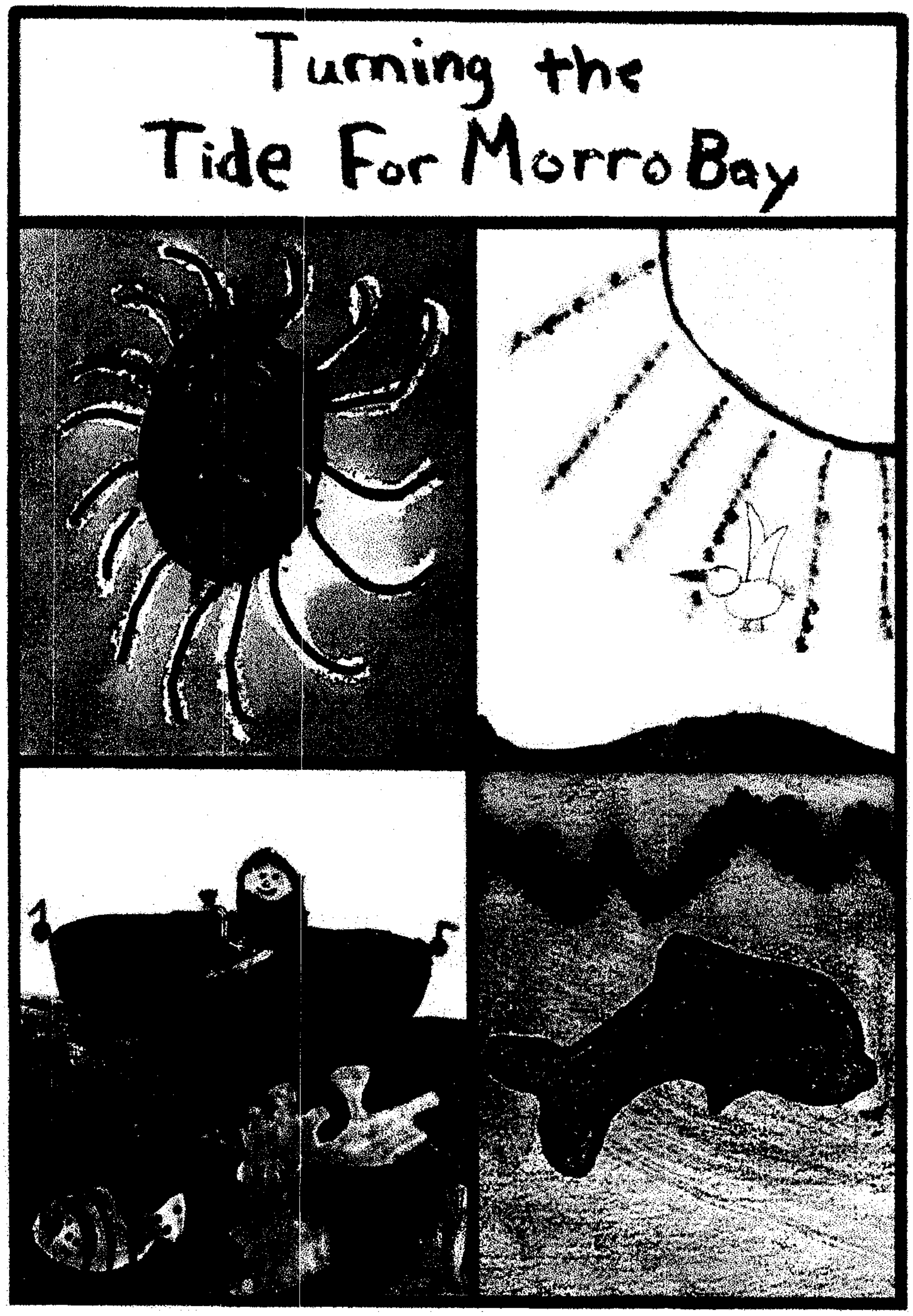


# COMPREHENSIVE CONSERVATION & MANAGEMENT PLAN FOR MORRO BAY

Published by the Morro Bay National Estuary Program,
The Bay Foundation of Morro Bay and the Central Coast Regional Water Quality Control Board
in cooperation with the U.S. Environmental Protection Agency Region IX

## VOLUME II

**Prepared by the Morro Bay National Estuary Program Management Conference & Staff**

**With the assistance of Battelle**

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## COVER DESIGN

In the fall of 1998, 211 Kindergarten through 12th Grade students entered the Morro Bay National Estuary Program "Turning the Tide" Poster Contest. Entries were judged in three age groups—Kindergarten through 3rd Grade, 4th through 6th Grade, and 7th through 12th Grade. Over 200 people attending the 1998 Oktoberfest in Baywood Park, California selected the final winners. Ben and Jerry's Ice Cream donated gift certificates to all of the winning entries, and Duke Energy and Kinko's Copies in San Luis Obispo provided funds for printing the 1999 MBNEP Calendars. The winning artwork provides the theme for the CCMP and appears throughout this document. Thanks to the following poster contest participants:

Cynthia Bernal, Sunnyside Elementary School
Chelsea Dauer, Home-school student
Jacqueline Echevarria, Baywood Elementary School
Tim Edge, Teach Elementary School
John Fields, Judkins Middle School
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Brittany Howlett, Judkins Middle School
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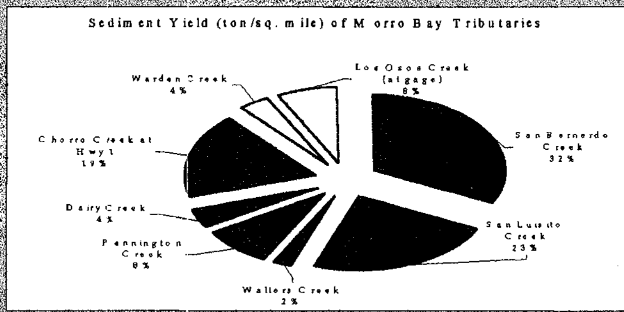


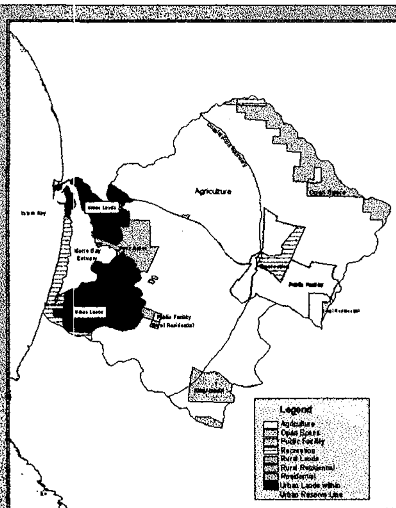


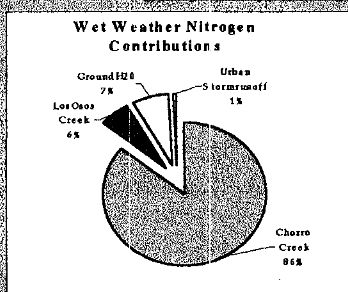


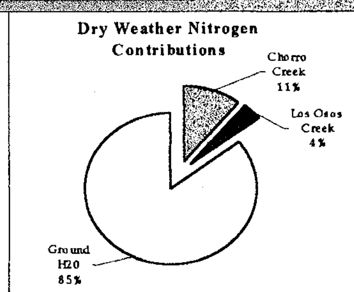


# Characterization
# Morro Bay National Estuary Program

July 2000

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# 1.0 GENERAL INTRODUCTION

## 1.1 WHY IS A CHARACTERIZATION DOCUMENT NEEDED?

In order to develop corrective actions for the Morro Bay estuary, it is first necessary to describe the resources and the problem sources impacting the estuary. This document represents a synthesis of existing research reports, recently collected data, and local and regional planning documents. It is meant to facilitate decisions that the local community will make regarding the actions to be implemented to protect the resources and the water quality of Morro Bay.

The Characterization document is a companion document to the CCMP, along with the Base Programs Analysis, a Monitoring Plan, and the Public Participation Strategy. These documents are required by Section 320 of the Clean Water Act.

In order to define priority problems and focus the characterization effort, over 100 meetings have been held in the local community over the past four years. The Characterization has been under preparation for approximately a year and a half. It includes references to studies dating from the 1960s, and monitoring that has been ongoing since the 1970s, or even earlier in some cases.

As part of this Characterization, five technical studies and/or modeling efforts were conducted to expand the information database, to further characterize the estuary, and to drive the development of action plans. These studies include:

- Sediment loading study;
- Watershed streamflow model;
- Morro Bay bathymetry and tidal circulation study;
- Nutrient loading study;
- Bacterial loading study; and
- Estuary habitat characterization and assessment.

Results of these studies are summarized in this Characterization document.

## 1.2 WHO IS THE INTENDED AUDIENCE?

This document is intended for the citizens, community groups, technical experts, government representatives, and resource management teams responsible for developing actions that will be used to protect the resources of Morro Bay estuary and watershed.

## 1.3 HOW IS THE DOCUMENT ORGANIZED?

This document is organized to provide an overview of the Morro Bay National Estuary Program (MBNEP) planning process, a description of the resources contained within the estuary and the watershed, and an understanding of the priority problems that have been identified in numerous community meetings. The Characterization has been divided into three principal parts. *Part 1* provides an overview of the MBNEP planning process and the makeup of the management conference. *Part II* describes the estuary and the watershed and the resources contained within them. This section also provides a detailed look at Morro Bay's geological, hydrological, and biological resources. Land and bay uses and other beneficial uses are identified. *Part III* describes the priority problems of the estuary and watershed. Where possible, problem sources are identified. Effects of these problems on bay resources and beneficial uses are also identified.

## 1.4 MORRO BAY CHARACTERIZATION STUDY AREA

The Morro Bay estuary is situated easterly of the larger Estero Bay, which stretches approximately 22 miles from Point Buchon in the south to Point Estero in the north. Estero Bay is located approximately half way between San Francisco and Los Angeles. The climate is Mediterranean, and most of the 16 to 22 inches of annual rainfall comes in the winter months. The MBNEP study area includes the estuary, the 48,000 acre watershed draining into the estuary and, to a certain extent, Estero Bay from Pt. Buchon to Pt. Estero (Figure 1-1). Although Estero Bay is included within the established jurisdictional boundaries of the National Estuary Program (NEP), it is not characterized in depth since the priority problems identified by NEP stakeholders are located primarily within the Morro Bay estuary and its watershed. However, the original seaward boundary of the study area has been retained in order to provide successful long-term management of potential problems that could originate in the near shore region.

A broad spectrum of activity occurs within Estero Bay that either impact or rely on the water and habitat quality of the Morro Bay estuary. These activities include an abalone farm, recreational use of beaches, oil terminals, commercial fishing, submarine cable activities, treated wastewater disposal, and offshore oil leasing areas, to name a few. In addition, there are direct linkages between Estero Bay and Morro Bay through the harbor mouth entrance. For example, when Morro Bay fecal coliform levels are extremely high, certain beaches and surf spots in Estero Bay could be subject to contamination from the plume flowing out of the bay. The bay's nutrient production and nursery functions are closely linked to nearshore ecosystem functions that support numerous species of plants and animals. Morro Bay is as deep as 45 feet at Fairbanks Narrows, but it has an average depth of three feet and covers approximately 2300 surface acres (U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration (NOAA) 1990).

## 1.5 BACKGROUND

The Morro Bay estuary supports the most significant wetland system on California's south central coast. It serves as a link for migratory birds and is home to a diverse collection of wildlife species, many of which cannot be found anywhere else in the world. The Morro Bay harbor is a nursery for fish species such as English sole, lingcod, and herring, and is important to the local tourist and commercial fishing industries.

As far back as the 1960's, the Legislature recognized the need for a comprehensive approach to planning and managing the watershed and the estuary. In 1966 the California State Legislature, in Senate Resolution No. 176, declared that the preservation of Morro Bay's fish, wildlife, recreational and aesthetic resources was of great importance to the people of California.

In the early 1970s, the Morro Bay Task Force was formed to begin the process of developing a comprehensive plan. Initially this group was composed of 23 local, state, and federal agencies and a 13-member citizen's advisory committee. A consulting firm was hired, and in 1975 *Coastal Watershed Environmental Management System, Morro Bay, California* was produced (Grote and Patri 1975). This report, along with providing several management options, identified a chronic problem facing the development of a comprehensive management plan: conflicting and overlapping responsibilities of local, state, and federal agencies. It is believed that this 1975 report, though technically sound, "fell into oblivion" due to lack of community involvement in its production (Eabry 1992). The Task Force disbanded shortly after release of the report.

In 1986, the Morro Bay Task Force was reestablished. The community was rejuvenated and revitalized and created two non-profit organizations, the Bay Foundation of Morro Bay and the Friends of the Estuary at Morro Bay. These two groups are charged with research and advocacy, respectively. A new Task Force started meeting on a quarterly basis and grew to 250 participants, ranging from state and federal agency representatives to private landowners and the general public. Through the efforts of this group, strong, widespread, and multi-partisan support for the development of a Comprehensive Conservation and Management Plan for Morro Bay and its watershed emerged (Laurent 1992).

The Coastal San Luis Resource Conservation District (RCD) had long recognized the importance of the Morro Bay Estuary. In the 1970's District leaders adopted the reduction of erosion in the Morro Bay watershed as one of their long-term goals. In 1987 the RCD obtained funding through the California State Coastal Conservancy (SCC) to quantify the historical loss of open water in the bay, and to locate and quantify sediment sources to the bay in order to create a baseline for future reference. The results of the study indicated that the bay had been filling in at a rate ten times greater during the last one hundred years than it had previously (Haltiner, 1988). The results also showed that the bay has decreased in volume by 25 percent in the last century (Haltiner, 1988).

Using these studies as a baseline, the RCD then hired the USDA Soil Conservation Service (now known as the Natural Resources Conservation Service) to develop the Morro Bay Watershed Enhancement Plan. The recommended plan detailed three phases of action. Phase I was land treatment. Phase II was a sediment trap on Los Osos Creek. Phase III was a sediment trap on Chorro Creek.

In Phase I, technical and financial assistance was given to land users to help them correct conservation problems. The RCD obtained a grant of $400,000 from the SCC to cost share with land users on land treatment measures. The RCD contracted with the SCS to provide the technical assistance to get the job done.

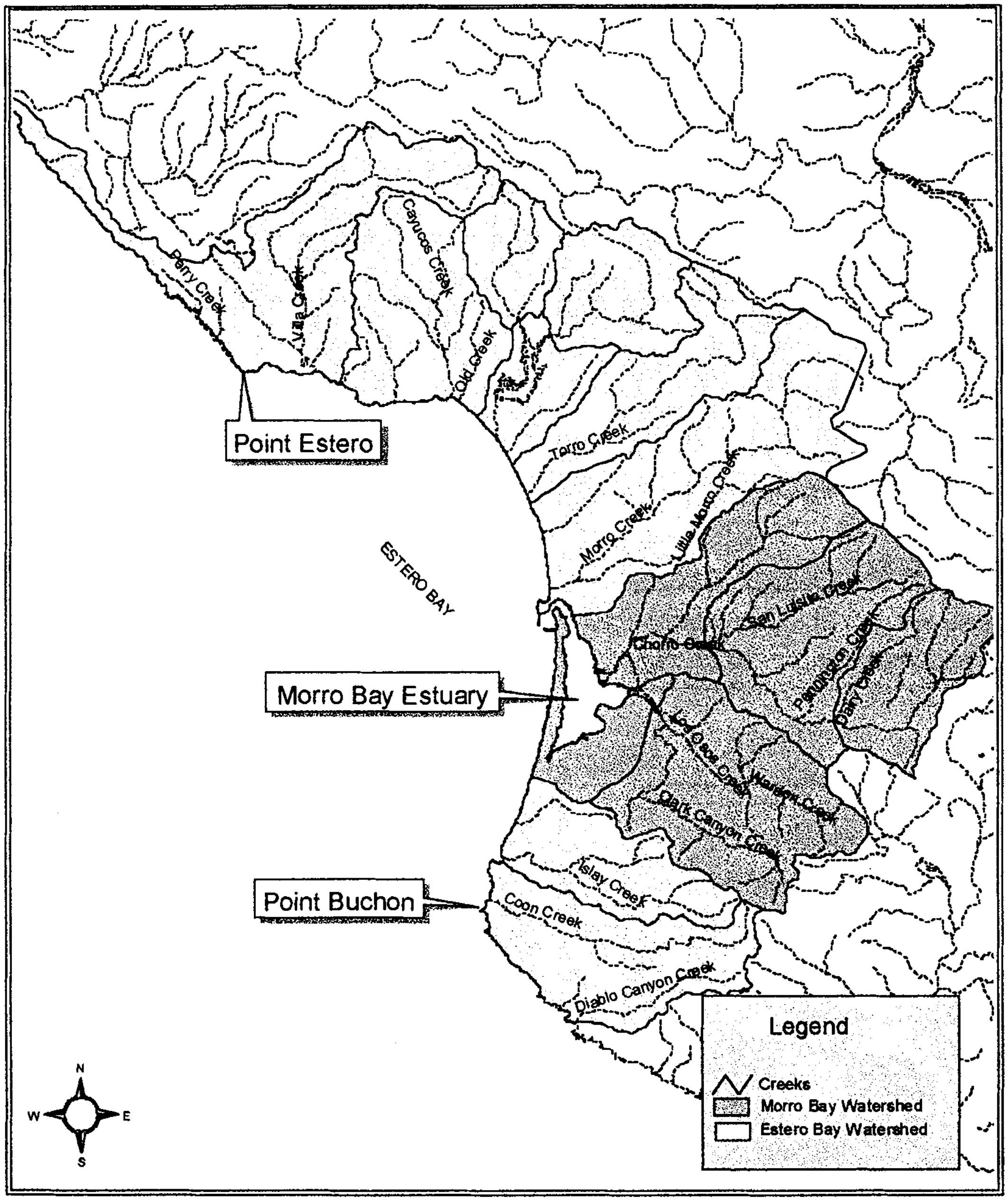



Figure 1.1 Location of MBNEP Study Area

MBNEP Characterization 1999

The U.S. Department of Agriculture (USDA) has also contributed funding for the enhancement of the Morro Bay watershed. A USDA water quality program was initiated in 1991. Funds were made available to three USDA agencies for accelerated work within the area. The SCS received $700,000 over five years for increased technical assistance. The Agriculture Stabilization and Conservation Service (now known as the Farm Service Agency or FSA) received $100,000 for increased cost-sharing assistance to land users, and $250,000 was granted to the University of California Cooperative Extension for information and education programs. The most innovative of which is the 4-H Environmental Watershed Program, which educates youth on the importance of water quality and watershed environments.

To date over 240 conservation practices have been installed in the watershed through technical and financial assistance provided through the Morro Bay Watershed Enhancement Project (MBWEP). These projects have resulted in the prevention of over 172,000 tons of soil erosion. Additionally, MBWEP projects have caught an estimated 300,000 cubic yards of sediment before it reached the bay.

Phase II of the MBWEP was completed in 1995 when the NRCS and the RCD purchased wetland easements from George Martines for his land at the confluence of Los Osos and Warden Creeks. The easements were purchased using a unique process combining federal and state funding. The NRCS used funding from the federal Wetland Reserve Program (WRP) to purchase a wetland easement in perpetuity over 111 acres. The RCD received funding from a grant made by the SCC to also purchase a wetland easement on the same land plus an agricultural easement on 33 additional acres. The site is now known as the Los Osos Creek Wetland Reserve. The 111 acres have been reestablished as a floodplain for Los Osos and Warden Creeks. Extensive willow growth on the site has created valuable wildlife habitat. Over the last four years it is estimated that at least 120,000 cubic yards of sediment has been deposited on the site.

Phase III of the MBWEP is the Chorro Flats Enhancement Project (CFEP). This project is a sediment capture, agricultural preservation, and habitat restoration and education project. The CFEP has essentially reconnected Chorro Creek with its historical floodplain, thereby allowing sediment to be deposited there instead of in Morro Bay. This is the most significant single action included in the plan. It was estimated that a sediment trap at this site could catch 35% of the sediment entering the Bay through Chorro Creek (USDA SCS 1989).

The MBWEP recognized that the Chorro Flats site would be an ideal place to trap sediment before it reached the Bay. The Chorro Flats site is especially suitable for sediment trapping because:

- Chorro Creek runs through the site;
- Chorro Flats is at the terminus of the watershed;
- Chorro Flats is relatively flat and well suited to trap sediment;
- The site historically was a floodplain, covered with riparian vegetation that naturally trapped sediment.

The passive sediment trapping system allows sediment to accumulate on the floodplain as a result of deposition during overbank flows. Increased vegetation on the floodplain helps to reduce the velocity of overbank flows and increase the rate of sediment deposition. Approximately 83 acres were included in the floodplain and 45 acres were reserved for agriculture. This allows for a capacity of in excess of 600,000 cubic yards and a projected lifespan of at least 50 to 70 years. The deposited sediment will primarily be sand-sized particles with a moderate amount of fine-grained materials (silt and clay). Most of the coarse grained material (pebble and cobble) will be trapped in the creek channel.

The project was constructed in 1997, and is now in the monitoring and maintenance phase. Recent surveys of the site have revealed that over 188,000 cubic yards of material have already been captured on the site.

The bay's importance was again recognized on June 29, 1990, when the Legislature enacted Assembly Concurrent Resolution 118. This resolution "affirms the importance and value of Morro Bay, its estuary, and its environs to the people of California and supports the nomination of Morro Bay as a National Estuary as provided in federal law, to be administered by the United States Environmental Protection Agency (EPA)". The community coalesced, and the first "State of the Bay" conference was held. However, Morro Bay was not yet accepted into the National Estuary Program.

In April 1994, through the efforts of the Friends of the Estuary, Governor Pete Wilson signed Assembly Bill 640, establishing Morro Bay as California's first State Estuary. This designation formally recognized the importance of "preserving and enhancing Morro Bay and its watershed as one of the state's rare natural treasures" and the special need for a multi-jurisdictional planning effort. Assembly Bill 640 mandated that a comprehensive management plan be developed for Morro Bay by July 1997. The Task Force convened an administrative committee, the Watershed Council, to oversee development of the plan. In 1998, the City of Morro Bay and the County of San Luis Obispo received the State Plan.

In October 1995, Morro Bay was accepted into the NEP primarily due in part to the long-term grass-root efforts, and because it was already a State designated estuary. The Central Coast Regional Water Quality Control Board and the Bay Foundation of Morro Bay, in conjunction with the EPA, Region IX, established a Management Conference to prepare the CCMP. This conference consists of the Local Policy Committee (nine representatives of local private and public organizations), the Watershed Committee (thirty representatives of key stakeholder groups in the watershed), a large and diverse Technical Advisory Committee, and a Citizen Advisory Committee. These groups are developing the CCMP for the Morro Bay estuary and watershed.

## 1.6 OVERVIEW OF PRIORITY PROBLEMS

In the documents nominating Morro Bay to national estuary status, a number of priority problems were identified. Sediment threatens to shorten the life of this open water resource by as much as ten-fold (Haltiner, 1988). Other water quality concerns include excessive levels of bacteria, nutrients, and heavy metals. Water diversion, urban and agricultural runoff, and increasing impervious surfaces threaten the long-term health of the bay.

Not all threats to the bay are tied to water quality. Reduction in fresh water flows adversely impact fish and wildlife species dependent upon freshwater and brackish water habitats, such as steelhead trout. Several species that are state and/or federally listed as endangered -- or are candidate species for listing -- are at risk. The direct and indirect loss of all habitat types due to human activities is another threat to the bay. Habitat loss impacts the diversity and abundance of wildlife historically found in the bay and its watershed, such as steelhead trout.

In summary, the seven priority problems identified by the MBNEP are: sedimentation, bacterial contamination, nutrient enrichment, loss of freshwater flow during dry seasons, toxic contamination (heavy metals), loss of habitat, and declines in steelhead trout.

Another concern is the lack of data that exists for resources. The Bureau of Land Management and the U. S. Fish and Wildlife Service have highlighted the lack of estuarine data from the central coast and the importance of this information to national planning. "Data on estuarine species inhabiting smaller estuaries and estuaries remote from university and/or marine labs (in particular, central California from Monterey to Point Conception) are scant. Biological and physical processes and interactions are poorly understood for major California estuaries and unknown for the smaller estuaries. The lack of such information severely limits the ability to assess potential effects on estuaries of human activities such as those associated with offshore oil and gas development" (Jones and Stokes 1981).

This document intends to fill some of those data gaps and focus the development of action plans on areas of greatest need.

# 2.0 PHYSICAL RESOURCES

## 2.1 MORRO BAY PROPER

The Morro Bay estuary has changed over time due to both natural and human-caused disturbances. This section describes some of those disturbances and processes.

### 2.1.1 General Description of Morro Bay and Navigational Channels - Prior to 1920

Morro Bay is a natural embayment located on the central coast of California about 96 km north of Point Conception and about 160 km south of Monterey Bay. The bay is situated approximately in the middle of Estero Bay in San Luis Obispo County. Estero Bay is bounded by Point Estero on the north and Point Buchon on the south (Figure 1-1). Morro Bay is a shallow lagoon, approximately 6.5 km long in the north-south direction and about 2.8 km wide in the east-west direction at its maximum width (Figure 2-2). The bay was formed by the submergence of the river mouth at the confluence of Chorro Creek and Los Osos Creek during the post-glacial sea level rise about 10,000 to 15,000 years ago. The Morro Bay watershed, drained by Chorro and Los Osos Creeks, has an area of about 186 $km^2$. Littoral and aeolian sand transport created the protective sand-spit barrier beach between Morro Bay and the Pacific Ocean.

In its natural condition, the entrance channel to Morro Bay passed around and close to the southeast and easterly sides of Morro Rock (see Figure 2- 1). Prior to 1910, Morro Rock was separated from the shoreline, and the main channel near the embarcadero was located just easterly of the sandspit, which was much thinner than it currently is (U.S. Army Corps of Engineers (ACOE) 1920, as represented in ACOE 1976). It is also important to note that in 1920, the State Park Marina and Cuesta inlet had not yet been dredged.

In the late 1890's, extensive quarrying of Morro Rock began, and tons of rock were removed to form the breakwater for Port San Luis (south of San Luis Obispo), as well as local buildings. Port San Luis became the major area port. There was general agreement in the local community that when and if the Morro Bay harbor were ever to be improved, the North Channel would be preserved. In 1910, this sentiment shifted because the north channel frequently filled with downcast drift, and incoming navigation was required to use the entrance on the south side. Eventually, in 1911, the San Francisco Bridge Company completed a barrier across the entire north entrance, but they did not leave the ACOE's requested entrance for fishing boats to be utilized during severe weather. This was the first bridge to Morro Rock.

### 2.1.2 General Description of Morro Bay and Navigational Channels - 1930's and 1940's

In 1941, the U.S. Navy requested that the Morro Bay harbor be improved for use as a base for naval patrol craft (ACOE 1991). From 1941 to 1946, the ACOE made a series of improvements, shown in Figure 2-2, which included:

- two stone breakwaters, the north and the south,
- a dike extending 1,600 feet from Morro Rock to the mainland,
- a 7,000 foot revetment,
- an entrance channel (16 feet deep by 350 feet wide),
- the Navy channel (16 feet deep by 800 feet maximum width), and
- the Morro channel (12 feet deep by 150 feet wide).

These structural changes and the dynamics of outgoing tidal velocity and incoming sediment transport have resulted in a continual shoaling problem in the entrance, Navy, and Morro navigational channels of the bay. From 1944 to 1975, maintenance dredging occurred in Morro Bay on average at least every 5 years (Noda and Jen 1975). A total of 3.5 million cubic yards had been dredged as of 1975. In 1976, the ACOE estimated that the rate of shoaling within the channels was 120,700 cubic yards per year (ACOE 1976). Presently, dredging occurs on an average of once every two to three years. In time, concern for the preservation of the Morro Rock resulted in the termination of the Morro Rock quarry operation, but the causeway has remained. No real cost estimates for removing the causeway have ever been developed.

### 2.1.3 Current Bathymetry of Morro Bay

Although there has been extensive damage sustained at the breakwaters, and continued shoaling problems as discussed above, the basic man-made improvements and the entrance channels remain largely the same today as they were at the close of the 1940's. Breaking waves at the entrance to Morro Bay have always presented a serious hazard to navigation. From 1979 to 1987, 21 people were killed in boating accidents in Morro Bay making it one of the eight most dangerous harbors in the United States (ACOE 1991).

In 1998, the Morro Bay National Estuary Program (MBNEP) funded a bathymetric and oceanographic survey (Tetra Tech 1999) to provide a basis for modeling efforts. Methods and results are presented below.

Historical bathymetric data for Morro Bay and Estero Bay was obtained from the National Oceanic and Atmospheric Administration (NOAA) National Ocean Service CD-ROM Geophysical Data System for Hydrographic Survey Data. Surveys of Morro Bay date back to the 1930s and were used for the early setup and testing of the hydrodynamic model. The ACOE periodically surveys the harbor and navigation channels in Morro Bay. A survey by the ACOE in June 1998 was used to develop bathymetry for the harbor and navigation channels in the hydrodynamic model.

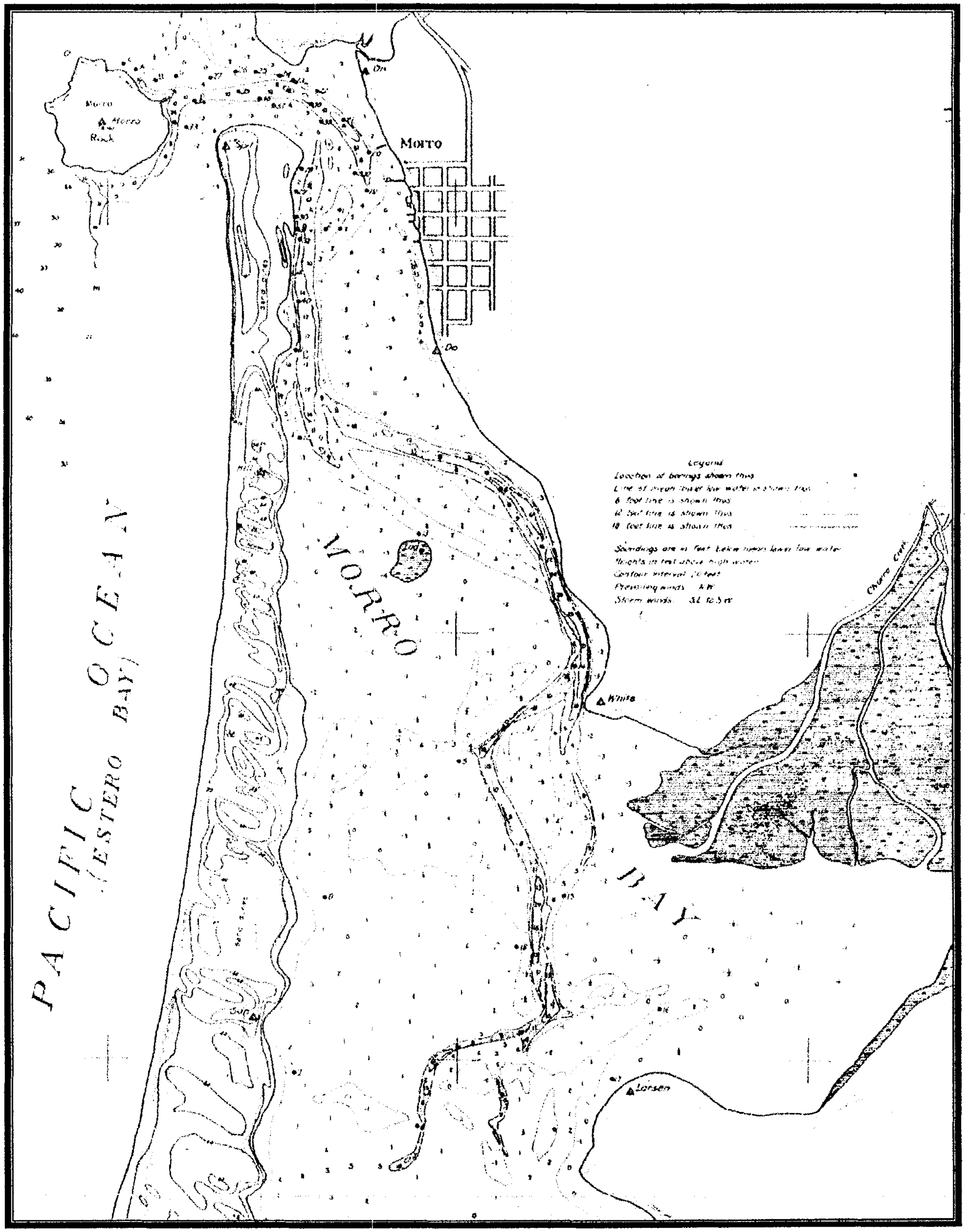



**Figure 2-1. Historical 1920 Map of Morro Bay Prior to Harbor Improvements.**

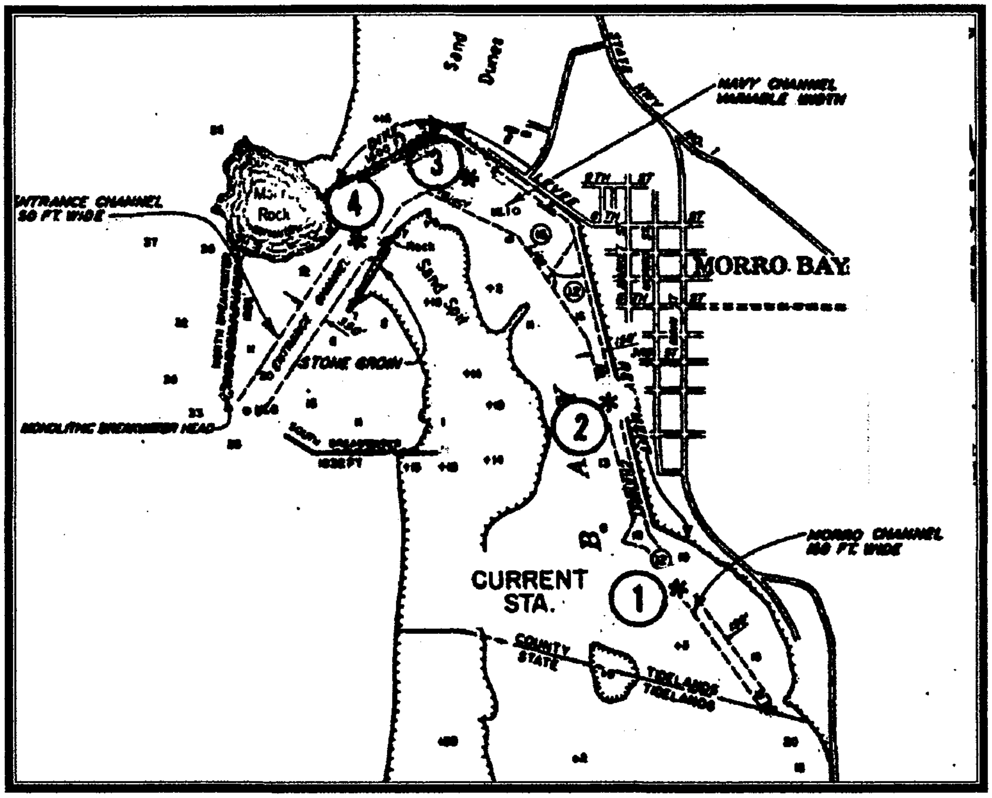



**Figure 2-2. Navigation Channels in Morro Bay as Diagrammed by Army Corps of Engineers** *(Source: Noda and Jen 1975)*

### *Tetra Tech Study Methods*

The purpose of the bathymetric survey of Morro Bay was twofold. The first objective was to provide the present water depths for input to the hydrodynamic model being developed for this study. The second objective was to use the same water depth data to produce a bathymetric chart showing depth contours at intervals of one foot for the entire bay. This information was presented as a large format chart (E-size) and was incorporated into a Geographic Information System (GIS). The bathymetric chart is located in the MBNEP office, and a reduced version is shown in Figure 2-3.

Survey lines were calculated at 500-ft intervals to cover the entire bay. Recording tide gauges were deployed, one at the northern end and the other at the southern end of the bay. Using a shallow draft duck boat, a small digital fathometer (meridata MD100) was used to measure water depths along the predetermined survey lines. A larger vessel was used in the relatively rougher water at the mouth and for the northern reaches of the bay.

The bathymetric survey began on March 11, 1998 and was completed on March 16, 1998. Over 4,500 depths were recorded, spaced 30 ft apart along the predetermined survey lines.

In conjunction with measuring the water depths, the mean higher water line was surveyed for the entire bay. A surveyor walked the high tide along the entire bay and delta from the breakwater at Morro Rock to the southern breakwater.

### *Tetra Tech Study Results*

The general bathymetry of the bay consists of extensive areas of mudflats with little variation in slope and of steep-sided channels that cut through the mudflats. The depth and width of these channels show considerable variability.

### *Historical Trends of Water Depths in Morro Bay*

Tetra Tech (1999) estimated long term changes in water depth and water volume in Morro Bay by comparing the changes in historical bathymetric data. Haltiner (1988), who conducted the most recent bathymetric survey in 1987, compared his survey results to three previous surveys of the bay (1935, 1919, and 1884). His analyses provide estimates of the changes in:

- the volume of water in Morro Bay;
- the area-depth relationships (hypsometry) within the bay (as reported in Josselyn, Martindale, and Callaway 1989); and,
- the mean tidal prism.

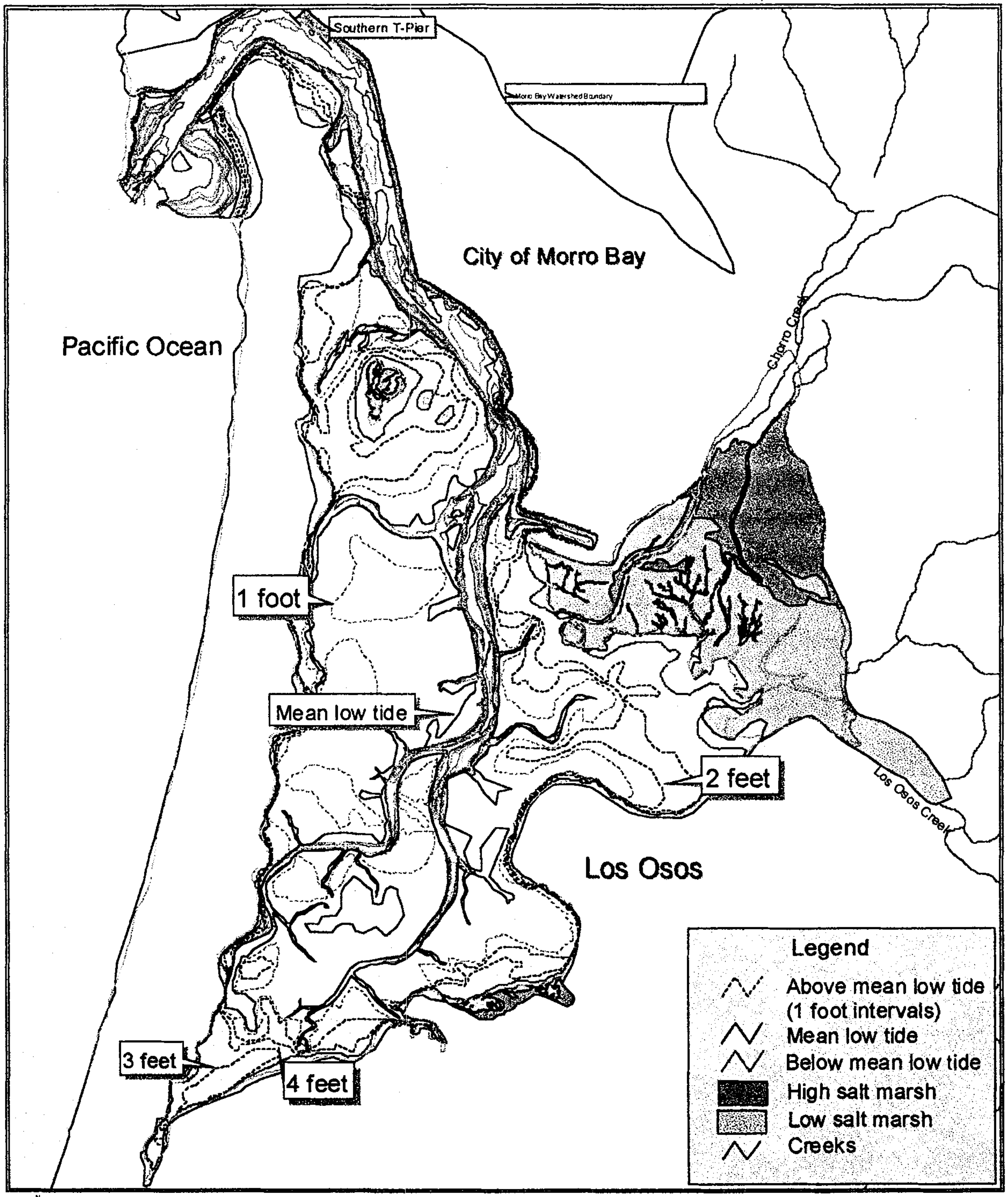



Figure 2.3 Map Showing Current Bathymetry of Morro Bay
Source: TetraTech Bathymetry Survey 1999
MBNEP Characterization 1999

Asquith (1991) has also reported on water depth changes. His study addressed changes in tidal channels, and focused on the location and a cross-section of channels at specific locations.

The 1998 Tetra Tech survey of water depths was used to produce a bathymetric chart of Morro Bay. The 1998 chart was developed using conventional contouring, aerial photos, and GIS tools. Each depth contour was created as a separate GIS coverage. Haltiner's (1988) bathymetry was digitized from a 1:5000 scale paper plot and added to the Morro Bay GIS.

Based on a comparison of results from the 1998 bathymetric survey and the previous bathymetric survey and historical analyses of Haltiner (1988), estimates of changes in water depths, area, and volume in Morro Bay over time can be made. In Tetra Tech's study, these estimates were based upon the assumptions that:

- bathymetric survey results for all years are of comparable accuracy;
- bathymetric charts from the 1884, 1919, 1935, and 1987 are plotted at comparable accuracy; and
- planimetric data collected by Haltiner from the historical charts are of comparable accuracy.

Data collected by Tetra Tech were plotted against historical data provided by Haltiner (1988) as shown in Figure 2.4 below and summarized in Table 2.1. The 1998 calculated volumes are substantially higher than all previous values, including the 1884 values. Inspection of the data shows a large (400 percent) discrepancy in the volume calculated below the –3ft mean low low water (MLLW) depth. Haltiner (1988) report values of 600 to 850 acre-feet at this depth for all previous surveys compared to 3,566 acre-feet calculated from the 1998 bathymetry.

It has been pointed out that the 1884 survey is of questionable accuracy, and that the 1987 survey was limited to the channels. Noting that there are two schools of thought on this issue, below is a comparison of the 1998 Tetra Tech bathymetry with the historical estimates of water depths:

The 1998 volumes fall between the 1987 and the 1884 values (Figure 2.4). This is an indication of the uncertainty of the methods, of the accuracy of historical charts, and the different level of detail used in calculating volumes rather than a representation of historical bathymetric trends.

It is unlikely that the volume of water in the bay has increased since 1987. Periodic dredging of the navigation channels in the north of the bay temporarily removes between 300 and 600 acre-feet of sediment every two to six years (Tetra Tech, 1998). Figure 2.5 shows the volumes of material dredged from Morro Bay by the USACE over the past thirty years. This is the equivalent of dredging approximately 100 acre-feet of sediment every year. By removing sediment, each dredging operation temporarily increases the volume of water below MLLW by about 7 percent. However, this sediment is replaced relatively quickly within a few (2 to 6) years and dredging is required again to maintain the navigation channel depths.

The major observations that can be made with these adjusted data are:

- the entire area of Morro Bay has decreased during the past 114 years by about 15 percent, from an estimated 2,300 acres to 2,024 acres
- the area covered by water at low tide has decreased by 60 percent, from 1,255 acres in 1884 to 523 acres in 1998
- the volume of water in Morro Bay at MHHW has decreased from 1884 to 1998 by approximately 20 to 25 percent or 2,000 acre-feet
- the decrease in the volume of water in Morro Bay at MLLW over the same period is approximately 18 to 22 percent or 1,200 acre-feet
- the decrease in volume below –1 ft MLLW is about 5 percent or 200 acre-feet
- the decrease in the mean tidal prism since 1884 is between 20 and 30 percent.

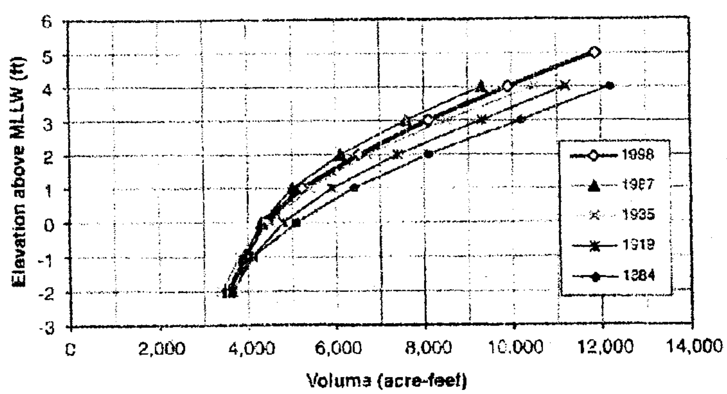



**Figure 2.4 Historical volume versus depth for Morro Bay, 1884-1998.**
*Source: Tetra Tech 1998*

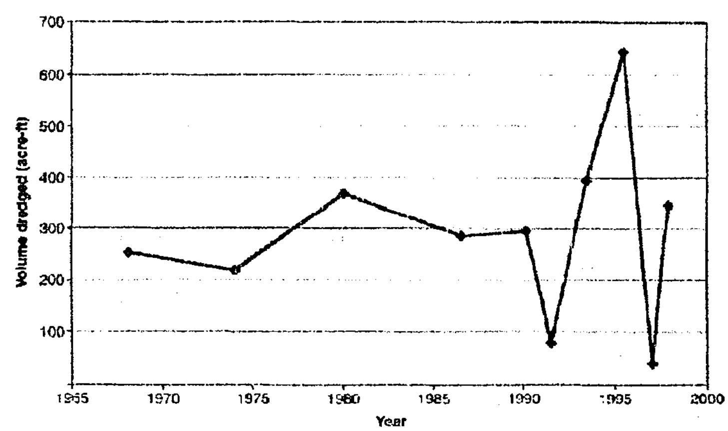



Figure K-3. Volumes of dredged sediment, Morro Bay, 1965 - 1998.

**Figure 2.5 Volumes of dredged sediment, Morro Bay, 1965-1998.**
*Source: Tetra Tech 1998*

These results, in combination with the approximately 15 percent loss of area in the bay, imply that encroachment from the margins and aggradation of the most shallow areas within the bay are the most likely processes causing the decrease in volume.

**Table 2-1. Hyposmetric (area versus depth) Data Summary for Morro Bay, 1884-1998**

| Cumulative Area (acres) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Year of bathymetric survey | | | | | Change in area | | | |
| **Height above MLLW** | **1998** | **1987 (digitized)** | **1987** | **1935** | **1919** | **1884** | **1884-1987** | **1884-1998** | **1987-1998** |
| **5** | 2024 | | | | | | | | |
| **4** | 1897 | | 1891 | 2158 | 2155 | 2240 | -16% | -15% | |
| **3** | 1697 | | 1805 | 2001 | 1900 | 2110 | | | |
| **2** | 1475 | 1542 | 1521 | 1733 | 1743 | 1985 | -23% | -26% | 4% |
| **1** | 1147 | 1024 | 1155 | 1423 | 1455 | 1697 | -32% | -32% | -11% |
| **0** | 523 | 567 | 629 | 907 | 1047 | 1255 | -50% | -58% | 7% |
| **-1** | 388 | 361 | 361 | 673 | 780 | 955 | -62% | -59% | |
| **-2** | 358 | | 315 | 267 | 350 | 592 | | | |
| **-3** | 336 | | 287 | 221 | 249 | 255 | | | |
| **-4** | 318 | | | | | | | | |
| **-5** | 301 | | | | | | | | |
| **-10** | 213 | | | | | | | | |
| **-15** | 102 | | | | | | | | |
| **-20** | 27 | | | | | | | | |
| **-30** | 5 | | | | | | | | |
| **-40** | .4 | | | | | | | | |

### 2.1.4 Morro Bay Substrate Composition

The substrate composition analysis of Morro Bay has yet to be compiled, and will be included in further versions of this document.

### 2.1.5 Morro Bay Tidal Circulation Patterns

In Morro Bay, there are two mechanisms available for dilution for flushing of bay waters. The primary mechanism is exchange with the Pacific Ocean (Estero Bay) through the open boundary at the entrance to Morro Bay. Bay water exits the entrance to Estero Bay during ebb tide and ocean water enters during flood tide. There is a certain amount of recirculation that occurs at the bay entrance at the change from ebb to flood tide flow. The diurnal tide range for Morro Bay is approximately 5.3 feet with a tidal prism of 8350 acre-feet (Tetra Tech 1998). In a 1974 study, the peak ebb tides were clocked at 1.7 knots in the Morro Channel. In a 1975 study, flows reached nearly 2.0 knots within the channel at the harbor entrance (Noda and Jen for ACOE; 1975). Later measurements taken by the City of Morro Bay in 1989 estimated current speeds of 1.8 knots.

Tetra Tech classified tides in Morro Bay as mixed, semi-diurnal with two highs and two lows occurring daily. A summary of the tide characteristics is shown in Table 2-2. Peak tidal current speeds in the entrance channel are as high as 1.03 m/sec (2.0 knots) and 0.87 m/sec (1.7 knots) in the interior Morro navigation channel.

**Table 2-2. High and Low Water Tidal Conditions and Corresponding Elevations in Morro Bay.**

| Tidal Condition | Elevation |
|---|---|
| Extreme High Water (EHW) | 2.29 m (7.5 ft) |
| Mean Higher High Water (MHHW) | 1.62 m (5.3 ft) |
| Mean High Water (MHW) | 1.46 m (4.8 ft) |
| Mean Tide Level (MTL) | 0.88 m (2.9 ft) |
| Mean Low Water (MLW) | 0.30 m (1.0 ft) |
| Mean Lower Low Water (MLLW) | 0.00 m (0.0 ft) |
| Extreme Low Water (ELW) | -0.76 m. (-2.5 ft) |

*Source: Draft Morro Bay Hydrodynamic Circulation Model (Tetra Tech 1998).*

The second mechanism available for dilution comes from the two streams, Chorro Creek and Los Osos Creek. The flushing analysis has shown that freshwater flows (or the lack thereof) from Chorro Creek and Los Osos Creek have a significant impact on Morro Bay. During low-flow periods in the summer months, the bay is especially susceptible to the build-up of pollutants in certain areas, most notably, the southwest portion of the bay, the State Park Marina, and the Chorro delta area.

Minimum flushing occurs in the southwest portion of the bay with flushing half-life times on the order of 12 to 18 days. Another area of low flushing is inside the State Park Marina where flushing half-life times range from 5 to 13 days. As with the low-flow simulation, the two areas of weak flushing are the southwest corner of the bay and State Park Marina. The maximum flushing time in the marina decreased from 13 days in the low-flow case to 9 days in the medium-flow case. The import of the higher stream flow rates result in significantly improved flushing in the Chorro-Los Osos Creek delta as compared to the low –flow case. The high flow case indicates extremely fast flushing throughout the bay with a maximum half-life of 7 days in the extreme southwest corner of the bay. It is unlikely, however, that this extreme flow rate of 1,146 cfs would be sustained for seven consecutive days.

Except during drought years, measurable dilution occurs in the tidal channels most years and in the bay itself during high flow events. In high flow events, the bay can be entirely dominated by freshwater (B. Hardy 1996 pers. comm.).

## 2.1.6 Morro Bay Water Quality Conditions

The levels of nutrients, toxic substances, hydrocarbons, bacteria, heavy metals, suspended sediment and turbidity in Morro Bay have been monitored by various entities for many years. The results of the monitoring efforts are discussed in Part III of this document, Priority Problems.

The Morro Bay estuary is considered "impaired waters" for sediment, pathogens, and metals under Section 303(d) of the federal Clean Water Act. Chorro and Los Osos creeks are listed for sediment and nutrients. Chorro is also listed for metals, and Los Osos is listed for priority organics. This designation requires the CCCRWQCB to determine pollutant loadings and develop attainment strategies for these water bodies. Pursuant to Section 303(d), a water is listed as "impaired" if evidence exists that a violation of a water quality standard has occurred, or there is a potential for a future violation.

### *2.1.6.1 Data Sources*

The following key water quality data sources have been included in this synthesis:

- CCRWQCB National Monitoring Program data;
- Friends of the Estuary/NEP/CCRWQCB volunteer monitoring program data;
- California Department of Health Services Sanitation Reports and sampling data.

The National Monitoring Program is discussed below in Section 2.2.4.

The joint Friends of the Estuary/MBNEP Volunteer Monitoring Program has monitored salinity, temperature, stormwater, bacteria, nutrient, and dissolved oxygen levels in the bay since about 1995. The VMP results and bay sampling sites are discussed in subsequent sections of this document.

Other agencies with regulatory jurisdiction over water quality issues also monitor specific parameters within the estuary, and private dischargers are required to monitor as a requirement of obtaining NPDES permits to discharge.

### *2.1.6.2 Point Source Inventory*

The following compilation gives a brief summary of the major point sources within the Morro Bay NEP study area and Estero Bay. The permitted sources are summarized below in Table 2-3.

**Table 2-3. National Pollutant Discharge Elimination System (NPDES)-Permitted Facilities in the vicinity of Estero Bay.**

| Facility | Receiving Water Body | Permitted Flow |
|---|---|---|
| Chevron Estero Marine Terminal | Estero Bay | 0.21 MGD[1] (intermittent) |
| Cayucos Water Plant | Old Creek to Estero Bay | 0.035 MGD[2] (intermittent) |
| Morro Bay/Cayucos Wastewater Treatment Plant | Estero Bay | 1.36 MGD[3] |
| Morro Bay Desalination Plant | Estero Bay | 0.83 MGD[4] (intermittent) |
| Morro Bay Power Plant | Estero Bay[5] | 725 MGD[6] |
| California Men's Colony Wastewater Treatment Plant | Chorro Creek to Morro Bay | 1.2 MGD[7] |

*Morro Bay Power Plant*

The Morro Bay Power Plant and neighboring switchyard occupy approximately 140 acres entirely within the boundary of the City of Morro Bay. The power plant consists of four generation units with a combined electrical production capability of 1030 gross megawatts. Although the plant was originally designed to utilize both fuel oil and natural gas as the source of fuel for the boilers, no fuel oil has been used since 1995. Current and future plant operations will use only natural gas as the fuel source.

Pacific Gas and Electric Co. (PG&E) purchased the property on which the Morro Bay Power Plant is built in 1951. Prior to 1951, the property was owned by the United States Navy and used as an amphibious training base. The post World War II period saw rapid growth in California—and a quickly increasing demand for electricity. In response, utilities such as PG&E built more electric generation to meet the demand. By 1956, construction of Units 1 and 2, the first two generating units, was complete. Units 3 and 4 were constructed between 1961 and 1963.

As a result of legislation encouraging the deregulation of the California's electricity market, PG&E sold the Morro Bay Power Plant to Duke Energy (Duke), of Charlotte North Carolina, in July of 1998. Since taking ownership, Duke has announced plans to retire the existing power plant and replace the units with smaller, more efficient generating units. Should Duke's project proceed, most of the existing power plant would be demolished by the year 2015.

[1] Dry weather flow, 30 day average (WDR Order No. 95-67).
[2] ......
[3] Peak flow, (WDR Order No. 98-15); Permitted dry weather flow is 1.6 MGD.
[4] ......
[5] A portion of site stormwater flows are discharged to Morro Bay harbor (outfall 002).
[6] Seawater (WDR Order No. 95-28).
[7] Dry weather flow rate, 30 day average (WDR Order No. 95-80).

The power plant's interaction with the Morro Bay estuary is primarily through its use of seawater. The plant's boilers use natural gas to create steam, which drives turbines that in turn drive electrical generators. Seawater is used to further cool and condense the steam after it leaves the turbines. The plant pumps seawater (limited to 725 MGD) from its intake structure located near the "T" Piers at the northernmost end of Morro Bay. The seawater passes through the condensers and is discharged into Estero Bay via tunnels and a canal at the base of Morro Rock. This discharge, and the use of seawater, is governed by the Central Coast Regional Water Quality Control Board (CCRWQCB), the agency that administers the plant's NPDES permit.

Tables 2-3 and 2-4 summarize the major monitoring requirements listed in the plant's NPDES permit. These tables reflect the monitoring required of the seawater used for once-through cooling. There are other NPDES-permitted discharges, but their combined flows are insignificant compared to the cooling water. These lists provide an overview but do not capture all of the reporting requirements specified in the permit.

**Table 2-4. Morro Bay Power Plant Monitoring Requirements.**

| Parameter | Limit | Monitoring Frequency |
|---|---|---|
| Flow | 725 million gallons/day (MGD) | Daily |
| Temperature | 30 F (35 during heat treatment) | Daily (continuous) |
| Residual Chlorine | 70 parts-per-billion (ppb) | Weekly |
| PH | 0.2 pH units change from intake value | Weekly |

***Source: James White, personal communication, 1999.***

Data on plant monitoring are reported to the CCRWQCB quarterly.

**Table 2-5. Morro Bay Power Plant Annual Monitoring Requirements.**

| Parameter | Six month median value Limit |
|---|---|
| Arsenic | 0.06 parts-per-million (ppm) |
| Cadmium | 0.01 ppm |
| Chromium, Hexavalent | 0.02 ppm |
| Copper | 0.01 ppm |
| Lead | 0.02 ppm |
| Mercury | 0.0005 ppm |
| Nickel | 0.06 ppm |
| Selenium | 17 ppm |
| Silver | 0.0063 ppm |
| Zinc | 0.14 ppm |
| Ammonia | 6.84 ppm |
| Non-chlorinated Phenolic Compounds | 0.34 ppm |
| Chlorinated Phenolic Compounds | 0.01 ppm |
| Chronic Toxicity | 11.4 toxicity units (TUc), instantaneous limit |
| Polychlorinated Biphenyl (PCB) | no permissible limit |

***Source: James White, personal communication, 1999.***

The plant is also required to submit the following annual reports:

*Intake Structure Monitoring Report:* summarizes the results of annual measurement of the cooling water intake approach velocity and sediment deposition at the intake structure. The plant is required to perform whatever maintenance is necessary to keep the intake approach velocity as close as practicable to the original design velocity

*Bottom Sediment Monitoring Report:* summarizes the results of annual bottom sediment sampling and analysis for heavy metals, sulfides and PCBs. Results from the analysis of sediments in the vicinity of the discharge canal are compared to control samples collected from background areas.

## 2.2 MORRO BAY WATERSHED

### 2.2.1 General Description

Morro Bay's watershed covers approximately 48,000 acres or 75 square miles (Figure 2-7). Its highest elevation is 2,763 feet above sea level and its furthest point from the bay is approximately 10 miles. Morro Bay's watershed is comprised of two subwatersheds, Chorro and Los Osos. Chorro Creek drains the larger Chorro Creek subwatershed, which occupies approximately 60 percent of the watershed. Los Osos Creek drains the remaining 40 percent, and consists of combined flow of Los Osos and Warden Creeks (Figure 2-8). The major creeks and their tributaries are described below. The primary land uses are agriculture (including lands that are under land conservation contract and lands that are not), urban lands, and multi-use public lands. These are discussed further in Section 4.0, Land Use.

### 2.2.2 Geomorphology, Soils, Geology

Morro Rock is the most westerly visible member in a chain of extinct volcanic plugs that are oriented east/west and divide the two coastal valleys that drain into the bay. These plugs and the land surrounding them are referred to locally as "The Morros Natural Area" (SLO County Natural Areas Plan 1992). They stretch from Cerro Cabrillo in the west to Cerro San Luis in the east. A local advisory committee, the Morros Advisory Committee has been meeting over the last four years to create a long range planning document for the Morros that will protect the areas' agriculture and conserve the area's natural resources.

