2004

Land use history and environmental change in the Carquinez Strait region

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LAND USE HISTORY AND ENVIRONMENTAL CHANGE IN THE CARQUINEZ STRAIT REGION

A Thesis

Presented to

The Faculty of the Department of Environmental Studies

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

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December 2004

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ABSTRACT

LAND USE HISTORY AND ENVIRONMENTAL CHANGE IN THE CARQUINEZ STRAIT REGION

by Andrew P.D. Martin

Physical and ecological changes in the Carquinez Strait Region have been closely associated with shifting patterns of human settlement and culturally-driven land use practices. This study tracked regional landscape changes across time and space by drawing upon multiple lines of evidence at multiple temporal and spatial scales. Primary methods included historical information recovery and comparative visual analysis of aerial photos, ground-based photos, and topographic maps.

Results showed that landscape changes in the Strait Region were rarely gradual or linear in nature and were often related to changes in local economy and technology. Each cultural transition was accompanied by changes in physical and biological conditions, including significant shifts in species composition, channel morphology, and air, soil, and water quality.

ACKNOWLEDGEMENTS

I would like to extend my appreciation to all of the people that donated their time and effort towards the completion of this thesis. Special thanks go to my committee members, Dr. Lynne Trulio, Dr. David Helgren, and Assistant Environmental Scientist at the San Francisco Estuary Institute Robin Grossinger. Additional thanks to the many volunteers and staff at the Vallejo Naval and Historical Museum, Contra Costa County History Center, and Benicia Historical Museum that assisted me in finding historic photographs. I would also like to acknowledge Doug Schenck at the USGS office in Menlo Park for his assistance in obtaining DOQs from the California Spatial Information Library website.

Finally, I would like to extend my gratitude for the encouragement and support given by my family, friends, and my life partner, Colleen Mullins.

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INTRODUCTION

PROBLEM STATEMENT

A look back through American history reveals that the continent has changed noticeably in the span of only two hundred years. The diaries of the Lewis and Clark expedition, for example, prove how dramatically the Great Plains has been transformed by Euro-American settlement and agriculture (Ambrose 1996). Further examples can be seen in the character of present-day ecosystems, as stumps of white pine in the Great Lakes region, non-native plants in the Intermountain West, and shrub-dominated former deserts in the Southwest bear testament to the consequences of human progress (Allen et al. 1998; Egan and Howell 2001).

In the San Francisco Bay Area alone, the scale and degree of historical landscape change has been particularly dramatic (Conomos 1979; Nichols et al. 1986; Grossinger 2001). Europeans first contacted the area in 1769 (Treutlin 1968). Within a decade, the Spanish established a mission and a military fort at the present-day site of San Francisco (Goals Project 1999). Spanish missionaries used the lands around the bay for grazing, and this eventually led to the conversion of native grassland habitat into non-native-dominated pasturelands. By the mid-1800s, as San Francisco evolved into a major transportation center, portions of the baylands were filled to support roads, railways, and shipping ports. It was also at this time that farmers began diking and draining tidal marshes to support cattle grazing and agriculture throughout much of the Bay and salt pond production in the South Bay. By the 1950s, only 50,000 acres, about one quarter of the historical amount of tidal wetlands in the Bay, remained (Goals Project 1999).

In recent years, the surrounding urbanized area has continued to exert pressure on the Bay's ecology and has produced changes to the appearance of its shoreline. Awareness of these changes has raised a greater interest in the ecological origins of the Bay ecosystem. Particular attention has been paid to the historical ecology of the baylands, tidal mudflats, and bay-floor, but little has been focused on the historical patterns of local land-use and their effects on Bay resources over time (Goals Project 1999).

This thesis examines the relationship between historical land use and environmental change in one the most heavily impacted regions of the Bay, the Carquinez Strait Region. Since the spring of 1772, when Pedro Fages and Father Juan Crespi led the first Spanish expedition along its southern shore, the Strait Region has been grazed by livestock, platted with port towns, and criss-crossed with streets, bridges, and railways. The region has also been utilized as a naval yard and military post, as well as a site for numerous factories, warehouses, and refineries (Treutlin 1968; Cohen 1996). In the more than 200 years since Europeans arrived, the region has changed so profoundly that is difficult to know for certain what of value has been lost and what still remains. An improved understanding of the relationship between historical human activities in the region and the resulting changes to landscape will lead to better predictive models for land-use planning (Sisk 1998), and will also provide a basis for ecosystem restoration and management.

BACKGROUND

Scientists and managers alike are increasingly using environmental history as a basis for understanding and managing ecosystems (Swetnam et al. 1999). Old assumptions about nature existing in a static, idealized state, devoid of human influence, have been abandoned in favor of a more dynamic view. Instead, says Sisk (1998), "we view nature as a dynamic system of which humans are a part, recognizing that a variety of forces – ranging from natural disturbance to climatic change, deforestation, and the conversion of native habitats to agriculture – are constantly interacting to determine the pace and direction of change."

With the emergence of a broader ecological worldview that incorporates both past and recent events, historical inquiry now plays a more prominent role in conservation (Meine 2001). It has become particularly important to the field of ecological restoration, where historical baseline information is often used to guide restoration efforts (Cairns 1991; White 1995; Kondolf and Micheli 1995; Henry and Amoros 1995; Goals Project 1999; Grossinger 2001; Walsh 2001). These efforts may use reference conditions, along with assessments of current conditions, social and economic constraints, and other relevant factors to set sustainable management goals (Swetnam et al. 1999).

Located somewhat ambiguously at the crossroads where historical inquiry and ecosystem management intersect is historical ecology. This relatively young discipline with roots in both ecology and historical geography, undertakes the study of historic lost or degenerated ecosystems (Egan and Howell 2001). Central to the study of historical ecosystems is the landscape, which Russell (1997) defines as "an assemblage of ecosystems – for example, forests, lakes, and streams… " Similar to the way that organisms interact with their environment, ecosystems "also interact, though less directly than the components of ecosystems." For the purposes of study, Egan and Howell (2001) call landscapes "the common unit of analysis for historical ecologists because landscapes hold the record of human activity on earth." Russell (1997) further corroborates this idea, saying that "historical ecology seeks to explain many enigmatic features of present ecosystems and landscapes by deciphering the legacies of past human activities."

In theory, knowledge gained from studying past human impacts on the landscape can be successfully applied to the task of restoration. However, there still remains much debate about how and to what extent reference conditions derived from historical ecology studies should be applied to land management and restoration decisions (Swetnam et al. 1999). At a minimum, the goal of historical ecology is to understand the background rates of change in ecological systems, often referred to as the natural (or historic) range of variability (Landres et al. 1994; Morgan et al. 1994; Egan and Howell 2001). As Egan and Howell (2001) explain, this concept refers to the range within which ecosystems are self-sustaining and beyond which they fall into a state of disequilibria. A logical step to follow, then, when modern ecosystems become unsustainable is to look back at the factors, or variables, that made these systems sustainable in the first place (Egan and Howell 2001).

Sisk (1998) suggests compiling a comprehensive history of land use to identify the range of variability within a given system. Of the many human activities undertaken at the expense of the planet, land use in particular has been recognized as a major force in shaping the biosphere (Turner and Meyer 1994). While many recent studies of land use have been aided by technological advancements, principally the imagery obtained from satellites, the study of land transformation is by no means a novel field of inquiry (Hooke and Kain 1982; Skole and Tucker 1993). Early works by Marsh (1864), Verdansky (1929), and Thomas (1956) analyzed the changes wrought by humans on the "natural" landscape well before the modern space age.

