous
  - 7 Evergreen
- FO FORESTED
  - 1 Broad leaved Deciduous
  - 2 Needle leaved Deciduous
  - 3 Broad leaved Evergreen
  - 4 Needle leaved Evergreen
  - 5 Dead
  - 6 Deciduous
  - 7 Evergreen
- OW OPEN WATER Unknown Bottom

R – RIVERINE

ECOLOGICAL SYSTEM

Ecological Subsystem

- **1 – Tidal**
- **2 – Lower Perennial**
- **3 – Upper Perennial**
- **4 – Intermittent**
- **5 – Unknown Perennial**

CLASS

Subclass

- EM – EMERGENT(1)
  - 2 Nonpersistent
  - 3 Narrow leaved Nonpersistent
  - 4 Broad-leaved Nonpersistent
- RB – ROCK BOTTOM
  - 1 Bedrock
  - 2 Boulder
- UB – UNCONSOLIDATED BOTTOM
  - 1 Cobble/Gravel
  - 2 Sand
  - 3 Mud
  - 4 Organic
- AB – AQUATIC BED
  - 1 Submergent Algal
  - 2 Submergent Vascular
  - 3 Submergent Moss
  - 4 Floating-leaved
  - 5 Floating
  - 6 Unknown Submergent
  - 7 Unknown Surface
- FL – FLAT
  - 1 Cobble/Gravel
  - 2 Sand
  - 3 Mud
  - 4 Organic
  - 5 Vegetated Pioneer
  - 6 Vegetated Non-pioneer
- SB – STREAMBED
  - 1 Cobble/Gravel
  - 2 Sand
  - 3 Mud
  - 4 Organic
- RS · ROCKY SHORE
  - 1 Bedrock
  - 2 Boulder
- BB BEACH/BAR
  - 1 Cobble/Gravel
  - 2 Sand
- OW OPEN WATER Unknown Bottom

(1) EM EMERGENTS are only found in the Riverine Tidal and Riverine Lower Perennial Ecological Subsystem. All other classes are found in all Riverine Ecological Subsystems.

MODIFYING TERMS

In order to more adequately describe wetland and aquatic habitats one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

WATER REGIME(1)

Non-Tidal

A Temporary
B Saturated
C Seasonal
D Seasonal Well-drained
E Seasonal Saturated
F Semipermanent
G Intermittently Exposed
H Permanent
J Intermittently Flooded
K Artificial
Z Intermittently Exposed/Permanent
W Intermittently Flooded/Temporary
Y Saturated/Semipermanent/Seasonal
U Unknown

Tidal

K Artificial
L Subtidal
M Irregularly Exposed
N Regular
P Irregular
R Seasonal Tidal
S Temporary Tidal
T Semipermanent Tidal
V Permanent Tidal
U Unknown

WATER CHEMISTRY

Coastal Salinity

1 Hyperhaline
2 Euhaline
3 Mixohaline (Brackish)
4 Polyhaline
5 Mesohaline
6 Oligohaline
0 Fresh

Inland Salinity

7 Hypersaline
8 Eusaline
9 Mixosaline
0 Fresh

pH Modifiers for all Fresh Water

a Acid
t Circumneutral
i Alkaline

SOIL

g Organic
n Mineral

SPECIAL MODIFIERS

b Beaver
d Partially Drained/Ditched
f Farmed
h Diked/Impounded
r Artificial
s Spoil
x Excavated

(1) Information on the water regime modifiers found on this legend, but not found in the classification system, may be obtained from the above listed source.

measure less than 0.5 ppt during the period of average annual low flow (Figure 7). In the subtidal system, the substrate is continuously submerged. In the intertidal subsystem, the substrate is exposed at times and flooded at times; this includes the associated splash zone. Examples of estuarine wetlands in Figure 7 include E1UB2 and E2RS2. E = estuarine system, 1 = subtidal subsystem, 2 = intertidal subsystem, UB = unconsolidated bottom class, RS = rocky shore class, 2 = sand subclass, 2 = boulder subclass (refer to legend of map Figure 7).

A palustrine system exists to the west of the estuarine system (Figure 7). The palustrine system includes all non-tidal wetlands dominated by trees, shrubs, emergent mosses or lichens, and all such wetlands that occur in non-tidal areas where salinity due to ocean-derived salts is less than 0.5 ppt (Cowardin et al. 1979). No subsystems exist in the palustrine system. Several classes exist which are based on dominant vegetation and/or substrate composition (Figure 7). Examples of palustrine wetland habitat in the area include PSS1 and PFL5W. P = palustrine system, SS = scrub shrub class, FL = flat class, 1 = broadleaved deciduous subclass, 5 = vegetated pioneer subclass, W = intermittently flooded water regime modifier.

Riverine wetland habitats are present upriver and landward of the Mattole estuarine system (Figure 7). Riverine wetland habitats are those contained within a channel that have less than 0.5 ppt content of ocean-derived salts and are not dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. Because this inventory was concerned with estuarine resources, the riverine habitats are not discussed.

Plants

This section presents a phylogenetic plant list for the Mattole estuary/lagoon (Table 3). The list is probably not complete; an intensive vegetative analysis could not be accomplished under the constraints of the 1987 study.

Table 3. Phylogenetic list of plant taxa identified in the Mattole River estuary/lagoon and surrounding riparian areas. Sources: McGeachy 1979; Present study. Taxonomic key used - Jepson 1975. Habitat types for various taxa as given by McGeachy (1979) are shown in brackets and are exemplified by words such as [Marsh]. Habitats of taxa identified during the present study are shown in parenthesis and are given alpha-numeric designations according to the classification system of Cowardin et al. (1979). An example of this is (E2RS2).

Scientific name	**Common name**	**Habitat type(s)**
Calamophyta	Horsetails	[Flood plain-marsh]
Equisetum sp.		
Pterophyta	Ferns	(PF01,3)(PF01)
Anthophyta	Flowering plants	
Dicothyledoneae	Dicots	
Aizoacea		
Mesembryanthemum sp.	Ice plant	(E2BB1)
Sesuvium sp.	Sea purslane	(E2BB1)
Anacardiaceae		
Toxicodendron diversilobum	Poison oak	(PSS1)(PF01,3)(PF01)
Araliacea		
Aralia sp.	-	(PF01,3)[Scrub in Alnus stand]
Betulaceae		
Alnus rubra	Red alder	(PF01.3)
Caprifoliaceae		
Sambacus sp.	Elder	(PF01)
Caryophyllaceae		
Silene gallica	Windmill pink	(PSSD(PFOl)
Silene california	Indian pink	(PSS1)(PF01)(E2BB1)
Chamaecyparis		
Cypressus sp.	Monterey cypress	(E2F06,7)
Compositae		
Achillea Millifotlium	Yarrow	(E2BB1)
Artemesia Douglasiana	-	[Scrub]
Baccharis pilularis	Coyote brush	[Scrub]
Erigeron gjaucus	Seaside daisy	(E2BB1XE2RS2)
Grindelia stricata	Gummy sunflower	(E2BB1HE2RS2)
Leontodon leysseri	-	[Flood plain]
Silybum marianum	Milk thistle	[Scrub and marsh]
Ambrosia chamissonis	Ragweed	[Beach]
Erechtites sp.	-	[Scrub]
Crassulacea		
Dudleya sp.	Live-forever	[Scrub]

Table 3. Phylogenetic list of plant taxa identified in the Mattole River estuary/lagoon and surrounding riparian areas. Sources: McGeachy 1979; Present study. Taxonomic key used - Jepson 1975. Habitat types for various taxa as given by McGeachy (1979) are shown in brackets and are exemplified by words such as [Marsh]. Habitats of taxa identified during the present study are shown in parenthesis and are given alpha-numeric designations according to the classification system of Cowardin et al. (1979). An example of this is (E2RS2) (continued).

Scientific name	**Common name**	**Habitat type(s)**
Brassicaceae		
Brassica campestris	Mustard	(PF01)(PSS1)(R2BB1W)
Cackile edentula	-	
Cackile maritima	Sea rocket	[Beach]
Erysimum conicinnum	-	[Beach]
Rhaphanus sp.	Radish	(PF01KR2BB1W)
Cucurbitaceae		
Marah oreganus	Man root or western cucumber	[Beach foredune] (E2RS2)(E2BB1)
Garryaceae		
Garrya ellipticata	Silk tassel	[Scrub]
Lamiaceae		
Stachys chamissonis	-	[Scrub]
Stachys rigida	-	[Scrub]
Fabaceae		
Lathyrus littoralis	Beach pea	[Beach]
Lotus corniculotus	Birds-feet trefoil	[Marsh]
Lupinus albifrans	Lupine	[Scrub]
Lupinus bicolor	Lupine	(R2BB1W)(R2BB2W)
Trifolium fucatum	Sour clover	[Scrub]
Trifolium Wormskjoldii	Clover	[Marsh]
Viciji sp.	Vetch	(PSS1)(PFL5W)
Malvaceae		
Sidalcea malachroides	-	[Scrub]
Nyctaginaceae		
Abronia latifolia	Sand verbana	[Beach]
Onagraceae	Willow herbs	
Clarkia amoena		[Scrub]
Epilobium watsonii franciscanum		[Scrub, Marsh]
Epibolium sp. (several sp.)		(E2BB1)(E2RS2)
Oxalidaceae		
Oxalis sp.	Wood sorrel	(PF01,3)
Papaveraceae		
Eschsholzia californica	California poppy	(E2BB1)(E2RS2)(PF01)

Table 3. Phylogenetic list of plant taxa identified in the Mattole River estuary/lagoon and surrounding riparian areas. Sources: McGeachy 1979; Present study. Taxonomic key used - Jepson 1975. Habitat types for various taxa as given by McGeachy (1979) are shown in brackets and are exemplified by words such as [Marsh]. Habitats of taxa identified during the present study are shown in parenthesis and are given alpha-numeric designations according to the classification system of Cowardin et al. (1979). An example of this is (E2RS2) (continued).

Scientific name	**Common name**	**Habitat type(s)**
Pinaceae		
Pseudotsuga menziesii	Douglas fir	(E2F06,7)
Plantaginaceae		
Plantago hirtella	Plantain	[Marsh](PSS1)(E2FL2P)(PFL5W)
Plantago lancelata	English plantain	(PSS1)(PFOl)
Polemoniaceae		
Gilia capitata	-	[Scrub]
Gilia tricolor	-	[Scrub]
Ranunculaceae		[Scrub]
Ranunculus californicum	California buttercup	(PF01)
Rhamnaceae		
Ceanothus spp.	Ceanothus	(PF01)
Rosaceae		
Holodiscus discolor	Cream bush	
Potentilla egedei	Five finger	[Marsh]
Salicaceae	Willows	
Salix couteri		(PFL5W)(PF01)
Salix sp. (several others)		(PFL5W)(PF01) (ED2F06)
Hippocastanaceae		
Aesculus californica	Buckeye	(E2F06,7)(PF01,3)
Saxifragaceae		
Ribes menziesii		[Scrub]
Scrophulariaceae		
Mimulus aurantiacus	Bush monkey flower	[Scrub]
Mimulus guttatus	Common monkey flower	(PF01)(E2BB1)
Orthocarpus sp.	Owl's clover	(PF01)(E2BB1)
Scrophularia californica	Figwort	(PF01)(E2BB1)
Castilleja sp.	Paintbrush	(E2BB1)(E2RS2)

Table 3. Phylogenetic list of plant taxa identified in the Mattole River estuary/lagoon and surrounding riparian areas. Sources: McGeachy 1979; Present study. Taxonomic key used - Jepson 1975. Habitat types for various taxa as given by McGeachy (1979) are shown in brackets and are exemplified by words such as [Marsh]. Habitats of taxa identified during the present study are shown in parenthesis and are given alpha-numeric designations according to the classification system of Cowardin et al. (1979). An example of this is (E2RS2) (continued).