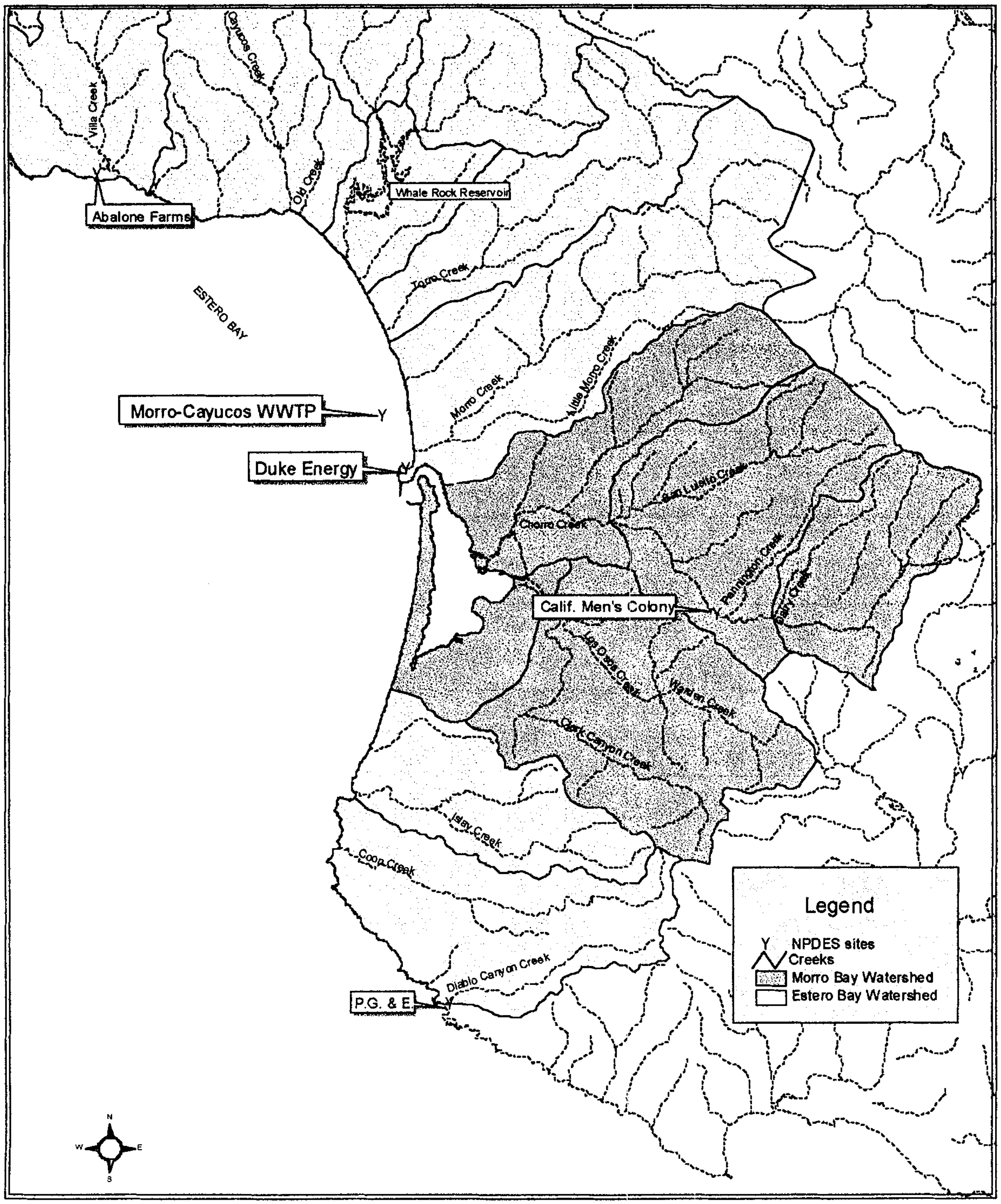



Figure 2.6 Locations of Permitted Industrial Point Sources in the MBNEP Study Area and vicinity
MBNEP Characterization 1999

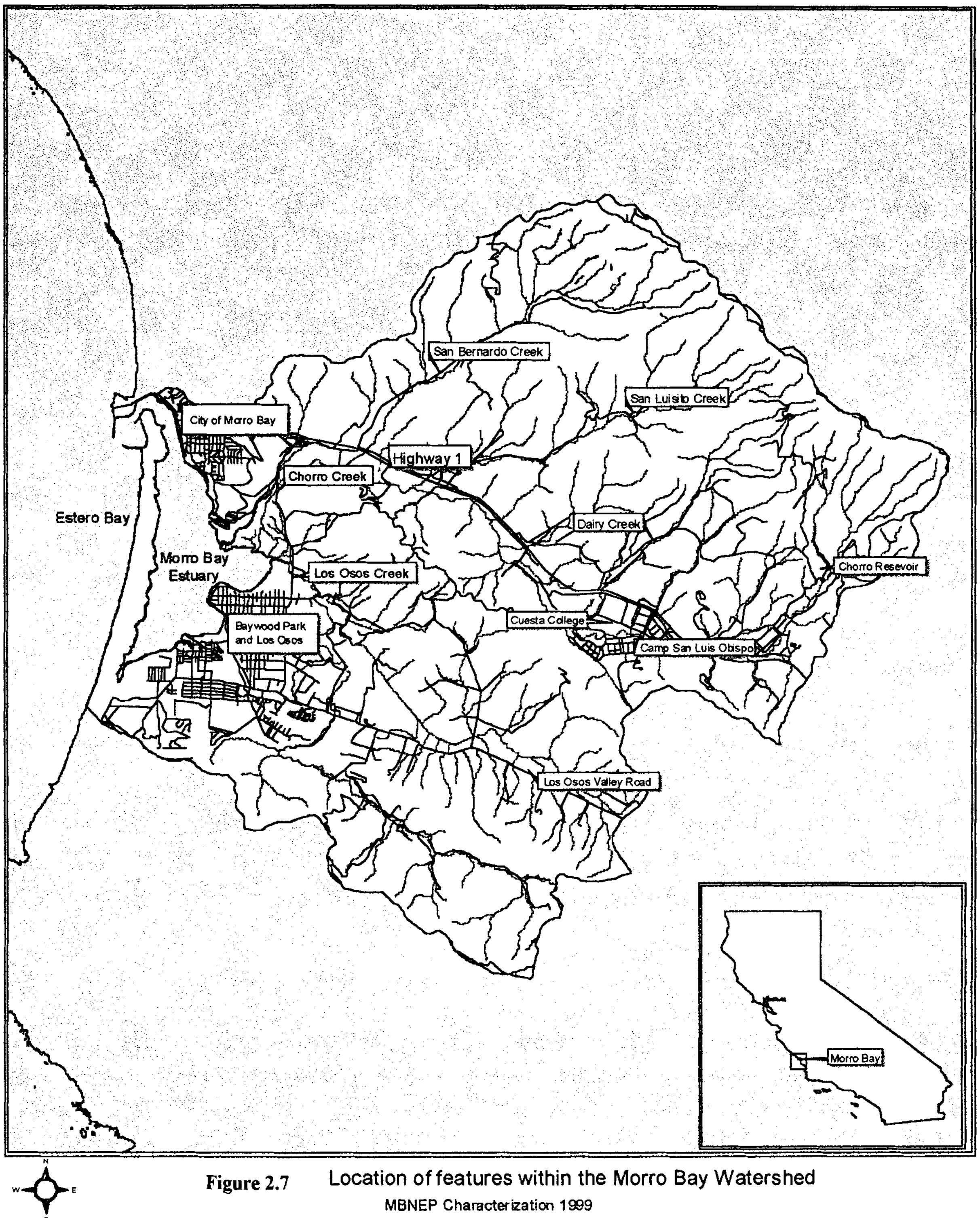



**Figure 2.7** Location of features within the Morro Bay Watershed

MBNEP Characterization 1999

The erosion of broadly folded sedimentary rocks, especially the highly erosive Franciscan Formation, formed the Chorro and Los Osos valleys. Underlying this deposition is a 180 million-year-old melange of igneous, metamorphic and sedimentary rock (SLO County Department of Planning and Building 1998). Like the Morros, the valleys are oriented nearly east/west, and are drained by Chorro Creek in the north and Los Osos Creek in the south. Chorro Creek terminates in a salt-marsh delta in the northeast portion of estuary, and Los Osos Creek terminates in tidelands in the southeast portion of the estuary.

The soils of the watershed are primarily clay loams in Clark Valley, and Diablo and Cibo clays in the Los Osos valley. Diablo clays and Salinas loams are predominant in Chorro Valley. Baywood fine sand is the predominant soil type in the South Bay area. Skirting the Morros are sandy loams and various rock outcrop complexes (USDA Soil Conservation Service (SCS) 1991). Serpentine outcrops and soils are present in certain areas. Serpentine soils have a high metal content, and often support special status plant species and/or unique vegetation.

The Morro Bay watershed is a seismically active area. Several active earthquake faults are within or near the watershed (SLO County Department of Planning and Building, 1998). The Los Osos Fault trends westerly along the Irish Hills. It has the potential for earthquakes with a magnitude 6.75 on the Richter Scale. Other faults located outside the watershed are the Hosgri and San Andreas faults. The Hosgri runs offshore and has the potential for a magnitude 7.5 earthquake. The San Andreas fault, though 40 miles to the east, has the potential for an earthquake with a magnitude 8.5.

Morro Bay is a relatively young geologic feature, less than 15,000-years old. The bay developed as a result of the gradual inundation of the valleys that drain into the bay by the rising post-Ice Age Ocean. A barrier beach known as the sandspit separates the estuary from the ocean, and is connected to the mainland only at its southern end. The sandspit runs along the western edge of the estuary and is approximately four miles long and averages about one-quarter mile in width.

The upper reaches of Chorro Creek and its tributaries Dairy Creek, Pennington Creek, San Luisito Creek, and San Bernardo Creek, burned in August 1994. The fire event was compounded with a near 100-year storm event in the winter of 1994-95, which resulted in a significant amount of flooding and erosion throughout the Chorro Creek subwatershed. This is discussed further in Section 5.

### 2.2.3 Streams and Riparian Systems

The major creeks within the Morro Bay watershed are also shown in Figure 2-8. As stated above, the watershed is divided into two primary systems, the Chorro Creek watershed and the Los Osos Creek watershed.

The creeks are typical of Central California coastal streams in terms of their aquatic fauna, riparian overstory, and general geomorphology. Both creek systems support an assemblage of native and non-native fish that include steelhead trout, three-spined stickleback, prickly sculpin, and, at least in the past, tidewater goby. The creeks serve as transportation corridors and habitat for numerous species of birds and wildlife.

Except for the dam at Chorro Reservoir, Chorro and Los Osos Creeks have mostly unimpaired natural connection to the ocean through the estuary and bay. However, both creeks supply highly variable fresh water flows to the estuary (see below).

***Chorro Creek Watershed***

Chorro Creek drains the northern two-thirds of the Morro Bay watershed, an area of approximately 43 square miles. The headwaters are located on the south-facing slopes of the Santa Lucia Mountains west of Cuesta Grade. Chorro Creek flows southerly to Chorro Reservoir on Camp San Luis Obispo, continues in a southerly direction until it reaches Highway 1, then flows westerly south of Highway 1 into Morro Bay. Along this route, at least five major tributaries contribute flow. Three of these five creeks, San Bernardo Creek, San Luisito Creek, and Chorro Creek (upstream of Highway 1), comprise about 58 percent of the total drainage area for Chorro Creek.

Flow Characteristics of Chorro Creek, Los Osos Creek, and other watershed streams are listed in Table 2-5. Land Use, vegetation, and other habitat characteristics are listed in Table 2-4.

Figure 2-9 illustrates the variation in channel bottom elevation (defined by the thalweg – the lowest point in a channel cross-section) and local streambed slope along Chorro Creek, between the outlet to Morro Bay and the Chorro Reservoir. Streambed slopes along Chorro Creek exceed 3 percent in the upstream reaches (just below Chorro Reservoir, and flatten to about 0.3 percent near the outlet to the Bay. Historical channel profiles for lower Chorro Creek are compared in Figure 2-10. This information indicates that the lower reaches of Chorro Creek, both upstream and downstream of the Twin Bridge, have been aggrading, or building up in elevation.

The California Department of Fish and Game (CDFG) conducted surveys on Chorro Creek in 1976 (Chappell 1976) for the purposes of documenting field habitat conditions for steelhead. They reported water depths ranging from 1 in. to 4 feet averaging 8 inches in June. The lower segment of Chorro Creek (below Canet Rd. to the estuary) was reported to vary from 2 to 60 ft. in width (averaging 12 ft.); the middle segment (Canet Rd. to Reservoir) varied from 1 to 15 ft. (averaging 6 ft.); and the upper segment (above the Reservoir) varied from 1 to 10 ft. in width (averaging 3 ft.). A portion of the middle segment (below the sewer plant) provides a significant percentage of the summer nursery habitat for steelhead, and sustains about 60 percent of the juvenile steelhead population. This middle segment has about a 30:70 riffle to pool ratio, with pools providing the majority of habitat. Gravels in the riffle areas vary from 0.25 to 3.5 inches in diameter. Summer water temperatures range from 58 to 71 degrees Fahrenheit, within acceptable limits for steelhead.

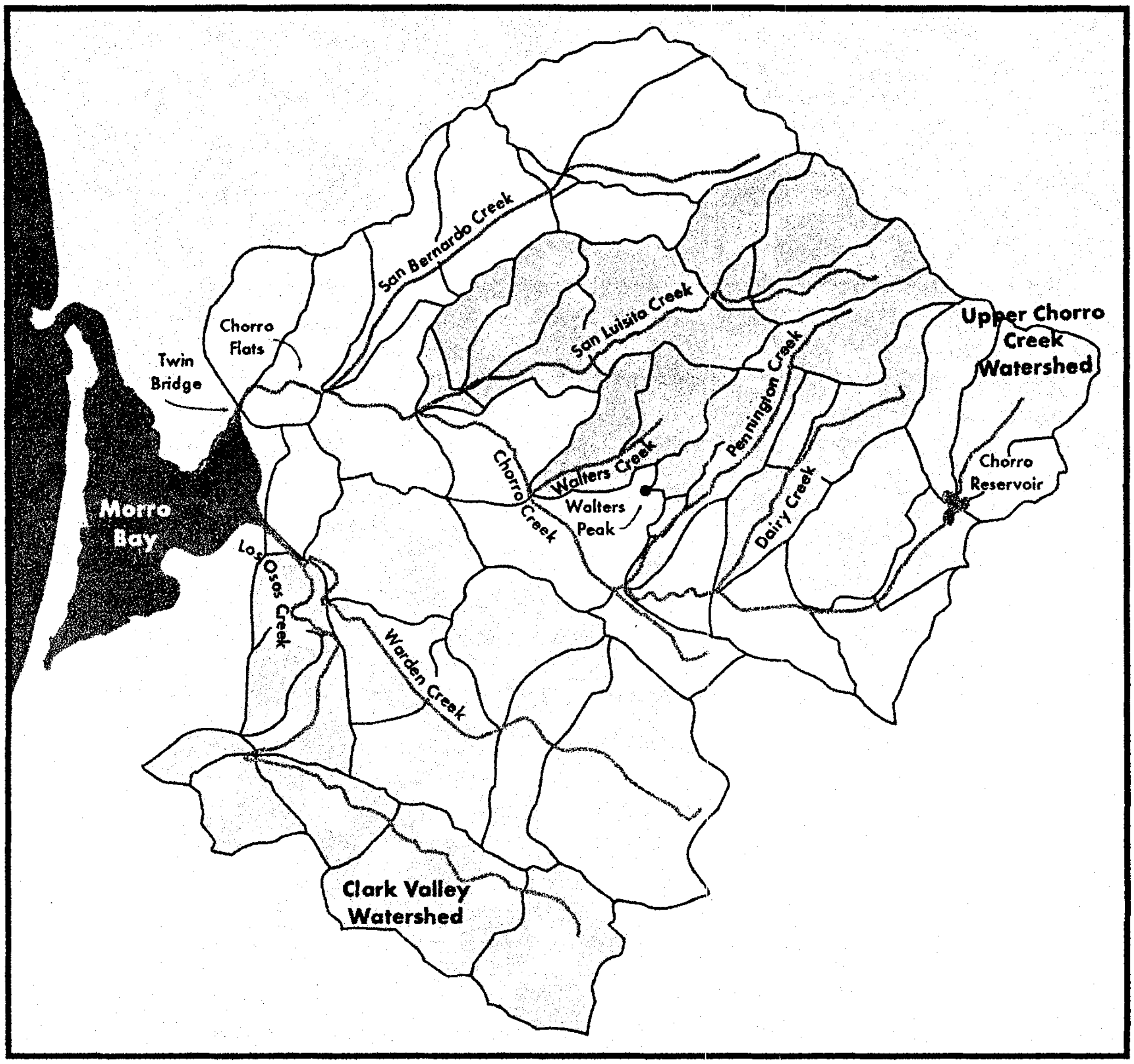



**Figure 2.8. Location of Major Sub-basins of the Morro Bay Watershed.** *Source: Tetra Tech 1999.*

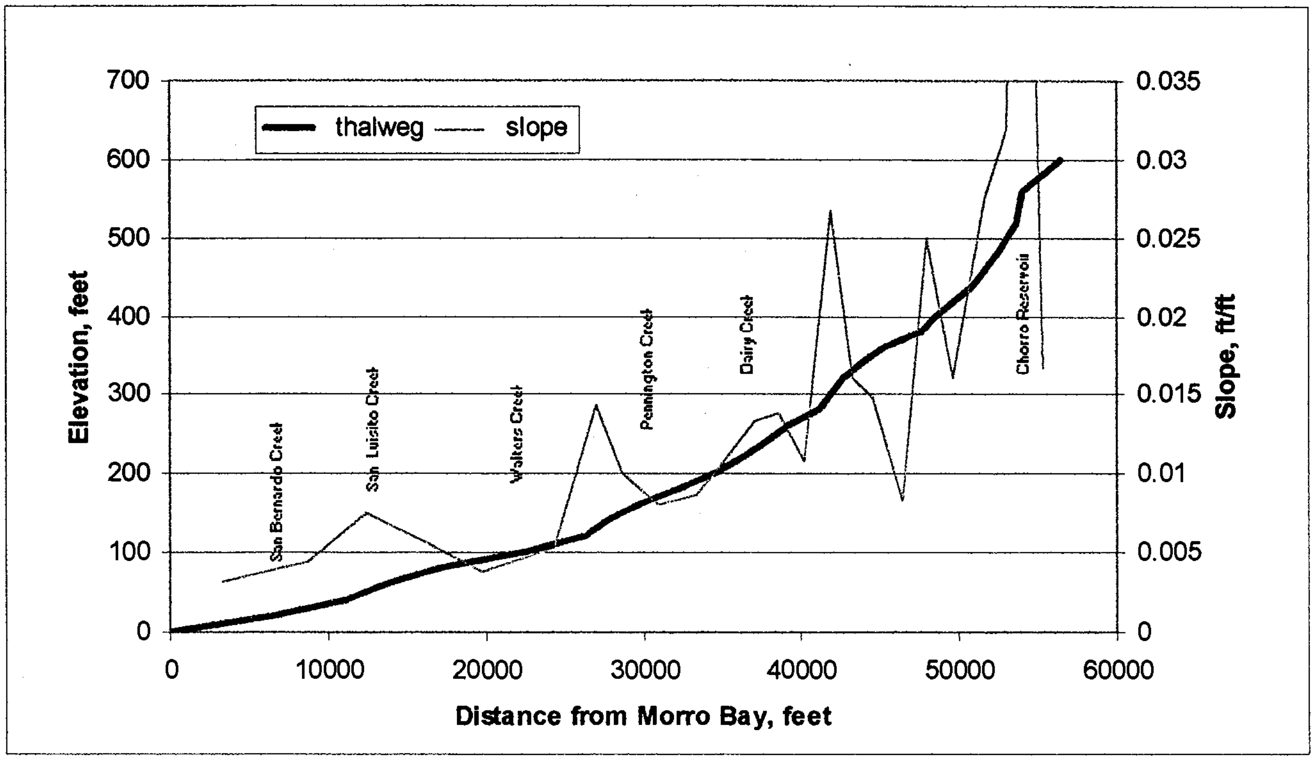



**Figure 2.9. Chorro Creek Profile and Slope between Morro Bay and Chorro Reservoir.**
***Source: Tetra Tech, 1998***

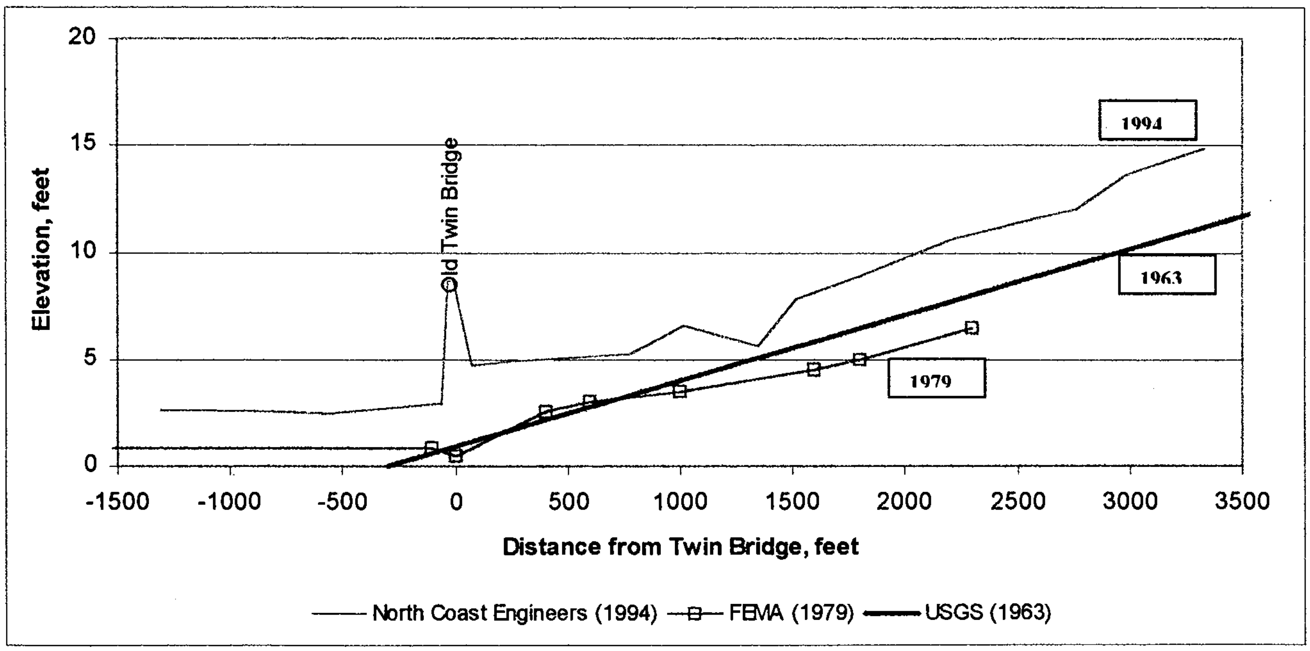



**Figure 2.10. Lower Chorro Creek Profiles near Twin Bridges in 1963, 1979, and 1994.**
***Source: TetraTech 1998.***

**Table 2-6. Flow Characteristics and Drainage Areas of Morro Bay Watershed Streams**

| Stream | 2 yr. event Average Flow (cfs)[8] | 100 yr. Event Average[9] | Drainage area (sq. mi.)[10] | Special Projects |
|---|---|---|---|---|
| Upper Chorro | 90 | 743 | 7.6 | Cattle exclusion |
| Dairy Creek | 12 | 262 | 2.5 | Cattle exclusion |
| Pennington | 14 | 318 | 3.0 | |
| Walters | 5 | 144 | 2.0 | Paired watershed |
| San Luisito | 36 | 829 | 8.3 | |
| San Bernardo | 46 | 957 | 8.5 | Maino |
| Lower Chorro | 119 | 1134 | 11.4 | Chorro Flats |
| Total Chorro | | | 43.37 | |
| Upper Los Osos – Clark Valley | 9 | 462 | 7.0 | Swift |
| Warden Creek | 15 | 773 | 12.93 | Los Osos Creek Wetland Reserve |
| Minor tribs | | | 3.2 | |
| Total Los Osos | | | 23.1 | |

**Table 2-7. Land Use, Vegetation, and Presence of Barriers to Steelhead in Morro Bay Watershed Sub-Basins and Streams**

| Stream | Steelhead (#barriers)[11] | Red-legged Frog | Land Use | Coastal Streams[12] | Predominant Vegetation |
|---|---|---|---|---|---|
| Upper Chorro | ✔ | ✔ | Public Facility | | Brushland |
| Dairy Creek | ✔ (3) | ✔ | Recreation | | Grassland |
| Pennington | ✔ | ✔ | Agriculture | ✔ | Grassland |
| Walters | | ✔ | Agriculture | ✔ | Grassland |
| San Luisito | ✔ (3) | ✔ | Agriculture | ✔ | Grassland |
| San Bernardo | ✔ (2) | ✔ | Ag – Grazing | ✔ | Grassland |
| Lower Chorro | ✔ | | Ag - Field crops | ✔ | Prime Farmland |
| Upper Los Osos –Clark Valley | ✔ | | Agriculture | ✔ | Oak Woodland |
| Warden Creek | | | Ag – Field crops | ✔ | Prime Farmland |

**[8] From Table 4, Tetra Tech Sediment Loading Study**
**[9] From Table 4, Tetra Tech Sediment Loading Study**
**[10] From Table 2, Tetra Tech Sediment Loading Study**
**[11] D. Highland, CDFG, pers. communication, 1999**
**[12] San Luis Obispo County, Estero Area Plan**

### *Chorro Reservoir*

Chorro Reservoir was constructed in 1941 to store runoff water for Camp San Luis Obispo, and had an original storage capacity of 213 AF. Capacity in 1994, however, was estimated at less than 150 AF due to sediment accumulation (USDA, SCS 1994). The State Water Resources Control Board (SWRCB) places release requirements on Chorro Reservoir. If the creek is flowing at more than 2 cubic feet per second (cfs) above Chorro Reservoir, 1 cfs must be released below the dam. If Chorro Creek is flowing less than 2 cfs above the reservoir, one-half of the flow must be released below the dam (USDA, SCS 1994).

Sediment has had a major impact on Chorro Reservoir. The California Men's Colony (CMC) has operated a suction dredge to remove sediment, but no accurate estimates of amounts are available, and the practice was stopped in the late 1980's. (Froland, J. pers. comm). The material is piped to basins on the east side of the reservoir, dried, then removed to other areas on camp, sometimes near enough to Chorro Creek to erode into it. Samples of the dredging piles and sediment basins show high levels of chromium and nickel (USDA, SCS 1994).

Characteristics of other creeks within the Chorro System are included in Table 2-3 above.

### *Los Osos Creek Watershed*

The Los Osos Creek system is a highly dynamic system. Before 1963, the U.S. Geological Survey (USGS) topographic map for the area indicated that the Clark Valley and Warden Creek forks met nearly a mile above the point where Los Osos Creek now outlets to the bay. Today, this confluence is approximately 4,000 feet further upstream.

The headwaters of Los Osos Creek are located on the north-facing slopes of the Irish Hills. The Creek drains approximately 23 square miles, and is divided into two primary subwatershed areas, the Warden subwatershed and the Clark Valley subwatershed. Both creeks drain portions of the Los Osos valley. In 1883, the Los Osos Valley was described as being a "spacious vale with numerous ponds." The soil was saturated and the valley difficult to cross. The western end of the valley was described as having "deep water courses"(Thompson & West 1883).

Figures 2-11 and 2-12 present profile and slope information for Los Osos Creek and Warden Creek, respectively. These figures were developed from quadrangle maps (United States Geological Survey (1965) 40-foot contour interval, with some 20-foot intermediate contours provided), which were prepared from aerial photographs flown in 1963. The figures illustrate the typical profile trend of most streams along the central California coastline, with a characteristic gradual flattening of slope as the downstream outlet is approached.

The slopes of the upstream reaches of Los Osos Creek exceed 3 percent. The lower reach of Los Osos Creek is significantly flatter than upstream, with a clear break in slope evident about 12,000 feet upstream of Morro Bay. Warden Creek is much flatter than either Chorro Creek or Los Osos Creek, with maximum streambed slopes of about 1.5 percent.

More recent topographic information is available for comparison with that derived from the USGS quads. In Figure 2-13, the recent thalweg survey of Los Osos Creek (Funk, 1997) is compared to the USGS quad information. This comparison indicates that the reach upstream of Los Osos Valley Road has flattened in slope (degraded), while the reach between the Warden Creek confluence the major grade break (located about 12,000 feet upstream of the Bay) has steepened (aggraded). Downstream of the Warden Creek confluence, the effects of recent dredging are evident, with practically zero slope present in the lower 4,500 feet of channel immediately upstream of the Bay.

***Stream Sediment Transport***

The MBNEP also funded a sediment yield and transport analyses (Tetra Tech 1998a) on the major tributaries to Morro Bay to evaluate the sources, sizes, and quantities of sediment loading to the bay.

Tetra Tech estimated the average annual loading to the bay to be 70,000 tons per year. About 10 percent of this loading is estimated to be composed of sands and gravels and about 90% is composed of fines. The event-based analysis results indicate a single 100-year event would contribute about 700,000 tons of sediment to the bay - about 400 acre-feet of sediment. In contrast, a two-year event is expected to contribute about 1,300 tons of sediment to the bay, or less than 1 acre-foot of sediment.

Los Osos Creek, which makes up about a third of the contributing drainage area, is estimated to supply only about 14 percent of the total average annual loading to the bay from watershed and riverine processes, and only about 3 percent of the coarse material. The Clark Valley is estimated to be the most significant source of sediment yield from within the Los Osos Creek watershed, despite its small size relative to Warden Creek (7.6 square miles versus 12.9 square miles).

Chorro Creek is estimated to contribute about 86% of the total average annual loading to the bay (Tetra Tech 1998a).

When these totals are considered on a per acre basis for the Chorro and Los Osos watersheds, Los Osos Creek's contribution increases to 23 percent, and Chorro Creek's contribution decreases to 77 percent. These figures suggest that the Chorro Creek watershed should be the focus of the majority of sediment related actions.

The results of the sediment loading study and the sources of the sedimentation problem are discussed further in Section 5.

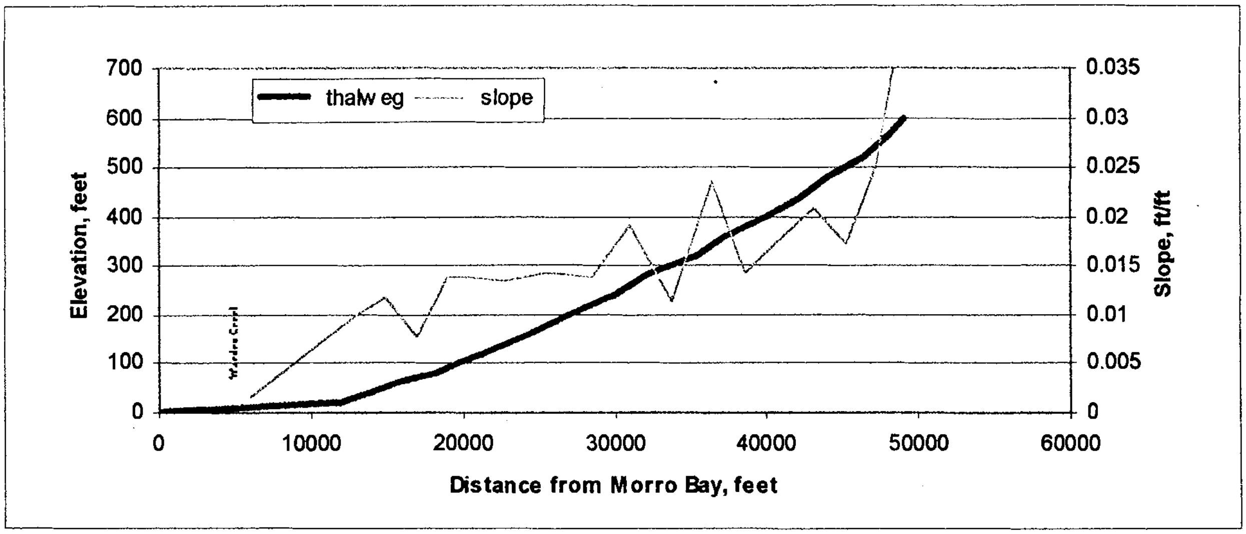



**Figure 2.11. Los Osos Creek Profile and Slope.** *Source: TetraTech 1998.*

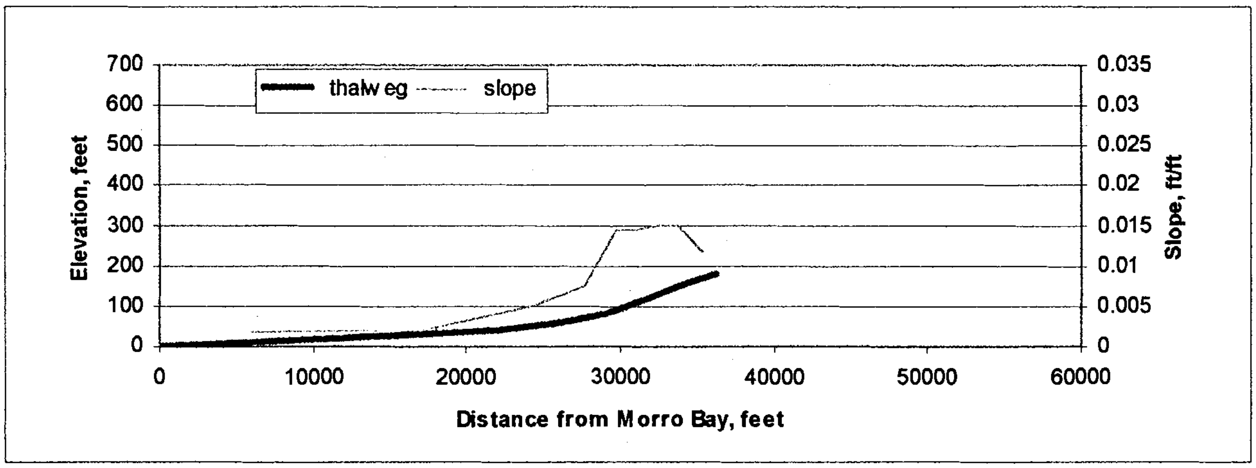



**Figure 2.12. Warden Creek Profile and Slope.** *Source: TetraTech 1998*

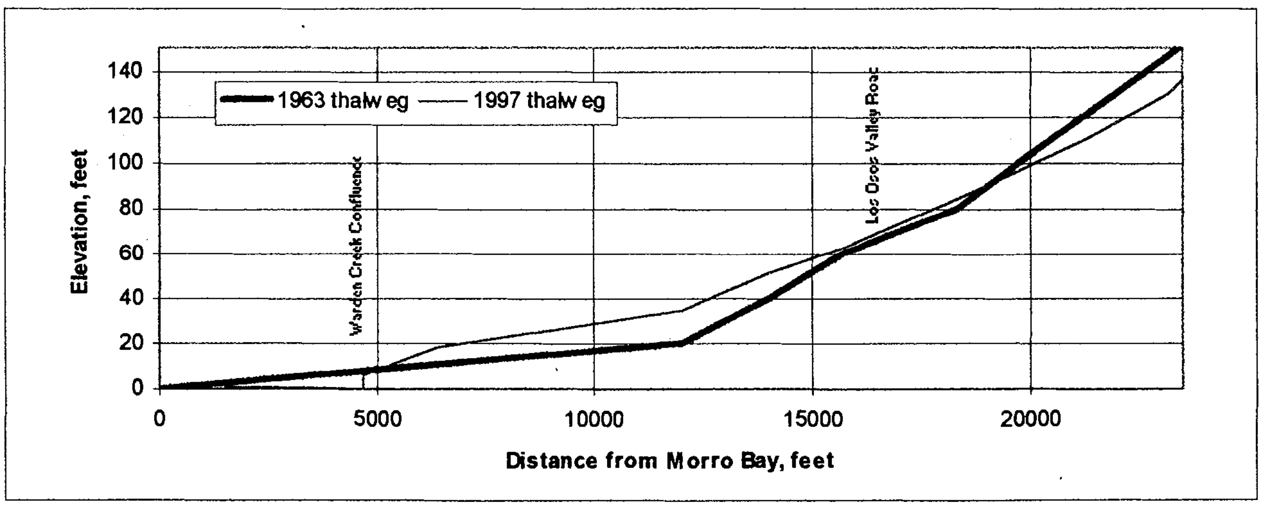



**Figure 2.13. Lower Los Osos Creek Profile and Slope in 1963 and 1977.**
***Source: TetraTech 1998, based on Funk 1997.***

### 2.2.4 Watershed Water Quality Conditions - The Morro Bay National Monitoring Program

The USEPA has embarked on a national water quality-monitoring program to assess the effectiveness of pollution prevention measures, or Best Management Practices (BMPs) in reducing non-point source pollution. This program is referred to as the National Monitoring Program (NMP) and is funded partially through Section 319 of the Clean Water Act. National Monitoring Program projects consist of a number of specific projects funded to document water quality improvements from non-point source controls. The Morro Bay Watershed has been selected as one of the watersheds to be monitored through a ten-year period.

The Morro Bay NMP project is conducted as a partnership between the CCRWQCB and Cal Poly State University. The CCRWQCB has been evaluating the effectiveness of BMPs, through the collection and analysis of even interval water quality sampling data, habitat evaluations, stream channel profiles, and rapid bioassessment. The CCRWQCB has subcontracted out to Cal Poly State University to measure water quality and streamflow during storm events, to document quality assurance of recorded vs. observed data, to compare data from Chumash and Walters Creeks, to conduct habitat sampling, and to maintain sampling and recording equipment.

Five annual reports have been prepared as part of this joint effort in evaluating the effectiveness of management measures in the Morro Bay Watershed (CCRWQCB 1999, 1998). Tasks conducted by Cal Poly during 1997-1998 are included in a companion Annual Report (Rice, 1998).

Currently, the 76 square mile watershed is impacted by various pollutants, including sediment, bacteria, metals, and nutrients. Several public agencies and private individuals are implementing BMPs aimed at reducing non-point source pollution in the watershed. The main goal of this study is to monitor the impacts of selected BMPs on water and habitat quality in the Morro Bay watershed. This will be accomplished through characterization of water quality and habitat conditions before, during, and following implementation of BMPs.

The project began on September 1, 1992. Funding in the amount of $200,000 (from 91-92 and 92-93) was provided on September 1, 1992. Two years of pre-implementation data collection and equipment installation (93-94 and 94-95) were funded for the project. Sampling during 95-96 was ultimately also included in the pre-BMP period, because changes to the land resulting from BMP installation were minimal and water quality data showed little change from past years. The first and second year of post-implementation sampling was conducted during 96-97 and 97-98. The project will be completed in September 30, 2001.

In general project objectives are as follows:

- Characterization of current sedimentation and water quality conditions in a portion of the Chorro Creek Watershed. This is being accomplished through sediment and water sample analyses in a paired watershed study (using Chumash Creek and Walters Creek).

- Evaluation of the effectiveness of a set of selected BMPs, including riparian pasture development, watering systems, culvert improvements, and revegetation, in improving water and habitat quality in one of the paired watersheds (Chumash Creek).

- Evaluation of the effectiveness of systems of BMPs in improving water and habitat quality in several locations in the Chorro Creek watershed (Chorro Flats Enhancement Project, Maino Ranch managed grazing project, and Dairy Creek and Chorro Creek cattle exclusionary fencing projects).

- Evaluation of overall water quality at select sites in the Morro Bay watershed to establish a data base, prioritize problem areas, and aid in future monitoring efforts.

- Evaluation of hydrologic and water quality indicators to document the health and stability of selected streams in the Morro Bay watershed through annual monitoring practices

Locations of Sampling Stations are show in Figure 2-14.

Water quality sampling has been effective at detecting improvements at various locations where BMPs are being implemented. It is important to take into consideration that the results are preliminary, as this is the seventh year of data collection for a ten-year project. Further analysis to confirm trends found after the eighth year of data collection will be included in later reports. Data from this monitoring effort is discussed in appropriate subsequent sections of this document.

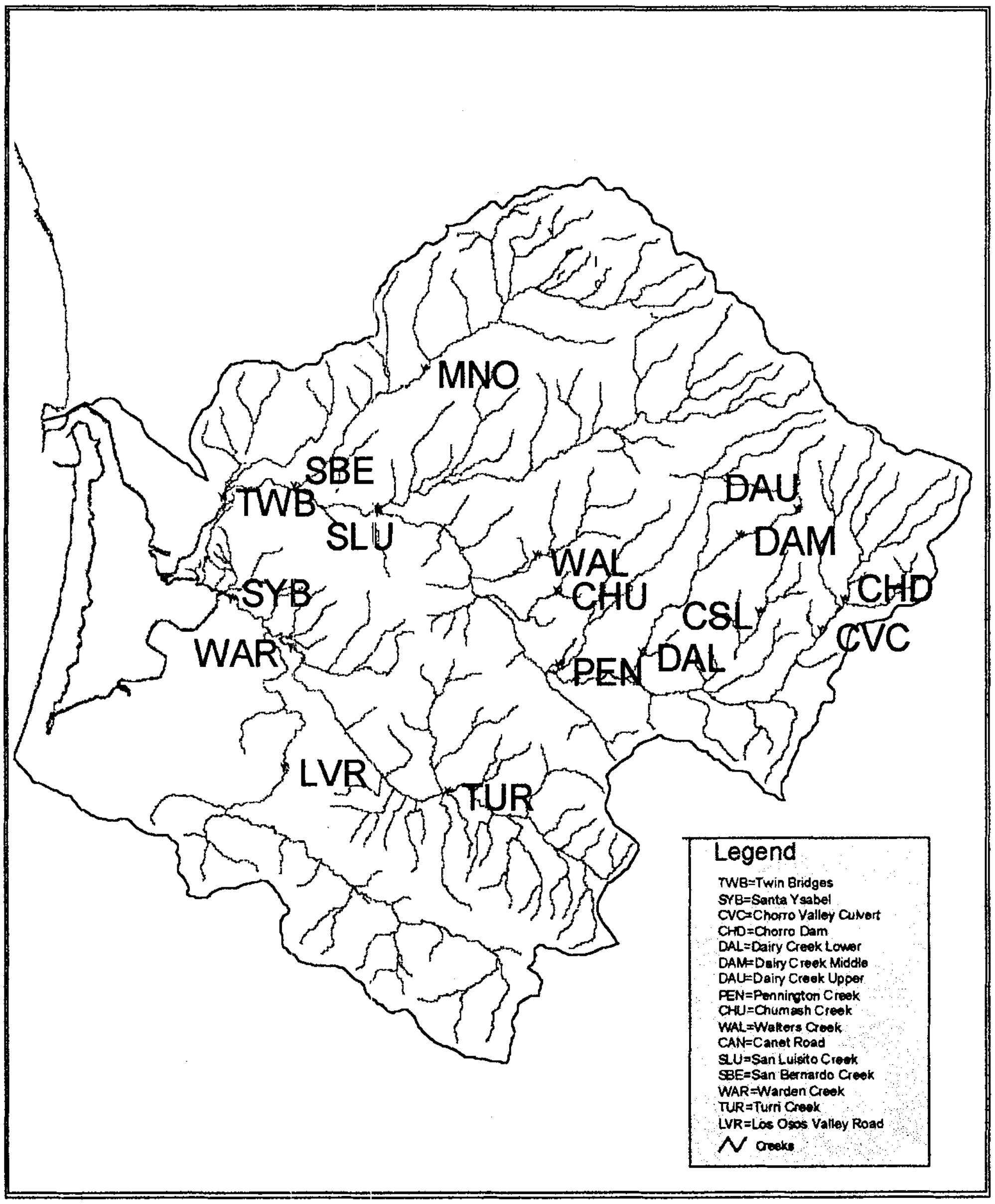
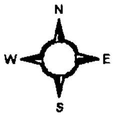



Figure 2.14 Locations of Morro Bay Watershed National Monitoring Program sampling stations




MBNEP Characterization 1999

# 3.0 BIOLOGICAL RESOURCES

San Luis Obispo County is known for its rich biotic diversity. The uniqueness of the biotic resources and the scenic attraction of Morro Bay and its wetlands are enhanced by its relatively natural state and geographic location. As the "most significant wetland system in the central coast of California" (Arnold 1987), it is of vital importance to a great variety of migratory and resident species, including many rare and endangered species.

The complex interaction of marine, estuarine and upland plant communities provides feeding, resting and nursery areas for thousands of migratory birds as well as fish and marine mammals. The high percentage of publicly owned lands in and adjacent to the bay helps to maintain the integrity of many environmentally sensitive areas, including habitats of rare species.

Unique, fragile or rare community types are represented in public areas such as Morro Bay sandspit, Los Osos Oaks State Preserve, and the Elfin Forest. Rare and endangered species are protected at Morro Rock, Morro dunes, Sweet Springs Preserve, and Morro Bay State Park. Coastal dune scrub, one of California's most endangered habitats, occurs in private land in Los Osos, and provides valuable habitat for many special status species. A number of Monarch Butterfly roosts are present that are not protected (Nagano and Lane, 1985). Outstanding representatives of natural communities are included within Morro Bay State Park, on Black Hill, and on the sandspit. Particular areas of educational value include the heron rookery at Morro Bay State Park, the Chorro delta, and Los Osos Oaks State Reserve. School groups and the public regularly visit all these areas.

The following discussion describes natural resources occurring within the estuary. Trends, where known, are indicated. The discussion centers first on the estuarine and wetland habitats, followed by upland and watershed habitats, special status species, and invasive exotic species. For additional information, the reader should refer to Gerdes (1974) and Josselyn (1989 and 1991).

The Morro Bay National Estuary Program (MBNEP) conducted a Habitat Characterization and Assessment Study to provide data to support the preparation of this document (Tetra Tech 1999). An initial step was to compile and review existing information. Field studies were also conducted, and the results are presented below.

## 3.1 EXISTING MORRO BAY ESTUARINE AND WETLAND HABITATS

The Estuarine System includes coastal wetlands such as salt and brackish tidal marshes, and intertidal flats, as well as deepwater channels, and coastal streams. The Estuarine System can be defined as consisting of deep water tidal habitats and adjacent tidal wetlands that are semi-enclosed by land but have access to the open ocean, and in which ocean water is diluted by freshwater runoff from the land. This system is strongly influenced by its association with terrestrial systems versus its association with the Marine System.

The two subsystems associated with the Estuarine System are subtidal and intertidal. The subtidal subsystem is defined as those areas where the substrate is continuously submerged. The Intertidal Subsystem is an area where the substrate is alternately exposed and flooded by tides and includes the associated splash zone (or area which is wet only by splashes from waves and not by tides.)

The Morro Bay estuary formed as a result of sea level changes since the last period of glaciations resulting in coastal submergence of ancient stream valleys. In general, estuaries are mixing areas, where rivers meet oceans. They can be extremely productive, as compared to other habitats. Estuaries are important habitats for many commercial fish stocks and support food chains upon which many animals depend.

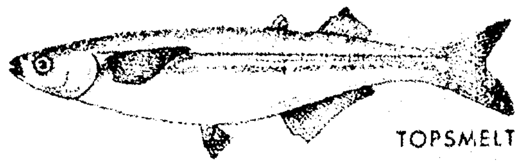
Wetland habitats found in Morro Bay include open water and channels, subtidal and intertidal eelgrass, mudflats, coastal or tidal salt marsh, brackish marsh, freshwater marsh, and riparian woodland (Table 3-1, Figure 3-1). These habitats support a number of sensitive or special status species.

**Table 3-1. Wetland Habitat Types within the Morro Bay Study Area.**

| Wetland Habitat Type | Wetland System, Subsystem and Class (Ferren et al. 1995) |
|---|---|
| Open Water/Channels | Palustrine and Estuarine Deepwater |
| Eelgrass | Estuarine intertidal aquatic beds |
| Mudflats | Estuarine and Intertidal unconsolidated shore |
| Rocky shore | Estuarine intertidal |
| Sandy beaches | Marine and Estuarine Intertidal Shore |
| Coastal Salt Marsh | Estuarine emergent wetland |
| Freshwater Marsh | Palustrine emergent wetland |
| Brackish Marsh | Estuarine intertidal emergent wetland |
| Riparian | Palustrine forested wetland<br>Riverine sand and mud bottoms |

Many of the estuarine and wetland habitat types of Morro Bay can be differentiated by their exposure to and tolerance of salt water or freshwater. The vegetated habitat types are typically characterized by one or two dominant plant species. These habitat types have and continue to undergo transition due to many factors, some of which include long-term past sea level changes, and elevation changes caused by sedimentation.

### 3.1.1 Open Water and Channels (Palustrine & Estuarine Deep Water)

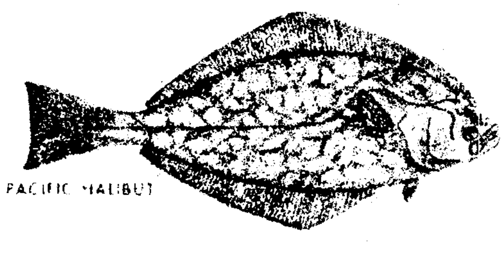



*Fisheries*

The role of the estuary as a fish nursery is significant to the coastal sport and commercial fishery. Recreational fishing takes place from shore, docks, piers, and from a variety of boats. Catches include a diversity of species with halibut, flounder, and shark in the prize category. The top species landed by fishermen include jacksmelt, black surf perch, starry flounder, and California halibut (Hardy 1992).

Fish are important economic, recreational, and ecological components of the estuary. There have been several studies of fish populations in the Morro Bay Estuary (Fierstine *et al* 1973; Horn 1980; Kelly *et al.* 1982; Worcester 1991; Crawford 1994). Various techniques have been used to collect fish; however, the most quantitative studies have utilized trawls and seines. Historically, the fish assemblage in Morro Bay has included marine, estuarine, and freshwater species because of Morro Bay's connection with the ocean and freshwater inputs from Chorro and Los Osos Creeks. Over 60 species of fish may use Morro Bay during the course of a year (Fierstine *et al.* 1973); however, on any given survey, the fish assemblage is numerically dominated by only a few species.

The California Department of Fish and Game (CDFG) has conducted bi-monthly trawl studies within Morro Bay since 1992 (Hardy 1999 pers. comm.). CDFG data provides valuable information regarding fish species within the bay, but populations are extremely cyclical.



Fierstine, Kline and Garman (1973) collected 66 fish species (including the endangered tidewater goby) in the estuary, and estimated that more than 15 species of fish are known to spawn in the bay (Fierstine, Kline and Garman 1973). California halibut young of the year are found in the estuary, as well as young of several other species such as English sole, lingcod, and occasionally herring (Hardy 1999 pers. comm.).

The distribution of Macrocystis (Giant Kelp) in Morro Bay is limited to a small area near the mouth of the bay near Morro Rock. This small area provides specialized habitat for fish, invertebrates, and marine mammals. Various species of rockfish and other reef-oriented fish are found only in this part of the bay. The kelp beds provide a popular fishing location, and they are the target destination for a local tour boat. This area also provides habitat for the threatened California sea otter.

The 1998 Tetra Tech fish survey yielded results similar to previous fish studies. However, fewer species were found during the 1998 survey compared to surveys in previous years and some fish that have been caught in previous studies (e.g., shiner perch, black surfperch, rockfish, English sole, speckled sanddab, starry flounder) were absent or found in low numbers in the 1998 survey. These differences may be related to sampling effort, sampling location, and/or seasonal or annual variation. The 1998 surveys of Chorro and Los Osos Creeks yielded similar results to previous studies in terms of species collected. Steelhead were absent in the 1998 fish survey probably because care was taken to avoid sampling in areas where "takes" of this protected species were likely to occur. In Tetra Tech's 1998 survey, topsmelt was the most abundant fish, accounting for 68% of the total catch.

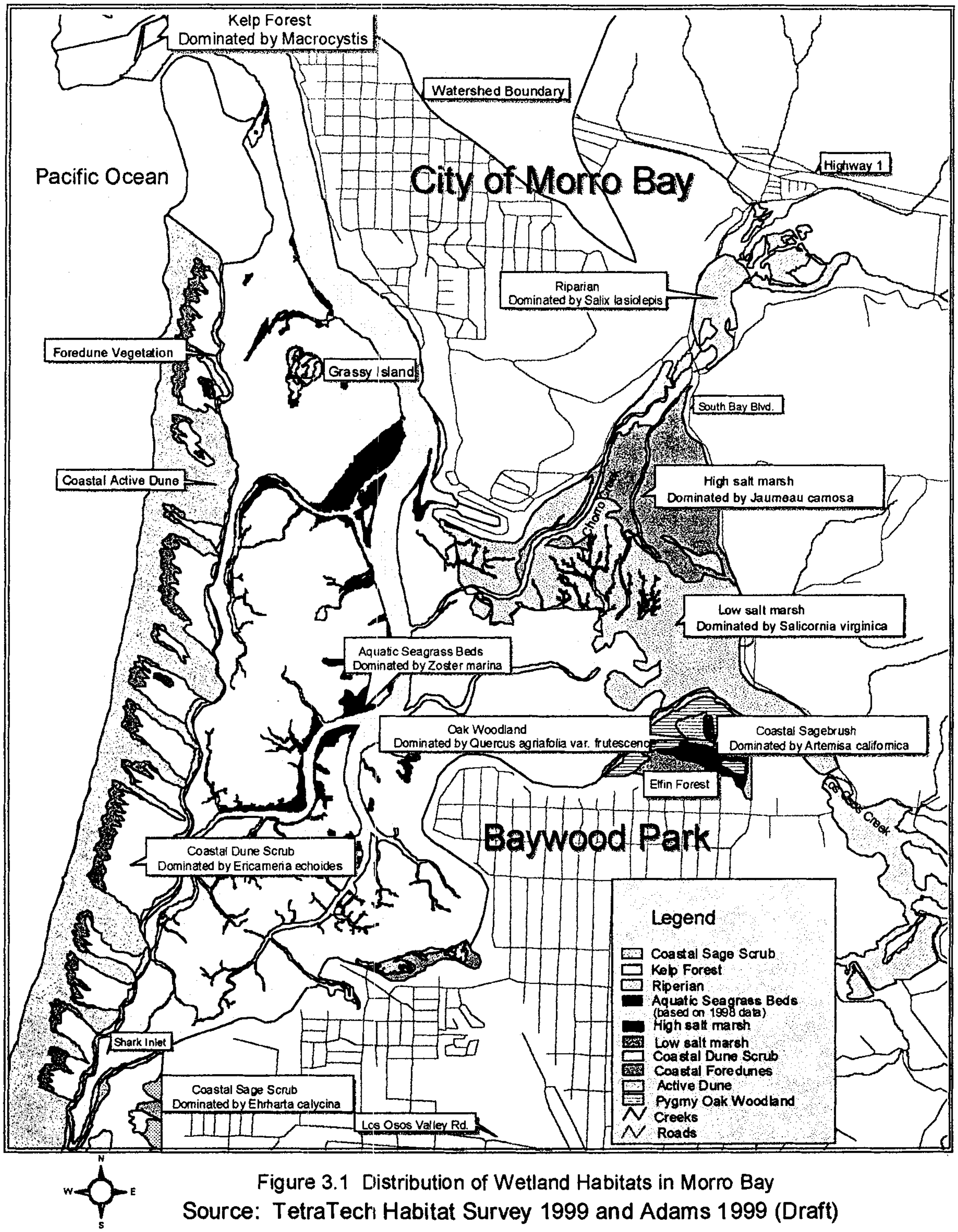



Figure 3.1 Distribution of Wetland Habitats in Morro Bay
Source: TetraTech Habitat Survey 1999 and Adams 1999 (Draft)

### *Previous Studies - Fisheries*

Kelly *et al.* (1982) sampled fish from the entrance of the bay to the end of the main channel next to the Museum of Natural History using tri-net trawls. Monthly surveys were conducted in June through August 1978 and July and August 1979. A total of 38 species was collected over all surveys, and the number of species range from 17 to 24 per survey. During 1978, shiner surfperch (*Cymatogaster aggregata*, juvenile rockfish (*Sebastes* spp.), black surfperch *Embiotoca jacksoni*), and grass rockfish *Sebastes rastrelliger*) accounted for 80% of the catch. Those species, as well as English sole (*Parophrys vetulus*), pile surfperch (*Damalichthys vacca*), and speckled sanddab (*Citharichthys stigmaeus*) comprised 80% of the catch in 1979.

Horn (1980) sampled fish off Baywood Park using seines. A total of 21 species was collected over four surveys taken at quarterly intervals between November 1974 and February 1976. The number of species collected on any given survey ranged from 11 to 16. During that study, topsmelt, shiner surfperch, and Pacific staghorn sculpin comprised almost 82% of the total individuals.

Fierstein *et al.* (1973) sampled fish from throughout the bay using otter trawls, seines, dip nets, hook-and-line fishing, and spearfishing. Nearly monthly surveys were conducted from January 1968 through December 1970. A total of 66 species of fish was collected. The total number of species collected in June and July were described by "zones" in the bay, as follows:

- Nine species were collected in the area from the entrance of the bay to Morro Rock (Zone 1).
- Eighteen species were collected in the area from Morro Rock to the commercial area public boat ramp (Zone 2).
- Fifteen species were identified in the area from the public boat ramp to the Museum of Natural History (Zone 3).
- Twelve species were collected in the area from the museum throughout the rest of the bay except the estuarine area formed from Chorro and Los Osos Creeks (Zone 4).
- No fish were collected in June or July, and seven species were collected in May in the estuarine area formed from the flows of Chorro and Los Osos Creeks into the bay (Zone 5).

The most abundant species, in order of decreasing abundance, were the shiner surfperch, northern anchovy, speckled sanddab, lingcod (*Ophiodon elongatus*), English sole, topsmelt, and starry flounder (*Platichthys stellatus*).

Worcester (1991) summarized the fish of Chorro and Los Osos Creeks as including steelhead trout (*Oncorhynchus mykiss*), threespine stickleback, and prickly sculpin (*Cottus asper*). The Sacramento squawfish was also present in Chorro Creek. Topsmelt, California killifish, starry flounder, and longjaw mudsucker inhabited the brackish areas of the creeks. Crawford (1994) found that the fish assemblage in Chorro Creek varied seasonally. Species collected during the summer included threespine stickleback, Sacramento squawfish, California killifish, topsmelt, Pacific staghorn sculpin, steelhead trout, mosquitofish, arrow goby, and speckled sanddab.

### *1998 Tetra Tech Fish Survey*

The 1998 fish survey in the main part of the bay yielded results similar to previous fish studies. Topsmelt and Pacific staghorn sculpin were the most abundant species caught in the 1998 survey (Table 3-2); these fish were also commonly collected in previous studies. One notable difference was that perch (especially shiner perch, black surfperch), rockfish, and flatfish (especially English sole, speckled sanddab, and starry flounder) were absent or found in low numbers in the 1998 survey; these fish have been numerically dominant in several of the previous studies. Differences are likely to be related to sampling effort, seasonable variation, and/or sampling location.

The 1998 Tetra Tech surveys of Chorro and Los Osos Creeks yielded similar results to previous studies in terms of species collected. One notable exception was the absence of steelhead trout in the 1998 samples. However, in the 1998 fish survey, care was taken to avoid sampling in areas where this protected species was more likely to occur (e.g., shaded pools).

**Table 3-2. Total Abundance and Number of Fish Species Collected in Morro Bay.**

| Common Name | Scientific Name | Beach Seine | Beam Trawl | Otter Trawl | Total | % of Total |
|---|---|---|---|---|---|---|
| **MOST ABUNDANT FISH** | | | | | | |
| Topsmelt | Atherinops affinis | 1180 | 6 | 0 | 1186 | 68 |
| Pacific Staghorn sculpin | Leptocottus armatus | 264 | 0 | 1 | 271 | 16 |
| Threespine stickleback | Gasterosteus aculeatus | 115 | 0 | 0 | 115 | 6.6 |
| Arrow goby | Clevelandia ios | 57 | 3 | 0 | 60 | 3.4 |
| Sacramento squawfish | Ptychocheilus grandis | 22 | 0 | 0 | 22 | 1.3 |
| Speckled dace | Rhinichthys osculus | 17 | 0 | 0 | 17 | 1.0 |
| California halibut | Paralichthys californicus | 14 | 2 | 0 | 16 | .92 |
| Shiner surfperch | Cymatogaster aggregata | 12 | 0 | 2 | 14 | .8 |
| Northern anchovy | Engraulis mordax | 6 | 5 | 0 | 11 | .63 |
| | | | | | | |
| 15 Spp. | | 30 | 1 | 1 | 32 | 1.8 |
| | **Total Count=** | **1717** | **23** | **4** | **1744** | |
| | **Number of Species=** | **21** | **6** | **3** | **24** | |

*Source: Tetra Tech, 1999*

Data collected in the 1998 Tetra Tech surveys alone are insufficient to determine the extent to which specific stressors (e.g., sedimentation, nutrient input, El Nino) may be affecting fish communities. Data from other estuaries indicate that there exists a high degree of natural variability in the distribution and abundance of fish in estuaries (Day *et al.* 1989; Asquith, 1990). This natural variability results in difficulty in establishing cause-and-effect relationships.

Open water areas provide important habitat for diving birds such as pelicans, Forester terns, and other waterfowl. Piers and breakwaters provide additional habitat diversity.

### 3.1.2 Eelgrass Habitat *(Zostera marina)* (Estuarine Intertidal Aquatic Beds)

Aquatic beds are wetlands and deep water habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years. They can be dominated by algal beds or by rooted vascular plants. Aquatic beds are found in all United States coastal areas, but the dominant plant species varies with location. For example, algae beds are well developed along the rocky northeast and west coast areas, while submerged, vascular plant beds are more common in the tropical and subtropical areas of Florida and the Gulf Coast. Algal beds are found both within the Estuarine System and the Marine System. The most common coastal vascular plant species in aquatic beds along the temperate North American coast are shoalgrass (*Halodule*), surf grass (*Phyllospadix*), widgeon grass (*Ruppia*), and eelgrass (*Zostera*). Eelgrass is the dominant plant in the aquatic beds of Morro Bay, and forms a critical element of the Morro Bay ecosystem.

***Importance of Eelgrass***

Dense stands of eelgrass form meadow-like beds in the lower intertidal zone of the Morro Bay estuary. Eelgrass is a perennial, submersed marine aquatic plant that usually grows from rhizomes. Eelgrass occupies temperate to cold marine waters in northern, central, and southern California, and it occurs in localized patches from Alaska to Baja California.

This habitat represents a critical element of the Morro Bay ecosystem. The eelgrass beds are a complex and highly productive environment. They serve as a spawning and nursery ground for many species of fish, including halibut and English sole. Eelgrass represents the preferred food resource for wintering populations of the Black brant; eelgrass makes up more than 75% of the brant's food intake. The density and diversity of benthic, or bottom dwelling, fauna are several times greater within the eelgrass beds than in other Morro Bay habitats (Tetra Tech 1998).

The Morro Bay estuary is the only significant eelgrass habitat available to the Black Brant (*Brant bernicla nigricans*) in central or southern California (Arnold 1987). The bulk of the flyway population of brant transits Morro Bay in the course of the coastwise spring migration. The future health of the Pacific flyway brant population is dependent on the continued preservation of this resource.