Turner and Meyer (1993) also point out that "the ability of humankind to effect significant environmental change, especially at the ecosystem level", is itself "ancient". Examples of early land use impacts abound. These include sizeable modifications to the Amazonian rainforest prior to the Columbian Encounter, and the "ecosystemic effects" caused by transcontinental interactions between colonial Europeans and their incorporated lands in Africa, Australia, Oceania, and Asia, and many places throughout the Western Hemisphere (Balee 1989; Roosevelt 1989; Turner and Meyer 1993).

Understanding the subtler patterns of landscape change, such as those described above, often requires a perspective reaching back to a much earlier time (Sisk 1998). By integrating multiple sources of historical data and developing the appropriate tools for analyzing change, Sisk (1988) suggests that land-use history studies add to the value of remotely sensed images by allowing scientists to interpret these data in the context of a dynamic historical process. Furthermore, they allow us to identify the cause and effect of local and regional landcover changes, increase our understanding of the environment we live in, and identify important questions for future research, restoration, and land management efforts.

A variety of historical techniques, datasets, and perspectives provide the tools for analyzing change. These include both "documentary" sources, such as historical records, surveys, oral histories, photographs and maps, and "non-documentary" sources, that is, phenomena that are directly measurable, such as pollen spores, tree rings, fire scars, sediments, or trace elements in water or soil (Hooke and Kain 1982). Additionally, recent advances in remote sensing technology, as well as the ability of geographic information systems (GIS) to manipulate multiple layers of spatially referenced data, provide historical ecologists with a powerful tool for monitoring and depicting change over time.

RELATED RESEARCH

Documentary research in historical ecology draws from a diverse sampling of archival materials. These include anything that has been written, tabulated, mapped, or photographed, such as census data, crop yield records, land deeds, explorers' journals, historiographic and ethnographic studies, land surveys, scientific research, maps, and aerial photographs (Swetnam et al. 1999).

Maps and Aerial Photos

According to Campbell (2001), "maps are especially effective devices for recording and communicating information about the environment." Provided they are interpreted correctly, maps can complement the study of historical land use and land cover changes by providing visual cues about the environment at a specific point in time

(Reithmaier 2001). Potentially useful maps for the study of historical changes include: cadastral, or land ownership maps (also known as plat maps); thematic maps, featuring the population, land use, transportation, vegetation or hydrography of a given area; USGS topographic maps; General Land Office surveys; navigational charts; coastal surveys; and maps by early European explorers, settlers, and Native Americans.

A variety of studies have used maps in some fashion to analyze historical patterns of landscape change. Iverson (1988) used thematic soil and vegetation maps superimposed with a USGS Land Use Data Analysis (LUDA) map to compare landscape patterns and attributes in Illinois over a 160-year period; Motzkin et al. (1996) used historical property maps drawn from original deeds to chronicle 124 years of change to a sand plain in the Connecticut Valley; Osh et al. (1996) used maps in combination with a number of secondary source materials to document the history of the lower St. Croix River valley over a166-year period; Auclair (1976) used 1:250,000 scale USGS topographic quads, along with corroborative data from other sources, to quantify changes caused by intensive agriculture in Wisconsin over a 150-year period; Odum and Turner (1990) looked at landscape and resource use in Georgia over a 50-year period using vegetation maps prepared by the Department of Natural Resources; and Whitney and Somerlot (1985) used township plat maps and an early forest vegetation map to compile data on the extent of forest resources in Wayne County, Ohio from as early as 1850.

Aerial photographs, though more limited in timeframe than maps, are also useful for assessing long-term changes in landscape features. Vertical photographs -- photos taken with the optical axis of the camera pointing directly perpendicular to the ground surface -- offer the most accurate perspective of areal features and can, therefore, be used in the corroboration or construction of maps.

For example, Motzkin et al. (1995) used two series of aerial photographs, a 1:36,000 black and white series from 1939 and 1:25,000 color (infrared) series from 1985, to document plant cover transformation in an area of central Massachusetts. Tree stand maps of the 775 ha study area were derived from both series using a digitizing system. The photos were also used to yield information on the timing and abandonment of agricultural activity, which was later used to construct land use and ownership maps.

Auclair (1976) used aerial photographs from the U.S. Department of Agriculture's Agriculture and Stabilization and Conservation Service to delineate crop, pasture, marsh, and forest habitats in a 361 km^2 area of southern Wisconsin. The photos, from four series taken between 1949 and 1968, were used to supplement data on vegetation and land use from an 1833 General Land Office survey and a 1934 land use inventory conducted by the Wisconsin Land Economic Inventory Division.

Together, maps and aerial photographs can be used to identify the major causal human activities that lead to a mosaic sequence, that is, a series of spatial patterns over time (Forman 1995). According to Forman (1995), these include deforestation, surburbanization, corridor construction, desertification, agricultural intensification, and reforestation. Resulting mosaic sequences include edges produced by new land types; new corridors that bisect the initial land type; nucleus-oriented sequences, such as urbanization patterns, that spread radially from a common center, leaving a ring of the initial land type on its perimeter; nuclei-oriented sequences, such as patterns formed by adjacent settlements, that spread from several locations within the landscape and expand radially towards one another; and dispersed sequences, such as the checkerboard patterns commonly associated with intensive logging, that eliminate large patches of the initial land type (Forman 1995).

Maps and aerial photos also help us to see how the spatial processes of land transformation affect the structure and function of ecosystem components at different hierarchal levels. Fragmentation, or the breaking up of large habitat or land areas into smaller parcels, is particularly destructive, since it can lead to extinction and loss of biodiversity, can disrupt the integrity of stream network systems, can affect groundwater recharge and quality, and can alter the natural disturbance regime of native species (Forman 1995). Such spatial attributes as patch size, inter-patch distance, total interior area, and connectivity are important measures of a fragmented landscape's ability to support movements and flows between ecosystems (Forman 1995).

Repeat Photography

Use of historical, ground-based photos is another method for comparing and analyzing landscape change over time. By comparing old photographs with newer ones taken at the same location, it may be possible to reconstruct land use and land cover changes in a given location (Reithmaier 2001). According to Swetnam et al. (1999), this process, known as repeat photography, provides "a simple, inexpensive, and elegant tool for reconstructing past environmental changes and for monitoring new ones." They add that the method is "particularly well suited for the relatively open landscapes of the western United States."

Repeat photography has been used primarily in studies of the southwestern and northwestern United States (Hastings and Turner 1965; Dutton and Bunting 1991; Bahre 1996; Webb 1996; Hall 2001). A classic example of repeat photography can be seen in "The Changing Mile" (1966) by James M. Hastings and Raymond M. Turner. Hastings and Turner used this technique to capture vegetation change in the southern Arizona desert over a 75-year period.

Skovlin et al. (2000) compared 45 photographs taken before 1925 to photographs taken as late as 1999 and documented landscape changes above 5,000 feet elevation in the Wallowa, Elkhorn, and Greenhorn Mountains of northeastern Oregon. They noted the following major changes from these comparisons: (1) the expansion of subalpine fir into mountain grasslands, (2) the invasion of moist and wet meadows by several tree species, (3) a loss of whitebark pine from subalpine habitats, (4) continued soil erosion stemming from livestock grazing long since discontinued, and (5) a high rate of natural gravitational mass wasting.

Bahre (1991) studied historical vegetation and land use change in southeastern Arizona, in an area located south of the Gila River and east of the Santa Cruz River. To discern vegetation changes and to correlate causal land-use activities in the region since 1870, Bahre examined repeat ground and aerial images, as well as detailed land-use histories and General Land Office surveyors' field notes to identify the types of changes in 100 randomly selected aerial photographs.