Scientific name	**Common name**	**Habitat type(s)**
Apiaceae		
Heracleum lanatum	Cow parsnip	[Scrub]
Conium maculatum	Poison hemlock	(PF01)(PF01,3)
Oenanthe sarmentosa		[Marsh]
Monocotyledoneae	Monocots	
Poaceae		
Distichlis spicata	-	[Scrub]
Anthoxanthum aristatum	Sweet grass	[Marsh]
Avena barbata	Wild oats	[Scrub]
Calamagrostis nutkaensis	Reed grass	[Scrub]
Holcus lanatus	-	[Marsh and floodplain]
Bromus diandrus	Brome grasses	[Beach]
Bromus mollis		[Scrub]
Cyperaceae		
Carex obnupta	Sedge	(E2F06,7)(E2FL2P)
Eleocharis palustris	_	(PSS1) [Scrub and marsh]
Cyperus sp.	Galingale	(E2F06,7)(PSS1)
Cynosurus echinatus	_	(PEM1W) [Scrub]
Lolium multiflorum	-	[Scrub]
Poa douglasii	Bluegrass	[Beach]
Iridaceae		
Iris douglasiana	Flag	[Scrub]
Juncaceae		
Juncus effusus	Bog rush	(Scrub and marsh)
Juncus sp.	Rush	(E1UB1)(E1UB2) (E2EM1) and most palustrine flats (PFL-)
Hordeum brachyantherum	-	[Scrub]

Planktonic Macrofauna

Qualitative and quantitative investigations of planktonic macrofauna were conducted during the 1986 and 1987 study periods. The data collected are currently being analyzed (Busby in prep.). Inspection of samples collected in 1986 revealed large numbers of aquatic mites, mysid shrimp, the gammarid amphipod *Corophium spinicorne* and terrestrial insects (ants, beetles, spiders). The marine/estuarine copepod *Arcartia clausii* was identified in samples collected while the lagoon was entirely freshwater. Samples collected in 1987 appear to contain many of the same organisms. Large numbers of threespine stickleback *(Gasterosteus aculeatus)* larvae, juveniles and adults were seen in samples collected in the late summer of 1987.

Benthic Macrofauna

The abundance, biomass, and species composition of benthic macrofauna in the Mattole River estuary/lagoon are currently being determined (Busby in prep.). Initial inspection of samples collected suggest that densities of benthic macrofauna are substantially greater in the upper lagoon. The gammarid amphipod *Corophium spinicorne* occurs throughout the lower lagoon and most of the upper lagoon, but was never found at water quality station 1 (Figure 2). *Corophium spinicorne* appears to be the most abundant benthic organism. The isopod *Gnorimosphaeroma oregoniensis* and a Trichopteran (caddis fly) larvae, *Gumaga griseus* are also abundant. Aquatic insects appear to be more abundant in the upper lagoon which has a cobble-gravel substrate more characteristic of riverine systems. Several other organisms have also been identified in the samples. A preliminary list of benthic macrofauna in the Mattole River estuary/lagoon is presented in Table 4.

Reptiles and Amphibians

No comprehensive studies or lists of reptile and/or amphibian species have been completed specifically for the Mattole River estuary/lagoon. The California Department of Fish and Game (1973) compiled a list of reptiles and amphibians for the entire drainage. This list is presented in Table 5. An asterix indicates that a particular species was sighted during the 1986-1987 study periods. All of the species in Table 5 are believed to occur in the Mattole River estuary/lagoon area (J. Decker, pers. comm.).

Fish

Fish surveys conducted in the Mattole River estuary/lagoon have focused primarily on the distribution, abundance and food habits of juvenile salmonids (Barnhart and Young 1985; Barnhart and Busby 1986; Young 1987; Present study). Of the juvenile salmonids occurring in the lagoon, chinook salmon (*Oncorhynchus tshawytscha*) have received the most attention. Most collections were made using a 54.7 x 4.8 m beach seine with 6.4 mm mesh set from a 4.3 m aluminum boat with a 25 horsepower outboard motor.

Several species of marine fish were caught in the estuary/lagoon while sampling juvenile salmonids. All fish species collected from May 1984 to November 1987 are listed in Table 6. Steelhead, chinook salmon and threespine stickleback were the most abundant fish species caught during the 1984 through 1987 study periods.

Schools of threespine stickleback utilized warm shallow fringe areas along the estuary/lagoon near submerged riparian vegetation or algal beds. Stickleback were also caught in beach seines in the deeper areas of the

Table 4. Preliminary list of benthic invertebrate macrofauna collected during the 1986-1987 study periods Mattole River estuary/lagoon, California. Taxonomic Sources: Smith and Carlton eds. (1975); Barnes (1980); Merritt and Cummings (1984).

Scientific name	**Common name**
I. Platyhelminthes	Flatworms
Turbellaria	
Seriata	
Tric1adia	Planarians
II. Nematoda	Roundworms
III. Annelida	Segmented worms, leeches
Oligochaeta	
Tubificida	
Tubificidae	
IV. Mollusca	Molluscs
Gastropoda	Snails, limpets, nudibranchs
Neogastropoda	
Olividae	
Olivella biplicata	Olive snail
V. Arthropoda	
Chelicerata	Nonantennate arthropods
Arachnida	Spiders, mites, ticks
Acarina	Mites, ticks
Hydracarina	Aquatic mites
Crustacea	Crustaceans
Ostracoda	Seed shrimps
Copepoda	Copepods
Calanoida	
Arcartia clausii	
Cyclopoida	
Cyclops sp.	
Malacostraca	
Mysidacea	
Mysidae	
Neomysis mercedis	Opossum shrimp
Isopoda	Isopods
Spaeromatidae	
Gnorimoiphaeroma oregoniensis	
Amphipoda	Amphipods
Corophiidae	
Corophium spinicorne	
Gammaridae	
Anisogammaraus conferviculous	

Table 4. Preliminary list of benthic invertebrate macrofauna collected during the 1986-1987 study periods Mattole River estuary/lagoon, California. Taxonomic Sources: Smith and Carl ton eds. (1975);Barnes (1980); Merritt and Cummings (1984). (continued)

Scientific name	**Common name**
Insecta	Aquatic, terrestrial insects
Coleoptera	Beetles
Chrysomelidae	
Dytiscidae	
Oreodytes sp.	
Elmidae	
Heterlimnus sp.	
Zaitzevia sp.	
Diptera	True flies
Chironomidae	Midges
Tipulidae	Craneflies
Ephemeroptera	Mayflies
Baetidae	
Baetis sp.	
Ephemerellidae	
Serratella sp.	
Leptophelebiidae	
Paraleptophlebia sp.	
Siphlonoridae	
Isonychia sp.	
Tricorythidae	
Tricorythodes sp.	
Hemiptera	True bugs
Corixidae	
Naucoridae	
Pelocris sp.	
Megaloptera	Alderflies, Dobsonflies
Sialis sp.	Alderflies
Plecoptera	Stoneflies
Capniidae	
Capnia sp.	
Trichoptera	Caddisflies
Hydroptilidae	
Ithytrichia sp.	
Oxythria sp.	
Lepidostomatidae	
Lepidostomus sp.	
Limnephelidae	
Dicosmecus sp.	
Sericostomatidae	
Gumaga griseus	

Table 5. Reptiles and amphibians of the Mattole River estuary/lagoon listed by order. Sources: California Department of Fish and Game 1973; U.S. Forest Service 1979.

Common name	**Scientific name**
Reptiles	
Western fence lizard*	Sceloporus occidentals
Sagebrush lizard	Sceloporus graciosus
Western skink	Eumeces skiltonianus
Northern alligator lizard*	Gerrhonotus coeruleus
Sharp-tailed snake	Contia tenuis
Racer	Coluber constrictor
Common king snake	Lampropeltis getulus
Western rattlesnake*	Crotalus viridis
Rubber boa	Charina bottae
Ringneck snake	Diadophis punctatus
Pacific gopher snake*	Dituophis catenifer
W. terr. gartersnake*	Thamnophis elegans
W. terr. aquatic gartersnake*	Thamnophis sirtalis
Common gartersnake*	Thamnophis couchi
Amphibians	
Pacific giant salamander*	Dicamptodon ensatus
N. rough-skinned newt	Taricha granulosa
Ensatina	Ensatina eschscholtzi
Ca. slender salamander*	Batrachoseps attenuatus
Speckle black salamander	Aneides flavipunctatus
Clouded salamander	Aneides ferreus
Arboreal salamander	Aneides lugubris
Brown N. W. salamander	Ambystoma gracile
Olympic salamander	Rhyacotrfton olympicus
W. toad	Bufo boreas
Pacific tree frog*	Hyla regilla
Red-legged frog (Cascade)	Rana aurora
Foothill yellow-legged frog	Rana boylei
Bull frog*	Rana cates beiana

*0bserved or collected during 1986-87 study periods.

Table 6. Fish collected Mattole River estuary/lagoon, California, May 1984 to November 1987.

Common name	**Scientific name**	**Anadromous**	**Freshwater**	**Marine**
Pacific lamprey	Lampetra tridentatus	X		
Coho salmon	Oncorhynchus kisutch	X		
Chinook salmon	O. tshawytscha	X		
Steelhead	Salmo gairdneri	X		
Surf smelt	Hypomesus pretiosus	X		
Threespine stickleback	Gasterosteus aculeatus		X	X
Redtail surf perch	Amphistichus rhodoterus			X
Shiner perch	Cymatogaster aggregata			X
Walleye surf perch	Hyperprosopon argenteum			X
Coastrange sculpin	Cottus aleuticus		X	
Prickly sculpin	Cottus asper		X	
Pacific staghorn sculpin	Leptocottus armatus			X
Speckled sanddab	Citharichthys stigmeus			X
Starry flounder	Platichthys stellatus			X

lagoon. The abundance of threespine stickleback was not estimated and little is known about their ecological relationships in the food web except that stickleback larvae are eaten by juvenile chinook salmon (Young 1987; Busby in prep.). They are, perhaps, the most abundant fish in the lagoon in mid to late summer.

Poor land use practices have severely impacted anadromous fishery resources in the Mattole River drainage (CDF&G 1965; Barnhart and Young 1985; Peterson 1985; Young 1987). The chinook salmon run size was estimated to be around 5,000 adult spawners per year in the 1960's (CDF&G 1965). Erosion and sediment deposition have caused significant degradation of spawning and rearing habitat (Peterson 1985; Young 1987). Estimates of recent chinook run sizes have approximated 1,000 spawners; the 1985 run was estimated at less than 600 spawners (Peterson 1985). The California Department of Fish and Game estimated that adequate habitat existed in the Mattole to accommodate 7,900 spawning pairs of chinook salmon in the early 1960's (CDF&G 1965).

Adult chinook migrate from the ocean into the estuary after the sandbar breaches anytime from September to November. We believe that some fish may enter the lagoon on large waves that break over the berm at high tides before breaching occurs. Chinook continue to move into the estuary and upstream to spawning areas through mid-January (G. Peterson, pers. comm.). Fry emerge in March and April (Brown 1972) and soon move downstream (G. Peterson, pers. comm.). Downstream migration usually peaks in April or early May and is complete by the end of June or the first week of July (G. Peterson, pers. comm.). Most chinook fry probably migrate directly to the ocean and avoid becoming trapped in the lagoon. This immediate downstream migration of chinook fry is probably due to high river temperatures. The only juvenile chinook in the river system during the summer are those in the lagoon (J. Decker, pers. comm.).

Juvenile chinook have been observed or collected in many areas in the estuary/lagoon during the 1984-1987 study periods (Barnhart and Young 1985; Barnhart and Busby 1986; Young 1987; Present study). These areas are delineated in Figure 8. Chinook were generally captured in the deeper areas of the lower lagoon. Chinook in this area exhibited more pronounced schooling behavior than steelhead which tended to forage in looser assemblages and only formed schools when disturbed. Steelhead also utilized shallower areas such as the upper lagoon and south slough to a greater extent than chinook. Chinook were, however, observed and collected in these areas but in smaller numbers. Chinook and steelhead in these areas coexisted and were not segregated.

