Observations of Steelhead trout *(Oncorhynchus mykiss),* Coho Salmon *(O. kisutch)* and Water Quality of the Navarro River Estuary/Lagoon May 1996 to December 1997.

Draft Report

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INTRODUCTION

This report presents the results from field investigations into fishery resources and environmental factors that act upon the Navarro River estuarine ecosystem. The study was conducted to provide information describing estuarine utilization by juvenile steelhead trout *(Oncorhynchus mykiss)* and coho salmon *(O. kisutch)* to the Navarro Watershed Restoration Plan. One of the goals of the Navarro River Watershed Restoration Plan is to identify habitat restoration projects that will restore or increase production of anadromous salmonid populations in the basin. A final objective for this study was to identify areas for habitat improvements which will benefit the estuarine ecosystem and salmonid production. In order to protect and restore salmonid populations and their habitat, detailed knowledge of their life history strategies and habitat conditions is required (EPA 1996). This means we need knowledge of how individual watersheds or portions of watersheds function as habitat and how fish populations interact with their environment. A study of the estuary was needed because the role of the Navarro River estuary/lagoon as fisheries habitat was poorly understood. The data collected for this study provides information to develop recommendations for fisheries and habitat management strategies and to help assess effects of restoration or enhancement activities. These data are made even more important because of the decision to list coho salmon under the federal endangered species act and growing concerns over declining steelhead populations. Additionally, adaptations to local environments such as estuaries are recognized as an "evolutionary legacy" to describe uniqueness of a population (McEwan 1996).

Estuaries are important nursery habitat for juvenile salmonids and other juvenile fish species (Busby and Barnhart 1995; Coots 1973; Day et al. 1989; De Ben et al. 1990; Hassler 1987; Healy 1982; Hofstra 1983; Johnson et al. 1986; McEwan and Jackson 1996; McMahon and Holtby 1992; Naiman and Sibert 1979; Puckett 1976; Reimers 1973; Simenstad 1983; Simenstad and Wissmar 1983; Smith 1990; Yoklavich et al. 1991; Zedonis 1993). Estuaries make good nurseries because they are high in habitat diversity, produce large quantities of low trophic level food, and offer a relatively sheltered environment from predators. Within these dynamic, and highly productive ecosystems, juvenile coho salmon and steelhead trout feed and grow while undergoing physiological and behavioral changes associated with smolt transformation. The additional growth added by juvenile anadromous salmonids while rearing in estuaries can increase their survival rates upon ocean entry, especially during years with poor ocean conditions (Holtby et al. 1990; Macdonald et al. 1988; Nicholas and Hankin 1989; Reimers 1973). Furthermore, there are indications that juvenile salmonids deprived of an estuarine residence may suffer from higher degrees of stress physiologically adapting to sudden exposure salt water than those encountering a gradual transition into salt water (Macdonald et al. 1988).

In California, juvenile steelhead have been observed residing in estuaries or lagoons of the Garcia, Mattole, and Eel Rivers and San Gregorio, Waddell, Pescadero, and Redwood Creeks (Cannata in prep; Coots 1973 Hofstra 1983; Higgins 1995; Puckett 1976; Smith 1990; Taylor 1990; and Zedonis 1993). Although, the role of California's estuaries as habitat for steelhead is not fully understood and even less is known about the importance of estuaries for coho salmon. Coho smolt migration through estuaries has been observed at a slower rate than riverine migrations, suggesting that a period of estuarine residence may be necessary for them to adjust their osmoregulatory capability, orient for their return migration, feed, or reduce there vulnerability to predators (Moser et al. 1991). Estuaries also may provide habitat for juvenile coho during the winter and spring seasons. As adults, anadromous salmonids pass through estuaries during upstream spawning migrations, and may use the estuaries for staging areas while waiting for river flows to increase before moving to upstream spawning grounds. Although, salmonid estuarine utilization patterns vary among species, populations and between estuaries, they are strategic environments for anadromous salmonids. (Busby and Barnhart 1995; Coots 1973; De Ben et al. 1990; Hassler 1987; Healy 1982; Hofstra 1983; Johnson et al. 1986; McEwan and Jackson 1996; McMahon and Holtby 1992; Naiman and Sibert 1979; Nicholas and Hankin 1989; Puckett 1976; Reimers 1973; Smith 1990; Taylor 1990; and Zedonis 1993).

The objectives for this study were: (1) to determine the role of the Navarro River estuary as habitat for steelhead trout and coho salmon; (2) determine environmental factors influencing fish abundance and distribution; and (3) use the information obtained from the field studies to make recommendations for maintenance of key processes or improving physical conditions in the estuary. We also collected data describing thirty-one non-salmonid fish captured or observed in the estuary. The additional knowledge of the estuarine fishery is essential when interpreting ecological relationships and making management recommendations for the estuary/lagoon (Simenstad 1983).

STUDY AREA DESCRIPTION

The Navarro River estuary is located approximately 115 miles northwest of San Francisco in Mendocino County. The area of the lower three miles of the estuary channel is about 93 acres at the high water mark. About 50 acres of estuarine channel exists below the Hwy 1 Bridge. The State owns 55.5 acres of land along the estuary and because it has been identified as a rare type of ecosystem in California, plans call for the Department of Fish and Game to manage the estuary as an ecological reserve (Parks and Recreation 1991). A map showing the study area and fish sampling sites is presented in Figure 1

The estuary is classified as a drowned river valley which is inundated with marine water except during periods of peak river flows. A lagoon usually develops in summer or fall seasons when formation of a sand bar combined with low river flows close the river mouth. The estuary/lagoon receives freshwater runoff from 303 square miles within Navarro River basin (USGS 1996). The basin terrain includes oak woodlands, grasslands, broad alluvial deposits and coniferous forests. Land use activities in the basin include timber harvests, road construction, agriculture, cattle ranching, and residential development. The majority of precipitation occurs during winter months and large amounts of rain may fall in a short period of time. Winter river flows increase quickly in response to rainstorms and typically reach a 10,000 cubic feet per second (cfs) or higher. The combination of large amounts rainfall in winter on unstable terrain has mobilized soils from hill slopes in much of the watershed. Eroded soils have collected in pool habitats and fine sediments have covered gravels important for fish spawning and invertebrate production in much of the river and tributary channels (Trihey 1997). High water temperature and low summer flows also limit

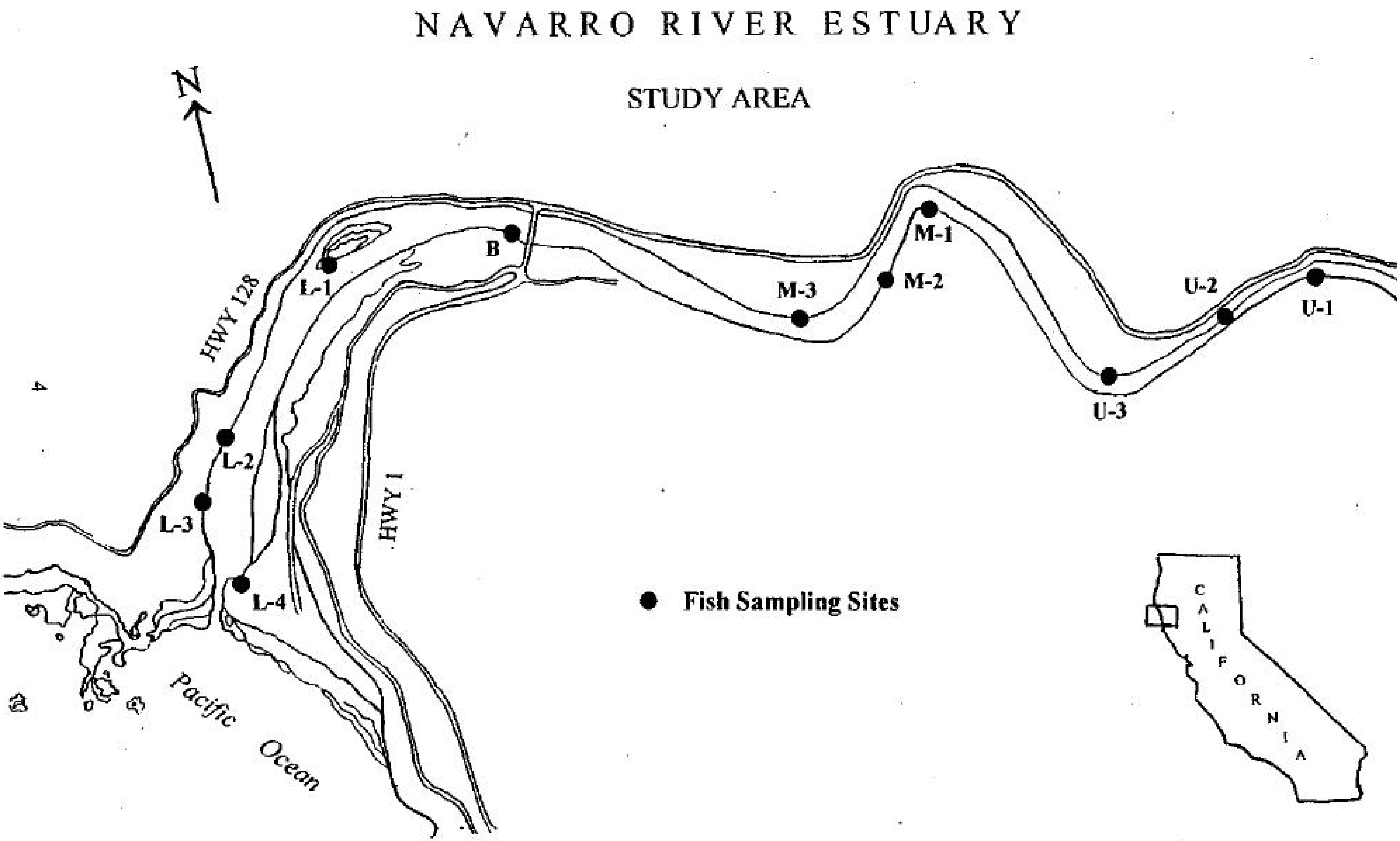

Figure 1.- Navarro River estuary fish and water quality samplng sites.

production of salmonids (especially coho salmon) in portions of the watershed. Documentation of high water temperatures has led to listing the Navarro River as an impaired water body. The decline of juvenile salmonid rearing capacity in the much of the basin increases the importance of the estuary as nursery habitat (McEwan and Jackson 1996) especially for yearling and older steelhead.

Estuaries are semi-enclosed aquatic boundaries between marine and freshwater ecosystems where water masses ($\geq 0.05\ ^{0}/_{00}$) are freely exchanged through tidal and riverine currents (Day 1989; Simenstad 1983). Predominant characteristics of the estuary are the dynamic mixing patterns of freshwater and seawater. The merging of river flows and tidal seawater produces vertical and horizontal salinity gradients that vary from oligosaline fresh, oligosaline marine, highly stratified, linear increases of salinity with depth, and well mixed water masses. The extent of the salinity gradients are influenced by seasonal variation in river discharge, daily tidal cycles, channel morphology, lagoon formation, weather conditions, and by the distance upstream from the river mouth.

Upstream boundaries of estuaries may be determined by two methods: 1) the upstream limit of tidal influence on the river including freshwater tidelands; and 2) the greatest distance upstream where water salinity is ≥0.05 ‰ (Day 1989). In order to estimate the upper boundary of the Navarro river estuary/lagoon we measured salinity and observed how far water backed up in the river as the lagoon formed. On November 3, 1997 saline water (22 ‰) was measured approximately 4.5 miles upstream from the river mouth at the 'Trestle hole". Tidal influence was observed a short distance further upstream to a site know as the "swimming hole". The lagoon influenced the river to a distance of approximately five miles upstream to a site know as the yellow gate. From these observations, the upstream boundary of the estuary may be defined on a seasonal basis to extend 4.5 to 5 miles from the river mouth.

The Navarro River typically forms a lagoon during the summer or fall season due to the building of a sand bar across the river mouth. The sand bar is an extension of the sand spit which borders the southwest edge of the estuary. When the mouth closes, a sharp pycnocline or salinity gradient persists separating the surface layer of freshwater from saline water in mid-water and bottom water. The static, saline water mass absorbs and stores heat from solar radiation which results in a condition known as seasonal meromixis or inverse temperature stratification. Seasonal meromixes was first detected in the upper sampling sites as the mouth was in the process of closing in 1996 and 1997 and was observed at downstream sites after the lagoon formed. Under meromictic conditions, bottom and mid-water temperatures reached as high as 30Cº and dissolved oxygen concentrations approached 0.0 grams per milliliter (g/mm). These environmental factors limit the amount of estuarine habitat available for salmonids and other components of the estuarine ecosystem. Under meromictic conditions, surface waters are much cooler than the underlying saline layer and it contains sufficient DO for fish respiration. Steelhead avoid poor water quality in the lagoon by seeking refuge in the surface and nearshore waters and by moving into areas upstream.

The timing and duration of lagoon formation varied between the two years of this study and could be correlated to river flow regimes. In both years, the mouth closed shortly before minimum river flows occurred. In 1996, the river mouth closed on September 20, and on September 29, the minimum flow of 5.5 cubic feet per second (cfs) was recorded at the U. S. Geological Survey (USGS) stream gauge located in Dimmick State Park (USGS 1997). In 1997, the river mouth closed on September 3, and a minimum flow of 5.0 cfs was recorded on September 6 (USGS 1998). Additionally, the amount of river discharge during the months of June, July, August, and September was quite different between 1996 and 1997 (Table 1).

Table 1. Monthly and total discharge in acre feet (AC-FT) recorded from USGS stream gage at Dimmick Park

Year/Month	June	July	August	September	Total AC-FT
1996	4651	1620	815	503	7589
1997	2220	996	522	411	4149

The lower mile of the estuary/lagoon is composed of a variety of habitats including a sandy beach near the mouth which borders an embayment approximately 600 feet wide. Steep coastal bluffs confine the estuary/lagoon to the north. Sand and mud flats and salt marsh are present along the margin much of the south shore and portions of the north shore. The salt marsh community is composed of salt-tolerant, water loving plants forming moderate to dense cover (Parks and Recreation 1991). It is dominated by pickleweed *(Salicornia virginica)* and salt grass *(Distichlis spicata* var. *stolonifera)* (Parks and Recreation 1991). Rip-rap was placed along a stretch of the north shore on either side of the Hwy 1 Bridge, next to Hwy 128. An island is located a short distance downstream from the Highway 1 Bridge. From inspection of historical photographs, the island has undergone changes in vegetation due to human activity. It was used for growing crops and once supported bridges across the estuary. Today, a dense stand of alders and willows, and fringing salt marsh vegetation cover the island. It appears that some of the area around the eastern tip of the island has eroded. On the eastern tip of the island, a sand flat is exposed during low tide and woody debris accumulate on the shallows. The island is an important component of the estuarine ecosystem because it adds habitat diversity including fringing salt marsh, sand/mud flats, and a relatively deep channel between the north island shore and the mainland. Maximum water depths in the lower mile of the estuary were measured to 10 feet near the Hwy 1 Bridge and depths to 15 feet were measured at the sampling site L-2 located further downstream.

A freshwater marsh is located on the south shore flat and extends on either side of the Hwy 1 bridge. The freshwater marsh vegetation includes a mixture of sedges, rushes, cattails, grasses and other herbaceous components (Parks and Recreation 1991). Two small slough channels in close proximity, are located on the south shore flats and extend into the freshwater marsh. The sloughs are both generally less than 1 meter (m) deep and less than 2 m wide. They become narrow (< 1m) in width a short distance from the main estuary channel. The sloughs pulse with tides and drain completely during low tides in summer months. After the lagoon forms and during high winter runoff, surface water flows through the slough channels into the freshwater marsh and may also exchange water with two ephemeral stream channels which meander through a red alder riparian forest. The alder forest is located a short distance downstream from the Hwy 1 Bridge. The alder forest provides habitat for a variety of birds as does the main estuary channel and riparian corridor. Seeps of freshwater were observed flowing into the riparian forest and freshwater marsh located on the south shore near the Hwy 1 Bridge. It is unlikely that the slough channels offer habitat for salmonids during summer months in their present configuration because of their small size. But when they are inundated by the lagoon or by high winter flows, they may provide fish habitat. In general, sloughs are important components of estuarine ecosystems.

Upstream of the Hwy 1 Bridge, the next two miles of the channel averages about 130 feet in width as it meanders through a narrow canyon. Maximum depths in this area range from less than 1.5 ft. in run type habitat to 18 ft. in the deepest pools. The river banks are generally well vegetated with alder, willow, mixed conifers, and other plant components of a well developed riparian corridor. A private road runs parallel to the estuarine channel on the south side and in places infringes on the riparian corridor. Rip rap has been placed along portions of the north river for bank stabilization next to Hwy 128. In rip rapped areas riparian vegetation is sparse.

A preliminary examination of the Navarro River estuary was conducted in 1892 by the U.S. Engineers office. On September 6, 1892 the following observations were recorded. "On both sides of its mouth are rocky cliffs, 200 to 400 feet in height, and these cliffs extend for several miles inland, where they are generally covered with redwood and pine timber. The narrowest place near the mouth was 30 to 40 feet in width with a maximum depth of 8 feet. On the south side of the mouth is a peninsula of sand 600 or more feet in length, of a width from 100 to 600 ft., and from 2 to 4 feet in height above mean low water level. This is covered with a mass of driftwood, in some places 10 feet in height, piled up by the action of the sea. For a half a mile upstream the low-water banks are 500-600 feet apart. In the waterway, there is a channel 60-100 feet in width and from 5-10 feet in depth. The tidal influence is felt up the river for about four miles above the mouth. The width of the river varies 100 to 600 feet in this distance and ranges from 1-10 feet in depth. The volume of water discharged in summer is insignificant, but in winter, six miles above the mouth, it has been known to rise 30 feet during a freshet. The tidal basin of the river being only four miles in length and averages about 200 feet in width has an area of little less than 100 acres. This would give a calculated tidal flow of about 360 cu. ft. per sec. which agrees with a measurement made on Sept. 6, 1892 when the observed tidal flow was 360 cu. ft. per sec."(Corps of Engineers 1892).

Comparisons between data collected in 1996 and 1997 with the description from 1892 and a series of historical aerial photographs, revealed the lower three miles of the channel has not significantly changed in shape in the last 100 years. However, considerable change has taken place on the flats where a lumber mill and small community was located in the 1870's. This area was once covered by structures, but is presently covered by salt marsh, a riparian forest, and two small slough channels. Channel depths also are similar to the 1892 description except in the region near the mouth where in 1996-97 it is shallower due to sediment deposition. Also, compared to 1892, the channel may have deepened in some areas, including pools we measured above the Hwy 1 Bridge or perhaps the 1892 survey did not observe these deep pools.

Historically, land use along the Navarro River estuary was quite different than we observe today. By the 1870's, a lumber mill was built near the river mouth. After the lumber mill was established, a general store, saloon, blacksmith shop, some residences, two warehouses, a butcher shop, a schoolhouse, and a church followed. All of these structures were built on "Navarro Flat", which was described as a large flat deposit of sand and gravel on the south side of the river mouth. The mill received timber transported by river from inland harvest sites. Four dams were constructed beginning in 1883, one in each of the largest branches, for the purpose of storing sufficient water in dry seasons to drive the logs into the Navarro main channel. A wharf and a railroad were constructed along the north side of the channel which extended into the ocean for loading sailing vessels with milled wood for export to San Francisco. The wharf was thought to help keep the sand bar from forming at the river mouth. Fires destroyed the mill, much of the community and the wharf. After the mill was destroyed by fire in 1890, a new mill was built about one mile further up on the flat. The water supply for the mill was built in 1893. It consisted of a flume 8 inches wide and 6 inches deep. The flume was connected to a 35,000 gallon holding tank situated on a hillside close to the mill. The source of the water supply was described as a living stream, never known to run dry, and it furnished more water than required. In the 1920's a breakwater was built on the north channel to keep the mouth open, but it was soon lost to heavy seas.[1]

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[1] This historical account was synthesized from information collected from visits to the Bancroft Library in Berkeley, libraries in Ukiah and Mendocino, newspaper articles, biographies, and the Mendocino Historical Society.

Today, only remnants of wooden pilings on both sides of the estuary channel and one building (Navarro by the Sea) remain as evidence of the lumber based community located on Navarro Flat. The estuary flat and channel is in a state of recovery from past land use activities but, how it compares to the pre settlement condition requires further study. Today, the flat is mostly covered by salt marsh vegetation and some willows, not gravel and sand as described above. The location the water source described as a "living stream, never known to run dry" may exists on the south side of the estuary within a draw located about 1.5 miles upstream from the Hwy 1 Bridge. We located remnants of the Flume in that area.

METHODS

We sampled fish populations and monitored water temperature, salinity, and dissolved oxygen at eleven to thirteen sites in the lower three miles of the estuary from May 20, 1996 to December 3, 1997. Fish were sampled by beach seine, gill net, and hook and line. Reconnaissance level snorkel surveys provided supplementary data to assess the netting efficiency and gather data from sites we could not sample with nets. Under lagoon conditions, some of the sites became flooded so beach seine samples were not collected. Additionally, during high winter flows, sampling was not possible. We also established transects at the fish sampling sites in order to survey cross sectional profiles of bottom topography, to characterize substrate composition, and to monitor bed load movement.

For purposes of discussion and data analyses, the lower three miles of the estuary was divided into three strata or zones, each about one mile in length: (1) a marine or lower estuary, in free connection with the open sea; (2) a middle estuary, subject to strong salt and fresh water mixing; and (3) an upper fluvial estuary, characterized by fresh water into the summer, but subject to daily tidal action (Fairbridge 1980). Zones were selected based on channel morphology, distance from the sea, and salinity characteristics. Although, the actual limits between these zones are variable, and are subject to seasonal change in the river discharge and daily tidal cycles, the locations of the selected zones or strata and sampling sites remained constant throughout the study.