Written Records

Written documents, in their many forms, offer a temporal context for studying the history of human impact on the landscape (Russell 1997). For the purposes of classification, Edmonds (1999), divides these into eight general categories, including documents originating from: (1) classic early explorations, (2) the Jesuit Relations, (3) traveler's accounts, (4) Native American sources, (5) official United States government expeditions, (6) local histories, (7) census schedules, and (8) early scientific investigations. The first four methods are generally useful for characterizing the pre-settlement or early post-settlement conditions of the landscape, while the latter four can provide years or decades of descriptive statistics on regional changes in land use and land cover. Potentially useful documents for studies of historical changes include U.S. census data, crop yield records, tax records, mission records, land deeds, explorers' journals, General Land Office survey notes, local histories, ethnographic studies, and scientific studies and inventories of regional geology, geomorphology, hydrology, soils, and ecology.

Many past studies have used written records to study historical patterns of land use and vegetative cover. Foster (1992) used an explorer's account of early post-settlement vegetation in Worcester County, Massachusetts to analyze changes in regional forest compositions, and also used proprieter's grants, deeds, land sale records, and tax valuation lists to develop a history of land ownership and land use in the region; Yahner et al. (1995) used existing scientific studies, local histories, tax records, and deeds to provide information on the natural and cultural history of a portion of the Appalachian

Trail corridor; Burgi (1999) used two centuries of data from forest management plans to study the historic forest development and use in the north-eastern lowlands of Switzerland; Osh et al. (1996) used federal census records, lumber and agricultural production records, descriptive accounts from early settlers, scientific reports from early settlers and historians, scientific reports, and General Land Office survey records to document landscape change in the lower St. Croix Valley; Auclair (1976) used General Land Office Survey records to reconstruct vegetation in south-central Wisconsin; Schneider (1996) used U.S. census data, data from the Maryland Board of Forestry and the U.S. Forest Service, colonial-era probate and land records, and local histories to reconstruct the history of land-use practices in the Chesapeake Bay Region; and Glitzenstein et al. (1990) used land records, agricultural statistics, and state and national population censuses to develop a history of agricultural development in Dutchess County, New York; Whitney and Somerlot (1985) used the national agricultural census, property tax records, assessors' reports, U.S. Forest Service inventories, and early forest surveys to determine the rate of forest clearance and the extent of grazing in Wayne County, Ohio; and Orwig and Abrams (1994) used land survey records and U.S. Park Service fire records to study land-use history and forest dynamics within the Piedmont and Coastal Plain of northern Georgia.

As the above examples show, many disparate sources of textual data can be used to fill in gaps in the historical record. However, when the process under study is mainly driven by anthropogenic factors, interpretation of the data can differ paradigmatically between one discipline and another. According to Crumley (1994), anthropologists, geographers, historians, and other social scientists have all studied complex interactions manifested in landscapes, but asserts that "the data have not been incorporated into a comprehensive, interdisciplinary framework reflecting the contributions of social, physical, and biological scientists and humanists". Burgi and Russell (2001) suggest improving interdisciplinary dialogue by defining interface categories - that is, terms that are meaningful and familiar for both ecologists and historians – that specify the diversity of human impacts on ecosystems in an ecological and historical context. An example of an interface category, they say, is the concept of "periods", which social scientist and humanists have traditionally used to define historical changes in human activities.

This concept has been successfully applied in several recent land use history studies, including a study by Black et al. (1998) that sought to develop a regional history of the Palouse Bioregion of southeastern Washington and west central Idaho over a 125-year period. By linking regional ecological changes with changes in technology, Black et al. (1998) structured their analysis around four time periods: European-American settlement (1870-1900), horse-powered agricultural (1901-1930), industrial agriculture (1931-1970), and suburbanization (1971-1990). Other studies that used a similar approach to classifying major periods of culturally-driven landscape change include Osh et al. (1996) and Burgi (1999).

Spatial Databases

The use of Geographic Information Systems (GIS), as a spatially referenced database and as a visualization and analytic tool (Gregory 2002), has to a large degree revolutionized the process of integrating and rectifying historical data. Gregory (2002) cites two basic sources of spatial data that are obtained during the data capture phase: primary sources, where data can be captured directly into GIS, such as through the use of Global Positioning Systems (GPS) or remote sensing, or secondary sources, where paper maps or photos are converted into a digital format.

Once captured, each data source is archived as a geographically referenced layer. When they are digitally registered with one another, the layers compose a spatial database related to a given problem. As an example, Dunn et al. (1991), in their study of the Cadiz township in Wisconsin, transformed aerial photographs and published maps into a common spatial referencing system using GIS, whereby they were converted to a uniform scale (1:24,000). Similarly, Grossinger (2001) used GIS to compile a variety of spatial data sources into a modern base map (USGS 7.5-minute quadrangles); the objective of this ongoing Historical Ecology Project was to develop an integrated picture of temporal landscape change in the San Francisco Bay region. Other regional studies that employed this approach using GIS include Iverson (1988), Motzkin et al. (1995), and Black et al. (1998).

In their study of a portion of the Appalachian Trail that runs through southern Pennsylvania's Cumberland Valley, Yahner et al. (1995) created an integrated base map (1:24,000 scale) using a computer-aided design (CAD) program. The program, normally used for its design applications by engineers and industrial designers, was chosen for "its flexibility in manipulating graphic information and its high-quality output." The map was constructed of a set of layers, which included information from various sources on contours, buildings, roads, property lines, and existing vegetation.

San Francisco Bay Area Historical Ecology Studies

A number of historical landscape-level studies have been carried out in the Bay Area, though few, it appears, have focused on both human and natural components of the landscape, and fewer still have analyzed these components over an extended period of time. Two studies, one by Clarke (1952) and another by Mayfield (1978), focused on the pre-settlement ecology of the Bay Area, but only limited historical background data on land use was provided by each. Another study, by Brown (1994), concerned land-use and land cover in the Bay Area at the time of European settlement. However, it, too, was limited in temporal focus.

Further studies of the historical Bay Area landscape were undertaken by Nichols and Wright (1971) and Atwater et al. (1979). Both studies looked at tidal landform change in San Francisco Bay since post-settlement; however, the focus of each remained strictly on the historical structure and function of the Bay's tidal marshes. More recently, a major effort by the San Francisco Estuary Institute "to recover and integrate diverse historical data into a publicly-accessible GIS" (Grossinger 1999), has greatly advanced the understanding of the Bay's historical ecological structure but with little emphasis on the historical land uses and what roles, if any, they play in the gradual degradation of the Bay ecosystem.

RELEVANCE

While most of the aforementioned studies have attempted to reconstruct the historic range of variability in the natural system, little written information is available on the historical variety, extent, and duration of land uses in the Bay Area. Furthermore, historical information about some areas in the Bay, particularly the Carquinez Strait Region, is lacking; thus, further investigation is needed.

This study applied a number of methods to compare and analyze temporal changes in land use, ecology, and geomorphology in the Carquinez Strait Region. By drawing on documentary records of land use, flora, fauna, and physical resources, the study has attempted to identify the major human factors responsible for regional landscape changes over time. The information it provides maybe useful to both research scientists and historians. The study may also be applicable to future land management efforts and could provide a basis for ecosystem restoration or regional land use planning. Potential agencies that may benefit from this study include local history societies, county and city governments, East Bay Regional Park District, Greater Vallejo Recreation District, and California State Lands Commission.