A small school of about 30 juvenile chinook was subsampled during an electrofishing survey of an isolated pool of the south slough on July 15, 1987. On a return survey conducted on September 19, the pool had dried up and all chinook were assumed to have perished.

The number of juvenile chinook that reside in the lagoon during the summer varies annually based on several interacting physical and biological factors. Annual variations in chinook abundance are demonstrated by mean monthly catch per seine haul data which are presented in Table 7.

Monthly estimates of juvenile chinook abundance in the lagoon were computed using the Peterson method (Ricker 1975). These estimates required mark and recapture experiments and that several assumptions be met to validate use of this method. These procedures and assumptions are described in detail by Young (1987). Estimated monthly abundances of juvenile chinook during the 1985-1987 study periods are compared in Table 8.

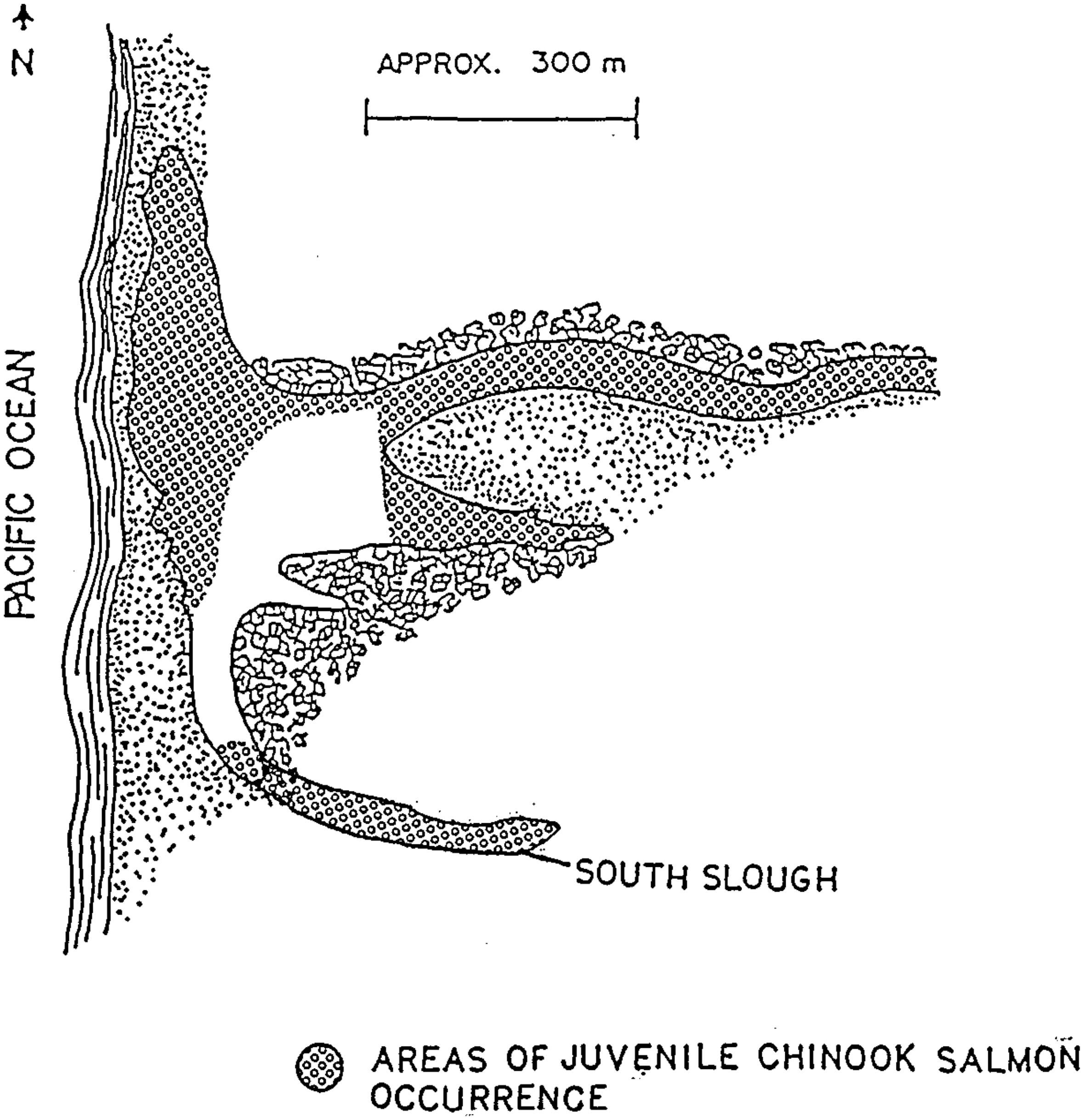

Figure 8. Distribution of juvenile chinook salmon in the Mattole Estuary/Lagoon May 1984-November 1987. Includes direct observations, beach and hand seine collections and boat or back-pack electro-fishing surveys.

Table 7. Mean monthly catch per beach seine set and total number of juvenile chinook salmon with overall CPUE for the 1984-1987 study periods, Mattole River estuary/lagoon. Sources: Barnhart and Young 1985; Barnhart and Busby 1986; Young 1987; Present study.

Year	Monthly CPUE					Total # fish	# of seines	overall CPUE
	June	July	Aug	Sept	Oct			
1984		33	31	91	5	229	7	33
1985	565	185	205	29	37	6,672	52	128
1986	99	58	27	27		1,066	21	41
1987	466	145	5	0		3,232	22	147

Table 8. Comparison of estimated monthly abundances (number of individuals) of juvenile chinook salmon in the Mattole estuary/lagoon during the 1985 through 1987 study periods. Limits of the 95% confidence interval and mean are given. Sources: Barnhart and Busby 1986; Young 1987; Present study.

	Month				
	June	July	Aug	Sept	Oct
1985		40783 ± 3393	83389 ± 29862	13786 + 6088	5475 + 2410
1986		9703 ± 3088	1962 ± 991		
1987	109508 ± 34937	32190 ± 11869	0 ± 0	23 ± 1*	

* Population was estimated using the Moran-Zippin multiple pass removal technique (Platts 1983) with data from boat electrofishing survey conducted September 19, 1987. Confidence interval is 79%.

The highest estimate of chinook abundance over all study periods was 109,508 + 34,637 individuals in June 1987 (Table 8, Figure 9). Within a month, however, the estimated number of fish declined to 32,190. In August, no marked fish were recaptured, thus invalidating the use of the Peterson estimate. No juvenile chinook were caught in the lower lagoon during

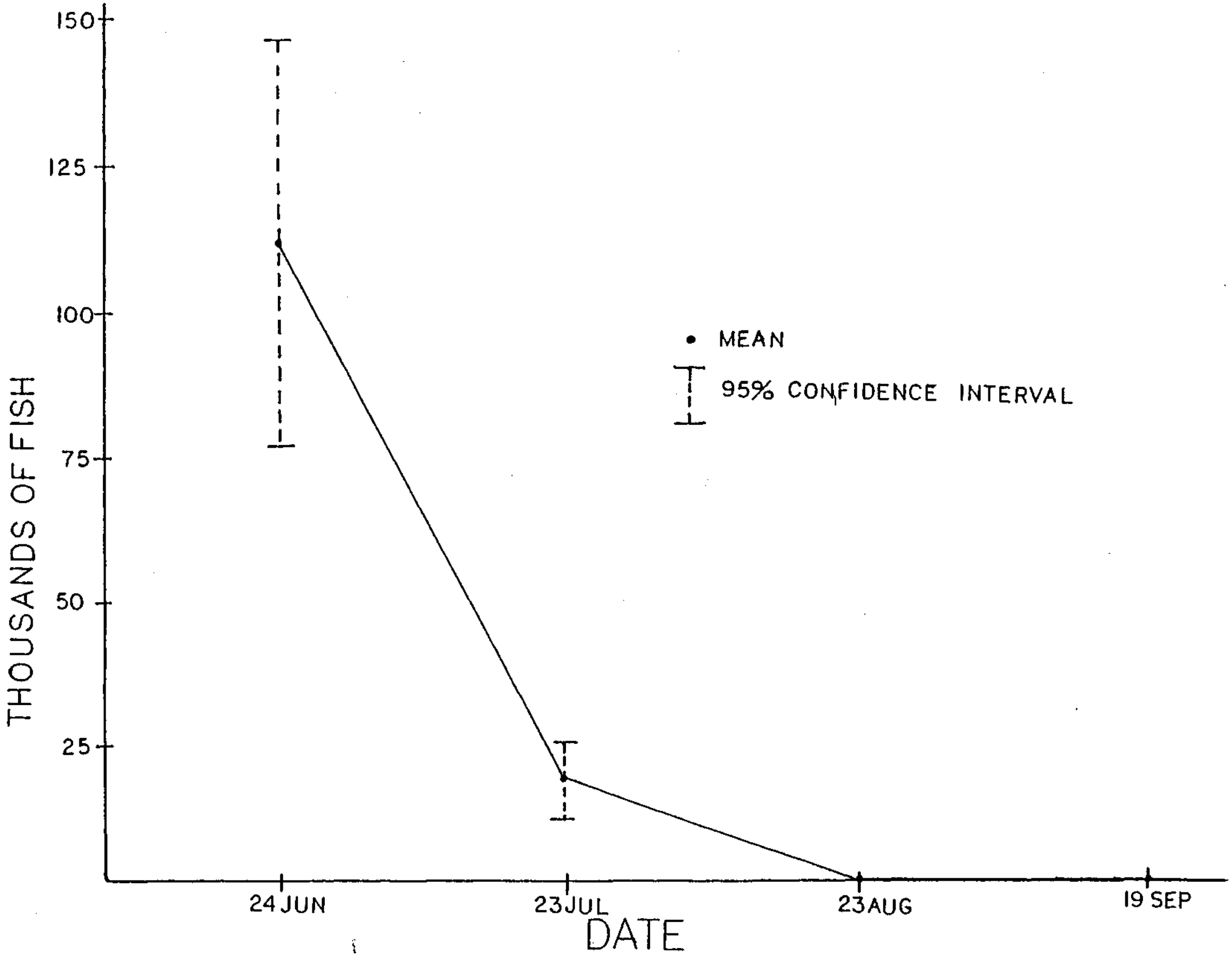

Figure 9. Abundance of juvenile chinook salmon. Mattole River Lagoon, California, summer 1987.

September 1987. Only 28 chinook were collected during a boat electrofishing survey of a 300 m stretch in the upper lagoon the same month. A Moran-Zippin multiple pass removal estimate (Platts 1983) was computed which gave a value of 23 ± 1 at the 79% confidence level. Similar chinook abundance trends were reported in 1985 by Young (1987). Chinook abundance and time of peak abundance differ each year.

Juvenile chinook appeared to undergo a period of suppressed growth associated with the decline in abundance during the 1987 study period (Figure 10). Young (1987) reported a similar but less dramatic period of suppressed growth during the time of peak abundance in 1985. In years of low chinook abundance in the lagoon, growth is not suppressed and the fish appear to attain larger sizes.

Table 9 presents mean monthly fork lengths of juvenile chinook salmon for each study period. Although no significant differences in mean fork length between sampling dates were found, comparison of the mean values provides general growth trends. The 1986 group may have reached the longest mean fork length of all years had the berm not breached in early September. After breaching, seine surveys have collected no chinook indicating that they probably all outmigrate. The fastest growth appears to have occurred during years with lower abundance of chinook (1984 and 1986). The percent of chinook trapped in the lagoon which survived to enter the ocean was not estimated in 1984 but Young (1987) estimated that 6% survived in 1985. In 1986, a year with substantially fewer chinook, survival was about 20%. Survival in 1987, the year of greatest chinook abundance, was less than 1%. The data indicate that growth and survival of chinook salmon are density dependent in the Mattole River lagoon.