Two beach seine sites were sampled in both the upper (Ul and U3) and middle estuary zones (Ml and M3), and four beach seine sites were sampled in the lower estuary zone (B, L1, L3, and L4) (Figure 1 .). The beach seine was set by holding one end near shore and the remaining portion was deployed by boat or by hand in a semi circle direction. The area sampled by beach seine was usually approximately 2500 square feet. The dimensions of the beach seine were 100 ft. X 8 ft. with an 8 ft X 8ft. bag. Mesh sizes were 1/2 inch in the seine and 3/8 inch in the bag. One gill net site (U2, M2, and L2) was sampled in each of the three zones. Gill nets were used to sample areas lacking suitable shoreline for beach seining. The gill net was originally 70 ft. x 7 ft. containing four 17.5 ft. panels with alternating mesh sizes: 1 in. and 1.5 in. stretch. In October 1996, twelve feet of 1.5 in. mesh was removed from the gill net. Thirty minute gill nets sets were successful in capturing fish and preventing incidental mortality or injury to most specimens. Sampling with gill nets was halted during May - July, 1997 to avoid capture of juvenile coho salmon and again in November, 1997 to avoid capture of coho adults, although we never captured a coho with the gill net. Two beach seine sampling sites (U2B and L2B) were in added in 1997 to replace gill nets sites during seasonal juvenile coho downstream migrations and adult upstream migrations. We were unable to add a beach seine site in the middle zone because of the lack of suitable area for seining. Figure 1 shows the location of the sampling sites.

Captured fish were identified to species and measured to the nearest millimeter (mm) fork length (FL) or total length (TL) depending on the caudal fin shape. Steelhead and coho were measured by fork length and were weighed to the nearest gram (g) using Pescola spring scales. Scale samples were collected from steelhead for determining age and early life history patterns. Fish scales were examined with a microfiche projector and photo copies were made at 27X for measuring scale radii annular marks, and other points of interest.

Data Analysis

Simple quantitative analysis methods were used to help describe the steelhead population and the Navarro River estuary/lagoon fishery:

Relative abundance or the proportion of a species compared to the total catch was determined by:

$$\frac{\text{number of species captured}}{\text{total number of fish captured}}$$

Catch per unit effort (CPUE) is an average measure of how many fish were captured per each beach seine haul or gill net set.

$$\text{CPUE} = \frac{\text{number of fish captured}}{\text{number of net samples}}$$

Absolute growth rates in terms of length were estimated monthly for yearling and older steelhead by calculating changes in median fork lengths measured at approximately monthly intervals from beach seine samples collected in 1996.

$$\text{Absolute growth rate} = \frac{\Delta L}{\Delta t} = \frac{Lt_2 - Lt_1}{t_2 - t_1}$$

Length-weight relationships also were used to compare seasonal growth rates of steelhead. Ordinary least squares linear regression was used to estimate parameters (slope and Y intercept) for the logarithmic form of the length- weight relationship for yearling and older steelhead captured from the estuary during different time periods. Weights were predicted for specific lengths (125, 150, 175, 200, 225, and 250 mm) from regression equations as a measure of seasonal variation in steelhead condition or rotundness. The general equation and equations used for the time periods were:

general equation	Log_{10} Weight = a + b (Log_{10} Length)
July 23 to Sept. 4, 1996	Log Weight = - 4.67 + 2.88 (Log Length)
Oct. 16 to Nov. 25, 1996	Log Weight = - 4. 11+ 2.64 (Log Length)
Feb. 15 to Mar. 26, 1997	Log Weight = - 4.74 + 2.89 (Log Length)
Apr. 23 to May 21, 1997	Log Weight = -5.10 + 3.07 (Log Length)
July 23 to Sep. 4, 1997	Log Weight = -4.71 + 2.89 (Log Length)
Oct. 16 to Nov. 25, 1997	Log weight = -4.55 + 2.81 (Log Length)

Steelhead length-weight data for regression analysis were pooled from hook and line and beach seine samples to increase the sample size for the period Feb. 15 to Mar. 26, 1997. All other length-weight data for regression analysis were only from beach seine samples.

Steelhead Population Estimate

The size of the steelhead population residing in the estuary/lagoon study area was estimated by a mark and recapture experiment after the sand bar closed the river mouth on September 3, 1997. Population estimates were made for two size groups < 150 mm fork length (FL) (mean FL = 119 mm) and ≥150 mm FL (mean FL = 177 mm). For the most part, the two groups represent age 1+ and 2+ steelhead respectively. On September 15 and 16, steelhead were captured by beach seine from upper, middle, and lower sampling sites, and marked by clipping a small portion from the lobe of the caudal fin. Steelhead captured from below the Hwy 1 Bridge were marked with lower lobe caudal clips and steelhead captured from above the bridge were marked with upper lobe caudal clips. After each seine and marking, steelhead were allowed to recover in buckets, then carefully released. A total of Eighthundred-one fish was marked. The marked fish were allowed to randomly disperse upon release and through September 17. On September 18 and 19, seining was resumed to recapture marked fish. Eighty-eight marked fish were recaptured along with 734 unmarked steelhead. We recovered lower caudal clips from the upper sites and upper caudal clips from the lower sites, indicating mixing of marked fish with the unmarked population was occurring.

Steelhead populations estimates were calculated by using the Adjusted Petersen estimator for recapture with replacement (Hankin 1987). Equations use to calculate the estimated population size (N), variance (V), and the 95% confidence interval (CI) were:

$$N = \frac{M(C+1)}{R+1} \; ; \qquad V(N)= \frac{M^2(C+1)(C-R)}{(R+1)^2\,(R+2)} \; ; \quad \text{and} \qquad CI = N \pm 1.96\sqrt{V(N)}$$

where M is the number of marked fish, C is the number of fish in the sample, and R is the number of marked fish recaptured in the sample. It is critical that the following assumptions are met for valid application of the Petersen estimator:

1. There is no differential mortality or emigration between marked and unmarked fish
2. No marks are lost or not observed at recapture.
3. Capture probability is the same for marked and unmarked fish during recapture.
4. Marked fish must be randomly mixed with the total population during recapture.
5. There must be no recruitment of unmarked fish over the course of the experiment.

Coho salmon captured by the Department of Fish and Game with a downstream migrant trap from the North Fork Navarro River and coho captured by beach seine from the Navarro estuary were compared using the Fulton condition factor (K). and a T-test for unequal variances (American Fisheries Society 1983; Sokal and Rolf 1981). Both groups were captured in May 1998.

Fulton-type condition factors are of the form: $K = \frac{W}{L^3} X$

Where K = condition factor W = weight, L = length, and X= an arbitrary scaling factor. A T-test was used to test for statistically significant differences between the mean K calculated for the two groups.

Water Quality

Vertical profiles of temperature, salinity, and conductivity were collected using a YSI Model 33 Temperature, Salinity, and Conductivity Meter. Measurements were taken at the surface, proceeding to the bottom at 0.5 meter intervals at each fish sampling site immediately before deploying the beach seine. Water quality was collected at the deepest location within the perimeter of the beach seine, which was not always the deepest point of the channel. At the gill net sites, water quality measurements were collected immediately after deploying the net and again just before retrieval to measure changes associated with tidal water movements. Starting May 20, 1996, we used a YSI meter with a cable length of 10 ft. Then in October, 1996, we used a YSI meter loaned to the project by the Department of Fish and Game with 50 foot long cable length that enabled water quality measurements to greater depths than previously obtainable. Dissolved oxygen was measured with CHEMets self-filling ampoules for colormetric analysis. Dissolved oxygen profiles were collected periodically, but most often under lagoon conditions. Hobo temperature recorders were installed at two locations in 1996. One was installed about 1/4 mile above the river mouth and the other was located under the Hwy 1 Bridge. In 1997, only one Hobo unit was installed about 1/4 mile from the mouth. Hobo temperature recorders were provided by the Mendocino Water Agency.

Channel Cross-Sections

Transects were established at fish sampling sites to survey cross sectional profiles of channel morphology, to characterize substrate composition, and to monitor bed load-transport. The surveys were conducted by Mendocino County Water Agency staff and the Navarro River estuary study crew. The surveys were performed with a Leitz B2C Automatic Level with a 32x telescope and using a 25-foot stadia rod. Approximately 90% of the time, a hand level was used with the stadia rod to keep the rod vertical. Horizontal distance was measured using a surveyor's tape and in 1997, stadia distances were calculated as a double check on the tape distances. The stadia distances showed the tape distance to be generally within about one foot of true distance, although some instances of two or three foot discrepancies occurred. The discrepancies are due to tape slack and the stadia rod not being held level because of winds and strong currents encountered in 1996. The vertical control is about 0.2 feet.

The surveys were conducted by tying off a guide rope at, or very near, the cross section end point. This rope was used to keep the boat on the cross section line along the transect. The boat was manually pulled along the guide rope, stopped (at generally pre-determined intervals) and the stadia rod set out at the edge of the boat for the shot. In most cases, the stadia rod shots were done from a single station set up.

RESULTS AND DISCUSSION

A total of 367 beach seine samples yielded 7,953 fully recruited individual fish and 111 gill net samples yielded 594 fish (Tables A14 to A26, Appendix). A total of thirty-four fish species from seventeen families was identified from the net samples and direct observation (Table 2). Young-of-the-year (YOY) or juvenile stages for 27 fish species were observed which verifies the use of the estuary as nursery habitat for a wide variety of fish species. Adults from five species with distinct reproductive strategies were captured in reproductive condition including top smelt *(Atherinops affinis),* Pacific herring *(Clupea harengus),* shiner surfperch *(Cymatogaster aggregata),* bay pipefish *(Syngathus leptorhynchus),* and three spine stickleback *(Gasterosteus aculeatus).* No adult sea run steelhead or coho were captured by beach seine or gill net which shows the sampling gear was selective for small fish. The overall catch by gill net was different from beach seines in the ranking by abundance and components of the catch. The difference could be attributed to selectivity and limitations of the each net type and by differences in habitat type sampled.

Beach Seine Catch

The beach seine catch was numerically dominated by juvenile steelhead, accounting for 44% of the total catch in 1996 and 31% in 1997. These are relatively high percentages considering the numbers of species present and the total number of fish captured by beach seine. Other fish commonly captured were: top smelt, surf smelt (Hypomesus pretiosus), bay pipefish, staghorn sculpin (Leptocottus armatus), English sole (Pleuronichthys vetulus), prickley sculpin (Cottus asper), threespine stickleback, Starry flounder (Platyichthys stellatus), Pacific herring, California roach (Hesperoleucus symmetricus), and shiner surfperch. Tables 3 and 4 show the total number, relative abundance, and catch per unit effort for all species (fully recruited) captured by a total 173 beach seine samples for the first year of study May 20, 1996 to May 7, 1997 and a total of 194 beach seine samples collected from May 21 to December 3, 1997. The diversity of fish species captured from the estuary generally declined with increasing distance from the mouth and also declined in the winter months. The high species diversity found in the lower zone is due to the presence of marine species carried by ocean tides or they actively seek the estuary from the nearshore marine environment for feeding, rearing or spawning purposes. Few of these marine or

Table 2. Common name, scientific name, and age class of species captured or observed from the Navarro River estuary May 20, 1996 to December 3, 1997.

Common Name	Scientific Name	Age Class Present YOY	Juvenile	Adult
Anadromous				
Coho salmon	*Oncorhynchus kisutch*		X	
Steelhead trout	*Oncorhynchus mykiss*	X	X	
Chum salmon (1)	*Oncorhynchus keta*			X
Pacific lamprey	*Lampetra tridentata*		X	X
Freshwater				
California roach	*Hesperoleucus symmetricus*	X	X	X
Coastrange sculpin	*Cottus aluticus*			X
Prickly sculpin	*Cottus asper*	X	X	X
Threespine stickleback	*Gasterosteus aculeatus*	X	X	X
Marine or Estuarine dependant				
Surf smelt	*Hypomesus pretiosus*	X	X	X
Night smelt	*Spirinchus starksi*			X
Staghorn sculpin	*Leptocottus armatus*	X	X	X
Tidepool sculpin	*Oligocottus maculosus*	X	X	X
Silverspotted sculpin	*Blepsias cirrhosus*			X
Top smelt	*Atherinops affmis*	X	X	X
Jack smelt	*Atherinops californiensis*			X
Starry flounder	*Platicthys stellatus*	X	X	?
Speckled sanddab	*Citharicthys sordidus*	. X		
English sole	*Pleuronichthys vetulus*	X		
Pacific sanddab	*Citharichthys stigmaeus*	X		
Pacific herring	*Clupea harengus*	X	X	X
Pacific sardine	*Sardinops sagax*		X	X
Shiner surfberch	*Cymatogaster aggregate*	X	X	X
Striped surrperch	*Embiotoca lateralis*			X
Spotfin surfperch	*Hyperprosopon anale*			X
Bay pipefish	*Syngnathus leptorhynchus*	X		X
Cabezon	*Scorpaenichthys marmoratus*	X		
Penpoint gunnel	*Apodichthys Jlavidus*	?	X	X
Saddleback gunnel	*Pholis ornata*		X	
Kelp greenling	*Hexogrammos decagrammes*		X	
Unk. Rock fish spp.	*Sebastes spp.*	X		
Vermillion rockfish	*Sebastes miniatus*	X		
Copper rockfish	*Sebastes caurinus*	X		
Pacific tomcod	*Microgadus proximus*		X	
Striped bass (2)	*Morons saxitilus*		X	
Crustaceans				
Dungeness crab	*Cancer magister*	X	X	X
Yellow shore crab	*Hemigrapsus oregonensis*		X	X
Amphipod	*Corophium spinicorne*			
Bay shrimp	*Crangon franciscorum*			
Amphipod	*Eogammarus confervicolus* sub			
Amphipods unk	Sub order *Gammaridea*			
isopod	*Idotea sp.*			
parasitic isopod	*Lironeca vulgaris*			
Parasite copepod	order Caligoida			
Unk. mysid	family Mysidae			

(1) Female carcus found at the Hwy 1 Bridge site September 4, 1996.

(2) Thirteen striped bass (380 – 500 mm estimated total length) observed near sites U-2 and U-3 August

Table 3. Total number of fish captured, relative abundance (rel abu), and catch per unit effort (CPUE) from 173 beach seine samples in the Navarro River estuary May 20,1996 - May 7,1997.

	Lower Estuary			Middle Estuary			Upper Estuary			All sites combined		
Species	Total	rel abu	CPUE	Total	rel abu	CPUE	Total	rel abu	CPUE	Total	rel abu	CPUE
Steelhead	843	0.38	9.58	246	0.61	5.35	264	0.63	6.77	1353	0.44	7.82
Surf smelt	567	0.26	6.44	2	0.00	0.04	0	0.00	0.00	569	0.19	3.29
Top smelt	402	0.18	4.57	51	0.13	1.11	1	0.00	0.03	454	0.15	2.62
Staghorn sculpin	128	0.06	1.45	13	0.03	0.28	6	0.01	0.15	147	0.05	0.85
Bay pipefish	44	0.02	0.50	30	0.07	0.65	37	0.09	0.95	111	0.04	0.64
Prickley sculpin	39	0.02	0.44	13	0.03	0.28	40	0.09	1.03	92	0.03	0.53
Threespine stickleback	22	0.01	0.25	24	0.06	0.52	44	0.10	1.13	90	0.03	0.52
Starry flounder	54	0.02	0.61	19	0.05	0.41	11	0.03	0.28	84	0.03	0.49
Pacific herring	66	0.03	0.75	1	0.00	0.02	0	0.00	0.00	67	0.02	0.39
California roach	7	0.00	0.08	0	0.00	0.00	8	0.02	0.21	15	0.00	0.09
Coho salmon	10	0.00	0.11	0	0.00	0.00	1	0.00	0.03	11	0.00	0.06
Shiner surfperch	1	0.00	0.01	0	0.00	0.00	9	0.02	0.23	10	0.00	0.06
Juvenile rockfish	10	0.00	0.11	0	0.00	0.00	0	0.00	0.00	10	0.00	0.06
Penpoint gunnel	8	0.00	0.09	0	0.00	0.00	0	0.00	0.00	8	0.00	0.05
Pacific sardine	5	0.00	0.06	0	0.00	0.00	0	0.00-	0.00	5	0.00	0.03
Cabezon	5	0.00	0.06	0	0.00	0.00	0	0.00	0.00	5	0.00	0.03
English sole	3	0.00	0.03	0	0.00	0.00	0	0.00	0.00	3	0.00	0.02
Speckled sanddab	3	0.00	0.03	0	0.00	0.00	0	0.00	0.00	3	0.00	0.02
Tidepool sculpin	3	0.00	0.03	0	0.00	0.00	0	0.00	0.00	3	0.00	0.02
Pacific lamprey	0	0.00	0.00	2	0.00	0.04	0	0.00	0.00	2	0.00	0.01
Coast range sculpin	0	0.00	0.00	0	0.00	0.00	1	0.00	0.03	1	0.00	0.01
Kelp greenling	1	0.00	0.01	0	0.00	0.00	0	0.00	0.00	1	0.00	0.01
Saddleback gunnel	1	0.00	0.01	0	0.00	0.00	0	0.00	0.00	1	0.00	0.01
Totals	2222		25.25	401		8.717	422		10.82	3045		17.60

Table 4. Total number of fish captured, relative abundance (Rel Abu), and catch per unit effort (CPUE) from 194 beach seine samples collected from the Navarro River estuary May 21 to December 3,1997.

	Lower Sites			Middle Sites			Upper Sites			All Sites Combined		
	Total	Rel Abu	CPUE	Total	Rel Abu	CPUE	Total	Rel Abu	CPUE	Total	Rel Abu	CPUE
Steelhead	1003	0.31	10.23	318	0.40	7.76	189	0.21	3.44	1510	0.31	7.78
Top smelt	472	0.15	4.82	245	0.31	5.98	91	0.10	1.65	808	0.16	4.16
Surf smelt	583	0.18	5.95	0	0.00	0.00	0	0.00	0.00	583	0.12	3.01
Bay pipefish	95	0.03	0.97	21	0.03	0.51	189	0.21	3.44	305	0.06	1.57
English sole	238	0.07	2.43	0	0.00	0.00	0	0.00	0.00	238	0.05	1.23
California roach	8	*	0.08	20	0.03	0.49	207	0.23	3.76	235	0.05	1.21
Staghorn sculpin	182	0.06	1.86	8	0.01	0.20	8	0.01	0.15	198	0.04	1.02
Shiner surfperch	0	0.00	0.00	125	0.16	3.05	6	0.01	0.11	131	0.03	0.68
Threespine stickleback	34	0.01	0.35	15	0.02	0.37	81	0.09	1.47	130	0.03	0.67
Pacific herring	122	0.04	1.24	1	*	0.02	0	0.00	0.00	123	0.03	0.63
Speckled sandab	61	0.02	0.62	0	0.00	0.00	0	0.00	0.00	61	0.01	0.31
Coho salmon	46	0.01	0.47	1	*	0.02	0	0.00	0.00	47	0.01	0.24
Prickley sculpin	29	0.01	0.30	4	0.01	0.10	10	0.01	0.18	43	0.01	0.22
Starry flounder	19	0.01	0.19	0	0.00	0.00	1	*	0.02	20	*	0.10
Tidepool sculpin	19	0.01	0.19	0	0.00	0.00	0	0.00	0.00	19	*	0.10
Pacific tomcod	10	*	0.10	0	0.00	0.00	0	0.00	0.00	10	*	0.05
Juvenile rockfish	8	*	0.08	0	0.00	0.00	0	0.00	0.00	8	*	0.04
Penpoint gunnel	6	*	0.06	0	0.00	0.00	0	0.00	0.00	6	*	0.03
Cabezon	5	*	0.05	0	0.00	0.00	0	0.00	0.00	5	*	0.03
Silverspoted sculpin	1	*	0.01	0	0.00	0.00	0	0.00	0.00	1	*	0.01
Nightsmelt	1	*	0.01	0	0.00	0.00	0	0.00	0.00	1	*	0.01
Pacific sanddab	1	*	0.01	0	0.00	0.00	0	0.00	0.00	1	*	0.01
Total Fish	3209		32.74	786		19.17	913		16.60	4908		25.30
Dugeness crab	2339	na	23.87	3	na	0.07	1	na	0.02	2343	na	12.08

*<0.01

estuarine dependent species were captured during the winter season when salinity values were relatively low.

Commercially important English sole and dungeness crabs were commonly captured from the Navarro River estuary in 1997, but were rarely captured in 1996. English sole and dungeness crabs are demersal species and are known to utilize estuaries for nursery grounds along the west coast (Cannata in prep.; De Ben et al. 1990, Johnson et al. 1986; Puckett 1977). In 1997, 238 YOY English sole and over 2300 juvenile dungeness crabs were captured from the lower estuary sites. After the Navarro lagoon formed, the catches of demersal species declined including English sole, staghorn sculpin, and dungeness crab. These species may have moved back to the ocean, avoided capture, or died due to lack of dissolved oxygen and high water temperatures in bottom waters of the lagoon. Juvenile English sole may have migrated back to the ocean because catches decreased in the Albion River estuary about the same time as in the Navarro estuary/lagoon (Cannata and Maahs 1998). The steep decline in the numbers of dungeness crabs after the lagoon formed in 1997 may indicate that many crabs died in the lagoon because of high water temperatures and low levels of dissolved oxygen encountered on bottom waters.

Gill Net Catch

Results from 63 gill net samples collected in the first year are presented in Table 5 and results from 48 gill net samples collected May to December 1997 are shown in Table 6. Steelhead comprised only 8% of the total gill net catch in 1996 and 13% in 1997. Relatively low numbers of steelhead captured by gill net may be partially due to their ability to avoid the gill nets. Gill nets were set during the day, often in clear water. The overall catch by gill net differed from beach seines in the ranking by abundance and components of the catch. For example, adult male and female Pacific herring in spawning condition were captured only by gill net May through August 1996 and March to August in 1997. The presence of Pacific herring in spawning condition indicates a protracted spawning period likely occurs in the Navarro River estuary. Pacific herring are valuable as prey species for anadromous salmonids and also are commercially important. Top smelt were also captured in spawning condition from April through August which suggests they have a similar spawning season in the estuary as Pacific herring. We found three YOY top smelt in

Table 5. Total number of fish captured, relative abundance (Rel Abu), and catch per unit effort (CPUE) from 63 gill net samples in the.Navarro River estuary May 20, 1996 - May 7. 1997.