LIMITATIONS

According to Hooke and Kain (1982), written records, maps, pictures and related sources "are very much subject to fashions of style and convention." Specifically, a certain amount of introduced bias, exaggeration, or semantic discord can seep into just about any form of historical documentation, thus rendering it unreliable.

Historical maps, for example, are often riddled with errors, deliberate distortions, and various types of representational biases. Improper storage or preservation techniques can also lead to map defects, such as tears, folds, creases, and shrinkage, which affect planimetric accuracy (Harley 1968; Hooke and Perry 1976; Margary 1977; Butler 1989; Locke and Wyckoff 1993).

Aerial photographs suffer from errors of visual displacement due to camera tilt, radial distortions due to the curvature of the lens, and scale differences between photos due to altitudinal changes (Crowell et al. 1991). Also, most aerial photographs cover only a limited timeframe, are typically taken over a very short time period, which may or may not include some of the crucial events driving landscape change, and vary significantly in visual quality (Avery 1985).

The effective use of ground-based repeat photography is limited by the number of photos depicting natural versus disturbed sites, the random and sometimes inconsistent patterns of vegetation change in the study area, the oblique and narrow field of view offered by ground-based photos, the lack of overlap between land-use histories and photographed sites, and the inadequate timing of historical photographs relative to the onset of anthropogenic disturbance.

Written records can also pose many problems. Specifically, the principal problems in using textual evidence are attributable to nomenclature, geography, and perceptual or cultural biases (Edmonds 2001).

With regard to creating spatial databases, Gregory (2001) cites certain limitations to GIS, including its reliance on graphic primitive elements -- points, lines, polygons, and pixels -- and precisely georeferenced data, and the exhorbitant cost of GIS software.

RESEARCH QUESTIONS

The goal of this study is to understand how, when, and to what degree change in the Carquinez Strait Region has occurred. Specifically, the research will integrate diverse historical data on the region in order to answer the following research questions:

- How was the landscape described or depicted prior to European settlement?
- What were the major periods of settlement and economic change in the region, and how were these changes manifested on the landscape?
- How has the physical and ecological character of the region changed over time? Are there detectable trends in the presence, absence, or dissolution of certain features of the landscape, such as vegetative patches, shorelines, etc.?

CHAPTER 2
METHODS

As with the rest of the San Francisco Bay Area, the Carquinez Strait Region has changed extensively over the past two centuries. Physical and ecological changes to the region have been closely associated with shifting patterns of human settlement and culturally-driven land use practices. Comparing change across time and space is difficult, because historical information is largely anecdotal and occurs at varying scales. Therefore, this study relies upon multiple lines of evidence at multiple temporal and spatial scales in order to develop a picture of how, when, and in what way change to the landscape has occurred over time. Primary methods include historic information recovery and comparative visual analysis of aerial photos, ground-based photos, and topographic maps.

APPROACH TO DOCUMENTING LANDSCAPE CHANGES

Settlement

Primary data from Native American demography was derived from the accounts of Spanish explorers and various ethnohistorical datasets. Additional information was obtained from archaeological surveys, or from local, county, or state histories.

Information on Hispanic and European-American settlement of the strait was obtained from local, county, and state histories and from early maps. Additional demographic data was obtained from US census reports.

Land Use

Information on regional land uses during the Native American and Hispanic periods was largely descriptive and included archaeological and paleoenvironmental studies, as well as local, county, and state histories, while information on early American Period land uses was derived from local, county, and state histories, and from early maps and photographs.

Flora

Narrative accounts of Spanish explorers provided the primary data source for characterizing historical plant cover. Information on plant cover during the early American period was derived from numerous sources, including local histories, maps, photos, and illustrations.

Current vegetation data was obtained from local resource plans, scientific studies, and aerial photos. The classification schemes of both Holland (1986) and Pavlik and Major (1988) were used to delineate various community types within the region. Additional data on rare, threatened, endangered, or candidate species were obtained from the California Department of Fish and Game's (CDFG) Natural Diversity Database and the California Native Plant Society's (CNPS) Online Inventory of Rare and Endangered Plants.

Rephotography, from known or approximated historical photo sites, was undertaken in an effort to provide graphic comparisons between current and historical plant coverages. Relocation of historical photo sites was guided by careful analysis of landscape features and objects depicted in photographs. It was be further aided by local museum curators having extensive knowledge of the area.

Photos selected for duplication were of reasonable clarity and offered diffuse coverage of the region from opposing viewpoints. Once duplicated, photographic pairs were juxtaposed in a side-by-side format for ease of visual comparison.

Fauna

Faunal occurrence prior to European contact was based exclusively on findings in archaeological and paleoenvironmental studies. Following European contact, information on fauna was obtained from Skinner (1962) and other sources.

Current faunal data was obtained from local resource plans and scientific studies. Additional information on rare, threatened, endangered, or candidate species was obtained from local resource plans and from the CDFG's Natural Diversity Database.

Physical Resources

Information on channel morphology and on historical waterfront development was derived from a combination of explorers' accounts, scientific studies, aerial photos, and topographic maps. Additional information on wetland and bayshore reclamation was derived from rephotographic analyses.

CHAPTER 3
ENVIRONMENTAL SETTING

The Carquinez Strait lies between the rolling, fault-straddled hills of northern Contra Costa County and southern Solano County in the Greater San Francisco Bay Area (Fig. 1). A crucial link in Northern California's inland waterway, the Strait provides a major breach and water gap through the Coast Ranges, connecting the Sacramento and San Joaquin Rivers to the east with San Pablo Bay and San Francisco Bay to the west. All told, the Strait is approximately eight miles long, about ½-mile to $1^{1/2}$ miles wide, and reaches depths of up to 800 feet when measured from the bluff tops to the bedrock bottom (Cohen 1996).

Although the Strait is an important feature of this study, its current health, function, and appearance are linked historically to changes in both land and water use. Therefore, the area of study includes the Strait, which on its southern shore lies between Bull's Head Point and Davis Point, and on its northern shore lies between Army Point and the tip of Mare Island; the water areas of Suisun Bay, San Pablo Bay, and Napa River that lead into the Strait; and the neighboring land areas, including Cierbo Creek and portions of the Rodeo Creek, Alhambra Creek, and Sulphur Springs Creek watersheds (Fig. 2).

TOPOGRAPHY

Generally speaking, the local topography of this region consists of rolling hills separated by narrow valleys that trend in a northwest-southeast direction in relation to faults and folds (Norris and Webb 1990). On the southern shore of the Strait, the East

Bay Hills rise rapidly from the water's edge, reaching their maximum elevation at around 700 to 1000 feet on Franklin Ridge. Where the hills meet the eastern rim of San Pablo Bay, a pair of prominent basal upfolds form the headlands of Selby Point and Davis Point; the snarled southern lip, if you will, at the mouth of the Strait.

By comparison, the northern shore rises more gradually from the Strait, culminating in a nameless assortment of rolling hills. Along the Strait proper, the shoreline hosts a jagged procession of coves (Southampton Bay, Glen Cove, Elliot Cove, and Morrow Cove) and headlands (Army Point, Dillon Point, and Semple Point). Another interruption occurs further to the west, where the terminus of the Napa River (Mare Island Strait) separates Mare Island from the remainder of the shoreline. An area of artificial fill along the southwestern tip of the island forms a snaggled tooth, beyond which the waters of the Strait flow to San Pablo Bay.