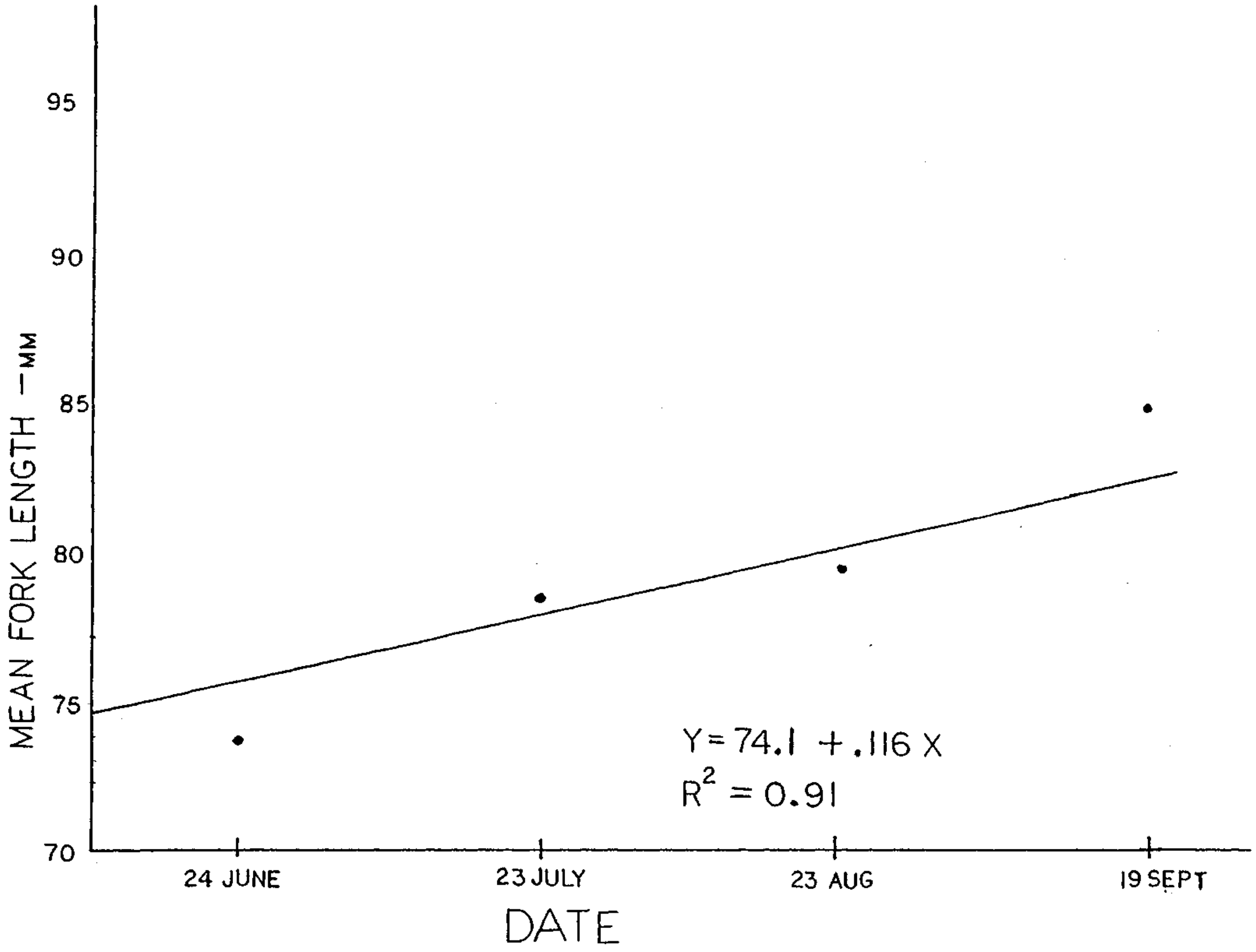

Figure 10. Growth of juvenile chinook salmon, Mattole River Lagoon, California, summer 1987,

Table 9. Mean monthly fork lengths (mm) of juvenile chinook salmon during the 1984-1987 study periods Mattole River estuary/lagoon, California. Final value given for each year is approximate mean fork length of chinook entering the ocean.

	Month					
	May	June	July	Aug	Sept	Oct
1984			81	91	108	119
1985	55	76	81	85	93	107
1986		82	92	100		
1987		74	79	80	85	

Adult steelhead pass through the estuary on their way to upstream spawning areas between October and April (G. Peterson, pers. comm.). Steelhead spawn throughout most of the drainage and have a wider spawning distribution than coho and chinook salmon (CDF&G 1965). In low flow years when the sand berm closes in late May, some adult steelhead returning to the ocean are trapped in the lagoon and in the isolated pools of the south slough (Figure 2). These fish are able to survive in the lagoon during the summer as an adequate supply of stickleback and juvenile salmonids exists as food. These adult fish are vulnerable to angling and several were seen taken during the 1987 study period. Numerous juvenile steelhead are also taken by anglers each year and are referred to as "rainbow trout".

Steelhead is the most abundant salmonid in the drainage with a spawning run size estimated at 12,000 fish in the early 1960's (CDF&G 1965). The Department estimated that the Mattole River had adequate habitat to accommodate 10,000 spawning pairs of steelhead at that time (CDF&G 1965). Current run size and spawning capacity for steelhead are unknown. Several unsubstantiated reports of a remnant population of summer run steelhead that

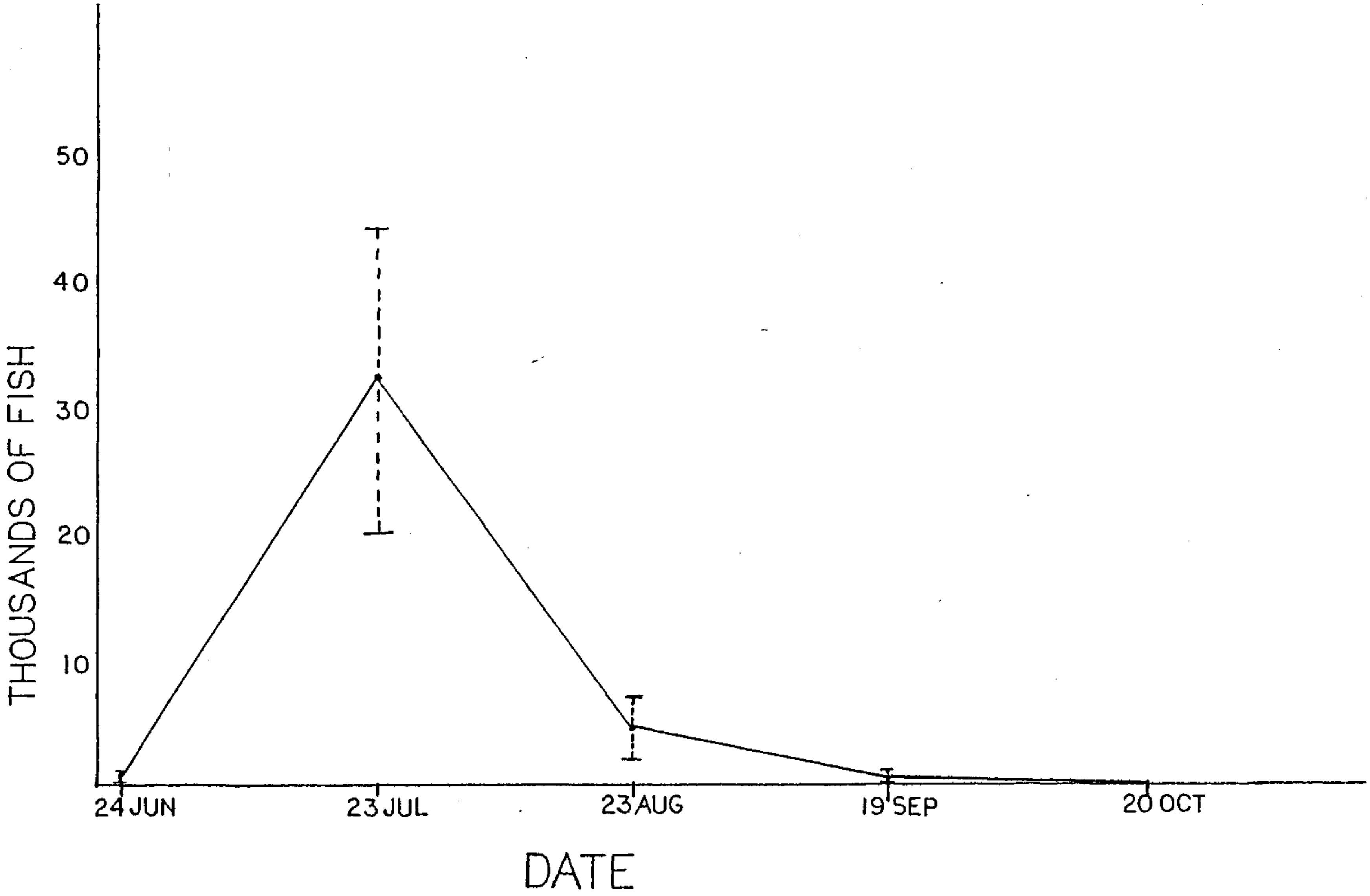

Figure 11. Abundance of steelhead Mattole River Lagoon, California, June-October i987

estimated from an electrofishing survey in the upper lagoon. Too few fish were captured in October and November to compute valid estimates. Although Peterson estimates were not conducted in 1986, the abundance of steelhead was approximated using the average chinook to steelhead ratio in seine hauls. These numbers were compared to 1987 values (Table 11).

Table 10. Steelhead mean monthly catch per beach seine set, total catch, and overall catch per unit effort, 1984-1987 study periods, Mattole River Lagoon, California. Sources: Barnhart and Young 1985; Barnhart and Busby 1986; Young 1987; Present study.

	Month						Total # fish	# of seines	Overall CPUE
Year	June	July	Aug	Sept	Oct	Nov			
1984		404	639	1,128	427		4,067	7	581
1985	158	180	193	48	86		5,686	52	109
1986	140	178	327				5,421	21	258
1987	30	150	28	2		1	1,276	22	58

Table 11. Comparison of juvenile steelhead population estimates, 1986-1987 study periods, Mattole River Lagoon, California. Sources: Barnhart and Busby 1986; Present study.

	Month				
Year	June	July	Aug	Sept	Oct
1986	15,000	29,000	49,000	-	-
1987	1,088	32,190	4,133	945	-

Juvenile steelhead were sampled by backpack electrofishing in isolated pools in the south slough on July 15, 1987. These fish probably perished because none were collected during a survey on September 19, 1987. One adult female steelhead (450 mm FL) was captured in the uppermost pool in the slough on both surveys and apparently survived summer isolation. This pool had approximately 90% shade canopy provided by alders and temperatures remained between 12.2-15.0 °C.

Age and growth of juvenile steelhead in the Mattole River estuary/lagoon have not been studied. Analysis of length frequency data revealed no distinct separation point between young-of-the-year, one and two year old steelhead. We do believe, however, that all three age classes were present in the lagoon each year. Although no significant differences in steelhead mean fork length could be detected between sampling dates in 1986 and 1987, a general growth trend appeared among all age classes in 1986 but not in 1987 (Figures 12 and 13). The lower mean fork length on September 19, 1987 may be due to smaller juvenile steelhead utilizing the upper lagoon where the sampling was conducted. Scale analysis would help greatly in separating age classes and determining growth rates of specific age groups of steelhead.

No information is available concerning the feeding habits of juvenile steelhead or diet overlap with other species in the estuary/lagoon. Apparently growth and survival of steelhead are also density dependent with chinook. Both populations experienced mass mortality and poor growth during the 1987 study period. Both populations should be assessed to determine the approximate carrying capacity for salmonids in the lagoon.