Species	Lower Estuary Total	Lower Estuary Rel Abu	Lower Estuary CPUE	Middle Estuary Total	Middle Estuary Rel Abu	Middle Estuary CPUE	Upper Estuary Total	Upper Estuary Rel Abu	Upper Estuary CPUE	All sites combined Total	All sites combined Rel Abu	All sites combined CPUE
Top smelt	73	.37	3.17	26	.42	1.30	50	.85	2.27	149	.47	2.37
Pacific herring	61	.31	2.65	19	.31	0.95	5	.08	0.23	85	.27	1.35
Surf smelt	40	.20	1.74	0	0	0.00	0	0	0.00	40	.13	0.63
Steelhead	13	.07	0.57	9	.15	0.45	3	.05	0.14	25	.08	0.40
Pacific sardine	4	.02	0.17	8	.13	0.40	0	0	0.00	12	.04	0.19
Shiner surfperch	5	.03	0.22	0	0	0.00	0	0	0.00	5	.02	0.08
Starry flounder	0	0	0.00	0	0	0.00	1	.02	0.05	1	<0.01	0.02
Striped surfperch	1	.01	0.04	0	0	0.00	0	0	0.00	1	<0.01	0.02
Totals	197		8.57	62		3.1	59		2.68	318		5.05

Table 6. Total number offish captured, relative abundance (Rel Abu), and catch per unit effort (CPUE) from 48 gill net samples in the Navarro River estuary May 21, to November 14, 1997.

	Lower Sites Total	Lower Sites Rel Abu	Lower Sites CPUE	Middle Sites Total	Middle Sites Rel Abu	Middle Sites CPUE	Upper Sites Total	Upper Sites Rel Abu	Upper Sites CPUE	All Sites Combined Total	All Sites Combined Rel Abu	All Sites Combined CPUE
Top smelt	71	0.26	1.48	8	0.03	0.17	48	0.17	1.00	127	0.46	2.65
Shiner surfperch	16	0.06	0.33	44	0.16	0.92	0	0.00	0.00	60	0.22	1.25
Steelhead	22	0.08	0.46	6	0.02	0.13	7	0.03	0.15	35	0.13	0.73
Surf smelt	20	0.07	0.42	4	0.01	0.08	0	0.00	0.00	24	0.09	0.50
Pacific herring	11	0.0 4	0.23	5	0.02	0.10	1	<0.01	0.02	17	0.06	0.35
Pacific sardine	1	<0.01	0.02	6	0.02	0.13	0	0.00	0.00	7	0.03	0.15
Juvenile rockfish	3	0.01	0.06	0	0.00	0.00	0	0.00	0.00	3	0.01	0.06
Staghom sculpin	0	0.00	0.00	0	0.00	0.00	1	<0.01	0.02	1	<0.01	0.02
Threespine stickleback	0	3 0.00	1	0.00	0.02	0		0.00	0.00	1	<l B.01	0.02
Northern anchovy	1	0.00	0.02	0	0.00	0.00	0	0.00	0.00	1	<0.01	0.02
Total Fish	145	0.53	3.02	74	0.27	1.54	57	0.21	1.19	276	1.00	5.75
dungeness crab	0	0.00	0.00	7	0.03	0.15	0	0.00	0.00	7	0.03	0.15

a stomach sample obtained from a juvenile steelhead in the lagoon on September 30,1997. This is important because other food sources such as epibenthic macroinvertebrates may become relatively rare in the lagoon as bottom water becomes anoxic and water temperatures increase.

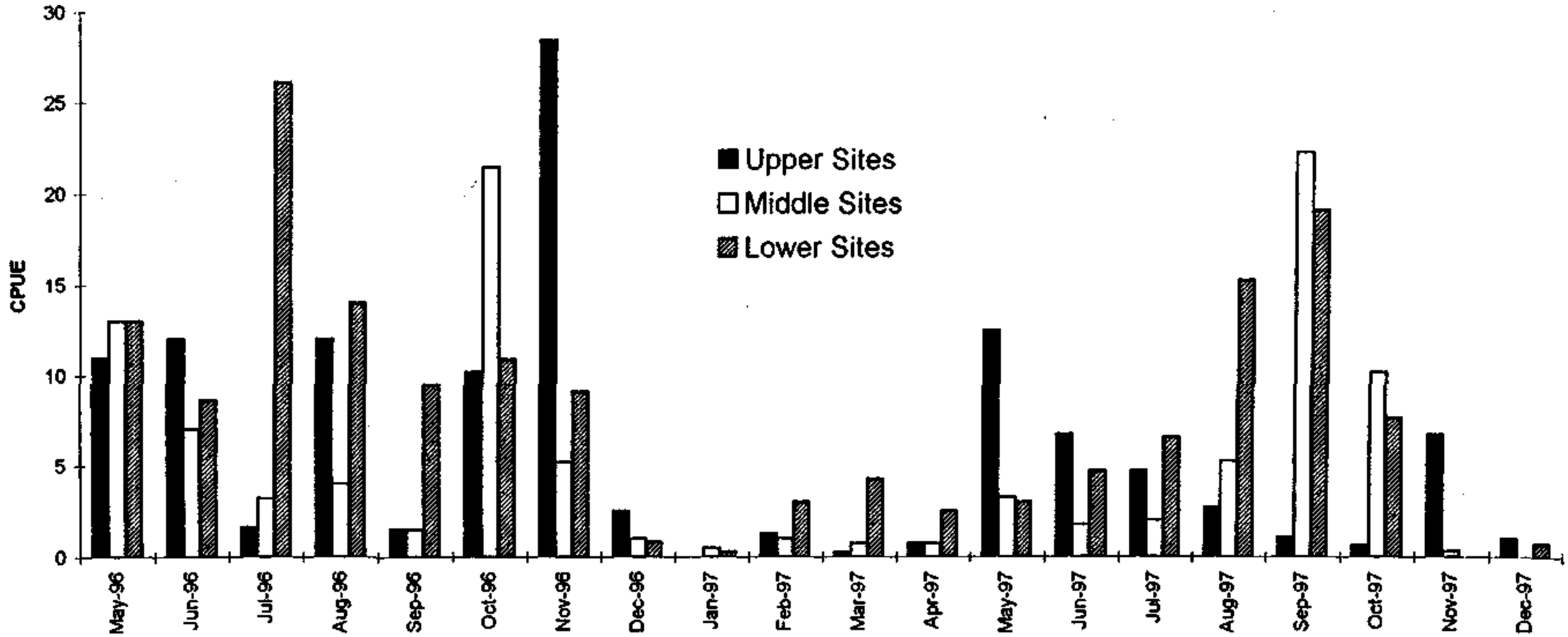
Snorkel Surveys

Young-of-the-year and yearling steelhead were often observed during snorkel surveys in the upper estuary zone and sometimes observed in the middle zone. Steelhead were usually observed in close proximity to large woody debris. In the spring and summer of 1996, Shiner surfperch were observed in groups of hundreds during snorkel surveys near the Ml site in dense beds of green alga enteromorpha sp. and California roach were observed in groups numbering 100's near large woody debris in the upper estuary zone. A small number of spotfin surfperch (Hyperprosopon anale) were occasionally observed mixed in with shiner surfperch. Bay pipefish, sculpin spp., threespine stickleback, tidepool sculpin (Oligocottus maculosus), and large colonies of amphipod (Corophium spinicorne) tubes were also observed during snorkel surveys of the upper and middle estuary zones.

Steelhead

Steelhead were captured year round at most sampling sites. They were usually most abundant in samples collected from the lower sites before the lagoon formed, and increased in abundance in the middle and upper sites after the lagoon formed (Figure 2). Before the lagoon formed in 1996, steelhead were generally segregated by size according to distance from the river mouth. Steelhead larger than 110 mm FL were almost exclusively captured from the lower sampling sites where water temperatures were cooler and salinities were higher than the middle and upper sites (Tables 7-9). In 1997, a similar spatial and temporal relationship was observed. A hook and line survey of the upper lagoon in early October 1997 revealed steelhead between 150 and 250mm FL had moved about one mile above the U-l sampling site.

The highest CPUE of steelhead by beach seine was from May to November in 1996 and 1997. Relatively low catches in winter may be partially due to high river flows which prevented efficient



CPUE	Jun-96	Jul-96	Aug-96	Sep-96	Oct-96	Nov-96	Dec-96	Jan-97	Feb-97	Mar-97	Apr-97	May-97	Jun-97	Jul-97	Aug-97	Sep-97	Oct-97	Nov-97	Dec-97
Upper sites	12	1.6	12	1.5	10.2	28.5	2.5	0	1.25	0.25	0.75	12.5	6.7	4.7	2.7	1.1	0.63	6.7	1
Middle Sites	7	3.2	4	1.5	21.5	5.2	1	0.5	1	0.75	0.75	3.25	1.75	2	5.25	22.4	10.2	0.33	0
Lower Sites	8.6	26.1	14	9.5	10.9	9.1	0.8	0.3	3	4.25	2.5	3	4.7	6.55	15.3	19.2	7.64	0	0.75

Figure 2. Monthly Steelhead catch per unit effort from beach seine samples collected from the upper, middle, and lower sites in the Navarro River estuary May 1996 to December, 1997. Notice increases in CPUE from the upper and middle sites after the lagoon formed on Septmer 20,1996 and September 3,1997. Low CPUE in the upper and middle sites January to April, 1997 are in part due to reduced capture efficiency related to high river flows.

Table 7. Length-frequency distributions and catch per unit effort (CPUE) for steelhead captured by beach seine from the lower Navarro River estuary May 20, 1996- June 23, 1997.

Fork Length (mm)	21- May	11-12 Jun	2-3 Jul	23-Jul	13-Aug	4-Sep	24-Sep	11-Oct	16-Oct	30-Oct	6-Nov	18-Nov	25-Nov	19-Dec	15-Jan	17-Feb	27-Feb	14-Mar	26-Mar	8-Apr	23-Apr	7-May	21-May	5-Jun	23-Jun
41-45																									
46-50																									
51-55																									
56-60														1											
61-65																									
66-70														1											
71-75			2																						1
76-80			3	2																				1	
81-85			3											1											
86-90			2	2	2	3																			
91-95			5	1		1																			1
96-100			1	5	2	1		1																1	1
101-105	1		4	2	3	2																		2	1
106-110				1	2	2																	1		
111-115	2		1	2	3	2															1			1	
116-120	4		3	2	2															1		2			
121-125	5	1	2	1											1								1	1	
126-130	5		3	2	3	3			1													2		3	
131-135	8	5	4	4	2																		2		2
136-140	5	4	11	8	3	2		1	1														1	1	1
141-145	4	4	11	6	1	1	1	1	1	1															3
146-150	6	5	11	6	1			4	5																
151-155	7	4	11	3	1	2		1	1																1
156-160	4	6	11	1	2	4	1	3	2	1							1					2			1
161-165	5	4	7	8	9	3	2	1	1	2													1		1
166-170		3	14	12	1	5		5	2	1	1	1												1	2
171-175	2	1	7	9	3	2	1	2	1	3	1	1									1	2			
176-180	3	3	6	9	9	5	1	4	5	2	1											1			1
181-185	1	1	4	6	7	3	2	1	1	4	1	2					1	1				2			
186-190		1	2	3	6	5	2	5	2	7	4	1				1	1					2			1
191-195	1	1	2	4	1	3	1	6	3	1	2	2					1								
196-200				4	3	3	1	7	1	7	2						1								1
201-205				1	1	4		6	1	1	3	4													
206-210					2	1	2	3	1	5	7	5					1					1			
211-215								6	2	5	7	4							3						
216-220			1			1	1	11	2	7	3	6					1			2	1				
221-225					2	1		5	1	4	6	6				1	2				1				
226-230						1		2	1	3	3	2				1	3					1			
231-235								2		2		3					1					1			
236-240						1		2	1	5		1					1	1		1					
241-245									1	2	1	2					3		2						
246-250										1							1		2		1				
251-255										1									2						
256-260																									
261-265																									
266-270																			3						
271-275																		1		1					
276-280																									
281-285																			2						
Total	63	43	131	104	71	61	15	79	37	65	42	40	0	3	1	3	18	3	14	5	5	16	6	11	18
CPUE	13	8.6	26	26	14	16	3.8	26	9.3	22	14	20	0	0.8	0.3	0.8	4.6	0.8	3.5	1.3	1.3	4	1.5	2.8	4.6

Table 7. Continued. Length frequency distributions for steelhead captured by beach seine from the Lower Navarro estuary sites.

Fork Length (mm)	7/7/97	7/15/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/24/97	9/30/97	10/9/97	10/16/97	10/25/97	11/3/97	11/14/97	12/3/97
56-60																		
61-65			1		1													
66-70		1			1													
71-75		1						2				1						1
76-80		3	1	4	3				1									
81-85	1	2		5	3	1		1		1								
86-90	2	1	1	8	8	2		1	1			1						
91-95		3	1	9	5	1	2	2	1	3								
96-100		2	2	6	6	2	4	1	3	3			2					
101-105		1	1	1	2	3	3	1	4	4	1	1		1				
106-110				1	2	3	2	6	1	3	2		2					
111-115	1				4	5	1	7	6	9	1			3				
116-120	1			2	1	5	2	8	16	4	3		2	1				1
121-125		2		1		3	4	5	8	16	7		5	5				
126-130	1	1	1		1	1	3	4	15	3		1	2	12	2			
131-135					1	3	1	3	8	5	3	5	4	14				
136-140					1		2	1	3	2	5	3		13	5			
141-145		2	1			2	2	2	4	3		2		18	2			
146-150		3	1	3	2	2	3	2	4	2	1	3	8	1	3			
151-155	1	1	5	1	3	1	2	3	3	2	4	4		8	4			
156-160		2	1	1	5	3	5	2	15	3	3	1		6	3			
161-165	1	1	5	2	5	1		7	7			3	2	9	5			
166-170		2	2	1	3	6	8	3	12	12	4	7		15	5			
171-175	1		3	1	5	5	8	6	18	2	2	4		7	2			
176-180			3	1	5	7	1	6	9	6	3	4		8	8			
181-185	1	1	2	1	4	3	5	1	17	9	4	4	3	3	1			
186-190			1		4		3	3	3	5	5	2	2	7	13			
191-195		1	1		4	2	1	2	7	2		2	4	7	2			
196-200			1		2		2		4	1		1	2	3	4			
201-205			1		2	1	2	1	5	1	3	2	4	1	4		1	
206-210			1		3	2	1	1	3		2	2		3	2			
211-215						1	1		4	1	1				3			
216-220					1			1	1	1		2			3			
221-225														1				
226-230					1									1				1
231-235																		
236-240						1												
241-245																		
246-250																		
>251		1					1				1				1	1		
Total	10	30	35	48	86	66	69	82	183	103	55	55	42	147	72	1	1	3

Table 8. Length-frequency distributions and catch per unit effort (CPUE) for steelhead captured by beach seine from the middle Navarro River estuary May 20,1996 - June 23,1997.

Fork Length (mm)	21-May	11-Jun	Jul 2&3	23-Jul	13-Aug	4-Sep	24-Sep	11-Oct	16-Oct	30-Oct	6-Nov	18-Nov	25-Nov	19-Dec	15-Jan	17-Feb	27-Feb	14-Mar	26-Mar	8-Apr	23-Apr	7-May	21-May	5-Jun	23-Jun
41-45																									
46-50															1										
51-55																1									
56-60																									
61-65	1	1	1										1												2
66-70	3		2	1	1																				
71-75	5	1		2	1																				1
76-80	3	3	3		1																				2
81-85	3	4	1	2	2																				
66-90	5		1		3	1																	1		
91-95	2																						1		
96-100	2		1																				1		
101-105			1																		1		2		
106-110		1				1															1		1	1	
111-115	1	3				2																1	3		
116-120		1																					1	1	
121-125							1																		
126-130								1	1												1		1		
131-135								1																	
136-140				1				2	2																
141-145								1	1			1													
146-150								2	2					1											
151-155																									
156-160								3				3							2						
161-165							1																		
166-170									1																
171-175								1	1			1				1									
176-180								4	1																
181-185								2	2			1													
186-190								3				2													
191-195								10	2																
196-200								12	2	1		1													
201-205								10		1		3													
206-210								13				3	1			1									
211-215								9	1			5		1											
216-220								10	5			3													
221-225								11	1			3													
226-230								4	1			1						1							
231-235								1				1													
236-240								3	1			2													
241-245																									
246-250												1													
251-255																									
256-260																									
261-265																1									
266-270																									
271-275																									
276-280																									
Total	25	14	10	6	8	4	2	103	24	2	0	31	2	2	1	3	0	1	2	0	3	1	11	2	5
CPUE	13	7	3.3	3	4	2	1	52	12	1	0	16	1	1	0.5	1.5	0	0.5	1	0	1.5	0.5	5.5	1	2.5

Table 8. Continued.   Length frequency distributions for steelhead captured by beach seine from the middle Navarro estuary sites.

Fork Length (mm)	7/7/97	7/15/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/1/97	9/24/97	9/3/97	10/9/97	10/16/97	10/25/97	11/3/97	11/14/97	12/3/97
56-60									1			1						
61-65	2																	
66-70	1							1						1				
71-75	5	1		1														
76-80	2				1		1		1	1								
81-85	1		1	2	2			1										
86-90		1		1	1		7			1		1		1				
91-95					1		1	2		5		1						
96-100	1	2					1	1	2	5	1				1			
101-105	2		1						2	8		3	4					
106-110							1	2	1	8	1	9	6					
111-115										7		5	4					
116-120							1	1		9	1	5	7			1		
121-125									1	1		8	9	1				
126-130											1	5	6					
131-135									1	1		7	6					
136-140										1	4	6	14					
141-145										1	1	4	6					
146-150									1			1	6					
151-155												3	2					
156-160								1	1	4		3	6		1			
161-165								2				3	5					
166-170									1		2	3	6			1		
171-175								2		2	1	3	2					
176-180								3		2	1	3	2					
181-185								1	1	1		1	4					
186-190								1		1		4	6			1		
191-195								1	1			2	2					
196-200										1			7		1			
201-205												2						
206-210								1				1						
211-215															2			
216-220												1	1					
221-225																		
226-230																		
231-235																		
236-240																		
241-245																		
246-250																		
>251																		
Total	14	4	2	4	5	0	12	20	14	59	13	85	111	3	5	3	0	0

Table 9. Length-frequency distributions and catch per unit effort (CPUE) for steelhead captured by beach seine from the Navarro River estuary May 20,1996 - June 23,1997.

Fork Length (mm)	20-21-May	11-Jun	2-Jul	23-Jul	13-Aug	4-Sep	24-Sep	11-Oct	16-Oct	30-Oct	6-Nov	18-Nov	25-Nov	19-Dec	15-Jan	17-Feb	27-Feb	14-Mar	26-Mar	8-Apr	23-Apr	7-May	2-May	5-Jun	23-Jun
41-45	2																								
46-50	6	2																							
51-55	4	4																							
56-60	1	6																							
61-65	3	5	1																					1	1
66-70		3																							2
71-75	2	2		1	2																				4
76-80	2	1			8	1		1														1		1	3
81-85				3	6																	1	1		
86-90	1			2	5		1																	1	1
91-95						1								1							2		4		
96-100							2																3	1	
101-105				1																	1		4	3	
106-110	1																						5		1
111-115					1				1														3		
116-120																									1
121-125							1	1					1										1		
126-130													1										2		
131-135					1																				
136-140									1	1			2												
141-145													4												
146-150													1												
151-155									1				1												
156-160								1	1				2	1											
161-165												1	1												
166-170								1					1												
171-175										1															
176-180													1						1						
181-185								1	1	2			4	1			1								
186-190								1				1	3												
191-195								3		1		1	4												
196-200								4		2		3	6				1								
201-205					1			3		2	1	2	7				1								
206-210								3		2		2	11												
211-215								4		3		2	5												
216-220								3		2		1	3				1								
221-225								1		1		2	12	1			1								
226-230								1				2	10												
231-235										1			7	1											
236-240													5												
241-245													4												
246-250																									
251-255																									
256-260																									
261-265																									
266-270																									
271-275																									
276-280																									
Totals	22	23	1	7	24	2	4	28	5	18	1	17	96	5	0	0	5	0	1	0	3	2	23	7	13
CPUE	11	12	0.3	3.5	12	1	2	14	2.5	18	1	17	48	2.5	0	0	2.5	0	0.5	0	1.5	1	12	2.3	4.3

Table 9. Continued. Length frequency distributions for steelhead captured by beach seine from the upper Navarro estuary sites.

Fork Length (mm)	7/7/97	7/15/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/1/97	9/24/97	9/3/97	10/9/97	10/16/97	10/25/97	11/3/97	11/14/97	12/3/97
56-60	1	2				7												
61-65	1																	
66-70		2																
71-75	4					1	1	1			1							
76-80		2	4			2							2					
81-85		2		1		1												
86-90						1												
91-95	1				1		2				1							
96-100	1				1	1		2										
101-105	3			1			2											
106-110	3		1	2			1				1					2		
111-115							1				1							
116-120		1												2				
121-125						1					1							
126-130				1											1	2		
131-135				1				1								1		
136-140																1		
141-145																		
146-150				2				1			1							
151-155								1		1								
156-160											1							
161-165				1														
166-170																		
171-175																		
176-180																		
181-185								1								3		
186-190								2								1		
191-195											1			1		1		
196-200											2							
201-205																		
206-210											1					1		
211-215				2												3		
216-220																1		
221-225																		
226-230																		
231-235																		
236-240																		
241-245																		
246-250																		
>251																2		
Total	14	9	5	11	2	14	7	9	0	1	11	0	2	3	1	18	0	0

deployment of the sampling gear, especially at the upper sites where current velocities were highest. During high runoff in February, March, and part of April we caught more juvenile steelhead at the upper sites by hook and line than by beach seine or gill net. The hook and line data were pooled with the beach seine data to predict weights from specific lengths using regression techniques. Hook and line data were not included in any other analysis.

Judging from interpretation of adult and juvenile scales, and the catch data, many Navarro River steelhead enter the ocean between March and May as they begin their third year of life and after spending at least one year in the estuary. This is also shown in the length frequency tables by the absence of steelhead larger than 175 mm FL after May 1997: Additionally, some appeared to enter the ocean in their second year and return to the river at age three. Examples of juvenile steelhead and adult steelhead showing estuarine rearing patterns on their scales are shown in Figures Al to A3 Appendix.

Steelhead Population Estimate

In order to estimate the numbers of steelhead residing in approximately the lower 2.5 miles of the estuary/lagoon, a mark and recapture experiment was conducted after the sand bar closed the river mouth in September 1997. The population was estimated for two size groups < 150 mm fork length (FL) (mean FL = 119 mm) and 150 mm FL (mean FL = 177 mm). For the most part, the two groups represent age 1+ and 2+ steelhead respectively. The population estimate and 95% confidence interval (CI) for steelhead < 150 mm FL was 2,921 ± 635. The population estimate and 95% CI for steelhead ≥150 mm FL was 5913 ± 2361. These fish likely represent a significant proportion of the yearling and older steelhead population in the Navarro basin.