Together, the folded and faulted valley walls on either side of the Strait give it a crooked appearance. This phenomenon did not escape the first Spanish visitors to the area, who noted that the Strait ran "not straight, but with bends and inlets" (Font 1930; Cohen 1996). The largest bend in the Strait appears at about its midpoint, where it circumnavigates the bulbous shoreline at Benicia, angling south and then north again within the span of about half a mile. According to Cohen (1996), this particular reach was probably displaced by an underlying right-lateral fault, the Southampton Fault, which enters the study area near Martinez, crosses the Strait near Port Costa, and continues a winding course along the western edge Southampton Bay (Weaver 1949; Graymer et al. 2002).

Swift currents and shifting tides have also made the Strait a preternaturally deep waterway. Only a few shallow areas of mud and emergent vegetation occur along the banks of the Strait, usually in coves or near locations where ebb tides are concentrated into narrow currents by shoreline projections (Danehy 1969). The rest of the Strait is deep throughout, averaging around 50 feet deep along the main channel and reaching a maximum depth of 125 feet near Dillon Point.

GEOGRAPHY, GEOLOGY, AND SOILS

Despite its modest size, the area of study is characterized by numerous subregions. Most of the area consists of Coast Range Uplands and Foothill Terraces, while the remaining portions consist of Flood plains, Fans, and Valley Terraces, and Tidal Baylands (adapted from Welch 1977; Bates 1977; Goals Project 1999).

Extremes of elevation are most evident in the Coast Range region of the study area, where altitudes range from sea level to around 1000 feet on both sides of the Strait. The upland areas of the Coast Range are composed primarily of marine sediments but include some metamorphic and basic igneous rocks (Bates 1977; Welch 1977). Ridges and gullies are composed of interbedded sandstone, shale, siltstone, lithic wacke, gritstone, and conglomerate, while upland stream valleys contain alluvial deposits of poorly compacted sand, gravel, silt, and clay (Graymer et al. 2002). Volcanic materials, such as rhyolite tuff and pumiceous sandstone, are also present in some strata. Soils in this region are typically well-drained loams and clay loams formed in materials weathered from interbedded sedimentary rock or sandstone (Bates 1977; Welch 1977).

Flood Plains, Fans, and Valley Terraces are usually limited to folds or troughs below ridges (Welch 1977). Elevations in this region range from near sea level to 200 feet, and fill material is composed of fine-grained sediments eroded from the Coast Range, usually in the form of sand, gravel, silt, and clay (Graymer et al. 2002). Soils are made up of very poorly- to very well-drained clays, loams, clay loams, and silty clay loams (Bates 1977; Welch 1977).

Tidal Baylands are solid areas of clay and silt that are subject to daily inundation by tides (Goals Project 1999). Clumped sediments are deposited by tidal action, currents and waves, and reworked by flood and ebb tides, until their surface rises just above sea level (Welch 1977). Because Baylands vary in tidal height and range widely in their ability to support vascular plant species, they are further divided into two ecological subdivisions, Tidal Flats and Tidal Marsh (Goals Project 1999).

Tidal flats, unvegetated expanses of fine-grained silts and clays, typically occur at elevations ranging from Mean Lower Low Water (MLLW) to Mean Tide Level (MTL) and support less than 10 percent vegetative cover (Goals Project 1999). According to Atwater et al. (1979), exceptions to the normal range do exist, as evidenced by the "broad berm of mud" that rises above Mean Higher High Water (MHHW) on the bayward side of Mare Island. The tidal flat at Southampton Bay, which grades into an adjacent marshland, is comparatively gentler.

The distribution of tidal flats also varies on an estuary-wide scale. On the whole, tidal flats are generally less common in freshwater areas, where marsh vegetation grows lower in the intertidal zone, than in saline areas (Atwater et al. 1979; Grossinger 1995;

Goals Project 1999). However, along the Strait, where the intermixing of fresh and saltwater occurs regularly in response to fluctuating tide levels, tidal flats are a common, if not ubiquitous, feature along the shoreline.

Tidal marshes, vegetated wetlands that are subject to tidal action, occur from the lowest extent of vascular vegetation and the top of the intertidal zone (Goal Project 1999). Along the Strait, salinity gradients account for significant phytological differences between marsh communities. Areas that are more saline, such as those approaching San Pablo Bay, are classified as tidal salt marsh, while areas that border the intermixing zone are considered tidal brackish marsh. These communities are further distinguished by their elevation and distance from shore. According to the San Francisco Bay Area Wetlands Ecosystem Goals Project (1999), "Low tidal marsh occurs between the lowest margin of the marsh and Mean High Water (MHW). Middle tidal marsh occurs between MHW and Mean Higher High Water (MHHW). High tidal marsh occurs between MHHW and the highest margin of the marsh." Again, as with tidal flats, exceptions to the normal range do occur. Atwater et al. (1979) contends that the differences in elevation between tidal marshes "exceed probable errors in measurement." Evidence may be drawn from the tidal marsh on Mare Island's bayward side, which appears to rise "0.2-0.5 m above MHHW". Such anomalously high elevations, say Atwater et al., may reflect the entrapment of suspended sediments in San Pablo Bay, which is enhanced by above normal high-tide levels. The unusually high rate of intertidal deposition at Mare Island may also reflect the influence of a nearby jetty.

The Strait itself, though not among the upland provinces considered here, occupies the lowest elevations in the study area. The youngest deposits in the Strait, excluding the shallow intertidal zones along its margins, are composed of clay and silt, and lesser deposits of sand and gravel (Denehy 1969). In relation to the elevation of the lowest tides (MLLW), these lie at depths ranging from just below sea level to more than 125 feet below sea level.

GEOMORPHIC HISTORY

Though much of it is filled in by accreted sediment, the Strait actually occupies a deep canyon, thought to be a superimposed streambed carved into bedrock by the Sacramento River (Norris and Webb 1990). Evidence derived from early geophysical investigations suggests that the river channel was subject to gradual downcutting during the mountain-building events of the late Pliocene and early Pleistocene (Lourderback 1951; Cohen 1996). As the events surrounding the orogeny unfolded, the river continued to ply its course, cutting down through the rising Coast Ranges until it extended to more than 167 feet below current sea level (Louderback 1951).

During subsequent glacial intervals, the incising of the Carquinez Canyon was interrupted numerous times by rising sea levels. This would explain the occurrence of oyster shell deposits in the hills above the Strait, 20-30 feet above current sea level (Gilbert 1917; Weaver 1949; Atwater 1980; Cohen 1996). Sea level rise following the last glacial period, the Wisconsin, is thought to be responsible for the flooding that produced San Francisco Bay (Louderback 1951). This flooding began filling the bay between 11,000 and 8,000 years ago, and reached the Strait over 7,000 years ago (Atwater et al. 1979, 1980; Cohen 1990, 1996), eventually meeting with the waters draining the Great Valley to form the modern estuary.

HYDROLOGY

For its part, the Strait is but a small piece of the San Francisco Bay estuarine system. This dynamic complex of interconnected embayments, marshes, channels and rivers is comprised of the Delta, which receives the waters of the Sacramento and San Joaquin Rivers, and the Bay proper, into which the Delta waters flow (Conomos 1979).

The Bay receives runoff from approximately 40 percent of the land area in California (Conomos 1979; Cohen 1996); ninety percent enters the Bay through the Sacramento-San Joaquin River Delta (Conomos 1979). After initially flowing into Suisun Bay, the water passes through the Strait to San Pablo Bay and empties into the broad basin of San Francisco Bay, before finally discharging to the Pacific Ocean through the Golden Gate.