The dense foliage of the beds functions as a trickling filter, providing the microbial environment that decontaminates the bay's water. The dense foliage serves as substrate for a vibrant community of epiphytic flora and fauna. The beds effectively moderate current and wave action, permitting suspended sediments and organic particles to settle. Eelgrass improves the water clarity and quality of the Bay.

Eelgrass is not robust in the face of environmental stresses. Research shows a correlation between the depth at which eelgrass will grow and depth of light penetration. Water transparency can be impacted by color (dissolved organic substances), turbidity (suspended sediments) and nutrient enrichment (increased algal abundance). Many studies have reported on the decline of seagrasses with degraded water clarity (Cambridge and McComb, 1984; Orth and Moore, 1983). It is quickly and profoundly influenced by the same stresses identified as critical to the bay's broader ecosystem – sediment and water quality. Eelgrass is easily monitored by low-cost survey techniques. Consequently, its condition serves as an ideal bio-indicator of the health of the estuary, if survey methods are properly standardized.

Eelgrass is a carefully regulated resource. Activities that directly impact its habitat are required by federal regulations to be fully mitigated. Impacts are additionally subject to state coastal review. However, the indirect cumulative effects associated with the urbanization of the watershed are not directly addressed in regulations. The indirect effects of urbanization in similar small estuaries have proven capable of completely eliminating eelgrass (Short 1991).

***Current Conditions***

The eelgrass beds in Morro Bay are known as the largest and least impacted of any in Central or Southern California (Hoffman in lit.). The estimated extent of eelgrass found in Morro Bay, however, has fluctuated widely. Published estimates have ranged between 335 and 732 acres of habitat. Recently, eelgrass in Morro Bay has undergone catastrophic contraction first observed in the 1994-95 winter season. This well documented decline coincides with the winter following the destructive Highway 41 fire in 1994, and the concurrent end of the 1990's drought cycle. Eelgrass distribution continued to decline for subsequent years, and reached an historic low of less than 50 total acres, in the Spring of 1997 (Chesnut 1999). Tetra Tech (1998) identified 82 acres of eelgrass in Morro Bay (see Table 3-3), but some "sparse" beds as defined by other researchers were not included in that analysis. In addition, the timing of the surveys (spring) was not optimal for the eelgrass resource. Chesnut mapped about 120 acres in September of 1998 (Chesnut 1999).

By November of 1999, the resource had recovered to its more typical acreage, as evidenced by sampling and maps prepared by Chesnut (Chesnut, pers. comm., Jan. 2000). About 400 acres of eelgrass were documented in that survey (see Figure 3-2.)

The locations of dense eelgrass can be observed on aerial photographs taken at low tide. Comparison of historic photographs reveals that prior to the recent contraction the core areas of greatest plant density have remained relatively stable over the long term since 1949. The complete loss of an eelgrass resource following catastrophic events is known from the Pt. Mugu lagoon and in numerous Atlantic estuaries (Josselyn 1989; Short 1991).

Shoaling as a result of the deposition of creek sediments has eliminated beds in the Chorro delta. Shoaling due to wind-deposited dune sand has eliminated beds on the western edge of the bay.

In its reduced state (1996/1997), eelgrass lined the harbor channels inland of Coleman Beach and it occurred opposite Tidelands Park and White's Point. The remnant of an extensive historic bed was found in the central portion of the bay (south of the oyster barge channel and north of Baywood Point). Eelgrass is not abundant in the southern and eastern side of the bay (Chorro delta, Baywood cove and south of Cuesta inlet).

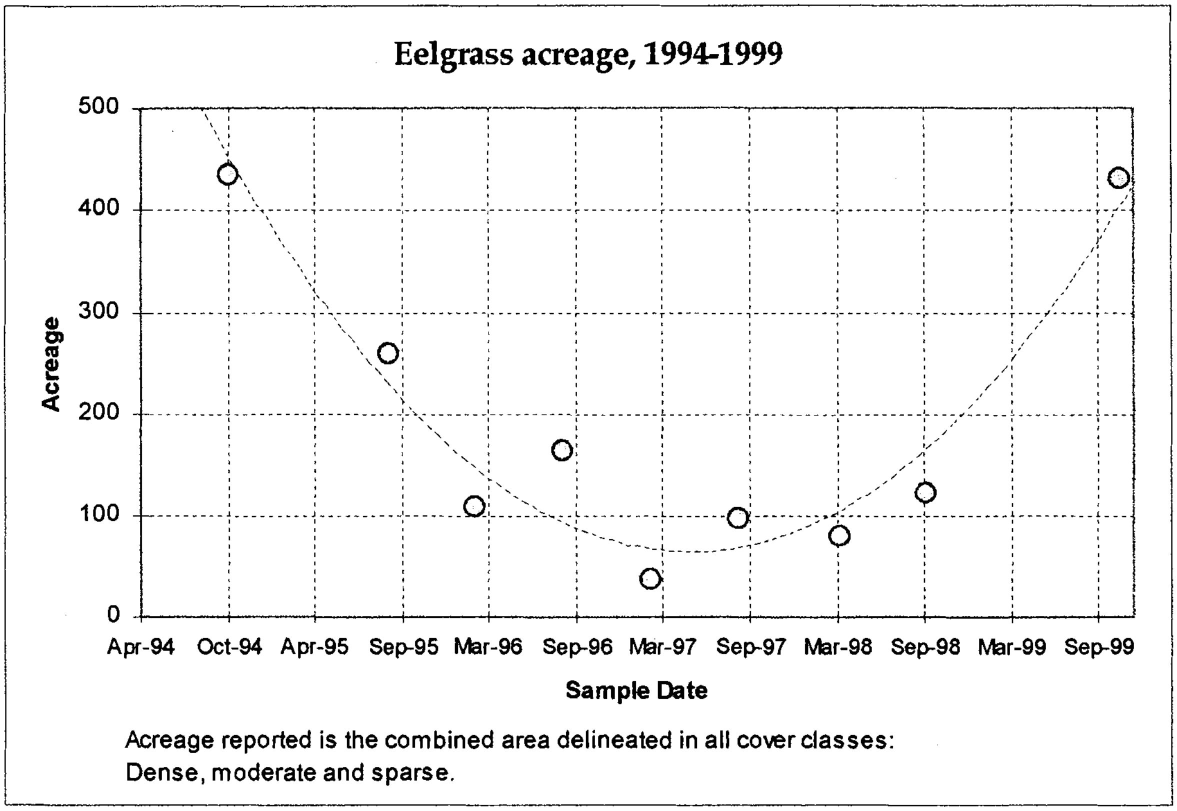



**Figure 3-2. Changes in Intertidal Eelgrass Acreage, 1994-1999.**

The condition of the present-day eelgrass resource in Morro Bay has been the subject of at least four separate surveys. These include (1) Bob Hoffman, for National Oceanic and Atmospheric Administration (NOAA); (2) Tetra-Tech for the MBNEP Habitat Characterization Study; (3) Coastal Resources (Ware) for the City of Morro Bay mooring project; and (4) Chesnut in an independent research project.

**Table 3-3. Summary of Eelgrass Surveys Conducted in Morro Bay.**

| Author | Survey Date | Acres | Classes | Extent | Method | Comments/Reference |
|---|---|---|---|---|---|---|
| Haydock | 1960 | 335 | 3: dense moderate sparse | Bay | Field survey, transect (2) | Base map: 1949 Photo (See Fig. 3-3) |
| CA Fish & Game | 1970 | 452 | None reported | Bay | Photo interpretation | Gerdes 1974 |
| Josselyn | 1988 | 732 | 2: dense (>50%), sparse (10-50%) | Bay | Photo interpretation, transect (1), spot check | Macroalgae may be included in delineation (Josselyn, 1989) |
| Nitsos | 1988 | N/A | | Harbor | Dive survey | Limited to restoration site (Nitsos 1988) |
| Ware | 1996 | N/A | | City Mooring | Dive quadrat | Limited to mooring project |
| Hoffman | 1990-1998 | N/A | | Harbor | Dive transect (3) | Fairbanks Pt., Target Rock, Tidelands |
| Chesnut | 1994-1998 | 450 | 3 classes | Back Bay | Quadrat sampling | See Fig. 3-4 (Chesnut 1996, 1997, 1999) |
| Tetra Tech | May, 1998 | 82 | 2: >30%, "potential" | Bay | Transect (4), Photo interpretation | Sparse beds excluded (See Fig. 3-1) |

*Source: Chesnut 1999*

The historic extents of eelgrass beds in Morro Bay are known from several records. These are summarized in Table 3-3, and are shown in Figures 3-1, 3-3, and 3-4. Haydock (1960) conducted an extensive survey in June- August of 1960 for the CDFG. Surveys were also conducted in 1970 by CDFG and published in Gerdes (1974).

The comparison of survey information is confounded by inconsistent definitions of what constitutes eelgrass habitat. Some of the published delineations are suspect because they were not supported by adequate field research.

Most eelgrass delineations have been made from the interpretation of aerial photographs. Research by Chesnut (1996) has demonstrated that there is a poor correlation between the measured density of sparse beds and photographic tone. According to Chesnut, dense beds are easily resolvable, but opacity of the water limits delineation along the lower depth in deep water. Color IR images do not contribute greatly to delineation because of a lack of separation in color between green algae and eelgrass.

No accepted definition for the delineation of sparse, marginal eelgrass is available (Fonseca 1998). In describing the habitats of Morro Bay, Tetra Tech (1999) used a wetlands classification prepared for the EPA by Ferren (1995). Eelgrass was mapped where cover was estimated to exceed 30% of transect area. Some habitat outside this delineation was mapped as "potential". Josselyn (1988) delineated beds into two classes, depending on whether photo interpretation predicted cover of greater than 50%. A limited number of transects were made by both studies to support these definitions.

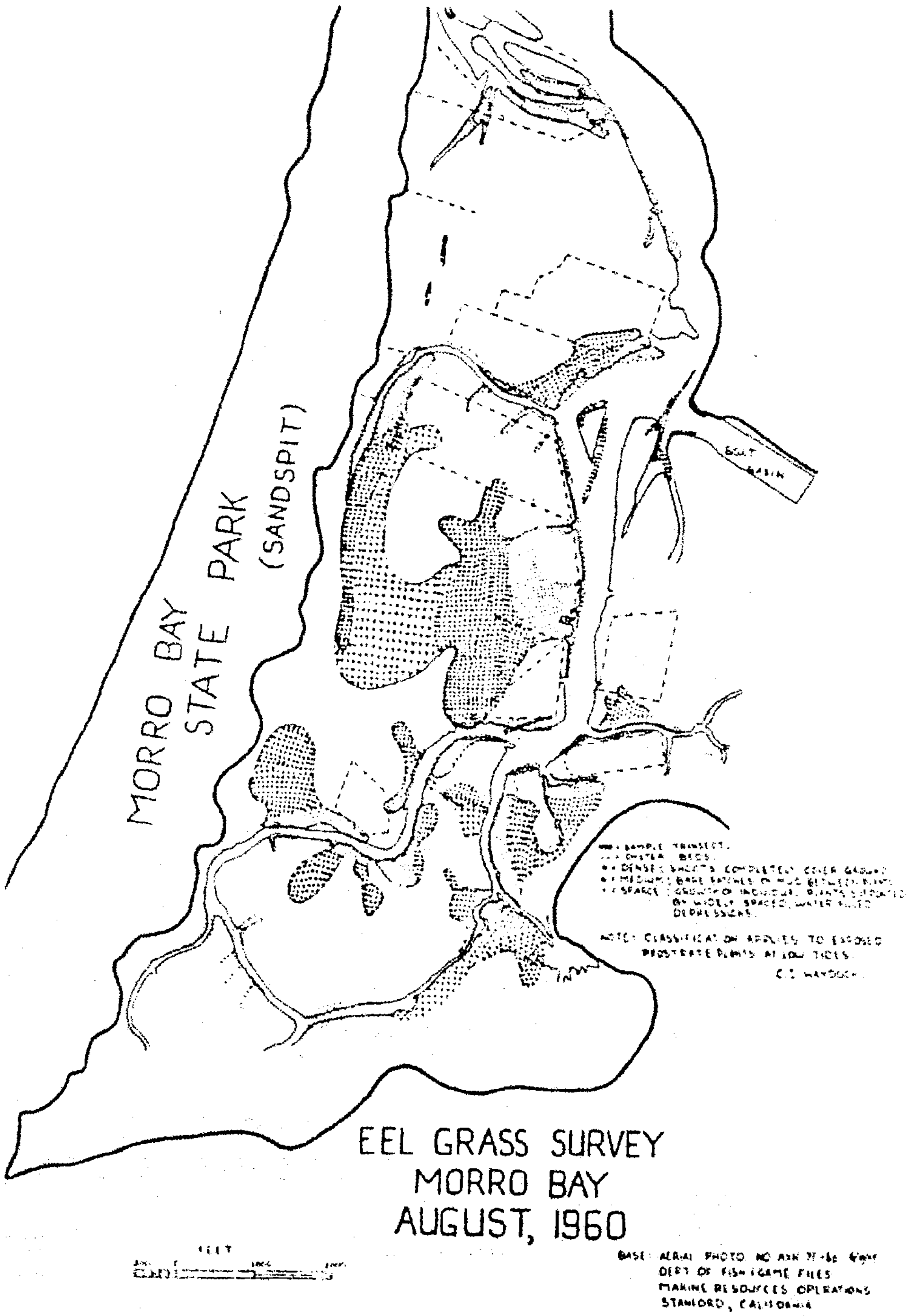



**Figure 3-3. Extent of Eelgrass Beds in Morro Bay as Mapped by Haydock in 1960.**

**October 1994**

**November 1997**

**December 1995**


**November 1999**

**Fig. 3-4. Changes in abundance and distribution of eelgrass habitat within Morro Bay, before and following the 1994 Highway 41 Fire and March 1995 Flood events.**

Fonseca (1998) cautions against the pejorative use of "sparse" to describe low-density beds. He points out that these areas have critical ecological functions. It is reported that over the short-term (5 years) clumps migrate to occupy all areas with in low-density beds.

Haydock 's (1960) definition of sparse beds was "growth of individual plants supported by widely spaced water-filled depressions." Haydock's definition is functional and descriptive, "I have observed that much of the loss in marginal eelgrass involves sediments filling the pothole depressions resulting in a featureless, evenly draining surface." A distance between clumps of less than 50 times the clump diameter (2% cover) is used by Fonseca to map marginal habitats.

The southern California eelgrass mitigation policy adopted in 1991 by NMFS, USFWS, and CDFG defines eelgrass habitat as area occupied by any density of eelgrass. (Hoffman in lit.) This policy was intended to standardize policies pertaining to mitigation of adverse impacts to eelgrass resources.

***Trends***

Comparison of 1949 and later aerial photographs demonstrate that the core eelgrass beds of greatest density within Morro Bay have been remarkably stable. Changes in distribution have mostly involved marginal extension of sparse beds along the upper intertidal zone. The predominance of acreage in this category accounts for much of the reported fluctuation in extent. However, as Josselyn concludes, it is difficult to determine whether changes in extent are an artifact of the various estimation methods. Delineations have used various classifications to distinguish dense beds from sparse ones.

Tetra Tech's 1998 survey identified a total of 81 acres of eelgrass in Morro Bay. Eelgrass was the dominant plant, accounting for nearly 100% of the vegetative cover. No nonnative plants were identified in eelgrass beds sampled. The results of the 1998 Habitat Characterization and Assessment Study suggest that the total acreage of eelgrass beds and the acreage of densely vegetated eelgrass beds in Morro Bay have decreased significantly compared with previous studies. However, the observed decrease may be due to differences in sampling period among studies, differences in sampling effort, known large (as large as an order of magnitude) natural interannual variations in eelgrass, and/or possible stressors (e.g., sedimentation).

Another key observation made by Chesnut was that, if trends in bathymetric measurements from 1919 to the present are accurate (see Section 2), then there appears to have been a decrease in the maximum potential growth area for eelgrass in the estuary. In other words, as the eelgrass "zone" experiences increased shoaling, its potential habitat decreases. Additional research is needed to confirm this and other questions relating to the eelgrass resource in Morro Bay.

### 3.1.3 Mudflats (Estuarine Intertidal Unconsolidated Shore)

Intertidal sand and mudflats are composed of soft to semi-soft substrate and they are generally shallow water habitats that include many hydrogeomorphic units that vary with flooding. Tidal flats develop with the accumulation of sediments. Organisms that inhabit tidal flats rely on organic materials imported from adjacent coastal, estuarine, riverine and salt marsh habitats. Many species of fish migrate over tidal flats with the incoming tides to feed on the organisms found on and in the sediments. Despite their lack of vegetation, tidal flats are recognized for their high productivity. This productivity is attributed to the diverse variety of primary food types such as benthic microalgae, phytoplankton, and imported particulate organic materials.

Tetra Tech's 1998 survey identified a total of 1,319 acres of mudflat in Morro Bay. For the most part, intertidal mudflats of Morro Bay were devoid of vegetation. However, algal species *Ulva* and *Enteromorpha* groups were observed in sparse patches in the high portions of these mudflats. Figure 3-7 shows mudflats and algal flats in the estuary.

Mudflats are the most abundant habitat type in Morro Bay, and provide primary foraging habitat for shorebirds. Invertebrate populations are large and diverse. Some of the more important species are discussed below.

***Invertebrates - Pacific Oysters***

Pacific Oysters *(Crassostrea gigas)* have been cultivated and harvested for commercial purposes in the bay since 1946 (Richards, no date). The California Department of Health Services (CDHS) and the California Department of Fish and Game (CDFG) regulate and monitor all phases of the harvesting. Oysters are filter feeders, and are critical indicators of water quality.

***Clams***

Bodkin and Rathbun (1988) conducted a clam abundance study in north Morro Bay during 1986 and 1987 to evaluate the impacts of dredging on sea otters. Sixteen subtidal sites were located between the mouth of the bay and Tidelands Park. Results indicated that the gaper clam (*Tresus nuttallii*) and the Washington Clam (*Saxidomus nuttallii)* are the two most abundant clams within the survey sites. Gaper clams are about four times as abundant as Washington clams. The clams are patchy in their distribution, occurring in greatest abundance near Target Rock, and most commonly along the northeast side of the main channel. Bodkin and Rathbun suggested that a possible mechanism that may be regulating the distribution of clams in Morro Bay is sediment transport and deposition along the southwest margin of the channel, combined with periodic maintenance dredging of the channel. They postulated that these factors prevent recruitment and subsequent growth of clams in this area. Gaper and Washington clams are deep burrowing species that often are found in burrows that exceed 40 inches in depth in soft sediment. Sea otter foraging data (Bodkin and Rathbun 1988) indicated that otters were feeding principally on these two clams, and, although the gaper clams were more abundant, the two species were represented almost equally in the diet of the sea otters of Morro Bay.

Popular clamming areas once existed between Fairbanks Point and White Point (shown on Fig. 6-1) on the east side of the bay, inside the breakwater on the northwest side of the sandspit, and across from the city's boat ramp on the east side of the sandspit (Sharpe 1974). Other clams occurring in the bay include Geoduck (*Panopea generosa*), Littleneck clams (*Protothaca staminea*), razor clams, bent-nosed clams, and basket cockles.

***Other Species***

Ghost Shrimp were once important commercially in Morro Bay. Ghost shrimp and innkeeper worms are currently used for bait by local fishermen.

***Vertebrates - Fish***

Tetra Tech observed that Topsmelt (*Atherinops affinis*) was the most abundant fish in the eelgrass habitat. Other species that were collected in relatively high abundance at eelgrass stations included Pacific staghorn sculpin (*Leptocottus armatus*), shiner surfperch (*Cymatogaster aggregata*), arrow goby (*Clevelandia ios*), and bay pipefish (*Syngnathus leptorhynchus*). Less abundant were California halibut (*Paralichthys californicus*), jacksmelt (*Atherinopsis californiensis*), longjaw mudsucker (*Gillichthys mirabilis*), and snubnose pipefish (*Cosmocampus arctus*). Many of these species forage at high tides throughout the mudflat areas as well as the rest of the bay.

***Shorebirds***

Mudflats and tidal flats also provide good-quality habitat for shorebirds. According to surveys done by the Point Reyes Bird Observatory (1991), up to 2,020,500 shorebirds utilize Morro Bay for feeding grounds, as well as resting and nesting areas. The most common shorebirds sited include: Black-bellied plovers, Willets,Whimbrels, Long billed curlews, Marbled godwits, Western sandpipers, Least sandpipers and Dowitchers.

### 3.1.4 Rocky Shore (Estuarine Intertidal)

Rocky substrate is found along the eastern shoreline of the estuary from Fairbank Point to the harbor entrance. Most of this is intertidal rip-rap placed to prevent erosion. Subtidal rocky bottom areas are most extensive near Target Rock and along the two breakwaters.

### 3.1.5 Sandy beaches (Marine and Estuarine Intertidal Unconsolidated Shore)

Sand swimming beaches are limited in occurrence in the estuary; however, the few that are present are near Coleman Beach (north of the T-piers in the vicinity of the Morro Bay Power Plant), and scattered areas on the eastern side of the sandspit. In addition, the Los Osos/Baywood Pier area at the southern end of 2nd Street, Cuesta inlet near Doris Avenue, and Pasadena access off of Pasadena Drive are used frequently for various in-water activities. Outside the estuary, within Estero Bay, sandy beaches exist north of Morro Rock and along the western edge of the sandspit. Dunes are generally found landward of beaches, and may or may not be vegetated. Sand verbena, beach primrose, live-forever, and sea rocket occur on the sandspit in the foredune communities and grade into other areas. Some of these dunes that contain little vegetation migrate with wind action.

The Morro Bay sandspit (part of Morro Bay State Park) provides crucial nesting habitat for the federally threatened western snowy plover. This bird uses the dunes for foraging and breeding activities.

Shorebirds and the Morro Bay Sandspit

### 3.1.6 Coastal Salt Marsh [Estuarine Emergent Wetland]

Coastal Salt Marsh (500 acres) is characterized primarily by the presence of pickleweed *(Salicornia virginica*). Coastal salt and brackish marsh are important components of the wetland habitat found at the edge of the Morro Bay estuary. Several sensitive species are found associated with these habitat types in Morro Bay, including California sea blight (*Suaeda californica*) which is endemic to Morro Bay estuary, salt marsh bird's beak (*Cordylanthus maritimus ssp maritimus*), and the California Black Rail. Portions of these habitats have been severely impacted by sedimentation and aggressive takeover by introduced weed species, particularly hoary cress.

***Tetra Tech 1998 Survey***

Tetra Tech's 1998 survey identified a total of 436 acres of salt marsh habitat in Morro Bay. However, the Tetra Tech surveys focussed on coastal salt marsh; smaller areas of freshwater and brackish marsh along the edge of the estuary were not included in their sampling, nor were they mapped. The sampled salt marsh was dominated by pickleweed (*Salicornia virginica*) in the low salt marsh, and Jaumea (*Jaumea carnosa*) in the high salt marsh. Cord grass (*Spartina* sp.) was not found in the low salt marsh of Morro Bay. Five nonnative plants were identified, including fennel (*Foeniculum vulgare*), wild radish (*Raphanus sativus*), poison hemlock (*Conium maculatum*), annual beard grass (*Polypogon monspeliensis*), and hoary cress (Cardaria draba, but were not dominant, in salt marsh and riparian habitats sampled.

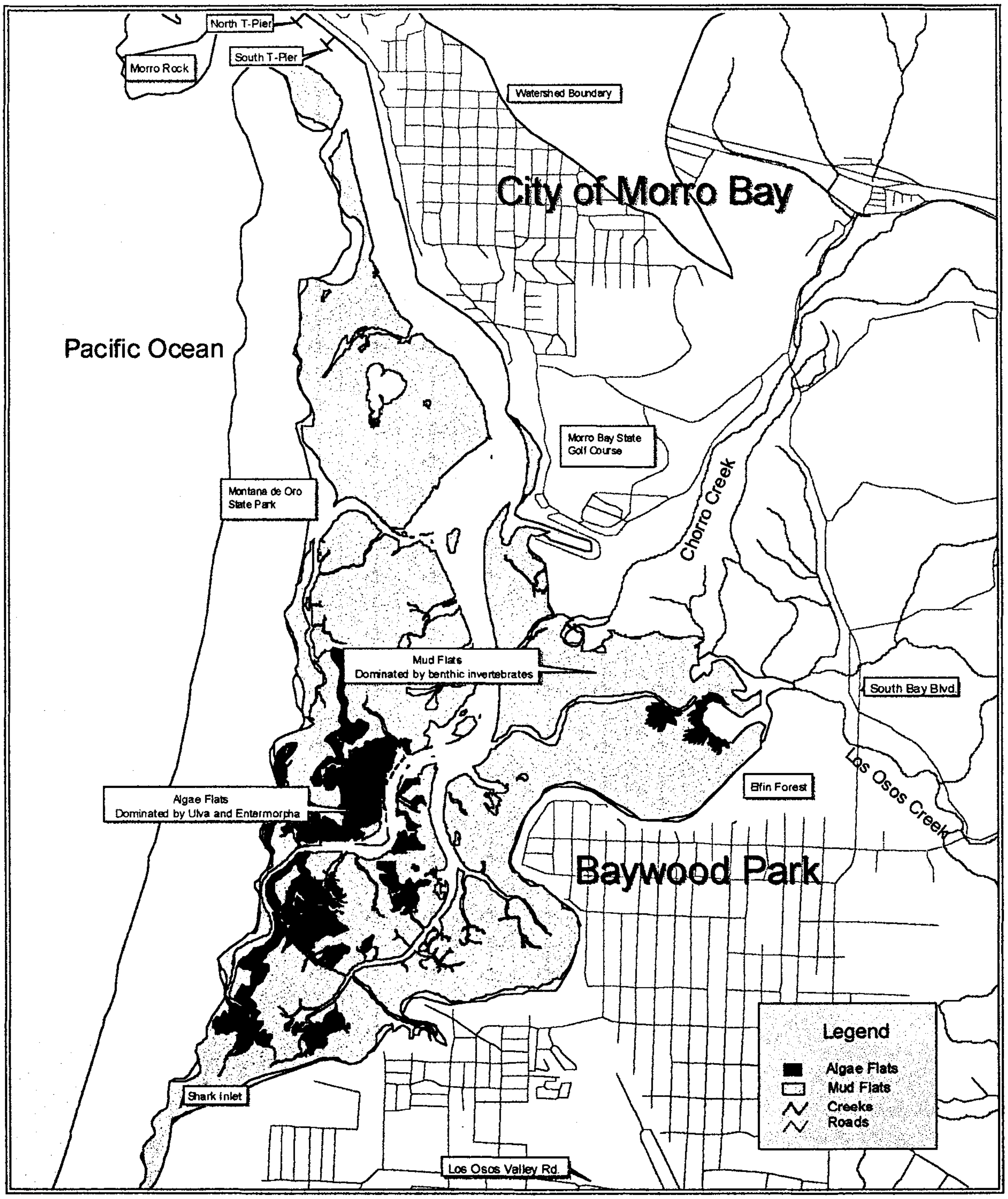



Figure 3.5 Distribution of Algae and Mud Flats in Morro Bay
Source: TetraTech Habitat Survey 1999
MBNEP Characterization 1999

The majority of the salt marsh habitat occurs in the Chorro/Los Osos Delta. A small portion of salt marsh habitat occurs near the Sweet Springs Preserve along the southern margin of the bay. Salt marsh exists at Shark Inlet, at several small inlets along the sandspit, and adjacent to Butte Drive (David Chipping 1998 pers. comm.).

Although 17 plant species were identified in salt marsh habitat, this habitat was dominated by pickleweed (*Salicornia virginica*) and jaumea (*Jaumea carnosa*). Vegetation sampling along the high mudflat/low salt marsh fringe revealed that pickleweed is the dominant vegetation, having a mean cover of 99%. Jaumea has a mean vegetative cover of 45% and is the dominant cover in the high salt marsh (from 3.5 to 5.5 feet NGVD) Cord grass (*Spartina foliosa*), which usually characterizes low salt marsh in most Northern California estuary systems, is not present in Morro Bay. However, cord grass is absent from most southern California coastal wetlands, suggesting that its absence in Morro Bay is not unusual.

The mosaic of middle salt marsh species at Morro Bay precluded detailed mapping of this community according to the Ferren *et al.* (1995) classification systems. Instead, a broader Ferren wetland classification was used to characterize this habitat type. Areas of higher elevation, particularly within the marsh plain, appears to support a more diverse assemblage of plant species, such as salt grass (*Distichlis spicata*), alkali heath (*Frankenia salina*), arrow grass (*Triglochin coccina*), and western marsh-rosemary (*Limonium californicum*). Salt grass and alkali heath had mean covers of 23% and 18%, respectively.

Due to cost and time constraints, not all areas of Morro Bay could be ground-truthed in 1998 to map salt marsh vegetation using aerial photos. Future monitoring studies should focus separately on the different habitat types; this would allow a more detailed and complete mapping of each of the habitat types.

### 3.1.7 Brackish Marsh (Estuarine Intertidal Emergent Wetland)

Coastal Brackish Water Marsh (80 acres), is found in the narrow zone between salt marsh and fresh water marsh or upland habitats, is characterized by salt grass (*Distichlis* sp.), Jaumea (*Jaumea carnosa)*, Bull rush (Scirpus americanus) and alkali heath (*Frankenia salina)*. These areas are also potential habitat for the threatened California Black Rail, which is found in neighboring salt marsh plant communities.

Tetra Tech documented brackish marsh near the mouth of Los Osos Creek and at Sweet Springs Marsh. Ferren and others (1995) include the mouth of Los Osos Creek in this category. These areas are often supported by seeps from adjacent forested wetlands.

### 3.1.8 Fresh Water Marsh (Palustrine Emergent Wetland)

Coastal freshwater marsh (35 acres) is primarily found at the edges of the south bay. This marsh is dependent on high ground water, and is supported in part by effluent from septic system disposal in Los Osos. California Black Rail, one of the species of concern, can be potentially found in bulrush, cattails (Typha spp.), and saltgrass (*Distichlis spicata*) (Fugro-West, 1997).

### 3.1.9 Riparian (Palustrine Forested Wetland; Riverine Sand and Mud Bottoms)

Healthy riparian corridors consist of tall overstory shade trees, shrubby vegetation, and under story grasses and forbs. The shade of the trees keeps creek water cool and reduces algal growth in the creek channel. Riparian corridors provide important nesting, feeding, and cover habitat for a number of birds, mammals, and other species. They also serve as wildlife corridors for migratory animals.

Riparian vegetation slows water velocities such that much sediment drops out before it reaches the stream. It also reduces channel downcutting and associated lowering of the water table, and prevents bank erosion. Streambank vegetation can shade out tules and other sun-dependent vegetation that can block high winter flow and increase flooding.

Healthy riparian corridors are an important component of high quality steelhead habitat. Healthy creekside vegetation is important because it:

- Shades the channel, lowering water temperatures and thereby assisting with maintaining needed oxygen levels in the creek
- Provides leaves and insects which serve as an important food base for other insects and the fish that feed on them
- Assists with bank stabilization, and prevents bank erosion, thereby reducing sediment deposition into creek water
- Filters runoff from uplands, thus reducing sedimentation to creeks, removing excess nutrients, and protecting spawning gravels; and
- Stabilizes undercut banks and provides important hiding and resting area for fish

***Tetra Tech 1998 Survey***

Tetra Tech's 1998 survey identified a total of 147 acres of riparian habitat in the 1-mile reach of Chorro and Los Osos Creeks closest to the estuary. Riparian habitat samples were dominated by arroyo willow (*Salix lasiolepis*). The exotic, invasive cape ivy (*Delairia odorata*) was a dominant plant in the herb layer of Chorro Creek that is also present along the lower reaches of Los Osos Creek.

The riparian habitats of Chorro and Los Osos Creeks were the most diverse of all habitats samples in Morro Bay. Forty-nine plant species were identified in riparian habitats. A brief description of each creek and its riparian habitat is provided.

**Chorro Creek**. For many years a portion of Chorro Creek just upstream from the Chorro Creek bridge was diverted and held in place by a levee. In 1994, as an emergency measure, the SLCRCD removed a 450-ft section of the levee and Chorro Creek was allowed to flow through the breech into a restoration channel. In 1997, another 2800 ft. was removed as part of the Chorro Flats project coordinated by the SLCRCD. The purposes of the project are (1) to allow sediment to deposit on the Chorro Creek floodplain instead of in the estuary; (2) to preserve agricultural land; and (3) to restore habitat.

The streambed of Chorro Creek consists of mixed coarse sand and small gravels in the 1-mile reach upstream from the tidal marsh. Larger gravels were observed in the upper portions of the reach. Low water conditions leave exposed gravel and sand bars along the stream, particularly upstream of the confluence with the restoration channel that was recently created as part of the Chorro Flats project. A thorough inspection of the channel within the study reach revealed no barriers to anadromous fish movement. This is discussed further in Section 5.5.6.

Topography and agricultural practices have resulted in a narrow riparian corridor in the upper portion of the 1-mile study reach of Chorro Creek. The corridor of riparian vegetation widens near the mouth, indicating that the main channel has meandered in the recent past. Arroyo willow (*Salix lasiolepis*) dominated the riparian habitat throughout the entire reach. In terms of mean percent cover, *Salix* accounted for 40% of the shrub and canopy layers. Exotic, invasive cape ivy (*Delairea odorata*) was a dominant of the shrub and herb layers in several locations along the reach, particularly in the lower portions. In the herb layer of Chorro Creek, Cape ivy accounts for 54% of the mean vegetative cover. Other exotics found in the riparian habitat of Chorro Creek include fennel (*Foeniculum vulgare*), annual beard grass (*Polypogon monspeliensis*), and Italian thistle (*Carduus pycnocephalus*).

**Los Osos Creek**. The narrow Los Osos Creek streambed is dominated by silt and mud in the 1-mile reach upstream from its confluence with a tidal channel. Dense vegetation and deep, soft sediments prevented a thorough inspection of the stream channel within the study reach. Where visible, there appeared to be no barriers to anadromous fish movement when high flows occur.

Aerial photos of riparian habitat along the lower 1-mile reach of Los Osos Creek indicate large areas of contiguous riparian habitat interspersed with small clearings and roads. Of the three willow species (*Salix lasiolepis, S. laevigata,* and *S. exigua)* observed during vegetation sampling at Los Osos Creek, arroyo willow *(Salix lasiolepis)* dominated the riparian habitat throughout the entire reach. Upstream areas of the floodplain adjacent to the reach appear to consist of evenly-aged stands of willow, indicating that either natural or man-made conditions had allowed willows to recently colonize this area.

In terms of mean percent vegetative cover, arroyo willow accounted for 19% of the shrub and canopy layers. California blackberry (*Rubus ursinus*) accounted for 23% of the herb layer. Exotic species found in the riparian habitat of Los Osos Creek include cape ivy, fennel (*Foeniculum vulgare*), annual beard grass (*Polypogon monspeliensis*), and Italian thistle (*Carduus pycnocephalus*).

## 3.2 MORRO BAY UPLAND AND WATERSHED HABITATS

Upland habitats within the watershed include coastal dune scrub, coastal sage scrub, maritime chaparral, grassland, oak woodland, closed cone conifer forest and montane hardwood.

### 3.2.1 Coastal Dune Scrub

In California, coastal dune scrub is restricted to a few isolated pockets of stabilized coastal sand dunes along the coast. In the Morro Bay watershed, this community occurs in the vicinity of Los Osos. This plant community is characterized by an assemblage of small shrubs, including mock heather (*Ericameria ericodies*), buckwheat (*Eriogonum parvifolium*), California sagebrush (*Artemesia californica*), sage (*Salvia sp.*), silver lupine (*Lupinus chamissonis*), and dune almond *Prunus fasciculata ssp. punctata*). The geographic isolation of coastal dune scrub in Los Osos from other dune habitats is thought to have given rise to the unique assemblage of plant and animal life which is expressed in the high degree of endemism for such a small area. Coastal dune scrub supports the federally endangered Morro shoulderband *snail (Helminthoglypta walkeriana*); the Morro Bay kangaroo rat (*Dipodomys heermanni morroensis*); the Morro blue butterfly (*Icariacia icariodes ssp. morroensis*), a Federal species of concern; and several rare lichens. Nonnative veldt grass (*Ehrharta calycina*) has infested many areas of coastal dune scrub within Montana de Oro State Park and undeveloped parcels in Los Osos. Without proactive habitat management actions, areas that contain patches of veldt grass are likely to replace coastal dune scrub and render it unsuitable habitat for the many sensitive species that rely upon it, as it has in other unmanaged areas in the vicinity of Los Osos. The inherent rarity of coastal dune scrub, its vulnerability to disturbance from nonnative vegetation and unmanaged recreation, and the pressure for coastal development make this one of the most imperiled habitat types in California.

### 3.2.2 Coastal Sage Scrub

Coastal sage scrub throughout Morro Bay watershed is most commonly on shallow soils dominated by California sagebrush (*Artemesia californica*) and Black sage (*Salvia mellifera*). The community is found in more xeric conditions and usually on steep south facing slopes and commonly associated with Chamisal chaparral. Coastal scrub tends to be lower growing and more open than chaparral and is composed of dominants that are active during the winter and avoid summer drought by shedding their leaves.

Most coastal scrub communities change little in species composition after 10 years post-fire event. Some sites can exist over 60 years without Common associates of Coastal sage scrub include California *buckwheat (Eriogonum fasciculatum)*, and Yucca (*Yucca whipplei*), Sticky monkeyflower (*Mimulus auranticus*), Poison oak (*Toxicondendron diversilobium*) and Deerweed (*Lotus scoparius*).

### 3.2.3 Maritime Chaparral

Perhaps the most distinctive of chaparral communities, central maritime chaparral is dominated by the sand dwelling shrub Morro manzanita (*Arctostaphylos morroensis*). It is scattered throughout the hillsides south of Los Osos and found on north-facing slopes of the marine terraces just south of Los Osos Creek (Mooney 1992). Maritime chaparral occurs on highly erosive, sandy soils, and grades into pygmy oak woodland and other coastal scrub communities. The cool, moist climate provides frequent fog drip, an extremely important factor limiting the distribution of this community.

The dominant species associated with central maritime chaparral include plants adapted to fire such as: Chamise (*Adenostema fasciculatum*); and dominant Morro manzanita (*A. morroensis*). There is little understory as the environment under this chaparral is one of low light and deep leaf litter. Chamise, as well as Morro manzanita, may be allelopathic, putting out toxins to retard other competitors. Only after a fire do other species get a foothold until canopies grow thick and are shaded out (Tyler and Odion 1996). Other characteristic plants are: Coast Live Oak (*Quercus agrifolia*); Indian Knob mountainbalm (*Eriodictyon actissimum*), a State and federally endangered species; Wedge-leaf ceonothus (*Ceanothus cuneatus*); Sticky Monkeyflower (*Mimulus aurantiacus*); and Manroot (*Marah fabaceus*). Maritime chaparral is discussed further in Section 3.3.7.

### 3.2.4 Grassland

Grassland is the most abundant upland habitat type in the Morro Bay watershed. Three types of grassland are generally recognized in the area: valley needlegrass, serpentine, and non-native grassland.

Valley needlegrass grassland occurs on heavy, clay soils that contain a large percentage of organic matter and have never been tilled. The soils are generally saturated in winter and dry in summer. Common plant species include both native and non-native annuals, which may be more abundant than the native bunchgrasses that are characteristic of the community (Holland, et al., 1986). Some of the more common plant species are California poppy (*Eschscholtzia californica*); shooting star (*Dodecatheon clevelandii*); succulent lupine (*Lupinus succulentus*); buttercup (*Ranunculus californica*); purple needlegrass (*Nassella pulchra*); slender needlegrass (*Nasella lepida*); and johnny-jump-up (*Viola pedunculata*).

Serpentine grassland occurs in shallow, rocky soils that are low in calcium and high in magnesium, nickel, and chromium. This community generally contains more native species than valley needlegrass grassland, and many species are locally rare. Some of the plaints making up this community are: *Astragalus curtipes* (rattleweed), *Calochortus obispoenis*+ (San Luis mariposa lily), *Calochortus clavatus* ssp. *clavatus*+ (club-haired mariposa lily), *Chorizanthe palmeri* (Palmer's spineflower), *Dichelostemma pulchellum* (blue-dicks), *Eschscholzia californica* (California poppy), *Layia jonesii*+ (Jones layia), *Lomatium parvifolium* (small-leaved lomatium), *Melica californica* (California melic-grass), *Monardella palmeri* + (Palmer's monardella), *Nasella pulchra* (purple needlegrass), and *Nasella lepida* (slender needlegrass).

Non-native grassland is the most abundant grassland type and plant community in the watershed. Most of this community is subject to grazing by domestic livestock, and has been greatly altered by human activities. It consists mostly of introduced annual grasses, such as slender *wildoats (Avena barabata*); common wild oats (*Avena fatua*); rip-gut brome (*Bromus diandrus*); soft *chess (Bromus mollis*); red brome (*Bromus hordeaceous*); ryegrass (*Lolium multiflorum*); foxtail barley (*Hordeum murinum*); and rat-tail fescue (*Vulpia myuros*) (Mooney 1992).

### 3.2.5 Oak Woodland

Within the watershed, two distinct phases of coast live oak woodland can be found. The common phase typically occurs on mesic soils of north facing slopes and canyons throughout the watershed. The "pygmy oak" phase, know locally as the "elfin forest," occurs only in the South Bay area (Holland and Keil 1986). Coast live oak *(Quercus agrifolia)* dominates both communities. The elfin forest is populated by a stunted, wind-pruned variety of coast live oak, called pygmy oak, often occurring as a many-stemmed, gnarled shrub or tree. The elfin forest sits atop the oldest dunes, and can be viewed on the south side of Los Osos Creek, at the Elfin Forest Small Wilderness Preserve. Los Osos Oaks State Reserve also contains stunning examples of the pygmy oaks. This type of oak woodland is known from only two other areas in the state: Burton Mesa in Santa Barbara County, and the Presidio area on the San Francisco peninsula. Some of the more commonly occurring under story species are wood fern; manroot (*Marah fabaceus*); bracken fern (*Pteridium aquilinum*); coast live oak; pygmy oak (*Quercus agrifolia* var. *frutescens*); wild blackberry (*Rubus ursinus*); gooseberry (*Ribes* spp.); and poison oak (*Toxicodendron diversilobum*).

Coast live oak communities are extremely variable, and often intergrade with riparian and chaparral types, especially in the South Bay area. A progression in cover types is generally recognized from open savanna to oak woodland, to oak forest. Oak savanna usually has grassy understory; oak woodland contains scattered oak trees generally with a chaparral understory and oak forest contains large specimen-size trees where canopies touch providing a shady environment for shrubs and many ferns. The upper watershed of Los Osos Creek supports undisturbed stands of mostly oak woodland and oak forest, providing valuable wildlife habitat (Mooney 1992).

### 3.2.6. Montane Hardwood-Conifer Forest

Poorly defined habitats of the Montane Hardwood-Conifer are found in the upper elevation range (1200-1800 feet) of Camp San Luis Obispo on the Henneke-Rock outcrop complex At least one third of the community is hardwood, such as Pacific madrone, tan bark oak, and one third is conifers including Coulter pine. At lower elevations, broadleaf evergreens forests dominated by coast live oak mix in dense patches, creating a mosaic effect. Big leaf maple is also a vegetation type found on northern slopes, or riparian ravines (USDA/SCS 1994).

Little understory occurs under this vegetation type at Camp San Luis Obispo, yet the cover grows denser as this community grades into riparian habitats. Regeneration after a fire is characterized by vigorous growth, with both shrubs and trees recovering. Growing stands are usually dominated by two layers, with faster growing conifers above and hardwoods below (USDA/SCS 1994).

## 3.3 SPECIAL STATUS SPECIES

Special status species are those species that are listed by various organizations and/or agencies as endangered, threatened, rare, or of special concern. Special Status Animal and Plant species found in the Morro Bay Area are listed in Table 3-4.

**Table 3-4. Special Status Species Known to Occur Within the Study Area.**

| Species | State Status | Federal Status | Recovery Plan Status |
|---|---|---|---|
| American peregrine falcon | Endangered | Delisted FE 1999 | Final 1983, Delisted 1999 |
| Brown pelican | Endangered | Endangered | Final 1983 |
| California Black Rail | Threatened | | |
| California Clapper Rail | Endangered | Threatened | |
| California red-legged frog | | Threatened | Public draft under development |
| California sea-blite | | Endangered* | Public draft under development |
| Chorro Creek bog thistle | Endangered* | Endangered* | Public draft 1997; final in progress |
| Cuesta Grade checkerbloom | Rare | | |
| Indian Knob mountainbalm | Endangered* | Endangered* | Public draft 1997; final in progress |
| Least Bell's vireo | Endangered | Endangered | Public draft 1988; final in progress |
| Morro Bay kangaroo rat | Endangered* | Endangered* | Final 1982; under revision |
| Morro manzanita | | Threatened* | Public draft 1997; final in progress |
| Morro shoulderband snail | | Endangered* | Public draft 1997; final in progress |
| Salt marsh bird's-beak | Endangered* | Endangered | Final 1982 |
| Southern sea otter | | Threatened | Final 1982; revised public draft, 1996 |
| Southern steelhead trout | | Threatened | Contact National Marine Fisheries Service |
| Southwestern Willow Flycatcher | | Endangered | |
| Swainson's Hawk | Threatened | | |
| Tidewater goby | | Endangered | |
| Western snowy plover | | Threatened | Public draft under development |

*endemic to the vicinity of the Morro Bay Watershed

***Source: U.S. Fish and Wildlife Service, 1999. California Department of Fish and Game 1999.***

Many species that are formally listed by the federal government as threatened and endangered are dependent upon the diverse habitats of the estuary and watershed for their survival and recovery (Table 3-5). Morro Bay is increasingly being recognized as an area that plays a critical role in supporting resident and migratory bird species. This makes the protection of estuary and wetland habitats increasingly important. Some of the Special status bird, mammal, amphibian, reptile, fish, and plant species occurring in the estuary and watershed are highlighted below.

**Table 3-5. Areas of Special Biological Importance Within the Morro Bay Study Area.**

| Area | Jurisdiction | Category |
|---|---|---|
| Black Hill Natural Area | State Parks & Recreation | 2, 4 |
| Elfin Forest | State Parks & Recreation (52 acres) | 1 |
| Elfin Forest | SLO County Parks & Recreation (38 acres) | 1 |
| Heron Rookery - Natural Preserve | State Parks & Recreation | 3, 5 |
| Los Osos Oaks State Reserve | State Parks & Recreation | 1, 5 |
| Los Osos Creek Mouth | State Parks & Recreation | 2, 5 |
| Morro Bay Sand Spit - Natural Reserve | State Parks & Recreation | 1, 4 |
| Morro Bay State Park | State Parks & Recreation | 3, 4, 5 |
| Morro Dunes Ecological Reserve | State Fish & Game | 2 |
| Morro Rock State Reserve | State Parks & Recreation | 2 |
| Morro Palisades | Private | 2 |
| Morros | Private | 1 |
| Sweet Springs Marsh | Morro Coast Audubon Society | 1, 2 |
| Warden and Eto Lakes | Private | 1 |
| Monarch Butterfly Wintering Areas | Private | 3 |
| Chorro Creek | State Fish & Game | 3 |

Categories:
1 = Unique, rare, or fragile community
2 = Rare or endangered species habitat
3 = Specialized wildlife habitat vital to a species survival
4 = Outstanding representative natural community with an unusual variety of plants or animal species
5 = Areas with outstanding educational values to be protected for scientific research and educational uses
*Source: Nomination of Morro Bay, 1995*

## 3.3.1 Birds

Bird species abundance and diversity are good indication of the quality and quantity of food and resting habitat around the bay. The Audubon Society's Christmas counts record Morro Bay as consistently among the top 5 spots out of 963 sites nationwide for diversity of winter bird species, with around 200 species and over 50,000 individual birds counted in a single day in December (Persons, pers. comm.).

Migratory birds use Morro Bay as a site to feed and rest during fall and spring migration or as wintering or summer nesting habitat. The U.S. Fish and Wildlife Service Migratory Bird List contains 44 coastal, pelagic and shoreline species; 30 waterfowl species; and 200 upland migratory bird species using the Morro Bay estuary.

Shorebirds are abundant in the Morro Bay estuary. Data for the period 1989 to 1994 indicate the willets, marbled godwits, westerns sandpipers, and least sandpipers sometimes number in the thousands in the late summer and early fall. Dowitchers, black-bellied plovers, semipalmated plovers, and long-billed curlews number in the hundreds (Point Reyes Bird Observatory 1999). Other shorebirds present in the area at various times include dunlins, sanderlings, whimbrels, avocets, and killdeer.

***Brant***

Morro Bay supports large numbers of Black brant from November through April. Black brant breed at coastal arctic nesting sites in eastern Russia, western and northern Alaska and northwestern Canada. Brant winter in lagoons and estuaries from the Pacific coastal states to the Baja peninsula and mainland Mexico. Outside of the breeding season brant are closely associated with their primary food source, eelgrass (*Zostera marina*).

An analysis of over 1,200 band reads obtained on Morro Bay from 11/97 to 4/99 indicates that Morro Bay supports both wintering and migrating brant (J. Roser pers. comm.). Brant bands were read from all black brant banding localities from Russia, Alaska and Canada. Wintering birds have been shown to reside up to 5 months on Morro Bay and exhibit strong wintering site fidelity (J. Roser pers. comm.; Reed et al. 1998). It has been estimated that as many as 25,000 brant may stop and utilize Morro Bay as a feeding and resting site during migration to and from Mexico, with the majority of brant stopping on their way north from mid-January through early May (D. Ward pers. comm.). During their southward migration many brant fly nonstop from their primary fall staging area on the Alaska Peninsula to Mexico, however, the northward migration is very different. Brant leapfrog up the coast stopping at regular feeding sites. This allows them to maintain higher body mass during migration, which ultimately leads to larger clutch sizes and increased reproductive fitness. Since many important brant wintering areas in southern California have been lost to habitat alteration, Morro Bay has become the last significant brant wintering area and migration stop between San Quintin Bay in Baja and northern California.

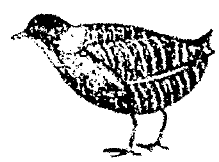
Eelgrass is the dominant forage of wintering brant on Morro Bay, but green algae (*Enteromorpha* sp., *Ulva* sp.) is also a significant food resource each year when abundant. During January of 1998 eelgrass acreage and/or density became so low brant completely abandoned foraging on eelgrass and began feeding in the coastal salt marsh habitats around the bay (Roser 1998). At the same time the population abruptly dropped from approximately 1,700 to 600 individuals. Algal growth in the salt marsh supported the remaining population for several weeks until vascular plant growth began. At this time arrowgrass (*Triglochin* sp.) and pickleweed (*Salicornia* sp.) became the dominant forage plants. Salt marsh foraging during this period occurred during all phases of the tidal cycle and brant did not begin revisiting the eelgrass beds until mid-March. During the following winter of 98/99 eelgrass acreage was up and brant did not abandon the eelgrass beds to forage in the salt marshes.

In California, wintering brant numbers have undergone a significant decline in the past few decades, possibly as a result of increasing disturbance from human activity as well as habitat loss

(Sedinger *et al.* 1994). Historical numbers for Morro Bay between 1950 and 1966 often exceeded 6,000 individuals, with a 1955 census totaling 11,500 brant (Gerdes et al., 1974). Brant numbers on Morro Bay in the 1990's ranged from 3,400 during the winter of 1995-96 to 1,700 in the winter of 1997-98 (Roser 1998). This downward trend over the past few decades may be due to a declining eelgrass resource.

Brant hunting, a traditional activity on Morro Bay, has declined significantly in the last few decades. During the 1957-58 brant season it was estimated that 1,860 brant were taken during 1,875 hunter days of activity (Gerdes *et al.* 1974). During the 1998 brant season, it was estimated that between 200 and 250 brant were taken during 203 hunter days (J. Roser pers. comm.). Brant hunting on Humboldt Bay in northern California has been shown to significantly reduce the number of brant use days during hunting season (Subcommittee on Pacific brant 1992). Brant on Morro Bay have been shown to alter their behavior during hunting season by avoiding eelgrass bed locations during high tide where hunting activity occurs in favor of low disturbance non-hunting zones devoid of eelgrass (Roser 1998).

Morro Bay will probably continue to support large numbers of brant in the future if two main conservation issues are monitored and addressed as necessary. These issues are: 1) important eelgrass foraging areas need to be conserved; and 2) human disturbance needs to be monitored to assure that it remains within tolerable levels for brant to maintain normal behaviors (appropriate foraging and resting time) to assure a healthy energy budget. Currently brant experience a significant amount of disturbance from recreational users (kayaks, canoes, sailboards, etc.) on some weekend days, but on most days there is relatively little disturbance. However, a steadily increasing regional and bayside population coupled with an increasing proportion of recreational users of the bay within this population could lead to unacceptable levels of human activity for wintering and migrant brant. Education of user groups could help reduce disturbance levels.



***California Black Rail***

The California Black Rail is a very reclusive bird found in emergent tidal wetlands dominated by pickleweed (Fugro West 1997). It occurs in localized patches from San Diego to Morro Bay, and inland to the Colorado River. The secretive black rail is protected by California threatened status, and is listed as a Federal species of concern (Fugro West 1997), but little is known about its population and distribution in Morro Bay. It has been found locally in upper Chorro delta (Manolis 1977; Westec 1988). It is also known to occur in Los Osos Creek and Cuesta by the Sea (Westec 1988). The narrow habitat requirements of the black rail suggest that less than 10 percent of the 575 acres of salt marsh is suitable rail breeding habitat (Evens *et al.*, 1986). In addition to saltmarshes, the black rail will also utilize bulrush, cattails (*Typha spp.*), and saltgrass (Fugro West 1997) vegetation.

The population trend for this species in California is considered to be declining due to loss of coastal salt marshes, inland freshwater marshes and Colorado River marshes. The California

Black Rail can be managed in two ways: protection and management of wetlands through acquisition; and restoration of degraded wetlands. Restoration efforts should include establishment of a high marsh component, and periodic surveys (at least every two years) to determine distribution, numbers, quality and extent of habitat at all sites (CDFG 1992).

### *California Clapper Rail*

Clapper Rail has been reported from marsh habitat near Chorro Creek (CDFG 1980; J. Lidberg, CDFG, pers. comm.). The Clapper rail was formerly more abundant in the Morro Bay marsh (Edell *et al* 1985) but it is no longer believed to occur as a breeding species in this location. Its range includes San Francisco Bay and Humboldt Bay in Northern California (CDFG 1992). Although the California Clapper Rail has been protected by State endangered status and is also listed as a Federal endangered species, little information is available regarding it's presence in Morro Bay.

Heavy loss and degradation of tidal marsh habitat has led to the endangerment of the rail and its population statewide. The rail is threatened today by pollution from sewage effluent, industrial discharges and urban runoff, which are contaminating its food resources. The California Clapper Rail eats a variety of invertebrates, including mollusks and crustaceans, which accumulate pollutants from filter feeding (CDFG 1992).

Management plans are active in San Francisco Bay to help the recovery of the rail. Such conservation measures may lead to translocating abundant breeding pairs to suitable habitat such as Morro Bay salt marsh (CDFG 1992). The population trend for this species had been declining until 1992. Based upon preliminary data, trends report that the localized San Francisco populations are nearing stabilization (CDFG 1992).

### *The California Brown Pelican*

The California Brown Pelican is a (May to February) visitor to Morro Bay whose breeding range extends from Point Lobos (Monterey County) to Isla San Martin (off the tip of Baja California). This pelican, unlike the white pelican, is a maritime bird that eats surface schooling fishes such as the Pacific mackerel, Pacific sardine, and the northern anchovy. The two latter species have declined to over fishing by humans, and over 90 percent of the pelican diet, based on the most recent food habits studies, consists of the anchovy during the critical pelican breeding season.

The breeding populations of the Federally endangered Brown Pelican can be differentiated into separate identifiable and geographical entities. The population of interest is the Southern California Bight (SCB) segment which breeds on the Channel Islands and other islands to the south. This population wanders frequently to Morro Bay and in the 1930's actually used to nest on Morro Rock (Edell, pers. comm. 1999). The decline of the SCB population is attributed to the following factors: low clutch size for four successive years; continued presence of relatively high levels of pesticide residues in the tissues of some pelicans; the dependence on the over-fished anchovy for food; human disturbance of the pelican at important Central California coast post-breeding roosts; physical injury and death due to fish hooks and entanglement of birds in abandoned fishing lines, and disease outbreaks resulting from overcrowding at fish disposal areas (CDFG 1992).

Management actions for SCB birds include: protection of nesting colonies in California; periodic assessment of reproductive success, investigation of post-breeding areas along the western coastline, disease investigations, and the effects of waterfowl shooting on pelicans. As of 1992, the trend overall is considered to be declining, as no funds have been prioritized for this recovery project and nesting colonies are being impeded by human impacts (CDFG 1992).

### *American Peregrine Falcon*

American peregrine falcons (*Falco peregrinus anatum*) range throughout California during migrations and in the winter season. The California breeding range includes the Channel Islands, coastal southern and central California, inland north coastal mountains, Klamath and Cascade ranges and the Sierra Nevada (CDFG 1992).

The varied habitats and associated bird life found within and around the Morro Bay estuary supports both resident and migratory peregrine falcons.

Morro Rock is a nationally known historic nest sites that continues to support the annual breeding attempts of one resident pair. Due to repetitive breeding failures at Morro Rock caused by biomagnification of pesticides and other chemical contaminants in peregrine food chains, biologists from the Santa Cruz Predatory Bird Research group conducted an intensive nest management campaign at Morro Rock from 1977 through 1992. Management techniques included removal and captive hatching of thin shelled eggs, double clutching, and fostering young peregrine chicks into the active eyrie. After direct management ceased in 1992, the Morro Rock pair produced young without assistance from 1993 through 1997. Breeding attempts failed in 1998 and in 1999 the pair was once again unable to hatch their own eggs and young were fostered into the eyrie (Schubert pers. comm. 1999).

The resident peregrines typically ingest a diet that includes a high proportion of migratory birds that undoubtedly bring chemical contaminants from areas far outside of the Morro Bay watershed. Management actions taken at the Morro Rock ecological Reserve that are important in achieving nesting success include reducing human disturbance by keeping climbers off the rock and eliminating feral cats from the reserve. Maintaining suitable habitat within and around the estuary will continue to attract large numbers of avifauna which will ensure an adequate food supply not only for the resident pair, but also for wintering and migrant peregrines.

### *Least Bell's Vireo*

The least Bell's vireo is a small, olive-grey migratory songbird that nests and forages primarily in riparian woodland habitats. Least Bell's vireos are almost exclusively insectivorous and are highly territorial. Typical nesting habitat consists of an understory of dense subshrub or shrub thickets dominated by sandbar willow (*Salix hindsiana*), mule fat (*Baccharis glutinosa*), and saplings of other willow species (*Salix* spp.). Important overstory species include mature arroyo willow (*S. lasiolepis*) and black willow (*S. gooddingii*), occasional cottonwoods (*Populus* spp.), and western sycamores (*Platanus racemosa*). Coast live oaks (*Quercus agrifolia*) can be a locally important overstory component, as can mesquite (*Prosopis* spp.). Least Bell's vireos generally arrive on their breeding grounds by mid to late-March and depart by late September. Few least Bell's vireos overwinter in California. Lone individuals of this species have been reported in the Chorro Creek area in the vicinity of Camp San Luis Obispo (M. Hansen 1997).

Historically, least Bell's vireos wintered in Mexico and ranged as far north as Tehama County, California. The current breeding distribution for the least Bell's vireo is restricted to southern California and northwestern Baja California. Generally, least Bell's vireos occupy home ranges that vary in size from 0.5 to 4.5 acres, although a few may be as large as 10 acres. Widespread habitat loss has fragmented most remaining populations of least Bell's vireos into small, disjunct, widely dispersed subpopulations, which are concentrated in San Diego, Santa Barbara and Riverside counties. Declines in the numbers of the least Bell's vireo have been attributed, in part, to the combined and perhaps synergistic effects of the widespread loss of riparian habitats and brood-parasitism by the brown-headed cowbird (*Molothrus ater*). The least Bell's vireo was federally listed as endangered on May 2, 1986 and critical habitat for was designated on February 2, 1994 (59 *Federal Register* 4845).

The draft recovery plan for the least Bell's vireo reports that since Federal listing in 1986 the species has experienced a dramatic increase in population numbers and is expanding its range and recolonizing sites unoccupied for decades. The draft recovery plan anticipates that least Bell's vireos could become reestablished in the central and northern portions of their historical range as populations grow and disperse northward (USFWS 1998).

### *Western Snowy Plover*

The western snowy plover is a small shorebird that forages on invertebrates in areas such as intertidal zones, the wrack line, dry sandy areas above the high tide line, salt pans, and the edges of salt marshes. Morro Bay populations are most abundant on the Morro Bay Strand State Park and the Morro Bay sandspit. The Pacific coast population nests near tidal waters along the mainland coast and on offshore islands from southern Washington to southern Baja California, Mexico. Most nesting occurs on unvegetated, or moderately vegetated, dune backed beaches, and on sand spits. Other less common nesting habitats include salt pans, dredge spoils, and salt pond levees. Nest site fidelity is common. Nesting and chick rearing activity generally occurs between March 1 and September 30. During the non-breeding season western snowy plovers may remain at breeding sites or may migrate to other locations. Most winter south of Bodega Bay, California. Many birds from the interior population winter on the central and southern coast of California.

The Pacific coast population of the western snowy plover has experienced widespread loss of nesting habitat and reduced reproductive success at many nesting locations. Factors resulting in loss of nesting habitat include urban development and the encroachment of European beachgrass. Reduced reproductive success is most frequently tied to disturbance from human activities. Activities such as walking, jogging, running pets, horseback riding, and off-road vehicle use frequently crush and destroy the western snowy plover's cryptic nests and chicks. These activities also flush adults off nests and away from chicks, and thus interfere with essential incubation and chick rearing behaviors.