Steelhead Growth

In 1996, yearling and older steelhead captured by beach seine increased an average of 63 mm fork length (0.37 mm/day) over a 176 day period between June 1 and November 16, (Table 10). The greatest increase in length (0.61 mm/day) occurred from mid-September to mid-October. These growth rate estimates are high in comparison to a study conducted in 1988 in the Matole estuary/lagoon Zedonis (1992). Zedonis reported from July 26 to

October 23, 1988 mean length increased 21.2 mm for yearling and a small percentage of 2+ steelhead. During the 88 day period, steelhead grew at an estimated mean rate of 0.24 mm/day in the Matole estuary/lagoon. Peak growth for the Matole estuary/lagoon study was from September 18 to October 23 when the steelhead increased 13.9 mm or 0.40 mm/day. The least amount of growth (4 mm) occurred July 26 to August 23 just after the lagoon formed on July 21. Zedonis reports a 0.5 mm decrease in length during August 23 to September 18 under lagoon conditions. The. Navarro River estuary/lagoon steelhead also exhibited the minimum growth (4 mm) during a similar time period. The minimum growth rate of 0.13 mm/day for Navarro estuary steelhead was from mid August to mid-September (Table 10). This is the period when the mouth was closing and the transition from estuary to lagoon occurred The Navarro mouth closed on September 20,1996. Steelhead growth rates accelerated in both the Navarro and Matole lagoons after a period of time and accumulation of fresh river water. These data show how steelhead growth may slow during lagoon formation and how growth rates may vary between years, fish stocks, and among estuaries along the California coast.

Table 10. Maximum, minimum, and median fork lengths (FL) and estimated growth rates (mm FL) for yearling and older steelhead captured by beach seine from the Navarro River estuary May 20 to November 25, 1996.

Sampling Dates (1996)	May 20, June 12	Jul 2, 23	Aug 13, 14	Sep 4, 24	Oct 11, 16, 30	Nov 6, 18, 25
Mean FL (mm)	148.5	158.9	172.3	179.1	197.1	210.0
Std Error	1.83	1.36	3.05	3.02	1.98	1.89
Median FL (mm)	148	159	176	180	200	211
Minimum FL (mm)	113	115	126	127	130	167
Maximum FL (mm)	195	219	225	236	252	245
Sample Size	105	209	57	65	184	82
Monthly increase (mm)		11	17	4	20	11
Growth rate mm/day		.26	.57	.13	.61	.38
Cumulative increase (mm)		11	28	32	52	63
Total growth rate		.26	.62	.42	.37	.37

In addition to seasonal increases in length, yearling and older steelhead exhibited seasonal variation in length-weight relationships. Steelhead weights predicted by least squares linear regression analysis were greatest during the October to November 1996 period. Steelhead weighed the least from February to March, 1997 (Figure 3). These data indicate steelhead were generally in the best

Specific Length (FL mm)	Predicted Weight (g) Jul 23-Sep 4, 96	Oct 16-Nov 25, 96	Feb15-Mar 26, 97	Apr 23-May21, 97	Jul 23 -Sep 4, 97	Oct16 - Nov 25, 97
125	23.44	26.75	20.44	21.57	22.39	21.88
150	39.63	43.3	34.6	37.54	38.02	37.15
175	61.79	65.07	53.99	59.96	58.89	56.23
200	90.78	92.61	79.39	89.96	87.1	83.18
225	127.45	126.42	111.55	128.68	123.03	114.82
250	NA	167	151.21	NA	166	154.88
N	181	396	98	31	354	246
r^2	0.95	0.97	0.94	0.98	0.97	0.97

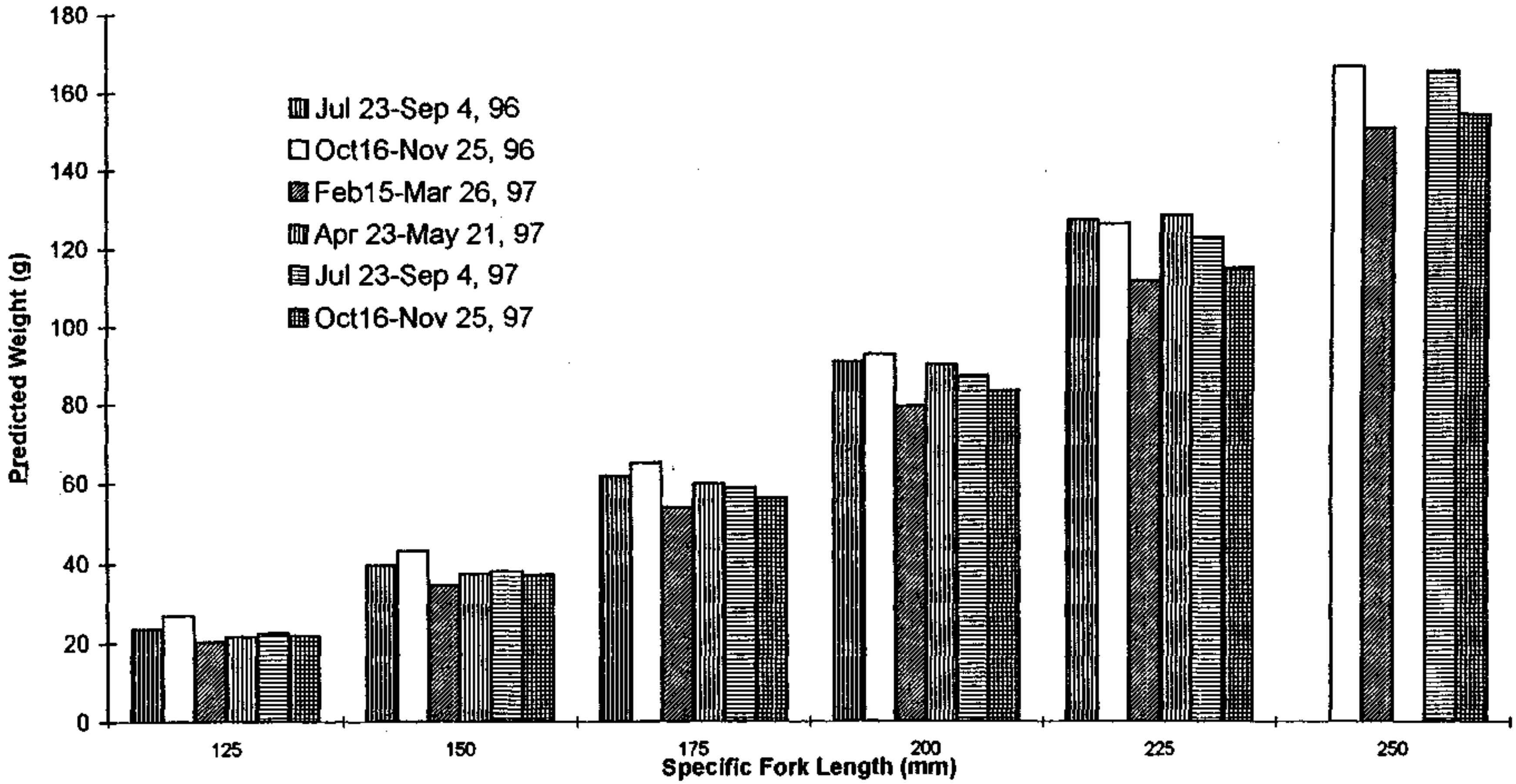


Figure 3. Seasonal variation in weights of juvenile steelhead predicted by length weight regression from the Navarro river estuary 1996 and 1997.

condition (as measured by length-weight relationships) going into the fall season and steelhead lost weight during the winter season. Predicted weights from specific weights also show that steelhead were generally in better condition in the summer and fall of 1996 compared to the same period in 1997. Additionally, length-weight data provided by the Department of Fish and Game (DFG) collected from downstream migrant trapping on the North Fork Navarro River were compared to length-weight data collected from steelhead in the estuary. The same regression techniques were used to predict weights from specific lengths of downstream migrants captured in April and May 1997 from the North fork Navarro and compared the results with those obtained from steelhead captured from the estuary during the same period in 1997 (Figure 4). The results from the regression analysis show steelhead captured with the downstream migration trap were heavier in the North Fork Navarro River at sizes of 80 to 110 mm FL compared to steelhead captured by beach seine from the estuary. However, steelhead 150 to 200 mm FL captured from the estuary were heavier than those of the same length captured from the North Fork Navarro river. Possible explanations for the differences are; 1) the small steelhead moving into the estuary initially lost weight as they made the journey and also require time to modify behaviors and adapt to the new type of environment before gaining weight; 2) larger steelhead captured from the estuary were probably rearing there since the previous summer, and steelhead production in the estuary is greater than production in the North Fork.

The peak period for yearling and older steelhead migrating downstream from the North Fork was from March 31 to May 11, 1997 and the mean length for this period was 99.0 ±3.5 mm FL. The mean length of yearling and older steelhead captured by beach seine from the estuary March 26 to May 8 was 186.3 ± 16.4 mm FL. Although the sample size (N=52) from the estuary is relatively small compared to the sample size (N=300) from the North Fork Navarro, these data suggest the number of larger 2+ steelhead residing in the estuary is greater than in the North Fork and that yearling steelhead are generally greater in length in the estuary than the North Fork Navarro River (Figure5).

Specific Length (FL mm)		Predicted Weight N. F. Navarro River	Predicted Weight Estuary
80		5.83	4.99
90		8.29	7.24
100		11.35	10.1
110		15.09	13.64
	N	145	40
	r^2	0.85	0.78
125		21.06	21.57
150		34.15	37.54
175		51.39	59.96
200		73.23	89.96
	N	18	31
	r^2	0.82	0.98

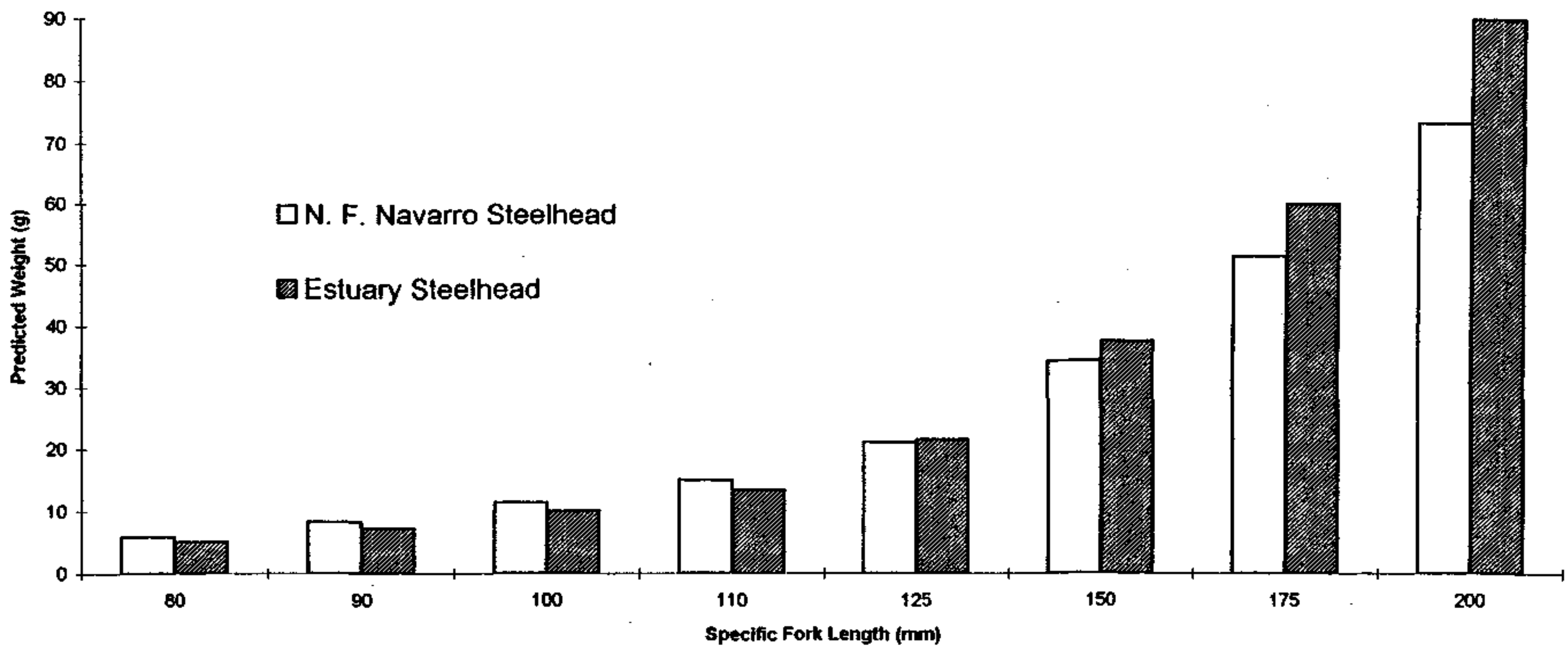
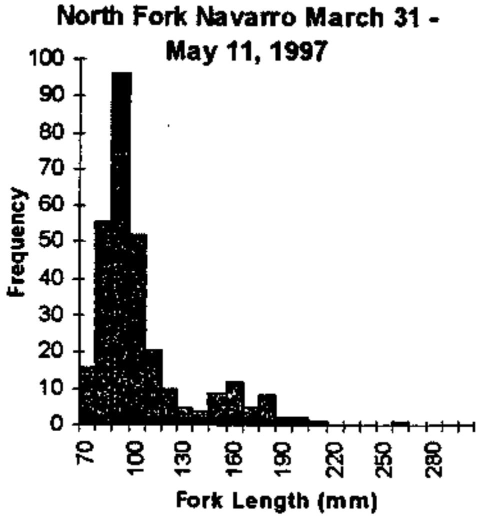


Figure 4. Variation in Weights of juvenile steelhead captured from the North Fork Navarro River and from the estuary April to May 1997. Weights are predicted by length weight regression. Sample Size (N) and regression coefficient (r^2).



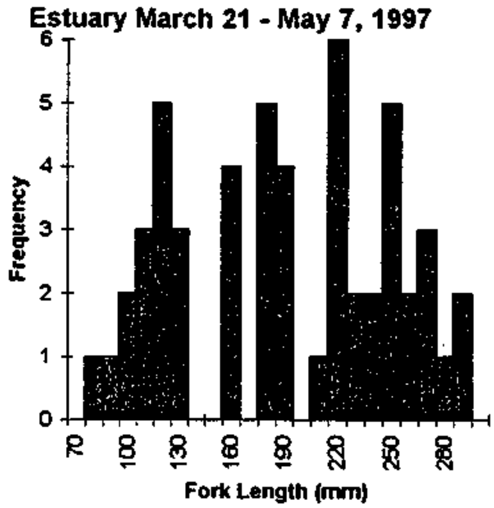


Figure 5. Length-frequency histograms for steelhead captured from North Fork Navarro river and the Navarro estuary.

Coho Salmon

Out-migrant coho salmon smolts were captured from the Navarro River estuary during May, June, and into July for both 1996 and 1997. All but two coho smolts were captured from the lower estuary sampling sites. This suggests that coho smolts may pass through the freshwater portions of the estuary rather quickly, but hold in the brackish water of the lower estuary.

Ten coho smolts were captured in 1996 (mean FL = 133 mm) and forty-eight were captured in 1997 (mean FL = 118). Table 11 presents the length frequency distribution and total number of all coho salmon captured from the estuary. Coho were not captured by gill nets in 1996 or 1997. Most of the coho caught in 1997 were collected in a single beach seine sample on May 21, when thirty-three were captured from site L-4 during an incoming spring tide. The site L-4 is located near the estuary mouth, but just inside of a small embayment where water velocity is much lower than in the adjacent main channel. These coho were probably preparing to enter the ocean and may have been in the final stages of acclimating to sea water and imprinting on the Navarro River. Coho salmon smolts are known to form aggregations in portions of estuaries having low water velocity and out migration is associated with spring tides (McMahon and Holtby 1992).

Table 11. Length-frequency distributions for coho salmon captured by beach seine from the Navarro River estuary May 20, 1996 - July 15,1997. Coho were captured from the lower estuary sites unless noted by " * " or “**”

Fork Length (mm)	20-21-May	11-Jun	2-Jul	23-Jul	13-Aug	4-Sep	24-Sep	11-Oct	16-Oct	30-Oct	6-Nov	18-Nov	25-Nov	19-Dec	15-Jan	17-Feb	27-Feb	14-Mar	26-Mar	8-Apr	23-Apr	7-May	21-May	5-Jun	23-Jun	15-Jul
51-55																										
56-60																										
61-65																										
66-70																										
71-75																										
76-80																						1*				
81-85																										
86-90																							1**			
91-95																							1			
96-100																							3			
101-105		1																					2	1		
106-110	1																						5			1
111-115																							2	2		
116-120		1																					8		1	
121-125			1																				4			
126-130	1																						2		2	
131-135		1																					3		1	
136-140																							4			i
141-145																							2			
146-150		1																					1			
151-155		1																								
156-160		2																								
161-165																										
166-170																										
171-175																										
176-180																										
181-185																										
186-190																										
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206-210																										
211-215																										
216-220																										
221-225																										
226-230																										
231-235																										
236-240																										
241-245																										
246-250																										
251-255																										
256-260																										
261-265																										
266-270																										
271-275																										
Totals	2	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	38	3	4	2

* Captured from upper estuary.

** Captured from middle estuary.

Data describing coho salmon length-weight relationships and the timing of downstream migrations collected from the North Fork Navarro River by the DFG in 1997 was used to make comparisons of length-weight-relationships with estuary caught coho (Table) and to achieve some understanding of the migration timing into the estuary. Results from a T-test showed there was a statistically significant difference between the mean condition factors (Fulton-K) for North Fork Navarro River coho captured May 5 to May 25, 1997 and coho captured from the estuary on May 21, 1997 $P(T \leq t = 0.0003)$. However, no difference was detected between the mean Fulton-K factor for coho captured from the North Fork Navarro River on April 21 to May 4, 1997 and coho captured from the estuary on May 21, 1997 $P(T \leq t = 0.39)$. Results from the DFG downstream migrant trapping showed a peak period of movement from the North Fork from April 21 to May 11, 1997. The mean length and the 95% CI (N=124) for coho during the peak period was 93.0 ± 1.7mm FL. The mean length and the 95% CI (N=38) for coho captured from the estuary on May 21 was 118.8 ±4.8 mm FL.

Table 12. Variation in weights predicted by regression and condition factors (Fulton-K) for coho salmon captured from the North Fork Navarro River and the Navarro River estuary .

	N F Navarro River April 21 to May 4, 1997	N F Navarro River May 5 to May 25, 1997	Navarro River estuary May 21, 1997
Specific Length (mm FL)	Predicted Weight grams (g)		
90mm	8.34 g	7.90 g	8.39 g
100mm	11.11 g	10.67 g	11.48g
110mm	14.4 g	14.00 g	15.25 g
Fulton-K	1.142	1.079	1.148
Sample Size (N)	79	68	38

The relatively small numbers of coho smolts captured from the estuary probably reflects their low abundance in the river system. It may be that most coho were aggregated into groups and we just missed them as they passed through the estuary. We observed similar aggregations of steelhead in the fall when large proportions of the total catch for the day would occur in one or two beach seine samples. The estuary however, is important for coho smolts as a transitional area between freshwater and saltwater environments, imprinting on their natal watershed, and as a forage area as they prepare for ocean entry. Because coho smolts were present in the Navarro estuary into July, portions of the population may utilize the estuary for extended rearing habitat. Not surprisingly, other studies have shown coho have developed more than one pattern of estuarine utilization throughout their range (Cannata in prep. Cannata and Maahs 1998; Holtby et al. 1990;McMahon and Holtby 1992; Smith 1990; Tschaplinski 1988). These results suggest more data may be needed to fully describe estuarine utilization by coho salmon in California.

Water Quality

Water temperature, salinity, and dissolved oxygen exhibited broad spatial and temporal variation in the Navarro River estuary (Tables Al to A13, Appendix). These water quality parameters are affected by dynamic interactions between several factors including riverine, marine, and estuarine water masses, circulation and mixing patterns, channel morphology, weather conditions, and the sand bar formation closing the river mouth. The variation in river flows is a significant factor influencing water quality parameters in the estuary. Navarro river discharge in acre feet/month from June to September is shown in Table 1.

An interesting and potentially harsh condition known as seasonal meromixis or inverse temperature stratification occurs when tidal exchange is restricted or prevented due to building of the sand bar across the river mouth. When the mouth closes, a sharp pycnocline or salinity gradient persists separating the surface layer of freshwater from saline water in mid-water and bottom water. The static, saline water mass absorbs heat from solar radiation which results in the meromictic condition. Seasonal meromixes was first detected in the upper sampling sites as the mouth was in the process of closing in 1996 and 1997 and was observed at downstream sites after the lagoon formed. Under meromictic conditions, water temperatures reached as high as 30C° and dissolved oxygen (DO) concentrations in bottom water approached 0.0 grams per milliliter (g/mm). These environmental factors limit the amount of estuarine habitat available for salmonids and other components of the estuarine ecosystem. Under meromictic conditions, surface waters are cooler than the underlying saline layer and it contains sufficient DO for fish respiration We found that Steelhead avoid high temperatures and low DO in the lagoon by seeking refuge in the surface and nearshore waters, and by moving into areas upstream. At this time the incoming freshwater inflows are important to deliver relatively cool and oxygenated water to the lagoon.

Dissolved Oxygen

Dissolved oxygen concentrations collected from the Navarro River estuary fish sampling sites are presented in Table Al, Appendix. Salmonids generally function normally at dissolved oxygen concentrations of 8 milligrams/liter (mg/1); exhibit distress systems at or below 6mg/l; and may be negatively affected by concentrations below 4 mg/1 (Barnhart 1986). Dissolved oxygen concentrations of less than 4 ppm generally indicates poor environmental conditions for salmonids and other aquatic species.

Prior to lagoon formation on September 20, 1996, dissolved oxygen (DO) levels were sufficient for juvenile salmonid functioning in rearing habitat. However, after the lagoon formed, DO dropped to critically low (1-3 mg/1) or to anoxic levels in water at or below 2 meters in depth. In 1997, critically low DO was detected in bottom water in August before the lagoon formed (Table 1 Appendix). The low DO concentration we observed was related to the loss of tidal flows, decreased circulation, and stratification by salinity of the water column associated with lagoon formation. Dissolved oxygen concentration increased in the water column as oxygenated freshwater inflows increased the depth of the lagoon and replaced anoxic saline water along the nearshore shallow areas. The freshwater inflows bringing oxygenated water into the estuary is important to prevent the potential mass die off of aquatic organisms due to lack of oxygen (Smith 1990). Anoxic conditions may persist in bottom water until a freshet breaches the sand bar. The return of tidal circulation and increased river flows introduces oxygen throughout the water column as shown for October 16, (Table Al, Appendix) after the sand bar was breached on October 12, 1997. The Sand bar re-formed by October 28 and low DO levels were again recorded from bottom water on November 14. The sand bar was breached again on November 15 during a freshet and it remained open after that date.