Coho salmon adults pass through the estuary from October to January and move upstream to spawn in tributaries throughout the basin (G. Peterson, pers. comm.). Juvenile coho rear in the river for one year and the majority enter the ocean before the sand bar closes. Very few juvenile coho were caught in the lagoon (Barnhart and Young 1984; Barnhart and Busby 1986; Present study). The California Department of Fish and Game (1965) estimated the spawning run size of coho in the Mattole drainage at 2,000 fish in the early 1960's. They

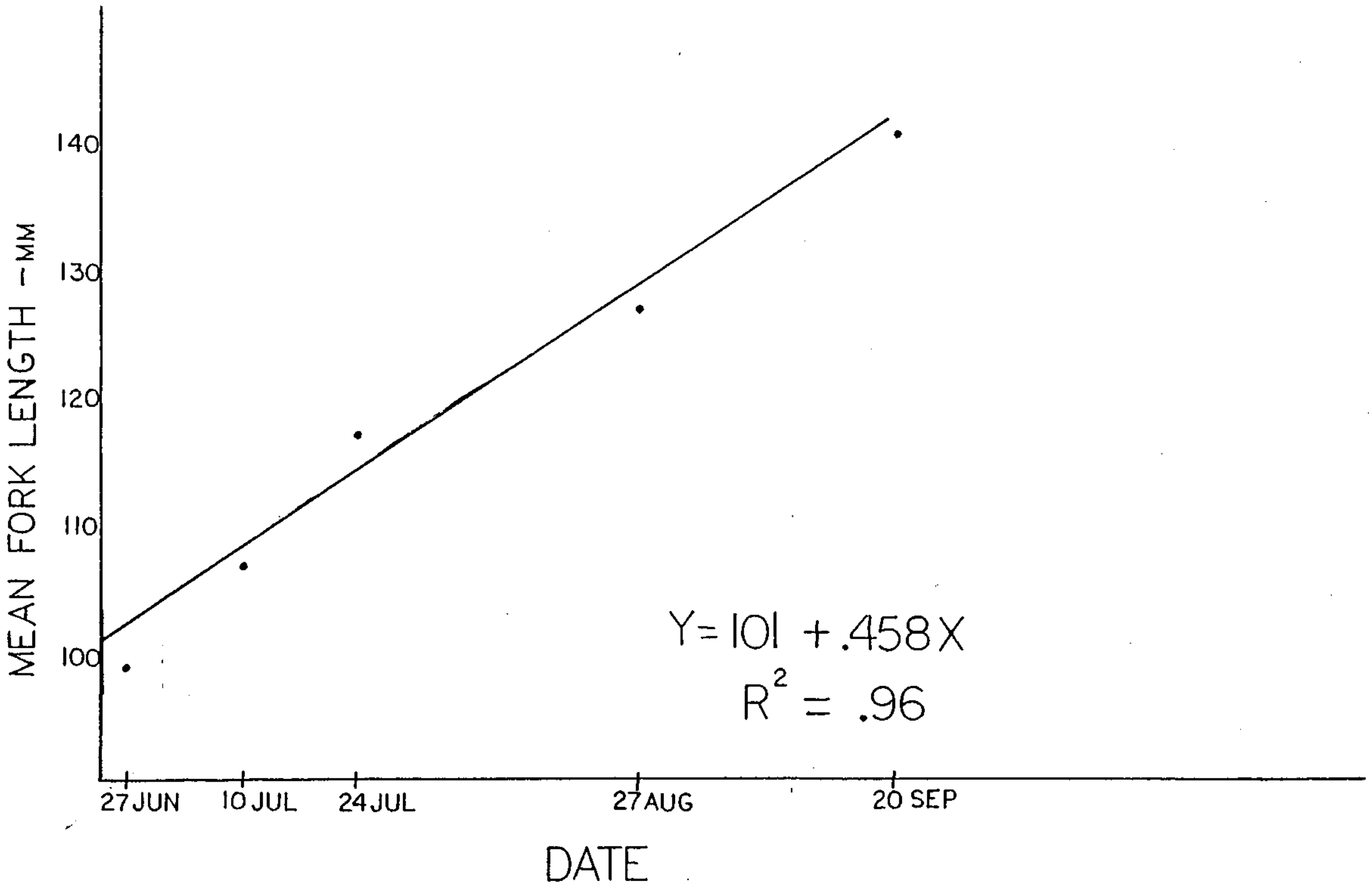

Figure 12. Growth of steelhead June - September 1986, Mattole River Lagoon, California,

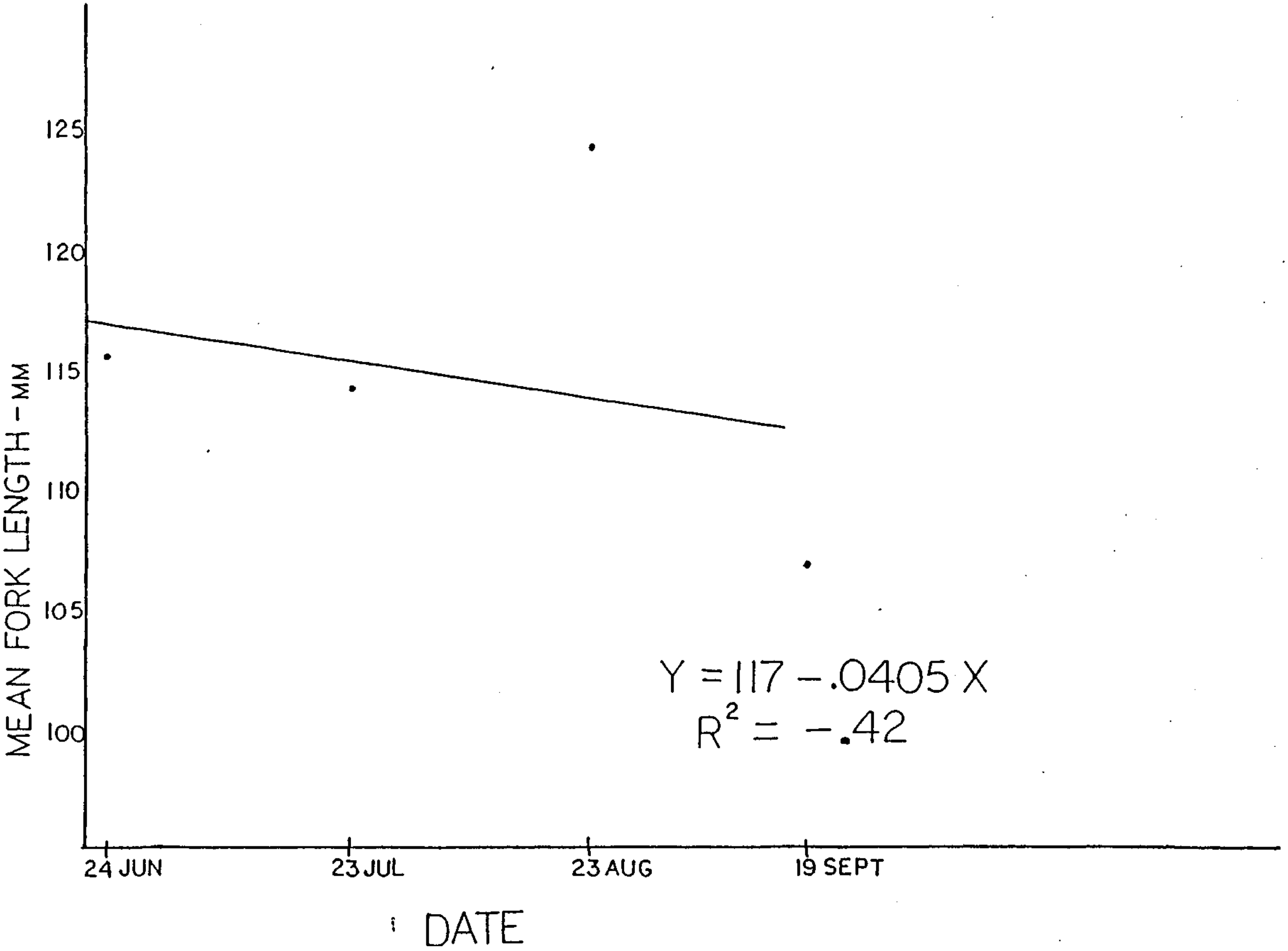

Figure 13. Growth of steelhead June-September 1987, Mattole River Lagoon, California,

suggested that at that time there was adequate habitat to accommodate 10,000 spawning pairs of coho. The 1987 run of adult coho salmon, estimated at over 1,000 spawners, was one of the best in recent years (G. Peterson, pers. comm.).

Birds

The Mattole estuary/lagoon and surrounding riparian vegetation provide suitable feeding, nesting, rearing and refuge habitat for many species of birds. Although no comprehensive study of avian abundance or species diversity has been conducted, lists of species observed in the area have been compiled by McGeachy (1979) and USDI-BLM (1988). A complete list of birds observed in the Mattole River estuary/lagoon and surrounding riparian vegetation is presented in Table 12.

Fledgling common mergansers were observed rearing in the lagoon during the 1986 and 1987 study periods. A brood of 6 fledglings was seen throughout the 1986 study period and 3 broods totaling about 25 fledglings were seen in 1987. These birds were often observed feeding on fish below overhanging riparian vegetation in the upper lagoon. Large numbers of marine and/or shore birds were frequently observed in the lagoon. Several hundred Caspian terns were observed diving on the lagoon and roosting on the sand berm on August 8, 1986 and on August 21, 1987. A flock of brown pelicans numbering between 50 and 60 appeared in the lagoon from August 21 to September 9, 1987.

Mammals

The Mattole estuary/lagoon and surrounding riparian vegetation provide suitable habitat for terrestrial, riverine and marine mammals. Table 13 lists the species of mammals observed in the estuary/lagoon between May 1984 and November 1987.

Table 12. Species of birds observed in the Mattole River estuary/lagoon listed by order. Sources: McGeachy 1979 and USDI-BLM 1988.

Common name	**Scientific name**
Order Gaviiformes	
Red-throated loon*	Gavia stellata
Artic loon*	Gavia arctic
Common loon*	Gavia limner
Order Podicipediformes	
Pied-billed grebe	Podilymbus podiceps
Horned grebe	Podiceps auritus
Red-necked grebe	Podiceps grisegena
Eared grebe*	Podiceps nigricollis
Western grebe*	Aechmophorus occidentalis
Order Pelecaniformes	
Brown pelican*	Pelecanus occidentalis
Double-crested cormorant*	Phalacrocorax auritus
Brandt's cormorant*	Phalacrocorax penicillatus
Pelagic cormorant	Phalacrocorax pelagicus
Order Ciconiiformes	
Great blue heron*	Ardea herodias
Great egret*	Casmerodius albus
Green-backed heron*	Butorides striatus
Black-crowned night heron*	Nycticorax nycticorax
American bittern	Botaurus lentiginosus
Order Anseriformes	
Whistling swan	Olor columbianus
Snow goose	Chen caerulescens
Brant	Branta bernicla
Canada goose*	Branta canadensis
Wood duck	Aix sponsa
Green-winged teal	Anas crecea
Pintail	Anas acuta
Mallard*	Anas platyrhynchos
Northern shoveler	Anas clypeata
Gadwall	Anas strepera
American wigeon*	Anas americana
Canvasback	Aythya valisineria
Redhead	Aythya americana
Ring-necked duck	Aythya collaris
Greater scaup*	Aythya marila
Lesser scaup*	Aythya affinis
Harlequin duck	Histrionicus histrionicus
Black scoter	Melanitta nigra
Surf scoter*	Melanitta perspicillata

Table 12. Species of birds observed in the Mattole River estuary/lagoon listed by order. Sources: McGeachy 1979 and USDI-BLM 1988 (continued).