***Southwestern Willow Flycatcher***

The Federally endangered southwestern willow flycatcher (*Empidonax traillii extimus*) is a small bird, approximately 15 centimeters (cm) (5.75 inches) long. It has a grayish-green back and wings, whitish throat, light grey-olive breast, and pale yellowish belly. The southwestern willow flycatcher occurs in riparian habitats along rivers, streams, or other wetlands, in southern San Luis county where dense growths of willows (*Salix* sp.), *Baccharis*, arrowweed (*Pluchea* sp.), buttonbush (*Cephalanthus* sp.), tamarisk (*Tamarix* sp.), Russian olive (*Eleagnus* sp.) or other plants are present, often with a scattered overstory of cottonwood (*Populus* sp.). Throughout the range of *E. t. extimus*, these riparian habitats tend to be rare, widely separated, small and/or linear locales, separated by vast expanses of arid lands. The southwestern willow flycatcher has experienced extensive loss and modification of this habitat and is also endangered by other factors, including brood parasitism by the brown-headed cowbird (*Molothrus ater*) (USFWS, 1999).

## 3.3.2 Mammals

***Morro Bay Kangaroo Rat***

The geographically isolated Morro Bay kangaroo rat is the smallest of the nocturnal genus *Dipodomys*. It has a multi-colored silky coat with colors ranging from white on the belly to tan and brown on the sides of its back. The name "kangaroo" is given to these rodents because their large hind feet, long tail, and ability to make long leaps in any direction when agitated (Mello, 1982). Habitat requirements include thinned vegetation for easy mobility and a large source of annuals plants for food supply. They feed primarily on dune buckwheat and California croton. The sandy loam of the coastal sage and strand plant communities provide soil needed for its burrows. Territory requirements are estimated at 50 feet radius per individual, as aggressive behavior keeps male and females isolated (Roest 1981).

The Morro Bay kangaroo rat (*Dipodomys heermanni morroensis*) has a very limited range on the south side of Morro Bay, California. It is considered to be one of the most endangered native subspecies in the nation (Mello, 1982) and is protected by the Federal Endangered Species Act since 1970. This species is listed as endangered. The kangaroo rat's survival is threatened by human modification of it's habitat (Roest 1981) in south bay communities of Los Osos and Baywood Park. The decline in it's population of 8,000 individuals (Stuart, 1958) within a 2.2 square miles area began in 1958 as the total occupied habitat decreased to 0.5 square miles in 1982 (Mello, 1982). Other factors, such as prolonged drought, which affects food supply, succession of coastal scrub into a denser chaparral from lack of periodic fires, inbreeding and predation by dogs and cats, have also been attributed for the decline in population (Roest 1977, Gambs 1990).

Historically, the most abundant sites included the Santa Ysabel dunes west of South Bay Boulevard, where annual plant growth is most abundant and is shielded by the wind (Roest 1977). A captive reproduction project began at California Polytechnic University, San Luis Obispo, in 1984 and continued to 1989 (Roest 1991). The project was subsequently transferred to the National Zoo in Washington D. C. to receive greater staff attention. Unfortunately, this program was not successful in rebounding the population in captivity. The last sighting of an individual was in 1988, but kangaroo rats are assumed to still exist on private lands where access has been prohibited to U.S. Fish and Wildlife Service (USFWS) and CDFG (Gambs 1999 per comm). Montana de Oro State Park, the primary continuous tract of suitable public land, has only 10 marginal acres, an area insufficient to insure survival of the animals (Roest 1973).

Past management actions to help conserve the population include: establishment of the Morro Dunes Ecological Reserve; habitat rehabilitation activities; partnering with local land owners to translocate individuals to thinned vegetation scrub on public lands and captive breeding programs; and education of landowners.

***Southern Sea Otter***

The sea otter (*Enhydra lutris nereis)* in California is considered a "threatened" species under the Federal Endangered Species Act of 1973 and "depleted" under the Marine Mammal Protection Act of 1972. Sea otters have been commercially harvested throughout their historic range, from approximately 1742 until early in the 20$^{th}$ century, when the International Fur Seal Treaty of 1911 protected them. Remnant populations persist in the eastern Soviet Union, the Aleutian Islands, mainland Alaska and central California (Bodkin & Rathbun 1988).

The California population currently ranges from northern Santa Cruz County to central Santa Barbara County and recent counts have been about 2200 animals (Hardy 1999 pers. comm.). The Estero Bay area, especially the area near Cayucos and southward to Pt. Buchon, was re-colonized by sea otters from the north during the early 1970's (Wild and Ames 1974). In 1982, sea otters began to be observed in large numbers within the harbor at Morro Bay. For a few years, large groups of otters were observed using the Morro Bay estuary as both a resting and feeding area (Siniff and Ralls 1985). In recent years, numbers of sea otters counted in the Morro Bay estuary have averaged less than 10 on an annual basis (Hardy 1999 pers. comm.).

Since the development of Morro Bay as a commercial and recreational harbor in the early 1930's, periodic dredging of the main navigational channel and surrounding areas has been required in order to maintain safe passage. In 1988, Bodkin and Rathbun conducted a study to evaluate the impacts of the maintenance dredging of the harbor on sea otters, and their primary food source, the clam populations within the bay. This research was initiated in November of 1986.

Bodkin and Rathbun concluded that the abundant clam resource within Morro Bay is supporting the high density of otters in the bay between early winter and early summer. They observed a decline in the abundance of sea otters coinciding with the beginning of the 1986 harbor-dredging project, but were unable to establish cause and effect. Bodkin and Rathbun (1988) also noted that dredging operations appeared to have little effect on the overall abundance of Washington or Gaper clams in the estuary. They recommended that future harbor dredging take place between July 1$^{st}$ and November 30 (late summer and fall months). Statewide, numbers of otters are apparently declining for unknown reasons.

***Harbor seal***

The local office of the CDFG has made periodic counts and observations of harbor seals in Morro Bay. They have identified at least three major haul-out areas on the mudflats in the southern bay. It is unusual not to observe harbor seals on one or more of the areas during low-tide time periods, but the highest numbers and frequency of harbor seal sightings occur during the late spring pupping period. Annual counts between 1982 and 1995 indicated 30 to 40 seals hauled out at low tides. Recent CDFG data indicates 26 individuals (Hardy 1999 pers. comm.).

Because of the safety provided to harbor seals by the deeper channels which create mudflat "islands," and possibly because fish are easily available as forage to the seals, the estuary is an important habitat for this species.

### 3.3.3 Amphibians

***California Red-legged Frog***

The California red-legged frog is protected by the CDFG as a species of special concern (1982) and is federally listed as threatened under the U. S. Endangered Species Act (United State Fish and Wildlife Service (USFWS) 1996). This species frequents marshes, slow parts of streams, lakes, reservoirs, ponds, and other usually permanent water sources. It occurs primarily in wooded areas in lowlands and foothills, although it can also be found in grassland. It is considered a pond frog (Stebbins 1966) and is typically associated with deep-water pools (at least 1.6 feet in depth) that are fringed by thick vegetation, particularly arroyo willow or cattails (*Typha* sp). During the breeding season, the males call from the water. The adults are strictly nocturnal and extremely wary; any attempt to census this species must be conducted at night (ERCE 1993).

The red-legged frog generally occurs where freshwater is present. Recent documented locations within the estuary include the mouth of Chorro Creek at the northern edge of the Chorro delta (Worcester 1991). Within the Morro Bay watershed, the red-legged frog is known to occur at locations along lower and upper Chorro, Dairy, Pennington, and Gilardi creeks, as well as some ponds on Camp San Luis Obispo (see Table 2-3) (Duke, B., pers. comm, Froland, J., pers. comm. 1999). Potential habitat also exists at Walters, San Luisito, and San Bernardo creeks (San Luis Obispo County 1997 - Chorro Valley Pipeline environmental monitoring records).

The decline of the California red-legged frog, as well as other western ranids (frogs), is believed to be the result of numerous confounding facts. These include competition and predation from introduced species (bullfrogs and squawfish), acid rain, pathogens and parasites, catastrophic events (severe drought and scouring floods), and habitat alteration (Hayes and Jennings 1988). These frogs often exist in small populations (Storm 1960) and as such are sensitive and subject to local extinctions. Red-legged frogs are not drought tolerant and are incapable of surviving without water for greater than six weeks. Dispersal in this species is apparently restricted to juveniles (females <80mm, males <65 mm) and, for the most part, occurs only within drainages rather than between drainages. The tadpoles of this frog require cool water; therefore, habitat alterations that increase water temperature, such as removal of riparian vegetation or reduction in stream flow, could lead to local extinctions. At this time, the California red-legged frog appears to be almost extinct south of Ventura County and is declining elsewhere in its range.

### 3.3.4 Reptiles

***Southwestern Pond Turtle (Clemmys marmorata pallida)***

Southwestern pond turtle is a federal species of concern. It is an aquatic turtle that is restricted to fresh or brackish water areas that have either mud or rocky bottoms. Much of its habitat has been disrupted by urban and agricultural development, including grazing. Threats to pond turtles include raccoon predation, especially in areas of residential development where outlaying food sources increase raccoon populations, as well as disruption of upland nesting habitat. The pond turtle is extremely temperature-dependent, as it relies on a diversity of temperature regimes to produce egg clutches that contain both male and female young. Without this diversity, the egg clutches, and subsequently the entire local population, can become wholly composed of a single sex, thus, rendering the population ineffective at reproduction. The removal of vegetation in areas where turtle populations are present can have catastrophic effects as this removal reduces the diversity of temperature regimes in which the turtles can lay eggs.

Diversion of water is one of the threats to this species. In a report to the CDFG, Brattstrom and Messer (1987) identified heavy demand for water resources for agricultural, industrial and domestic users as having an adverse impact on southwestern pond turtle habitat. When water tables are lowered, streams that once supported southwestern pond turtles change from perennial streams to streams with either seasonal or no flow. This study concludes that the change in stream flow may be "a major factor in the demise of turtles in some regions" (Brattstrom and Messer 1987).

Southwestern pond turtles are known to occur at the mouth of Chorro Creek where it enters the bay (Westec Services 1988) as well as Chorro Creek reservoir and other ponds on Camp San Luis Obispo.

### 3.3.5 Invertebrates

***Morro Shoulderband Snail***

The Morro shoulderband snail ( *Helminthoglypta walkeriana*) was first described in 1911 near "Morro, California". It is found only near Morro Bay, primarily in the dunes of Los Osos and north of Hazard Canyon. This federally endangered population (1994) used to range easterly to the city of San Luis Obispo and north to Cayucos (Roth 1985). The Morro shoulderband snail, also known as the banded dune snail, occurs in coastal dune and sage scrub communities. Mock heather is it's primary plant associate, but it can be found with buckwheat (*Eriogonum parvifolium*), eriastrum (*Eriastrum densifolium*), silver lupine (*Lupinus chamissonis*), iceplant (Carpobrotus edulis), California sagebrush (Artemesia californica), and black sage (*Salvia mellifer*) (Roth 1985). It is suggested that fungal mycelia growing on plant litter is the snail's primary food source (Hill 1974), however studies are underway to confirm this assumption.

The survival of the Morro shoulderband snail is threatened by the destruction of its habitat from increased development in the Los Osos area. Degradation of its habitat due to invasion of non-native species (i.e. veldt grass) and recreational use of dune areas are also threats to its conservation. Competition for resources with the non-native brown garden snail, predation from the decollate snail (*Rumina decollata*), and snail baits used to trap the brown garden snail may also adversely affect the Morro shoulderband snail (USFWS 1998).

According to a recent county survey of Morro shoulderband snail (*Helminthoglypta walkeriana*) in the Los Osos area, 172 of the 567 undeveloped parcels that are less than one acre in size contain suitable snail habitat (SLO County Department of Planning and Building 1999). In addition, 38 of the 86 parcels greater than an acre in size contain suitable snail habitat. Negotiations between USFWS and the County to establish a habitat replacement ratio for disturbance to habitat on privately owned lots developed within the urban service line are currently underway (Crawford Multari & Clark Associates 1998). These negotiations may include the newly formed Los Osos Community Service District, depending on how plans for a community sewer develop.

### 3.3.6 Fish

***Tidewater Goby***

The tidewater goby *(Eucyclogobius newberry)* is federally listed as endangered under the Endangered Species Act. This species is restricted to brackish water lagoons or estuaries in coastal California. It is distributed from the mouth of the Smith River in Del Norte County to Agua Hedionda Lagoon in San Diego County, and is unique in its restriction to a narrow range of low salinity water (Swift et al., 1989). Tidewater gobies are typically found in water with salinities less than 10 parts per thousand (PPT), and appear to require unconsolidated sand for their reproductive burrows. The low vagility, restricted habitat, and short lifespan of this species make its populations vulnerable to elimination by human disturbance. Destruction of habitat, siltation, water quality degradation, water diversion, and introductions of exotic, predatory species especially threaten the tidewater goby. The tidewater goby has been reported to occur in the estuary where Chorro Creek enters the bay and in lower Los Osos Creek (California Natural Diversity Data Base1989; Swift *et al.* 1989). Until recently, they had not been observed since 1984. (Westec Services 1988; Worcester 1991; Crawford 1994.) According to the CCRWQCB, the species has recently been found in the estuary during monitoring conducted by the Morro Bay Power Plant (Worcester, K., pers. comm., 1999).

The apparent loss or reduction in population numbers of this species may be to loss of habitat due to drought and sedimentation in the lower creek (Worcester 1991). Salinity does not seem be as much as a impact, as studies indicate tidewater gobies can tolerate higher salinity levels, though high mortality rates were documented in experimental groups held at salinity levels exceeding 41 percent (Swift 1989). Crawford documented salinity levels as high as 40 percent at his downstream site in the Morro Bay delta.

***Steelhead Trout***

Southern steelhead populations have been listed as federally endangered by the National Marine Fisheries Service because of declining habitat quality throughout the species range. This species is an anadromous fish that migrates from coastal streams to the ocean and back to the same stream to spawn. Chorro and Los Osos Creeks both support populations of this species. Water diversion projects, migration barriers, drought and siltation upstream have greatly reduced the viability of local steelhead populations in these two streams. Steelhead trout are generally spring spawners, but will often move up major coastal rivers in the fall and wait until spring to spawn (McGinnis 1984).

Steelhead populations in the Morro Bay watershed fall into the South-Central Evolutionary Significant Unit (ESU) as defined by the National Marine Fisheries Service. This ESU's critical habitat of 7,246 square miles includes all river and estuarine reaches from the Pajaro River down to the Santa Maria River. It is part of the larger grouping of southern steelhead (all populations south of San Francisco) which has been suggested to be the "most ancient of all rainbow trout". Main characteristics of this ESU habitat include flash floods and high erosion rates that are thought to be stressful to steelhead. Historically, the southern steelhead trout populations once numbered in the ten thousands. Presently, the population has declined to less than "one percent of their 1850 abundance" (Edmondson 1999).

Steelhead trout are a cold water fish species. Temperatures over 65°F can become lethal for these fish, particularly over prolonged periods. When water flow is abundant and shaded by adjacent vegetation, temperatures remain cool. Steelhead also require fairly high dissolved oxygen levels in the water. Cooler water holds more oxygen. Well-shaded corridors are an important way to maintain appropriate water quality temperatures for these fish.

If steelhead trout are stranded in pools, the increased water temperature and decreased dissolved oxygen levels can be fatal. The CDFG documented such a steelhead trout kill in 1976. This incident was attributed to water diversion (Worcester 1991).

Sedimentation of instream habitat is another serious problem. Steelhead are anadromous, which means that they spend most of their adult life in the ocean, returning eventually to their home streams to spawn. Spawning success can be greatly affected by the amount of sediment present in the spawning gravel. Sediment fills in the spaces between the gravel, actually smothering eggs and larvae, reducing the insect food sources attached to the gravel, or "cementing" the gravel, making it too compacted for use as spawning habitat. Creek gravels that are clean enough to support steelhead spawning and reproduction probably also indicate a system that isn't overloaded by sediment.

Steelhead trout are an important recreational species on the Pacific coast. The CDFG Code recognizes steelhead as a valuable resource that has a limited range. It also recognizes that California's steelhead resources are largely dependent upon the quality and quantity of habitat available to them.

Because of damage and threats to their restricted habitat, state policy requires that emphasis shall be placed on management programs to inventory, protect, and restore or improve the habitat of natural steelhead stocks (CDFG). The Federal Fishery Conservation and Management Act of 1976 and Fish and Wildlife Coordination Act also emphasize the importance of maintaining anadromous fishery resources and habitats. Section 404(b)(1) of the Clean Water Act (450 CFR Part 230) specifically identifies riffle and pool habitat "complexes" as special aquatic sites of concern. These areas provide primary feeding, spawning and rearing habitat for steelhead and other fish. Siltation is regarded as a source of fill under Section 404, and is particularly detrimental to riffle and pool habitat. The Clean Water Act specifically recognizes the need to regulate the discharge of fill in and adjacent to riparian habitats, wetlands and streams.

Additional details regarding threats to steelhead habitat and trends is in the resource presented in Section 8, "Freshwater Flows," and Section 10, "Habitat Loss."

**Steelhead in the Morro Bay Estuary.** During some life phases, steelhead are especially dependent upon low salinity estuarine environments and fresh water habitats. The Morro Bay estuary provides the transition environment critical to the juvenile phase of this fishery. Estuary and lagoon environments have been identified as the optimum nursery areas for juvenile steelhead with growth rates and densities of fish much higher than in fresh water areas (Smith 1987).

**Steelhead in the Chorro Creek Watershed.** There has been a marked reduction in the number of steelhead trout in the streams of the Morro Bay watershed (Asquith 1990). Water diversion, coupled with drought, has impacted surface flows in the lower Chorro Creek, an area identified by Paul Chappell in 1987 testimony as supporting significant rearing habitat. Though 0.75 cubic feet per second (cfs) of California Men's Colony (CMC) effluent is dedicated to supporting steelhead trout and other fishery resources in the lower creek, this amount seldom reaches the estuary during dry years (Worcester 1991).

In the dry summer months instream flow is critical. Crawford and others monitored changes in Chorro Creek stream flow and water temperature in the Chorro Flats. On July 23, instream flow ranged between 1 and 2 cfs (Crawford, et al. 1992). At that time there was flow throughout the length of the area and researchers observed squawfish as large as 275 millimeters in several large pools, as well as thousands of three-spined stickleback. On August 5 three recording thermometers were installed 200 yards, 820 yards, and 1,425 yards downstream of the Chorro Road crossing. By August 19, shallow pools, riffles, and runs were completely dry, and only remnant pools remained in deeper areas. The lack of inflow to pools resulted in water temperatures up to 101°F. Squawfish were no longer observed and signs of predation by raccoons and fish-eating birds were evident.

Biologists conducted fish surveys from Twin Bridges to above Chorro Creek Road on August 19 and 20, 1992 (Crawford, et al., 1992). Flows had dried up from Chorro Creek Road down, and only three-spined sticklebacks were found in the intermittent pools along this reach. Above Chorro Creek Road, where continuous flow was still present, one trout was captured.

In 1994, David Crawford conducted a fish survey at five locations on Chorro Creek and included capture by seining, dip nets, hook and line, and minnow traps. Sampling occurred in spring 1993, summer 1993, fall 1993, and winter 1994. Site 1 was in the Morro Bay tidal flats and Site 2 was in the large pool below Twin Bridges. Other sites were much farther upstream, above the CMC wastewater discharge. Eight trout were found at Site 2 in the summer of 1993, one in the fall of 1993, and one in the winter of 1994. No trout that were captured or observed were large enough to be considered anadromous. Only 15 trout in total were captured throughout the entire study, none larger than 14 inches. (Crawford 1994).

The construction of Chorro Reservoir eliminated steelhead trout access to the upper watershed. Steelhead strain trout are still present above the reservoir and are trapped within the reservoir. Fish passage structures constructed above the reservoir apparently do not work (USDA, SCS 1994).

In Chorro Creek, steelhead migrate upstream from the ocean during the winter months (December to March). Chorro Creek and its tributaries are all historical steelhead trout habitat when flows are sufficient for fish to move into these tributaries.

The Chorro Creek watershed supports one of the southernmost remaining runs of steelhead on the Pacific Coast. From this standpoint they represent a valuable genetic resource for restoration of populations in more southerly streams, as southerly stocks are more tolerant of the extreme conditions found in southern California streams. CDFG estimates that the Chorro Creek drainage will support a basin run of at least 450 adult steelhead. This run was estimated at 160 adults in 1976. The current run is thought to be only a fraction of this number (Marshall 1995).

Other creeks in the Chorro watershed that are considered to be steelhead habitat when flows are sufficient include San Luisito, Pennington, Dairy, and San Bernardo creeks.

**Steelhead in the Los Osos Creek Watershed.** Worcester (1999 pers. comm.) reports having observed adult steelhead recently in Los Osos Creek, along with resident trout.

### 3.3.7 Plants

The special-status plant species occurring within the estuary or the watershed are discussed below.

**Chorro Creek bog thistle** (*Cirsuim fontinale var. obispoense*), a member of the composite family (Asteraceae), requires freshwater with serpentine soils for its survival. This plant tolerates high levels of metals such as chromium and nickel. This species is known to occur in serpentine seeps and swales on Camp San Luis Obispo and above Pennington and San Bernardo Creeks where the estimated numbers of individuals have been declining (USFWS 1997). In 1995 on Chorro Creek at Camp San Luis Obispo, 2900 individuals were estimated, whereas in 1997 the population dropped to 1100. This drop followed the establishment of a fence around the site to exclude grazing. Currently, grazing has been reinitiated and is reversing this trend. The only other stands of this plant are outside the watershed within San Luis Obispo County, primarily in private holdings.

Due to narrow habitat requirements, the Chorro Creek bog thistle has never been very abundant. Cattle trampling, road maintenance, water diversions, invasive species and drought conditions are its primary threats.

Grazing exclusions have been the primary source of protection of Morro Bay Chorro Creek and Pennington Creek populations. Ongoing monitoring of population response to limited grazing is being administered by the California Military Department at Camp San Luis Obispo in conjunction with the USFWS recovery team (USFWS 1997).

**Morro manzanita** (*Arctostaphylos morroensis*) is an extremely localized shrub species occurring only in the Los Osos area. It is of the heath family (*Ericaceae*), growing to the height of 4.0 meters with white to pinkish flowers (5 to 8 millimeters long). This species occurs on soils derived from ancient sand dunes (Baywood fine sands) and is found associated with coastal dune scrub, maritime chaparral, and coast live oak woodland communities. On steeper slopes, Morro manzanita occurs in dense stands with few understory species. Canopies in localized stands reach 33 feet in diameter, and individuals in the Elfin Forest of Los Osos are over 47 years old (Tyler and Odion 1996).

Historically, Morro manzanita habitat was estimated to be about 2,000 acres (McGuire and Morey 1992), but recent estimates indicate a decline to 840 to 890 acres (LSA 1992). This decline is primarily due to development in the Baywood Park, Los Osos, Cuesta-by-the-Sea, and the steeper slopes of the Irish Hills. The existing stands are small, low-density patches in developed areas of Los Osos and Baywood Park. According to U.S. Fish and Wildlife, approximately 65 per cent of remaining Morro manzanita habitat is in private ownership. Thirty five per cent of suitable habitat is on publicly owned lands in Montana de Oro State Park. Groves of non-native *Eucalyptus* trees planted in the early 1900's have encroached on nearby stands of Morro manzanita (Holland et al. 1990). Iceplant (*Carpobrotus spp.* and *Conocosia pugioniformis*) is also noted to be the most "pernicious" exotic species problem in maritime chaparral (Tyler and Odion 1996), crowding out Morro manzanita seedlings. Management efforts include removing invasive species such as *Eucalyptus* and iceplant, and developing partnering strategies with local landowners, for habitat conservation.

**California sea blight** (*Suaeda califonica*), endemic to Morro Bay, is found in a very narrow, incomplete "bath tub ring" distribution around the estuary. A Federally and State protected species, populations exist at the State Park marina (approximately 31 individuals), on the Baywood Park peninsula (approximately 15 individuals), and along the estuarine side of the Morro Bay sandspit (approximately 84 individuals) (Baye, pers. comm. 1999). Threats to this federally endangered species include dune migration, iceplant overgrowth, and heavy tidal scouring from storms. Populations are being cultivated to help reintroduce this species into past historical ranges.

**Salt marsh bird's beak** (*Cordylanthus maritimus ssp. maritimus*), listed as a Federal and State endangered plant, is an indicator of the freshwater/brackish water interface at the edge of the estuary. Salt marsh bird's beak is of the figwort family (*Scrophulariaceae*), and is a semiparasitic herb, 15-30 cm tall with lanceolate leaves. Historic range included Pacific Coast salt marshes between Carpinteria and San Quintin in Baja California. The species is known to occur in the Sweet Springs area in Los Osos and other marshy areas at the edge of the estuary. Sedimentation, alterations in shallow groundwater flows, and foot traffic pose a threat.

**Indian Knob Mountain Balm** (*Eriodictyon altissimum*) is a diffusely branched evergreen shrub of the waterleaf family (*Hydrophyllaceae*) found primarily on the north slopes of the Irish Hills, south of Los Osos, and in Montana de Oro State Park. The perennial shrub reaches an average height of 3 meters and has lavender flowers in coiled clusters. The plant is fire-adapted to produce new growth from rhizomatous suckers. It has been noted that prescribed fire may be needed to revitalize stands, as individuals appear mature or senescent in age (USFWS 1997).

The common habitat for Indian Knob mountain balm includes soils with marine sandstone tar deposits, as well as Baywood fine sands. It co-associates with Morro manzanita in several location in maritime chaparral (USFWS 1997) and often has large lichens along it's woody stems.

Development on private lands is the greatest threat to Indian Knob mountainbalm. Successful efforts have been made to avoid disturbing individuals during construction projects, and the City of San Luis Obispo purchased a 1500 acre conservation easement that provides protection for a large population of mountainbalm from development and mining.

Other plant special-status species known to occur in the watershed include Jones layia, Blochman's dudleya, San Luis mariposa lily, Indian Knob mountain balm, Palmer's monardella, Club-haired mariposa lily, and San Luis dudleya.

## 3.4 EXOTIC SPECIES

A number of exotic and invasive species have been increasing in distribution in both estuarine and watershed habitats, thereby crowding out native species. These species are discussed in Section 10 of this document, Habitat Loss.

# 4.0 LAND USE AND POPULATION: STATUS AND TRENDS

The population within the Morro Bay watershed as of January 1998 is roughly 25,000 people, resulting in a watershed population density of 333 persons per square mile.

San Luis Obispo is one of the fastest growing counties in California, growing at a rate of 2.7 percent from 1997 to 1998 (California Dept. of Finance 1998). It is estimated that the county population will increase 46 percent between 1988 and 2010 (United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) 1990).

The two key land use jurisdictions in the watershed are the County of San Luis Obispo and the City of Morro Bay. There are, however, complex jurisdictional issues associated with the tidelands and the agencies having jurisdiction over them in the estuary. The various jurisdictions are discussed below and shown in Figure 4-1. This discussion is followed by a description of the City and County land use categories, and a discussion of the CCRWQCB beneficial uses supported by the estuary.

## 4.1 MORRO BAY ESTUARY TIDELANDS

Tidelands within the Morro Bay estuary are owned or managed by a variety of entities, including private individuals (about 604 acres), the City of Morro Bay (about 440 acres), and State tidelands and submerged lands that are ungranted (1,300 acres).

The tidelands outside the City limits are under the jurisdiction of the State Lands Commission as sovereign public trust lands. In 1992, the State Lands Commission entered into a 25-year lease agreement with the California Department of Fish and Game (CDFG) and the California Department of Parks and Recreation (CDR) (Morro Bay State Park) to manage the tidelands outside the City limits. These lease areas are known as Area 1 and Area 2 (see Figure 4-1), and are managed by DPR and CDFG, respectively.

Prior to the 1992 lease agreement, DPR and CDFG administered some of the "backbay" area of the estuary for recreational boating and natural resource protection, preservation, and management. CDFG also managed private shellfish mariculture and had oversight of waterfowl sport hunting activities. (Elliott and Cicero,1995). DPR currently manages their lease area for recreation, natural resource conservation, and as a wildlife habitat refuge, while CDFG currently manages their lease area for shellfish mariculture and seasonal sport hunting.

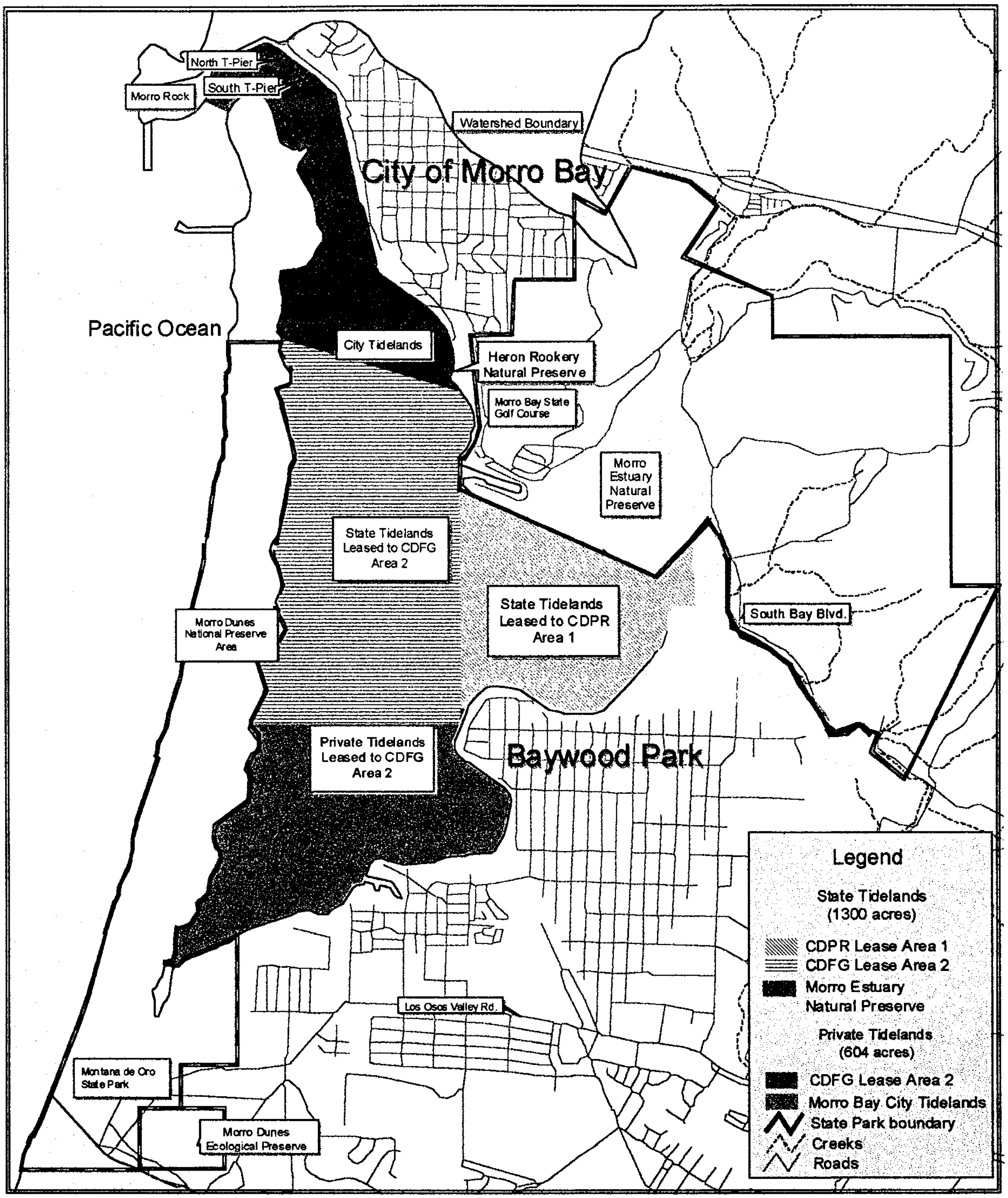



Figure 4.1 Governmental Tideland Jurisdictions in Morro Bay and Vicinity
MBNEP Characterization 1999

## 4.2. CURRENT LAND USE TYPES AND PATTERNS IDENTIFIED BY THE CITY OF MORRO BAY

### 4.2.1 Land Use

The City of Morro Bay identifies the following land use/zoning types:

- Agriculture
- Suburban residential
- Neighborhood commercial
- General office
- Light industrial
- Coastal dependent industrial
- Open area
- Waterfront
- Commercial/recreational fishing
- Harbor and navigable ways
- Mariculture and marine research
- Environmentally sensitive habitat overlay

These land use types are defined below.

***Agriculture***

The purpose of the Agriculture (AG) District is to provide for the continuation of agriculture uses in suitable areas and for supplemental commercial uses, which may be necessary to support such continued agricultural activities. New development in this District shall also be sited and designed to protect and enhance scenic resources associated with the rural character of agriculture lands. (Ord. 263 Sec. 1 (part), 1984.)

***Suburban Residential***

The purposes of the Suburban Residential (R-A) District is to (1) permit estate lot homes and small scale agricultural uses; and (2) provide an area for people to have parcels of land larger than more typical single-family residential lots where livestock, poultry and small animals may be raised in limited number for home use or pleasure. (Ord. 263 Sec. 1 (part), 1984)

***Neighborhood Commercial***

***General Office***

The purpose of the General Office (G-O) District is to accommodate public, general business and professional offices and commercial uses which complement and support office development along with residential uses, which are compatible with office and commercial uses. (Ord. 263 Sec. 1 (part), 1984).

***Light Industrial***

The purpose of the Light Industrial (M-1) District is to provide districts for industrial development wherein manufacturing and other industries can locate and operate, while maintaining an environment minimizing offensive or objectionable noise, dust, odor or other nuisances, all well designed and properly landscaped. (Ord. 263 Sec. 1 (part), 1984).

***Coastal Dependent Industrial***

The purpose of the Coastal-Dependent Industrial (M-2) District is to provide districts for industrial development wherein manufacturing and other industries which require a site on or close to the ocean or harbor can locate and operate while maintaining an environment minimizing offensive or objectionable noise, dust, odor or other nuisances, all well designed and properly landscaped. (Ord. 263 Sec. 1 (part), 1984).

***Open Area***

The purpose of the Open Area (OA) District is to provide for the maintenance of areas in a natural state and preservation of scenic values and the utilization of natural features and resources of the area and bay for the recreational and aesthetic benefit of the public. (Ord. 263 Sec. 1 (part), 1984).

***Waterfront***

The purpose of the Waterfront (WF) District is to provide for the continued mixture of visitor-serving commercial and recreational and harbor-dependent land uses in appropriate waterfront areas (Ord. 263 Sec. 1 (part) 1984).

***Commercial/Recreational Fishing***

The purpose of the Commercial/Recreational Fishing (CF) District is to promote and accommodate both the commercial fishing industry and non-commercial recreational fishing activities in appropriate waterfront areas. (Ord. 263 Sec. 1 (part), 1984)

***Harbor and Navigable Ways***

The purpose of the Harbor and Navigable Ways (H) District is to designate the area with City limits covered by water, excluding sensitive habitat areas, for those uses which must be located on the water in order to function, or as an accessory use to a land based/shore facility or structure. (Ord. 263 Sec. 1 (part), 1984)

*Mariculture and Marine Research*

The purpose of the Mariculture and Marine Research +(MMR) District is to provide locations within the City for the establishment and operation of coastal-dependent mariculture and marine research utilizing sea water for research and breeding, hatching and raising fish, shellfish and marine organisms for scientific and commercial purposes. (Ord. 338 Sec. 2 (part), 1988)

*Environmentally Sensitive Habitat Overlay*

The purpose of the environmentally sensitive habitat overlay zone or "ESH" overlay zone is to protect and preserve areas in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could easily be disturbed or degraded by human activities and development. Environmentally sensitive habitat overlay zones shall extend not only over an ESH area itself but shall also include buffers necessary to ensure continued protection of the habitat areas. Only uses dependent on the sensitive resources and which do not result in significant disruption of habitat values shall be permitted in the ESH overlay zone. The ESH overlay zone may apply to areas not currently mapped as ESH designation. (Ord. 263 Sec. 1 (part), 1984)

A number of types of environmentally sensitive habitat areas exist within the City of Morro Bay. The nature of these ecosystems and their susceptibility to possible degradation by difference human activities varies among habitat types. Environmentally sensitive habitat areas are classified into one of the following types:

- Wetlands
- Estuary
- Sand dunes, sandspit
- Stream corridors
- Restricted areas
- Other

### 4.2.2 Population Trends

Morro Bay attracts an average of 4,000 tourists daily, or 1.5 million annually to its environs. In fact, Morro Bay's economy is dominated by tourism and visitor serving businesses, generating 37 percent of all jobs in the city and one-third of the city's general fund revenues. The motel industry contributes the majority of the city's tourism generated revenues. There are 930 motel rooms (42 motels) in the City of Morro Bay, representing 37 percent of all motel rooms on the north coast of San Luis Obispo County from Los Osos to San Simeon. Bed taxes were $845,000 in fiscal year 1988-1989.

On an annual basis, several million tourists travel north and south on Highway One as it passes through the City of Morro Bay. Consequently, in addition to tourist and recreational visitation destined specifically for the bay, millions of persons each year use the bay in an incidental way. Primary attractions for this high level of tourism include the active fishing and recreational boating activities along the waterfront, the estuary, and the surrounding watershed. The health of the estuary has been identified as critically important to the long-term tourist and economic life of the city.

Presently, the City of Morro Bay has a population of about 9,845. The primary industries are commercial fishing, electric power generation, and tourism. Within the city limits of Morro Bay there are 156 acres zoned for light industry, all of which are currently in use. The rate of growth in the City for 1997-98 was 1.5 percent. As shown in Section 1, Figure 1-1, only the southern portion of the city is within the Morro Bay watershed.

The Chorro Valley pipeline of the State Water Project now provides the city's primary domestic water source. In 1998, the SWP delivered 1270 AF of water to the City. Before the importation of State water, wells within the Chorro and Morro Valley basins were the City's primary source of water. The city also owns a desalination plant, but this plant provides less than 1 percent of the community's current annual needs (McCray 1999 pers. comm.).

The city has a wastewater treatment facility that currently discharges advanced secondarily treated effluent into the ocean. City officials are currently exploring the concept of increasing the treatment level of the wastewater effluent and using it for groundwater recharge in the Chorro Basin.

## 4.3 CURRENT LAND USE PATTERNS AND CATEGORIES IDENTIFIED BY SAN LUIS OBISPO COUNTY

### 4.3.1 Land Use Categories

The San Luis Obispo County Department of Planning and Building (1998) identifies the primary land use categories within the Morro Bay watershed as follows:

- Agriculture
- Rural lands
- Recreation
- Open space
- Residential rural
- Urban land use categories (including residential suburban, residential single family, residential multi-family, office and professional, commercial retail, and commercial service)
- Public facilities

These land use categories, as defined in the San Luis Obispo County "Framework for Planning, Coastal Zone" (1996) are discussed below, and shown in Figure 4-2. Figure 4-3 shows percentages of land use categories in the Morro Bay watershed.

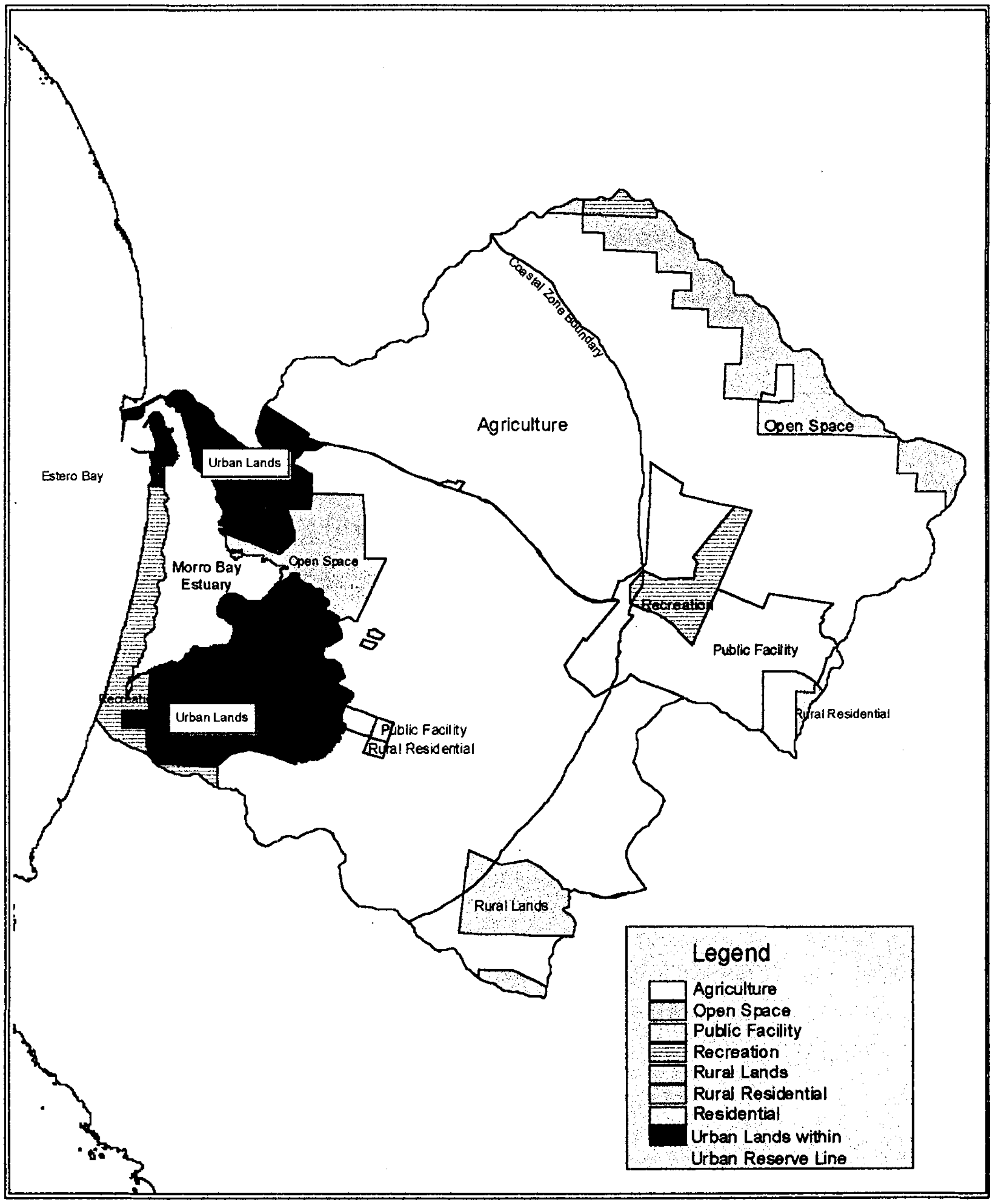



Figure 4.2 San Luis Obispo County Land Use Categories within the Morro Bay Watershed



Source: TetraTech 1998 from San Luis Obispo County

MBNEP Characterization 1999

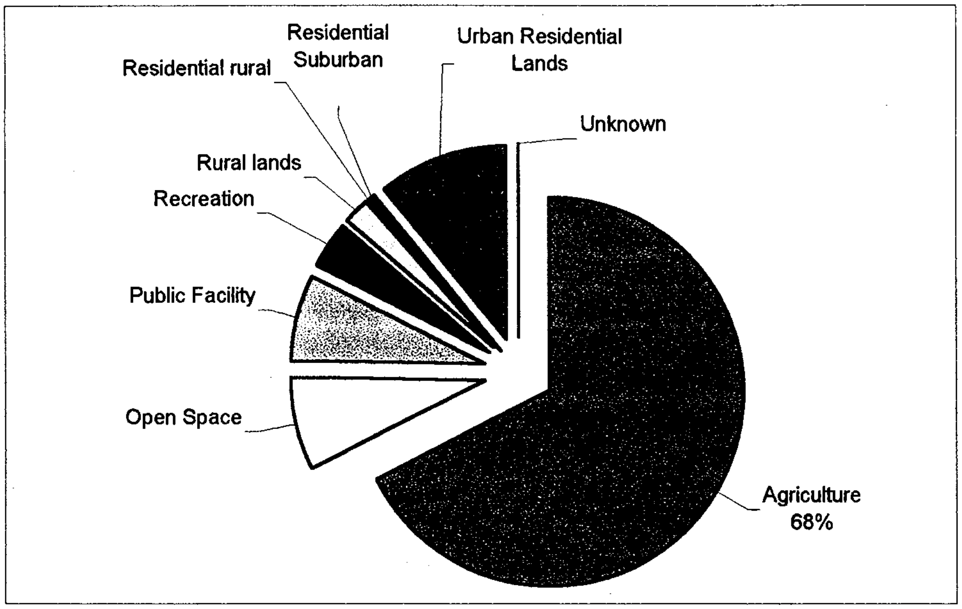



**Figure 4.3 Percentages of Land Use Categories in the Morro Bay Watershed.**
*Source: California Polytechnic University and San Luis Obispo County.*

### *Agriculture*

Areas of prime and non-prime agricultural soils, and other productive and potentially productive lands located inside and outside of urban and village reserve lines where land use conflicts with other adjacent uses can be mitigated.

### *Rural Lands*

Areas outside urban and village reserve lines that have open space value for retaining large parcel sizes, in support of large acreage homesites for hobby farming or ranching, but are not feasible for commercial agriculture.

### *Recreation*

Areas of existing and/or proposed private recreational uses that emphasize and retain a recreational resource on a significant portion of the site. Areas shown on an adopted State Park System Master Plan, or on acquisition lists of the state or county parks and recreation departments. Areas of existing public recreational uses. Areas reserved for active and intensive recreational activities, such as golf courses and campgrounds. Existing established state, county, or city park holdings, as well as those areas of the national forest where active recreation uses exist.

*Open Space*

The Open Space category is applied to lands in public fee ownership, or private lands where an open space or easement has been executed between the property owner and the county. The category may also be applied to areas left open as part of density transfer negotiated through the amendment process. Applying the Open Space category to a parcel of land does not, in and of itself, convey or imply any right of public access, use, trespass or violation of privacy. The open space designation may be applied to public or private lands with public easements, including the undeveloped portions of state park properties.

***Residential Rural***

Areas of existing small-acreage parcels no more than three miles from urban reserve lines that are not commercially viable for agriculture, where the average parcel size within any contiguous area is below 19 acres.

***Urban (including residential single family, residential multi-family, commercial service, & office and professional)***

The unincorporated community of Los Osos/ Baywood Park represents part of the urban area in the watershed that is under County jurisdiction.

***Public Facilities (public facilities & recreation)***

Areas with existing public or quasi-public facilities and uses, or publicly owned lands intended for development with public facilities.

*Conservation Overlays*

The Estero Area Plan, a part of the county's Local Coastal Program, contains overlays to zoning called Sensitive Resource Area (SRA) combining designations. These combining designations apply in addition to the normal requirements of the applicable land use category. SRAs identify areas of high environmental quality, including but not limited to important geologic features, wetlands and marshlands, undeveloped coastal areas, and important watersheds. Some SRAs are applied to areas that have environmentally important coastal resources protected by the California Coastal Act: wetlands, coastal streams and riparian vegetation, terrestrial habitat, and marine habitat. Those SRAs are called Environmentally Sensitive Habitats.

SRAs are intended to enhance and maintain the amenities accruing to the public from the preservation of the scenic and environmental quality of the county. SRAs also provide for review of proposed alterations to the natural environment and terrain in areas of special ecological and educational significance (*Framework for Planning, Coastal Zone*).

The Coastal Zone Land Use Ordinance contains detailed standards that apply to proposed development within SRA combining designations. A primary objective of those standards is to identify and protect Environmentally Sensitive Habitats through means such as building setbacks, use limitations, and other appropriate regulations.

***Morro Estuary Greenbelt Alliance and the Los Osos Greenbelt***

The Morro Estuary Greenbelt Alliance (MEGA), a local non-profit organization that was formed in 1998, is dedicated to the preservation of sensitive habitat through education, outreach, and coordination with state, local and federal agencies. The focus is on land acquisition projects where willing sellers have been identified. The organization is currently pursuing grants for stewardship, coordination, and land acquisition. Many of the parcels identified for acquisition are part of the Los Osos greenbelt project initiated by the San Luis Obispo Land Conservancy, another local non-profit organization, in 1993.

### 4.3.2 Los Osos - Population Trends

Los Osos-Baywood Park, with a population of 14,600 (SLO County Dept. of Planning & Bldg., 1999), is located at the southern end of the bay. Between 1970 and 1980, population growth jumped from 3,490 to 10,933, or an increase of 213%, about 4.5 times more than the growth rate for the county as a whole. The Los Osos Community Advisory Council expects a maximum build out population of 19,000 (Bowker, R. pers. comm). The growth rate in some areas of the community has been curtailed since 1988 as a result of Resolution 83-13 of the Central Coast Regional Water Quality Control Board (CCRWQCB) that prohibited septic tank discharges. Population trends are discussed further in Section 10, Habitat Loss.

### 4.3.3 Other Watershed Areas - Population Trends

San Luis Obispo County population figures show approximately 470 people residing in the unincorporated portions of the watershed outside of the community of Los Osos. Cuesta College has an annual enrollment of about 7,900; the California Men's Colony has a population of about 9,000; and Camp San Luis Obispo is approximately 1,000.

## 4.4 BENEFICIAL USES IDENTIFIED BY EPA AND THE REGIONAL BOARD

The discussions that appear in Part III of this document, Priority Problems, describe the impacts of the various problems on the varied beneficial uses of the bay and watershed. The Morro Bay estuary, Chorro Creek and its tributaries, and Los Osos Creek and other wetlands in the watershed support the following beneficial human uses, as identified and defined by the CCRWQCB (1994):

- agricultural water supply
- commercial and sport fishing
- navigation
- aquaculture

- shellfish harvesting
- water contact recreation (REC-1)
- non-contact water recreation (REC-2)
- industrial service supply: cooling water for electric power generation
- wildlife habitat
- rare and endangered species habitat
- municipal and domestic water supply
- groundwater recharge
- cold freshwater habitat
- warm freshwater habitat
- migration of aquatic organisms (e.g, anadromous fish)
- spawning, reproduction, and/or early development of fish
- biological habitat of special significance (parks, reserves, etc.)
- estuarine habitat
- freshwater replenishment

A healthy bay and watershed are important to all of these activities and enterprises. Though Morro Bay remains relatively unspoiled, action is needed to restore, maintain and enhance the bay and its watershed before its natural and economic resources are irretrievably damaged.

The CCRWQCB has developed objectives for maintaining water quality such that these uses remain viable (CCRWQCB, 1994). This has been discussed in the MBNEP Base Programs Analysis. Where the objectives are numeric, the objectives are included below. The CCRWQCB also has an anti-degradation policy that states: "Wherever the existing quality of water is better than the quality of water established...as objectives, such existing quality shall be maintained..." The beneficial uses listed above are described below in more detail.

### *Agricultural Water Supply*

Livestock Production. Rangeland (grassland) comprises approximately 60 percent of the watershed study area. Livestock operations are principally cow/calf enterprises supported by highly productive grasslands. Recent emphasis on rangeland beef production and economic return has brought steeper and more marginal areas of rangeland into use.

Cultivated Agriculture. Cropland is farmed using a grain-garbanzo bean rotation. Grazing livestock uses the grain stubble. Snow peas and vegetables are grown where irrigation water is available and winter temperatures permit active growth.

### *Commercial, Sport, and Recreational Fishing Industry*

The central coastline of California from Monterey to Morro Bay represents one of the longest unprotected shorelines on the Pacific Coast. The Morro Bay estuary provides a large year-round and all weather commercial and recreational boating harbor. The nearest such harbors are Monterey Bay, over 125 miles to the north, and Santa Barbara, 100 miles to the south. Because Morro Bay provides the only location within many miles to gain year-round boating access to the

Pacific Ocean, it provides a critical resource to the commercial fishing and recreational boating industries.

Within Morro Bay there is an extensive complex of private and public berthing facilities consisting of docks, piers and fixed moorings. The Morro Bay Harbor Department manages approximately 450 berths or moorings. In addition, the state park marina at Morro Bay State Park provides recreational berthing for another 100 or more vessels. A boat launch ramp is available to the public for launching trailered boats. Piers or platforms extending from street ends into the bay are available for recreational fishing. There continues to be demand for berthing beyond the available supply.

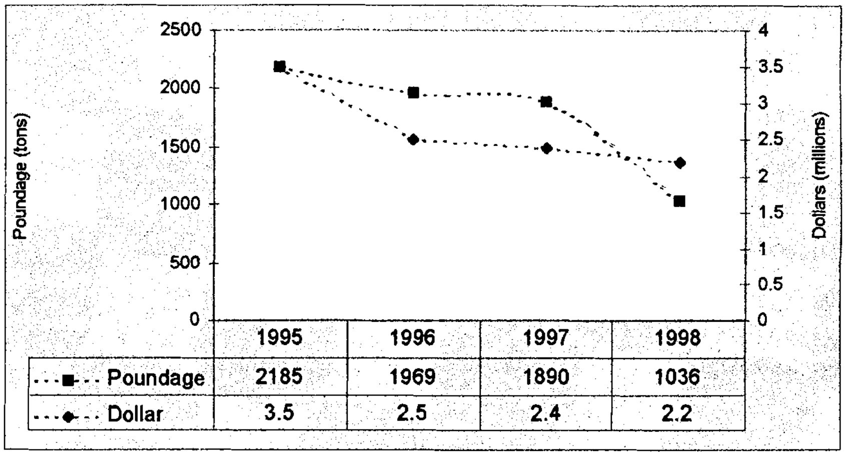
The rock revetment along the north shore of Morro Bay estuary is used extensively by sport fishermen and scuba divers. In the southern end of Morro Bay, many private homes have small docks or beaches from which small recreational craft are launched. A small dredged marina is located at Cuesta-by-the-Sea. In addition, several small beaches within the bay are sites for launching of small craft, including powerboats, sailboats, canoes, kayaks, rafts, and sailboards.

Commercial Fishing. Commercial fishing is the second major industry in Morro Bay._As the only year-round all-weather port on the Central Coast, Morro Bay has long been important as a commercial fishing center. Indeed, the City of Morro Bay takes its very origins from the commercial fishing industry and is widely identified as a fishing community. Commercial fishing remains one of the area's chief economic activities. Fishing activities include hook and line fishing, trawling, gillnetting, purse seining, and trap fishing. It is estimated that there are approximately 70 commercial fishing boats in the area (Allayaud 1991).

The commercial fishing industry targets a wide variety of commercial species and brings in approximately $7 million annually. A recent economic study prepared by the City of Morro Bay indicated that commercial fishing and related support activities contributed significantly to the city's overall operating income. Highest valued fisheries were rockfish, thornyhead, dover sole, spot prawn, cabezon, squid and salmon.

According to the Morro Group and ADL (1999), the ex-vessel value of total fishery landings at Morro Bay and Port San Luis reached a peak of about $9.5 million in 1995. The decline in poundage and dollar value between 1995 and 1998 is shown below in Figure 4.4.

Figure 4.4. Morro Bay Fish Landings, Poundage and Dollar Values (*Morro Group and ADL, Inc. 1999*).




<u>Sport fishing.</u> For the saltwater angler, year-round opportunities provide catches of lingcod, many rockfish species, and cabezon, along with seasonal catches of king salmon (February to November), albacore (September to November), and halibut (July to December). Sport fishing is an important part of the local economy. These boats collectively generate between $1 million and $1.5 million per year in gross revenues and employ 65-70 employees during the summer and 30-35 employees during winter months.

### *Navigation*

Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels. The CCRWQCB interprets NAV as, "Any stream, lake, arm of the sea, or other natural body of water that is actually navigable and that, by itself, or by its connections with other waters, for a period long enough to be of commercial value, is of sufficient capacity to float watercraft for the purposes of commerce, trade, transportation, and including pleasure; or any waters that have been declared navigable by the Congress of the United States" and/or the California State Lands Commission.

### *Aquaculture*

Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.

Historically, abalone production has occurred in Morro Bay. While production is not currently occurring in the estuary, it could contribute important economic benefits to the local area. The available sites on the shores of Morro Bay where clean seawater can be extracted and then returned provide an operating environment for these activities. Maintenance of high water quality in the estuary is vital to ongoing mariculture operations.

### *Shellfish harvesting*

Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sport purposes. This includes waters that have in the past, or may in the future, contain significant shellfisheries.

Morro Bay is the site of one primary shellfish operation. Central and southerly portions of the estuary are used for oyster growing. Presently, 269 acres of mudflats are leased for shellfish growing. The CDFG leases land to one oyster farmer; and the California Department of Health Services oversees water quality in oyster harvesting areas. The shellfish harvested from these beds are sold to local markets and restaurants; they are also shipped to other regions of the world.

### *Water Contact Recreation (REC-1)*

This entails use of water for recreational activities involving body contact with water, where ingestion of water is reasonable possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

### *Non-contact Recreation (REC-2)*

As defined by the CCRWQCB, this entails use of water for recreational activities involving proximity to water, but not normally involving body contact with water. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities. Some of these activities are discussed further below.

Morro Bay and Montana de Oro State Parks represent the second largest land use acreage next to agriculture in the watershed. State and city parks and beaches in the area include over 2250 acres within the city limits of Morro Bay.

Morro Bay State Park, one of the oldest state parks in California, provides diverse recreational amenities. These include a golf course that is certified as an Audubon Environmental Sanctuary, a marina with a capacity of 100 boats, a launch ramp for public use, and a natural history museum supported to a great degree by volunteer docent guides. Morro Bay State Park is largely within the city limits of Morro Bay and is adjacent to the estuary. It encompasses a variety of fresh and saltwater wetlands, open water, and upland habitats. It contains a large intensively used campground with 130 campsites. The park is used year round by 500,000 visitors from throughout the state and nation who come to enjoy Morro Bay's pristine and scenic natural setting.

The south and west shores of Morro Bay are bordered by Montana de Oro State Park. Morro Rock and Morro Strand State Beach are located to the north of the estuary. These parks are under the supervision and management of the California Department of Parks and Recreation.

Morro Rock is a spectacular 587-foot-high volcanic plug, and the largest such feature on the entire California coastline. The rock itself is a significant visitor-destination point and landmark that contributes to the unusual and spectacular setting for which the estuary is known.

Wildlife resources also bring visitors to the area. The City has designated bay land under its jurisdiction as a bird sanctuary, and portions of state parklands are set aside as environmentally sensitive wildlife and plant habitats.

Several commercial "party boats" fish out of Morro Bay on a year-round basis. These boats operate from private wharves within the city limits, fishing along the coast as well as within the bay, and providing whale-watching opportunities during the California Gray Whale migration. Their owners also operate fishing equipment supply outlets.

Although clams are not nearly as prevalent as they once were, shellfish are still an important recreational resource in the bay. There are 19 species that can be collected. The most commonly harvested species are Washington, gaper and geoduck clams. Rock and dungeness crabs can also be found seasonally by resourceful fishermen, and ghost shrimp are harvested from the mudflats.

The last decade has seen a dramatic increase in the numbers of individuals enjoying the use of canoes, kayaks, and small boats. There are now a number of businesses that rent small boats. Both private and rented small craft represent one of the best ways to experience the bay. One local entrepeneur even offers rides to the small kelp forest on a semisubmersable boat.

***Industrial Service Supply for Electric Power Generation***

Near the mouth of Morro Bay is the site of one of the major steam electric-generating plants on the Pacific Coast. Owned by Duke Energy Power Services, the Morro Bay Power Plant draws water directly from the bay to cool its boilers. Heated water is discharged to the ocean just north of the bay. The Duke facility is the single largest industrial employer in Morro Bay and is a mainstay of the local economy, employing 130 people. Effects of the Morro Bay Power Plant on the estuary are discussed further in Section 2.

***Education and Scientific Research***

There is increasing interest in the Morro Bay estuary as a site for educational and scientific research. The estuary contains large tracts of intertidal and marsh area and the area's ready accessibility provides an ideal location for both educational and scientific work. The Bay Foundation of Morro Bay is a private, non-profit organization conducting research on the bay. The Coastal Resources Institute at California Polytechnic State University, San Luis Obispo focuses on research efforts in Morro Bay and nearby coastal waters. Several other universities schedule regular field trips to Morro Bay, and many students from the Central Valley come to the Kern County Environmental education camp. The Morro Bay Natural History Museum serves 10,000 students, and a total of 79,000 visitors annually.

### *Wildlife Habitat*

Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

### *Rare and Endangered Species Habitat*

Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rate, threatened, or endangered.

### *Municipal and Domestic Water Supply*

Uses of water for community, military or individual water supply systems, including, but not limited to, drinking water supply.

### *Ground Water Recharge*

Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater acquifers. Ground water recharge includes recharge of surface water underflow.

### *Cold Freshwater Habitat*

Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates.

### *Warm Freshwater Habitat*

Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates.

### *Migration of Aquatic Organisms*

Uses of water that support habitats that are necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.

### *Spawning, Reproduction, and/or Early Development of Fish*

Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

### *Biological Habitat of Special Significance*

Uses of water that support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance, where the preservation or enhancement of natural resources requires special protection. In Morro Bay, this includes areas such as Morro Bay State Park, portions of which are a Natural Preserves or Reserves, Sweet Springs, Marsh, and Morro Dunes ecological reserve (see Figure 4-1.)

### *Estuarine Habitat*

Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds). An estuary is generally described as a semi-enclosed body of water having a free connection with the open sea, at least part of the year and within which the seawater is diluted at least seasonly with fresh water drained from the land. Included are water bodies that would naturally fit the definition if not controlled by tidegates or other such devices.