Temperature

Water temperature profiles varied among seasons and locations in the estuary (Tables A-2 to A-13, Appendix). Interactions between channel depth, salinity, tides, circulation patterns, weather conditions, and lagoon formation also affect the temperature within the water column. For most of the year temperature regimes mainly reflect the influence of both riverine and marine water masses. Mixing of these water masses within the channel habitat creates a temperature structure which varies according to the contribution of each water mass (Simenstad 1983). Under lagoon conditions, the saline water absorbs heat and an inverse temperature structure persists until tidal exchange is resumed by breaching of the sand bar,

We measured water temperatures in the estuary ranging from 7.5 C° in January, 1997 to 30C° on September 10,1997 when seasonal meromixis was most pronounced. The lowest and highest temperatures were observed in the upper estuary sites. The lower sites exhibited the least amount of temperature variation. Temperatures generally increased with distance upstream from the river mouth and decreased with increasing depth until the lagoon formed.

In 1996, the most pronounced difference in temperature in the water column was observed in the upper sites. The lower water column temperature was as much as 11 C° higher than surface temperature (11 C° Vs 22 C°) on November 6 at the U-3 site in the upper estuary zone (Table A-4, Appendix). During October and November, at the deeper sites in the middle and lower estuary zones, the highest water temperatures were recorded from the mid to lower portions of the water column, bottom water was cooler, and the coldest temperatures were measured at the surface. The lower water column temperature was as much as 11 C° higher than surface temperature (11 C° Vs 22 C°) on November 6 at the U-3 site in the upper estuary zone (Table A-4, Appendix) Surface water temperature was noticeably cooled due to direct exposure to cool air temperatures in November. On September 10,1997 the highest water temperature (30C°)occurred in the bottom water while surface temperature was 21C° at sites U-2 and U-l (Tables A2 and A3, Appendix).

Salinity

Predominant characteristics of the estuary are the dynamic mixing patterns of freshwater and seawater. The merging of river flows and tidal seawater produces vertical and horizontal salinity gradients that vary from oligosaline fresh, oligosaline marine, highly stratified, linear increases of salinity with depth, and well mixed water masses (Tables A2 - A13, Appendix). The extent of the salinity gradients are influenced by seasonal variation in river discharge, daily tidal cycles, channel morphology, lagoon formation, weather conditions, and by the distance upstream from the river mouth. Generally, surface water salinity decreased with increasing distance from the river mouth and increased with depth. Salinity of the surface water gradually increased in the middle and upper sites as river flows declined in summer and fall seasons. The salinity significantly decreased in the surface waters at all sites in the estuary after the lagoon formed. The strongest pycnoclines were observed from the upper sites during summer months, from the lower sites in winter and at all sites under lagoon conditions. At a secondary level, salinity can be influenced by bathymetry. This was observed in summer when dense, marine water pushed upstream during high tides was impounded in deep water or pools in the middle and upper estuary zones. At these relatively deep sites, saline water masses, meromictic conditions and low dissolved oxygen levels remained longer than shallower areas of the estuary channel.

Channel Cross Sections

Cross-sectional profiles of the estuarine channel surveyed in 1996 and 1997 are shown in Figures A27 - A3 6, Appendix. Overlays of the channel cross-sections indicate sediments were scoured by 1997 river flows at sites L-2, Bridge, M-l, M-3, U-2, and U-3. None of the sites show signs of excessive deposition. However, we moved fish sampling site L-4 (which was not surveyed for a bottom profile because of its orientation) upstream about 100 m from its original location because an accumulation of sands made the site too shallow for effective seining. Concurrently, silt and fine sands which characterized nearshore portions of site L-3 in 1996 were scoured, revealing sediments composed of cobble and small boulders in 1997.

The movement of bed-load sediments are controlled by interactions between particle size, channel morphology, and flow conditions (Leopold et al. 1964). During storm events, extensive bed-load movement may occur if the energy conveyed to the channel bed is great enough (Swanston 1991). The energy to mobilize embedded gravel and larger sized particles in the estuary occurs for brief periods of flushing flows during peak runoff periods in winter. Sands and silt are transported during lower river flows and by tidal currents. In order to assess if sediments are accumulating in the estuary over the long term monitoring of bed-load movements should be continued.

Conclusions

Estuaries play important roles in production of anadromous salmonids and other fisheries resources which contribute to California's economy, biodiversity, and aesthetic values. There are a number of studies which emphasize the importance of west coast estuaries as juvenile salmonid rearing habitat, but few are focused on California's steelhead trout or coho salmon. This study provides insight into the complexities of the Navarro River estuary and how spatial and temporal changes in water quality and fish behavioral patterns affect juvenile salmonid distribution and production or growth.

This study documents seasonal distribution and the relative abundance of steelhead trout, coho salmon and other fish species from the Navarro River estuary/lagoon. It also shows that the Navarro River estuary/lagoon provides habitat year round for steelhead. The estuary is particularly important in summer and fall seasons when river headwaters and tributaries have low stream flows and high water temperatures that limit the carrying capacity, especially for larger fish. Furthermore, many steelhead continue to utilize the estuary over winter months before migrating to the ocean in the spring or remain in the estuary another year. These data lead to the conclusion that the Navarro River estuary provides important year round habitat for steelhead and that steelhead have adapted a unique behavioral pattern to utilize the estuarine ecosystem. This adaptation to a local environment could be recognized as an "evolutionary legacy" to describe uniqueness of a population (McEwan 1996).

Spatial and temporal changes in water temperature, salinity and dissolved oxygen are important environmental factors that influence distribution of salmonids and other organisms both in the vertical water column and along a gradient extending upstream from the river mouth. Fish cope with changing water quality by moving to a more favorable environment, or by making physiological adaptations. However, if conditions are too rigorous, they may die. We found that Steelhead avoid high temperatures and low dissolved oxygen levels in the lagoon by residing into the upper water column, and by moving into areas further upstream. At this time the incoming freshwater inflows are particularly important to deliver relatively cool and oxygenated water to the lagoon. Large woody debris also is an important component to provide cover for fish high in the water column.

Perhaps the most important difference between the two years of this study was the lower river flows in the summer of 1997 which probably led to the earlier lagoon formation and associated changes in water quality. Steelhead production as measured by length-weight relationships was generally higher during the summer and fall of 1996 compared to 1997. The slowest steelhead change in length in 1996 was estimated for the period as the estuary transforms into a lagoon. A similar trend is shown in length-weight relationships for the lagoon transition period in 1996 and 1997. Steelhead lost weight during the winter months when growth may be slowed by cold water temperatures and reduced food availability. It is not known how steelhead densities in the estuary influenced the differences in growth between the two years and we did not investigate the abundance of food sources. These are important topics for future research and were not within the scope of this study. However, the total steelhead catch per unit effort (CPUE) for all beach seine sites June to October in 1996 was 8.4 steelhead per seine and for June to October 1997 the CPUE was 7.7 steelhead per seine. The CPUE suggests steelhead densities were similar between the two years and the differences in length-weight relationships is probably not due to density dependent growth. The differences in length-weight relationships appears to be related to lower summer river flows and earlier lagoon formation in 1997.

The deepest portions of the estuary may provide valuable fish habitat for most of the year but became unsuitable in late summer and fall due to high temperatures and anoxic conditions associated with lagoon formation and seasonal miromixis. At this time steelhead rely on the shallow, nearshore areas and the mid and surface waters of the channel. Large wood functions as cover to protect fish from predators when they are confined to shallow areas. Fish may make temporary excursions into warm, anoxic conditions, but will not survive there for extended periods. High water temperatures and low dissolved oxygen levels may initiate a shift from feeding on epibenthic amphipods to drifting invertebrates and pelagic larval fishes.

Freshwater inflows into the lagoon are extremely important for delivery of oxygenated and relatively cooler water and to provide a source of circulation in the lagoon surface waters (Smith 1991). Restoration efforts in the watershed which result in reducing river water temperatures and increasing flows will benefit the estuary especially during the critical processes involving lagoon formation.

Because of the broad spectrum of abiotic and biotic conditions found in estuarine systems, and the diversity of behavioral patterns observed in anadromous salmonids, each estuary along the coast may support a salmonid population with a distinct estuarine utilization pattern. Although, the adaptive significance of different patterns of estuarine residence are not well understood for steelhead trout or coho salmon, our data indicate coho salmon smolts utilize the area for rearing, and for behavioral and physiological adaptations before ocean entry and a substantial number of juvenile steelhead rely on the Navarro River estuary for rearing habitat for a significant portion of their early life history.

The final objective for this study was to identify areas for habitat improvements that will benefit the estuarine ecosystem and salmonid production. In my opinion, the Navarro River estuary is in a state of recovery from events that occurred in the late 1800's and early 1900's. However, excessive sediments may be accumulating in portions of the estuary and the amount of large wood present may be less than in the pre-settlement era. Unlike many estuarine systems on the west coast, the Navarro River estuary is relatively isolated from industrial, commercial, and agricultural uses. Therefore, the area has retained much of its natural form and function.

Areas in the estuary that may be protected from erosion and slumping of banks by planting riparian vegetation and placement of woody debris include the east tip of the island and along the south channel bank just below the HWY 1 Bridge. The north bank at road marker 1.62 of HWY 128 has a problem with undercutting of the bank, willows may not be rooting through geotextile material, and rip rap is beginning to fall into the channel. Additional studies are needed to determine if water quality can be improved in the lagoon. Yearly surveys of channel cross-sections will provide data describing bathymetry and sediment characteristics. Further studies of the slough channels and wetlands located along the flats near the HWY 1 Bridge may reveal potential for habitat restoration. Unfortunately, road work conducted on HWY 1 south of the bridge resulted in sliding of soils across the beach access road during early fall rains. Much of the soil may end up in the wetland.

The estuary and wetlands are unique in character and considered rare habitat in California. The area is vulnerable to current and future land and water use practices in the watershed that potentially threaten the integrity of the estuarine ecosystem. Excessive accumulation of sediments in the estuary would reduce the tidal prism and probably contribute to early formation of the sand bar across the river mouth. Stabilizing upstream hill slopes and reducing upstream water temperatures by restoring the riparian corridor along the river and tributaries and will indirectly benefit the estuary/lagoon. A water management plan should be developed to coordinate water diversions that considers estuarine water quality, all life history stages of coho salmon and steelhead, and hydrologic processes.

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Table Al. Dissolved oxygen (DO) concentrations (mg/1) measured from the Navarro River Estuary. * indicates DO concentraion at the bottom of the channel.

Date	Depth	Site L-4	L-2	M-3	M-l	U-2
7/23/96	surface	8			10	
	1					
	1.5	8*				
	2		8*			9
	2.5					
	3					
	3.5				10*	
	4					
	4.5			8*		

Date	Depth	Site L-2	B	U-3	U-l
8/13/96	surface		8		7
	1				
	1.5				9*
	2				
	2.5		8*	11	
	3	7*			

Date	Depth (M)	Site M-l
9/4/96	surface	
	1	
	1.5	
	2	
	2.5	
	3	
	3.5	
	4	8*

mouth Date	closed Depth (M)	Site B	M-3	U-2
9/24/96	surface	8	8	9
	1			
	1.5	8		9
	2			
	2.5	8*	6*	8*

Table Al. Dissolved oxygen (DO) concentrations (mg/1) measured from the Navarro River Estuary. * indicates DO concentraion at the bottom of the channel.

mouth	closed	Site								
Date	Depth	L-4	L-3	L-2	L-l	B	M-3	M-2	M-l	U-3
10/11/96	surface	7	8			10				
	1	5								8
	1.5									
	2	1*		1	1*	4		4		
	2.5		1*							
	3						0*			1*
	3.5					1*				
	4									
	4.5			1*						
	5								0	

mouth	closed	Site							
	Depth	L-4	L-3	L-2	L-l	M-3	M-2	M-l	U-2
10/16/96	surface					10			
	1	8*					9		
	1.5				10				
	2		7	10	2.5*	4	2.5	1	
	2.5		1*	4.5		1*			
	3			1					1*

mouth	closed	Site							
Date	Depth	L-4	L-2	L-l	B	M-3	M-2	M-l	U-l
10/30/96	surface	6							
	1							10	
	1.5	7*							9
	2		10	9		11			
	2.5						6		1
	3		7	1*		1*	3*	1.5	
	3.5								
	4		1*		1*			1	

Table Al. Dissolved oxygen (DO) concentrations (mg/1) measured from the Navarro River Estuary. * indicates DO concentraion at the bottom of the channel.

mouth	closed	Site				
Date	Depth	L-2	L-l	M-3	M-l	U-2
11/6/96	surface					
	1					
	1.5					8
	2	8	11	7	8	
	2.5					4
	3	4*		4*	1.5	
	3.5					4*
	4				1*	

mouth	closed	Site		
Date	Depth	L-2	M-2	U-2
11/18/96	surface			
	1			
	1.5			6
	2	9	8	
	2.5			
	3	5	1*	1*
	3.5			
	4	1*		

mouth	open	Site	
Date	Depth (M)	M-l	U-3
12/19/96	surface	8	10
	1		
	1.5		
	2		
	2.5		
	3	7*	10*

		Site
Date	Depth (M)	M-3
	surface	
1/15/97	1	
	1.5	
	2	
	2.5	
	3	
	3.5	8*

Table Al. Dissolved oxygen (DO) concentrations (mg/1) measured from the Navarro River Estuary. * indicates DO concentraion at the bottom of the channel.

Date	Depth (M)	Site L-2
2/17/97	surface	
	1	7
	1.5	
	2	
	2.5	7*

Date	Depth (M)	Site M-l
3/14/97	surface	
	1	
	1.5	9
	2	
	2.5	
	3	
	3.5	
	4	
	4.5	9*
	5	

Table A-2.- Sampling dates and verticle water quality profiles collected from the Navarro River estuary May 20,1996 - December 3,1997.

Site U-1

Site U-1	5/21/96	6/11/96	7/2/96	7/23/96	8/13/96	9/4/96	9/24/96	10/11/96	10/16/96	10/30/96	11/6/96	11/18/96	11/25/96	12/19/96	2/17/97	2/27/97	3/14/97	3/26/97	4/8/97	4/23/97	5/7/97	5/21/97	6/4/97	6/23/97	7/7/97	7/15/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/24/97	9/30/97	10/9/97	10/16/97	10/25/97	11/3/97	11/14/97	12/3/97
Temperature (C°)																																										
Surface	16	23	23	24	23	21	19	21	16	13	12	13	14	8	12	11	12	16	15	17	21	22	22	22	24	24	22	24	24	23	23	25	26	26	22	21	17	16	15	16	14	10
.5M(1)																									23	24	21	24	24	23	24	28	26	26	22	21	17	17	17	16	13	10
1 M	16	23	23	25	22	20	24	22	20	15	14	13	14	8	12	11	12	16	15	17	20	21	23	21	23	25	20	23	24	24	24	27	29	28	23	22	19	17	17	16	14	10
1.5M		23					25	25	23	17	17	13	14	8		11	12	16	15		21	22	19	21	23	25	20	23	24	23	23	25	28	32	24	26	19	16	16	16	14	10
2M	16		21	26	21	20	25	26	25	20	19	14	14	8				16	15		19		18	20	21	25	20	22	23	23	23	24	28	32	29	28	20	16	16	17	16	10
2.5 M								27	25		23	18							15						21				23		22		27	30	31	29	25			19	18	10
3M											25	23																							31	30	28			20	19	10
3.5 M												24																							30		28					
Salinity (ppt)																																										
Surface	0	0	2	0	6	8	7	6	6	1	0	1	1	0	0	0	0	0	0	1	1	2	1	2	11	1	5	4	10	3	4	7	10	9	3	4	1	8	2	1	0	0
.5M																									16	10	18	10	14	3	28	26	10	14	3	5	1	10	29	4	0	0
1 M	0	0	2	26	25	28	24	12	12	6	3	2	1	0	0	0	0	0	0	1	1	20	1	17	17	22	21	22	27	30	28	29	28	19	10	9	8	17	27	17	4	0
1.5M		0					31	18	19	7	6	2	22	0		0	0	0	0		1	25	22	19	20	22	21	24	28	29	29	29	29	29	14	17	9	22	28	21	9	0
2M	0		27	26	25	28	30	26	29	10	9	4	22	0				0	0		15		23	19	22	22	21	24	28	30	28	30	28	29	25	22	18	23	28	25	17	0
2.5 M								27	30		18	7							0						22				28		29	30	30	30	28	27	23			28	25	0
3M											27	23																							28	28	26			28	26	0
3.5 M												26																							28		28			28		
Tide height (ft.)(2)	4	2	4	5	3	5	1	1	5	3	1	3	3	4	0	4	4	4	4	3	4	3			5	3	5	3	5	3	5		3	5	5	2		1	2	5		
Tide(3)	HS	F	E	F	E	F	LS	E	E	E	LS	F	E	E	LS	HS	F	E	E	E	E	E			E	F	F	LS	F	F	E		E	F	F	E		E	LS	E		

(1)Meters below surface.

(2)Tides predicted for Albion CA

(3)Flood (F), Ebb (E). High Slack (HS), Low Slack (LS).

Table A-3.- Sampling dates and verticle water quality profiles collected from the Navarro River estuary May 20,1996 - December 3,1997.

U-2

Site U-2	5/21/96	6/11/96	7/2/96	7/23/96	8/13/96	9/4/96	9/24/96	10/11/96	10/16/96	10/30/96	11/6/96	11/18/96	11/25/96	12/19/96	2/17/97	2/27/97	3/14/97	3/26/97	4/8/97	4/23/97	5/7/97	5/21/97	6/4/97	6/23/97	7/7/97	7/15/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/24/97	9/30/97	10/9/97	10/16/97
Temperature																																						
Surface	16	22	23	23	22	21	18	20	16	13	12	14	14	8	8	12	11	11	16	16	17	20	21	22	23	23	22	23	26	25	21	21	17	16	15	16	13	10
.5M[1]																								22	23	23	23	24	29	25	21	21	17	16	16	16	13	10
1 M	16	22	23	26	22	20	23	23	20	14	14	12	14	8	8	12	11	11	16	15	17	19	20	21	22	24	23	23		29	22	21	19	16	16	16	14	10
1.5 M								24	23	16	17	12	13	8	8			11	16	15	17	19	20	20	21	24	23	23	26	28	24	26	19	16	16	16	14	10
2M	16	23	21	26	21	19	25	25	24	20	18	14	13	8		12	11	11	16	15	17	18	20	19	22	22	21	22	24	27	28	28	23	16	16	18	16	10
2.5 M					20		25	27	25	24	23	18	13				11		16	15	17	18			22	22	21	22	24	27	30	29	26	16	16	19	18	10
3M										25	25	23					11			15	17	17			22	22	21	22	24	26	30	30	27				18	10
3.5 M											25	24																			30	30	28				19	
4M																															29	30					19	
Salinity (ppt)																																						
Surface	0	0	3	0	7	8	8	5	6	1	1	1	1	0	0	0	0	0	0	0	1	2	2	7	5	15	3	5	8	10	4	3	1	8	1	1	0	0
.5M																								10	13	22	4	28	28	11	4	4	7	17	27	8	2	0
1M	0	0	9	27	25	29	24	17	13	5	4	2	19	0	0	0	0	0	0	0	1	3	19	18	23	28	30	28	29	29	11	7	8	21	27	16	4	0
1.5M								20	20	7	6	2	23	0	0			0	0	0	1	4	24	21	25	28	29	29	30	29	14	17	9	23	27	23	9	0
2M	0	23	27	27	27	30	30	25	28	11	10	4	24	0		0	0	0	0	0	1	19	25	22	25	28	30	29	30	30	25	22	18	23	28	26	17	0
2.5 M					27		30	27	31	22	21	8	24				0		0	0	1	20			26	29	30	29	30	30	27	25	23	24	28	27	24	0
3M										26	21	22					0,			0	1	18			26	29	30	29	30	30	29	26	27				26	0
3.5 M											27	25																			29	27	29				27	
4M																															28	26					28	
Tide height	4	2	4	5	3	5	2	2	5	5	2	3	5	3	3	0	4	3	4	4	3	4	3		3	4	3	5		3	4	2			2	5		
Tide[3]	HS	HS	E	F	E	F	E	E	E	HS	LS	F	E	E	F	LS	HS	F	E	E	E	E	E		LS	E	F	E		E	F	E			LS	E		

(1) Meters below surface (M).
(2) Tides predicted for Albion CA.
(3) Flood (F), Eeb (E), High Slack (HS), Low Slack (LS).

Table A-4. Sampling dates and verticle water quality profiles collected from the Navarro River estuary May 20, 1996 - December 3,1997.