Common name	**Scientific name**
Order Anseriformes (continued)	
White-winged scoter	Melanitta deglandi
Common goldeneye	Bucephala clangula
Bufflehead*	Bucephala albeola
Common merganser*	Mergus merganser
Red-breasted merganser	Mergus serrator
Ruddy duck*	Oxyura jamaicensis
Order Falconiformes	
Osprey*	Pandion haliaetus
Bald eagle	Haliaeetus leucocephalus
Golden eagle*	Aquila chrysaetos
Northern harrier*	Circus cyaneus
Sharp-shinned hawk*	Accipiter striatus
Cooper's hawk	Accipiter cooperii
Red-shouldered hawk*	Buteo lineatus
Red-tailed hawk*	Buteo jamaicensis
American kestrel*	Falco sparverius
Merlin	Falco columbarius
Peregrine falcon	Falco peregrinus
Prairie falcon	Falco mexicanus
Order Galliformes	
California quail*	Lophortyx californicus
Order Gruiformes	
Virginia rail	Rallus limicola
American coot*	Fulica americana
Sora	Porzana Carolina
Order Charadriiformes	
Black-bellied plover*	Plurialis squatarola
Snowy plover*	Charadrius alexandrinus
Semipalmated plover	Charadrius semipalmatus
Kill deer*	Charadrius vociferus
Black oystercatcher	Haematopus bachmani
Greater yellowlegs	Tringa flavipes
Willet	Catoptrophorus semipalmatus
Wandering tattler	Heteroscelus incanus
Black turnstone*	Arenaria melanocephala
Ruddy turnstone	Arenaria interpres
Spotted sandpiper*	Actitis macularia
Whimbrel*	Numenius phaeophus
Marbled godwit*	Limosa fedoa
Surfbird	Aphriza virgata
Sanderling*	Calidris alba

Table 12. Species of birds observed in the Mattole River estuary/lagoon listed by order. Sources: McGeachy 1979 and USDI-BLM 1988 (continued).

Common name	Scientific name
Order Charadriiformes (continued)	
Western sandpiper	Calidris mauri
Baird's sandpiper	Calidris bairdii
Rock sandpiper	Calidris ptilocnemis
Dunlin*	Calidris alpina
Short-billed dowitcher	Limnodromus griscus
Long-billed dowitcher	Limnodromus scolopaceus
Common snipe	Capella gallinacjo
Red-necked phalarope	Phalaropus lobatus
Red phalarope	Phalaropus fulicarius
Bonaparte's gull*	Larus phi ledelphia
Herman's gull*	Larus heermanni
Mew gull	Larus canus
Ringed-billed gull*	Larus delawarensis
California gull*	Larus californicus
Black-headed gull	Larus ridibundus
Herring gull*	Larus argentatus
Thayer's gull	Larus thayeri
Western gull*	Larus occidentalis
Glaucous-winged gull	Larus glaucesens
Black-legged kittiwake	Rissa tridactyla
Caspian tern*	Sterna caspia
Common tern	Sterna hirundo
Foster's tern*	Sterna forsteri
Common murre	Vria aagle
Pigeon guillemot	Cepphus columba
Marbled murrelet	Brachyramphus marmoratus
Ancient murrelet	Synthliboramphus antiquus
Rhinoceros Auklet	Cerorhinca monocerata
Order Columbiformes	
Mourning dove*	Zenaida macroura
Order Strigiformes	
Western screech owl*	Otus asio
Great horned owl	Bubo virginianus
Northern pygmy owl	Glaucidium gnoma
Order Apodiformes	
Anna's hummingbird*	Calypte anna
Allen's hummingbird*	Selasphorus sasin
Order Coraciiformes	
Belted kingfisher*	Megaceryle alcyon

Table 12. Species of birds observed in the Mattole River estuary/lagoon listed by order. Sources: McGeachy 1979 and USDI-BLM 1988 (continued).

Common name	**Scientific name**
Order Piciformes	
Acorn woodpecker	Melanerpes formicirorus
Red-breasted sapsucker	Sphyrapicus varius
Downy woodpecker	Picoides pubescens
Hairy woodpecker	Picoides villosus
Northern flicker*	Colaptes auratus
Order Passeriformes	
Western wood pewee	Contopus sordidulus
Harmond's flycatcher	Empidonax hammondii
Western flycatcher*	Empidonax difficilis
Black phoebe*	Sayornis nigricans
Ash-throated flycatcher	Myiarchus cinerascens
Purple martin	Progne subis
Tree swallow	Iridoprocne bicolor
Violet-green swallow*	Tachycineta thalassina
Rough-winged swallow*	Stelgidopteryx ruficollis
Cliff swallow*	Petrochelidon pyrrhonota
Barn swallow*	Hirundo rustica
Scrub jay*	Aphelocoma coerulescens
American crow*	Corvus brachyrhynchos
Common raven*	Corvus corax
Chestnut-backed chickadee	Parus rufescens
Bushtit*	Psaltriparus minimus
Red-breasted Nuthatch	Sitta canadensis
Bewick's wren	Thryomanes bewickii
House wren	Troglodytes aedon
Winter wren	Troglodytes troglodytes
Marsh wren*	Cisthothorus palustris
American dipper	Cinclus mexicanus
Ruby-crowned kinglet	Regulus calendula
Western bluebird*	Sialia mexicana
Swainson's thrush	Catharus ustulatus
Hermit thrush*	Catharus guttatus
American robin*	Turdus migratorius
Varied thrush	Ixoreus naevius
Water pipit*	Anthus spinoletta
Cedar waxwing*	Bombyc ilia cedror urn
Starling*	Sturnus vulgaris
Solitary vireo	Vireo solitarius
Hutton vireo	Vireo huttoni
Warbling vireo	Vireo gilvus
Orange-crowned warbler*	Vermivora celata
Nashville warbler	Vermivora ruficapilla
Yellow warbler	Dendroica petechia
Audubon's warbler	Dendroica coronata

Table 12. Species of birds observed in the Mattole River estuary/lagoon listed by order. Sources: McGeachy 1979 and USDI-BLM 1988 (continued).

Common name	**Scientific name**
Order Passeriformes (continued)	
Townsend's warbler	Dendroica townsendi
MacGillivray's warbler	Oporornis tolmiei
Common yellowthroat	Geothlypis trichas
Wilson' s warbler	Wilsonia pusilla
Yellow-breasted chat	Icteria virens
Western Tanager*	Piranga ludoviciana
Black-head grosbeak	Pheucticus melanocephalus
Lazuli Bunting	Passerina amoena
Rufous-sided townee*	Pipilo erythrophthalmus
Lark sparrow	Chondestes grammacus
Fox sparrow	Passerella iliaca
Song sparrow*	Melospiza melodia
Lincoln's sparrow	Melospiza lincolnii
Golden-crowned sparrow	Zonotrichia atricapilla
Red-winged blackbird	Agelaius phoeniceus
Dark-eyed junco*	Junco hyemalis
Brown-headed cowbird	Molothrus ater
Northern oriole	Icterus galbula
Purple finch	Carpodacus purpureus
House finch	Carpodacus mexicanus
Pine siskin	Carduelis pinus
Evening grosbeak	Hesperiphona vespertina

*Sighted during 1986-87 study periods.

Table 13. Species of mammals observed in the Mattole River estuary/lagoon and surrounding riparian vegetation May 1984-November 1987. Taxonomic key used: Burt and Grossenheider (1976).

Common name	**Scientific name**	**Terrestrial**	**Riverine**	**Marine**
Opossum	*Didelphis virginiana*	x		
Bat	Unknown, probably *Myotis sp.*	x		
Racoon	*Procyon lotor*	x	x	
Ringtail	*Bassariscus astutus*	x		
River otter	*Lutra canadensis*	x	x	
Striped skunk	*Mephitis mephitis*	x		
Coyote	*Canis latrans*	x		
Grey fox	*Urocyon cinereoargentus*	x		
Bobcat	*Lynx rufus*	x		
Stellar sea lion	*Eumetopias jubatus*			x
Harbor seal	*Phoca vitulina*			x
California ground squirrel	*Spermophilus beecheyi*	x		
White footed mice	*Peromyscus sp.*	x		
Dusky footed woodrat	*Neotoma fuscipes*	x		
Porcupine	*Erethizon dorsatum*	x		
Blacktail jackrabbit	*Lepus californicus*	x		
Brush rabbit	*Sylvilaqus bachmani*	x		
Blacktail deer	*Odocoiles hemionus*	x		

More blacktail deer and porcupine were observed in 1987 than in previous years (G. Peterson, pers. comm.). Both of these species are found in the riparian vegetation near the estuary and Lighthouse Road (Figure 7). Many deer were seen along the north bank of the upper lagoon near the mouth of Collins Gulch. A majority of the deer observed in 1987 were young-of-the-year. Many blacktail jackrabbits were observed on gravel bars in the upper lagoon in 1986 and 1987. Harbor seals and Stellar sea lions were observed in the estuary only when the sand berm was open. Additional information on wildlife in the area can be found in Decker (1983).

DISCUSSION AND MANAGEMENT RECOMMENDATIONS

Wetlands such as the Mattole estuary/lagoon provide fish and wildlife values, environmental quality values, and socio-economic values (Tiner 1984). Fish and wildlife values include habitat for many organisms such as the ones listed in this report. Environmental quality values include water quality maintenance, aquatic productivity, pollution filtration and others (Tiner 1984). Socio-economic values include flood, erosion and wave damage control; education; research; asthetics; fishing, hunting and other forms of recreation.

Despite the many functions and uses of wetlands, great reductions in the amount of these habitats have occurred as a result of human activity. Approximately 54% of the original wetland habitat in the lower 48 states was lost by the mid-1970's (Tiner 1984). Agricultural development is believed to be responsible for 87% of the national loss with urban and other development accounting for the remaining 13%. California has lost over 90% of its wetlands (Tiner 1984).

The Mattole estuary/lagoon represents a unique resource in that it remains relatively unthreatened by agriculture and urban encroachment. The entire drainage is also unique because it contains no major urban centers or developments, such as hydroelectric dams and water diversion projects.

Estuary Management Recommendations

1. Protect the estuary from agricultural use, urban and other development. This may require fencing off the area to exclude stray cattle and maintaining the "conservation area" status of the area.
2. Protect the unique fish and wildlife resources of the estuary. This could be done by implementing a "wildlife refuge" designation for the area with enforcement support.
3. Promote non-degradative recreational uses of the estuary. This includes the continued exclusion of off-highway vehicles which threaten sensitive and endangered plant species and distract from the areas asthetics.
4. Protect, restore and enhance riparian areas surrounding the estuary/lagoon as they provide significant habitat for amphibians, reptiles, fish, birds, and mammals.

Despite the Mattole Rivers' remoteness from major urban centers, the basin is not free from negative human impacts. Poor land management, combined with the basin's unstable geologic formations and high winter runoff have altered the river throughout its entire length (California Department of Water Resources 1973). The disturbed land is susceptible to slumping, erosion, and landslides (Barnhart and Young 1985).

Sediment deposits from upstream sources have created extensive sandbars and caused aggradation of the river channel in the estuary (Barnhart and Young 1985; Young 1987). Historical analysis of aerial photographs revealed that sediment deposition diverted the lower river channel from the southern edge of the valley to its present course along the northern edge. Sediment deposition has caused reductions in depth and habitat available to fish. Temperatures in the estuary have likely increased as a result.

Basin Management Recommendations

1. Identify point and non-point sources of sedimentation and any toxic pollutants.
2. Set basin wide standards or goals for sediment load and work with local residents, agriculture and industry to achieve them within a specified time period.
3. Educate private landowners in techniques that reduce erosion and sediment loading.
4. Increase inspections of near and instream activities on private land and fish and game warden patrols. Prosecute landowners who fail to comply with sedimentation guidelines.
5. Continue efforts to repair and rehabilitate known point sources of sedimentation. This may include pursuing legislation which would provide continued funding for watershed rehabilitation, including economic incentives for private landowners to protect and restore sensitive or damaged riparian zones.