### *Freshwater Replenishment*

Uses of water for natural or artificial maintenance of surface water quantity or quality (e.g., salinity) which includes a water body that supplies water to a different type of water body, such as, streams that supply reservoirs and lakes, or estuaries; or reservoirs and lakes that supply streams. This includes only immediate upstream water bodes and not their tributaries.

## 4.5 AREAS WITH SPECIAL DESIGNATIONS

### *Pismo Clam Preserves*

Within Estero Bay area there are two California State Refuge designations. Atascadero Beach Pismo Clam Preserve is located on the coast just north of Morro Rock. It extends northerly from Morro Rock about 1.5 miles to Azure Street in Morro Bay, and westerly 3.0 nautical miles. The Morro Beach Pismo Clam Preserve is located on the coast between Hazard Canyon in Montana de Oro State Park and the southern portion of the sandspit (McArdle 1997). The Morro clam preserve also extends westerly 3.0 nautical miles. In these areas, the taking or possessing of any clam or any equipment capable of being used to dig clams is restricted (CDFG, Code 10500).

# 5.0 RAPID SEDIMENTATION AND EROSION IN THE MORRO BAY WATERSHED AND ESTUARY

## 5.1 INTRODUCTION

Studies conducted by various authors over the past 25 years have concluded that Morro Bay is suffering from a rapid increase in sedimentation. These studies have provided estimates of sediment loadings to the bay from the creeks emptying into the bay and estimates of sediment accumulations within the bay. One of these studies (Haltiner 1988) estimated that Morro Bay has lost more than one quarter of its tidal volume in the last 100 years. In this study, Haltiner estimated that under "normal" circumstances, the bay would naturally fill in with sediment in several thousand years. If, however, the recent accelerated rates continue, Haltiner suggested, the bay could fill in within the next 300 years. Other studies (Noda and Jen 1975; USDA Soil Conservation Service (SCS) 1989a) have reached similar conclusions regarding sediment yields. Most recently, the Morro Bay National Estuary Program (MBNEP) and Tetra Tech, Inc. evaluated sources, sizes, and quantities of sediment loadings to the Morro Bay estuary in order to provide input to a tidal circulation model of the estuary (Tetra Tech 1998a).

Increasing sedimentation in the bay adversely impacts recreational activities and navigational channels throughout the harbor. Overall loss of tidal volume from sedimentation has significant implications for the estuary's long term flushing ability and the abundance of eelgrass. Accumulated sediment has caused the creek bottom at Twin Bridges to rise over 13 feet in the last 50 years. In addition, over time, there has been an associated rise in the elevation of the Chorro delta as well. Sediment has other environmental and economic impacts on the bay and watershed. Areas in the back bay that used to be navigable by small boats are no longer navigable. Areas in the Chorro delta that were formally wetlands are now covered by weedy plant species like hoary cress. Sediment greatly impairs stream habitat, causing damage to fish, particularly steelhead trout. Increased deposition of sediment in the vicinity of the Twin Bridges crossing of South Bay Boulevard over Chorro Creek required the replacement of the bridge. This was an expensive, multimillion-dollar undertaking. The large amount of sediment that entered the bay following the fire of August 1994 and the floods of 1995 destroyed many acres of oyster beds. It is estimated that the local oyster grower's business suffered $30,000.00 damage from this event alone. (Williams, B., pers. comm. 1998).

Over time, all estuaries eventually fill in due to sedimentation. However, in Morro Bay this natural process has been accelerated due to watershed disturbance. The changes due to increased sedimentation are most evident in the delta formed by Chorro and Los Osos Creeks and in the southern portion of the bay in general.

The following sections of this document provide some key definitions, summarize the available sediment literature, discuss the impacts that sedimentation is having on resources and beneficial uses of the bay, identify likely sources and trends, and finally present key problems to be resolved.

## 5.2 DEFINITIONS

*Bed material sediments* are coarse sediments found in the streambed.
*Wash load* are the sediments transported through a creek system.
*Filterable solids* are suspended sediments in a water body.
*Fluvial* processes are those that pertain to rivers.
*Littoral* processes are those that pertain to wave action.
*Shoaling* refers to changes in the estuary channel depths brought on by currents, sediments, and tidal action.
*Suspended sediment* are filterable solids suspended in water.
*Turbidity* is the clarity of water in a creek, estuary, or other water body.

## 5.3 APPLICABLE STANDARDS

The Central Coast Regional Water Quality Control Board (CCRWQCB) Basin Plan objective for sediment is that loadings of surface waters shall not be altered in such a manner that adversely affects beneficial uses. Some beneficial uses have been affected, as discussed below.

## 5.4 IMPACTS TO BENEFICIAL USES

### 5.4.1 Navigation

The bay is an important harbor for commercial and recreational fishing vessels. Shoaling, which results from excessive sediment supply, causes a need for increased dredging. Boats can be stranded in the State Park Marina during low and medium tides, causing a potential safety hazard.

As previously mentioned, the channel that is regularly dredged by the U.S. Army Corps of Engineers (ACOE) is impacted primarily by littoral drift (sediment brought in by the tides) and not by sediment brought down by the two creeks (ACOE 1988). The continuing loss of tidal prism has a direct impact on tidal flow velocity in the channels of the bay. Tidally driven currents directly affect the deposition and scouring of sediment in all the channels of the bay. Sedimentation affects navigation through shoaling, and as it causes changes to the circulation patterns in the bay.

### 5.4.2 Commercial and Sport Fishing

Most commercial fishing in this area is conducted outside the Morro Bay estuary. However, steelhead trout was historically a popular sport fish prior to listing. Impacts to riparian and marine fishing resources include heavy storms, creating plumes of sediment from watershed creeks that reach outside the estuary into Estero Bay.

### 5.4.3 Shellfish Harvesting

Although sedimentation could clearly affect shellfish populations, there is no document that establishes, either qualitatively or quantitatively, a clear impact. Josselyn, *et.al.* (1989) discusses the impact of increased sedimentation in Morro Bay, and identifies the importance of shellfish, but they draw no conclusions as to the impact of sedimentation except to state that siltation is a threat to oyster cultures. The economic impacts are evidenced, however, by $30,000 in lost revenue reported by the local oyster grower following the Highway 41 fire and winter storms.

### 5.4.4 Estuarine Habitat

Excessive sediment loading into the bay is of primary concern to the long-term health of Morro Bay. Sedimentation is resulting in losses of mudflat and open water habitat and other resources dependent upon specific water depths and salinity concentrations. Elevated turbidity and suspended solids result in decreased light penetration through the water column, impacting aquatic plants and the organisms dependent on them. Aquatic vegetation, fish, and bottom dwelling organisms can be smothered by excessive sedimentation, both in the estuary and in adjacent tributaries.

In Morro Bay it has been observed that the salt marsh area is increasing in size, the riparian area at the mouth of Chorro Creek may be increasing, and the deeper water areas, those that support eelgrass, are decreasing due to bottom buildup of sediment. The degree of physical change caused by the sedimentation has typically been estimated by making comparisons of historic photographs and bathymetric surveys. (See Sections 2.1.3 and 5.5.3 below.)

With increased sedimentation, habitat quality at this expanding interface near the delta has been severely degraded (Josselyn *et al.* 1991). Salt marsh habitat is being replaced near the delta in the upper delta by lower salinity tolerant species. These include undesirable, introduced, and extremely invasive species such as Hoary Cress (*Cardaria draba*), and, in riparian woodlands adjacent to the delta, Cape Ivy (*Senecio mikanioides).* The ability of these non-native species to take hold is probably exacerbated by disturbed soils resulting from sedimentation.

The degree of ecological change caused by the sedimentation is less definitively described in the literature. The seasonal runoff from the watershed produces measurable turbidity in mid-estuary zones (Phillips 1984). Increased turbidity leads to decreased eelgrass growth, and reduces the depth range at which it will occur in the estuary. Desiccation through sediment accumulation is a major factor limiting the upper intertidal distribution of eelgrass. There appears to be no species succession in the eelgrass stage of the ecosystem. Eelgrass is the initial colonizer as well as the climax stage of development (Phillips 1984). The impacts to eelgrass habitat are discussed further in Section 10, Habitat Loss.

### 5.4.5 Wildlife Habitat

As discussed earlier, increased sediment is causing changes in the wildlife habitats within the estuary and the watershed.

Increased temperatures and light resulting from shallower depths due to sedimentation may be a factor in the increase of the algal species *Ulva* and *Enteromorpha*, which inhabit the upper elevations of the mudflats.

Coastal brackish marsh, a sensitive habitat present at the mouths of the creeks, is being rapidly lost due to silt accretion (California Natural Diversity Database 1988). This affects rare and/or endangered species such as salt marsh bird's beak, the California brackish water snail, and the California black rail.

### 5.4.6 Warm & Cold Freshwater Habitat; Migration of Aquatic Organisms; Spawning

Chorro and Los Osos Creeks are anadromous fish (steelhead trout) streams. Sedimentation can affect the steelhead reproductive processes when fine materials being deposited smother the gravel beds that are critical for spawning. Sediment also fills the deep pools that smolts need to survive dry periods. Eroding gravel banks provide a source of spawning gravel for a stream, but erosion of fine textured soils (e.g., clays, silts, and fine sands) can reduce habitat quality for fish (Flosi 1991). Excessive sediment during high flow events impairs steelhead migration, as sediment can erode gills, and stress fish considerably.

Near the mouth of the creek at the Chorro Creek Bridge, sediment buildup has been instrumental in the transformation of a brackish marsh area into a riparian/fresh water wetland with totally different plant species than what historically existed (Josselyn *et.al.* 1989). Tetra Tech (1998a) concluded that Chorro Creek contributes 86% of the sediment load to the bay.

Chorro and Los Osos creeks support two of the southernmost populations of steelhead trout in the state (Worcester 1991). However, after five years of drought and the increase in freshwater diversions over the last two decades, the health of the steelhead population is probably more precarious then ever before. The California Department of Fish and Game (CDFG) has indicated that there have been no recent surveys on either stream, the last being conducted in the 1970s. A new survey of steelhead and comprehensive IFIM stream study should be performed over a suitable amount of time that would take into consideration flows, habitat, food sources and populations. The U.S. National Marine Fisheries Service has recently listed steelhead as a threatened species because of its diminishing status along the coast. Steelhead are discussed further in Section 3.3.6.

### 5.4.7 Rare and Endangered Species Habitat

Three additional sensitive species found in cold water systems, the red-legged frog (federally threatened), the southwestern pond turtle (a federal species of concern), and the tidewater goby (federally endangered), are all adversely affected by sedimentation. The sediment fills in pools that would normally provide safe habitat, especially during summers and droughts, when the creeks have little or no flow.

Chorro and Los Osos Creeks both contain examples of good condition riparian vegetation. These habitats support a multitude of both plant and animal species. However, erosion and sedimentation can have a significant impact on the wildlife habitat that depends upon the riparian vegetation. This process occurs through accelerated stream bank erosion and resulting instability of the riparian corridor. Near the mouth of Chorro Creek, the riparian area is being degraded by exotic species, which multiply in disturbed soils in the depositional areas, as previously mentioned.

### 5.4.8 Water Contact and Non-Contact recreation in the Morro Bay Estuary

The bay is an important recreational area. Sedimentation can impact recreational activities such as kayaking, boating, and wind surfing that rely on the bay's open water areas. Increased sedimentation affects the capacity of the bay to support these uses.

### 5.4.9 Municipal Water Supply

Drinking water sources can be impacted by sedimentation. Sedimentation of the Chorro Reservoir has reduced the carrying capacity of the reservoir.

### 5.4.10 Agriculture

Agricultural lands can be adversely impacted by erosion. Valuable topsoil lost from erosional processes can have substantial long-term economic impacts due to lower productivity. Streambank erosion results in a loss of valuable land..

## 5.5 SOURCES AND TRENDS

### 5.5.1 Overview

Noda and Jen (1975) estimated that about 5,000 cubic yards (6,300 tons/year) of coarse material is deposited annually in the Morro Bay estuary from bed material loading. The SCS/National Resource Conservation Service (NRCS) has estimated that, on the average, approximately 37,000 cubic yards, or 45,500 tons, of fines, sand, and gravel are annually deposited in the bay (USDA SCS 1989a). In reality, in years without much rainfall or with smaller storms spaced evenly apart, only small amounts of sediment are delivered; in severe storm events, amounts much greater than 37,000 cubic yards are delivered. Haltiner (1988) estimated accumulation in the bay and arrived at an annual figure that translates to about 40,000 tons/year. Tetra Tech (1998) estimates an average annual loading of approximately 70,000 tons/year. Ten percent of this total loading is sands and gravels, and 90 percent of this is fines.

TetraTech (1998a) estimated that the Chorro Creek watershed contributes 86% of the total (60,689 tons) sediment produced in the Morro Bay watershed and that the Los Osos watershed contributes 14%, or 9,557 tons. San Bernardo, San Luisito, and Chorro Creek above Highway 1, and the Clark Valley segment of Los Osos creek contribute the greatest amounts of sediment to the bay. This is discussed further below (Section 5.5.3).

### 5.5.2 Transport Mechanisms

The above sediment studies (Haltiner 1988; USDA/SCS, 1989a; ACOE 1988) indicate that accelerated sedimentation has been caused primarily by river and ocean sediment transport. Sedimentation at the harbor entrance is dominated by ocean transport, or longshore transport, whereas sedimentation in the southern and eastern bay is dominated by fluvial or river transport.

Long-Shore Transport. The Haltiner study identified sediment that is transported down the coast by long-shore currents as the single largest source of sediment. However, this sediment is removed through regular dredging to maintain the harbor and navigable waterways.

Lags in back bay water levels are estimated to correspond to tidal influences and imply that inflows and outflows are impacted by cross sectional flow constrictions and other impedances to flow within the estuarine system (Haltiner 1988). One such flow restriction is believed to be at the "narrows" at Fairbanks point, which is located north of the Morro Bay Natural History Museum. The primary sediment transport mechanisms are discussed below.

Fluvial Processes. Pillsbury (1979) and USDA/SCS (1989) identify sheet and streambank erosion as a cause of sedimentation in the bay. This erosion originates from brushland, rangeland, cropland, and urban areas, generally because of lack of adequate vegetative cover, and is transported through the creeks to Morro Bay. Events like catastrophic wildfire and major storm events can greatly accelerate this form of erosion. Erosion is also caused by land disturbances such as roads, construction, agricultural activities, and mining activity.

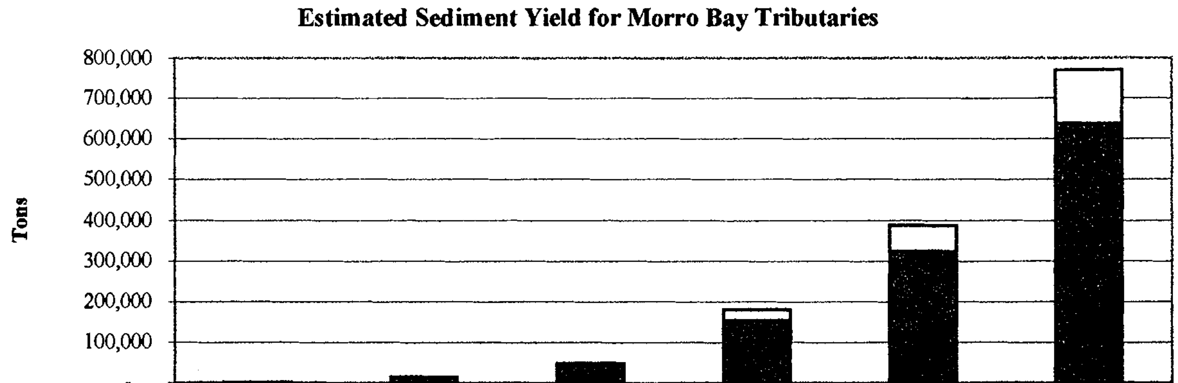
Aeolian Processes - Migration of the Sandspit. Haltiner (1988) estimated that the average annual displacement of the bay's volume by eastward migration of the sandspit was approximately 4,000 to 5,000 cubic yards of the tidal prism. A 1975 estimate was made of 8,300 cubic yards per year of total aeolian transport. The difference of 4,000 cubic yards per year is accounted for by the amount of wind deposited sediment transported and deposited elsewhere in the bay through the tidal channels.

### 5.5.3 Sediment Loading in Creeks and Streams

As discussed above, the MBNEP conducted sediment yield and transport analyses (Tetra Tech 1998a) on the major creeks and tributaries to Morro Bay to evaluate the sources, sizes and quantities of sediment loading to the Bay. These analyses were based both on storm-events and average annual yield estimates.

***Storm Event Analysis***

For the analysis of both measured and hypothetical storm events, Tetra Tech classified soils over the entire watershed, and quantified flow rates, volumes, and sediment for three years (1995-1997) on Walters and Chumash creeks. Initially, they also extrapolated rainfall data collected at Walters Peak in the Chorro watershed to the rest of the watershed. This analysis led to the development of a HEC-1 model for Morro Bay. This analysis lead to the development of a HEC-1 model for Morro Bay, which simulates runoff response to storm events. The MUSLE (Modified Universal Soil Loss Equation) was used to predict sediment yields to a given point in the watershed. To translate MUSLE yields into sediment flow rates, the total tonnage were distributed over the flow hydrograph in a consistent manner (Tetra Tech 1998). The analyses are based on two, five, ten, 25, 50, and 100-year storm events. Results are presented in Figure 5-1 for Los Osos Creek and Chorro Creek. The results indicate that a single 100-year storm event would contribute about 700,000 tons of sediment to the Bay – about 400 acre-feet of sediment. In contrast, a 2-year event, the more likely event, is expected to contribute about 1,300 tons of sediment to the Bay, or less than 1 acre-foot of sediment (Tetra Tech 1998a).




| | 2 year storm | 5 year storm | 10 year storm | 25 year storm | 50 year storm | 100 year storm |
|---|---|---|---|---|---|---|
| Los Osos Creek | 38 | 1,089 | 5,321 | 26,067 | 61,771 | 134,661 |
| Chorro Creek | 1,330 | 13,634 | 43,354 | 154,348 | 325,075 | 637,272 |

**Figure 5-1. Sediment Yield for Morro Bay Tributaries based on 2, 5, 25, 50, and 100 Year Storm Events.**
*Source: Tetra Tech Morro Bay Watershed Sediment Loading Model 1998, pg. 12*

For the analysis of annual sediment yield to the bay, Tetra Tech considered the magnitude and frequency of flows that have occurred over a recent 18-year period (1978-1995) at the Canet Road gauge on Chorro Creek to be indicative of the long-term trend in the watershed. This flow data, combined with the results of the HEC-1 model for storm events, resulted in estimates of average annual loading in the bay. Based on this, the average annual loading to the bay was estimated at 70,000 tons per year. About 10 percent of this loading was estimated to be composed of sands and gravels, and about 90 percent fines. These fine particles typically require almost no-flow conditions to settle out. These conditions do not occur until stream flow meets the bay.

For an average storm event, Chorro Creek is estimated to contribute about 86% of the total sediment yield to the bay (Figure 5-2).

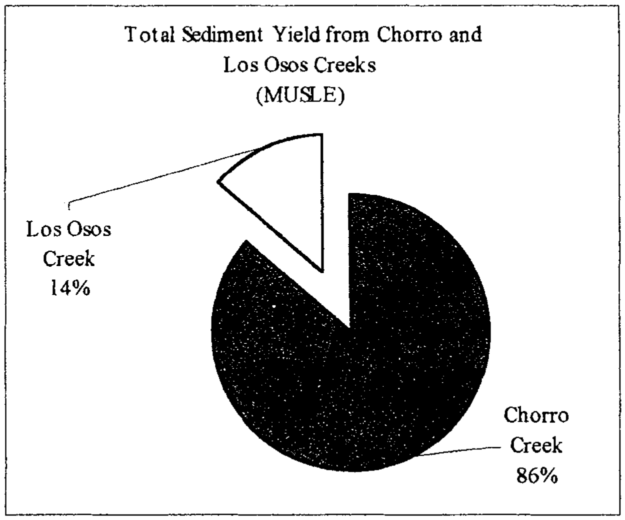



**Figure 5-2. Total Sediment Yield from Chorro and Los Osos Creeks for an Average Storm Event.** *Source: TetraTech Morro Bay Watershed Sediment Loading Model (MUSLE), 1998, pg. 23-25.*

Los Osos Creek, which makes up about a third of the contributing drainage area, supplies only about 14 percent of the total average annual loading to the Bay and only about 3 percent of the coarse material (Figure 5-2). The Clark Valley is estimated to be the most significant source of sediment yield from within the Los Osos Creek watershed, despite its small size relative to Warden Creek (7.6 square miles versus 12.9 square miles). Although the percentages change slightly (23% Los Osos vs. 77% Chorro), when total sediment loading is examined on a per square mile basis, the same general patterns are apparent (Figure 5-3). Sediment yield from all tributaries within the watershed are shown in Figure 5-4.

In addition to those discussed above, the key findings and conclusions from the Tetra Tech study include:

- Erosion from brush-covered steep slopes is the most significant source of sediment loading to Morro Bay;

- Streambank erosion contributes relatively little to the total sediment loading to the bay; while shet and rill erosion contribute the most;
- identification of an aggradational trend (an increase in sediment) in the lower reaches of Chorro and Los Osos creeks, with a resultant very low capacity of the lower 2 miles or so to transport *coarse* sediments;
- the *bed material* transport capacity of the lower reaches of Chorro and Los Osos creeks prevents the delivery of *bed material* sediments to the bay (as opposed to the supply from the upstream watershed); and
- *wash load materials* (fines) have a limited presence in the local bed load of Chorro and Los Osos creeks, indicating that the supply of fines available from the upper watershed is controlling the amount of these materials delivered to the bay.

The Tetra Tech study involves numerous assumptions, regressions, and reconstruction techniques, but the results are considered to be comparable with the previous Noda and Jen 1975 study and the 1989 SCS study (Tetra Tech 1998a).

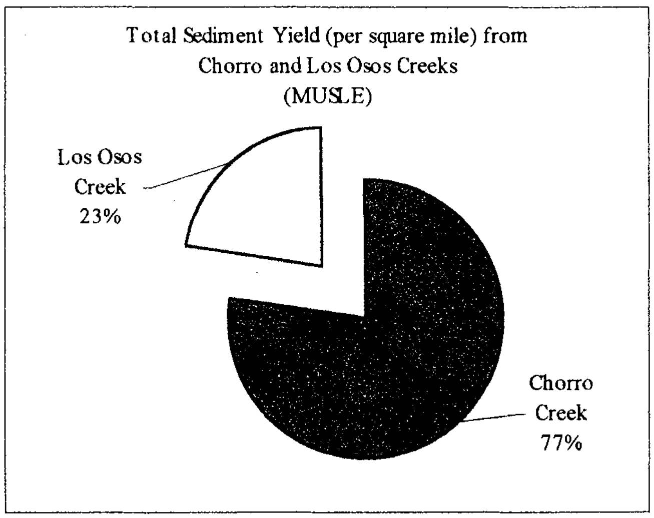



**Figure 5-3. Total Sediment Yield per square mile from Chorro and Los Osos Creeks for an Average Storm Event.** *Source: TetraTech Morro Bay Watershed Sediment Loading Model (MUSLE), 1998, pg. 23-25.*

Although the Tetra Tech study indicates that the majority of sediment transport to the bay consists of fine-grained sediment, information in the report related to larger particle sizes is also very important. While the bay in general is not being exposed to deposition of large particle size sediment, certain very important areas are clearly being heavily impacted by large particle size sedimentation. The following examples illustrate this point:

- During the last few years the northern channel of Chorro Creek in the delta area has been dramatically impacted by large particle size deposition. Twice in the last five years, the primary flow channel of Chorro Creek has been filled in with sediment. This occurred shortly before the installation of the new bridge in 1997, and again after the area was dredged and the new bridge was built.

- The area under the new bridge is filling at a rapid and the materials are primarily gravels and sand.
- On the south side of Turri Road east of Los Osos Creek the Wetland Reserve has captured a large amount of sand-sized particles believed to be from stream bank erosion of the "Clark Valley" portion of Los Osos Creek.

Some are concerned that endangered species like the tide water goby and red-legged frog are more affected by the 10% of the erosion problem consisting of large particles than the 90% consisting of small particles. (Paradies, D., 1999 pers. comm.)

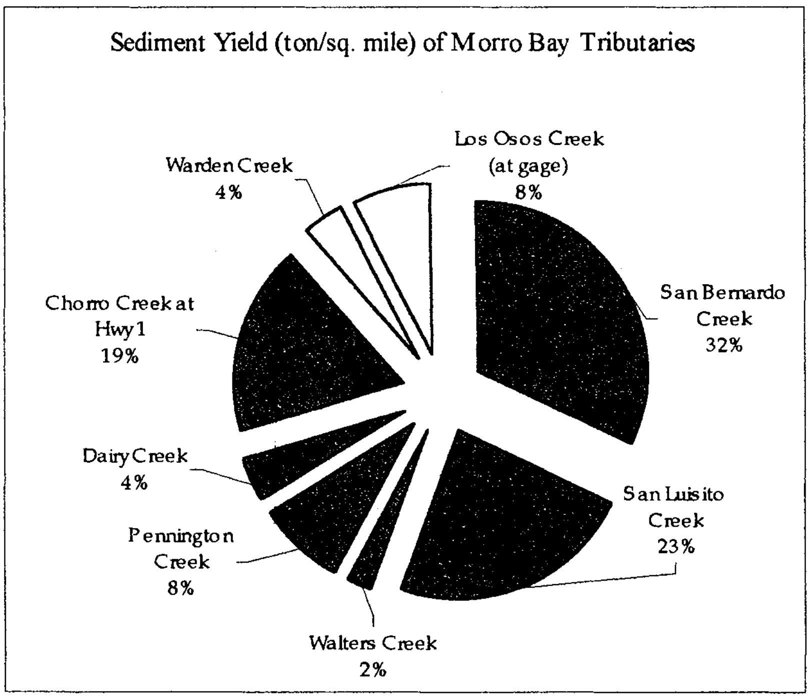



**Figure 5-4. Relative Sediment Yield from Individual Tributaries to Los Osos (light colored) and Chorro Creeks (dark colored), based on 10 year storm event.** *Source: TetraTech Sediment Loading Model, 1998, pg. 12.*

## 5.5.4 Sediment Resulting From Catastrophic Fire Events

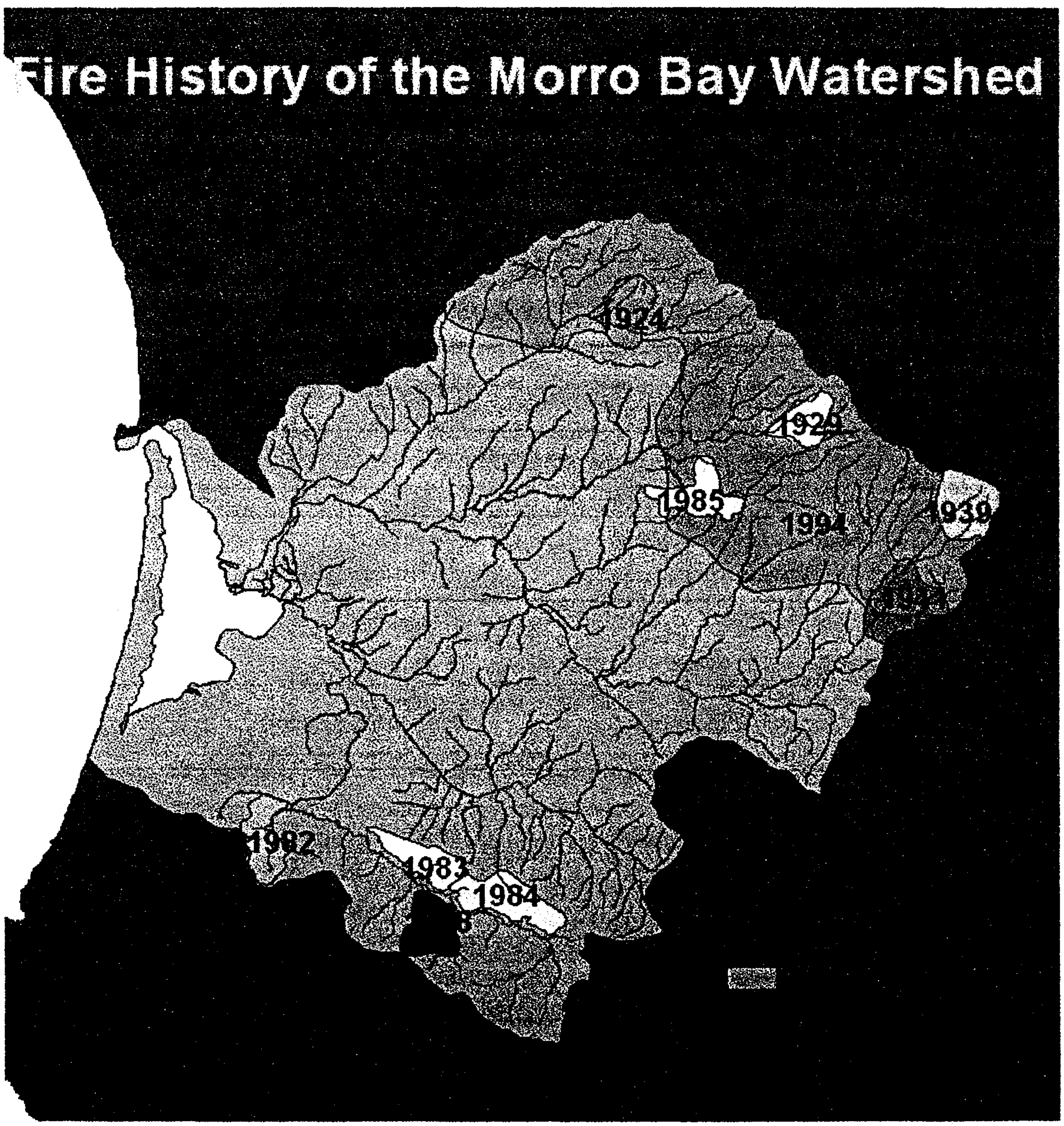
Sediment that results from major storms and flooding after fire events can have major impacts on the estuary. In fact, wildfire has played an important part in the evolution of watershed ecosystems. Fires that have occurred in the watershed since 1920 are shown in Figure 5-5.

The Highway 41 fire burned the upper watersheds of Chorro, Dairy, Pennington, San Luisito, and San Bernardo Creeks in 1994. The steep slopes of the San Luisito watershed consist primarily of rangeland and brushland. High turbidity and suspended solids levels have been recorded every winter at this site since the Highway 41 fire in 1994. This is probably a result of high erosion rates in the upper watershed. This trend appears to be stabilizing, as samples from the National Monitoring Program indicate (CCRWQCB 1996, 1997, 1998).

As mentioned in Section 2, the Morro Bay National Monitoring Program (NMP) is monitoring turbidity and suspended sediment at specific creek locations within the Chorro and Los Osos watersheds. This data is being collected both to assess the effects of *Best Management Practice* implementation, and to learn more about ambient water quality in the watershed.

NMP sample sites are shown in Figure 2-11. Further discussion of the results of the NMP sampling is presented in the 1997/1998 annual report (CCRWQCB, 1999).

**Figure 5-5. Locations and Dates of Wildfires.**



### 5.5.5 Sediments in Urban Runoff

Urban runoff contributes to high turbidity and suspended sediment levels in the bay. Construction and landscaping activities are also sources of sediment, particularly when undertaken during the rainy season. Unvegetated areas, including unpaved roads and road shoulders, contribute to these increased sediment concentrations.

The "first flush" sampling conducted by CCRWQCB staff in 1995 showed that turbidity levels and filterable solids increase in gutters and storm drains throughout the urban drainages of Morro Bay and Los Osos during storm events. Though the sediment load carried to the bay by way of the creeks is undoubtedly a far more significant source (Haltiner 1998; Tetra Tech 1998), sediment leaving urban areas may also be a problem in some areas, particularly since other pollutants may be carried with the sediment. In 1991, Allayaud indicated that sediment from urban runoff is not a significant problem in this area, relative to other sources.

### 5.5.6 Sediment Reduction Actions Recently Implemented in the Morro Bay Watershed

A few key actions have been taken in recent years to help improve the situation regarding sedimentation and erosion in the watershed. These actions are discussed below.

*Morro Bay Watershed Enhancement Project (MBWEP)*

The Morro Bay Watershed Enhancement Project is a collaborative effort between the NRCS, CSLRCD, UCCE, SCC, CCRWQCB and the Morro Bay NEP. The MBWEP was started after the State Coastal Conservancy funded the two erosion and sediment studies and the Morro Bay Watershed Enhancement Plan. The plan recommended three phases of action:

- Phase I - install land treatment measures;
- Phase II- construct a sediment trap on Los Osos Creek
- Phase III- construct a sediment trap on Chorro Creek.

In Phase I, technical and financial assistance was given to landusers to help them correct conservation problems by installing land treatment measures. The RCD obtained a grant of $400,000 from the State Coastal Conservancy to cost-share with landusers on land treatment measures. The RCD contracted with the SCS (now the NRCS) to provide the technical assistance to get the job done.

To date, over 240 conservation practices have been installed in the watershed through technical and financial assistance provided through the MBWEP. It is estimated that these projects have resulted in the prevention of over 172,000 tons of soil erosion. Additionally, MBWEP projects have caught an estimated 300,000 cubic yards of sediment before such sediment reached the bay.

Phase II of the MBWEP was completed in 1995 when the NRCS and the RCD purchased wetland easements from George Martines for his land at the confluence of Los Osos and Warden Creeks. The easements were purchased using a unique process combining federal and state funding. The NRCS used funding from the federal Wetland Reserve Program (WRP) to purchase a wetland easement in perpetuity over 111 acres. The RCD received funding from a grant made by the SCC to also purchase a wetland easement on the same land plus an agricultural easement on 33 additional acres. The site is now known as the Los Osos Creek Wetland Reserve. The 111 acres have been reestablished as a floodplain for Los Osos and Warden Creeks. Extensive willow growth on the site has created valuable wildlife habitat. Over the last four years it is estimated that at least 120,000 cubic yards of sediment has been deposited on the site.

Phase III of the MBWEP is the Chorro Flats Enhancement Project (CFEP). This project is a sediment capture, agricultural preservation, habitat restoration and education project. The CFEP has essentially reconnected Chorro Creek with its historical floodplain, thereby allowing sediment to be deposited there instead of in Morro Bay. This is the most significant single action included in the plan. In 1989, it was estimated that a sediment trap at this site (USDA/SCS 1989) could catch 35% of the sediment entering the Bay through Chorro Creek.

The Morro Bay Watershed Enhancement Plan recognized that the Chorro Flats site would be an ideal place to trap sediment before it reached the Bay. The Chorro Flats site is especially suitable for sediment trapping because:

- Chorro Creek runs through the site;
- Chorro Flats is at the terminus of the watershed;
- Chorro Flats is relatively flat and well suited to trap sediment;
- The site historically was a floodplain, covered with riparian vegetation that naturally trapped sediment.

The passive sediment trapping system allows sediment to accumulate on the floodplain as a result of deposition during overbank flows. Increased vegetation on the floodplain helps to reduce the velocity of overbank flows and increase the rate of sediment deposition. Approximately 83 acres were included in the floodplain and 45 acres were reserved for agriculture. This allows for a capacity of in excess of 600,000 cubic yards and a projected lifespan of at least 50 to 70 years. The deposited sediment will primarily be sand-sized particles with a moderate amount of fine-grained materials (silt and clay). Most of the coarse grained material (pebble and cobble) will be trapped in the creek channel.

The Chorro Flats project was constructed in 1997, and is now in the monitoring and maintenance stage. Recent surveys of the site have revealed that over 188,000 cubic yards of material have already been captured on the site (Robbins and McEwen 1999).

*Paired Watershed Monitoring Project (CCRWQCB/Cal Poly/EPA/HUA)*

Another project being implemented to determine and document the performance of installed "best management practices" (BMP's) in the Morro Bay watershed is the Morro Bay National Monitoring Program. The basic tenets of the Program are to compare control and treatment sites, conduct pre-and post-treatment data collection, and to ensure a sufficient period of time to detect change within the watershed. One of the studies is the "paired watershed" study. In this study, turbidity samples have been taken in a control watershed, Walters Creek, and in an adjacent treated watershed, Chumash Creek, where BMP's have been installed. The objective is to evaluate the effectiveness of BMPs in reducing erosion. Management practices include developing smaller pastures, improving roads with water bars and culverts, and revegetating portions of the creek corridor.

Baseline data collection began in 1993. As reported in the most recent annual report (CCRWQCB 1999), storm-event sampling has been effective in documenting decreases in turbidity at Chumash Creek relative to Walters Creek. This data indicates that the best management practices that have been implemented in the treated watershed (Chumash Creek) are resulting in decreased turbidity levels during storm events. Even interval data has not yet detected changes in turbidity.

*Camp San Luis Obispo Habitat Restoration Projects*

For the past five years, Camp San Luis Obispo has been working with the NRCS, RCD, and various other agencies on instream and upland habitat improvement projects (Froland, pers. comm. 1999). These projects include:

- Installation of a fish passage structure, riparian fencing, and revegetation on Chorro Creek;
- Erosion control at 14 sites needing restoration after the highway 41 fire, and installation of various measures at other sites; and
- Fencing pastures and implementing rest-rotational grazing systems.

### 5.5.7 Further Sediment Research Needs

Conducting further research provides a better understanding of the processes that occur in the watershed and estuary. The additional knowledge provides the program with the tools and techniques that can help guide management decisions. The following sediment research needs were developed by the MBNEP Technical Advisory Committee (TAC). These research needs include, but are not limited to:

1. What are the sediment plume effects on Morro Bay and Estero Bay?
    - Sediment deposition is filling in the Bay, impacting a wide variety of habitats, and affects virtually all other aquatic biological species.

2. What is the effective minimum width for fenced riparian buffer to improve water quality improvement?
   - Buffer strips are a proven effective BMP at reducing sediment, bacteria, and nutrient levels in surface waters. Buffer width effectiveness is dependent on various factors such as slope length, slope angle, soil type, vegetation types, volume of runoff, and adjacent land uses.

3. Is there a positive correlation between salt and freshwater flow mixing zone and spatial particle size deposition?
   - Sediment deposition in the estuary is influenced by differences between fresh and salt-water density.

4. Is the lack of water clarity positively correlated with decreasing eelgrass productivity?
   - Eelgrass production appears to be dependent upon low turbidity conditions. A decrease in the area of eelgrass has been observed after high runoff seasons with large sediment loads.

5. Does dredging cause toxic substances to be re-suspended?
   - Toxic substances may be buried in the bottom sediments and not impacting the biota since they are unavailable.

6. What are the effects of Morro Bay Power Plant on bay air deposition?
   - Impacts from air deposition are not currently suspected, but lack of data prohibits any conclusions on impacts.

# 6.0 INCREASED BACTERIA LEVELS IN MORRO BAY AND WATERSHED STREAMS

## 6.1 INTRODUCTION

Twenty-five of the 28 National Estuary Programs, from every region of the United States, have identified pathogens such as bacteria as a water quality management issue. In Morro Bay, elevated levels of bacteria present a potential health threat to those who utilize the bay for recreational purposes and economic threats to those who depend upon the resources of the bay for their livelihood. Elevated levels of bacteria are an indication that other pollutants such as bacterial or viral pathogens may be present.

Human illness can result from eating seafood that has been contaminated by bacteria. To prevent illness, the California Department of Health Services (DHS) requires the Morro Bay oyster grower to shut down for many days after significant rainfall and not harvest on portions of his lease area. Elevated levels of fecal coliforms are an indication that the bay may be unsafe for seafood consumption as well as swimming and other forms of water contact activities.

In Morro Bay, oysters have been harvested since the 1930's and 1940's. The first oyster lease was established in 1932, and shortly thereafter Morro Bay became the leading oyster-producing area in the state (Sharpe 1974). Recently, portions of the bay's oyster beds have been closed for harvest because of high fecal coliform levels. One area of the bay was reclassified in 1996 as "restricted" for shellfish harvesting; this greatly reduces the economic viability of the oyster operation (Figure 6-1).

Recreation and tourism play a large part in this area's economy. Both of these uses are becoming increasingly important in Morro Bay. However, in the Morro Bay estuary, water quality has exceeded safe water body-contact standards as defined by the Central Coast Regional Water Quality Control Board (CCRWQCB). The following sections provide key definitions, some background information, applicable standards, impacts, and source information for this priority problem.

## 6.2 DEFINITIONS

*Pathogens* are viruses, bacteria, and protozoans that cause diseases in plants, humans, and other animals. Pathogens commonly found in marine waters include those causing gastroenteritis, salmonellosis, and hepatitis A. Since coliform bacteria are easily measured, and since they typically have the same sources as other pathogens, states are using either total or fecal coliform, *E. coli*, or enterococcal organisms as indicators of more serious pathogens.

*Total coliform bacteria* can occur in human feces, but they can also be present in rotting plant matter, soil, submerged wood, animal manure and other places outside the human body. The detection of total coliform bacteria is not as specific as that of fecal coliform, and so total coliform are no longer recommended as an indicator of health risk. They are, however, still used for wastewater treatment discharge requirements.

*Fecal coliform bacteria* are a subset of total coliform bacteria that are more fecal-specific in origin. Fecal coliforms are being used in most states as indicators of health risk.

*Escherichia coli (E. coli)* is a single species in the fecal coliform group. The detection of *E. coli* indicates fecal contamination from warm-blooded animals, including birds, wildlife, pets, and humans. *E. coli* is considered to be a more specific indicator of health risk than fecal coliform and is currently recommended by U.S. Environmental Protection Agency (EPA) for use in fresh water sampling.

The *Enterococcus* group is a subgroup of fecal coliform that is recommended for use in saltwater sampling. It is a valuable indicator for determining the extent of fecal contamination of recreational surface waters.

*Conditionally Approved Lease Area:* As defined by the National Shellfish Sanitation Program (NSSP) Manual of Operations, which the DHS uses, a conditionally approved area is one which meets the NSSP water quality standards for an approved area (an area from which shellfish may be harvested for direct marketing for human consumption), except during relatively short periods of time when it does not meet the standards and must be closed. Shellfish may be harvested subject to certain "conditions." (Morro Bay Management Plan, DHS 1991). Certain areas of Morro Bay are subject to closure in accordance with rainfall closure and reopening rules contained in the Morro Bay Management Plan.

*Restricted Lease Areas:* Generally, these areas do not meet standards on a regular basis. The restriction requires a management plan describing changes in harvesting practices, such as a reduction in allowable harvesting areas or an additional depuration process, to ensure that there is no health risk. These practices may be cost prohibitive for certain operations. A portion of the lease area in Morro Bay (near Station 13) is restricted from harvesting (Figure 6-1).

*Prohibited Areas:* According to DHS (1996), these are areas of the bay that are closed to commercial shellfishing activities. Areas near the State Park marina and the mouth of the bay are currently prohibited (Figure 6-1).

*Unclassified:* Areas not designated as lease areas that are closed to commercial shellfishing. All parts of Morro Bay not specifically designated as aquaculture leases are "unclassified," and therefore considered "prohibited" areas. (Morro Bay Management Plan, DHS, 1991).

## 6.3 BACKGROUND

### 6.3.1 Early California Department of Health Services Shellfish Studies

In 1974, the DHS conducted a Shellfish and Water Quality Study that identified probable sources of bacteria based on sampling of 21 bay stations, 10 tributary stream stations, and 19 samples of oyster meat during unfavorable pollution conditions (Sharpe 1974). Half of the shellfish samples

were found to contain elevated fecal coliform levels. Probable sources were identified and a recommendation was made to apply a "conditional" growing area classification to the bay. Other recommendations included: discouraging the public from harvesting sport clams; initiating a shoreline sampling program at Cuesta inlet and Baywood Park to confirm that septic failures are not contributing to the problem; and applying specific measures at the "Camp San Luis Obispo" (actually California Men's Colony (CMC)) Waste Water Treatment Plant (WWTP).

In 1979 a second Shellfish and Water Quality Study was completed (DHS 1979). This study was similar to the 1974 survey, except that 15 bay stations, six tributary stream stations, and 12 oyster meat samples were taken. Rain occurred during this sampling effort, whereas in 1974 no rain had occurred during the sampling period. This study concluded that it takes at least five days for the shellfish in the area to purge after a 0.5 inch rainfall during a 24-hour period. Additional sources were identified; these included urban runoff and the CMC's WWTP. A recommendation to close Morro Bay to oyster harvesting for five days following 0.5 inch storm events was made to allow shellfish to purge contamination caused by runoff. The "conditionally approved" classification was continued. (See Section 6.2 for definitions of classifications.)

By 1984, DHS was still documenting elevated coliform levels in the vicinity of the oyster beds (DHS 1984). DHS conducted a sanitary investigation and sampling at 30 sites in September 1984, and January 1985. The study had many objectives, one of which was to identify pollution sources in the bay. This study indicated that bacterial contamination was entering the bay from the ocean, and the most probable source was identified as the effluent outfall from the City of Morro Bay's WWTP (DHS 1984). At this time, the City had begun discharging unchlorinated wastewater since 1983, and was the only new source of pollution identified in the study. DHS recommended that Morro Bay be closed to commercial and sport shellfish harvesting until the pollution source was eliminated, that the bay be reclassified as "restricted" for shellfish, and that the City disinfect its wastewater effluent before discharging it to the ocean. It is important to note that during a 1986-87 CCRWQCB's study, the City was required to upgrade their treatment to include chlorination process for disinfection.

At this time, sport clamming was very popular in the Morro Bay area. In 1986, partially due to concerns about bacterial contamination, the California Fish and Game Commission closed Morro Bay to the harvesting of shellfish in general (Hardy pers. comm. 1999). Shortly after the City of Morro Bay initiated a chlorination process at its wastewater treatment plant the Commission's prohibitions were removed.

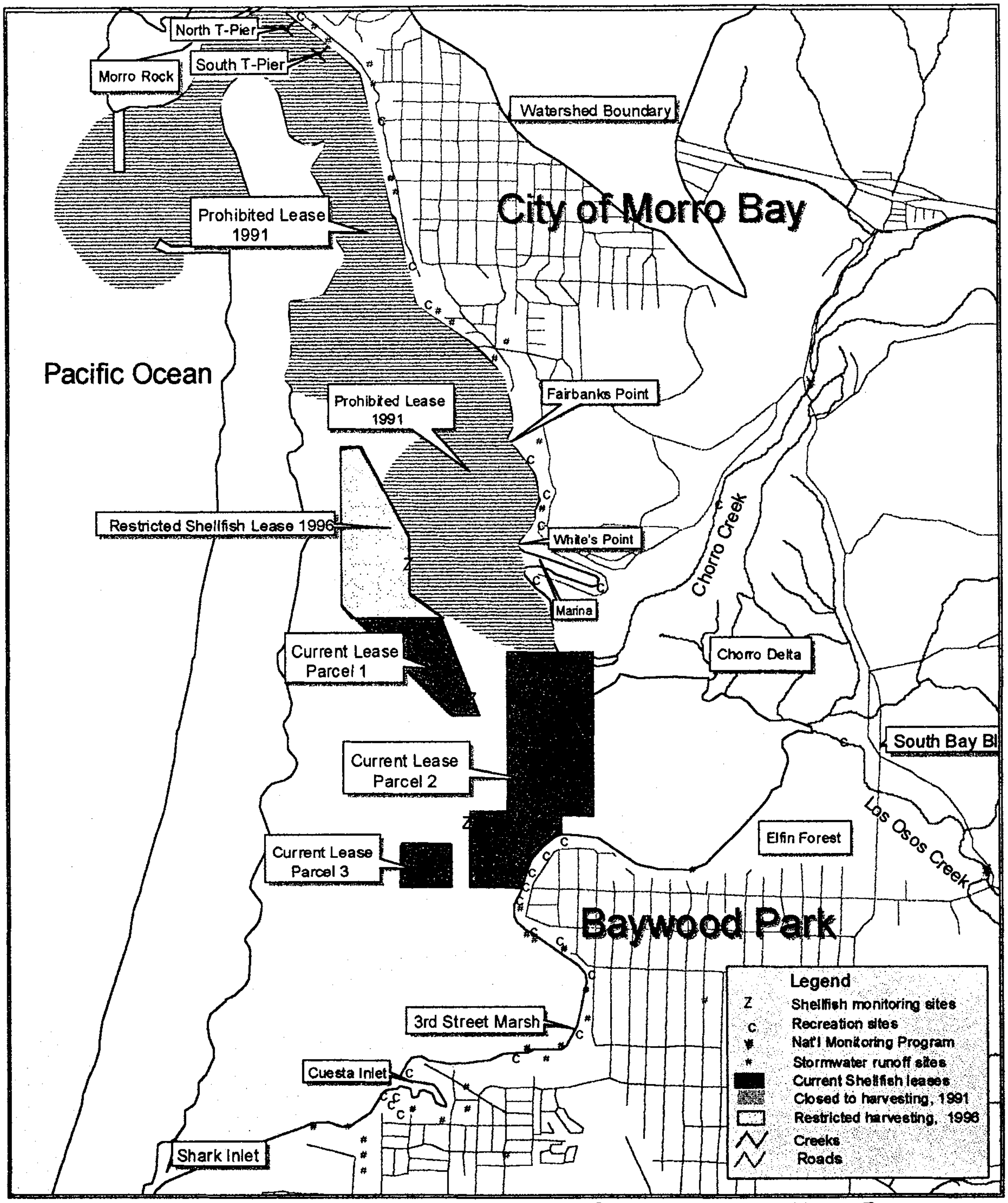



Figure 6.1 Shellfish Leases and Bacteria Sampling sites in Morro Bay
Source: Dept. of Health Services, RWQCB and MB Volunteer Monitoring Program
MBNEP Characterization 1999

## 6.3.2 Regional Water Quality Control Board 1988 Study

Perhaps the most thorough study of bacteria in Morro Bay was the 1986-1987 (CCRWQCB) Bacteria Study of Morro Bay. This study indicated that the greatest single point source of bacterial contamination to the bay was Chorro Creek (Anthony, et al. 1988). Elevated levels of bacteria were also found at the State Park Marina, along the Embarcadero, and in regions of the back bay. According to Anthony, certain areas within the estuary were not significant sources of bacteria, specifically, Los Osos Creek, the bay entrance, and the waters around the oyster beds. This finding distinguishes Los Osos Creek from Chorro Creek, even though they have similar watersheds. The major difference in land use between the two watersheds is the presence of the CMC on Chorro Creek with its effluent discharge into the creek, and the larger acreage devoted to rangeland and cattle operations. The bay entrance was of interest because there had been speculation that bacteria may be from the City of Morro Bay's offshore waste discharge, which received a waiver of secondary treatment requirements. The findings of the Anthony study appear to eliminate the City's discharge as a source of bacteria in Morro Bay. Finally, the oyster beds are of interest because the water around them was apparently clean, but the oyster meat often is contaminated. The implication is that the mud is contaminated, rather than the ocean water that passes by with each change of tide. Given the shellfish grower's belief that dredging leads to a major shutdown of his operation, this needs further investigation. Storm transports of bacteria may not have been considered in this study.

The CCRWQCB published a report based on their study which attempted to pinpoint the sources of the bacteria and what should be done to correct the problem (Anthony, et al 1988). For their two-year study, the CCRWQCB established 38 sampling stations around the bay and a short distance up the two creeks. They attempted to account for effects of weather (runoff from rain) and tides, and also investigated a number of point sources that were suspected origins of bacteria. After completion of the three-phase monitoring program and using prior data gathered by the DHS, the CCRWQCB was able to make several conclusions about where the bacteria counts were highest and violated standards.

Determining the source of the bacteria in Morro Bay was the main purpose of the 1988 study by the CCRWQCB. However, despite making progress in identifying levels of bacteria in certain areas of the estuary, the concentrations and loadings from specific land use has not yet been determined. For example, in the southern portion of the estuary, or Back Bay, bacteria counts were high, but it was not clear whether the problem was from birds, septic systems, or Chorro Creek.

## 6.3.3 1991-1996

In 1991, DHS prepared its Morro Bay Management Plan (DHS 1991). This document sets forth all aspects of the DHS program to regulate commercial shellfish harvesting in Morro Bay. It identifies potential sources of pollution, identifies prohibited areas around the Morro Bay/Cayucos wastewater treatment plant, Morro Bay State Park Marina, City-owned boat mooring areas and the embarcadero, live-aboard boats, and waters immediately outside the entrance to the bay. The document also includes closure and notification procedures. At that time, although not actually in production, Morro Bay was the third largest shellfishing area in California, after Humboldt Bay and Drakes Estero. In 1991, there were about 757 acres of commercial aquaculture leases in Morro Bay, and the bay was classified as "conditionally approved" for harvesting.

In 1993, the National Monitoring Program (NMP) established a program of collecting water samples from the two primary creeks, Los Osos Creek and Chorro Creek, and their tributaries that enter the bay. Total and fecal coliform levels have been monitored weekly during the winter season and every other week during summer months. Relatively high values have been documented in many parts of the watershed throughout the year.

In 1995 the MBNEP established a subcommittee to address the problem of bacteria in Morro Bay; this committee was subsequently renamed the Morro Bay Shellfish Technical Advisory Committee to satisfy the requirements of the Shellfish Protection Act. Approximately 12 meetings of these committees have been held in the past four years. The goals of the Morro Bay Shellfish TAC are to conduct water quality investigations and make recommendations for remedial actions to improve water quality in the affected shellfish harvesting areas. This TAC has a specific charge as spelled out in the 1993 Shellfish Protection Act of 1993, and is different than the NEP TAC.

The California Shellfish Protection Act of 1993 requires the regional boards to develop, with the assistance of a local Technical Advisory Committee (TAC), water quality investigation projects for threatened shellfish areas. Once the sources of pollution are determined, the CCRWQCB may, on the advice of the TAC, order appropriate remedial action to abate the pollution affecting the commercial shellfish growing area. The Act requires the CCRWQCB to monitor water quality in the threatened area during the implementation of pollution abatement measures to ensure that the measures are effective and to provide the results of the monitoring to the TAC.

The DHS 1996 Sanitary Survey Report (for the northern portion of lease M-614-01) reclassified the shellfish lease area from "conditionally approved" to "restricted" because sampling in the vicinity of station 13 (Figure 6-1) indicated that the area did not meet the National Shellfish Sanitation Program criteria for a conditionally approved growing area. This condition essentially led to the development of the Shellfish TAC referred to above. The rainfall closure period was extended from four days to eight days after 0.5" of rain for the conditionally approved areas. New sample sites were designated around Station 13 (13A, B, C, and D) and prohibited areas were established around the State Park Marina, city-owned boat slips, and boat mooring areas (DHS 1996).

### 6.3.4 1996 -Present

The DHS 1997 Sanitary Survey Update included the following conditions:

- Stations 11, 11A, 13AA, 13BB were conditionally approved; the rainfall closure threshold changed from 0.5 inches within any 24 hour period to 0.4 inches within any 24 hour period; 8-day closure;

- Station 12 was conditionally approved; closure duration reduced from eight to five days; threshold 0.4 inches.
- Stations 13, 13CC, 13DD were downgraded to prohibited; meets restricted

The DHS 1998 Sanitary Survey Update included the following conditions:

- Stations 11, 11A, and 12 were conditionally approved;
- Station 13 is prohibited. Sampling data indicates station 13 and other added stations in that prohibited area fail to meet the criteria for a conditionally approved classification.

In 1998, the Williams operation was 269 acres on two California Department of Fish and Game leases. Recommendations in the 1998 DHS report include continuing the prohibited classification near station 13, and studying the sources of pollution and developing a risk assessment of each identified source. By 1998, DHS also refers to failing septic systems as a potential source of unpredictable fecal contamination (DHS 1998). Most recently, the MBNEP sponsored a study to examine bacterial loadings in the estuary. Results are discussed below in Section 6.6.

## 6.4 REGULATORY STANDARDS

The concentration of pathogens in the water is measured, and compared to a "standard," the desirable level above which water quality is degraded and human illness or other problems could occur.

### *Central Coast Regional Water Quality Control Board*

The CCRWQCB is charged with determining trends in water quality as these trends relate to beneficial uses occurring in the bay. In 1997-98, CCRWQCB conducted an extensive sampling program to determine whether various regions of the estuary meet water contact recreational standards contained in the Basin Plan.

The CCRWQCB has relatively strict standards for water contact recreation, (also known as REC-1). For REC-1, the CCRWQCB measures *fecal* coliform and requires that the geometric mean of five samples within a 30-day period must not exceed 200MPN/100ml; or ten percent of all samples taken during any 30-day period must not exceed 400MPN/100ml. This standard provides a good statistical tool for data analysis of trends in water quality, but has not been found to be practical for beach closures due to the time required for collecting and analyzing data. For non-water contact recreation (REC-2), the standards are not as strict: 2000MPN/100ml and 4000/MPN/100ml. For shellfish harvesting, the RWQCB standard us based on median *total* coliform concentration throughout the water column. Median total coliform concentrations shall not exceed 70/100 ml for any 30 day period.

### *County Environmental Health*

The San Luis Obispo County Department of Environmental Health (DEH) has jurisdiction over public health in recreation areas, and part of their charge is to post health advisories near beaches and waters where it is unsafe to swim. The DEH measures water quality at beaches, where people are more likely to recreate. Because the County is responsible for protecting public health, they need to know about water quality problems as soon as possible. The County samplers generally take a few "grab samples," return to the lab and get results within 24-48 hours. If the results indicate poor water quality, the beach can be posted to warn bathers.

The DEH standards are based on *total* coliform. Currently they require that no more than 20 percent of the samples in any 30-day period shall exceed 1,000 MPN/100ml, and no single verified or duplicated sample shall exceed 10,000 MPN/100ml within a 48-hr period. These standards are used for beach or bathing area closures.

New standards for e*nterococcus* and *fecal* coliform are presently being proposed through AB411 (Draft Standards, February, 1 1999). The new minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas are proposed to be:

1) Based on a single sample, the density of bacteria in water from each sampling station as a public beach or public water contact sports shall not exceed:

   a) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform bacteria exceeds 0.1; or
   b) 10,000 total coliform bacteria per 100 milliliters; or
   c) 400 fecal coliform bacteria per 100 milliliters; or
   d) 104 enterococcus bacteria per 100 milliliters.

2) Based on a the mean of the logarithms of the results of at least 5 weekly samples during any 30-day sampling period, the density of bacteria in water from any sampling station as a public beach or public water contact sports shall not exceed:
   a) 1,000 total coliform bacteria per 100 milliliters; or
   b) 200 fecal coliform bacteria per 100 milliliters; or
   c) 35 enterococcus bacteria per 100 milliliters.

### *California Department of Health Services*

California DHS is charged with implementing the federal National Shellfish Sanitation Program, which calls for sampling during adverse pollution conditions in shellfish lease areas. DHS standards are for monitoring oyster-harvesting areas. For water quality samples taken on a monthly basis during a three-year period, no more than 10% of the samples shall exceed 43 MPN 100 ml for fecal coliform; or, 2) the geomean of the samples shall not exceed 14 MPN/100 ml.

There is no pre-harvest standard for shellfish meat samples, but the post-harvest standard is that the geomean of the samples shall not exceed 230 MPN/100 ml for fecal coliform.

## 6.5 IMPACTS TO BENEFICIAL USES

As discussed previously, the commercially harvested oyster beds have been periodically shut down due to intermittent and unpredictably high bacteria counts in the bay. This has resulted in financial impacts to the current grower. Increased levels of bacteria also present a potential health threat to those who utilize the bay for recreational purposes. Elevated bacteria levels can also have adverse effects on marine species utilizing the bay and are also an indication that other pollutants may be present. These impacts are discussed below.

### 6.5.1 Shellfish Harvesting

Oysters are filter-feeders. They take in water and draw off bacteria and nutrients, and sometimes retain bacteria in large concentrations. This can render them unsafe for human consumption. The DHS has been monitoring total and fecal coliform levels in Morro Bay for the protection of shellfish and public health since the mid 1980's. Results indicate that total and fecal coliform levels have been increasing at several monitoring locations. Data trends from Station 13 are shown in Figure 6-2. This portion of the local shellfish growing operation has recently been downgraded by DHS from "conditionally approved" to "restricted," resulting in economic losses to the oyster grower.

Others areas of the bay are closed to shellfish harvesting for 5-8 days following significant rainfall. The DHS closes the local commercial oyster operations if 0.4 inches of rain occurs in a 24 hour period. Stations 11 and 11A are closed for 8 days, and Station 12 is closed for 5 days. The DHS believes that the less frequent closures in the early 1990's resulted from the drought (Patrick Wells, DHS, pers. comm.).

In response to the increasing bacteria levels found by DHS, the CCRWQCB and the MBNEP began additional sampling efforts in the bay in March 1996. CCRWQCB and MBNEP staff collected total and fecal coliform samples in the bay during various tides in an effort to identify potential pollutant sources. These efforts are described in detail in later sections as they relate to specific sources. Sample sites are shown in Figure 6-1.

### 6.5.2 Water Contact Recreation

Rising levels of bacteria could also adversely impact existing recreational uses of the bay. Sailing, recreational boating, canoeing, and kayaking are increasing on the bay. Occasional wading and swimming occurs in some areas. During winter rains, bacteria levels at times exceed CCRWQCB standards for Water Contact Recreation for fecal coliform (200 MPN/100 ml) in certain regions of the bay. These elevated levels can make the bay unsafe for swimming and other forms of recreation as disease-causing organisms may be present.

In Spring of 1998, the CCRWQCB documented levels of bacteria in the Back Bay that exceeded the maximum allowed for water contact activities. The MBNEP is currently working with the CCRWQCB and Environmental Health to establish a coordinated monitoring program to document the observed trends and effectively notify the public of potential hazards, if necessary.

Sampling in the spring of 1998 resulted in the County posting body-contact advisories to notify residents that the water was contaminated.