Site U-3

Site U-3	5/20/96	6/11/96	7/2/96	7/23/96	8/13/96	9/4/96	9/24/96	10/11/96	10/16/96	10/30/96	11/6/96	11/18/96	11/25/96	12/19/96	1/15/97	2/17/97	2/27/97	3/14/97	3/26/97a	3/26/97b	4/8/97	4/23/97
Temperature (C°)																						
Surface	18	20	21	20	22	21	20	17	20	15	13	11	13	8	8	12	10	12	15	16	14	17
.5M">																						
1M	18	19	20	17	24	19	16	19	21	19	14	12	13	8	8	12	10	12	14	16	14	17
1.5 M	18						16	22	24	23	15	15	12	8	7		10	12	13	16	14	17
2M		19	18	16	22	18	16	21	24	22	20	18	14	8	7	12	10	11	12	15	14	17
2.5 M					21	19	16	20	23	3	22	21	18	8	7	12	10	11		15	14	
3M											23	22	21	8	7		10	11	11	15	13	
3.5 M											22	22	22							15	13	
4M																						
4.5 M																						
5M																						
Salinity (ppt)																						
Surface	0	0	7	2	1	16	12	10	4	7	1	1	1	0	0	0	0	1	1	0	0	2
.5M																						
1 *M*	0	15	20	28	30	29	32	22	11	13	5	2	1	0	0	0	0	1	4	0	0	2
1.5M	0						33	30	19	20	7	5	2	0	0		0	1		0	0	2
2M		26	30	29	31	31	33	31	24	25	12	11	4	0	0	0	0	1	25	0	2	2
2.5 M					30	30	33	33	27	25	19	18	8	0		0	0	1		0	4	
3M											25	23	20	0	0		0	1	26	0	19	
3.5 M											26	27	25							0	21	
4M																						
4.5 M																						
5M																						
Tide height (ft.)'2*	4	2	*5*	0	4	4	4	2	2	6	5	2	2	2	2	0	4	3	4	4	4	4
Tide 13'	F	LS	E	F	F	E	F	E	E	HS	E	E	F	E	F	LS	F	F	F	E	E	E

Site U-3	5/7/97	5/21/97	6/4/97	6/23/97	7/7/97	7/15/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/24/97	9/30/97	10/9/97	10/16/97	10/25/97	11/3/97	11/14/97	12/3/97
Temperature (C°)																						
Surface	18	19	22	22	24	22	22	22	22	22	24	25	25	24	20	20	17	16	14	16	13	11
.5M">					23	21	20	21	22	22	22	27	25	25	20	20	17	16	14	16	13	11
1M	18	18	21	19	22	19	19	21	22	22	22	25	28	26	20	19	18	16	15	16	13	11
1.5 M	17	18	19	18	20	19	18	19	21	21	21	23	27	28	24	20	18	16	15	16	14	10
2M	17	18	17	18	20	13	18	19	20	19	20	22	26	28	28	23	21	16	15	17	17	11
2.5 M	15	18	17	17	19	18	18	19	20	19	20	22	25	27	29	26	25	16	15	17	18	11
3M	15	17	16	17	19	18	18	19	19	19	20	21	23	25	29	27	26	16	15	18	18	11
3.5 M	15	17				18		19	19	18	20	21	23	24	27	27	26	15	15	17	18	11
4M											20	21	22	23	26	27	26		15	17	18	12
4.5 M																26	25				18	
5M																24	24					
Salinity (ppt)																						
Surface	5	7	7	5	14	3	10	9	26	7	4	8	9	4	4	4	1	18	13	2	0	1
.5M					15	15	20	21	26	10	28	29	14	15	6	5	4	19	26	8	0	1
1 *M*	7	25	9	22	18	25	22	26	27	29	30	29	27	18	10	6	8	20	28	16	4	1
1.5M	14	27	21	25	28	26	24	28	29	29	30	29	30	28	13	8	9	21	28	24	7	1
2M	17	29	29	25	28	27	25	28	29	30	30	30	30	29	24	19	16	22	23	27	18	3
2.5 M	25	29	29	25	28	27	25	28	29	30	30	30	30	29	25	24	23	22	28	27	24	6
3M	26	30	30	25	29	27	25	28	30	30	30	30	31	30	28	24	23	23	28	28	25	8
3.5 M	26	30				27		28	30	30	30	30	31	30	29	28	28	24	28	28	26	14
4M											30	30	30	30	29	29	29		28	29	27	15
4.5 M																29	29				28	
5M																30	29					
Tide height (ft.)'2*	5	4			5	4	4	3	5	3	6	3	4	4	4	2	5		2	6		
Tide 13'	E	E			HS	F	F	LS	E	LS	E	E	E	F	F	E	F		LS	«		

(1)Meters below surface (M).

(2)Tides predicted for Albion CA.

[3]Flood (F). Ebb (E), High Slack (HS), Low Slack (LS).

Table A-5. Sampling dates and verticle water quality profiles collected from the Navarro River estuary May, 20 1996 - December 3,1997.

Site M-1

Site M-1	5/20/96	6/11/96	7/2/96	7/23/96	8/13/96	9/4/96	9/24/96	10/11/96	10/16/96	10/30/96	11/6/96	11/18/96	11/25/96	12/19/96	1/15/97	2/17/97	2/27/97	3/14/97	3/26/97a	3/26/97b	4/8/97	4/23/97
Temperature (C°)																						
Surface	16	20	20	22	20	18	18	18	15	13	11	13	14	9	8	12	10	13	15	15	18	18
.5[1]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1 M	16	17	16	23	16	16	17	18	17	13	11	12	13	8	7	12	10	12	15	15	17	15
1.5M								22	19	14	12	12	12	8	7	12	10	11	15	14	16	14
2M		15	15	19	15	15	21	24	22	17	16	12	12	8	7	12	10	11	14	13	14	14
2.5 M	14		15	18	15	15	20	23	22	22	20	17	12	8		12	10	11	14	12	14	14
3M								23		23	22	20	12	11		12	10	11	13	12	13	13
3.5 M								23		22	22					12	10	11	12	12	13	13
4M								20		21	21					12	10	10		12	13	
4.5 M								18			20						10	10		12	13	
5M								18			19						10					
Salinity (ppt)																						
Surface	0	2	7	1	19	17	16	6	8	1	2	2	5	0	0	0	0	1	0	4	0	14
.5M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1 M	1	27	29	27	32	32	21	10	13	4	2	2	28	0	0	0	0	1	0	7	1	29
1.5 M								16	16	6	3	2	28	0	0	0	0	22	0	21	2	31
2M		29	31	31	33	32	31	22	23	9	8	3	28	4	1	0	0	25	8	25	18	31
2.5 M	28		31	31	33	32	32	25	28	18	14	8	28	4		0	0	25	8	27	25	32
3M								27		23	22	15	28	28		0	13	25	22	27	26	32
3.5 M								29		26	25					0	14	25	24	27	27	32
4M								29		28	28					0	15	26		27	27	
4.5 M								29			29						15	26		27	28	
5M								29			30						15					
Tide height (ft.)[2]	3	2	5	4	4	4	3	4	6	5	2	2	6	1	2	1	4	2	4	5	4	5
Tide[3]	F	E	HS	F	E	F	E	E	HS	E	E	LS	E	E	F	E	F	F	S	E	E	HS

Site M-1	5/7/97	5/21/97	6/4/97	6/23/97	7/7/97	7/15/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/24/97	9/30/97	10/9/97	10/16/9	10/25/97	11/3/97	11/14/97	12/3/97
Temperature (C°)																						
Surface	19	20	20	21	21	20	21	22	21		22	24	25	24	20	21	17	15	14	15	14	11
.5[1]	-	-	-	21	21	20	21	22	20		22	25	25	24	20	20	18	15	14	15	13	11
1 M	16	17	17	19	IB	19	20	21	21		21	23	25	24	20	19	18	15	15	16	13	12
1.5M	16	16	16	17	17	17	19	21	19		19	21	27	28	24	23	17	15	15	16	13	13
2M	15	16	15	17	16	16	18	20	18		18	20	27	29	26	26	20	15	15	16	16	13
2.5 M	15	15	15	16	16	16	18	19	18		19	20	25	28	28	27	23	15	15	17	18	14
3M		16	15	16	16	16	17	18	17		19	20	23	26	28	27	24	15	15	17	18	
3.5 M			15	16	16	16	17	18	17		19	19	22	24	28	27	26	15	14	17	18	
4M			14	16	15			18	17		19	19	20	22	25	26	26	15	14	17	18	
4.5 M			14	16	15			18	16				19				25	15	13		18	
5M				16	15			17									23				18	
Salinity (ppt)																						
Surface	13	9	8	14	10	11	17	27	12		6	11	14	6	7	4	1	23	8	2	1	1
.5M	-	-	-	16	11	12	17	27	19		29	30	14	9	7	6	5	23	24	3	1	1.
1 M	27	25	26	24	28	22	25	27	30		30	30	23	15	7	8	7	23	28	15	3	18
1.5 M	28	27	27	28	28	26	28	28	30		31	31	28	26	14	18	8	23	28	20	7	20
2M	28	28	28	28	29	27	29	29	30		31	31	29	29	22	22	16	23	28	27	16	24
2.5 M	28	28	28	29	29	28	29	30	30		31	31	29	29	26	23	23	24	28	28	24	24
3M		28	28	29	29	28	29	30	30		31	31	30	30	28	28	23	24	28	29	25	
3.5 M			28	29	29	28	30	30	30		31	31	30	30	28	28	27	25	29	29	27	
4M			29	29	29			30	31		31	31	31	30	29	29	28	25	29	29	27	
4.5 M			29	29	29			30	32			31	31				29	25	29		28	
5M				29	29			30				31					29				28	
Tide height (ft.)[2]	4			4	3	4	3	5	3		6	3	4	4	3	2	4	3	2	6		
Tide[3]	E			F	LS	F	E	HS	LS		HS	E	E	F	F	E	F	E	E	HS		

(1)Meters below surface.

(2)Tides predicted for Albion CA.

(3)Flood (F), Ebb (E), High Slack (HS). Low Slack (LS).

Table A-6. Sampling dates and verticle water quality profiles collected from the Navarro River estuary May 20,1996 - December 3,1997.

Site M-2

Site M-2	5/20/96	6/11/96	7/2/96	7/23/96	8/13/96	9/4/96	9/24/96	10/11/96	10/16/96	10/30/96	11/6/96	11/18/96	11/25/96	12/19/96	2/17/97	2/27/97	3/14/97	3/26/97b	4/8/97	4/23/97	5/7/97	5/21/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/24/97	9/30/97	10/9/97	10/16/97	10/25/97	11/3/97	11/14/97	12/3/97
Temperature (C°)																																						
Surface	18	19	20	21	20	18	15	18	16	13	11	13	13	9	12	10	11	15	14	17	17	18	20	20	21	20	22	23	24	23	21	20	18	-	13	16	13	11
.5M[1]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	20	21	20	22	23	24	23	20	20	17	-	13	15	13	11
1M	17	16	17	21	16	16	16	18	16	13	12	12	12	8	12	10	10	15	14	16	14	16	17	20	20	20	21	23	25	23	20	20	17	-	15	15	13	11
1.5 M						15	20	19	19	13	13	12	12		12	10	10	15	13	15	14	15	16	19	18	20	19	21	26	28	22	24	17	-	15	16	13	12
2M	15	13	14	16	15		20	23	22	18	15	12	12		12			12	12	13	13	15	15		18	18	19	20	25	29	25	25	21	-	15	17	16	14
2.5 M								23	22	21	20	17						12							17		19		25	28	28	27	24	-		17	17	14
3M										22	22	20																			28	27	26	-		18	18	14
Salinity (ppt)																																						
Surface	1	3	6.5	2	19	19	17	6	7	2	2	1	6	2	0	1	2	2	8	2	13	17	14	19	27	13	7	15	19	6	7	5	1	-	12	2	1	1
.5M																							15	19	27	20	25	28	19	7	7	6	6	-	24	3	1	1
1 M	1	27	*28*	30	32	33	22	10	2	4	2	2	27	2	0	3	29	2	19	3	29	30	27	25	28	29	29	30	27	16	8	7	6	-	28	15	3	8
1.5 M						33	30	17	15	5	5	2	29		0	17	29	2	24	18	30	31	28	28	30	29	30	31	30	26	14	18	8	-	28	22	8	15
2M	10	31	31	33	32		30	23	24	10	8	3	29		0			26	27	27	32	32	28		30	30	31	31	31	25	20	22	17	-	28	25	18	26
2.5 M								24	27	17	14	7						27							30	-	31		31	29	27	23	21	-		26	24	26
3M										21	19	16																			27	27	23	-		27	26	26
Tide height (ft.)[2]	4	3	5	3	5	3	4	4	6	5	3	2	6	1	1	3	2	4	5	4	5	4		3	5	3	6	3	5	4	3	4	4	3	3	6		
Tide[3]	HS	E	HS	F	E	F	E	E	HS	HS	E	LS	HS	E	E	F	F	HS	HS	HS	HS	HS		E	HS	LS	HS	E	E	F	F	E	F	E	E	HS		

[1]Meters below surface (M)

[2]Tides predicted for Albion CA.

[3]Flood (F), Ebb (E), High Slack (HS), Low Slack (LS).

Table A-7. Sampling dates and verticle water quality profiles collected from the Navarro River estuary May 20,1996 - December 3,1997.

Site M-3

Site M-3	5/20/96	6/11/96	7/2/96	7/23/96	8/13/96	9/4/96	9/24/96	10/11/96	10/16/96	10/30/96	11/6/96	11/18/96	11/25/96	12/19/96	2/17/97	2/27/97	3/14/97	3/26/97b	4/8/97	4/23/97	5/7/97	5/21/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/24/97	9/30/97	10/9/97	10/16/97	10/25/97	11/3/97	11/14/97	12/3/97					
Temperature (C°)																																											
Surface	18	19	20	22	20	20	18	17	19	15	13	12	13	13	9	7	11	10	11	13	16	17	18	19	20	22	20	20	20	21	19	21	23	24	24	20	19	18	17	13	15	13	11
.5 M">																										20	20	20	20	21	19	22	23	24	24	20	20	17	16	14	15	13	11
1 M	16	14	18	16	19	17	15	17	18	16	13	12	13	12	9	7	11	10	10	12	15	14	16	17	15	16	17	17	19	20	19	21	23	25	24	20	20	17	16	14	15	13	11
1.5 M									21	19	14	15	12	12	9	7	11	10	10	12	15	13	15	16	14	15	15	16	17	18	18	19	22	26	28	21	22	17	16	14	16	13	14
2M	15	13	16	15	15	15	14	21	23	22	18	18	12	12	9	8	11	10	10	11	13	12	15	16	13	14	15	15	17	18	18	19	21	25	29	27	26	20	15	14	1B	16	14
2.5 M	14	13	14		15	15	14	19	22	21	21	20	16	12	11	10	11	10	10	11	13	11	15	15	13	14	15	15	17	17	17	19	20	24	27	28	27	26	15	14	17	18	14
3M									21	20	22	21		12	11	10	11	10	10	10	13		14	14	12		15	15	17	17	17	19	19	22	26	28	27	26	15	14	17	18	14
3.5 M														12		10	11	10	10	10	13				12		14	15	16	17	16	18	19	21	24	27	26	26	15	14	17	18	14
4M																															16	18	19	20	22	25	26	25			17	18	14
4.5 M																																			20		24					18	
5M																																					21						
Salinity (ppt)																																											
Surface	1	5	5	4	2	21	21	18	6	7	2	1	1	5	3	2	0	0	2	13	2	13	16	10	8	15	10	14	19	27	20	7	15	15	6	7	5	2	21	8	2	1	1
.5M																										21	14	16	19	29	21	27	21	16	13	7	7	8	22	24	5	1	1
1 M	17	29	28	28	31	31	33	20	10	12	4	2	1	26	3	1	1	11	25	26	6	28	27	25	28	28	28	27	27	29	29	29	30	23	15	7	8	8	25	29	15	3	10
1.5 M									17	17	7	5	2	29	7	1	1	22	25	29	19	30	30	27	28	29	29	28	29	30	30	31	30	30	26	12	16	9	25	29	22	9	24
2M	25	31	30	29	32	32	33	29	22	23	10	8	2	29	23	22	9	25	28	31	26	31	31	28	29	30	29	29	29	31	30	30	29	30	29	23	21	18	26	29	27	17	26
2.5 M	27	31	31		32	33	33	30	25	28	17	14	6	30	*30*	27	19	25	28	32	26	31	31	29	29	30	29	29	29	31	30	30	30	30	29	27	23	22	26	29	27	25	26
3M									26	30	24	19		30	30	28	21	25	29	34	27		32	29	29		30	29	30	30	30	30	30	31	29	27	25	23	26	29	28	26	26
3.5 M														30		28	21	25	29	34	27				29		30	29	30	30	30	31	30	31	29	28	27	27	26	29	29	27	26
4M																															30	31	30	31	29	28	28	28				28	26
4.5 M																																			30		28					28	
5M																																					29						
Tide height (ft.)[2]	4	3	5	2	3	*5*	3	4	5	5	6	3	2	6	1	2	1	3	2	5	4	5	4			4	3	3	3	5		6	4	5	4	3	4	4	5	3	6		
Tide[3]	HS	E	F	F	F	HS	LS	E-	E	F	HS	E	LS	HS	E	LS	E	F	F	HS	HS	H S	HS			F	E	F	E	F		HS	E	E	F	LS	E	F	E	E	HS		

(1) Meters below surface.
(2) Tides predicted for Albion CA.
(3) Flood (F), Ebb (E), High Slack (HS), Low Slack (LS).

Table A-8. Sampling dates and verticle profiles of water quality collected from the Navarro River estuary May 20 1996 - December 3,1997.

Hwy 1 Bridge

Site Bridge	5/21/96	6/11/96	7/2/96	7/23/96	8/13/96	9/4/96	9/24/96	10/11/96	10/30/96	11/6/96	11/18/96	11/25/96	12/19/96	1/15/97	2/17/97	2/27/97	3/14/97	3/26/97b	4/8/97	4/23/97	5/7/97	5/21/97	6/4/07	6/23/97	7/7/97	7/15/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/30/97	10/9/97	10/25/97	11/3/97	11/14/97	12/3/97
Temperature (C°)																																								
Surface	16	17	20	18	18	16	16	20	13	12	13	13	9	7	11	10	12	14	ll	16	15	17	17	19	19	20	18	19	20	19	22	22	23	22	19	17	12	15	13	11
.5M[1]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	18	18	18	20	19	21	21	23	22	19	17	12	15	13	11
1M	16	12	15	17	15	15	16	17	12	11	13	12	9	7	11	10	10	14	11	13	13	14	16	13	16	16	15	18	17	18	19	21	24	23	19	17	12	15	13	13
1.5 M	14					14		19	13	11	13	12	9	8	10	9	9	14	10	13	12	14	15	12	14	15	14	17	16	17	18	21	25	26	23	17	14	15	13	14
2M		12	13	14	13	14	20	23	16	15	13	12	9		10	9		11	10	12	11	13	14	11	12	14	13	16	15	17	18	19	26	28	25	21	14	16	14	14
2.5 M				14	13		19	22	20	19	14	12							10	12	11	13	13		5			15	14	16	18	18	24	27	25	24	14	17	14	15
3M									21	20	19								10			13										18	23	26	25	25		17	1S	
3.5 M								19	20	20	20																						20		25	25		17	18	
4M									19	19	19																								24	25			18	
Salinity (ppt)									.																															
Surface	4	8	7	5	23	25	17	7	2	2	2	6	4	2	1	2	4	4	32	6	17	18	26	15	21	13	20	22	28	25	23	18	16	11	6	4	17	5	2	1
0.5 M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	27	21	24	28	26	23	26	16	11	6	5	21	5	2	2
1 M	13	26	30	31	32	32	22	8	3	3	2	29	4	4	4	25	28	7	34	26	29	31	28	32	28	29	29	27	30	29	30	30	25	16	7	6	27	19	2	16
1.5M	25					32		16	6	3	2	29	4	9	24	27	29	7	35	27	30	31	31	33	30	29	30	29	31	30	30	29	26	25	17	9	28	22	9	25
2M		28	33	32	33	32	30	23	10	7	2	29	4		25	27		27	36	28	31	33	32	33	30	30	31	30	31	30	30	30	30	29	22	19	28	26	12	27
2.5 M				33	33		31	24	17	13	5	29							36	28	31	33	33					29	29	30	31	30	30	29	23	22	29	27	23	27
3M									22	20	16								36			33										30	31	30	24	25		28	25	
3.5 M								27	25	26	20																						31		26	26		29	27	
4M									26	25	26																								28	27			27	
Tide height[2]	1	3	4	2	5	3	5	5	6	3	2	6	1	2	3	3	1	4	5	4	4	4	na	na	4	3	2	4	5	3	6	4	5	3	4	3	4	5	na	na
Tide[3]	F	E	F	F	HS	F	E	HS	HS	E	E	HS	LS	LS	E	F	F	F	HS	HS	F	HS	na	na	F	E	F	E	F	E	F	E	HS	LS	E	LS	E	F	na	na

[1] Meters below surface (M)

[2] Tides predicted for Albion CA.

[3] Flood (F), Ebb (E), High Slack (HS), Low Slack (LS).

Table A-9. Sampling dates and verticle water quality profiles collected from the Navarro River estuary May 20,1996 - December 3,1997.

Site L-1

Site L1	5/21/96	6/11/96	7/2/96	7/23/96	8/13/96	9/4/96	9/24/96	10/11/96	10/16/96	10/30/96	11/6/96	11/18/96	11/25/96	12/19/96	1/15/97	2/17/97	2/27/97	3/14/97
Temperature (C°)																		
Surface	16	14	19	18	18	15	15	18	14	13	11	13	13	10	8	11	10	12
.5 M[1]																		
1M	15	11	14	14	12	13	15	17	14	12	11	13	12			11	10	
1.5M		11		14	12	13	19	19	16	12	11	13	12					
2M							20	22	21	15	19	13						
2.5 M									21	19	19	18						
Salinity (ppt)																		
Surface	5	23	9	7	24	27	14	9	10	3	2	3	8	4	4	2	3	6
.5M																		
1M	20	28	32	33	33	33	21	9	10	3	3	3	30			12	4	
1.5 M		28	31	33	33	33	29	19	19	4	3	3	30					
2M							29	23	26	10	7	3						
2.5 M									28	17	14	14						
3M										21	20	16						
Tide height (ft.)[2]	0	4	3	2	4	3	5	5	5	5	4	3	6	1	2	1	2	1
Tide[3]	F	E	F	LS	F	LS	HS	HS	F	F	E	E	F	LS	LS	E	F	F

Site L1	3/26/97b	4/8/97	4/23/97	5/7/97	5/21/97	6/4/07	6/23/97	7/7/97	7/15/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/24/97	9/30/97	10/9/97	10/16/97	10/25/97	11/3/97	11/14/97	12/3/97
Temperature (C°)																									
Surface	14	11	14	15	16	13	18	19	18	18	16	19	19	20	21	23	21	19	19	17	14	12	15	13	11
.5 M[1]								12	15	18	15	18	19	20	20	23	21	19	18	17	14	12	15	13	10
1M	12	11	12	11	13	14	11	11	14	16	15	13	18	19	20	24	21	19	18	16	14	11	15	13	13
1.5M	11	10	12		12	14					15	12	17	18	19	25	26	21	22	16	13	11	15	13	14
2M																	27	25	24	19	13		16	14	15
2.5 M																		25	24	24			17	15	
Salinity (ppt)																									
Surface	5	36	18	25	20	29	14	16	16	21	28	28	28	25	20	16	13	8	8	5	28	20	6	2	3
.5M								30	28	22	29	29	28	26	22	16	12	8	8	5	28	20	6	2	4
1M	23	37	28	32	30	29	30	30	29	28	29	31	29	29	29	27	16	14	19	5	29	21	18	5	24
1.5 M	28	38	29		32	29					30	31	30	29	30	30	27	19	19	8	29	29	24	9	27
2M																	29	24	22	19	29		25	14	28
2.5 M																		25	23	22			27	22	
3M																				23				25	
Tide height (ft.)[2]	4	5	4	4	4	na	na	3	3	2	4	4	4	6	5	5	3	3	5	3	6	4	5	na	na
Tide[3]	F	F	F	F	F	na	na	F	E	F	E	F	E	F	E	HS	LS	LS	E	LS	HS	E	F	na	na

[1] Meters below surface (M).