Inevitably, a certain amount of tidal mixing occurs as the Delta flows make their way towards the ocean. This happens, more often than not, in the region around the Strait. The diffusion of land bound tidal currents and ocean bound river flows results in the creation of vertical and horizontal salinity gradients (Cohen 1996). According to the Bay Conservation and Development Commission (2004), the horizontal gradient, also referred to as the entrapment or null zone, appears "where less-dense, fresh water flowing seaward out of the Delta and more-dense, salt water flowing landward on the tides into the Bay from the Pacific Ocean meet and mix, producing an abundance of suspended nutrients and creating one of the Bay's most productive areas for fish and other aquatic organisms." Typically, this zone occurs downstream of the Strait in San Pablo Bay during high spring flows, and upstream in Suisun Bay or the Delta during lower summer and fall flows (Arthur & Ball 1978, 1979; Cohen 1990, 1996).

Non-Delta inflows account for the remaining 10 percent of the annual river inflow to the Bay (Conomos 1979). Numerous tributaries around the Bay provide local drainage, but only those draining the uplands in the immediate vicinity of the Strait -- often referred to as the upper watersheds -- are of consequence to this study.

On the south side of the Strait, the upper watershed originates on the Franklin Ridge. Franklin Creek descends the ridge in a southeasterly direction through Franklin Canyon, joining Alhambra Creek in the floodplain currently occupied by the City of Martinez. Together with its tributaries, Alhambra Creek drains an approximately 16.5 square mile area of northern Contra Costa County (ACWPG 2001). It merges with Franklin Creek in downtown Martinez, between Walnut Avenue and Alhambra Way, and then flows through a series of underground culverts before finally discharging into the Strait through a wetland area near the Martinez Marina.

The opposite side of the ridge drains in a southwesterly direction to the shore of San Pablo Bay, dividing a cluster of bluff promontories at Selby Point, Davis Point, and Lone Tree Point (Cohen 1996). Rodeo Creek, which terminates about one mile south of Davis Point, serves as a line of demarcation for the western half of the study area. Cierbo

Creek descends the ridge through a narrow valley, Canada del Cierbo, and enters the Strait between Davis and Selby Points.

On the north side of the Strait, the upper watershed has two distinct origins: the mountains of the Napa Valley and the Sulfur Springs Mountains. The Napa River drains an approximately 230 square mile area covering a large portion of Solano and Napa Counties (Caltrans 2004). From its source near Mt. St. Helena, the Napa River flows to Mare Island, where it empties into the Carquinez Strait.

CLIMATE

The region around the Carquinez Strait experiences a Mediterranean climate year-round, characterized by rainy winters and hot, dry summers (Cohen 1996). Prevailing winds are from the west, particularly during the summer (BAAQMD 2004). During summer and fall months, high pressure offshore, coupled with thermal low pressure in the sun-baked Central Valley, draws marine air eastward through the Carquinez Strait. Wind speeds of 15 to 20 mph are common throughout the Straits region, and are intensified by the venturi, or funneling, effects of the surrounding hills.

Air temperatures near the Carquinez Strait do not appear to be significantly affected by proximity to water or to the passage of oceanic air flows; however, the region immediately surrounding the Strait is generally a few degrees cooler than regions to the north and south (Thompson 1957; Cohen 1990; BAAQMD 2004). Based on climate data from the Martinez Water Plant over a 33-year period (1970-2003), average daily maximum temperatures are mid-50s to low 60s in the winter and mid- to high 80's in the summer, while average minimum temperatures are high 30's to low 40's in winter and mid-50's in summer (WRCC 2004).

Rainfall amounts in the region vary, depending upon proximity to terrain. In flatter areas, such as Fairfield, the annual rainfall is 23 inches. In hillier areas, where local topography induces a rain shadow effect, as in Martinez, the rainfall is 19.5 inches per year (Starratt 2001; BAAQMD 2004; WRCC 2004).

FLORA

The Strait Region is situated in the California Floristic Province, an area of about 125,000 square miles that spans the coast from Baja to southern Oregon (Pavlik and Major 1984). The relative stability of climate and habitat diversity makes this region one of the richer areas of rare and endemic taxa in California (CSCRCC 1998). It has also been recognized as a biodiversity hotspot at a global scale (Noss et al. 2002). In a recent global analysis, only three regions in North America -- the California Floristic Province, Mesoamerica, and the Caribbean -- are designated as biodiversity hotspots (Myers et al. 2000; Noss et al. 2002).

Due to its amenable climate and diverse topography, the region surrounding the Carquinez Strait supports a wide variety of plant communities, including Valley and Foothill Grassland, Coast Live Oak Woodland, Northern Coastal Scrub, Northern Coastal Salt Marsh, Coastal Brackish Marsh, and Coastal and Valley Fresh Water Marsh (Holland 1986). A general description of each community type follows.

Valley and Foothill Grassland consists of a mixture of native and non-native grasses. On the hills and bluffs overlooking the Strait's southern shoreline, common non-natives include wild oats (*Avena fatua*), brome grasses (*Bromus spp.*), wild barley (*Hordeum leporinum*), ryegrass (*Lolium mutiflorum*), silver hairgrass (*Aira caryophyllea*), dogtail grass (*Cynosurus echinatus*), and annual bluegrass (*Poa annua*). Natives include junegrass (*Koeleria micrantha*), and a variety of needlegrasses (*Stipa spp.*), wildryes (*Elymus spp.*), and melicgrasses (*Melica spp.*). Native grass species sometimes occur as intergraded clusters within adjacent community types. On the northern shore of the Strait, purple needlegrass (*Stipa pulchra*) occurs in tussocks near Glen Cove (CDPR 1991; CSRCC 1998). Called Valley Needle Grassland by Holland (1986), this community type has also been found to overlap with oak woodland habitats.

Coast Live Oak Woodland occupies exposed north-facing slopes and canyons along the Strait and is named for its most dominant tree species, live oak (*Quercus agrifolia*). Characteristic overstory species include bay laurel (*Umbellularia californica*) and buckeye (*Aesculus californica*). Shrub species include coyote bush (*Baccharis pilularis*), poison oak (*Toxicodendron diversilobum*), and hill gooseberry (*Ribes californicum*). The herb layer is usually continuous and is made up of numerous native and non-native grasses and forbs (EBRPD 1992; Holland 1986; CSRCC 1998).

Northern Coastal Scrub usually occurs on windy, exposed sites with shallow, rocky soils, and is especially common on the bluffs and canyons overlooking the south side of the Strait. Representative species include California sagebrush (*Artemisia californica*), coyote brush (*Baccharis pilularis*), sticky bush monkeyflower (*Mimulus *aurantiacus*), and poison oak (*Toxicodendron diversilobum*) (EBRPD 1992; Holland 1986; CSRCC 1998).

Northern Coastal Saltmarsh is subject to periodic tidal inundation by saltwater. Because of this, it is mainly colonized by salt-tolerant plant species. Dominant species include cordgrass (*Spartina foliosa*), pickleweed (*Salicornia virginica*), salt grass (*Distichlis spicata*), jaumea (*Jaumea cornosa*), and frankenia (*Frankenia grandiflora*) (Holland 1986; CDPR 1991; CSRCC 1998).

Coastal and Valley Freshwater Marsh occurs in areas where freshwater influence exceeds the influence of saline tides. Prolonged saturation in freshwater also allows for the accumulation of deep, peaty soils, often dominated by cattail (*Typha latifolia*), and bulrushes (*Scirpus spp.*). Other marsh species include coast willow-weed (*Epilobium watsonii var. franciscanum*), and baltic brush (*Juncus balticus*) (Holland 1986; CDPR 1991; CSRRC 1998).