### 6.5.3 Eelgrass Habitat

Eelgrass habitat has been known to have a positive impact on water quality in the estuary, particularly in its ability to reduce levels of fecal coliform. Eelgrass habitat is discussed further in Chapter 3.

### 6.5.4 Municipal and Domestic Water Supply [TBD]

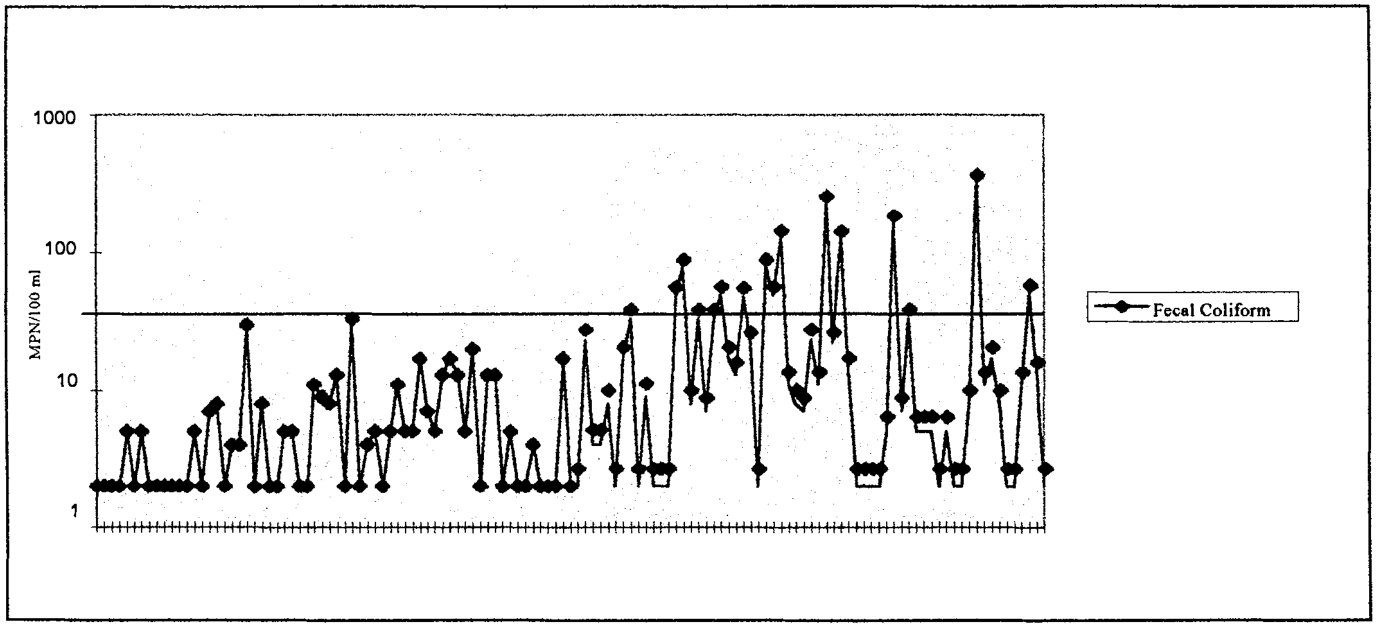



**Figure 6-2. Time series graph of Fecal Coliform Levels at Station 13 in the Morro Bay Shellfish growing areas, 1989-1997.** Horizontal line represents 43 MPN (Dept. of Health Services Shellfish Harvesting Standard). *Source: DHS data.*

## 6.6 SOURCES AND TRENDS

### 6.6.1 Overview

There are a number of point and non-point sources of bacteria to Morro Bay. Potential non-point sources include the following: agricultural runoff, urban runoff, leaking or failing septic systems, illegally moored boats with inadequate waste disposal capabilities (includes proper Marine Sanitation Device or ability to move to pump-out facilities), malfunctioning sewer lifts, domestic animal waste, and waste from marine mammals and wildlife. Many situations leading to discharge arise only during storm events, while others are year-round. Potential point sources are discussed in Section 2 of this document. They include the Morro Bay/Cayucos wastewater treatment plant, and the CMC wastewater treatment plant.

Table 2-4 lists the potential point sources of bacterial contamination via direct (or indirect) discharge to the bay and provides estimates of the relative flow rates. Ongoing efforts to reduce bacterial pollution from many of these point sources include activities such as wastewater treatment plant operation improvements.

The various non-point source activities leading to bacterial contamination are summarized in Table 6-1. On going efforts to reduce bacterial pollution from non-point sources include cattle exclusions and managed riparian pastures (e.g. time-controlled grazing), sediment retention projects and boater education. The magnitude of each source contribution is not yet known, but in 1986 it was estimated that Chorro Creek was contributing the greatest amount (Anthony et al., 1988).

### 6.6.2 1998 MBNEP Bacteria Study

In 1998, the MBNEP funded a Bacteria Loading and Circulation Study, conducted by Tetra Tech, to provide information and analyses to support the preparation of the Program's Comprehensive Conservation Management Plan (CCMP). The study entailed developing a model to show relative changes in bacteria levels based on alternative scenarios. It is the relative change that provides managers with information on where to focus attention for implementation of potential management practices to reduce the sources of contamination. The draft report from this study is currently under review. The preliminary results are described below.

The bacteria loading and circulation study was initiated to address three principal questions:

- What is the bacteria loading to the bay from various sources?
- How much of the bacteria present in oyster growing areas and recreational areas can be attributed to specific sources?
- How will bacteria concentrations in oyster growing areas and recreational areas respond to changes in bacteria loading?

The study assessed bacteria inputs from Chorro Creek and Los Osos Creek, urban runoff from the cities of Morro Bay and Los Osos, and groundwater inputs. Inputs from Chorro Creek and Los Osos Creek were established based upon data from the Section 319 NMP for the Morro Bay watershed. Urban stormwater runoff volumes were estimated based upon contributing areas and surface flows. Bacteria concentrations associated with that runoff were estimated based on measurements from the MBNEP volunteer water quality sampling and analysis program. Groundwater inflow volumes used were based on published studies, and associated concentrations were estimated based upon previous groundwater sampling studies and on reconnaissance sampling of freshwater seeps.

In order to quantify the concentration of bacteria present that can be attributed to specific sources and to predict impacts of changes in bacteria loading on bacteria concentrations in oyster growing areas and recreation areas, the circulation and die-off of bacteria in the bay were simulated using the Environmental Fluid Dynamics Code (EFDC) hydrodynamic circulation model of Morro Bay. This circulation model was developed as part of an earlier study in this series of technical studies conducted to support the MBNEP. The circulation model was calibrated for the period March 9, 1998 to April 9, 1998, to coincide with the period when tide and current data were recorded.

For the bacteria loading and circulation study, the model was set up to simulate bacteria impacts in the bay during a wet-weather period and during a dry-weather period. The wet-weather period covered a 20-day period from March 21 to April 9, 1998, and was chosen for the simulation because it included three storm events with associated runoff of fecal coliform bacteria through the stormwater inlets draining to the bay. The dry-weather period also covered a 20-day period from August 10 to August 30, 1997, when no rainfall was recorded. These 20-day periods provide ideal times for bacteria simulation because they included representative wet- and dry-weather conditions, and they were short enough to allow for reasonable model execution times. The model was calibrated based on bacteria monitoring data collected between July 1993 and July 1998 at three water quality monitoring stations located in oyster growing waters of the bay and reconnaissance data collected from recreation areas.

Six scenarios were simulated with the model to determine the impact of the various sources on fecal coliform bacteria concentrations in the three aquatic lease parcels and at 25 of the recreational water quality (REC-1) monitoring locations during wet-weather conditions. In addition to the wet weather scenarios, four scenarios were simulated with the EFDC model to determine the impact of the various sources on fecal coliform bacteria concentrations in the three aquatic lease parcels and at 25 of the recreational monitoring locations during dry-weather conditions. The predicted discrete values of fecal coliform bacteria concentrations computed by the model are best estimates based on the limited information available. Since the model has not been rigorously calibrated for fecal coliform bacteria, the discrete values computed by the model should not be used for regulatory purposes. The value of the model simulations lies in the relative change in fecal coliform bacteria due to the various alternative scenarios.

The Tetra Tech Bacterial Study focused on three key sources: (1) stream inputs from Chorro Creek and Los Osos Creek; (2) non-point source urban runoff; and (3) groundwater inputs. Their results, and results from other sampling efforts, are presented below.

**Table 6-1. - Relative Contributions of Potential Sources of Increased Bacterial Concentrations.**

| Location, Source | Relative Contribution | Reference |
|---|---|---|
| Bay, State Park Marina: Lack of Vessel waste-disposal facilities | Unknown; Could be locally high | Anthony 1988; DHS 1991 |
| Bay: Morro Bay embarcadero storm drains | High | Anthony 1988; DHS 1991 TetraTech 1999 |
| Bay: Morro Bay/Cayucos wastewater treatment effluent | Historically from 1955; currently not a source | DHS 1984; DHS 1991; Marine Research Specialists 1998 (Annual Monitoring Report) |
| Bay, Los Osos: Failing septic systems (groundwater) | None reported in 1974; further study needed; Frequent reports to SLO County of failing systems | DHS 1996; DHS 1998; Asquith 1998 pers. Comm.; TetraTech 1999; Martin, pers. comm. 1999 |
| Bay: Unauthorized live-aboard vessels | Small number, but no opportunity for pathogen die-off; high concentrated local source | Sharpe 1974; DHS 1991 |
| Bay: Polluted natural seeps | Low | Anthony 1988; TetraTech 1999 |
| Urban runoff (via storm drains) | High | DHS 1979; Anthony 1988; TetraTech 1999 |
| Bay: Waste from marine mammals and wildlife (birds) | Unknown | Sharpe 1974; Anthony 1988; TetraTech 1999 |
| Bay: Domestic animal waste | Moderate | Tetratech 1999 |
| Bay: Malfunctioning sewer lifts (City) | Low | |
| Chorro basin creeks: Agricultural runoff/confined animals | High | Sharpe 1974; Anthony 1988; TetraTech 1999 |
| Chorro basin creeks: periodic effluent spills at CMC wastewater treatment plant | Low | Sharpe 1974; DHS 1979; Anthony 1988 |
| Chorro basin creeks: Feed lots along San Bernardo Creek | No longer present; currently not a source | Robbins, pers. comm. 1999 |
| Los Osos Creek | Moderate | CCRWQCB 1998 |

### 6.6.3 Stream Inputs from Chorro and Los Osos Creeks

***National Monitoring Program (NMP) Results***

Numerous management practices are being implemented in the Morro Bay Watershed to reduce bacteria levels in the creeks that feed Morro Bay.

As part of the NMP, fecal coliform samples have been taken at 17 stream locations since 1995 in order to evaluate the effectiveness of BMPs in reducing bacteria levels. The impacts of traditionally managed "open pasture" cattle grazing on fecal coliform contamination are best illustrated by comparing concentrations at paired sites in the watershed. Fecal coliform values declined at the treatment sites on Chumash, Lower Chorro, and Upper Chorro Creeks (CHU, CVC, and DAM) relative to the respective control sites after implementation of best management practices. As indicated in Section 2, Chumash and Walters Creeks are being monitored in a paired watershed study, and are very similar in many respects. However, in Chumash Creek best management practices including a managed grazing system have been implemented. The resulting geometric mean fecal coliform concentration in Chumash Creek (CHU) is 108.2 MPN/100 ml versus a geometric mean concentration of 554.5 MPN/100 ml in Walters Creek (WAL). Given these observations, it appears that cattle grazing has a significant impact on the fecal coliform concentrations in Chorro and Los Osos Creeks and thus on the bacteria loading to Morro Bay.

Preliminary NMP data collected since 1993 suggests that best management practices such as managed grazing systems and cattle exclusions are effective in reducing fecal coliform concentrations. Implementation of these types of BMPs throughout the watershed could reduce the bacteria loading in Chorro Creek, and thus reduce the potential for contamination of oyster growing areas. Additional details can be found in the National Monitoring Program's 1998 annual report (CCRWQCB, 1998.)

For the Chorro Creek watershed, the lowest geometric mean fecal coliform concentrations are found in the upper parts of the watershed below the Chorro Creek Dam and along Dairy Creek. The highest geometric mean fecal coliform concentrations are found in streams draining cattle grazing areas. Geometric mean fecal coliform concentration at the Canet Road sampling station on Chorro Creek is lower than for the upgradient grazing-impacted tributaries, but the concentration rises at the Twin Bridges station where Chorro Creek enters Morro Bay, most likely due to the high concentration inputs from San Bernardo Creek and San Luisito Creek.

For the Los Osos Creek watershed, geometric mean fecal coliform concentrations are highest at Turri Road sampling location, which is downstream of grazing-impacted drainages and adjacent to row crops. Geometric mean concentrations at the remaining Los Osos Creek watershed stations range from around 190 to 280 MPN/100 ml, values that are lower than most observed in the lower part of the Chorro Creek watershed.

### *Tetra Tech Modeling Results*

In order to calculate bacteria loading to Morro Bay from Chorro Creek and Los Osos Creek, samples collected from the Twin Bridges (TWB) and Santa Ysabel Road (SYB) sampling locations (Figure 5-5) were used along with flows derived from the Morro Bay Watershed Streamflow Modeling Study (Tetra Tech 1998). Concentrations for days when samples were not collected were estimated using linear interpolation. As indicated, concentrations are typically below 1,000 MPN/100 ml, but on occasion can rise to over 50,000 MPN/100 ml. As with Chorro Creek, concentrations in Los Osos Creek are typically below 1,000 MPN/100 ml, but on occasion can rise to over 30,000 MPN/100 ml.

### *Recreational Water Quality Results*

The 1995-1998 NMP and recreational water quality monitoring data indicate that both Chorro and Los Osos Creeks are substantial contributors to the fecal coliform levels in the bay. Samples taken from the mouths of Los Osos and Chorro Creeks (Figure 6-1) indicate that high levels of fecal coliform are being discharged to the bay.

Figure 6.3 illustrates Chorro Creek levels are above the RWQCB screening levels year round and 50% of the samples (n=142) exceed screening levels of 200 MPN/100ml. Los Osos Creek levels are higher than Chorro Creek primarily during wet weather periods and approximately 60% of the samples (n=113) exceed screening levels. It is believed that this is primarily due to grazing.

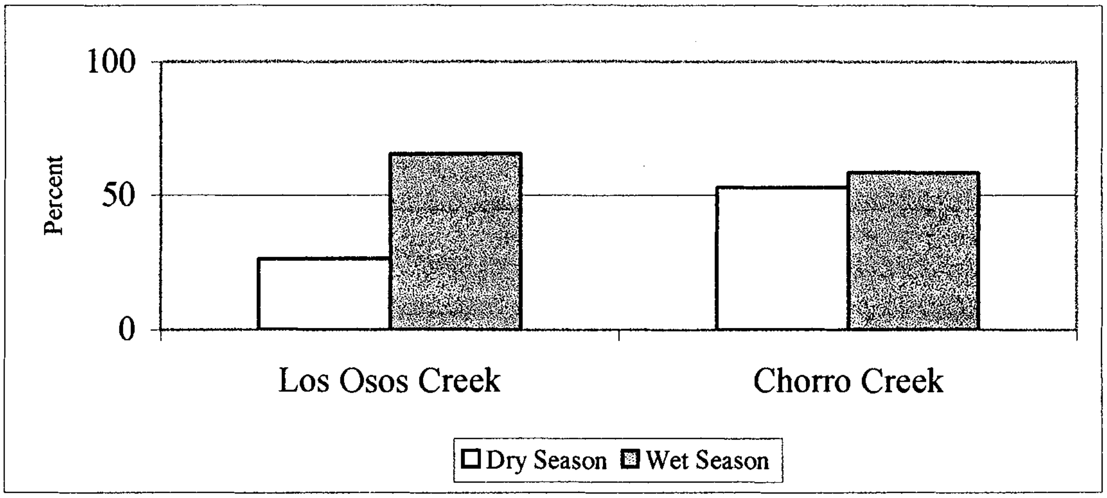



**Figure 6-3. Percentage of samples exceeding 200 MPN (CCRWQCB Rec-1 Standard) Fecal coliform in Los Osos and Chorro Creeks.** *Source: Regional Water Quality Control Board, Rec-1 and National Monitoring Program Sampling data.*

Because the flow rate of Chorro Creek in a 100 year storm event is about four times that of Los Osos Creek (Table 6-1), thus making it the largest contributor of fresh water flow to the estuary, Chorro Creek is a significant source of bacteria to the estuary and, not surprisingly, has an enormous fecal coliform load.

Based upon available data, Tetra Tech estimated total fecal coliform bacteria loading to Morro Bay over the wet weather simulation period to be 13.8 x $10_{12}$ MPN. Of this total, 48% comes from Chorro Creek, 9% from Los Osos Creek, 42% from surface runoff, and less than 1% from groundwater, as charted in Figure 6-4. These are preliminary results, however, and the amounts are still being verified. The results of the 1999 Tetra Tech study indicate that bacteria loadings from Chorro Creek have the greatest effect on bacteria concentrations at two of the three shellfish aquaculture lease parcels.

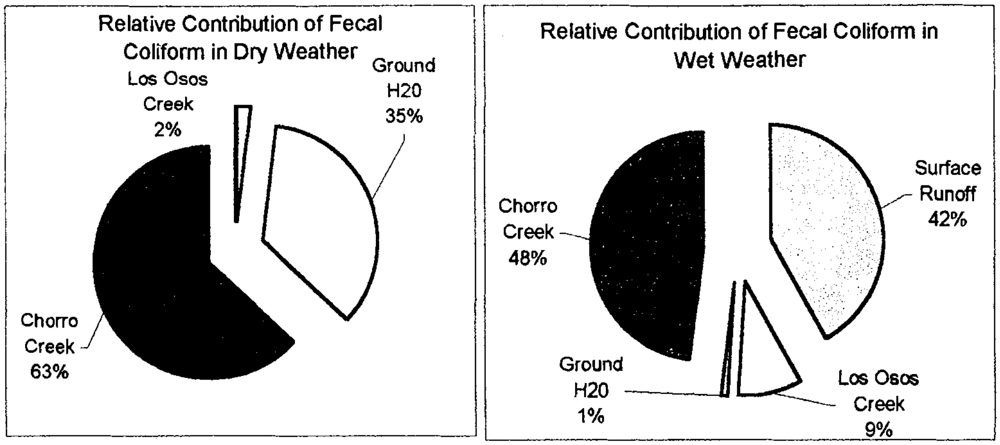



**Figure 6.4 Estimated Relative Contributions of Fecal Coliform in Dry and Wet Weather.**
*Source: TetraTech Bacteria Loading Study 1999.*

## 6.6.4 Urban Surface Water Runoff

Urban runoff to Morro Bay also constitutes an important source of bacteria. The CCRWQCB conducted a recreational water quality (REC-1) sampling effort in 1997 an 1998. Over 300 water samples were taken at 31 sites during a 3 day period. Sites were located at: (1) shoreline areas along the perimeter of the bay; (2) Chorro and Los Osos Creeks (Figure 6-3); and, (3) at freshwater seeps (Figure 6-1). Samples taken from Chorro Creek and the freshwater seeps were elevated during both the dry and wet seasons. (CCRWQCB 1998). During the dry season, the geomean of all shoreline sites sampled were within standards (Figure 6-5). Of the 25-shoreline sites sampled during the wet season, the geomean of samples taken at Cuesta Inlet and Baywood Cove exceeded Basin Plan standards (Figure 6-5).

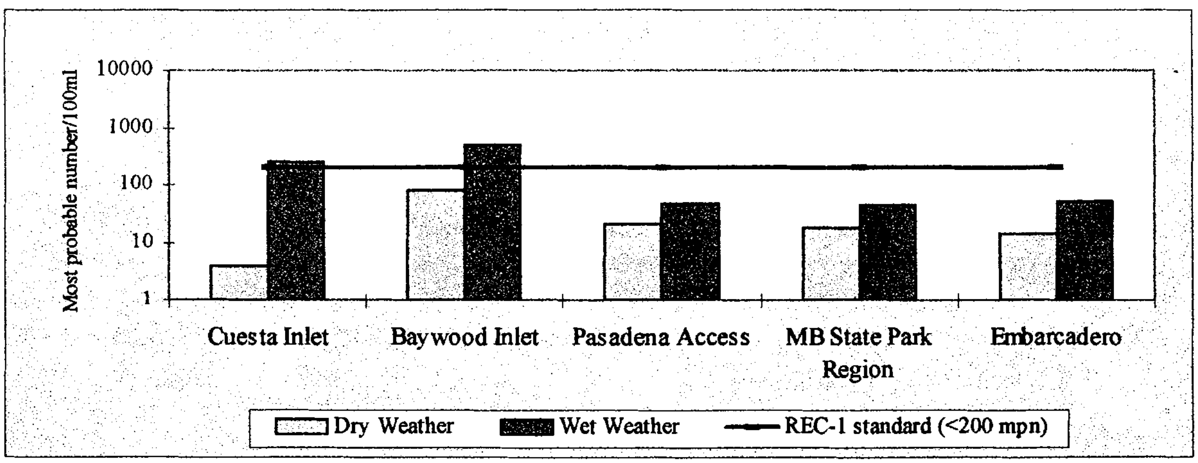



**Figure 6-5. Comparison of fecal coliform geomeans in Morro Bay recreational areas, dry weather (Fall 1997) and wet weather (Spring 1998).** All value bars represented by 25 samples each, each site an average of 5 regional sites. *Source: Regional Water Quality Control Board Rec-1 Sampling.*

As previously discussed, bacteria levels are greatly elevated in runoff to the bay when it is sampled during wet weather. In an effort to characterize water quality of urban runoff, samples were collected during the "first flush" winter rains of 1995-96 through 1997-98. Sample sites are shown in Figure 6-1. Figure 6-6 summarizes the data from the three-year period of collection. Samples were taken from gutters, culverts and storm drains throughout the urban areas adjacent to Morro Bay and Los Osos. Results show extremely elevated levels of fecal coliform (as high as 900,000 MPN/100ml). The geometric means of fecal coliform levels documented in Los Osos (111,435 MPN/100ml) were significantly higher than those in Morro Bay (9,266 MPN/100ml). Samples from the Morro Bay urban areas are consistently lower than samples from the Los Osos urban areas. Exact reasons for this are unknown, and the MBNEP "first flush" data is very limited. Additional information is needed to determine trends.

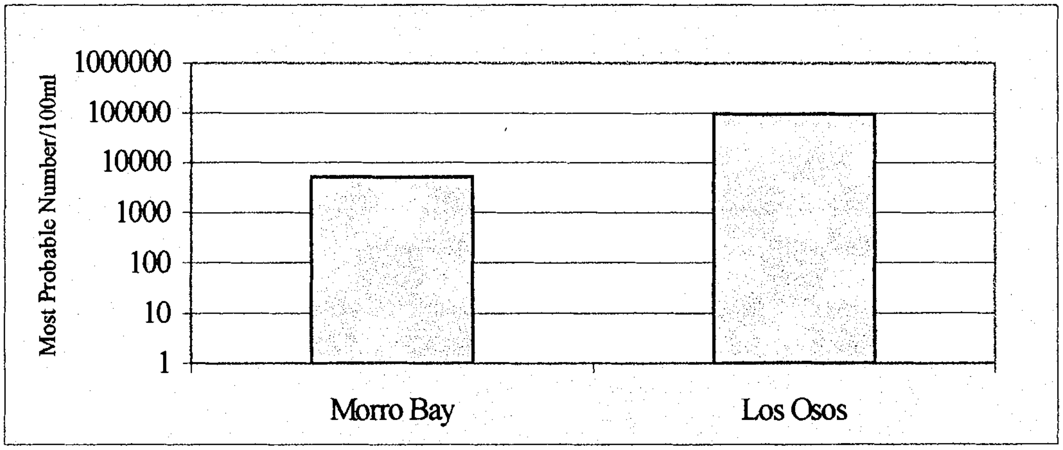



**Figure 6-6. Fecal Coliform geomeans for storm event sample sites in Los Osos and Morro Bay.** *Source: Regional Water Quality Control Board, MBNEP and FOE Volunteer Monitoring Program stormwater runoff data.*

The Morro Group and Tenera Environmental Services (Asquith 1990) estimated volumetric surface inputs to the bay from nine locations. Tetra Tech (1999) estimated bacteria inputs to the estuary from these points based upon the results of the volunteer stormwater sampling efforts described above. Data inputs into the model for first flush fecal coliform bacteria concentrations associated with the Los Osos area ranged from 1,600 MPN/100 ml to 90,000 MPN/100 ml and those associated with the City of Morro Bay ranged from 4,500 MPN/100 ml to 90,000 MPN/100 ml.

The preliminary results of the Tetra Tech Draft Bacterial Loading study (1999) indicate that stormwater runoff from Los Osos has the greatest impact on bacteria concentrations at the southernmost shellfish lease parcel. However, the draft study indicates that stormwater runoff significantly impacts fecal coliform concentrations in the oyster growing areas in general. Recreational areas are affected most by bacteria loadings from nearby surface runoff during the wet season. This suggests that studies into the feasibility of the collection and treatment of stormwater might be appropriate. A wide array of treatment options may be appropriate, but a cost-effective alternative that should be considered if a study of this type is initiated is wetland treatment. Such treatments may include a constructed wetland that is designed to simulate the water quality improvement functions of natural wetlands such that it treats and contains storm water runoff pollutants and decrease loadings to surface waters (EPA 1993). This alternative is passive and offers the benefit of flow equalization as well as removal of contaminants.

### 6.6.5 Groundwater Inputs

Another potentially important source of bacteria to the City of Morro Bay is that generated from leaking and failing septic tanks in the Community of Los Osos. These bacteria enter the bay through groundwater.

The U.S. Geological Survey (USGS) estimated groundwater inputs from the Morro Bay watershed to the ocean and the bay at 590 acre-ft/yr in 1985 (Yates and Wiese 1988), with approximately two-thirds going to the ocean and the remainder to the bay. However, 1985 was a very dry year and the USGS estimate is widely regarded as low for an average year. Therefore, the volumetric input value used for circulation modeling purposes was 600 acre-ft/yr directly to the bay.

The bacteria concentration associated with groundwater inputs was taken from samples labeled "freshwater seepage" in a data set from a 1996 reconnaissance study of seeps and freshwater discharges. Four values of fecal coliform were reported: 2, 4, 240, and 240 MPN/100 ml. Based upon very limited available bacteria data taken during dry weather, a value of 100 MPN/100 ml was chosen for use as input for the circulation modeling. This value seems low given the high nitrate concentrations associated with the same samples (~70 mg/l), but selection of a higher value for fecal coliform concentration could not be justified on the basis of the freshwater seepage data or the "*Los Osos/Baywood Park Area Consideration of an Immediate Prohibition of Waste Discharge from Additional Individual Waste Water Disposal Systems*" study (CCRWQCB 1984), which had a single observation of groundwater fecal coliform concentration of 1,100 MPN/100 ml but all remaining samples were below 150 MPN/100 ml with most less than detection levels.

Elevated fecal coliform levels have been continuously found in freshwater seeps located along the fringes of Los Osos and Baywood Park. Levels reaching 28,000 MPN/100ml were found at one location in August 1997. Elevated levels of nutrients have also been documented at various freshwater discharges into the bay (see Section 7.0).

Samples of freshwater seeps taken during both dry weather and wet weather periods have been elevated. Likely sources include leaking or failing septic tanks, birds and wildlife, or domestic animals. Additional research is needed to determine if the fecal coliform is of human or animal origin.

Discharge of collected surface and subsurface flow to the bay occurs at two San Luis Obispo County sites. These are the "standpipe" in the bay near the intersection of 3rd and El Moro Streets, and the outfall near the intersection of Ramona and Fearn Streets. The standpipe drains the 8th and El Moro sump area, and the Ramona outfall drains the Donna and Mitchell area. The CCRWQCB has taken quarterly samples at the intake and outfall for each drainage station. Both locations show higher fecal coliform levels during the wet season due to surface runoff although additional data is needed to establish trends, these discharges are draining high groundwater areas in Los Osos. It is believed by some that increased development of septic systems in Los Osos has caused water levels in the upper aquifer to rise in elevation. This is due to the presence of an underlying clay layer that is believed to separate the upper and lower aquifers, and prevent movement of water from the upper to the lower.

There is a widespread, and not unreasonable, perception that septic systems in Los Osos are contributing to contamination of the bay. This perception is supported by the extremely high (e.g., 70+ mg/l) nitrate concentrations observed in groundwater wells and in freshwater seeps.

However, commensurately high concentrations of fecal coliform bacteria are not observed in the groundwater wells or freshwater seeps. In addition, the 1998 Tetra Tech model results suggest that groundwater fecal coliform concentrations higher than those supported by observations might explain the lower-than-observed simulated coliform concentrations at the recreational areas. All of these points taken together suggest the need for an intensive analysis of the role of groundwater in fecal contamination of the recreational areas. The type of study needed would involve intensive monitoring of groundwater elevations and contaminant concentrations over an extended period of time (i.e., 2 or more years).

The preliminary results of the 1999 Tetra Tech study indicate that bacteria from groundwater sources have little effect on any shellfish lease parcel. In the dry season, groundwater loadings have the greatest effect on the recreation areas along the shoreline of the southern portion of Morro Bay.

### 6.6.6 Derelict and Liveaboard Vessels

On May 5, 1992, the State Lands Commission (SLC) entered into a lease with the CDFG and the State Department of Parks and Recreation (DPR) for the management of two adjacent tracts in south Morro Bay (Figure 4-1). The purpose of this lease was to allow these two agencies, each with a staff presence in the Morro Bay area, which the SLC lacks, an opportunity to better manage the resources and the uses of the bay. A variety of initiatives were undertaken by the lessees to resolve the problem of unauthorized vessel mooring. A census of vessels was conducted; research of records was initiated to establish, where possible, vessel ownership; contact was made with the owners of the vessels-in-question; volunteer groups were approached for assistance; and various meetings were held. In addition, considerable time and energy was expended in pursuit of a formalized marina concept as a means to solve the problem. Ultimately, and for a variety of reasons, this marina solution did not appear to be feasible, and a management plan still has not been agreed upon.

There is both a direct and indirect problem associated with the unauthorized vessels in the south part of Morro Bay. Of direct concern is the fact that many of these vessels are occupied (liveaboards) and dispose of their waste at anchorage. Given the proximity to the shellfish lease, this most certainly is contributing to the fecal coliform problem the DHS is monitoring. Solutions include reducing the number of these vessels by removing them or equipping them with MSDs.

Discharge from liveaboards in Morro Bay is not always effectively controlled because of multiple governmental jurisdictional areas in the Bay. As discussed above, 2,000 acres of the estuary are leased to CDPR and CDFG by the State Lands Commission. A liveaboard ordinance developed by the City of Morro Bay defines liveaboard vessels and requires regular inspections of vessels and pump-out stations (City of Morro Bay Ordinance No. 407 "Vessel Habitation"). Currently, there are four pump-outs located near the bay. They are located at Tidelands Park (this location is most accessible), Marina Square, the south T. Pier, and beacon fuel dock. The marina within Morro Bay State Park does not have a pump-out facility.

### 6.6.7 Birds and Wildlife

According to Tetra Tech, the model simulations described above do not include estimates of fecal coliform bacteria loadings from waterfowl or other wildlife. Given the reasonable agreement shown between simulated and observed concentrations in the oyster-growing areas without invoking these sources, the model indicates that the impact of fecal coliform loadings from waterfowl or other wildlife are small relative to the sources included and have minimal impacts on the bacteria concentrations in the aquatic lease parcels. However, the underestimates of fecal coliform concentrations for the recreation areas indicate that local sources such as waterfowl may play an important role in determining fecal contamination levels in these areas. A study focused directly on estimating these inputs for specific local areas may provide insights regarding the importance of wildlife inputs. However, relatively little could reasonably be done to reduce these loadings.

### 6.6.8 Fish Processing Activities

Lastly, fish processing on commercial fishing boats has previously been discussed as a source of bacteria, but it has not yet been identified as a significant source. Because the Morro Bay estuary does support a viable fishing industry, potential opportunities exist to work with the fish processing industry to explore innovative treatment methods (e.g. salt water) in the future.

### 6.6.9 Further Bacteria Research Needs

Conducting further research provides a better understanding of the processes that occur in the watershed and estuary. The additional knowledge provides the program with the tools and techniques that can help guide management decisions. The following bacteria research needs were developed by the MBNEP Technical Advisory Committee (TAC). These research needs include, but are not limited to:

1. What other processes are effective at filtering bacteria from surface water? Wetlands? Floodplains, etc?
    - Constructed wetlands have demonstrated high removal rates for bacteria. Providing streams access to their floodplains would reduce bacteria and other pollutant loads from reaching the Bay.

2. What is the effective minimum width for fenced riparian buffer to improve water quality improvement?
   - Buffer strips are a proven effective BMP at reducing sediment, bacteria, and nutrient levels in surface waters. Buffer width effectiveness is dependent on various factors such as slope length, slope angle, soil type, vegetation types, volume of runoff, and adjacent land uses.

3. What is the best pathogen indicator for stormwater runoff?
   - Technical studies have demonstrated high bacteria levels in stormwater runoff from urban and suburban areas.

# 7.0 INCREASED NUTRIENT LEVELS IN MORRO BAY AND WATERSHED STREAMS

## 7.1 INTRODUCTION

Nutrient enrichment, primarily nitrogen and sometimes phosphorous, has been identified as one of the primary problems confronting the nation's estuaries. Impacts of nutrient enrichment include increased algal growth, decreased water clarity, toxicity, and reduced dissolved oxygen levels. When excessive nutrients are present, alga growth can become excessive and eutrophication can result as the alga dies and decays and robs the water of oxygen. Fish kills and losses of sea grass beds are common consequences. Both the nitrate form of nitrogen and phosphates can lead to eutrophication; however, in the Morro Bay watershed it is believed that phosphate is regulating dissolved oxygen levels more than nitrates (as discussed in Section 7.5.3.)

Nutrients found in the Morro Bay estuary may originate from urban run-off, leaking or failing septic systems, animal waste, wastewater discharges, urban and agricultural fertilizer application, birds and wildlife, and other natural processes. Changes in the nutrient balance entering the estuary can be anticipated over the coming years, as changes in wastewater treatment facilities, population levels, and agricultural practices occur.

Nutrients are of concern both in the estuary and the watershed. Bay researchers have identified algae blooms as a problem in the back bay, particularly those involving *Ulva* and *Enteromorpha*, which are both opportunistic algal species which thrive in nutrient-rich environments (Josselyn 1989). Blooms are often the result of excessive nutrients reaching the water body.

Much of the bay flushes completely during tidal changes and the overall impacts of nutrients on the health of the system is currently unclear. There is a need for a more detailed examination of the current impacts of nutrients on the estuary, and an assessment of probable future impacts linked to predicted changes in nutrient loading. The supply of dissolved oxygen is crucial for freshwater and marine organisms to respire.

High levels of nutrients are being documented entering Morro Bay from its tributary creeks, from shoreline seepage in the vicinity of onsite systems, and from surface and groundwater discharge systems. The Morro Bay National Monitoring Program (NMP) has developed a relatively long-term database for nitrate and phosphate, and dissolved oxygen levels in the Chorro Creek watershed. Five years of data have been collected from a number of locations on a biweekly basis, with weekly sampling during winter months. The results of this effort are discussed briefly below and in Section 7.5.3.

## 7.2 DEFINITIONS

*Dissolved Oxygen* is the concentration of oxygen (mg/l or % saturation) that is dissolved in a water body.

*Eutrophication* is a process that relates to natural and sometimes artificial addition of nutrients to a system resulting in depleted oxygen concentrations.

## 7.3 REGULATORY STANDARDS

According to the Central Coast Regional Water Quality Control Board (CCRWQCB) Basin Plan, the objectives for all inland surface waters, enclosed bays, and estuaries, include the following:

- *Dissolved oxygen* concentrations shall not be reduced below 5.0 mg/l at any time. Median values should not fall be low 85 percent saturation as a result of controllable water quality conditions. In cold freshwater and marine habitats, dissolved oxygen concentrations shall not be reduced below 7.0 mg/l at any time.

- *Biostimulatory substances (i.e., nutrients)* should not be present in concentrations that promote aquatic growth to the extent that such growths cause nuisance or adversely affect beneficial uses.

- *Nitrate (as NO3)* shall not exceed 45 mg/l for domestic or municipal water supplies.

## 7.4 IMPACTS TO BENEFICIAL USES

### 7.4.1 General Impacts

***Nutrient Enrichment***

Recent monitoring conducted through the NMP has documented high levels of nitrate and phosphate in lower Chorro Creek. Some of this is a result of effluent discharge, but high levels have also been detected in San Bernardo Creek and Turri Road, which drains agricultural lands. High nitrate levels have also been detected in the bay, just offshore of the Los Osos area. These high levels may result from septic systems in the area. Location of nutrient sampling sites in Morro Bay are shown in Figure 7-1.

***Dissolved Oxygen Effects***

Dissolved oxygen (DO) levels are monitored bi-weekly throughout the Morro Bay watershed for the (NMP). Low dissolved oxygen levels have been detected periodically throughout the watershed, primarily during low flow periods, and have been seen to contribute to steelhead kills. Reduced oxygen levels have been consistently detected downstream of Warden Lake on Los Osos Creek and at Twin Bridges on Chorro Creek. In both locations, low water flows, increased nutrient levels, and tidal influence contributes to this problem. Other incidents of low dissolved oxygen appear to be directly related to reduced water flow and increased temperatures in the creek. Water quality objectives are violated when oxygen levels drop below 7.0 mg/l. At the Los Osos site in particular, levels are often below this level, except during high flow events.

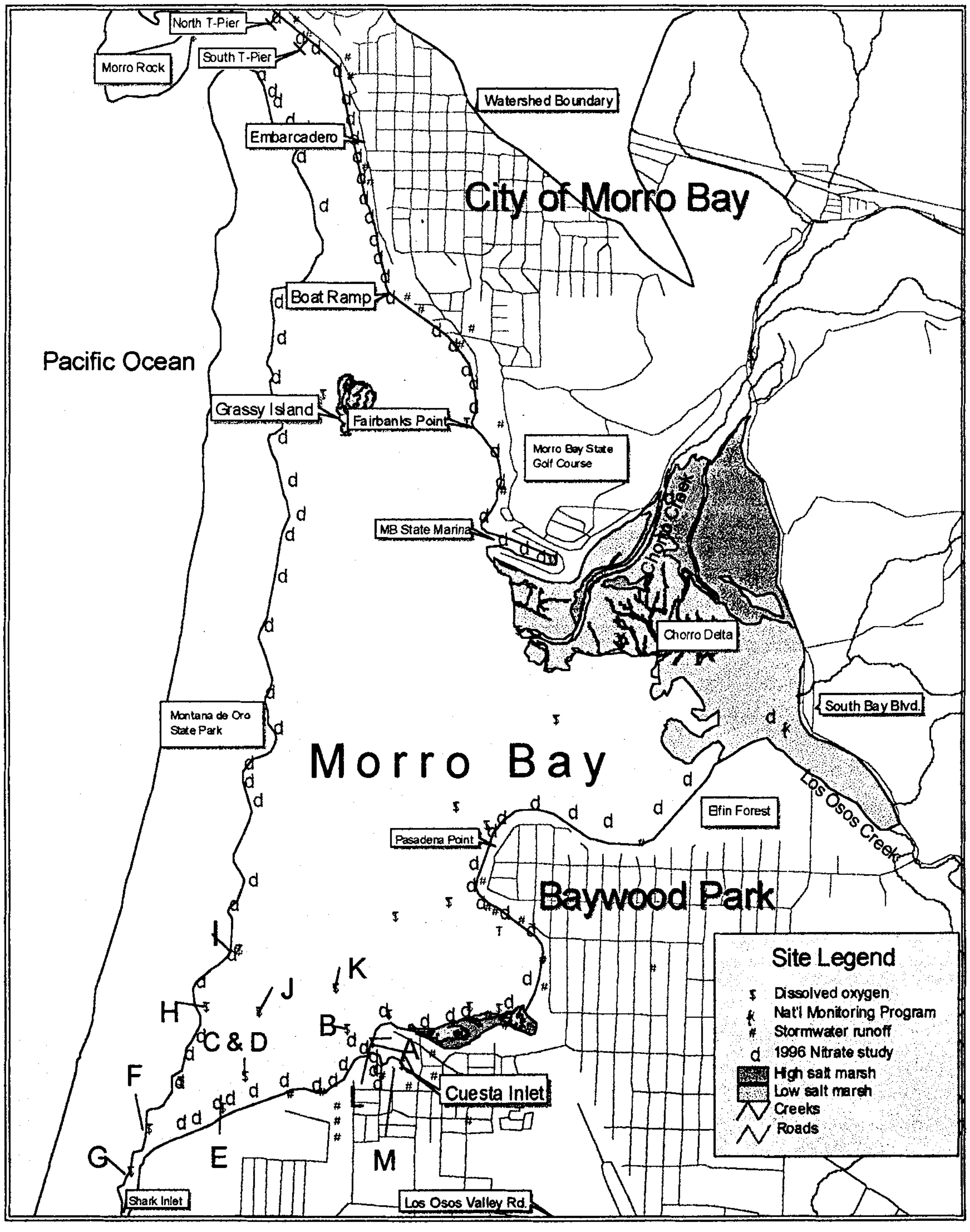



Figure 7.1 Location of Nutrient Sampling Sites in Morro Bay

Source: Morro Bay Volunteer Program and Regional Water Quality Control Board

MBNEP Characterization 1999

Sampling of dissolved oxygen by volunteer monitors in the backbay at pre-dawn has also shown depressed levels. As illustrated in Figure 7-2, dissolved oxygen levels fell below 5.0 mg/l, which can stress biological organisms. Shark's Inlet, at the southern most part of the estuary, has consistently the lowest average (4.80 mg/l) of dissolved oxygen levels most likely due to low tidal circulation. In Fall, levels increase, possibly because algae decomposition is lowest this time of year. While depressed levels that may impact marine organisms have been found, continuous hypoxic or anoxic conditions have not been documented. More data throughout the delta region is required to establish trends and any correlations.

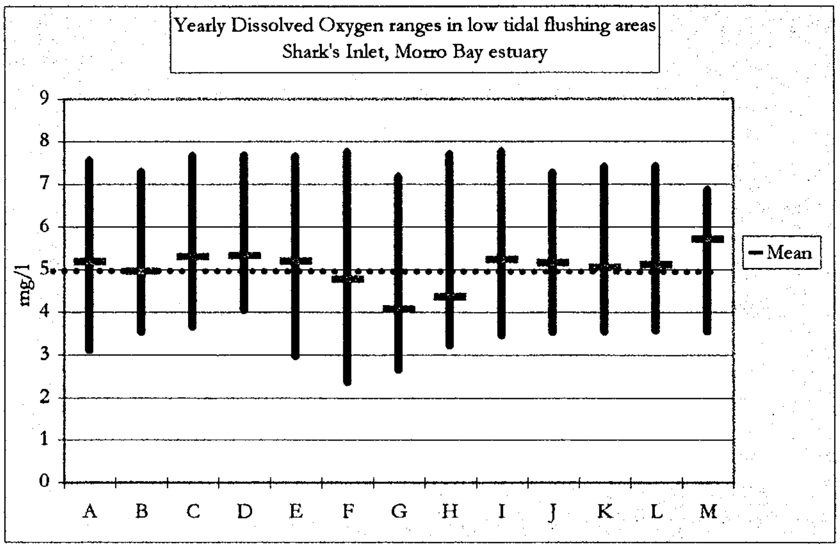



**Figure 7.2. Mean values of Dissolved Oxygen for sampling sites located in Shark's Inlet, Morro Bay, 1997-1998.** (A, B, C, etc. refer to site locations in Figure 7-1.) *Source: MB National Estuary Program Volunteer Monitoring data*

## 7.4.2 Beneficial Uses Affected

***Municipal Water Supply***

High nutrient levels impact community, military, or individual water systems making the sources unsafe for use as drinking water. All surface waters are to be considered for drinking water unless found to be unsuitable as defined in the Basin Plan.

***Cold Fresh Water Habitat***

High nutrient levels contribute to lower dissolved oxygen levels in the creeks, impairing them as cold fresh water habitat, and possibly as warm fresh water habitat and wildlife habitat. Levels falling below 5.0 mg/l can cause anoxic conditions, where there is not enough oxygen available for organisms.

*Preservation of Rare and Endangered Species*

High nutrients and low dissolved oxygen combined with low water flows impairs habitat for tidewater goby, a federally endangered species in the brackish water habitat where the creeks meet the bay.

*Ocean Commercial and Sport Fishing; Shellfish Harvesting*

Excessive algal growth in the bay results in dissolved oxygen reductions, impairing the bay as nursery habitat for fish.

## 7.5 SOURCES AND TRENDS

### 7.5.1 Overview

There are several sources of nutrients present in the watershed. They include fertilizer applications to lawns and croplands, leaking and failing septic systems, and runoff from urban areas. Nutrients have not been studied in detail in Morro Bay proper, but nitrate in particular is a pollutant of concern. A dissolved oxygen sampling program throughout the bay has recorded depressed levels on a number of occasions, particularly in the southern reaches of the bay. Algal species Ulva and Entermorpha appear to have increased in recent years, although it's effects have yet to be studied.

The community of Los Osos/Baywood Park, population 15,000, is located directly on the edge of Morro Bay, and is still served primarily by onsite septic systems. It has been determined that effluent has been entering groundwater in this area (Brown and Caldwell, 1984). This has provided the basis for a 14 year building moratorium. It is possible that some of this degraded groundwater is emerging from natural springs or seeps and entering the bay. Very high pulses of nutrients exceeding State drinking water standards (45 mg/l) have been noted entering the bay following rain events (at times over 150 mg/1 nitrate) and throughout the year from subsurface flows (exceeding 65 mg/1). Nitrate levels in the bay adjacent to Los Osos are elevated and runoff from the area often exceeds 50 mg/1. A new sewer system is planned, but exact project component details are not known yet. Through state regulation, standards for nutrient treatment must be met before any approval of a sewer system is granted; which would result in the lifting of the building moratorium.

Intensive farming occurs adjacent to both Chorro and Los Osos creeks. High levels of nitrates impair groundwater in both watersheds. Freshwater entering the bay is also relatively high in both nitrate and phosphate concentrations.

Unless significant changes to waste water treatment and fertilizer application occur, nutrient loading to the bay from urban areas will probably increase as the population of the area continues to grow.

## 7.5.2 1998 MBNEP Nutrient Study

In 1998, The MBNEP funded a Nutrient Loading and Cycling Study, conducted by Tetra Tech, to provide information and analyses to support the preparation of the Morro Bay National Estuary Program's (MBNEP) Characterization Report and the Comprehensive Management Plan. The model developed (Tetra Tech 1999), however, is not in good agreement with the observations, and the use of the model is limited to characterizing broad relative changes. The relative change in nitrogen concentrations for the scenarios analyzed in the Tetra Tech study still give meaningful insight as to which loading sources have significant impacts on bay water quality. It is the relative change that provides managers with information on where to focus attention for implementation of potential management practices to reduce the contamination. The purposes and preliminary results are described below.

The nutrient loading and cycling study was initiated to address three principal questions:

- What is the nutrient loading to the bay from various sources?
- What percentage of the nutrients found in the bay can be attributed to specific sources?
- How will nutrient concentrations in the bay respond to changes in nutrient loading?

The Tetra Tech study assessed nutrient inputs from Chorro Creek and Los Osos Creek, urban runoff from the cities of Morro Bay and Los Osos, and groundwater inputs. Inputs from Chorro Creek and Los Osos Creek were established based upon data from the Morro Bay Watershed Clean Water Act Section 319 National Monitoring Program. Urban stormwater runoff volumes were estimated based upon contributing areas and surface flows. Nutrient concentrations associated with that runoff were estimated based on observations from a volunteer water quality sampling and analysis program. Groundwater inflow volumes used were based on published studies, and associated concentrations were estimated based upon previous groundwater sampling studies and on reconnaissance sampling of freshwater seeps.

The objective of the Tetra Tech study was to quantify the concentration of nutrients present that can be attributed to specific sources and to predict impacts of changes in nutrient loading on nutrient concentrations in the bay. The cycling of nutrients in the bay was simulated using the Environmental Fluid Dynamics Code (EFDC) hydrodynamic circulation model of Morro Bay. This circulation model was developed as part of an earlier study in this series of technical studies conducted to support the MBNEP. The model was calibrated based on data collected in 1996 at over 100 stations located along the shoreline of the bay.

Six scenarios were simulated with the model to determine the impact of the various sources on nitrate and phosphate concentrations at the monitoring locations during wet and dry weather.

In order to calculate nitrate and phosphate loading to Morro Bay from Chorro Creek and Los Osos Creek, samples collected from the Twin Bridges (TWB) and Santa Ysabel Road (SYB) NMP sampling locations were used along with flows derived from the Morro Bay Watershed Streamflow Modeling Study (Tetra Tech, Inc., 1998).

Results indicate that total nitrogen loading to Morro Bay over the simulation 20-day period (late March) is 42,000 kg (41 tons). Of this total, nutrient loadings from Chorro Creek have the greatest effect on the water quality of the estuary, based on samples taken along shorelines throughout the bay. Figures 7-3 and 7-4 summarize the relative contributions, based on TetraTech's study, for both nitrogen and phosphorous. Preliminary results indicate that total phosphorous loading to Morro Bay over the 20-day simulation period is 1,100 kg (1 ton). However, simulated data may be higher than actual values as model was calibrated using primarily wet weather samples and did not factor in organism nutrient uptake. Although specific loadings are not highly correlated with observed values ($R^2$=.57) and should not be used for management decisions until the model is strengthened, and percent relative contribution can be assessed for each source.

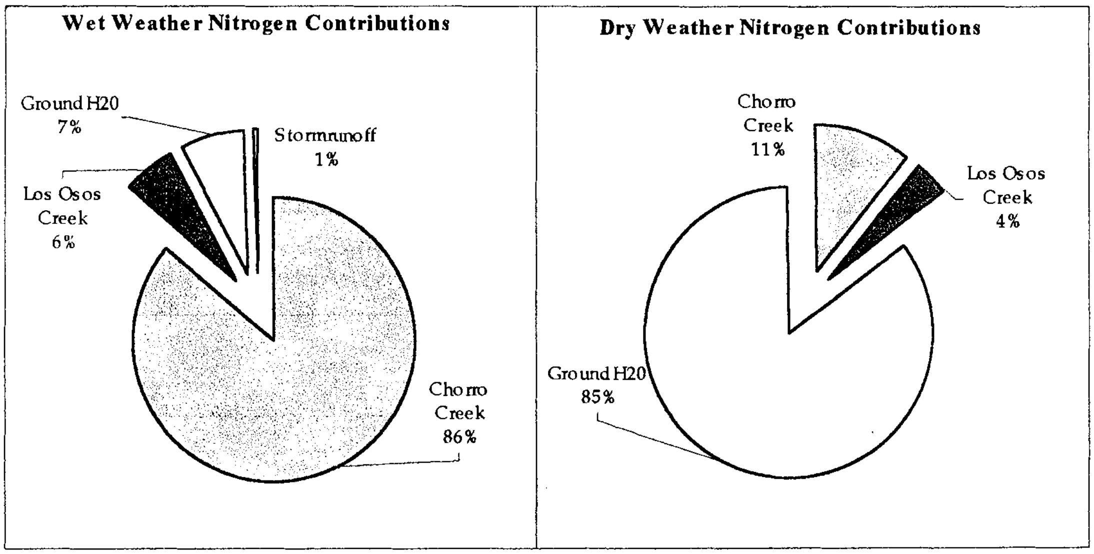



**Figure 7-3. Relative Contributions of Potential Sources of Nitrogen.**
*Source: Tetra Tech Nutrient Loading Model 1999*

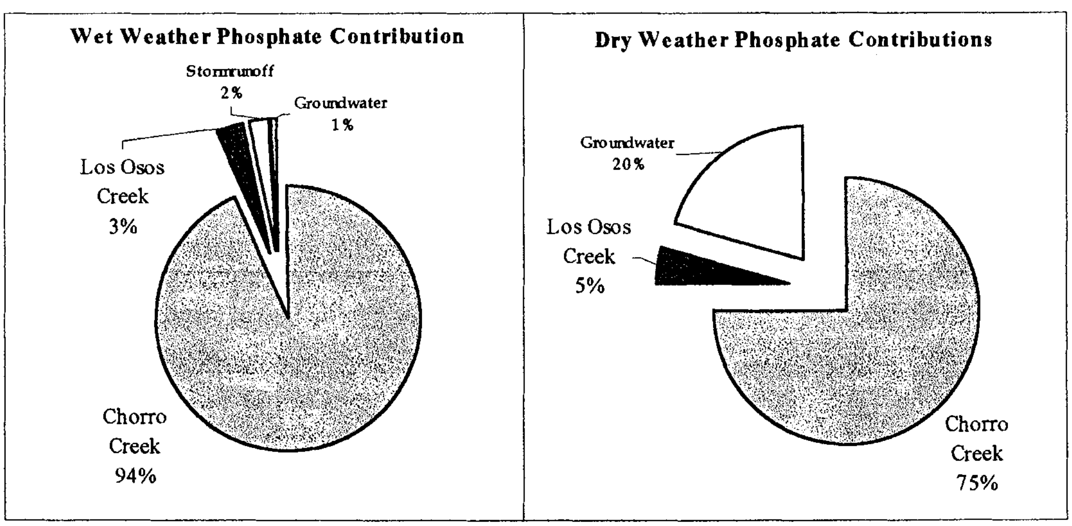



**Figure 7-4. Relative Contributions of Potential Sources of Phosphate.**
*Source: Tetra Tech Nutrient Loading Model 1999*

## 7.5.3 Stream Inputs from Chorro and Los Osos Creeks

*Chorro Creek*

As part of the NMP, nitrate and phosphate concentrations have been measured on a weekly basis during the wet season and on a bi-weekly basis during the dry season at 17 stream sites throughout the Morro Bay watershed since 1995. Tables 7-2 and 7-3 provide statistical summaries of the data associated with these sampling efforts (Tetra Tech, 1999).

There is currently one wastewater treatment facility discharging to Chorro Creek, resulting in an elevation of nutrients in surface waters and associated underflow. The California Men's Colony (CMC) discharges approximately one million gallons (or 133,690 cubic feet) per day to the creek. The City of Morro Bay currently discharges wastewater effluent to the ocean, but is contemplating reclamation of a portion for discharge to Chorro Creek.

**Table 7-1. Statistical Summary of Nitrate Data (mg/l) from the Morro Bay Watershed Section 319 National Monitoring Program**

| Sampling Site | Minimum | Maximum | Points | Mean | Median | Std Deviation |
|---|---|---|---|---|---|---|
| Twin Bridges (Chorro Creek Mouth) | 1.9 | 75.3 | 90 | 7.607 | 6.6 | 7.676 |
| Santa Ysable (Los Osos Creek Mouth) | 2.9 | 120 | 69 | 13.690 | 11 | 16.608 |
| Chorro Valley Culvert | 0.53 | 8.8 | 23 | 2.107 | 1.8 | 1.663 |
| Chorro Dam | 1.6 | 1.6 | 2 | 1.600 | 1.6 | 0.000 |
| Dairy Creek Lower | 0.2 | 8.4 | 28 | 1.949 | 1.4 | 1.732 |
| Dairy Creek Middle | 0.2 | 18.2 | 53 | 2.095 | 1.5 | 2.573 |
| Dairy Creek Upper | 0.2 | 17.3 | 66 | 2.185 | 1.8 | 2.239 |
| Pennington Creek | 0 | 2.2 | 8 | 0.925 | 0.9 | 0.688 |
| Chumash Creek | 0 | 16.8 | 65 | 1.678 | 1.3 | 2.193 |
| Walters Creek | 0.2 | 29.1 | 39 | 2.863 | 0.9 | 5.849 |
| Canet Road | 2.2 | 34.1 | 73 | 13.436 | 10.6 | 7.370 |
| San Luisito Creek | 0.4 | 26.6 | 64 | 2.340 | 1.35 | 3.526 |
| San Bernardo Creek | 1.3 | 47.4 | 72 | 6.631 | 5.8 | 5.180 |
| Warden Creek | 0 | 186 | 81 | 20.807 | 17.3 | 24.411 |
| Turri Creek | 1.7 | 63.8 | 93 | 22.570 | 21.7 | 12.431 |
| Los Osos Valley Road | 0.2 | 50.5 | 43 | 3.894 | 1.6 | 9.087 |

*Source: Regional Water Quality Control Board/National Monitoring Program data 1993-1998.*

For all creeks sampled (except Pennington Creek), excessive nitrogen has saturated organism physiological requirements. Since organism nutrient requirements are at a nitrate to phosphate ratio of 8:1, any ratio of nitrate to phosphate over 8 indicates a system that is limited in phosphate, and saturated in nitrate. Therefore, algal growth, as well as all biological organisms, in the Morro Bay watershed has all the nitrates required and depends on the pulses of phosphates that is bound to sediments. Pennington Creek, which is used as a control for BMPs because of its healthy corridor and lack of impacting uses, is the only system that is nitrogen limited. This ratio can effect management decisions for controlling algal blooms and eutrophication illustrating a relative demand on a system. This relationship does not infer nitrates are less of a priority in cases such as drinking water contamination or impacts on other beneficial uses. Table 7-3 encapsulates this relationship between nitrates and phosphates at sampled creeks.

Nitrates. Chorro Creek drains both non-irrigated rangeland and irrigated cropland. For the Chorro Creek watershed, the highest median nitrate concentrations are found in the lower parts of the watershed at the Canet Road (10.6 mg/l) and Twin Bridges (6.6 mg/l) sampling locations. The median nitrate concentrations at the remaining stations in the Chorro Creek watershed range from 0.9 to 1.8 mg/l, with the lone exception of the San Bernardo Creek station, where the median nitrate concentration is 5.8 mg/l.

**Table 7-2. Statistical Summary of Phosphate Data (mg/l) from the Morro Bay Watershed Section 319 National Monitoring Program.**

| Sampling Site | Minimum | Maximum | Points | Mean | Median | Std Deviation |
|---|---|---|---|---|---|---|
| Twin Bridges (Chorro Creek Mouth) | 0.10 | 0.94 | 51 | 0.351 | 0.25 | 0.218 |
| Santa Ysable (Los Osos Creek Mouth) | 0.04 | 0.33 | 53 | 0.117 | 0.10 | 0.058 |
| Chorro Valley Culvert | 0.01 | 0.51 | 18 | 0.094 | 0.03 | 0.146 |
| Chorro Dam | 0.02 | 0.04 | 2 | | 0.03 | 0.016 |
| Dairy Creek Lower | 0.02 | 1.20 | 64 | 0.098 | 0.08 | 0.144 |
| Dairy Creek Middle | 0.04 | 0.24 | 95 | 0.087 | 0.08 | 0.036 |
| Dairy Creek Upper | 0.02 | 1.80 | 95 | 0.102 | 0.06 | 0.188 |
| Pennington Creek | 0.10 | 0.20 | 10 | 0.128 | 0.12 | 0.027 |
| Chumash Creek | 0.01 | 1.60 | 52 | 0.091 | 0.04 | 0.228 |
| Walters Creek | 0.01 | 0.36 | 49 | 0.066 | 0.04 | 0.071 |
| Canet Road | 0.05 | 8.50 | 73 | 1.037 | 0.74 | 1.120 |
| San Luisito Creek | 0.02 | 0.98 | 73 | 0.113 | 0.08 | 0.123 |
| San Bernardo Creek | 0.04 | 0.55 | 73 | 0.165 | 0.15 | 0.076 |
| Warden Creek | 0.03 | 1.20 | 48 | 0.182 | 0.07 | 0.259 |
| Turri Creek | 0.01 | 0.51 | 29 | 0.078 | 0.04 | 0.109 |
| Los Osos Valley Road | 0.01 | 0.50 | 30 | 0.125 | 0.11 | 0.079 |

*Source: Regional Water Quality Control Board/National Monitoring Program data 1993-1998.*

Effluent from the CMC wastewater treatment plant is discharged into Chorro Creek above the Canet Road crossing. Figure 7.1 shows 97/98 nitrate and phosphate levels for Chorro Creek near CMC, Canet Road (CAN), and the Mouth of Chorro Creek (TWB) as flow travels "downstream" from site to site. Nitrate levels continue to remain higher at CAN than on any other sample station in the Chorro Creek watershed. The CMC Treatment Plant discharge upstream of the Canet Road sample station may contribute to elevated nitrate levels on this creek.

Chorro Creek contributes 113 mg/l/s of nitrate during base (=normal) flows (Figure 7.2). During peak flow the loading is much greater than base flow, reaching an average 14,944 mg/l/s of nitrate.

**Table 7-3. Nutrient Limiting Factors on Morro Bay Watershed Creeks (Using all samples).**

| Sampling Site | Nitrate (Means) | Phosphate (Means) | N03/PO4 Ratio | Organism Limiting Factor |
|---|---|---|---|---|
| Pennington Creek | 0.900 | 0.128 | 7.031 | N* |
| Canet Road | 13.436 | 1.030 | 13.045 | P |
| Chumash Creek | 1.670 | 0.091 | 18.352 | P |
| Dairy Creek Lower | 1.940 | 0.098 | 19.796 | P |
| San Luisito Creek | 2.330 | 0.113 | 20.619 | P |
| Dairy Creek Upper | 2.185 | 0.101 | 21.634 | P |
| Twin Bridges (Chorro Creek Mouth) | 7.600 | 0.350 | 21.714 | P |
| Chorro Valley Culvert | 2.100 | 0.094 | 22.340 | P |
| Dairy Creek Middle | 2.090 | 0.087 | 24.023 | P |
| Los Osos Valley Road | 3.890 | 0.125 | 31.120 | P |
| San Bernardo Creek | 6.630 | 0.165 | 40.182 | P |
| Walters Creek | 2.860 | 0.066 | 43.333 | P |
| Chorro Dam | 1.600 | 0.029 | 55.172 | P |
| Warden Creek | 20.807 | 0.182 | 114.324 | P |
| Santa Ysabel (Los Osos Creek Mouth) | 13.600 | 0.117 | 116.239 | P |
| Turri Road | 22.570 | 0.078 | 289.359 | P |

*A Nitrate/Phosphate ratio < 8 indicates nitrate is the limiting factor.