The length of residency in estuaries and the utilization of estuarine food sources have been well documented as important factors in the growth and survival of outmigrating juvenile chinook salmon (Reimers 1973; Reimers 1978; Reimers et al. 1978; Healey 1980; Healey 1982; Kjelson et al. 1982; Meyers and Horton 1982; Simenstad et al. 1982; Nicholas and Hankin 1988; and others). Estuaries provide an environment for productive foraging, physiological transition to oceanic conditions and refuge from predators (Simenstad et al.

1982). Our data and observations suggest that the Mattole River estuary provides only limited benefits because of the seasonal closure of the sand bar and subsequent formation of the lagoon which is essentially fresh water.

The food web in a true estuary (Pritchard 1967) is based on inputs of organic carbon from several ecosystems: marine, estuarine, riverine and terrestrial (Darnel1 1967; Simenstad 1983). Seasonal formation of the lagoon, however, effectively cuts off the input of marine components such as dissolved and particulate organic carbon, algae, detritus, phytoplankton, and micro and macrofauna. The marine influence is important to estuarine systems, especially in areas of coastal upwelling such as the northern California coast.

For this reason, the Mattole lagoon is probably less productive as a summer rearing habitat for juvenile salmonids than true estuaries of northern California and Oregon. Studies on the abundance of benthic and planktonic macrofauna and their importance to the chinook diet may help determine this (Busby in prep.). Investigations of this type should be carried out several years sequentially to determine yearly variation in food availability to juvenile chinook. Studies of primary productivity and the importance of the various carbon inputs would also be of value.

Data from Oregon estuaries indicate that fish growth varies with population abundance, temperature, prey composition and production, and rearing space (Reimers and Concannon 1977; Reimers and Downey 1982). Nicholas and Hankin (1988) believe that the growth rate of juvenile salmon in estuaries is directly influenced by their abundance in the system, probably through competition for food. Reimers and Concannon (1977) and Reimers and Downey (1982), suggest that growth to at least 120 mm is required for good marine survival. Chinook in the Mattole attained similar lengths at ocean entry in 1984 only (Table 9).

Growth and survival of juvenile chinook in the Mattole estuary/lagoon are variable and influenced by a complex array of interacting physical and biological factors which are not yet completely understood. These factors include success of adult spawning, abundance of downstream migrants, river flow, temperature, timing of downstream migration, timing of lagoon formation, area and depth of the lagoon, predation, availability of submerged and riparian cover, amount and frequency of seawater overwash, food abundance and availability, intra and interspecific competition, and timing of lagoon breaching.

Reimers (1973) concluded that a survival advantage was gained by individuals that reared three months (June-August) in the Sixes River estuary over those fish which outmigrated directly. He suggested that these fish grew to larger size and were probably more fit for ocean life. He also indicated that these fish composed about 90% of the returning adults. In the Mattole estuary/lagoon this does not seem to be the case. Preliminary inspection of adult scales suggests that the majority of returning adults outmigrated as juveniles before closure of the sandbar and did not reside in the lagoon (Hinkson 1987 unpubl.). Additional research is necessary to further substantiate this. It should be noted, however, that in the systems studied in Oregon, chinook had the option to outmigrate if temperature, food availability, or predation pressure became intolerable. This may account for the observed declines in abundance noted after population peaks (Reimers 1973; Nicholas and Hankin 1988).

Predation of juvenile salmonids by birds, fish and mammals has been observed in the Mattole estuary/lagoon; it may be significant. Recent studies on eastern Vancouver Island, B.C. suggest that common mergansers consumed 24-65% of the wild coho production in two coastal streams (Wood I987b). In these studies mergansers, while in fresh water, ate salmonids almost exclusively (Wood 1987a). Mattole merganser broods were observed several times feeding on salmonids in the upper lagoon in 1986 and 1987. Large numbers of other piscivorous birds were observed (Table 12). Stomach analysis of adult steelhead trapped in the lagoon as a result of early closure in 1987 revealed juvenile steelhead in their diet.

Chinook salmon populations in the Mattole watershed represent a unique genetic resource. No state or federal hatcheries are present in the basin, and chinook salmon from other drainages have never been introduced. A few coho salmon have been introduced from the Eel and Noyo rivers by the MWSSG. Except for a small-scale native chinook and coho hatchbox program operated by the MWSSG, the salmonid populations of the Mattole River are self-sustaining despite the severe impacts they have experienced.

Formation of the lagoon may limit the potential for enhancing chinook salmon in the Mattole drainage. Berm closure may represent a bottleneck for the number of juveniles the system can produce, especially in years of good smolt production such as 1985 and 1987 when large numbers of chinook were trapped in the lagoon and experienced high mortality.

Immediate downstream migration and early ocean entry may be adaptive behavior of Mattole chinook. Lagoon formation in this sense may be considered part of the natural selection process. There are management possibilities which would either allow more opportunity for salmonids to outmigrate or increase the rearing capability of the lagoon. These suggestions are listed below.

Salmonid Management Suggestions

1. Estimate chinook and steelhead abundance in early May during low flow years. If populations exceed 25,000 and the berm appears to be closing, consider opening it periodically by artificial means until approximately June 15 to allow outmigration.
2. Continue watershed rehabilitation and enhancement programs.
3. Continue native chinook and coho hatchbox programs. Release fish from hatchbox facilities early or further downriver, possibly in the estuary, to allow a greater opportunity for outmigration before closure of the berm. This would help to minimize competition with wild fish.
4. As an adjunct or alternative to Salmonid Management Suggestion #4 above, hold and rear hatchbox-produced chinook in off-stream ponds or rearing units through the summer and release as large smolts in the fall after the river mouth opens. This would minimize competition with naturally spawned chinook also.
5. Place permanent structures such as logs and boulders in the lagoon which will serve as traps for organic carbon and provide feeding and refuge areas for juvenile salmonids.
6. Explore feasibility of adding fish food to the lagoon during periods of peak salmonid abundance, basically using the lagoon as a managed rearing pond.
7. Explore the feasibility of direct ocean release of Mattole imprinted salmonids.

RESEARCH NEEDS

The following is a summary of what we believe are important research needs in the Mattole estuary/lagoon:

1. Physical-Chemical-Geological
    a. Continued monitoring of night water quality; especially dissolved oxygen concentrations which have been shown to decrease near the bottom in late summer/early fall,
    b. Monitoring of water quality while sand berm is open (estuary phase). Little is known about water quality conditions in the estuary,
    c. Detailed study of sediment particle size distribution in the estuary/lagoon. Rates of sediment accumulation and scouring.
2. Biological-General
    a. Determine the effects of reduced dissolved oxygen concentrations on populations of benthic organisms and community structure,
    b. Determine annual primary and secondary productivity. Compare to other estuaries,
    c. Quantify energy transfers between trophic levels 1°, 2°, 3°. Quantify the amount of energy available from the various inputs of detrital organic carbon,
    d. Determine the population, age structure, and growth of three-spine stickleback and assess their role in the estuarine/1agoonal food web.
3. Biological-Salmonids
    a. A more detailed analysis of returning adult chinook salmon scales is required for age and growth determinations. It is also needed to determine if the majority of returning adult spawners are direct outmigrants as juveniles and spend little or no time residing in the estuary as was suggested by Hinkson (1987 unpubl.). Tetracycline marking of hatchbox produced fish and/or trapped downstream migrants may be of great value if scales and otoliths of marked returning adults could be recovered.

b. Increase efforts to accurately determine spawning run sizes of chinook, coho and steelhead in the drainage. This may be done by a combination of extensive weir trapping and carcass counting,

c. Determine the effects of flow and temperature on downstream migration timing (chinook salmon and steelhead),

d. Determine the temperature tolerances of Mattole River juvenile chinook under various dissolved oxygen and salinity regimes,

e. Determine the population age structure and growth of juvenile steelhead in the estuary/lagoon,

f. Acquire additional years of quantitative benthic and planktonic macrofaunal data to assess annual variations in secondary production and availability for salmonids,

g. Determine the extent of competition for food and habitat resources between chinook salmon and steelhead,

h. Determine the extent of competition between juvenile chinook and stickleback,

i. Determine the presence or absence of summer run steelhead in the Mattole drainage. This could be accomplished with a combination of snorkel surveys in the upper drainage and electrophoretic studies,

j. Quantify predation of salmonids by birds, especially the common merganser (Mergus merganser).

k. Determine the effects of angling on populations of two year old plus steelhead in the lagoon.

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APPENDIX

Table 1. Salinity profiles (ppt) recorded at 4 water quality stations Mattole River Lagoon May 26, 1987 - November 13, 1987.

Date	Depth (m)	Station 1	Station 2	Station 3	Station 4
05/26	0.0	-	0.1	_	0.1
	0.5	-	0.1	-	0.1
	1.0	_	0.1	-	0.1
	1.5	-	0.1	-	0.1
	2.0	_	0.1	-	0.1
	2.5	_	_	_	0.1
	3.0	-	-	-	3.1
	3.5	-	-	-	4.2
	4.0	-	-	-	4.2
06/05	0.0	0.1	0.1	0.1	0.1
	0.5	0.1	0.1	0.1	0.1
	1.0	0.1	0.1	0.1	0.1
	1.5	-	0.1	0.1	0.1
	2.0	_	0.1	0.1	0.1
	2.5	-	-	-	0.1
	3.0	-	-	-	0.1
06/18	0.0	0.1	0.1	0.1	0.1
	0.5	0.1	0.1	0.1	0.1
	1.0	0.1	0.1	0.1	0.1
	1.5	-	0.1	0.1	0.1
	2.0	-	-	-	0.1
	2.5	-	-	-	0.1
06/29	0.0	0.1	0.1	0.1	0.1
	0.5	0.1	0.1	0.1	0.1
	1.0	-	0.1	0.1	0.1
	1.5	_	0.1	0.1	0.1
	2.0	-	-	-	0.1
	2.5	-	-	-	0.1
07/29	0.0	0.1	0.1	0.1	0.1
	0.5	-	0.1	0.1	0.1
	1.0	-	0.1	0.1	0.1
	1.5	-	0.1	0.1	0.1
	2.0	-	-	0.1	0.1
	2.25	-	-	-	0.1
08/12	0.0	_	0.1	0.1	0.1
	0.5	_	0.1	0.1	0.1
	1.0	-	0.1	0.1	0.1
	1.5	-	0.1	0.1	0.1
	2.0	-	-	0.1	0.1
	2.5	-	-	-	0.5
	3.0	-	-	-	1.0

Table 1. Salinity profiles (ppt) recorded at 4 water quality stations Mattole River Lagoon May 26, 1987 - November 13, 1987 (continued)

Date	Depth (m)	Station 1	Station 2	Station 3	Station 4
08/29	0.0	-	0.1	0.1	0.1
	0.5	_	0.1	0.1	0.1
	1.0	_	0.1	0.1	0.1
	1.5	-	-	0.1	0.1
	2.0	-	-	-	0.1
09/09	0.0	_	0.1	0.1	0.1
	0.5	-	0.1	0.1	0.1
	1.0	_	0.1	0.1	0.1
	1.5	-	0..1	0.1	0.1
	2.0	-	-	-	0.1
10/03	0.0	_	0.1	0.1	0.1
	0.5	_	0.1	0.1	0.1
	1.0	-	0.1	0.1	0.1
	1.5	-	-	0.1	0.1
	2.0	-	-	-	0.1
10/07	0.0	_	0.0	0.5	0.5
	0.5	-	8.0	8.5	7.0
	1.0	-	16.0	15.0	13.2
	1.5	_	16.0	17.3	17.0
	2.0	_	-	17.5	17.8
	2.5	-	-	-	17.5
10/08	0.0	_	0.1	_	0.5
	0.5	-	0.1	-	4.8
	1.0	_	9.8	-	10.5
	1.5	_	14.0	-	18.2
	2.0	-	-	-	19.8
	2.5	-	-	-	20.5
11/01	0.0	0.1	0.1	0.2	0.5
	0.5	0.1	0.1	0.2	0.5
	1.0	_	0.1	0.2	1.5
	1.5	-	0.1	12.0	11.5
	2.0	-	-	12.0	14.2
	2.5	-	-	-	14.5
11/13	0.0	0.1	0.1	0.5	0.5
	0.5	0.1	0.1	0.5	0.5
	1.0	0.1	1.0	0.5	0.5
	1.5	0.5	6.0	0.5	1.0
	2.0	-	-	-	2.5
	2.5	-	-	-	13.0
	3.0	-	-	-	13.8

Table 2. Daily maximum surface temperatures (°C) measured by thermograph of the upper and lower Mattole River Lagoon July 7, 1987 to September 30, 1987.