Coastal Brackish Marsh is an intermediate community type between Northern saltmarsh and Coastal and Valley Freshwater with some plants characteristic of each. Salinity may vary considerably, and may increase during high tides and decrease during periods low freshwater inflow. Examples of Coastal Brackish Marsh can be found in Southampton Bay, where it intergrades with saltmarsh near mudflats. Dominant species include pickleweed, saltgrass, jaumea, common reed (*Phragmites communis*), cord grass (*Spartina foliosa*), and tule (*Scirpus acutus*) (Holland 1986; CDPR 1991; CSRRC 1998).

Tidal flats occur in areas where accreted sediments have transformed formerly subtidal areas to tidal habitats. These expanses of fine-grained silts and clays support an extensive community of diatoms, worms, and shellfish, and algal flora such as green algae, red algae, and sea lettuce (Goals Project 1999). Terrestrial vegetative associations, where they occur, appear to be related to the salinity content of the soil (Arbegast and Newton 1974). Common tidal flat species recorded in the vicinity of Martinez include California sea blite (sueda californica), pickleweed, saltbush (Atriplex patula ssp. hastata), and silverscale (atriplex argentea).

FAUNA

The complex assemblage of habitats in the region provides hunting, foraging, and nesting areas for wildlife. Grasslands support a variety of raptors, including golden eagles (*Aquila chrysaetos*), red-tailed hawks (*Buteo jamaicensis*), and black-shouldered kites (*Elanus caeruleus*), and songbirds such as Western meadowlarks (*Sturnella neglecta*) and Western bluebirds (*Siala mexicana*). Black-tailed deer (*Odocoileus hemionus*) and coyote (*Canis latrans)* also use this habitat for hunting and foraging, and California ground squirrels (*Spermophilus beecheyi*), black-tailed jackrabbits (*Lepus californicus*), California voles (*Microtus californicus*), and gopher snakes (*Pituophis melanoleucus*) are common throughout (Smith 1959; EBRPD 1992; CSRRC 1998).

Wooded areas provide shelter for many species of wildlife, including birds such as acorn woodpeckers (*Melanerpes formicivorus*), white-breasted nuthatches (*Sitta carolinensis*), scrubjays (*Aphelocoma coerulescens*), dark-eyed juncos (*Junco hyemalis*), chestnut-backed chickadees (*Parus rufescens*), and rufous-sided towhees (*Piplio *erythrophthalmus*). Racoons (*Procyon lotor*), red foxes (*Vulpes vulpes*), deer, and ground squirrels also use the woods for cover (Smith 1959; EBRPD 1992; CSRRC 1998).

Though they are fairly exposed, with dense, low shrubs, and scattered grassy openings, scrub habitats are utilized by many animals as forage and cover. Examples include rufous-crowned sparrows (*Aimophila ruficeps*), rock wrens (*Salpinctes obsoletus*), wren-tits (*Chamaea fasciata*), brush rabbits (*Sylvilagus bachmani*), and Western fence lizards (*Scleroporus occidentalis*) (Smith 1959; Holland 1986).

Riparian areas are of significant value for many animal species, offering foraging, nesting, and breeding habitat for many, and serving as a corridor to adjacent habitats for others. Willow-dominated riparian drainages provide excellent breeding habitats for a variety of songbirds, including yellow warblers (*Dendroica petechia*), yellow-breasted chats (*Icteria virens*), and rufous-sided towhees. Amphibians and reptiles, such as garter snakes (*Thamnophis spp.*), Northern alligator lizards (*Elgaria coerulea coerulea*), Pacific tree frogs (*Hyla regilla*), slender salamanders (*Batrachoseps attenuatus*), and Western toads (*Bufo boreas halophilus*) breed in these areas as well. Deer, raccoon, striped skunks (*Mephitis mephitis*), and foxes use riparian drainages to pass between adjacent habitats (Smith 1959; EBRPD 1992; CSRRC 1998).

Marsh areas along the Strait provide an important ecological connection to the tidal estuary. For this reason, they are utilized by many types of aquatic and terrestrial organisms. Dense, reedy freshwater vegetation provides excellent breeding habitat for common yellowthroats (*Geothlypus trichas*) and red-winged blackbirds (*Agelaius phoeniceus*), and many species of amphibians (CSRRC 1998).

Salt and brackish tidal marshes provide cover, forage, and nesting habitat for the endangered salt marsh harvest mouse (*Reithrodontomys raviventris*), and Suisun shrew (*Sorex ornatus sinuosus*). Two rare rails, California black rail (*Laterallus jamaicensis coturniculus*) and California clapper rail (*Rallus longirostris obsoletus*), also live secretly among the dense stands of pickleweed and cordgrass, and venture out onto mudflats at low tide to feed on insects and crustaceans (CSRRC 1998).

LAND USE

Land use in the region ranges from large tracts of open space to dense urban and industrial developments along the waterfront. A number of medium to high density waterfront communities occur along the Strait, including Vallejo (pop. 116,760), Martinez (pop. 35,866), Benicia (pop. 26,865), Crockett (pop. 3,194), and Port Costa (pop. 232) (U.S. Census Bureau 2000). Many industrial developments can also be found along the Strait, including four of California's twelve largest oil refineries - Shell, Tosco, Exxon, and Unocal (Cohen 1996). Other large industrial sites include the C & H Sugar refinery and the Energy National cogeneration plant, both in Crockett. The region also has many areas of open space developed for tourism and recreation, including a variety of municipal parks, state recreation areas, and regional shorelines.

Maritime-related activities include commercial shipping in the Strait area, as well as ships bound to or returning from ports in Sacramento, Stockton, and the Pittsburgh/Antioch areas. Naval vessels also pass through the Strait going to and from the Concord Naval Weapons Station. Municipal wharfs and commercial terminals line both sides of the Strait, serving largely to facilitate the handling of dry bulk goods and petroleum products (USACE 2000).

Three fixed highway bridges, including the recently constructed Alfred Zampa Memorial Bridge, cross the Strait at Crockett. Two more bridges -- one a trestle bridge owned by Union Pacific Railroad, the other a fixed bridge for the Benicia-Martinez Highway -- cross over the Strait near its junction with Suisun Bay. A trestle bridge, with a bascule draw across Mare Island Strait, also connects the Navy Yard on Mare Island with Vallejo (USACE 2000).

CHAPTER 4
RESULTS

EARLY CHANGES

Native American Period

Ethnography

Archaeological records indicate that the Carquinez Strait, and most of the San Francisco Bay Area, for that matter, has been inhabited for at least the last 4000 years (Nelson 1909; Bickel 1978; Moratto 1984). Prior to European contact, the Strait was inhabited by at least one, and possibly two, major Native American groups within the Penutian language family. Ethnologists have generally placed the Southern Patwin along the northern shore of the Strait, and the Ohlone, also called Costanoan (from the Spanish *Costanos* for "coastal people"), along the southern shore of the Strait (Powers 1877; Powell 1891; Barret 1908; Bennyhoff 1977, Figs. 3a and 4a; Johnson 1978; Levy 1978). However, an alternative view, which places the Ohlone on both sides of the Strait, seems strongly supported by linguistic evidence (Beeler 1954; Kroeber 1957; Heizer 1966; Milliken 1995, Figs. 3b and 4b).