*Source: Regional Water Quality Control Board/National Monitoring Program data 1993-1998.*

The pattern of higher concentrations at downgradient stations is the opposite of that observed for fecal coliform bacteria concentrations (Bacteria Loading and Circulation Study, Tetra Tech, Inc., 1999), suggesting a different mechanism for nitrate loading to the streams. Examination of relationships between nitrate concentrations and streamflows indicate that reasonable relationships exist between flow and concentration at Chumash Creek ($r^2 = 0.69$, where $r^2=1.00$ is perfect correlation) and at Pennington Creek ($r^2 = 0.66$). Similar relationships are not observed between fecal coliform concentrations and streamflows, suggesting that nitrate concentrations are controlled by runoff from watershed soils. Thus while bacteria concentrations appear to be strongly influenced by grazing practices (Tetra Tech 1999), nitrate concentrations appear to be controlled by fertilization and soil management practices.

Although flows were not directly measured at the Twin Bridges sampling location where Chorro Creek enters Morro Bay, there are reasonable relationships between observed nitrate concentrations at Twin Bridges and flows in upgradient streams. Thus, these relationships could be used to determine nitrate concentrations entering Morro Bay for periods when data were unavailable. However, for the bay nutrient modeling conducted for this study, observed data were available for use as model inputs.

Evaluation of phosphate concentrations in the Chorro Creek watershed indicates that, as with nitrate, the highest median concentrations are found in the lower parts of the watershed at the Canet Road (0.74 mg/l) and Twin Bridges (0.25 mg/l) sampling locations. The median phosphate concentrations at the remaining stations in the Chorro Creek watershed range from 0.029 to 0.15 mg/l. The reasons for this are unclear and further research is needed to clarify trends . Suspended sediment and phosphate concentrations however are loosely correlated, as indicated by NMP data (CCRWQCB 1998).

*San Bernardo Creek*

Nitrates. Nitrate levels on San Bernardo Creek have been relatively high. Nitrate spikes occur periodically on San Bernardo Creek, probably due to flushing from agricultural land (Figure 7.5). High values in 1995 are most likely related to heavy rains of the "El Nino" weather patterns. Levels appear to be declining over time since sampling began in 1993, although this trend has not been statistically confirmed.

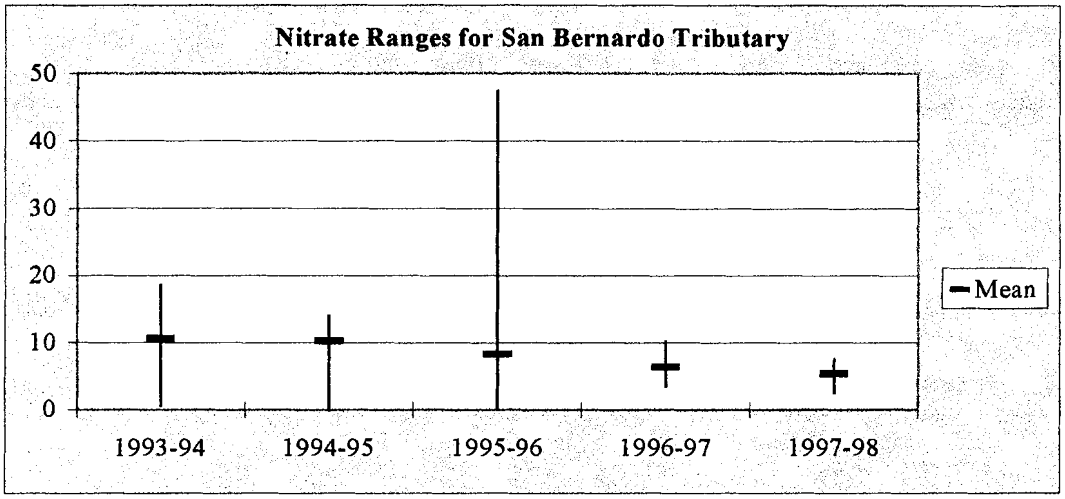



**Figure 7.5 Nitrate distributions in San Bernardo Creek, 1993-98.** *Source: Regional Water Quality Control Board 1997-1998 National Monitoring Program Annual Report.*

*Los Osos Creek*

Nitrates. In the Los Osos Creek watershed, median nitrate concentrations are high at the Turri Road (21.7 mg/l), Warden (17.3 mg/l), and Santa Ysabel Road (11 mg/l) sampling locations. At the Los Osos Valley road sampling location, the median nitrate concentration is lower (1.6 mg/l). Although stream flows were not measured in the Los Osos Creek watershed, there is a relationship between nitrate concentrations at the Santa Ysabel Road station and flows at Chumash and Walters Creeks. This suggests that runoff or rising groundwater, drives nitrate loading to the streams. The observations of high nitrate concentrations at the Turri Road, Warden, and San Bernardo Creek stations, and the relationships between streamflows and nitrate concentration, lend further credence to the statement above that fertilization and soil management practices are largely responsible for determining nitrate loading to the streams. All these sampling sites are located in areas where the crop cultivation upstream is a significant land use.

Nitrate levels are generally high at Turri Road (TUR) and Warden (WAR) on Los Osos Creek compared to other stations around the Morro Bay Watershed, although all stations on Los Osos Creek have high nitrate means compared to only downstream sites Chorro Creek. Agricultural fields surround the TUR site, and high nitrate levels can probably be attributed to this source. WAR is generally as high as TUR, which is somewhat unexpected, since typically, wetland conditions with low stream flow velocities, high aquatic and riparian vegetation and associated chemical processes can reduce nitrate levels.

Base flow from Los Osos creek has been roughly estimated to a concentration of 84 mg/l/s of nitrate, or 43% contribution to the bay, relative to Chorro Creek at the confluence of the creek and the estuary (56%) and freshwater seeps (1%). Peak flow contribution for Los Osos creek is not yet available at this time. Los Osos Creek's main nutrient source is the Warden Branch of Los Osos creek. Levels of 49 mg/l were seen in 1998. Figure 7.3 shows nitrate levels on the Warden tributary as flow transports downstream at the three sites between Turri Road (TUR) and the Santa Ysabel Bridge (SYB) on Los Osos Creek.

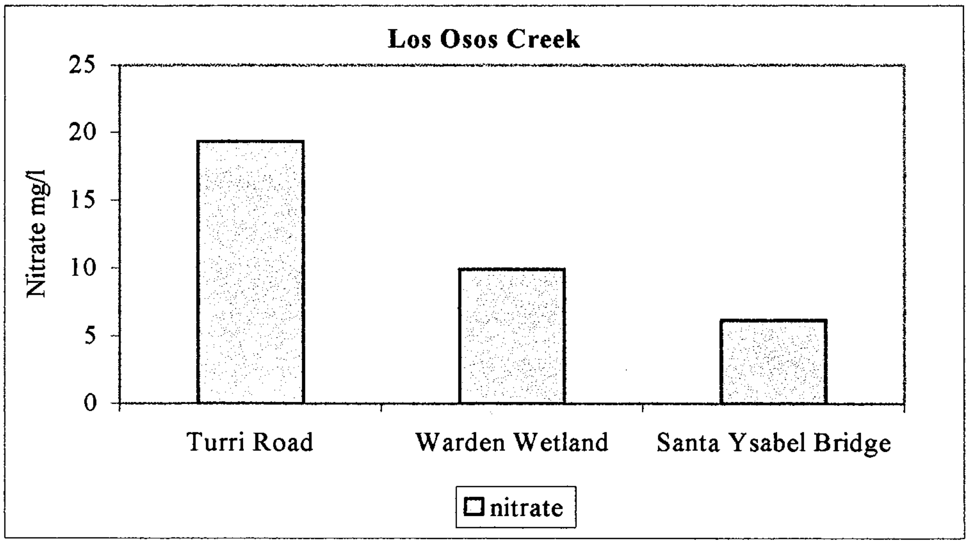



**Figure 7.6 Average Values of Nitrate for 3 Sites Along Los Osos Creek.** *Source: Regional Water Quality Control Board, National Monitoring Program data, 1997-1998.*

<u>Phosphates</u>. Phosphate concentrations at all sampling locations in the Los Osos Creek watershed are lower than those in the lower part of the Chorro Creek watershed, ranging from 0.04 to 0.11 mg/l.

Samples taken through the NMP illustrate higher levels of phosphate discharging into the bay from Chorro Creek than Los Osos Creek (Figure 7.5). Potential sources include detergents discharged from the CMC wastewater treatment plant and soil erosion, both of which are present in Chorro Creek.

### 7.5.4 Urban Surface Water Runoff

Urban runoff to Morro Bay may constitute an important source of nutrients. The Morro Group and Tenera Environmental Services (Asquith 1990) estimated volumetric surface inputs to the bay from nine locations indicated on Figure 7-9. Nutrient inputs from these points were estimated based upon the results of the volunteer stormwater sampling efforts collected along the urbanized areas of the City of Morro Bay and Los Osos (Section 6, Figure 6-8). Storm runoff from the perimeter of the estuary has an estimated 2% relative contribution of phosphate (or 25kg) to Morro Bay during wet weather (Figure 7-?). Nitrogen in storm runoff accounts for only 1% of relative contribution to the estuary (or 279kg) as simulated by Tetra Tech (1999). However, TKN levels ranging from 0.5-20mg/l were found in first-flush samples collected in 1995 and 1996. In California, the value most often observed in urban runoff samples is 2.0mg/l. The preliminary results indicate that surface runoff can have localized effects.

### 7.5.5 Groundwater Inputs

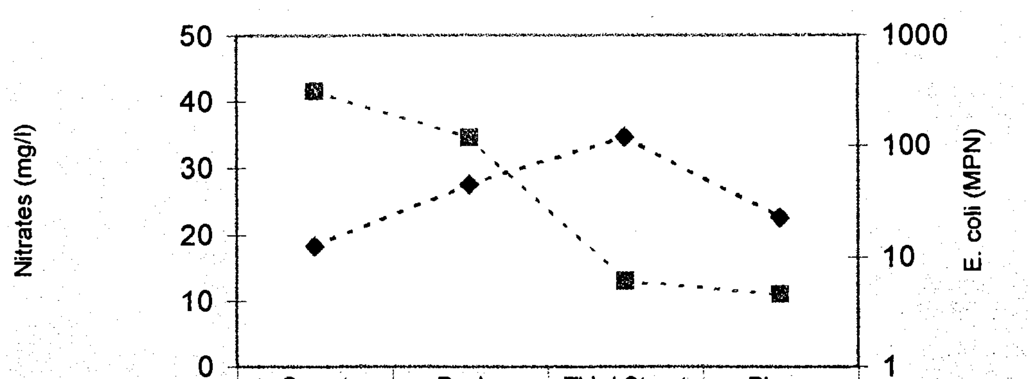
Another potentially important source of nutrients to Morro Bay is that generated from leaking and failing septic tanks in Los Osos. These nutrients can enter the bay with groundwater. A considerable database exists on nitrate levels in groundwater, as a result of years of disputes over the necessity for a sewer in the community of Los Osos, and from the periodic concerns over elevated levels in City of Morro Bay well water. It is anticipated that the proposed Los Osos sewer plant will recharge groundwater basins.

The U.S. Geological Survey (USGS) estimated groundwater inputs from the Morro Bay watershed to the ocean and the bay at 590 acre-ft/yr in 1985 (Yates and Wiese, 1988), with approximately two-thirds going to the ocean and the remainder to the bay. However, 1985 was a very dry year and the USGS estimate is widely regarded as low for an average year.

Elevated levels of nitrates have been detected draining to the bay from freshwater discharges in the Los Osos area. Levels of nitrates approaching 65 mg/l are consistently released from the San Luis Obispo County "standpipe" at El Moro and 3rd Streets in Los Osos during non-rainfall periods. This standpipe was originally designed for surface stormwater runoff as an emergency measure, but now also discharges groundwater nearly continuously. The $8^{th}$/El Moro sample site had the highest sampled value of 55.4 mg/l during October 1996. Average nitrate values were 46.41 mg/l. The Donna and Mitchell intake ranked lowest at 3.06 mg/l.

Nutrients have also been monitored bimonthly at freshwater seeps located in the bay. Nitrate (as $NO_3$) and *E. coli* levels found in freshwater seeps were variable (Figure 7.7). Samples from Sweet Springs exhibit consistently high nitrate values, whereas levels of *E. coli* are inversely low. In contrast nitrates at the Third Street dock are low, while *E.coli* levels are elevated. Additional information is needed to assess water quality trends in freshwater seeps. These high levels may be related to previously identified high nitrates in Los Osos groundwater, which have been attributed to septic disposal systems in the area.

The MBNEP/Friends of the Estuary Volunteer Monitoring Program nutrient sampling effort that was conducted quarterly during 1996 (see Figure 7-1) detected elevated nitrates in bay water in localized areas, but in many samples nitrate was not detected. Tetra Tech's preliminary results indicate that groundwater sources of nitrogen are important at south shore stations.




| | Sweet Springs | Pecho Marsh* | Third Street Dock* | Pismo Wetland |
|---|---|---|---|---|
| Nitrates | 41.51 | 34.51 | 13.11 | 10.98 |
| E.coli | 12.7 | 45.2 | 120.04 | 22.5 |

*MPN exceeded detectable range

**Figure 7.7. Average Value for Nitrates and *E.coli* at Baywood Freshwater Seeps.**
*Source: MB National Estuary Program Volunteer Monitoring data.*

In addition, preliminary results show that stormwater runoff from Los Osos was has a significant effect on nutrient concentrations in the bay. This suggests that studies into the feasibility of the collection and treatment of stormwater might be appropriate. A wide array of treatment options may be appropriate, but a cost-effective alternative that should be considered if a study of this type is initiated is wetland treatment. This alternative is passive and offers the benefit of flow equalization as well as removal of contaminants.

### 7.5.6 Further Nutrient Research Needs

Conducting further research provides a better understanding of the processes that occur in the watershed and estuary. The additional knowledge provides the program with the tools and techniques that can help guide management decisions. The following nutrient research needs were developed by the MBNEP Technical Advisory Committee (TAC). These research needs include, but are not limited to:

1. Are nutrients adversely affecting aquatic communities? Eelgrass?
   - High nutrient loads increase algal blooms, which reduce dissolved oxygen levels and impacts aquatic biota.

2. What is the effective minimum width for fenced riparian buffer to improve water quality improvement?
   - Buffer strips are a proven effective BMP at reducing sediment, bacteria, and nutrient levels in surface waters. Buffer width effectiveness is dependent on various factors such as slope length, slope angle, soil type, vegetation types, volume of runoff, and adjacent land uses.

3. What is the optimum amount of nutrients needed for row croppers of the Los Osos and Chorro Valleys?
   - Excess nutrient applications can drain into surface or ground water causing algae blooms, which reduces dissolved oxygen levels and impacts aquatic biota.

4. What function does nutrient variances have on Eelgrass productivity in Morro Bay? (Comparison of Instantaneous And Comprehensive Methodologies)
   - Eelgrass habitat has been highly variable over time and provides the primary food source for the over-wintering brant geese population.

5. What are the ecological effects of algal blooms (Freshwater And Estuarine)
   - Algal blooms decrease dissolved oxygen levels, which can impact other aquatic biota.

6. What are the extent of natural and anthropogenic sources of hypoxia?
   - High nutrient loads increase algal blooms, which reduce dissolved oxygen levels and impacts aquatic biota.

7. What are the limiting nutrients in both freshwater and estuarine environments?
   - Available nutrient sources are limiting to population size and community diversity.

# 8.0 LOSS OF DRY SEASON FRESHWATER FLOWS

## 8.1 INTRODUCTION

The word estuary, by definition, describes a place where freshwater flowing off the land mixes with the saltwater of the sea. This mixing supports a unique ecosystem containing numerous plants and animals which are not found in either totally freshwater systems nor the ocean.

The freshwater that flows into Morro Bay comes from a variety of sources largely dependent upon the seasons. During large rainfall events the dominant freshwater inflows to the bay come from Chorro Creek, Los Osos Creek, and urban runoff from the City of Morro Bay and Los Osos. As the rainy seasons give way to the dry summers typical of this part of the coast of California, surface water runoff from the watershed and urban areas is virtually non-existent and the freshwater inflows to the estuary are highly dependent upon subsurface water. The subsurface water makes it way to the estuary in several ways. In the inland portions of the watershed water that has soaked into the soil at high elevations seeps into the creeks and maintains their surface flows during some portion of the dry season. In effect the watershed acts as a storage device, retaining some of the rainwater of the winter and gradually releasing it to the streams after the rains have stopped. Historically, three streams flowed into Morro Bay. One of these streams, Morro Creek, was diverted from the bay in the 1940's State Water Resources Control Board (SWRCB) 1995).

Another significant source of freshwater flow to the bay during the dry season comes from shallow groundwater that seeps and upwells into the bay both at the shoreline and in open water areas. The South Bay area with its unique sand dune geology contains numerous areas of freshwater seeps. While a few of these freshwater springs, such as Sweet Springs, may be affected by the Los Osos fault, an earthquake fault that runs through the valley and into the bay, the majority of the flow results because of the nature of sand dunes. The wind shapes the dunes. Over time some areas in the dunes become shaped like bowls. During rainy seasons fine sediment is washed into the bottom of the bowls. When enough sediment is washed to the bottom of the bowl it begins to bind together to become clay. Unlike the surrounding sand that allows water to flow freely between the grains, the clay presents a barrier that prevents the water from flowing upward or downward. The South Bay area contains a virtually uncountable number of large and small barriers of this type. This results in subsurface water in some areas travelling horizontally far more quickly than it can travel vertically.

The differences in the processes that provide freshwater flow to the bay during the dry season require different ways of evaluating the issues and different forms of solutions to problems.

## 8.2 IMPACTS TO BENEFICIAL USES

Reductions to freshwater flows in the watershed and to the bay have a direct impact on a wide variety of designated beneficial uses of water and on social and economic conditions in the region. Concerns over degradation to a number of these uses have caused portions of the Chorro Creek Watershed and the entire Los Osos Creek Watershed to be listed by the SWRCB as "fully appropriated". What this means in somewhat oversimplified terms is that anyone seeking to extract water from these areas and use it in other areas must provide the State Board with evidence that the extraction will not cause damage to the designated beneficial uses. All of Los Osos Creek including all of its tributaries are listed as fully appropriated from May 15 through October 31. Chorro Creek and all of its tributaries downstream of the California Men's Colony (CMC) Waste Water Treatment Plant (WWTP) outfall are listed for the period between July 15 and November 30.

The beneficial uses affected are:

- Municipal and Domestic Drinking Water Supply
- Agricultural Supply
- Groundwater Recharge
- Freshwater Replenishment
- Water Contact Recreation
- Non-Contact Recreation
- Sport Fishing
- Warm and Cold Freshwater Habitat
- Estuarine Habitat
- Wildlife Habitat
- Preservation of Biological Habitats of Special Significance
- Rare, Threatened, and Endangered Species
- Spawning, Reproduction, and Early Development of Fish
- Migration

### 8.2.1 Municipal and Domestic Drinking Water Supply

The City of Morro Bay has traditionally relied upon wells in the Chorro Valley as a major source of domestic water. The CMC, County of San Luis Obispo, Cuesta College and Cal Poly have also used wells in the valley to meet the freshwater needs of their facilities. The completion of the state water pipeline and the fact that a number of these water users are subscribers to state water has changed the water budget of the watershed. Reduced extractions from both groundwater and subterranean creek flows should result in increased surface flow in the creek for some period of time.

### 8.2.2 Agricultural Supply

Agricultural interests in both the Chorro and Los Osos valleys rely upon ground water and creek flows for both stock watering and crop production.

### 8.2.3 Groundwater Recharge

In some areas both Chorro Creek and Los Osos creek are either known to recharge or are very likely a source of recharge for several groundwater basins.

### 8.2.4 Freshwater Replenishment

Both Chorro and Los Osos creek act as a source of freshwater replenishment for other types of water bodies (e.g., Chorro Reservoir, agricultural storage reservoirs). Both streams support the estuary and adjoining wetland areas.

### 8.2.5 Water Contact Recreation

This beneficial use is normally referred to in association with concerns due to exposure to pathogens. Pathogens are dealt with in Section 6 of this document. Water contact recreation can also be impacted by the absence of water.

### 8.2.6 Non-Contact Recreation

As in the case of water contact recreation, non-contact recreation such as picnicking, hiking, sightseeing, and aesthetic enjoyment can be affected by the absence of water in streams and excessive reductions in stream flow.

### 8.2.7 Sport Fishing

Fishing for steelhead in our local streams is now only a fond memory in the minds of long term residents. The steelhead is now a federally listed species. In the past surface water extractions have resulted in fish kills (Chappell 1976). Sport fishing in most of the creeks of the watershed is presently an unattainable beneficial use.

### 8.2.8 Cold Freshwater Habitat

Shortened durations of flow and significant reductions in flow can have an impact on instream and riparian habitats. As stated previously, past surface water extractions have resulted in fish kills (Chappell 1976).

### 8.2.9 Estuarine Habitat

The volume of dry season freshwater inflow can impact the existence and well-being of brackish water areas that exist where the streams enter the bay, and on the shorelines of the bay.

### 8.2.10 Wildlife Habitat

Shortened durations of flow and significant reductions in flow can have a direct impact on the instream and riparian habitats of the watershed. Wildlife from other areas are also dependent upon the streams for drinking water.

### 8.2.11 Preservation of Biological Habitats of Special Significance

This refers to uses of water that support designated areas or habitats such as established refuges, parks, sanctuaries, ecological reserves, or areas of special biological significance where the preservation of or enhancement of natural resources requires special protection. Dry season flows support the City designated bird sanctuary, Morro Bay State Park, the state designated State Estuary, and the federally designated National Estuary at Morro Bay.

### 8.2.12 Rare, Threatened, and Endangered Species

Steelhead, western pond turtles, red-legged frogs, and tidewater gobies are a few of the federal and state listed species that depend on dry season flows during some life stages.

### 8.2.13 Spawning, Reproduction, and Early Development of Fish

Fish depend upon both surface flow and subterranean flow that maintains pools for space to live and develop during the dry season.

## 8.3 SOURCES AND TRENDS

### 8.3.1 Chorro Creek

Chorro Creek surface and subsurface flows are impacted by a variety of public and private sector activities. The watershed and its creeks have been altered and managed for so long that attempts at determining natural flow levels are speculative at best. During the dry season, Chorro Creek flow is often entirely dependent upon the effluent outflow from the CMC WWTP. A recent study of freshwater influences on Morro Bay estimated that, during drought years, Chorro Creek was dry at its confluence with the bay for 126 days per year (Asquith 1990). A more recent study that employed more extensive numeric modeling techniques indicated that Chorro Creek was dry at its confluence with the bay for more than 300 days per year during dry years (Cleath 1994). Extensive diversion occurs in the watershed for both agricultural and municipal purposes, and it has resulted in a severe lack of flow in the lower reaches of the creeks.

***Recent Efforts to Resolve Chorro Creek Issues***

A number of efforts over the last few years have been undertaken to ameliorate the problems. In issuing well permits to the City of Morro Bay the SWRCB placed specific limitations on the amount and timing of extractions that are permitted. The City will be installing flow gages upstream and downstream of its well fields in order to provide the information necessary to manage extractions while at the same time maintaining minimum stream flow at 1.4 cubic feet per second. In the past the City has derived up to 2/3 of its domestic drinking water supply from the Chorro Creek watershed. The completion of the State Water pipeline in the valley and the City's use of state water as opposed to Chorro Creek water have dramatically altered the water budget of the Chorro Valley at the present time. Two of the major users of water in the valley, the City of Morro Bay and the CMC, are now utilizing state water and for the immediate future have significantly reduced extractions from the Chorro Valley.

The CMC wastewater treatment plant has dedicated 0.75 cfs of effluent as a continuous flow to Chorro Creek for the purpose of maintaining public trust resources in the form of steelhead habitat from their point of discharge to the estuary (Kellerman, pers. comm. 1999).

As a condition of other water diversion permits in the watershed, the California Department of Fish and Game (CDFG) has been given the responsibility and authority to manage releases of water from the Chorro Reservoir for the purpose of maintaining the public trust resources dependent upon stream flows.

A study conducted for the State Department of Parks and Recreation (SDPR) suggests that willows in the vicinity of Twin Bridges may be dying as a result of higher than normal salinity levels resulting from water diversion (Josselyn and Los Huertos, 1991). This Josselyn study detected a negatively sloping groundwater table at piezometer well borings measured during drought conditions (November 9, 1990). They state, "this reverse slope is most likely the result of over pumping in upstream water supply wells." They also found that upstream salinity levels were relatively high as a result of intrusion of saline water produced by the negatively sloping groundwater table. This high salinity may be adversely affecting the growth of willow trees in the vicinity.

### *City of Morro Bay Wells*

The City of Morro Bay wells have been a subject of debate before the SWRCB for many years. Prior to the importation of State water, the City extracted two-thirds of its water supply from the Chorro Creek watershed and disposed of its effluent through an ocean outfall. The City now receives water from the State Water Project and owns a desalinization plant. The desalinization plant is not used except in emergency situations.

In 1995 the SWRCB, through decision 1633, approved the issuance of five water right permits to the City of Morro Bay to divert the underflow of Chorro Creek (Cal EPA Biennial Report, 1998). In addition to approving the permits, decision 1633 also placed conditions on the City to curtail water extraction when stream flow is less than what is required to protect steelhead trout and other public trust resources. The SWRCB determined that to accomplish this, the Romero well field is not to be pumped whenever surface flow below the well site is less than 1.4 cfs. All City of Morro Bay wells are to cease pumping if the Chorro Creek surface flows at the Canet Road gauge station are less than 0.85 cfs (SWRCB 1995 "Decision Approving Issuance of Permit to City of Morro Bay Subject to Specified Conditions").

### *Dairy Creek Golf Course*

The County of San Luis Obispo operates several facilities within the Chorro Creek basin including a new golf course. The golf course has been designed to use effluent from the CMC wastewater treatment plant located on Chorro Creek. The County is supplementing its water supply through the State Water Project. The golf course uses approximately 212 acre-feet-per-year. It receives 100 acre-feet-per-year from the CMC (Envicom 1994).

The County of San Luis Obispo conditioned the construction of the Dairy Creek Golf course to include several design and operation components intended to provide adequate stream flow dedicated to both downstream users and the public trust resources of wildlife and instream habitat. A specific provision in the project approval by the County Board of Supervisors expresses the County's commitment to work with other water users in the Chorro valley to maintain a minimum instream flow of 1.5 cubic feet per second from the area of the CMC to the bay.

### *Chorro Reservoir*

The CMC operates Chorro Reservoir. CMC also imports Whale Rock water into the basin, supplements its water supply through the State Water Project, and extracts water from wells in the basin. CMC operates a wastewater treatment facility that disposes its effluent into Chorro Creek and also to Cal Poly and the Dairy Creek golf course.

Chorro Reservoir has a capacity of 166 acre-feet per year with a yield of 103 acre-feet per year. The combined summertime discharge from Chorro Reservoir and the wastewater treatment facility provides approximately half of the flow in Chorro Creek (Envicom 1994).

### *CMC Wastewater*

The CMC has dedicated 0.75 cubic feet per second, or the entire output of its treatment plant (whichever is less), for the purpose of maintaining downstream habitat. The facility processes the wastewater from the CMC, Camp San Luis Obispo, the County of San Luis Obispo, and Cuesta College. The reclaimed wastewater is discharged downstream of Pennington Creek (Envicom 1994).

Both the City of Morro Bay and the CMC have agreements with the county to acquire additional State water during drought periods. The intent of these agreements is to provide the fully-subscribed amount of water, even when the State Project cuts back its deliveries to customers in general. California Polytechnic State University, San Luis Obispo's Chorro Valley Ranch maintains two storage reservoirs with a total capacity of 84 acre-feet. These reservoirs are charged by CMC effluent discharge (Envicom 1994). The ranch also uses two wells on the property.

Agricultural water users within the Chorro basin rely on Chorro Creek and other groundwater sources for irrigation of their crops. The viability of prime agricultural land within the Chorro valley is dependent upon equitable management of upstream sources of creek flow and groundwater recharge.

### 8.3.2 Los Osos Creek

In drought years, extractions may exceed the total surface flow of the creek (Asquith 1990). The SWRCB has listed the Los Osos drainage as "fully appropriated" and believes the drainage can not support further appropriative extractions from the area (Worcester 1991).

Since the 1970's significant flooding has and continues to occur in the community of Los Osos/Baywood Park, in part due to residential development and the corresponding increase in impermeable surfaces (Table 8-3). Development has resulted in increased impervious surfaces, disruption of natural drainage routes without provisions for surface drainage, and inadequate containment of onsite drainage. Rising groundwater is also likely a factor.

In Los Osos, the lower aquifer is used as a domestic water supply while households are discharging septic system leach field effluent into the upper aquifer (EDA and The Morro Group 1998). One study indicates that 65% of the water used by residents which comes from the lower aquifer is discharged to the upper aquifer with an unknown amount of return flow to the lower aquifer (EDA and Morro Group 1998). This is contributing to rising groundwater elevations in the upper aquifer (Table 8-4). Thus, rising groundwater elevations affect the ability of the upper aquifer to retain water, resulting in increased overland flow to the bay and streams.

It is believed that the upper aquifer is a fresh water source for springs at the south end of the bay. The amount of flow from these springs controls the boundary and vitality of fresh and brackish water ecosystems. If overdraft of the aquifer occurs, seawater intrusion of the sub-estuary aquifers may occur as the area's population increases (Yates and Wiese 1988).

### 8.3.3 Further Freshwater Flow Research Needs

Conducting further research provides a better understanding of the processes that occur in the watershed and estuary. The additional knowledge provides the program with the tools and techniques that can help guide management decisions. The following freshwater flow research needs were developed by the MBNEP Technical Advisory Committee (TAC). These research needs include, but are not limited to:

1. How do changes in wastewater management affect distribution of freshwater wetland habitats?
   - Freshwater flow volume is essential to aquatic habitat needs and the survival of threatened and endangered species.

2. What is the effective minimum width for fenced riparian buffer to improve water quality improvement?
   - Buffer strips are a proven effective BMP at reducing sediment, bacteria, and nutrient levels in surface waters. Buffer width effectiveness is dependent on various factors such as slope length, slope angle, soil type, vegetation types, volume of runoff, and adjacent land uses.

3. Is there a positive correlation between salt and freshwater flow mixing zone and spatial particle size deposition?
    - Sediment deposition in the estuary is influenced by differences between fresh and saltwater density.

4. What are the optimum instream flow allotments for the Chorro Valley Users Group?
    - Water diversions and withdrawals directly affect freshwater flow available for aquatic habitat and threatened and endangered species.

5. What are the effects of Morro Bay Power Plant on bay circulation patterns?
    - The power plant's cooling water intake structure is located near the mouth of the bay. The power plant is currently permitted to intake up to 725 million gallons a day.

6. What are the impacts of changes in freshwater inflow on oligohaline habitats?
    - The freshwater/saltwater interface is a critical ecotone where changes in biota could be an indicator for evaluating progress on the priority problems.

# 9.0 HEAVY METALS AND OTHER TOXIC POLLUTANT LEVELS

## 9.1 INTRODUCTION

Toxic pollutants include pesticide residuals, organic compounds, and heavy metals. Heavy metals such as iron, nickel, cadmium, chromium, and arsenic are a serious water quality concern because of their toxicity, persistence, and potency. Recent sampling has shown that the concentrations of chromium and nickel in Chorro Creek sediments exceed the Regional Water Board Basin Plan Water Quality Objectives (CCRWQCB, 1999). Contact and non-contact water recreation are two uses that could be adversely affected by concentrations of these pollutants, and human health impacts could result. Marine wildlife, shellfish harvesting, fish migration, spawning habitat, and rare, threatened, and endangered species habitat are additional beneficial uses that could potentially be affected by heavy metals and other toxic pollutants. Such metals can accumulate in sediments and concentrate in fish and shellfish tissue. Aquatic organisms can be acutely affected even by very low concentrations of toxic pollutants.

Sources of metals and toxic pollutants vary, but they are often found in storm water runoff. Typical sources are vehicle brake pad dust, runoff from inactive mine tailings, solid waste disposal areas, and household and industrial sources. Copper and lead were once used in "antifouling" paints used on boats. These materials were added to paints to prevent marine invertebrates from fouling the bottoms of boats. Toxic pollutants can be discharged to surface waters during wet weather storms or they can arise from other incidents such as oil spills or illegal discharges. Both toxic constituents and metals can sometimes be found in wastewater discharge.

Dredging of sediments that contain metals or toxic pollutants in concentrations that are determined to be unsuitable for unconfined aquatic disposal can result in additional costs for material handling, treatment, and disposal. This special handling of unsuitable material significantly increases the cost of dredging.

Data collected from the State Mussel Watch and the Toxic Substance Monitoring Programs suggest that metal concentrations and other toxic pollutants (e.g., synthetic organics) are not present in estuary waters in concentrations dangerous to fish or mussels (SWRCB, Bulletin 96-2WQ, 1996). However, as mentioned above, sampling within the upper watershed suggests a persistent problem with chromium and nickel that are believed to be eroding from inactive mines. Effective Best Management Practices and monitoring at regular intervals can detect current levels and ensure that water quality standards are protected.

Industrial pollutant point-source control has been extremely effective in reducing levels of heavy metals and organic compounds that enter wastewater treatment plants. Hence, concentrations of metals in treated sewage sludge and liquid effluent are not high.

The Morro Bay estuary and Chorro Creek are listed on the Central Coast Regional Water Quality Control Board (CCRWQCB) 303(d) list as "impaired water bodies" for metals. The 303(d) list identifies water quality limited water bodies. A water quality limited segment is any known segment that does not meet applicable water quality objectives and/or is not expected to meet applicable water quality objectives, even after the application of technology-based effluent limitations or other Regional Board requirements. Los Osos Creek is listed for priority organics primarily because of historical data regarding pollutants from the Los Osos landfill. More recent data show that this problem has been corrected (San Luis Obispo County Engineering Department, 1998).

### 9.2.1 DEFINITIONS

*Toxic pollutants include:*
*Synthetic organic compounds* such as DDT, chlordane, parathion, and PCB's, and
*Heavy Metals,* including the trace elements mercury, iron, nickel, cadmium, chromium, copper and aluminum
*Pesticides* are organic compounds.

## 9.3 APPLICABLE STANDARDS

***Central Coast Regional Water Quality Control Board (Water Column Only)***

The CCRWQCB has adopted the Water Quality Control Plan for the Central Coast Region (SWRCB, 1994). The Basin Plan establishes water quality standards (i.e., beneficial uses and water quality objectives) for waters in the region that include Chorro Creek and its tributaries, the Morro Bay Estuary, and the Pacific Ocean. The Basin Plan also includes, by reference, plans and policies adopted by the SWRCB. Applicable plans and polices include the Non-point Source Management Plan and the Ocean Plan. There currently are no sediment criteria for the metals of concern in the bay. This makes assessing the impacts and implementing control measures more difficult.

Water quality objectives have been established to protect beneficial uses associated with contact and non-contact water recreation, and wildlife habitat. Standards apply to surface and ground waters and include narrative limits for toxicity and chemical constituents (e.g., metals). The CCRWQCB has established these limits and is required to incorporate them into permits and waste discharge requirements for point source discharges regulated by the CCRWQCB.

Several industrial facilities that are regulated by federal National Pollutant Discharge Elimination System (NPDES) permits are located within the Chorro Creek watershed as illustrated in Figure 2-4 in Section 2. These facilities include the California Men's Colony wastewater treatment plant and the Morro Bay power plant.

The CCRWQCB currently does not directly regulate non-point source discharges (i.e., urban stormwater runoff, agricultural (crop) runoff, pasture runoff, road construction runoff, mining, etc.). As a result, limits for these types of discharges have not yet been specified. The CCRWQCB is currently developing Total Maximum Daily Loads (TMDL's) for Morro Bay; this program will define targets for many of the toxic pollutants of concern. The sources can be addressed through the non-point source control Program. The CCRWQCB's current approach is to encourage voluntary implementation of measures to uphold water quality standards.

Dredging is an activity regulated by the U.S. Army Corps of Engineers (ACOE), and in some cases, the Corps itself conducts dredging and disposes of dredge spoils. Dredging is typically conducted under Clean Water Act U.S. Army Corps of Engineers Section 404 process. Part of the 404-permit process is for the CCRWQCB to certify that the discharge will uphold water quality standards. However, Board standards relate only to water column standards and not to sediment. In addition, the Ocean Plan standards do not apply to dredging.

At present, no sediment discharge standards apply at the federal or state level. The ACOE, in coordination with the U.S. Environmental Protection Agency (EPA), determine dredge disposal suitability based on sediment analysis. The ACOE makes a determination as to whether the sediment is suitable or unsuitable for unconfined aquatic disposal. Some re-suspension of fine grain sediments is associated with dredging. However, the activity and the potential impacts are limited in duration and typically do not pose significant long-term effects to surface waters.

### *Cal EPA Department of Pesticide Regulation (DPR)*

Cal EPA's Department of Pesticide Regulation is the principal state agency regulating the registration and use of agricultural pesticides. The California Food and Agriculture Code and the California Code of Regulations outline the state's pesticide law and implementing regulations respectively.

All growers producing agricultural commodities for sale are required to hold a Pesticide Use Permit. Permits specify which types of pesticides a grower may use, each growing site, and the commodities on which pesticides may be applied.

California law requires that the County Agriculture Commissioner be notified 24 hours prior to the intended application of a Restricted Use Pesticide. Restricted Use Pesticides include those substances defined by DPR as having the greatest potential to cause human health or environmental problems if misused. County Agricultural inspectors review each request and many sites are visited prior to approval of the chemical application.

Following pesticide applications, growers and agricultural pest control businesses are required to submit monthly Pesticide Use Reports to the Ag Commissioner documenting 100% of the pesticide applications at all growing locations. These Use Reports are then entered into DPR's statewide database of pesticide use. This database is used to map trends in pesticide use and any resulting problems such as human health issues, crop damage, or correlation with pesticide residues found in crops.

The DPR is not presently monitoring water quality for concentration of pesticides currently in use. New pesticide compounds are released every year, and funding for monitoring is not currently available.

*San Luis Obispo County (Pesticides)*

The San Luis Obispo County Department of Agriculture is responsible for Pesticide use enforcement. County Agriculture Commissioners, under working agreements with DPR, are given the authority to oversee and regulate the site-specific applications of pesticides. In the event that enforcement action is required to assure compliance with California pesticide law, the Agriculture Commissioner has the authority to impose civil penalties (monetary fees/fines).

## 9.4 IMPACTS TO BENEFICIAL USES

The CCRWQCB has identified metals as potentially affecting aquatic life in Morro Bay. The beneficial uses that could be affected are: ocean commercial and sport fishing, preservation of rare and endangered species, marine habitat, warm fresh water and cold fresh water habitats, fish spawning, shellfish harvesting, water contact recreation, non-water contact recreation, and domestic, municipal, and agricultural water supply.

Metals can be toxic to adult steelhead trout or their young in any stage of their development. The CCRWQCB is currently conducting studies on benthic invertebrates in Chorro Creek to determine if any impairment to aquatic life has occurred from heavy metals. Benthic invertebrates, if present in a stream, are an indicator of good-quality habitat for fish.

Those uses that could be affected by high or persistent levels of toxic pollutants are: water contact recreation; ocean commercial and sport fishing; warm fresh water habitat; cold fresh water habitat; wildlife habitat; preservation of rare and endangered species; marine habitat; shellfish harvesting; fish migration; and fish spawning. None of these are impaired by toxics to date.

## 9.5 SOURCES AND TRENDS

Table 9-1 summarizes the potential sources and relative contributions of heavy metals and toxics in Morro Bay and the estuary. Additional discussion is provided below.

**Table 9- 1. Relative Contributions of Potential Sources of Heavy Metals in Morro Bay**

| Potential Problem | Source | Relative Contribution | Reference |
|---|---|---|---|
| Increased heavy metals: copper, nickel, cadmium, chromium, arsenic | Urban runoff | Moderate | CCRWQCB first flush monitoring data, 1995, 1996; U.S. EPA 1990 |
| | Abandoned Mines (via Chorro Creek and its tributaries) | High | Schwartzbart 1998 |
| | Maintenance activities at boatyards (vessel antifouling paints) | Unknown | Young et al. 1974 |
| | Wastewater Discharges | Unknown | |
| **Potential Problem** | **Source** | **Relative Contribution** | **Reference** |
| Other toxics: Pesticides | Agriculture; Irrigation Practices | Minimal | San Luis Obispo County Agriculture Department 1999 |
| Other toxics: polycyclic aromatic hydrocarbons (PAH's) | Fuel stations; Oil spills | Unknown | |
| Other toxics: polychlorinated biphenyls (PCB's) | | Unknown | |
| Other toxics | Los Osos landfill | Minimal | San Luis Obispo County Engineering Department, Los Osos Landfill Annual Report, 1998 |

### 9.5.1 Morro Bay Estuary

Although the sources of metals and toxic pollutants in the estuary cannot yet be definitively identified, some of the data relating to quantities found is discussed below.

***Tissue Samples - metals***

The Toxic Substances Monitoring Program Ten Year Summary Report 1978-1987, (SWRCB, 1988) provided limited data regarding trace metal analysis in fish and invertebrates. Information showed a presence of trace metals in whole body tissues for samples collected in 1986. Mercury and cadmium have been found in bay mussels.

The State Mussel Watch (SMW) program is the State Board's long-term marine water quality monitoring program. The SMW program measures concentrations of pollutants in mussels (primarily the common bay mussel, *Mytilus edulis*, and the California mussel, *Mytilus californianus*) as a means of monitoring for the presence of toxic substances in marine and estuarine waters. For Morro Bay, most data is from the State Mussel Watch Program and the Department of Health Services (DHS) oyster meat sampling. Samples have never contained levels high enough to violate health standards, but on a one-time basis, cadmium and mercury were found at a higher than expected level in mussel meat (SWRCB, 1988).

### *Tissue Samples – Organics*

The toxic pollutants, lindane, chlorbenside, and phosphorothoic acid were found in higher than expected concentrations in mussels on a one-time basis (SWRCB, 1989). Lindane and Chlorbenside are pesticides, but detection in the mussel tissue did not result in regulatory action such as initiation of public health quarantine on commercial oysters grown in Morro Bay. Similarly, neither of the compounds were identified as problems for Morro Bay or its tributaries in the CCRWQCB 1998 report to the U.S. EPA required under Section 303(d) (SLO County Department of Agriculture, 1999).

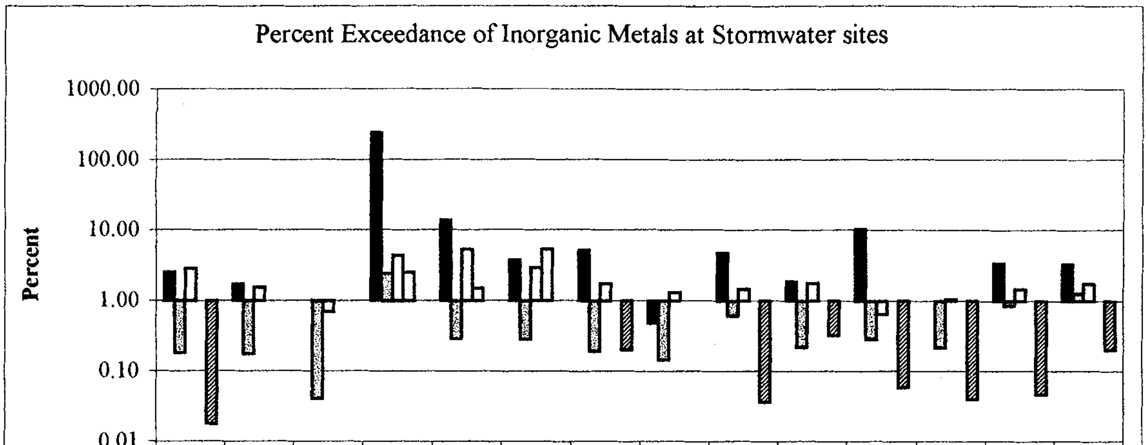
### *Bottom Sediments*

Bay bottom sediments have not been systematically sampled. However, Morro Bay was included as a bottom sediment sampling location as part of the Statewide Bay Protection and Toxic Cleanup Program. This program was funded from fees collected by dischargers into bays and estuaries and was intended to identify so-called toxic "hot spots." Monitoring in Morro Bay occurred in only a few locations, and the data collected do not suggest a problem. However, further monitoring and investigation is warranted, as suggested by the Morro Bay Task Force in 1990.

Tenera, Inc. (1996) found chromium, copper, nickel, and zinc in sediment samples taken prior to dredging that was undertaken in the Morro Bay harbor mooring area. This analysis indicated that sediment material to be dredged was "relatively clean."

### *Estuary Water Quality - Stormwater Runoff*

The CCRWQCB found elevated levels of heavy metals such as copper and lead in "first flush" storm sampling events of 1995 and 1996. This sampling effort is intended to capture samples of the runoff from the first storms of the season, and determine the levels of pollutants in those samples. Although Morro Bay stormwater sampling data are limited, and additional data are necessary to determine trends, it is generally recognized that urban and boatyard runoff is a significant source of toxics and metals. Figure 9.1 illustrates the percent exceedance by heavy metals of NOAA/Hazmat's Screening Criteria for freshwater surface waters. This criteria, CMC, (Criteria Maximum Concentrations) is merely a screening level, to denote the highest level for a 1-hour average exposure not to be exceeded more than once every three years, and is synonymous with "acute" (NOAA 1999). These limits are based upon the protection of aquatic organisms. Based on 1994-1997 stormwater sampling data, the boatyard in on Morro Bay waterfront displays the highest copper levels, exceeding 240 times the CMC screening level (Figure 9-1).




| | Shasta St. * | 451 Embacader | Harbor/Beach | Coastal Boatw | Bob's Boat Rental | Northern T-pier | Pecho Marsh Culver | Baywood Pier | 3rd/El Morro Stand | Kansas/Oklahoma | SLO CO garag | Trash Yard | 349th Maintenanc | Haz Mat |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Copper | 2.56 | 1.69 | 0.00 | 240.56 | 13.83 | 3.81 | 5.17 | 0.47 | 4.78 | 1.86 | 10.39 | 1.00 | 3.42 | 3.31 |
| Lead | 0.18 | 0.17 | 0.04 | 2.40 | 0.28 | 0.28 | 0.19 | 0.14 | 0.60 | 0.22 | 0.28 | 0.22 | 0.86 | 1.27 |
| Zinc | 2.83 | 1.53 | 0.69 | 4.38 | 5.30 | 2.92 | 1.74 | 1.31 | 1.47 | 1.77 | 0.64 | 1.04 | 1.46 | 1.74 |
| Iron | | | | 2.49 | 1.50 | 5.40 | | | | | | | | |
| Nickel | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 | 0.04 | 0.32 | 0.06 | 0.04 | 0.05 | 0.20 |

**Figure 9.1 Percent Exceedance by heavy metals of NOAA Screening Criteria (Criteria Maximum Concentrations, and should not be exceed more than once every three years) for freshwater surface waters at Morro Bay watershed stormwater sampling sites.** *Source: CCRWQCB, Morro Bay Volunteer Monitoring Program and NOAA/Hazmat Screening Tables.*

## 9.5.2 Chorro Creek Watershed

**Urban Runoff.** As mentioned above, another potential source of toxic pollutants is runoff from streets.

**Metals in Watershed /creeks.** In 1994, the RWQCB collected sediment samples from 5 locations at the Creek mouths and in the bay. The upstream Chorro location contained the most chromium and nickel (80 and 280 ppm, respectively), followed by the Chorro Creek mouth location and the upper Los Osos creek location (37 and 35 ppm, respectively) (Schwartzbart 1998).

The Central Coast Ambient Monitoring Program (CCAMP) data show elevated levels of nickel and chromium in sediment samples taken from Chorro Creek (CCRWQCB 1998), when compared to other coastal creeks (Figure 9-2). This could be due to geological strata that include nickel and chromium –bearing formations that have been mined throughout the basin's economic history. Not all levels are due to human impacts.

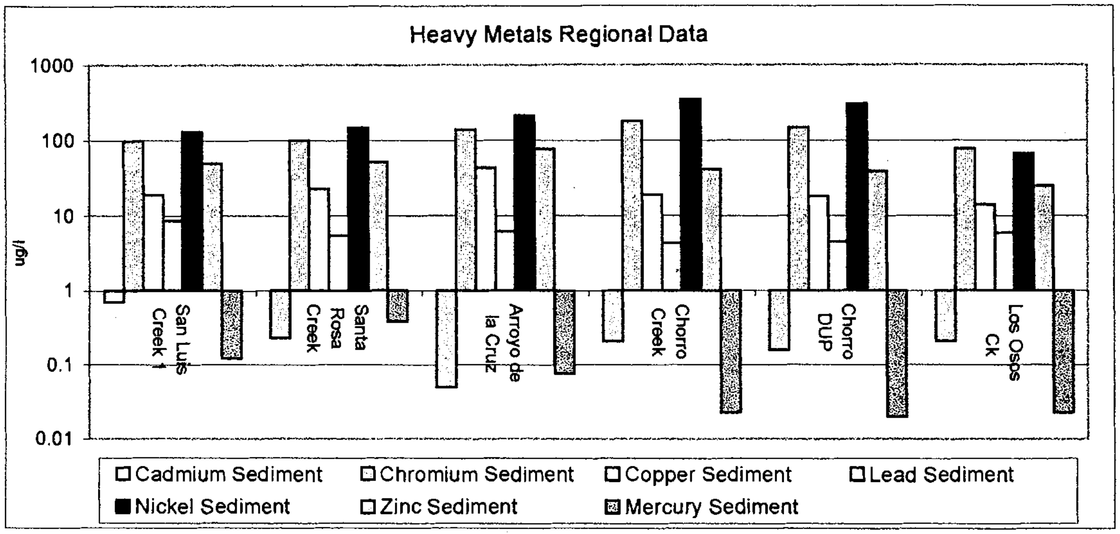



**Figure 9-2. Concentrations of heavy metals in sediment in six Central Coast creeks.**
*Source: Regional Water Quality Control Board regional monitoring data*

In comparison, heavy metals in Los Osos Creek are relatively low. Note, however, that the data are based upon a single sample from 1998.

**Organic Compounds in Creeks**. The CCAMP monitors levels of toxic pollutants in numerous creeks in the region. The preliminary results indicate that Chorro and Los Osos Creeks have relatively low detectable levels. Minute levels of 4,4'-DDT and 4,4'-DDE (a DDT derivative) were found in Chorro Creek. In contrast, creeks in neighboring watersheds, such as San Luis Creek, had elevated levels of PCBs, and Santa Maria Creek, with its intensive agriculture and higher populations, had much higher levels of DDT compounds.

**Inactive Metal Mines in the Upper Watershed.** Chromite has been mined sporadically in San Luis Obispo County since 1870, with peak production occurring during WWI. Most mines were never properly reclaimed, and waste rock and polluted flow are entering nearby creeks. Heavy metals are believed to be eroding from several key inactive chromite mines that are located near the ridges at the northern perimeter of the watershed (see Figure 9-3) Extensive data show that the major source of metals contamination in the Chorro Creek watershed is several abandoned chromium mines in the major tributaries of Chorro Creek (Schwartzbart, 1993; RWQCB, 1999*).* It has also been shown that, in the absence of acid producing elements, the metals in the Chorro Creek watershed are bound in sediments and are not readily leached (Schwartzbart, 1993). Therefore, it appears that the predominant source of metals contamination in the watershed are metal-enriched sediments which are primarily the products of erosion from mine tailings and barren slopes at specific inactive mine sites.

Contaminated sediments have eroded and washed into sediment basins on Camp San Luis Obispo and into Chorro reservoir. In addition, dredged materials from the reservoir and mine tailings have been used to resurface roads, thus adding to the contamination problem (USDA/NRCS, 1998).

From 1992 to 1996, Regional Board staff conducted limited monitoring of water quality and sediments in Chorro reservoir, Chorro Creek, Chorro Creek tributaries, and Morro Bay (Schwartzbart 1998). Grab samples of sediment were collected and analyzed for various metals. In sediments from the Chorro reservoir, the primary constituents found were chromium (262-474 ppm) and nickel (543-2139 ppm). Nickel was found to be over the hazardous waste level of 2000 ppm, exceeding Hazardous Waste standards. These elevated levels are most likely the result of sediment from abandoned chromium mines located within the upper watershed.

**Organics from the Los Osos Landfill.** There has been concern that the now-closed Los Osos landfill may leach toxics into Los Osos Creek and possibly the bay, but recent data indicate that leaching is not occurring(County Engineering, 1998, Los Osos Landfill Annual Report). In the past, toxics have been found in monitoring wells at the landfill.

**Metals from Boat Paint Residues**. Boat paint residues have been identified as a problem in the bay, but there is very limited data to document the severity of the problem. Nickel has been found in bottom sediment near boating operations, but the exact source is unknown. The CCRWQCB 1990 study (CCRWQCB 1990) also indicates that additional potential sources of toxic pollutants include agriculture, irrigation practices, and the Men's Colony wastewater treatment plant discharge.

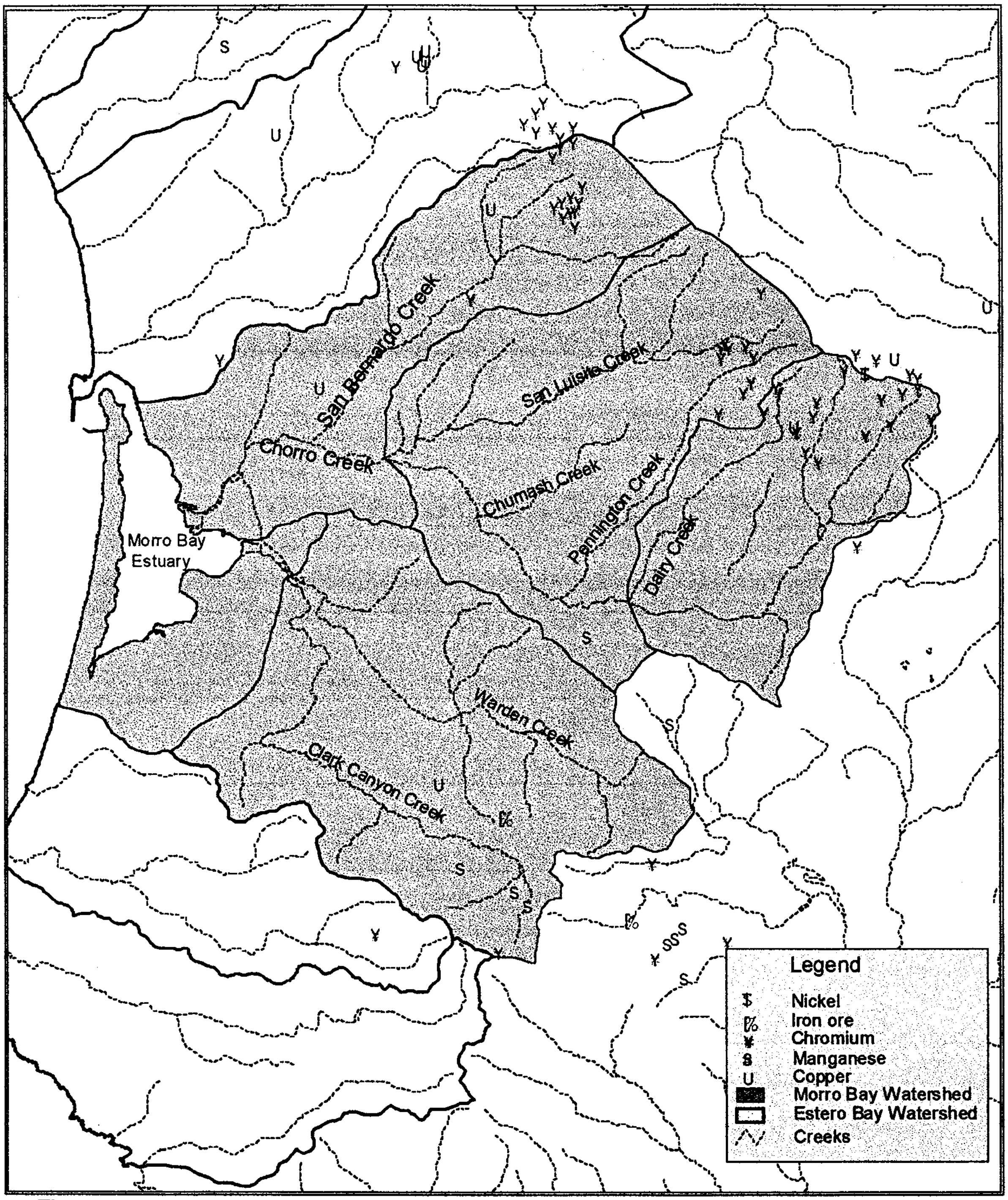



Figure 9.3 Locations of Historic and Inactive metal mines in the Morro Bay Watershed
Source: California Dept. of Conservation Division of Mines and Geology
MBNEP Characterization 1999

### 9.5.3 Further Heavy Metals and Other Toxic Pollutant Levels Research Needs

Conducting further research provides a better understanding of the processes that occur in the watershed and estuary. The additional knowledge provides the program with the tools and techniques that can help guide management decisions. The following heavy metals and other toxic pollutant levels research needs were developed by the MBNEP Technical Advisory Committee (TAC). These research needs include, but are not limited to:

1. Are marine and freshwater organisms in Chorro and Los Osos Creeks and in the Morro Bay estuary impacted by concentrations of metals or toxic chemicals?
   - These substances can enter the streams and estuary from many sources including abandoned mines, roads, industrial areas, urban areas, and agricultural practices.

2. Do metals degrade any surface water beneficial uses?
   - Metals typically accumulate in the food chain and become toxic to the higher trophic levels. These substances can enter the streams and estuary from many sources including abandoned mines, roads, industrial areas, urban areas, and agricultural practices.

# 10.0 HABITAT LOSS IN THE MORRO BAY WATERSHED

## 10.1 INTRODUCTION

Habitat loss occurs as a result of many of the other priority problems discussed in previous sections of this document. Although there is little quantitative data showing decreases in habitats over time, there are general trends that are being observed.

Wetland habitats being threatened include eelgrass beds, coastal salt, brackish, and freshwater marsh, and riparian vegetation. Eelgrass beds were seriously affected by the sedimentation caused by the highway 41 fire and the storms that resulted afterward. These eelgrass beds are critically important as a food resource for brant geese. Portions of coastal salt marsh, brackish marsh and freshwater marsh habitats have been greatly affected by sedimentation and aggressive takeover by invasive exotic species. As developable lots in Los Osos decrease, more pressure is put on wetland habitats that occur at the edge of the bay. Some are protected by virtue of their present land ownership status.

Riparian areas are increasingly being threatened by residential development and the threat of encroaching agricultural activities in the watershed.

Threatened upland types include coastal dune scrub and maritime chaparral. Coastal dune scrub is considered one of the most imperiled habitat types in California. It is inherently rare, occurring only in a few areas along the California coast and, locally, it has been seriously affected by the spread of invasive exotic species (e.g., veldt grass) and the pressures of residential development.

Maritime chaparral provides habitat for the endangered Morro manzanita. Habitat for this species is declining due to past and potential development in the Los Osos area. Maritime chaparral habitat overall is also being affected by off-road-vehicle use and invasive exotic species introduction and spread, as mentioned in Section 3 of this document.

Many of the wetland habitats discussed above are shown in Figure 3-1 of Section 3 of this document. Upland habitats in the vicinity of Los Osos that are being considered for the purposes of developing a greenbelt are shown in Figure 10-1. The impacts to beneficial uses are discussed further below.

The MBNEP will initially focus acquisition, preservation, and restoration activities based upon the multiple resource benefits achieved, including, but not limited to, the following factors:

1. The ability to remove or control pollutants threatening the estuary;
2. The number of species benefited;
3. Missing linkages to wildlife corridors or access to habitat;
4. The number of threatened and endangered species benefited;
5. Threats to land use conversion;
6. Recreation benefits.

## 10.2 IMPACTS TO BENEFICIAL USES

Virtually all those who use the estuary and watershed are or will be impacted by habitat loss. The impacts include those discussed below. Losses of these crucial habitats directly affect wildlife populations, pollutant loads and the recreational and commercial value of Morro Bay.

The primary impacts to beneficial uses include: land development, competition from introduced species, road maintenance activities, off-road vehicle activity, cattle grazing and farming, and water diversions.

***Waterfowl and Wildlife Habitat***

Changes in Morro Bay's wintering Brant populations are intimately tied to forgeable acreage. The decrease of approximately 10,000 Brant over the last thirty years may be due to declining eelgrass beds in the estuary (Gerdes et al. 1974; Roser 1998). The decline in eelgrass habitat is discussed in Section 3 of this document and is further summarized in Table 10-2 in this section.

***Preservation of Biological Habitats of Special Significance, Rare, Threatened, or Endangered Species***

The Morro Bay Kangaroo Rat has lost approximately 97 % of its coastal dune scrub habitat to development and is now considered the most endangered species in California. Other species such as the Morro shoulderband snail and the shrub, Morro manzanita, are also affected by changes to coastal dune scrub habitats.

Habitat alteration in or near riparian corridors also directly affects special status species such as red-legged frog, tidewater goby, steelhead trout and many shorebirds and migratory species.