[2] Tides predicted for Albion CA.

[3] Flood (F), Ebb (E), High Slack (HS), Low Slack (LS).

Table A-10. Sampling dates and verticle water quality profiles collected from the Navarro River estuary May 20,1996 - December 3,1997.

Site L-2

Site L-2	5/21/96	6/11/96	7/2/96	7/23/96	8/13/96	9/4/96	9/24/96	10/11/96	10/16/96	10/30/96	11/6/96	11/18/96	11/25/96	12/19/96	1/15/97	2/17/97	2/27/97	3/14/97	3/26/97b	4/8/97	4/23/97	5/7/97	5/21/97	7/15/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/24/97	9/30/97	10/9/97	10/16/97	10/25/97	11/3/97	11/14/97	12/3/97
Temperature (C°)																																							
Surface	16	12	19	17	18	15	14	17	14	12	12	13	12	10	8	11	10	11	14	11	15	13	16	17	15	18	18	19	20	22	22	19	19	18	14	11	15	12	10
.5 M[1]>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	15	17	18	19	20	22	22	19	18	17	14	11	15	12	11
1M		10	14	15	12	13	15	16	14	12	11	14	12	10	8	11	10	9	11	10	12	11	13	14	14	14	18	18	20	24	21	19	18	16	14	11	15	12	13
1.5 M	16						19	17	14	12	11	13	11		10	11	9	9	11	10	12	11	13	13	14	13	15	17	19	25	26	22	21	17	14	11	15		14
2M		10	11	13	11	13	19	21	20	14	11	13	11	10	11	11	9	9	10	10	12	10	13	13	14	12	15	16	18	22	27	25	23	20	14	13	16	13	14
2.5 M	12	10	11	12	11	12	17	20	20	18	18	18	11	11	11	11	9	8	10	10	12	10	12	13	14	12	15	16	18	21	24	25	22	24	14	13	16	14	14
3M								19		20	19	19	11	11	11				10	10	12	10	12	13	14	12	15	16	17	20	22	25	22	25	14	14	16	17	15
3.5 M										20	19	19	11							10	12	10	12	13	14	12	14	16	17	18	20	25	21	24	14		16	18	15
4M										19	19	19											12	13	14	12	14	16	17	1		22	22	23	14		16	18	15
4.5 M								16		18	18													13	14					18		21	21	22	14		16	18	15
SM										17	18																			18		20	20	21			16	17	
Salinity (ppt)																																							
Surface	3	24	10	11	25	25	15	9	10	3	3	3	6	4	8	2	4	6	5	27	10	22	18	21	29	28	29	28	19	16	12	8	7	4	28	21	6	2	3
,5M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	30	29	29	29	20	16	12	8	8	5	28	20	6	3	5
1M		31	31	32	34	32	21	10	10	3	4	4	30	4	12	3	28	28	27	30	28	31	30	29	30	31	29	30	30	29	16	16	18	6	28	21	11	7	22
1.5 M	3						29	11	12	4	4	4	30		25	26	28	28	27	30	28	32	31	29	30	31	31	30	30	29	27	18	20	3	28	27	22	15	26
2M		33	33	33	34	33	30	24	24	11	3	4	31	13	30	28	28	29	29	30	29	33	31	30	30	31	31	31	30	30	29	23	21	18	28	28	24	22	28
2.5 M	32	33	33	36	33	33	31	25	28	16	14	11	31	27	31	28	29	30	29	30	29	33	30	30	31	31	31	31	31	30	29	25	22	21	28	29	25	25	28
3M								26		20	18	15	31	27	31				29	30	29	33	31	30	31	31	30	31	31	31	29	27	22	22	29	29	28	26	28
3.5 M										24	21	18	31							30	29	33	31	30	31	32	31	31	31	31	29	28	28	23	29		29	27	28
4M										26	25	22											31	30	31	30	31	31	31	31	29	29	28	26	29		30	27	28
4.5 M								25		27	28													30	31		30			31		29	28	28			30	28	28
5M										28	28																			31		30	29	29			30	28	
Tide height (ft.)[2]	2	4	2	2	4	3	5	5	4	5	5	3	6	1	2	1	2	1	3	4	4	3	4		4	4	4	4	5	5	3	3	5	3	6	4	5		
Tide[3]	F	HS	F	LS	F	LS	HS	HS	F	F	E	E	F	F	E	F	F	LS	F	F	F	F	HS		E	F	E	F	HS	F	LS	LS	E	LS	HS	E	F		

(1)Meters below surface (M).

(2) Tides predicted for Albion CA.

(3) Flood (F), Ebb (E), High Slack (HS). Low Slack (LS).

Table A-11. Sampling dates and verticle water quality profiles collected from the Navarro River estuary May 20,1996 - December 3,1997.

Site L-3

Site L-3	5/21/96	6/12/96	7/2/96	7/23/96	8/13/96	9/4/96	9/24/96	10/11/96	10/16/96	10/30/96	11/6/96	11/18/96	11/25/96	12/19/96	1/15/97	2/17/97	2/27/97	3/14/97	3/26/97b	4/8/97	4/23/97	5/7/97	5/21/97	6/4/97	6/23/97	7/7/97	7/15/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/24/97	9/30/97	10/9/97	10/16/97	10/25/97	11/3/97	11/14/97	12/3/97
Temperature (C°)																																											
Surface	15	16	18	17	17	14	14	17	14	12	10	14	12	10	8	12	10	10	13	10	15	15	13	14	16	17	14	16	16	18	18	19	20	22	21	18	18	18	15	10	14	12	11
.5M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	13	14	15	16	18	18	20	22	21	18	18	16	14	10	14	12	11
1M	15	10	13	14	12	13	14	17	14	11	10	13	12	10	8	11	10	9	13	10	12	11	12	13	12	13	13	14	14	15	16	17	20	22	21	18	18	16	14	10	14	12	12
1.5M	14	10			12	12	18	17	14	11	10	14	12			11	10	9	12	10	12		12	13	10	12	13	14	14	13	15	16	19	24	25	17	21	15	14	11	15	12	14
2M			11	13		12	17	20	19	12	10	17											11	13			13				15		18		25	17	22	19		11	15	14	
2.5 M								20	20	17	17	17																								20	21	23			16	16	
3M										19	19	19																								23					16	17	
3.5 M												19																														18	
Salinity (ppt)																																											
Surface	4	12	11	7	20	25	15	9	11	4	4	4	11	5	9	2	4	11	5	29	7	16	27	31	19	21	29	23	28	26	28	28	21	17	14	9	8	5	28	22	7	2	4
.5M	7	32	29	32	33	33	21	9	11	4	3	4	30	6	14	4	10	17	8	32	29	31	32	33	28	28	30	29	29	29	30	31	21	18	14	9	8	5	29	22	7	2	7
1 M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	29	30	30	30	31	24	18	15	13	8	5	29	22	7	2	23
1.5 M	13	33			33	33	29	10	11	4	4	4	30			19	17	24	24	33	29		32	33	31	30	30	29	30	31	30	32	30	30	27	17	18	5	29	28	24	9	24
2M			33	33		33	29	22	25	4	4	8											32	33			30				31		30		29	21	20	17		27	26	14	
2.5 M								24	28	16	15	13																								24	21	21			27	23	
3M										20	18	15																								25					27	25	
3.5 M												22																														26	
Tide height (ft.)[2]	0	2	0	2	3	3	5	5	4	4	5	4	5	1	2	2	2	1	3	4	4	3	4	na	na	2	4	0	5	2	4	3	5	4	3	3	5	3	6	5	5	na	na
Tide[3]	LS	LS	F	E	F	LS	HS	F	F	F	E	E	F	F	E	E	F	LS	F	F	F	F	F	na	na	F	E	F	HS	F	HS	F	HS	F	E	E	HS	E	F	E	F	na	na

(1) Meters below surface (M).

(2) Tides predicted for Albion CA.

(3) Flood (F), Ebb (E), High Slack (HS), Low Slack (LS).

Table A-12. Sampling dates and verticle water quality profiles collected from the Navarro River estuary May 20,1996 - December 3,1997.

Site L-4

Site L-4	5/20/96	5/22/96	6/11/96	6/12/96	7/2/96	7/3/96	7/23/96	8/13/96	8/14/96	9/4/96	9/24/96	10/11/96	10/16/96	10/30/96	11/6/96	11/18/96	11/25/96	12/19/96	1/15/97	2/17/97	2/27/97	3/14/97
Temperature (C°)																						
Surface	16	15	13	16	17	20	17	15	13	13	14	16	14	11	10	13	13	10	8	11	9	10
.5M[1]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1 M	12	15	10	12	13	14	13	12	13	13	15	16	14	11	10	13	12	11	8	11	9	
1.5 M		15	9	11	12	14	13		12	13	19	16		11	10	14	12			11	9	
2M											19	20										
2.5																						
Salinity (ppt)																						
Surface	14	6	18	18	7	25	11	24	35	26	18	9	11	4	4	2	9	6	10	2	4	14
.5M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1M	34	7	32	31	32	30	32	33	35	26	18	10	11	6	3	3	23	27	12	3	4	
1.5 M		9	32	32	33	26	32		34	33	28	10		6	4	4	26			5	5	
2M											28	22										
2.5																						
Tide height (ft.)[2]	2	0	4	2	1	4	2	3	4	3	5	4	3	3	5	4	5	2	2	2	2	1
Tide[3]	F	F	HS	LS	F	F	E	F	E	E	F	F	F	F	HS	E	F	F	E	E	LS	LS

Site L-4	3/26/97b	4/8/97	4/23/97	5/7/97	5/21/97	6/4/97	6/23/97	7/7/97	7/15/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/24/97	9/30/97	10/9/97	10/16/97	10/25/97	11/3/97	11/14/97	12/3/97
Temperature (C°)																									
Surface	13	12	13	16	11	18	18	17	13	15	15	16	15	18	19	21	21	18	18	16	13	10	15	12	11
.5M[1]	-	-	-	-	-	-	-	17	13	15	15	15	15	18	20	21	21	18	18	15	13	10	14	12	10
1 M	12	10	13	14	11	18	18	13	13	13	15	14	15	17	19	21	21	18	18	15	13	10	14	12	12
1.5 M					11				13				15	16	18	23		18	19	15			15	12	13
2M					12													23		20			16	14	
2.5																								17	
Salinity (ppt)																									
Surface	5	10	17	18	30	15	18	19	29	23	28	31	29	29	22	18	15	9	9	5	21	20	7	2	4
.5M	-	-	-	-	-	-	-	20	30	27	29	32	29	30	22	18	15	9	9	5	24	20	7	2	4
1M	17	30	27	29	30	23	18	29	30	30	29	32	30	30	22	18	15	9	9	5	25	20	7	2	22
1.5 M					29				30				31	31	30	30		18	14	5			21	7	24
2M					30													22		18			24	14	
2.5																				21				22	
Tide height (ft.)[2]	2	3	3	2	3				4			2	5	0	4	3	3	4	5	3	5	4	4		
Tide[3]	F	F	F	F	F				HS			F	HS	F	F	F	E	E	F	E	F	E	F		

(1) Meters below surface (M).
(2) Tides predicted for Albion CA.
(3) Flood (F), Ebb (E), High Slack (HS). Low Slack (LS).

Table A-13. Sampling dates and verticle water quality profiles collected from the Navarro River estuary July 7, to December 3,1997.

Sites U-2B L-2B

Site U-2B	7/7/97	7/15/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/24/97	10/16/97	10/25/97	11/3/97	11/14/97
Temperature (C°)															
Surface	24	22	22	22	23	22	23	26	25	25	21	16	14	16	13
.5M	22	22	21	22	22	23	23	28	26	25	20	16	15	16	13
1M[1]	21	20	19	20	22	23	21	25	29	26	22	16	15	16	13
1.5 M	21			20		23		24	28	30	25			17	14
2M										30	27			17	16
2.5 M														17	18
3M															18
3.5 M															
Salinity (ppt)															
Surface	15	3	10	8	22	5	4	10	9	4	5	11	3	1	0
.5M	17	16	13	22	26	15	28	29	15	15	5	16	26	5	0
1 M	18	24	21	26	29	30	28	30	29	20	10	21	28	16	4
1.5 M	19			26		30	28	30	29	28	14	22	28	24	16
2M										28	22			26	17
2.5 M															23
3M															27
3.5 M															
Tide height (ft.)[2]	5	3	5	3	4	3	5	4	3	5	4			2	2
Tide[3]	HS	F	F	LS	E	LS	E	E	E	F	F			E	LS

Site L-2B	7/7/97	7/15/97	7/24/97	7/30/97	8/7/97	8/14/97	8/20/97	8/28/97	9/3/97	9/10/97	9/24/97	9/30/97	10/9/97	10/16/97	10/25/97	11/3/97	11/14/97	12/3/97
Temperature (C°)																		
Surface	19	14	16	16	17	17	18	20	23	21	18	18	17	14	11	15	12	11
.5M	15	13	16	15	17	17	18	20	22	21	18	18	16	14	11	15	12	11
1M[1]	14	13	14	14	13	16	17	20	22	21	18	18	16	14	11	15	12	13
1.5 M	13	13	14	14	12	15	17	19	24	26	19	21	16	14	11	15	13	14
2M						14	16	16	23	27	18	21	20				14	
2.5 M								18		26	22						16	
3M											23						17	
3.5 M																		
Salinity (ppt)																		
Surface	19	29	25	27	29	31	28	20	16	13	8	8	5	27	21	6	2	3
.5M	26	30	28	30	31	30	30	22	18	13	9	8	5	27	21	6	2	9
1 M	31	30	31	30	33	30	31	26	18	17	12	8	5	28	21	7	3	23
1.5 M	31	30	31	30	32	31	31	29	30	28	18	18	5	28	25	23	10	27
2M						31	31	30	29	29	20	20	17				14	
2.5 M								30		29	24						23	
3M											7						25	
3.5 M																		
Tide height (ft.)[2]	2	3	1	5	3	4	3	5	4	3	4	5	3	6		5		
Tide[3]	F	E	F	HS	F	E	F	HS	F	LS	E	HS	LS	F		F		

(1)Meters below surface (M)
(2)Tides predicted for Albion, CA.
(3)Flood (F), Ebb (E), High (HS), Low Slack (LS).

Table A-14.Number of specimens captured by beach seine from the Navarro River estuary May 21,1996 - Decembers, 1997. Site U-1.

Site U-1	Coho salmon (smolts)	Steelhead (juveniles)	Surf smelt	Surf smelt (<60 mm) *	Staghorn sculpin	Staghorn sculpin (<40mm)*	Prickley sculpin	Prickley sculpin(<40 mm)	Coast range sculpin	Top smelt	Top smelt (<60 mm) *	Starry flounder	English sole	Speckled sandab	Shiner surfperch	Pacific sardine	Striped surfperch	Pacific herring	Kelp greenling	Bay pipefish	Cabezon	Saddleback gunnel	Penpoint gunnel	Juvenile rockfish	Threespine stickleback	Stickleback (<40mm) *	California roach	Tidepool sculpin	Pacific lamprey	Silverspoted sculpin	Northern anchovey	Pacific tomcod	Nightsmett	Pacific sanddab	Total Fish	Dugeness crab
5/21/96		18							1																		1								20	
6/11/96		22					1																		4		6								33	
7/2/96		1										1													1										3	
7/23/96		6			1																				2										9	
8/13/96		22																		2					2	7									33	
9/4/96		1																		2						3									6	
9/24/96		3																		2						1									6	
10/11/96		1																																	1	
10/16/96		1																							1										2	
11/25/96																																			0	
12/19/96		2																							1	1									4	
2/27/97		3																																	3	
3/26/97		1																																	1	
4/8/97																																			0	
4/23/97																																			0	
5/7/97	1	2										1																							4	
5/21/97		23								1										2					17										43	
6/5/97		6													1										2										9	
6/23/97		4			1		1																		2										3	
7/7/97		14									3				2					8						3	2								32	
7/15/97		6									3									3					2	4	26								49	
7/24/97		5									1									2					1										9	
7/30/97		1																		24						4	14								43	
8/7/97																									3										3	
8/14/97		8																		25					2	2	17								54	
8/20/97		1																		5							1								7	
8/28/97		1									1									22							8								32	
9/3/97																											5								5	
9/10/97																									1										1	

3124197		2																																	2	
9/30/97		1								1																									2	
10/9/97																																			0	
10/16/97		2																		5					3										10	
10/25/97							1			4										2					4	1									12	
11/3/97		1																									1								2	

* Fish captured: too small to be fully recruited to the beach seine.

Table A-15. Sampling dates and number of specimens captured by gill net from the Navarro River estuary May 21,1996 - December 3, 1997.
Site U-2.

Site U-2	Coho salmon (smolts)	Steelhead (juveniles)	Surf smelt	Surf smelt (<60 mm) *	Staghorn sculpin	Staghorn sculpin (<40mm)*	Prickley sculpin	Prickley sculpin(<40 mm)	Coast range sculpin	Top smelt	Top smelt (<60 mm) *	Starry flounder	English sole	Speckled sandab	Shiner surfperch	Pacific sardine	Striped surfperch	Pacific herring	Kelp greenling	Bay pipefish	Cabezon	Saddleback gunnel	Penpoint gunnel	Juvenile rockfish	Threespine stickleback	Stickleback (<40mm) *	California roach	Tidepool sculpin	Pacific lamprey	Silverspoted sculpin	Northern anchovey	Pacific tomcod	Nightsmelt	Pacific sanddab	Total Fish	Dugeness crab
5/21/96																																			0	
6/11/96																																			0	
7/2/96										2																									2	
7/23/96																																			0	
8/13/96		1																																	1	
9/4/96																																			0	
9/24/96																																			0	
10/11/96																																			0	
10/16/96												1																							1	
10/30/96										3																									3	
11/6/96																																			0	
11/16/96		1																4																	5	
11/25/96																																			0	
12/19/96																																			0	
1/15/97		1																																	1	
2/27/97																																			0	
3/14/97																																			0	
3/26/97																																			0	
4/8/97																																			0	
4/23/97																																			0	
5/21/97										45								1																	46	
7/30/97		4																																	4	
8/7/97										3																									3	
8/14/97																																			0	
8/20/97		1																																	1	
8/28/97																																			0	
9/3/97																																			0	
9/10/97		1																																	1	
9/24/97		1																																	1	
9/30/97																																			0	
10/9/97																																			0	
10/16/97																																			0	
10/25/97																																			0	
11/3/97					1																														1	

Table A-16. Number of specimens captured by beach seine from the Navarro River estuary June 5,1996 - November 3,1997. Site U-2b

SiteU-2b	Coho salmon (smolts)	Steelhead (juveniles)	Surf smelt	Surf smelt (<60 mm) *	Staghorn sculpin	Staghorn sculpin (<40mm)*	Prickley sculpin	Prickley sculpin(<40 mm)	Coast range sculpin	Top smelt	Top smelt (<60 mm) *	Starry flounder	English sole	Speckled sandab	Shiner surfperch	Pacific sardine	Striped surfperch	Pacific herring	Kelp greenling	Bay pipefish	Cabezon	Saddleback gunnel	Penpoint gunnel	Juvenile rockfish	Threespine stickleback	Stickleback (<40mm) *	California roach	Tidepool sculpin	Pacific lamprey	Silverspoted sculpin	Northern anchovey	Pacific tomcod	Nightsmett	Pacific sanddab	Total Fish	Dugeness crab
6/5/97		20					1																		3		1								2	
6/23/9		9								4	1														1	1	6								2	
7/7/97		9									31				1												1								4	
7/15/9		2																		1															3	
7/24/9		6																		1					2		1								1	
7/30/9		4									5									4					5		2								2	
8/7/97		2								1	2																								5	
8/14/9		6									1									10					2		6								2	
8/20/9		4																		4					3		4								1	
8/28/9		2					1													11					10		36								60	1
9/3/97								1												1															2	
9/10/9																																			0	
9/24/9		6																																	6	
10/16/		1																							2										3	
10/25/		1					1	1																		1									4	
11/3/9		17																																	17	

* Fish captured: too small to be fully recruited to the beach seine.

Table A-17. Number of specimens captured by beach seine from the Navarro River estuary May 20,1996 - December 3,1997. Site U-3

Site U-3	Coho salmon (smolts)	Steelhead (juveniles)	Surf smelt	Surf smelt (<60 mm) *	Staghorn sculpin	Staghorn sculpin (<40mm)*	Prickley sculpin	Prickley sculpin(<40 mm)	Coast range sculpin	Top smelt	Top smelt (<60 mm) *	Starry flounder	English sole	Speckled sandab	Shiner surfperch	Pacific sardine	Striped surfperch	Pacific herring	Kelp greenling	Bay pipefish	Cabezon	Saddleback gunnel	Penpoint gunnel	Juvenile rockfish	Threespine stickleback	Stickleback (<40mm) *	California roach	Tidepool sculpin	Pacific lamprey	Silverspoted sculpin	Northern anchovey	Pacific tomcod	Nightsmett	Pacific sanddab	Total Fish	Dugeness crab
5/20/96		4																																	4	
6/11/96		1			2		6													3					4										16	
7/2/96										1																									1	
7/3/96		1					3													4					6										14	
7/23/96		1			1		15					1								4					2										24	
8/13/96		1			1		1								9					3					2	5									22	
9/4/96					1		5	8			3	2								4					5	41									69	
9/24/96		1					7	5				1								9					8	a									39	
10/11/96		27																																	27	
10/16/96		5					2													2					4										13	
10/30/96		18										1								2					1										22	
11/6/96		1						1																											2	
11/18/96		17										1																							18	
11/25/96		96																																	96	
12/19/96		3																									1								4	
1/15/97												1													1										2	
2/17/97																																			0	
2/27/97		2																																	2	
3/14/97												1																							1	
3/26/97																																			0	
4/8/97																																			0	
4/23/97		3										1																							4	
5/7/97																																			0	
5/21/97																																			0	
6/5/97		1																																	1	
6/23/97							1																		1										2	
7/7/97		1						3		45	4														2	13	1								69	
7/15/97		1			4			1			1									8							18								33	
7/24/97		S			2										2					7					3	3									22	
7/30/97		2						2			1														2										7	
8/7/97					1			2			4									15					1										23	
8/14/97							4	3		1										17					1		11								37	
8/20/97		2								18	1									5						1	16								43	
8/28/97		6						1		16	1	1								3					3	14	8								53	
9/3/97											1									1															2	
9/10/97		1									3									2					1	1									8	
9/24/97		2																									13								15	
9/30/97																																			0	
10/9/97		1																		1							5								7	
10/16/97																									2										2	
10/25/97																																			0	
11, 3/97		2																									3								5	
123/97		1																									1								2	

* Fish captured: too small to be fully recruited to the beach seine.