Date	Upper	Lower
07/07	23	20
07/08	23	19
07/09	23	19
07/10	23	20
07/11	23	21
07/12	22	20
07/13	22	20
07/14	22	20
07/15	23	20
07/16	21	18
07/17	19	17
07/18	21	18
07/19	22	20
07/20	21	20
07/21	20	19
07/22	23	20
07/23	22	20
07/24	22	19
07/25	22	21
07/26	23	21
07/27	22	20
07/28	22	21
07/29	22	20
07/30	22	20
07/31	23	20
08/01	22	21
08/02	22	29
08/03	21	19
08/04	21	19
08/05	23	19
08/06	23	19
08/07	20	19
08/08	23	20
08/09	20	19
08/10	21	18
08/11	22	19
08/12	19	18
08/13	22	18
08/14	22	20
08/15	22	19
08/16	21	19
08/17	22	19
08/18	23	20
08/19	20	19
08/20	20	18
08/21	22	19
08/22	22	19
08/23	20	19
08/24	21	18
08/25	21	19
08/26	21	19
08/27	20	18
08/28	21	19
08/29	21	20
08/30	21	20
08/31	21	20
09/01	19	19
09/02	21	18
09/03	20	18
09/04	19	17
09/05	21	19
09/06	19	18
09/07	19	18
09/08	20	18
09/09	20	18
09/10	20	19
09/11	20	18
09/12	19	18
09/13	20	18
09/14	21	18
09/15	20	18
09/16	19	17
09/17	20	17
09/18	18	17
09/19	18	16
09/20	17	16
09/21	19	16
09/22	19	16
09/23	16	16
09/24	18	17
09/25	18	17
09/26	19	17
09/27	19	16
09/28	19	16
09/29	19	17
09/30	18	17

Table 3. Water temperature profiles (°C) at four water quality stations, Mattole River Lagoon May 26, 1987 - November 13, 1987.

Date	Depth (m)	Station 1	Station 2	Station 3	Station 4
05/26	0.0	-	17.8	_	16.2
	0.5	-	17.5	-	16.2
	1.0	-	17.5	-	16.0
	1.5	-	17.5	-	16.0
	2.0	-	17.5	-	15.9
	2.5	-	-	-	15.9
	3.0	-	-	-	15.9
	3.5	-	-	-	15.9
	4.0	-	-	-	16.1
06/05	0.0	21.5	21.0	19.2	20.0
	0.5	21.5	21.0	19.2	20.0
	1.0	21.5	20.0	18.2	20.0
	1.5	-	20.5	16.0	19.8
	2.0	-	21.0	16.0	19.8
	3.0	-	-	-	19.8
06/18	0.0	19.0	20.0	19.0	19.0
	0.5	19.5	20.0	19.5	19.8
	1.0	20.0	20.0	19.5	20.0
	1.5	-	20.0	19.5	20.0
	2.0	-	-	-	20.0
	2.5	-	-	-	20.0
06/29	0.0	20.0	19.6	18.1	18.2
	0.5	19.9	19.1	17.9	17.9
	1.0	-	19.0	17.9	17.9
	1.5	-	18.9	17.9	-
	2.0	_	_	_	17.8
	2.5	-	-	-	17.8
07/29	0.0	_	21.0	18.0	19.5
	0.5	-	20.0	18.2	19.0
	1.0	_	20.0	18.2	19.0
	1.5	-	20.0	18.2	19.0
	2.0	-	-	18.2	19.0
	2.25	-	-	-	19.0
08/12	0.0	_	18.0	17.0	17.5
	0.5	-	18.0	17.0	17.5
	1.0	_	18.0	17.0	17.5
	1.5	-	18.0	17.0	17.5
	2.0	_	-	17.0	17.5
	2.5	_	_	-	17.5
	3.0	-	-	-	18.0

Table 3. Water temperature profiles (°C) at four water quality stations, Mattole River Lagoon May 26, 1987 - November 13, 1987 (continued).

Date	Depth (m)	Station 1	Station 2	Station 3	Station 4
08/28	0.0	-	20.0	17.0	17.0
	0.5	-	20.0	17.0	16.8
	1.0	-	20.0	17.0	16.8
	1.5	-	-	17.0	16.8
	2.0	-	-	-	16.5
09/09 (night)	0.0	_	16.5	18.0	18.0
	0.5	-	16.5	18.5	18.0
	1.0	-	16.9	18.8	18.0
	1.5	-	16.9	18.8	18.2
	2.0	-	-	-	18.0
09/09 (day)	0.0	_	19.0	17.8	18.0
	0.5	-	19.0	17.8	18.0
	1.0	_	19.0	17.8	18.0
	1.5	-	19.0	17.5	18.0
	2.0	-	-	-	17.5
10/03	0.0	_	20.0	17.9	17.5
	0.5	-	20.0	18.0	17.2
	1.0	_	20.0	18.0	17.2
	1.5	_	-	18.0	17.0
	2.0	-	-	-	17.0
10/07 (night)	0.0	_	17.5*	17.5*	17.8*
	0.5	-	19.0	18.0	18.0
	1.0	-	17.5	17.0	17.0
	1.5	-	16.5	15.5	16.0
	2.0	-	-	15.0	15.2
10/08 (day)	0.0	_	17.2	_	17.2*
	0.5	-	17.2	-	18.0
	1.0	-	18.5	-	18.0
	1.5	-	18.5	-	16.0
	2.0	-	_	-	15.5
	2.5	-	-	-	15.2
11/01	0.0	15.2	15.8	15.2	15.5
	0.5	15.5	15.8	15.2	15.8
	1.0	_	16.0	15.2	15.8
	1.5	-	16.0	15.2	15.8
	2.0	_	-	15.2	15.0
	2.5	-	-	-	14.8
11/13	0.0	14.9	14.8	14.8	14.8
	0.5	14.9	14.8	15.0	14.8
	1.0	14.9	14.8	15.0	14.8
	1.5	15.0	14.8	15.0	14.8
	2.0	-	14.8	15.0	14.8
	2.5	-	-	-	14.8
	3.0	-	-	-	14.8

*Distinct thermocline.

Table 4. Dissolved oxygen profiles (ppm) at four water quality stations, Mattole River Lagoon May 26, 1987 - November 13, 1987.

Date	Depth (m)	Station 1	Station 2	Station 3	Station 4
05/26	0.0	-	9.0	-	10.0
	0.5	_	9.0	-	10.0
	1.0	_	9.5	_	10.0
	1.5	-	10.0	_	10.0
	2.0	-	10.0	-	10.0
	2.5	-	-	-	9.9
	3.0	-	-	-	10.0
	3.5	_	-	-	10.1
	4.0	-	-	-	10.0
06/05	0.0	9.4	9.8	8.6	8.0
	0.5	9.6	9.8	8.6	8.0
	1.0	9.6	10.0	8.6	7.9
	1.5	_	10.0	9.1	7.8
	2.0	-	10.0	9.0	7.8
	2.5	_	_	-	7.8
	3.0	-	-	-	7.8
06/18	0.0	8.4	9.0	8.0	8.3
	0.5	8.6	8.8	7.9	8.2
	1.0	8.6	8.8	7.9	8.2
	1.5	-	8.4	7.9	8.1
	2.0	-	-	-	8.0
	2.5	-	-	-	8.0
06/29	0.0	8.9	9.4	8.0	8.0
	0.5	8.8	9.2	8.0	8.0
	1.0	-	9.2	7.9	-
	1.5	-	9.0	8.0	7.9
	2.0	-	-	-	7.9
	2.5	-	-	-	1. 9
07/29	0.0	_	9.0	10.0	8.1
	0.5	-	9.0	10.0	8.0
	1.0	_	8.9	10.0	7.6
	1.5	-	8.9	10.0	7.7
	2.0	-	-	11.0	7.9
	2.25	-	-	-	7.9
08/12	0.0	_	9.4	8.1	8.1
	0.5	-	9.4	8.0	8.0
	1.0	-	8.3	8.0	8.0
	1.5	-	8.3	8.0	7.8
	2.0	-	-	8.0	7.8
	2.5	_	-	-	8.2
	3.0	.	-	-	7.8

Table 4. Dissolved oxygen profiles (ppm) at four water quality stations, Mattole River Lagoon May 26, 1987 - November 13, 1987 (continued).

Date	Depth (m)	Station 1	Station 2	Station 3	Station 4
08/28	0.0		10.8	8.8	8.5
	0.5	-	10.8	8.7	8.5
	1.0	_	10.7	8.6	8.4
	1.5	-	-	8.5	8.4
	2.0	-	-	-	8.4
09/09 (night)	0.0	_	7.0	10.8	11.0
	0.5	-	7.0	10.8	11.0
	1.0	-	7.0	10.8	11.0
	1.5	_	2.8	7.4	11.0
	2.0	-	-	-	8.0
09/09	0.0	_	10.7	9.0	9.0
	0.5	-	10.7	9.0	8.9
	1.0	_	10.7	9.2	8.9
	1.5	-	10.7	9.4	8.9
	2.0	-	-	-	10.5
10/03	0.0	_	10.6	10.8	10.2
	0.5	-	10.6	10.8	10.2
	1.0	_	10.5	10.8	10.2
	1.5	-	-	10.7	10.2
	2.0	'	-	10.7	10.2
10/07 (night)	0.0	_	6.2	9.4	9.8
	0.5	_	7.8	8.6	9.6
	1.0	-	8.2	9.1	10.4
	1.5	_	6.1	8.1	9.2
	2.0	-	-	5.2	8.4
	2.5	-	-	-	8.2
11/01	0.0	14.5	10.8	10.6	9.8
	0.5	14.5	11.3	10.6	9.8
	1.0	-	11.3	10.6	9.6
	1.5	_	11.4	10.2	9.5
	2.0	-	-	11.8	9.2
	2.5	-	-	-	9.0
11/13	0.0	10.0	8.4	9.3	9.8
	0.5	9.9	8.3	9.2	9.8
	1.0	9.7	8.2	8.2	9.8
	1.5	9.6	8.0	8.2	9.6
	2.0	-	4.7	8.2	8.8
	2.5	_	-	-	8.0
	3.0	-	-	-	5.2

Table 5. Surface turbidity values (NTU) at four water quality stations, Mattole River Lagoon May 26, 1987 - November 13, 1987.

Date	Station 1	Station 2	Station 3	Station 4
05/26	-	0.41	-	0.45
06/05	0.52	0.43	0.43	0.45
06/18	0.45	0.55	0.55	0.60
06/29	0.55	0.50	0.50	0.65
07/29	-	0.49	0.45	0.62
08/12	-	0.47	0.55	2.00
08/28	-	0.30	0.45	0.35
09/09	-	0.70	0.50	0.60
10/03	-	0.37	0.58	0.62
11/04	0.25	0.52	0.58	0.65