***Migration of Aquatic Organisms, Spawning, Reproduction, and/or Early Development and Cold Freshwater Habitat***

As discussed in Sections 5, 7 and 8 of this document, many of the priority problems (sediment, nutrients and lack of freshwater flow) in the estuary have caused loss of habitat for aquatic organisms. Decreased stream flow caused by municipal and agricultural well pumping and water diversions has fragmented habitat for steelhead trout. Increases in fine sediment deposition can create unsuitable conditions for migrating, spawning or developing aquatic organisms.

***Contact (REC-1) and Non-Contact (REC-2) Water Recreation***

Habitat loss reduces the recreational and commercial value of wetlands and estuaries. Non-contact recreational uses, such as hiking, beachcombing, sightseeing, and birding also rely on open areas with high animal and plant diversity that increases the intrinsic value of the Morro Bay area.

***Agricultural Supply, Ground Water Recharge and Fresh Water Replenishment***

Reduced wetland acreages can decrease the buffering capacity of the estuarine and riparian systems, and thereby increase pollution inputs to the estuary due to the loss of the filtration function that the habitat provides. A healthy wetland buffer surrounding streams, springs or other drainages, slows and filters sediment and nutrient pollutants. Without such filtering, excess algae blooms can occur leading to fish kills.

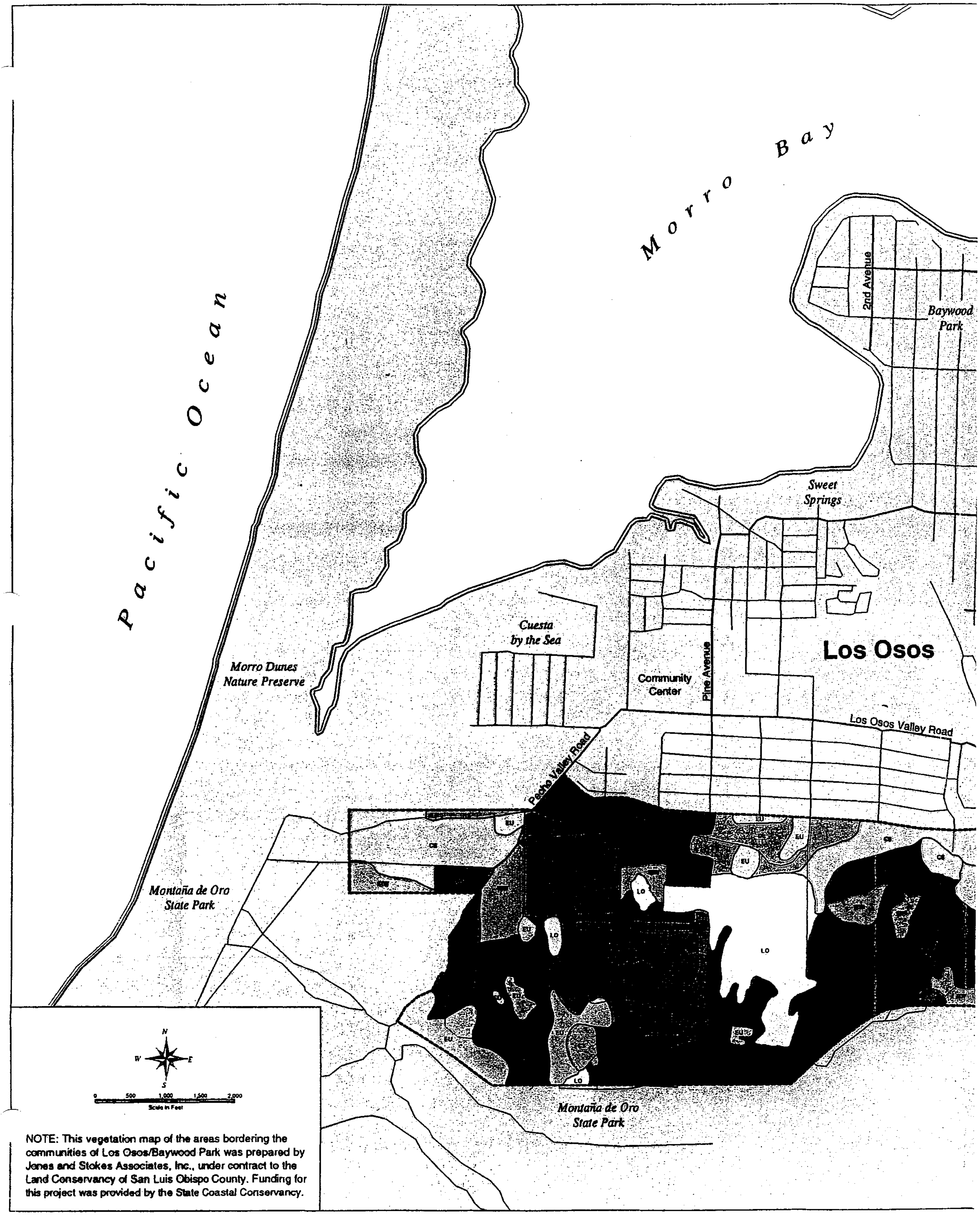
## 10.3 SOURCES AND TRENDS

Table 10-1 summarizes the potential causes of species habitat loss in the Morro Bay watershed.

### 10.3.1 Land Development

Urban development results in the direct loss of habitat. According to San Luis Obispo County (1999), 85 percent of the Los Osos area coastal dune scrub community has been converted to suburban or urban development. Residential development in the Los Osos area has increased drastically since about 1969, rising to 6,597 units in 1999 (see Figure 10-3). The year 2015 build-out goal is 11,179 units, a large increase from current numbers. This housing trend is also reflected in the decrease in acreage of habitat for endemic species such as the Morro Bay Kangaroo Rat (see Figure 10-4), Morro manzanita and the Morro shoulderband snail. All these species occur in areas of Baywood fine sands, where development also occurs. Their numbers continue to decline because of urban development. The 353 acres of Morro manzanita habitat remaining is a small range for any species, especially considering that approximately 76 percent of this is private, fragmented holdings (Tyler and Odion 1996). Figure 10-5 displays Morro manzanita habitat acreages and ownership categories.

**Figure 10-1**
**Distribution of Upland Greenbelt Habitats in the Vicinity of Los Osos**




NOTE: This vegetation map of the areas bordering the communities of Los Osos/Baywood Park was prepared by Jones and Stokes Associates, Inc., under contract to the Land Conservancy of San Luis Obispo County. Funding for this project was provided by the State Coastal Conservancy.


**Figure 3.**
**Plant Community Map of the Los Osos/Baywood Park Greenbelt & Conservation Area**

**Maritime Chaparral**
- Morro Manzanita Series (MM)
- Morro Manzanita - Wedgeleaf Caenothus Series (MW)
- Morro Manzanita - California Sagebrush Series (MS)
- Morro Manzanita - Coast Live Oak Series (MO)
- Morro Manzanita - Chamise Series (MC)
- Chamise Series (CH)
- Chamise - Black Sage Series (CB)
- Wedgeleaf Ceanothus Series (WC)

**Coastal Sage Scrub**
- California Sagebrush - Black Sage Series (CS)
- Coyote Brush Series (CY)
- Dune Lupine - Goldenbush Series (DL)
- Dune Almond Series (DA)
- California Sagebrush - Black Sage Disturbed Series (CSD)
- Dune Lupine - Goldenbush Disturbed Series (DLD)

**Wetlands/Riparian**
- Arroyo Willow Series (AW)
- Cattail Series (CT)
- Pickleweed Series (PW)
- Black Cottonwood Series (BC)
- Narrow - Leaf Rush (RU)
- Coast Live Oak - Arroyo Willow Series (LW)
- Sedge Series (SS)
- Disturbed Wetlands (DW)

**Woodlands / Grasslands**
- Coast Live Oak Series (LO)
- Bishop Pine Series (BP)
- Eucalyptus (EU)
- California Annual Grassland (CA)
- Landscape Trees (LT)

**Other Habitats / Land Uses**
- Open Water (OW)
- Residential (RS)
- Agriculture Land (active) (AG)

Jones & Stokes Associates, Inc.

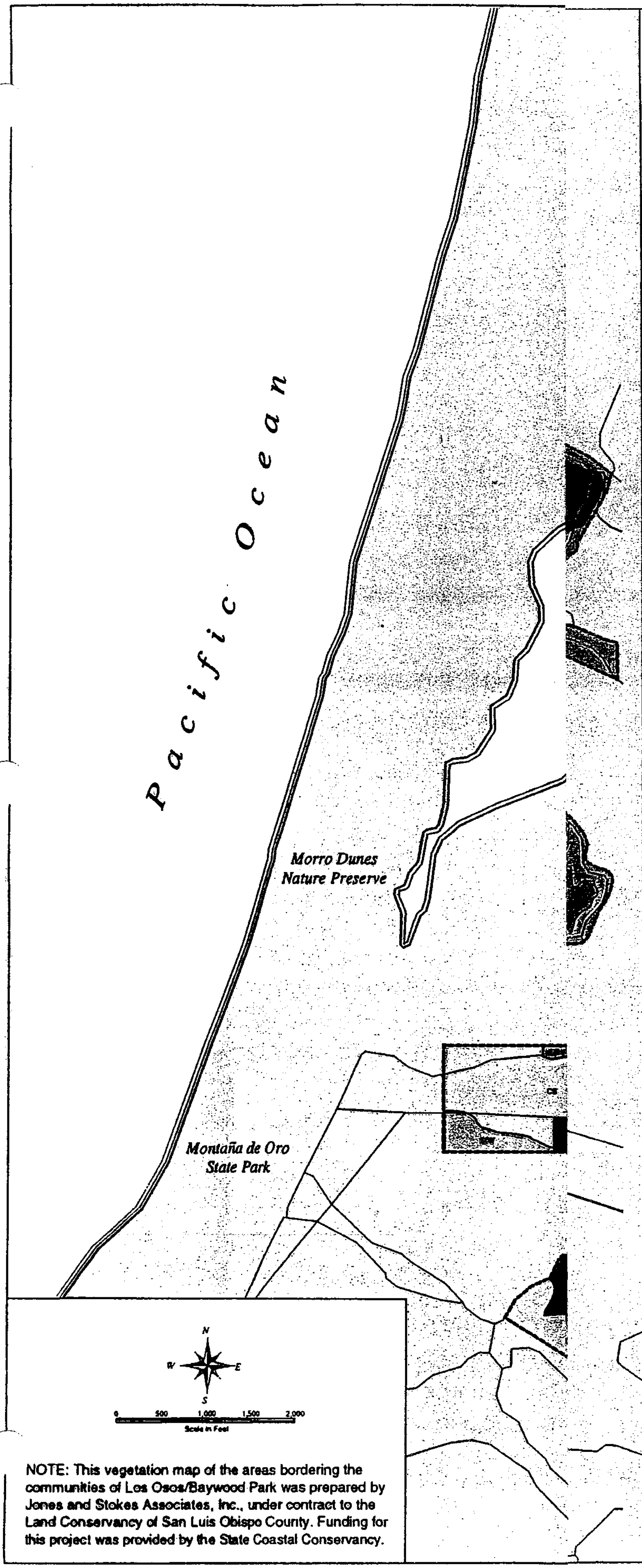



**Figure 3.**
**Plant Community Map of the Los Osos/Baywood Park Greenbelt & Conservation Area**

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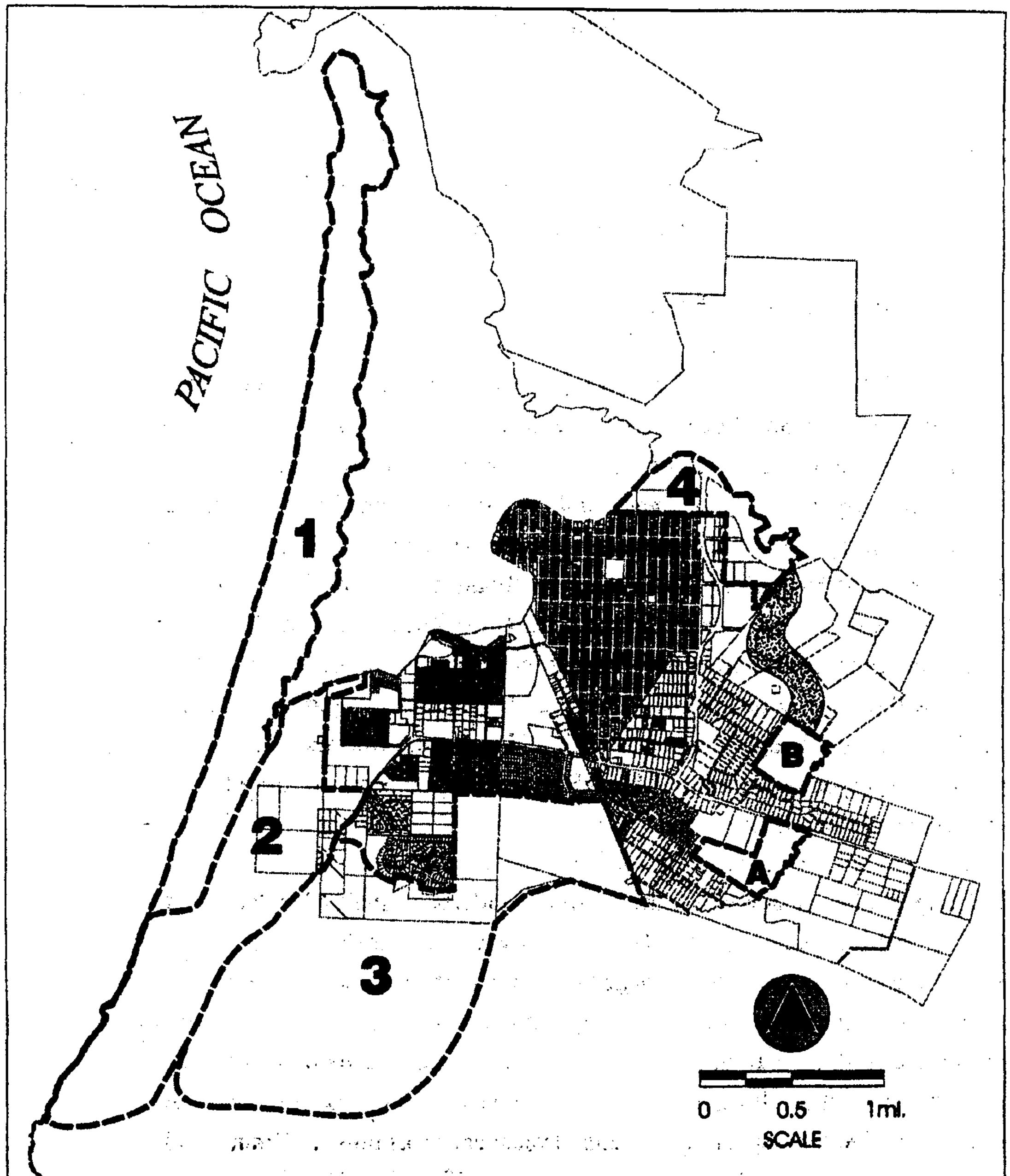


**Conservation Planning Areas:**
1 Morro Spit
2 West Pecho
3 South Los Osos
4 Northeast Los Osos

**Other Habitat Areas:**
A Los Osos Oaks Preserve
B Buckskin Site

Potential Restoration Corridor

Source: US Fish and Wildlife Service; SLO County Planning Department; Crawford Multari & Clark Associates

**Figure 10-2**
**Conservation Planning Areas in the vicinity of Los Osos**
*Source: Estero Area Plan Update (Public Hearing Draft 1999)*

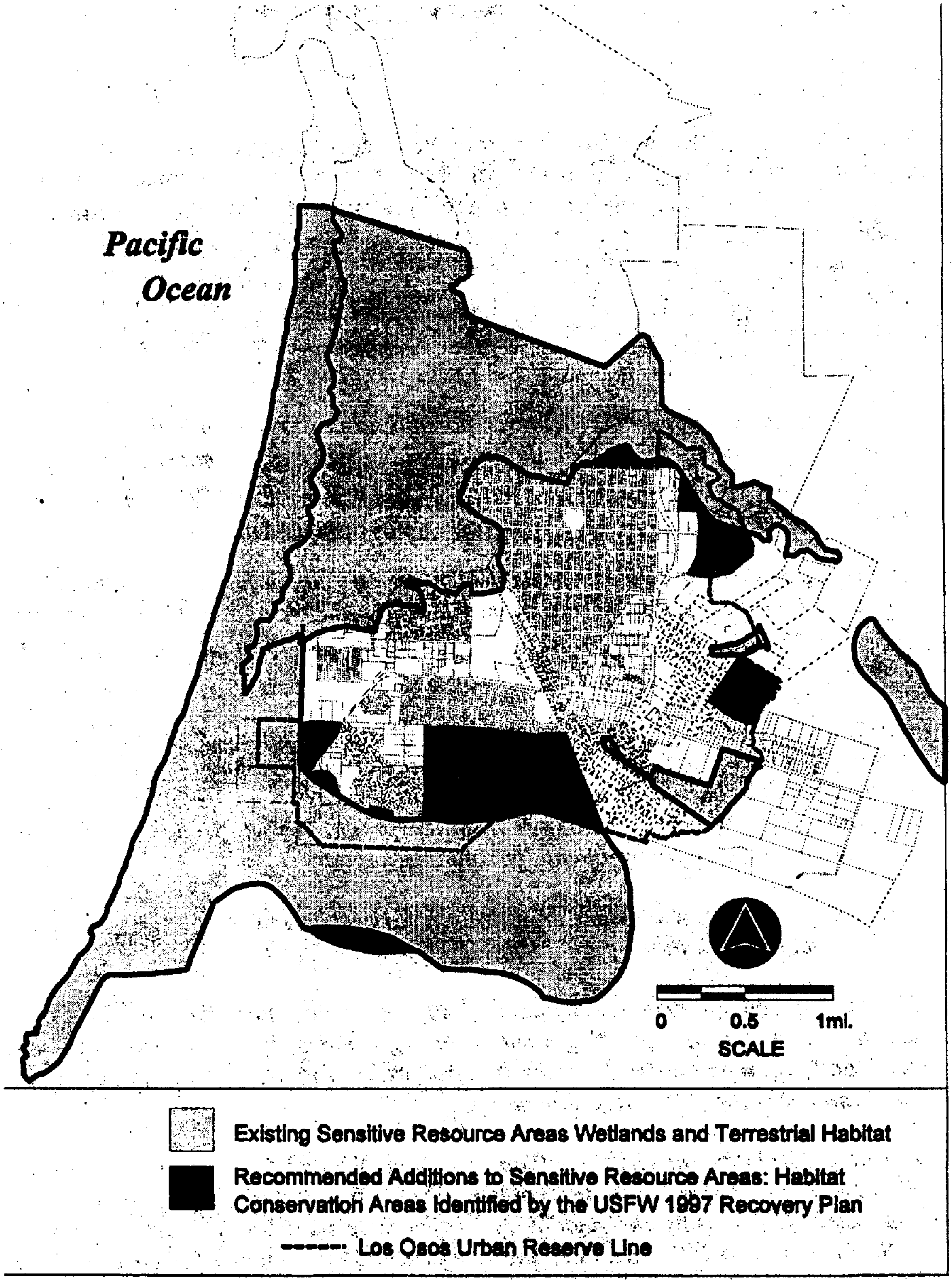


**Figure 10-3**
**Additions to Sensitive Resource Area Combining Designation**
Source: Estero Area Plan Update (Public Hearing Draft 1999)

**Table 10- 1. Potential Causes of Species Habitat Loss in the Morro Bay Watershed.**

| Habitat | Species | Cause of Decline* | Reference |
|---|---|---|---|
| Brackish Marsh | Tidewater goby | Alterations of flow and changes in salinity distributions; Sedimentation of habitat | USFWS 1994; Worcester, 1999 |
| Maritime Chaparral | Morro manzanita | Growth and development leading to population fragmentation | Tyler and Odion 1996 McGuire and Morey 1992 |
| | | Invasive exotic species: iceplant | Tyler and Odion 1996; USFWS 1998 |
| | | Invasive exotic species: eucalyptus | McGuire and Morey 1992 |
| Coastal Dune Scrub | Morro Shoulderband Snail | Invasive exotic species: veldt grass | USFWS 1998 |
| | | Recreational use (off-road vehicles) | USFWS 1998 |
| Coastal Salt Marsh | California Suaeda | Wetland alterations | USFWS 1996 |
| Sandy Beaches | Western Snowy Plover | Dredging; recreational use | USFWS 1993 |
| | | Invasive exotic species: European beachgrass *(Ammophila arenaria)* | USFWS 1993 |
| Freshwater wetland and Riparian | Bog thistle | Livestock grazing | USFWS 1998 |
| Riparian | Red-legged frog | Growth and development | USFWS 1998 |
| | | Livestock grazing | USFWS 1998 |
| | | Wetland alterations | USFWS 1996 |
| | | Storm damage repair and flood control maintenance on streams | USFWS 1996 |
| | | Stream channelization projects | USFWS 1996 |
| Riparian/Aquatic | Steelhead | Sedimentation | Worcester, pers. comm. 2000 |
| | | Introduced exotic species: squawfish | Worcester, pers. comm. 2000 |
| | | Water diversions (see freshwater flow) | Chappell 1976 |
| | | Water extraction (see freshwater flow) | USFWS 1998; Rathbun et al. 1991 |

*Does not include disease or predation, as these are difficult to control.

In addition to direct habitat loss, habitat fragmentation caused by new residences and roads is likely to: (1) eliminate effective dispersal resulting in isolated populations; (2) diminish or eliminate gene flow between these isolated populations; and (3) diminish the likelihood of habitat maintenance such as the use of prescribed burns (U.S. Fish and Wildlife Service (USFWS) 1997). Further demands are a threat to habitat conservation.

**Table 10-2. Cause of Eelgrass Decline in the Morro Bay Estuary.**

| Habitat | Cause of Decline | Relative Percent Contribution | Reference |
|---|---|---|---|
| Eelgrass | Suspended and resuspended fine sediments and resultant reduced water clarity [see sedimentation] | High - One of the two pollution problems having the greatest impact on seagrass decline | Short et al. 1991; Chesnut 1999 |
| Eelgrass | Competition with macroalgae such as *Ulva, Enteromorpha,* which smothered beds after the Highway 41 fire | High | Chesnut 1999 |
| Eelgrass | Nutrient discharge and resultant excess nitrogen loading and inadequate dissolved oxygen levels for marine plant life (source of nitrogen is groundwater discharge, urban runoff, golf course discharge, Ag runoff) [see nutrients discussion] | High - One of the two pollution problems having the greatest impact on seagrass decline; the major long-term threat to seagrasses. | Short et al. 1991; Capone 1985 and Lee and Olsen 1985 (as reported by Chesnut 1999) |
| Eelgrass | Mechanical disruption from propellers, dock facilities, mooring chains | Low | Short et al. 1991 |
| Eelgrass | High water velocities in tidal channels at ebb tide (prevents the establishment of beds) | Moderate? | Chesnut 1999 |
| Eelgrass | Dredging, to the extent that it increases the velocity of tidal exchange; may increase the severity of desiccation in the intertidal flats | Moderate? | Chesnut 1999 |

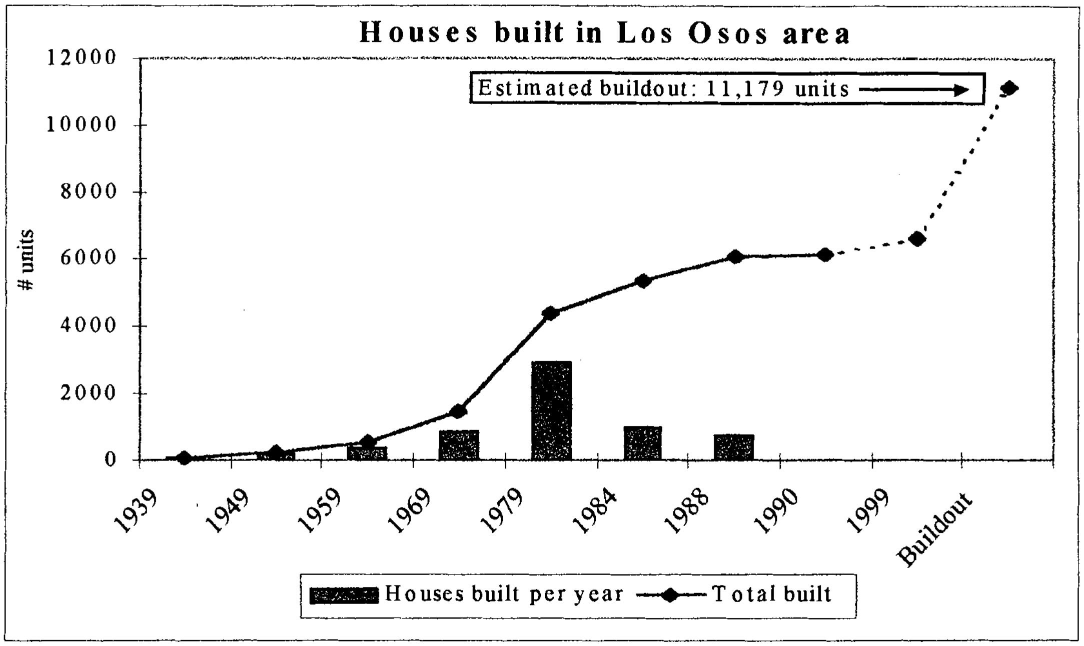


**Figure 10-4. Time Series Bar Charts showing Number of Houses Built and Projected to be Built in Los Osos, 1939-2015.** *Source: Estero Area Plan Update, Public Hearing Draft-1999.*

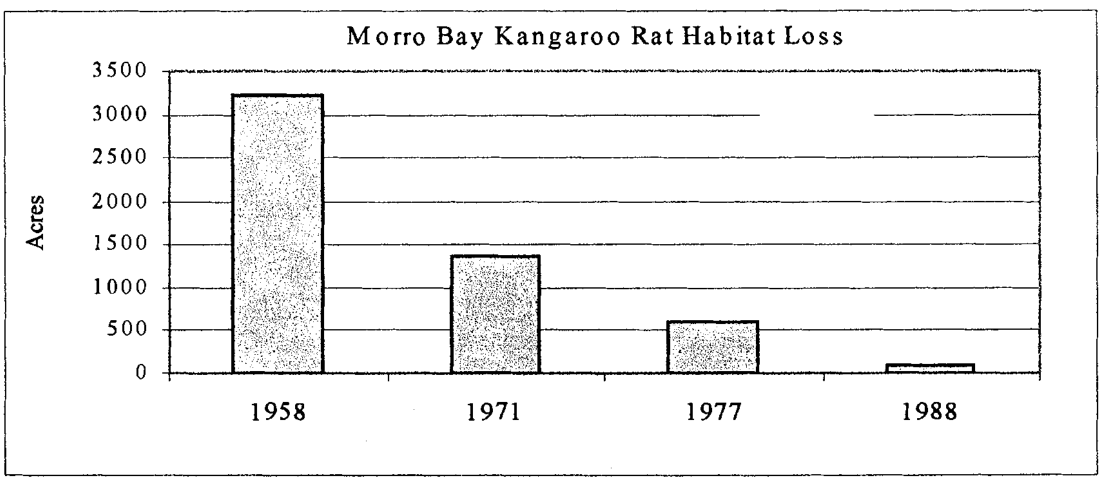


**Figure 10-5. Acres of Habitat, Morro Bay Kangaroo Rat (*Dipodomys heermanni morroensis*), 1958-1988.** *Sources: Gambs and Holland 1988; Stewart and Roest 1960; Roest 1977; Congdon and Roest 1975; Congdon 1971; Stewart and Roest 1960.*

Efforts to preserve sensitive habitats in the Los Osos area are ongoing. The County of San Luis Obispo Planning and Building Department (1999) has identified many factors relating to habitat conservation in the area. Some of these factors include:

- The construction of an anticipated wastewater treatment facility and its impact on endangered species. Approximately 100 acres are expected to be protected as mitigation for the facility.
- Approximately 38 undeveloped parcels that are greater then one acre in size contain suitable Morro Shoulderband Snail habitat (see Figure 10-6). Increased development in these areas is expected when the building moratorium is lifted. San Luis Obispo County and the U.S. Fish and Wildlife Service are currently negotiating a habitat replacement ratio for mitigation purposes.
- New Programs are being developed to protect sensitive habitats. Where there are willing sellers, land acquisition and easements are being considered for areas along Los Osos Creek, west of Pecho Valley Road, and on the hillsides on the southern perimeter of Los Osos.
- The U.S. Fish and Wildlife Service Recovery Plan for the Morro shoulderband snail and the four plants from western SLO County (USFWS 1998) identifies four "Conservation Planning Areas" where certain endangered species overlap, the habitats are in public ownership, and the habitats are relatively large and unfragmented. These areas are shown in Figure 10-1.

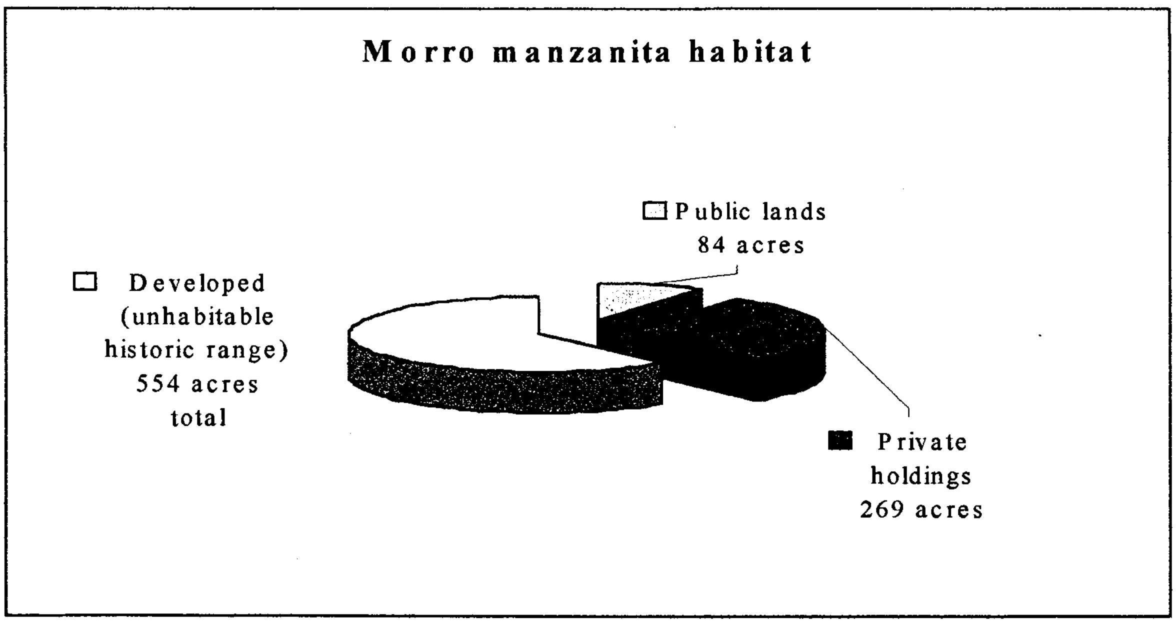


**Figure 10-6. Pie Chart Showing Acres of Habitat by Ownership Category for Morro Manzanita.**
*Source: Tyler and Odion 1996, McGuire and Morey 1992.*

## 10.3.2 Competition from Introduced Species

Several invasive and non-native plant species and aquatic organisms are encroaching into native habitats. Since European settlement of the Morro Bay area, substantial expanses of native habitats have been lost to exotic plant species. Tyler and Odion (1996) and Jones and Stokes (1997) provide recent summaries of the non-native plant species invading the native plant communities in the Morro Bay area.

***Eucalyptus.*** Two species of eucalyptus (*Eucalyptus globulus* and *E. camaldulensis*) invade native habitats in the Morro Bay area. After a fire, eucalyptus seedlings can outgrow and displace maritime chaparral dominated by manzanita. Another threat posed by eucalyptus is that during fire events, its vigorous combustion produces firebrands that can cause spotfires several kilometers downwind, increasing fire hazard to surrounding areas.

***Iceplant.*** Fig-marigold (*Carpobrotus edulis*), whose seeds are spread in the feces of deer and rabbits, forms dense mats in coastal dune scrub on the sandspit and in openings in maritime chaparral on Baywood fine sands. Fig-marigold recruits abundantly in burned or mechanically disturbed areas if a seed source is in the vicinity. Although most of the seeds are destroyed by fire, in chaparral new seeds can be carried into chaparral by deer. Mats of Carpobrotus establish quickly, crowding out slower growing manzanita seedlings. Established mats of Carpobrotus, with their fleshy leaves, will not completely burn in a fire. Therefore, with successive burns, iceplant displacement of maritime chaparral can be virtually complete (USFWS 1998). The California Exotic Plant Pest Council (CalEPPC) considers this to be one of the most invasive pest species of concern in the state (Cal EPPC 1999).

Slender-leafed iceplant *(Conocosia pugioniformis)* is a more recent iceplant arrival in the Morro Bay area. It has wind dispersed seed, and is also invading openings within maritime chaparral and coastal dune and sage scrub. Removal methods for iceplants that do not damage other species are currently restricted to manual removal.

***Veldt Grass***. Veldt grass (*Ehrharta calycina*) is an aggressive perennial, non-native grass that occurs in coastal dune scrub and other sandy habitats where it fills openings between shrubs and out-competes other species. Its seeds are wind-dispersed, and once established it is extremely difficult to remove. Although it does not offer suitable habitat, it occurs in habitat occupied by the Morro shoulderband snail, and invasively replaces the native vegetation that does provide suitable habitat (USFWS 1998). In 1999, the San Luis Obispo County Land Conservancy, using funds provided by the MBNEP, conducted a successful veldt grass removal project on the west side of South Bay boulevard in Los Osos. Other options for continued management of this exotic are being explored. CalEPPC considers this to be one of the most invasive pest species of concern in the state (Cal EPPC 1999).

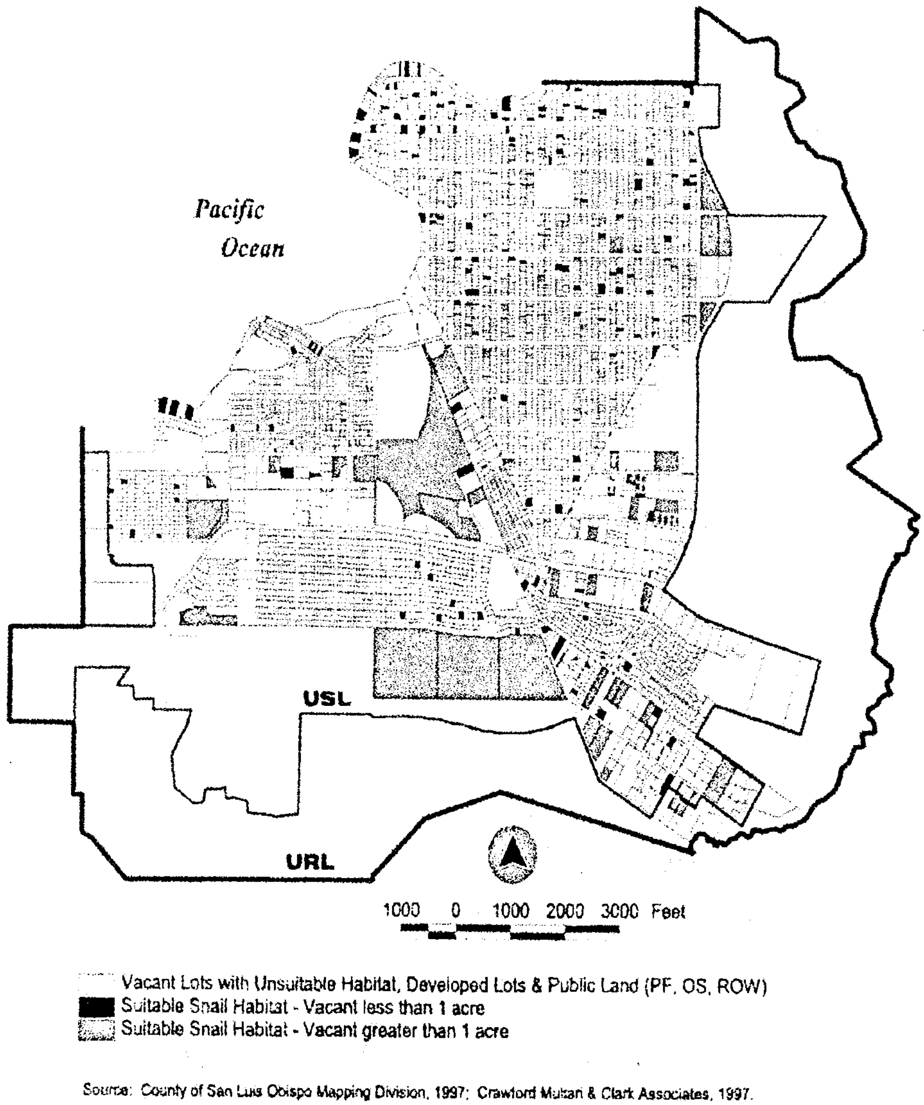


**Figure 10-7**
**Habitat for Morro shoulderband Snail Within the Los Osos Urban Service Line.**
*Source: Estero Area Plan Update (Public Hearing Draft 1999)*

### *Non-native Annual Grass Species*

Non-native annual grasses have become common in many California plant communities, especially those prone to disturbance, either natural or human-caused. Annual grasses are short-lived, but produce copious seed, dispersed by wind or animal. Livestock grazing and human activities such as road grading tend to cause habitat disturbance and disperse the seed, enhancing the opportunities for invasion of these species. Non-native grasses, including bromes (Bromus sp.), wild oats (Avena sp.) and (Lolium perenne) may be a threat to native species when they occur in high densities.

**Cape Ivy.** Cape Ivy (*Delaria odorata*), a climbing perennial of the composite family (*Asteraceae*), can be found in aggregate clumps on lower Chorro Creek near Chorro Bridge and along Los Osos Creek within the study area. This species has a dense, fast-growing epiphitic canopy that can smother native riparian species and alter the microclimate of a site. Fragments of this plant can be carried by surface runoff and landscape machinery and can take root and grow rapidly. The species is considered a very serious pest, as the plants growth habit necessitates removal of native shrubs along with the ivy during removal efforts.

**Pampas Grass.** Pampas Grass (*Cortaderia selloana*), native to South America, is found in many south bay communities, in addition to the Morro Bay sandspit and the uppermost reaches of the Chorro Creek watershed. It is one of the many invasive grasses that have no biocontrol. It can outcompete natives with the first rain of the season. CalEPPC considers this to be one of the most invasive pest species of concern in the state (Cal EPPC 1999).

**Hoary Cress.** Hoary Cress (*Carderia draba*), a member of the mustard family (Brassicaceae) is a widespread perennial weed native to Central Europ. It ranges throughout the state and occurs in a variety of disturbed habitats. It is a found in Morro Bay near Chorro bridge, at the elevation intermediate between roadside (ruderal) vegetation and tidal salt marsh (Josselyn 1991). Its fast sprouting, rhizome-like roots make the plant difficult to control.

**Poison-hemlock.** Poison-hemlock (*Conium maculatum*), of the umbell family (*Apiacae*) occurs extensively throughout the Morro Bay watershed, concentrated in disturbed areas. In the Twin Bridges/Chorro Flats area of Chorro Creek, the occurrence of poison-hemlock is attributed to the two to three foot increase of sedimentation. This deposition has lifted the area above tidal influence, allowing weedy species to flourish (Haltiner and Thor 1988; Mooney 1992).

**Giant Reed.** Giant reed (*Arundo donax)* is a perennial rhizomatous grass that resembles bamboo. It is extremely fast-growing and occurs along creeks and streams throughout California. In the Morro Bay study area, it occurs in localized patches along Chorro Creek near Cuesta College, and along one of Chorro's tributaries, Dairy Creek. It consumes 5.62 acre feet of water per year compared to native vegetation, which consumes 1.872 acre feet per year. Giant reed can severely decrease plant diversity throughout the entire riparian corridor. CalEPPC considers this to be one of the most invasive pest species of concern in the state (Cal EPPC 1999).

**Castor Bean.** Castor bean (*Ricinus communis*) is an aggressive, fast-growing European exotic distributed primarily throughout the Chorro Delta. Shrubby, and sometimes tree-like, it shades out native plants such sticky monkeyflower and watercress in riparian corridors. It is most likely to be found in disturbed areas with an ample moisture supply such as roadsides or stream deposition zones.

**Sacramento Squawfish** are an introduced freshwater fish that compete with steelhead trout for food and habitat resources.

**Bullfrog** (*Bufo spp.)* are an aggressive amphibian that is exploding in population and is a competitor with steelhead trout for food resources.

**Tortellini Sea Slug**. This sea slug (*Philine auriformis*) arrived in Morro Bay in 1995, and it's population has been increasing ever since. This sea slug from New Zealand was first seen in San Francisco Bay in 1992. It now ranges along the Pacific Coast from Coos Bay, Oregon to Mission Bay in southern California. This slug feeds primarily on small clams, competing with shorebirds for food.


Tortellini Slug (2" long)

## 10.3.3 Road Maintenance Activities

Special status plant populations adjacent to roads are vulnerable to maintenance activities, including mowing, grading, herbicide application, and road expansion. In addition to subjecting individual plants to removal, these activities may create conditions favorable to the establishment and spread of invasive, non-native species. Improper maintenance also can cause habitat disturbances such as erosion gullies and landslides causing off site impacts.

## 10.3.4 Off-Road Vehicle Activity

Off road vehicles are destructive to most plant communities, primarily because they disturb soil and make it easier for weedy species to become established. They can also adversely affect wildlife food sources and shelter. Once vegetation cover is lost, soil movement is increased whether in sand dunes or silty farmland. The eroded material then drains into the estuary, clogging filter feeders such as oysters and clams, and blocking sunlight for sensitive eelgrass. Historically, off road vehicle activity was heavy on the Morro Bay's sand spit, and degraded much of the coastal dune scrub. A ban on vehicle use on the spit has resulted in a significant re-growth in dune vegetation (Keil 1999 pers. comm).

Dune stabilization has been approached using fast growing European beach grass and iceplant (Holland and Keil 1995). However, because these aggressive non-natives have crowded out indigenous dune scrub species other alternatives are being researched.

### 10.3.5 Cattle Grazing and Farming

The MBNEP biological workgroup identified cattle grazing as a potential issue primarily for riparian and upland habitats. Overgrazing by cattle can result in vegetation removal, streambank vegetation damage, increased levels of bacteria and nutrients in streams, soil compaction, change in species composition through selective grazing by cattle, and increased runoff and sedimentation. Proper stocking rates and rangeland pasture utilization by cattle can avoid these types of disturbances. U.S. Fish and Wildlife Service has discussed overgrazing as a potential factor in the decline of some special status species.

Approximately 26,162 acres (60 %) of the Morro Bay watershed, formerly a USDA Hydrologic Unit Area, are grazed by cattle, and represent a primary agricultural value to surrounding communities and the County (Stechman, J., 1999, pers. comm). Limited studies by the UCCE and USDA in the early 1990's found generally satisfactory watershed conditions for uplands of the watershed.

Preliminary data collected for the National Monitoring Program since 1993 suggest that bacteria levels in creeks can be reduced by installing streamside fencing and developing upland watering systems (CCRWQCB 1998, 1999).

### 10.3.6 Water Diversion

Both Chorro and Los Osos creeks have historically supported steelhead populations and both still have remnant populations of resident (non-migratory) steelhead trout. In 1976, more than a dozen adult steelhead were found stranded and killed in a single pool as a result of a surface water diversion. This points to one of the primary problems confronting these fish, which is excessive water diversion from the creeks. Steelhead need adequate winter flows to enable them to migrate up and down the creek to the ocean, and sufficient summer flows to maintain sufficient cold-water habitat for juvenile rearing. In past years, large numbers of ocean run fish have been documented in Chorro Creek.

### 10.3.7 Summary and Future Direction

The loss of a wide variety of habitats within the Morro Bay Watershed is a result of land use activities and other priority problems discussed in this document. The activities threatening these habitats include: land development, competition from introduced species, road maintenance activities, off-road vehicle activity, cattle grazing and farming, and water diversions.

The MBNEP's strategy for habitat protection will initially focus acquisition, preservation, and restoration activities based upon the multiple resource benefits achieved, including but not limited to the following factors:

1 The ability to remove or control pollutants threatening the estuary
2 The number of species benefited
3 Missing linkages to wildlife corridors or access to habitat
4 The number of threatened and endangered species benefited
5 Threats to land use conversion
6 Recreation benefits

### 10.3.8 Further Habitat Research Needs

Conducting further research provides a better understanding of the processes that occur in the watershed and estuary. The additional knowledge provides the program with the tools and techniques that can help guide management decisions. The following habitat research needs were developed by the MBNEP Technical Advisory Committee (TAC). These research needs include, but are not limited to:

1. What are the sediment plume effects on Morro Bay and Estero Bay?
   - Sediment deposition is filling in the Bay, impacting a wide variety of habitats, and affects virtually all other aquatic biological species.

2. What is the effective minimum width for fenced riparian buffer to improve water quality improvement?
   - Buffer strips are a proven effective BMP at reducing sediment, bacteria, and nutrient levels in surface waters. Buffer width effectiveness is dependent on various factors such as slope length, slope angle, soil type, vegetation types, volume of runoff, and adjacent land uses.

3. Is there a positive correlation between salt and freshwater flow mixing zone and spatial particle size deposition?
   - Sediment deposition in the estuary is influenced by differences between fresh and saltwater density.

4. Is the lack of water clarity positively correlated with decreasing eelgrass productivity?
   - Eelgrass production appears to be dependent upon low turbidity conditions. A decrease in the area of eelgrass has been observed after high runoff seasons with large sediment loads.

5. Perform Wetland Delineation using Satellite Imagery Analysis and groundtruthing
   - Location and extent of wetlands will be valuable during the implementation and acquisition components of the CCMP.

6. What are the most critical habitats impacted by recreation and economic uses?
   - Identifying and avoiding future land use conflicts will help protect the most critical habitats

7. What is the temporal species richness and relative abundance of benthic invertebrates in Morro Bay?
   - Benthic invertebrates provide a valuable indicator for evaluating progress on the priority problems.

8. What is the extent of acreage of the most invasive exotic species? What are the trends over time?
   - Exotic species can easily out-compete native species and cause habitat conversion and loss.

9. What function does nutrient and turbidity variances have on Eelgrass productivity in Morro Bay? (Comparison of Instantaneous And Comprehensive Methodologies)
   - Eelgrass habitat has been highly variable over time and provides the primary food source for the over-wintering brant geese population.

10. What are the ecological effects of algal blooms (Freshwater And Estuarine)?
    - Algal blooms decrease dissolved oxygen levels, which can impact other aquatic biota.

11. What is the extent of natural and anthropogenic sources of hypoxia?
    - High nutrient loads increase algal blooms, which reduce dissolved oxygen levels and impacts aquatic biota.

12. What are the ecological impacts of Morro Bay Power Plant?
    Air Deposition, Entrainment,' Circulation (Data Stream Tracking)
    - The power plant's cooling water intake structure is located near the mouth of the bay. The power plant is currently permitted to intake up to 725 million gallons a day.
    - Fish and invertebrate larvae are drawn in with the cooling water and killed.
    - Impacts from air deposition are not currently suspected, but lack of data causes this issue to be unknown at this time.

13. What are the impacts of changes in freshwater inflow on oligohaline habitats?
    - The freshwater/saltwater interface is a critical ecotone where changes in biota could be an indicator for evaluating progress on the priority problems.

14. What habitats are crucial to special species? Are there recreational activities that interfere with their critical habitat needs?
    - Identifying and avoiding future land use conflicts will help protect the most critical habitats

15. What exotic species are in the estuary and watershed? Are they increasing or decreasing? what impacts do exotic species have on native species?
    - Exotic species can easily out-compete native species and cause habitat conversion and loss.

16. How do changes in wastewater management affect distribution of freshwater instream and terrestrial wetland habitats?
    - Freshwater flow volume is essential to aquatic habitat needs and the survival of threatened and endangered species.

# 11.0 STEELHEAD TROUT

## 11.1 INTRODUCTION

Historically Los Osos Creek, Chorro Creek, and their tributaries supported steelhead populations when flows were sufficient for migration. The steelhead trout populations in the Morro Bay watershed fall into the South-Central Evolutionary Significant Unit (ESU) as defined by the National Marine Fisheries Service. This ESU is part of a larger grouping of southern steelhead (all populations south of San Francisco), which has been considered to be the "most ancient of all rainbow trout" (Figure 1).

But over the last 100 years, the steelhead population has rapidly declined bringing the focus of their habitat degradation to the forefront. Historically the southern steelhead trout populations once numbered in the ten thousands. Currently, the population is estimated to be less than one percent of its historic levels. In 1976, CDFG estimated the adult population for Chorro Creek at 160 individuals. Current estimates are believed to be only a fraction of that number.

Since the Morro Bay Watershed supports one of the southernmost remaining steelhead runs on the Pacific Coast, it contains a valuable genetic resource for restoration of populations in streams south of Morro Bay. This genetic stock of steelhead should be more tolerant and better suited for the conditions found in southern California streams, which are similar to the conditions found at Morro Bay.

Steelhead trout serve as an excellent overall indicator of water quality and aquatic habitat quality, since they are sensitive to degraded stream conditions. In addition, steelhead is an important recreational species on the Pacific Coast. Both Chorro and Los Osos Creeks currently support small steelhead populations. The CDFG Code recognizes steelhead as a valuable resource that has a limited range. It also recognizes that California's steelhead resources are largely dependent upon the quality and quality of available habitat. Southern steelhead populations have been listed as federally endangered by the National Marine Fisheries Service because of declining habitat quality throughout the species range. Because of damage and threats to their available habitat, state policy requires that emphasis be placed on management programs to inventory, protect, improve, and restore the habitat of native steelhead stocks (CDFG).

## 11.2 HABITAT REQUIREMENTS AND IMPACTS

Steelhead trout are anadromous fish, which hatch and rear in coastal streams and estuaries, migrate to the ocean for most of their adult life, and return back to their home stream for spawning. Habitat requirements for steelhead during their coastal stream life stage include:

1. Cold water with high dissolved oxygen (DO) levels
2. Access to spawning areas, and clean, well graded spawning gravel's
3. Adequate freshwater flow volume, especially during the dry season
4. Adequate depth and frequency of pool-riffle habitat for cover, feeding, and rearing
5. Brackish (low salinity) habitat in the estuary during the juvenile stage of development
6. A productive aquatic food chain, as a food source

Steelhead trout are a coldwater fish species requiring high dissolved oxygen levels to survive. Prolonged exposure to water temperatures over 18 degrees Celsius can be lethal to this specie. Additionally, water temperature and DO levels are inversely proportional to each other, as water temperature rises DO levels fall.

Native riparian vegetation is an important component for establishing and maintaining a healthy aquatic habitat. In addition, it provides important habitat and transportation corridors for terrestrial species. The riparian vegetation provides stream bank stability to reduce erosion, stream shading to maintain cool water temperatures and high DO levels, and leaf litter as the food base for the aquatic food chain.

The Morro Bay estuary provides the brackish habitat environment critical to the juvenile phase of the fishery. Estuary and lagoon environments have been identified as the optimum nursery areas for juvenile steelhead, where growth rates and densities of fish are much higher than in fresh water areas.

When stream geomorphology is undisturbed and in balance, then clean spawning gravel and pool-riffle habitat will develop through natural stream geomorphic processes. Generally speaking, when the watershed and streams are undisturbed and healthy then the physical, chemical, and biological habitat requirements for the native species will be provided.

There have been many alterations to the Morro Bay watershed and streams that have impacted the various components of steelhead habitat. Increased erosion rates from mining, agriculture, ranching, urban development, roads, riparian vegetation removal, and manipulation of stream channels and floodplains has caused increased sedimentation of spawning, pool, and estuarine habitats. Spawning success can be greatly affected by the amount of sediment present in the spawning gravel. Sediment fills in the spaces between the gravel, actually smothering eggs and larvae, reducing the insect food sources attached to the gravel, or "cementing" the gravel, making it too compacted for use as spawning habitat.

Water diversions or withdrawals during the dry season not only reduce the freshwater flow, but also cause increased temperatures and lower DO levels. Straightening and dredging of stream channels generally removes riparian vegetation and causes additional erosion impacts due to down cutting of the streambed, and stream bank failure. The use of levees to restrict a stream's access to its floodplain only increases the stream bed and bank erosion and reduces natural sediment deposition and pollutant removal on the floodplain.

The removal or loss of riparian vegetation decreases shading of the stream which causes increased water temperatures, lower DO levels, and removes leaf litter, the primary food source in the aquatic food chain. Man-made and natural migration barriers to upstream habitat areas are another impact to the species. Many of these obstructions are a result of abandoned agriculture diversions or poorly designed road crossings. Chorro Reservoir is a major barrier to steelhead migration into the upper reaches of the watershed. In fact, there is a land-locked resident strain of steelhead that uses Chorro Reservoir and the upstream creek reaches for habitat.

## 11.3 IMPACTS TO BENEFICIAL USES

### 11.3 Migration of Aquatic Organisms, Spawning, and Reproduction

Sedimentation can affect the steelhead reproductive processes when fine materials being deposited smother the gravel beds that are critical for spawning. Sediment also fills the deep pools that smolts need to survive dry periods. Eroding gravel banks provide a source of spawning gravel for a stream, but erosion of fine textured soils (e.g., clays, silts, and fine sands) can reduce habitat quality for fish (Flosi 1991). Excessive sediment during high flow events impairs steelhead migration, as sediment can erode gills, and stress fish considerably.

Near the mouth of the creek at the Chorro Creek Bridge, sediment buildup has been instrumental in the transformation of a brackish marsh area into a riparian/fresh water wetland with totally different plant species than what historically existed (Josselyn *et.al.* 1989).

Chorro and Los Osos creeks support two of the southernmost populations of steelhead trout in the state (Worcester 1991). Steelhead depends upon both surface and subsurface flow that maintains pools for space to live and develop during the dry season. However, after five years of drought and the increase in freshwater diversions over the last two decades, the health of the steelhead population is probably more precarious then ever before. The California Department of Fish and Game (CDFG) has indicated that there have been no recent surveys on either stream, the last being conducted in the 1970s. A new survey of steelhead and comprehensive IFIM stream study should be performed over a suitable amount of time that would take into consideration flows, habitat, food sources and populations. The U.S. National Marine Fisheries Service has recently listed steelhead as a threatened species because of its diminishing status along the coast. Steelhead is discussed further in Section 3.3.6.

### 11.3.2 Cold Freshwater Habitat

Shortened duration of flow and significant reduction of flow can have an impact on instream and riparian habitats. Decreased flow can result in higher water temperatures. Higher water temperatures can lower the amount of dissolved oxygen available for fish species and other organisms. This is discussed further in Section 3.0. As stated previously, past surface water extractions have resulted in fish kills (Chappell 1976).

In addition, high nutrient levels contribute to lower dissolved oxygen levels in the creeks, impairing them as cold freshwater habitat. Levels falling below 5.0 mg/l can cause anoxic conditions, where there is not enough oxygen available for organisms.

### 11.3.3 Sport Fishing

Historically, steelhead trout was a popular sport fish prior to being listed as an endangered species. The impacts from pollutant loads and habitat loss have drastically reduced the population to the point where sport fishing in the creeks is presently an unattainable beneficial use.

Eventually, the restoration of steelhead habitat in the watershed could result in the reestablishment of a sport fishery that would supply additional economic, social, and cultural benefits

### 11.3.4 Estuarine Habitat

The reduction of dry season freshwater inflow impacts the existence and well being of brackish water areas that exist where the streams enter the bay and on the shorelines of the bay. High nutrient loads cause excessive algal growth in the bay, which results in dissolved oxygen reductions that, impacts the bay as nursery habitat for fish

Excessive sediment loading into the bay is of primary concern to the long-term health of Morro Bay. Sedimentation is resulting in losses of mudflat and open water habitat and other resources dependent upon specific water depths and salinity concentrations. Elevated turbidity and suspended solids result in decreased light penetration through the water column, impacting aquatic plants and the organisms dependent on them. Aquatic vegetation, fish, and bottom dwelling organisms can be smothered by excessive sedimentation, both in the estuary and in adjacent tributaries.

In Morro Bay it has been observed that the salt marsh area is increasing in size, the riparian area at the mouth of Chorro Creek may be increasing, and the deeper water areas, those that support eelgrass, are decreasing due to bottom buildup of sediment. The degree of physical change caused by the sedimentation has typically been estimated by making comparisons of historic photographs and bathymetric surveys. (See Sections 2.1.3 and 5.5.3 below.)

With increased sedimentation, habitat quality at this expanding interface near the delta has been severely degraded (Josselyn *et al.* 1991). Salt marsh habitat is being replaced near the delta in the upper delta by lower salinity tolerant species. These include undesirable, introduced, and extremely invasive species such as Hoary Cress (*Cardaria draba*), and, in riparian woodlands adjacent to the delta, Cape Ivy (*Senecio mikanioides).* The ability of these non-native species to take hold is probably exacerbated by disturbed soils resulting from sedimentation.

The degree of ecological change caused by the sedimentation is less definitively described in the literature. The seasonal runoff from the watershed produces measurable turbidity in mid-estuary zones (Phillips 1984). Increased turbidity leads to decreased eelgrass growth, and reduces the depth range at which it will occur in the estuary. Desiccation through sediment accumulation is a major factor limiting the upper intertidal distribution of eelgrass. There appears to be no species succession in the eelgrass stage of the ecosystem. Eelgrass is the initial colonizer as well as the climax stage of development (Phillips 1984). The impacts to eelgrass habitat are discussed further in Section 10, Habitat Loss.

## 11.4 SOURCES AND TRENDS

### 11.4.1 Steelhead in the Morro Bay Estuary.

During some life phases, steelhead is especially dependent upon low salinity estuarine environments and fresh water habitats. The Morro Bay estuary provides the transition environment critical to the juvenile phase of this fishery. Estuary and lagoon environments have been identified as the optimum nursery areas for juvenile steelhead with growth rates and densities of fish much higher than in fresh water areas (Smith 1987).

### 11.4.2 Steelhead in the Chorro Creek Watershed.

There has been a marked reduction in the number of steelhead trout in the streams of the Morro Bay watershed (Asquith 1990). Water diversion, coupled with drought, has impacted surface flows in the lower Chorro Creek, an area identified by Paul Chappell in 1987 testimony as supporting significant rearing habitat. Though 0.75 cubic feet per second (cfs) of California Men's Colony (CMC) effluent is dedicated to supporting steelhead trout and other fishery resources in the lower creek, this amount seldom reaches the estuary during dry years (Worcester 1991).

In the dry summer months instream flow is critical. Crawford and others monitored changes in Chorro Creek stream flow and water temperature in the Chorro Flats. On July 23, instream flow ranged between 1 and 2 cfs (Crawford, et al. 1992). At that time there was flow throughout the length of the area and researchers observed squawfish as large as 275 millimeters in several large pools, as well as thousands of three-spined stickleback. On August 5 three recording thermometers were installed 200 yards, 820 yards, and 1,425 yards downstream of the Chorro Road crossing. By August 19, shallow pools, riffles, and runs were completely dry, and only remnant pools remained in deeper areas. The lack of inflow to pools resulted in water temperatures up to 101°F. Squawfish were no longer observed and signs of predation by raccoons and fish-eating birds were evident.

Biologists conducted fish surveys from Twin Bridges to above Chorro Creek Road on August 19 and 20, 1992 (Crawford, et al., 1992). Flows had dried up from Chorro Creek Road down, and only three-spined sticklebacks were found in the intermittent pools along this reach. Above Chorro Creek Road, where continuous flow was still present, one trout was captured.

In 1994, David Crawford conducted a fish survey at five locations on Chorro Creek and included capture by seining, dip nets, hook and line, and minnow traps. Sampling occurred in spring 1993, summer 1993, fall 1993, and winter 1994. Site 1 was in the Morro Bay tidal flats and Site 2 was in the large pool below Twin Bridges. Other sites were much farther upstream, above the CMC wastewater discharge. Eight trout were found at Site 2 in the summer of 1993, one in the fall of 1993, and one in the winter of 1994. No trout that were captured or observed were large enough to be considered anadromous. Only 15 trout in total were captured throughout the entire study, none larger than 14 inches. (Crawford 1994).

The construction of Chorro Reservoir eliminated steelhead trout access to the upper watershed. Steelhead strain trout are still present above the reservoir and are trapped within the reservoir. Fish passage structures constructed above the reservoir apparently do not work (USDA, SCS 1994).

### 11.4.3 Steelhead in the Los Osos Creek Watershed.

Worcester (1999 pers. comm.) reports having observed adult steelhead recently in Los Osos Creek, along with resident trout.

Additional details regarding threats to steelhead habitat and trends is in the resource presented in Section 8, "Freshwater Flows," and Section 10, "Habitat Loss."

### 11.4.4 Future Direction and Actions

Section 404(b)(1) of the Clean Water Act (450CFR Part 230) specifically identifies pool and riffle habitat complexes as special aquatic sites of concern, since these areas provide primary feeding, spawning, and rearing habitat for steelhead and other aquatic species. In addition, Section 404 recognizes the need to regulate the discharge of fill material in and adjacent to riparian habitats, wetlands, and streams due to sedimentation of pool and riffle habitat.

Future erosion control and water quality improvement projects will reduce the pollutant loads entering the streams and the estuary. In addition, stream restoration projects that incorporate the science of fluvial geomorphology with proven restoration techniques will be used to repair and revegetate the degraded riparian habitat conditions.

With improved habitat conditions, CDFG estimates Chorro Creek could support at least 450 adult steelhead. In addition, if habitat restoration is successful the Morro Bay strain of steelhead could provide genetic stock for restoration of steelhead populations in streams south of Morro Bay. Ultimately, the restoration of a sustainable steelhead population in the watershed could result in reestablishment of a sport fishery, along with the associated economic, social, and cultural benefits.