Table A-18. Number of specimens captured by beach seine from the Navarro River estuary May 21,1996 - December 3,1997. Site M-1

Site M-1	Coho salmon (smolts)	Steelhead (juveniles)	Surf smelt	Surf smelt (<60 mm) *	Staghorn sculpin	Staghorn sculpin (<40mm)*	Prickley sculpin	Prickley sculpin(<40 mm)	Coast range sculpin	Top smelt	Top smelt (<60 mm) *	Starry flounder	English sole	Speckled sandab	Shiner surfperch	Pacific sardine	Striped surfperch	Pacific herring	Kelp greenling	Bay pipefish	Cabezon	Saddleback gunnel	Penpoint gunnel	Juvenile rockfish	Threespine stickleback	Stickleback (<40mm) *	California roach	Tidepool sculpin	Pacific lamprey	Silverspoted sculpin	Northern anchovey	Pacific tomcod	Nightsmett	Pacific sanddab	Total Fish	Dugeness crab
5/21/96		4																																	4	
6/11/96		4																						1										5	
7/2/96		3					1													1															5	
7/23/96		4			5		5					1								6					4										25	
8/1 3/96		8						4				2								7						12									33	
9/4/96		4			3	2	2	2												1						1									15	
9/24/96		2										3								3					1										9	
10/11/96		1																																	1	
10/16/96		4										3																						7	
10/30/96												3																						3	
1 1/6/96																																			0	
11/18/96		23																																	23	
11/25/96				2	1					1																									4	
12/19/96																																			0	
1/15/97																																			0	
2/17/97		2																																	2	
2/27/97																																			0	
3/14/97																																			0	
3/26/97		2	1																																3	
4/8/97										2																									2	
4/23/97		2																																	2	
5/7/97		1					1			1														1										4	
5/21/97		1																																	1	
6/5/97																																			0	
6/23/97		5																																	5	
7/7/97		3			1					54										1					1		1								61	
7/15/97																									3		5								8	
7/24/97		2																		1					1										4	
7/30/97																				1						1								2	
8/7/97										24									3																27	
8/14/97										1																									1	
8/20/97		9																		1															10	
8/28/97		15																																	15	
9/3/97		1								3	1																								5	
9/10/97		44								16	5				1																					66	
9/24/97		7																		1						2								10	
9/30/97		7																																	7	
1 0/9/97		29																																	29	
10/16/97		3								34																									37	
10/25/97		1																																	1	
11/3/97																									1										1	
12/3/97																																			0	

* Fish captured : too small to be fully recruited to the beach seine.

Table A-19. Number of specimens captured by gill net from the Navarro River estuary May 20,1996 - November 3,1997. Site M-2.

Site M-2	Coho salmon (smolts)	Steelhead (juveniles)	Surf smelt	Surf smelt (<60 mm) *	Staghorn sculpin	Staghorn sculpin (<40mm)*	Prickley sculpin	Prickley sculpin(<40 mm)	Coast range sculpin	Top smelt	Top smelt (<60 mm) *	Starry flounder	English sole	Speckled sandab	Shiner surfperch	Pacific sardine	Striped surfperch	Pacific herring	Kelp greenling	Bay pipefish	Cabezon	Saddleback gunnel	Penpoint gunnel	Juvenile rockfish	Threespine stickleback	Stickleback (<40mm) *	California roach	Tidepool sculpin	Pacific lamprey	Silverspoted sculpin	Northern anchovey	Pacific tomcod	Nightsmett	Pacific sanddab	Total Fish	Dugeness crab
5/20/96		2								4								b																	11	
6/11/96																																			0	
7/2/96																																			0	
7/23/96																																			0	
8/13/96		1																																	1	
9/4/96																																			0	
9/24/96																																			0	
10/11/96		1								5																									6	
10/16/96										4																									4	
10/30/96																8																			8	
11/6/96		2								2																									4	
11/18/96																																			0	
11/25/96		1																																	1	
2/27/97																																			0	
3/14/97																																			0	
3/26/97																																			0	
4/8/97																																			0	
4/23/97		1								11								14																	26	
5/7/97																																			0	
5/21/97		1																																	1	
6/23/97																																			0	
8/7/97		2	1							5					12			5																	25	
6/14/97															2	4																			6	
8/20/97			2												9																				11	
8/28/97		1								2					9	2																			14	
9/3/97		1																																	1	
9/10'97															10																				10	4
9/24/97																																			0	
9/30/97		1																																	1	
10/9/97																																			0	
10/16/97																																			0	
10/25/97																																			0	
11/3/97			1																																1	

Table A-20. Number of specimens captured by beach seine from the Navarro River estuary May 20,1996 - December 3,1997. Site M-3.

Site M-3	Coho salmon (smolts)	Steelhead (juveniles)	Surf smelt	Surf smelt (<60 mm) *	Staghorn sculpin	Staghorn sculpin (<40mm)*	Prickley sculpin	Prickley sculpin(<40 mm)	Coast range sculpin	Top smelt	Top smelt (<60 mm) *	Starry flounder	English sole	Speckled sandab	Shiner surfperch	Pacific sardine	Striped surfperch	Pacific herring	Kelp greenling	Bay pipefish	Cabezon	Saddleback gunnel	Penpoint gunnel	Juvenile rockfish	Threespine stickleback	Stickleback (<40mm) *	California roach	Tidepool sculpin	Pacific lamprey	Silverspoted sculpin	Northern anchovey	Pacific tomcod	Nightsmett	Pacific sanddab	Total Fish	Dugeness crab
5/20/96		21																																	21	
6/11/96		10			1					13		1													1										26	
7/2/96		2								7		1													2										12	
7/3/96		5			1		2					1								2															11	
7/23/96		2			1		1			1		3								2					11										21	
8/13/96								1		17		1													1	1									21	
9/4/96							1			9										4															14	
9/24/96																																			0	
10/11/96		103	1															1																	105	
10/16/96		20																																	20	
10/30/96		2																																	2	
11/6/96																																			0	
11/18/96		8																																	8	
11/25/96		2		1																															3	
12/19/96		2																							1										3	
1/15/97		1																							1										2	
2/17/97		2																																	2	
2/27/97																				2									2						4	
3/14/97		1																																	1	
3/26/97																																			0	
4/6/97					1																														1	
4/23/97		1																																	1	
5/7/97						1														2															3	
5/21/97	1	11								1																									13	
6/5/97		2			1															2															5	
6/23/97					2		4			17										1															24	
7/7/97		3			2					56								1		1					2										65	
7/15/97		4			2			1																	2										9	
7/24/97										1										3															4	
7/30/97		4																							1										5	
8/7/97		5													43																				48	
8/14/97		5									1									1					2	2									11	1
8/20/97		3																		1					1	1	1								7	
8/28/97		5								14																									19	
9/3/97		13								6										2															21	
9/10/97		15								5	2																								22	1
9/24/97		13																		1															14	
9/30/97		79													81												2								162	
10/9/97		28		15																															43	
10/16/97										13																									13	1
10/25/97																																			0	
11/3/97		1																		1					1		6								9	
11/14/97																																			0	
12/3/97																											2								2	

* Fish captured: too small to be fully recruited to the beach seine.

Table A-21. Number of specimens captured by beach seine from the Navarro River estuary May 21,1996 - October 25,1997. Site Bridge.

Site Bridge	Coho salmon (smolts)	Steelhead (juveniles)	Surf smelt	Surf smelt (<60 mm) *	Staghorn sculpin	Staghorn sculpin (<40mm)*	Prickley sculpin	Prickley sculpin(<40 mm)	Coast range sculpin	Top smelt	Top smelt (<60 mm) *	Starry flounder	English sole	Speckled sandab	Shiner surfperch	Pacific sardine	Striped surfperch	Pacific herring	Kelp greenling	Bay pipefish	Cabezon	Saddleback gunnel	Penpoint gunnel	Juvenile rockfish	Threespine stickleback	Stickleback (<40mm) *	California roach	Tidepool sculpin	Pacific lamprey	Silverspoted sculpin	Pacific tomcod	Nightsmett	Pacific sanddab	Total Fish	Dugeness crab
5/21/96		17			12							1													1									31	
6/11/96	1	7			4		2																		1									16	
7/2/96		12			1		3																		1									17	
7/23/96		2			1		12													3					8									26	
8/13/96		14																																14	
9/4/96		5					3	2		1																								11	
9/24/96																																		0	
10/16/96																																		0	
11/25/96																																		0	
12/19/96		3																							3	5	7							18	
1/15/97																																		0	
2/17/97		1										1																						2	
2/27/97		12																																12	
3/14/97		3														5																		8	
3/26/97		6																		1														7	
4/6/97		5								380																								385	
4/23/97		3																																3	
5/7/97		16								18															1									35	
5/21/97	3	4																																7	
6/5/97		5			1		1			1															2									10	
6/23/97		5			6		4						1												3									19	
7/7/97		7			2		1																		1									11	10
7/15/97	1	12			1		4			19		1								2						4								44	54
7/24/97		3			7		6				5									2					5			i						29	22
7/30/97		33			1					1										1														36	19
8/7/97		33																																33	3
8/14/97		9								9																								18	4
8/20/97		1																																1	
8/28/97		16								12															1									29	
9/3/97		200																																200	
9/10/97		10																							1									11	9
10/25/97		81																																81	

* Fish captured: Too small to be fully recruited to the beach seine.

Table A-22. Number of specimens captured by beach seine from the Navarro River estuary May 21, 1996 - December 3,1997. Site L-1.

Site L-1	Coho salmon (smolts)	Steelhead (juveniles)	Surf smelt	Surf smelt (<60 mm) *	Staghorn sculpin	Staghorn sculpin (<40mm)*	Prickley sculpin	Prickley sculpin(<40 mm)	Coast range sculpin	Top smelt	Top smelt (<60 mm) *	Starry flounder	English sole	Speckled sandab	Shiner surfperch	Pacific sardine	Striped surfperch	Pacific herring	Kelp greenling	Bay pipefish	Cabezon	Saddleback gunnel	Penpoint gunnel	Juvenile rockfish	Threespine stickleback	Stickleback (<40mm) *	California roach	Tidepool sculpin	Pacific lamprey	Silverspoted sculpin	Northern anchovey	Pacific tomcod	Nightsmett	Pacific sanddab	Total Fish	Dugeness crab
5/21/96	1	36			12		4					1			1				1						3										5ft	
6/11/96	1	16			1		2																		1										21	
7/2/96		36			3		1																												40	
7/23/96		88	1		13		4					1																							107	
8/13/96		42			4		3	1																				1							61	
9/4/96		33	5		2															1															41	
9/24/96		11																																	11	
10/11/96			1		1																														2	
10/16/96		12										1								1								1							16	
10/30/96		39					1																												40	
11/6/96		41																																	41	
11/18/96		38																																	38	
11/25/96																																			0	
12/19/96																										2									2	
1/15/97		1																																	1	
2'17/97		2																																	2	
2/27/97		6																																	6	
3/14/97																									1										1	
3/26/97		1																																	1	
4/8/97																																			0	
4/23/97		2			2																														4	
5/7/97						3																													3	
5/21/97	1				1																														2	
6/5/97		1			1																														2	
6/23/97					4																														4	
7/7/97					8		2													1	1		1												13	3
7/15/97		10					1													5															16	84
7/24/97		5			3															4	1		1		2			1							17	2
7/30/97		12			1															2															16	3
8/7/97		39			1		3													11															64	9
8/14/97		41					3													2															46	19
8/20/97		58								2										2															62	20
8/28/97		47			3					10																									60	17
9/3/97		15		1	1					5																									22	3
9/10/97		15																		1								1							17	4
9/24/97		2								2																									4	11
9/30/97		9	15		1					3				1																					29	
10/9/97		5																																	6	
10/16/97		1	3		1					29	1																								35	
10/25/97												1																							1	
11/3/97										1																									1	
12/3/97			4																																4	

* Fish captured: too small to be fully recruited to the beach seine.

Table A-23. Number of specimens captured by gill net from the Navarro River estuary May 21,1996 - November 14,1997. Site L-2.

Site L-2	Coho salmon (smolts)	Steelhead (juveniles)	Surf smelt	Surf smelt (<60 mm) *	Staghorn sculpin	Staghorn sculpin (<40mm)*	Prickley sculpin	Prickley sculpin(<40 mm)	Coast range sculpin	Top smelt	Top smelt (<60 mm) *	Starry flounder	English sole	Speckled sandab	Shiner surfperch	Pacific sardine	Striped surfperch	Pacific herring	Kelp greenling	Bay pipefish	Cabezon	Saddleback gunnel	Penpoint gunnel	Juvenile rockfish	Threespine stickleback	Stickleback (<40mm) *	California roach	Tidepool sculpin	Pacific lamprey	Silverspoted sculpin	Northern anchovey	Pacific tomcod	Nightsmett	Pacific sanddab	Total Fish	Dugeness crab
5/21/96		4																19																	23	
6/11/96		4																5																	9	
7/2/96		3																3																	6	
7/23/96		1	3															3																	7	
8/13/96																																			0	
9/4/96															5																				5	
9/24/96			1														1																		2	
10/11/96			3							15																									18	
10/16/96			3							2																									5	
10/30/96			10							34																									44	
11/6/96			2																																2	
11/18/96			18							22						4		2																	46	
11/25/96																																			0	
12/19/96		1																17																	18	
1/15/97																																			0	
2/17/97																																			0	
2/27/97																																			0	
3/14/97																																			0	
3126/97																																			0	
4/8/97																																			0	
4/23/97																		5																	5	
5/7/97																																			0	
5/21/97																		7																	7	
7/30/97			1															2																	3	
8/7/97																1																			1	
8/14/97		2	1															1																	4	
8/20/97		3	1												2			1						3							1				10	
8/28/97		3	4							1					5																				13	
9/3/97		1	10							14																									25	
9/10/97		1								5					9																				15	
9/24/97		6								8																									14	
9/30/97		3								40																									43	
10/9/97		1								3																									4	
10/16/97			2																																2	
10/25/97			1																																1	
11/3/97		1																																	1	
11/14/97		1																																	1	

Table A-24. Number of specimens captured by beach seine from the Navarro River estuary June 5 - December 3,1997. Sites L-2b and L5.

Site L-2b &L-5	Coho salmon (smolts)	Steelhead (juveniles)	Surf smelt	Surf smelt (<60 mm) *	Staghorn sculpin	Staghorn sculpin (<40mm)*	Prickley sculpin	Prickley sculpin(<40 mm)	Coast range sculpin	Top smelt	Top smelt (<60 mm) *	Starry flounder	English sole	Speckled sandab	Shiner surfperch	Pacific sardine	Striped surfperch	Pacific herring	Kelp greenling	Bay pipefish	Cabezon	Saddleback gunnel	Penpoint gunnel	Juvenile rockfish	Threespine stickleback	Stickleback (<40mm) *	California roach	Tidepool sculpin	Pacific lamprey	Silverspoted sculpin	Northern anchovey	Pacific tomcod	Nightsmett	Pacific sanddab	Total Fish	Dugeness crab
6/5/97	1	18		6	15	6						1																							47	
6/23/97	4	13	6		17								2								1														43	4
7/7/97		3	2		5							1	4										1												16	19
7/15/97		8	2		4							2	2																						18	49
7/24/97		27			2					41																									70	27
7/30/97		1			3							1								1															6	7
8/7/97		13			5								2										1												21	1
8/14/97		6								3																		1							10	3
8/20/97		8			1					74																									83	235
8/28/97		12			3					9		1		1																					26	
9/3/97		5		3		1						1		1						4															15	43
9/10/97		16			1					10	1	2								2															32	66
9/24/97		11			1							1		1						1															15	81
9/30/97		17								6		1		1						2							i								28	
10/9/97		10																																	10	
10/16/97		3								103															1										112	
10/25/97																																			0	
11/3/97										7																									7	
12/3/97		3				3				4															11	2									23	
Site L-5																																				
9/3/97				27	1								1							14			1		1			1				10			56	52
9/10/97			2	190									1	2						6				1				1							203	160
9/24/97		2	12				1			22																									37	55
9/30/97		10	19																	3															32	
10/9/97		3	1																	1															5	
10/25/97																																			0	
11/3/97											11																								11	

* Fish captured: too small to be fully recruited to the beach seine.

Site L-3	Coho salmon (smolts)	Steelhead (juveniles)	Surf smelt	Surf smelt (<60 mm) *	Staghorn sculpin	Staghorn sculpin (<40mm)*	Prickley sculpin	Prickley sculpin(<40 mm)	Coast range sculpin	Top smelt	Top smelt (<60 mm) *	Starry flounder	English sole	Speckled sandab	Shiner surfperch	Pacific sardine	Striped surfperch	Pacific herring	Kelp greenling	Bay pipefish	Cabezon	Saddleback gunnel	Penpoint gunnel	Juvenile rockfish	Threespine stickleback	Stickleback (<40mm) *	California roach	Tidepool sculpin	Pacific lamprey	Silverspoted sculpin	Northern anchovey	Pacific tomcod	Nightsmett	Pacific sanddab	Total Fish	Dugeness crab
5/22/96					9																														9	
6/12/96		7	1									3																							11	
7/2/96		7			5							11						3																	26	
7/23/96		20	24		3							2						5																	54	
8/13/96		16			5	2						2										1													26	
9/4/96		1	21		2							2																							26	
9/24/96		2	5																	2															9	
10/11/96		12	43															53		2															110	
10/16/96		7	3																	1															11	
10/30/96		22																																	22	
11/6/96		1																																	1	
11/6/96		1																																	1	
11/25/96																																			0	
12/19/96							1																		1	1									3	
1/15/97																																			0	
2/17/97																																			0	
2/27/97																									1										1	
3/14/97																																			0	
3/26/97																																			0	
4/3/97																																			0	
4/23/97			1				1																												2	
5/7/97			1																																1	
5/21/97		1																																	1	
6/5/97	2	5											4																						11	
6/23/97			2		4								1																						7	9
7/7/97		4	1		1																			2											8	9
7/15/97	1	1	9		4								3					43			1							1		1					63	5
7/24/97		1	10															25																	36	4
7/30/97					1																														1	
8/7/97		3					2						1							1				2											9	4
8/14/97		10			4								1	1										1				7							24	8
8/20/97		3			1								2							6				1				1							14	26
8/28/97		5	3		2									1						1				1				1							14	6
9/3/97		7								5				1						1															14	8
9/10/97		43								2										2								2							49	1
9/24/97		22										1																							23	7
10/16/97		1								34																									35	
10/25/97																									1										1	
11/3/97																																			0	
12/3/97			18																								6	1							25	

Table A-26. Number of specimens captured by beach seine from the Navarro River estuarv May 20. 1996 - December 3. 1997. Site L-4.

Site L-4	Coho salmon (smolts)	Steelhead (juveniles)	Surf smelt	Surf smelt (<60 mm) *	Staghorn sculpin	Staghorn sculpin (<40mm)*	Prickley sculpin	Prickley sculpin(<40 mm)	Coast range sculpin	Top smelt	Top smelt (<60 mm) *	Starry flounder	English sole	Speckled sandab	Shiner surfperch	Pacific sardine	Striped surfperch	Pacific herring	Kelp greenling	Bay pipefish	Cabezon	Saddleback gunnel	Penpoint gunnel	Juvenile rockfish	Threespine stickleback	Stickleback (<40mm) *	California roach	Tidepool sculpin	Pacific lamprey	Silverspoted sculpin	Northern anchovey	Pacific tomcod	Nightsmett	Pacific sanddab	Total Fish	Dugeness crab
5/20/96					2																		1	1											4	
5/22/96	1	28	34		5																1														69	
6/11/96			6		4		1					1																							12	
6/12»96	5	20	157		3								1								1														187	
7/2/96	1	25	5		17					3					•						1		1												53	
7/3/96		19	4		3							3																							29	
7/23'96		3	3		4							6								1															17	
8/13/96		1										5								1			1												8	1
8/1 4/96		12	179		7							6						3		1															208	
9/4/96		27					1													12			5	4											49	3
9/24/96		2										1																							3	
10/11/96		68																		8															76	
10/16/96		19										1								7															27	
10/30/96		11	27																																38	
11/6/96																																			0	
11/18/96		3	2																	1															6	
11/25/96			3															2																	5	
12/19/96			1	69																															70	
1/15/97																																			0	
2/17/97																																			0	
2/27/97			1																																1	
3/14/97			10	33								3								2															48	
3/26/97																																			0	
4/8/97			22	64	1																														87	
4/23/97			7									1												1				1							10	
5/7/97					2							2	2	3							2			4											15	1
5/21/97	33	2	29		2																														66	
6/5/97			7		13	1				8			19										1												49	
6/23/97					11								42	1						1															55	5
7/7/97		2	302										73								1														378	73
7/15/97			5		6								31	2				13																	57	10
7/24/97			1		2								23	2																					28	8
7/30/97		2	63		1		1						2					37							1										107	15
8/7/97			4		2					4			8	23				2		3					1										47	62
8/14/97			19		1								9	9				1							1										40	111
8/20/97			2		1					10		2	5	1																					21	178
8/28/97		1	1		1					2				6																					11	76
9/3/97			2		1							1						1																	5	264
9/10/97		10		1	11							1	1	3						7													1		34	29
9/24/97		2			8									3						1														1	14	320
9/30/97		7	10		1															1															19	1
10/9/97		3	25							1										1															30	
10/16/97					1					7		1													1										10	2
10/25/97					1									1						3					1										6	
11/3/97										21	2																								23	
12/3/97			4		1	1																					1								7	

* Fish captured: Too small to be fully recruited to the beach seine.