From the lower reaches of the Sacramento River, Southern Patwin territory is thought to have extended south to Suisun and San Pablo Bay, and west to the Napa River (Johnson 1978). The basic political unit of the Patwin was the "tribelet", which Kroeber (1932) described as "groups of small size, definitely owning a restricted territory, nameless except for the tract or its best known spot, speaking usually a dialect identical with that of several of their neighbors, but wholly autonomous." Often, these tribelets consisted of one primary and several satellite villages, all located within a well-defined territory (Kroeber 1925; Johnson 1978).

The Ohlone are thought to have occupied an area extending from the eastern, southern, and peninsular shores of San Francisco Bay to the Carmel/Big Sur area (Levy 1978). Within this area there lived approximately 50 politically autonomous tribelets, ranging in size from 50 to about 500 persons and scattered among one or more permanent village sites.

The southern side of the Carquinez Strait is thought to have been held by the Karkin tribelet, whose main village, called Karkin, was located somewhere near Martinez (Merriam 1968; Bennyhoff 1977). Other known village sites in Karkin territory included a settlement at Crockett called Suyusuyu, and another at Tormey called Turis. A fourth village near Rodeo Creek was doubtfully inhabited by the Karkin, since that area is commonly assigned to the neighboring Huichiun or Huichiun-Aguasto tribelet (Bennyhoff 1977; Milliken 1995).

The exact location and size of village sites along the southern shore of the Strait is not known. However, the diaries kept by members of early Spanish expeditions, in particular, the 1772 Fages-Crespi expedition (Crespi 1927), the Canizares expeditions of 1775 and 1776 (Canizares 1971), the 1776 Anza-Font expedition (Anza 1930; Font 1930), and the 1810 Viader expedition (Cook 1957), provide an important source of primary ethnographic information. In his diary of the 1772 expedition, Fray Juan Crespi noted a number of "large villages" extending along the southern shore from Pinole to Crockett or, possibly, Martinez (Crespi 1927; Bennyhoff 1977). A few years later, Jose

Canizares reported a village on the western end of the Strait "whose population might exceed some 400 souls" (Canizares 1971). Font later encountered this same village, probably Turis, and arrived at the same estimate -- 400 people -- as Canizares had a year earlier; Anza's estimate -- 500 people -- was somewhat higher (Anza 1930; Font 1930; Cook 1957).

Font's reference to the village at Martinez, which he described as "a village not very far away" from the Spanish camp at Pacheco Creek, is less clear in terms of locality (Font 1930). However, Manuel Villavicencio clearly indicated a village at Martinez on his 1781 woodcut based on an earlier map Canizares had drawn in 1775 (Fig. 5), and Fray Jose Viader mentioned an abandoned village site at Martinez following his exploration of the area in 1810 (Galvin 1971; Cook 1957).

Given that so few details were provided by the early Spanish explorers about the inhabitants on the north side of the Strait, little of value can be extrapolated from their reports. Numerous archaeological sites have been found from Glen Cove west to Mare Island (Nelson 1909; Dietz and Jackson 1973; Chavez 1977, Roop and Flynn 1984), yet only Crespi's mention of seeing "many villages", as he gazed towards the northern banks, lends any narrative support to the existence of settlements in the Mare Island-Glen Cove vicinity (Crespi 1927).

On the other hand, Villavicencio clearly indicates a village site at Southampton Bay on his 1781 map (Galvin 1971). Based on mission baptismal records, Bennyhoff (1977) speculates that this village was called Ssogoreate. Its inhabitants, he asserts, "spoke a Southern Patwin dialect heavily infused with Costanoan words" and were identified in the baptismal register as Huchiun-Aguasto, a composite form of the Huichiun Costanoan and Aguasto Patwin tribelets. Milliken (1995) allows that Huchiun-Aguasto had almost certainly withdrawn to the north side of the Strait by the end of 1805. However, he disputes the idea that the north side was exclusively their domain: "The specific Aguasto group of that area... may have held the north side of the Carquinez Strait from Glen Cove west to Mare Island, but they were clearly Costanoan speakers and were heavily intermarried with the [Karkins]." Furthermore, the relative frequency with which Spanish observed the natives crossing from one side of the Strait to the other would make Karkin occupation of the northern side a likely scenario (Milliken, pers. comm.). Thus, it is difficult to know with any degree of certainty whether the region was regularly inhabited, how it was settled, and by whom (Cohen 1996).

Material Culture

From what is known about the resource adaptations of native Californians, much can be inferred about their role in shaping the prehistoric landscape. According to Mayfield (1978), resource use by the various native groups "reflected exploitable habitat types more than their political or linguistic affiliations." A remarkable consistency in land use and subsistence patterns occurred between geographically isolated groups having similar habitats at their disposal but no direct cultural contact (Beals 1974; Mayfield 1978).

Thus, whatever geographical, political, or cultural factors may have separated the Strait's earliest settlers from one another, or from neighboring Bay Area tribes, their lifestyles were probably very similar. Many early explorers, for example, noted a preponderance of thatch-covered structures at village sites throughout the Bay Area (Switzer 1974). At a village near present-day Antioch, Font observed many dwellings, which he described as being "large, round, and well made" and constructed with "tule mats with a framework of slender poles inside, and with doors" (Font 1930). Dance enclosures or plazas typically occupied the center of the village, with dwellings scattered around their periphery (Levy 1978). Font observed one such structure at Tormey, noting that the natives danced at a "level spot like a plaza" in the middle of the village (Font 1930).

Not far from the village, Font also observed several "launches", or tule balsas, anchored near the shore. These balsas, which the natives propelled through the water with double-bladed paddles, were formed from rolls of tightly-bundled tule reeds (Switzer 1974). The extreme lightness of the boats gave them superb buoyancy, allowing them to glide easily on the water (Margolin 1978). Anza, who watched a party of boats crossing the western end of the Strait, seemed particularly impressed by their speed, noting that the crafts had "crossed from this side of the river to the other in less than a quarter of an hour" (Anza 1930). Font further commented that native boatmen "went to the other side with great ease, steadiness, and rapidity..." (Font 1930).

Men in the Strait Region usually went naked, while women wore skirts or aprons of tule (Johnson 1978; Levy 1978). The natives also wore a variety of decorative beads. Albert B. Elasser, for example, found several interesting beads at a site near Rodeo (CA-SOL-547), including several olive shell (*Olivella biplicata*) beads and a cylindrical bead made of serpentine or steatite (Elasser 1957; Garaventa et al. 1993).

In addition to their many personal adornments, various flowers, hides, and feathers were used by the natives as ceremonial decorations. At Tormey, Font observed strips of animal skin and tufts of feathers, which the natives suspended from long poles (Font 1930). Additional details about the manner of local dress and décor were provided by Anza:

> *"... ten heathen came adorned with plumes and garlands of flowers to invite us to pass through their settlement. They came to our camp singing, and in the same way they continued to their village, from which all the people came out to welcome us, following in some order the three singers, who placed in the tops of trees three bunches of feathers and some strings of feathers of various colors, which were moved and raised up by the wind"* (Anza 1930).

Though none survived, coiled or twined baskets were extremely important items for almost all aspects of food collection, preparation, serving, and storage (Johnson 1978). Common materials used in native basketry included willow (*Salix sp.*), rush (*Juncus sp.*), tule (*Scirpus sp.*), and a variety of grass species (Levy 1978). Netting and cordage of wild hemp (*Apocynum cannabinum*) and milkweed (*Asclepias sp.*) fibers were by used by the natives for hunting and fishing (Johnson 1978; Levy 1978).

A number of tools and implements were also used by the natives in the making and procuring of food. N.C. Nelson (1907), who surveyed more than 400 Bay Area shellmounds between 1906 and 1908, found mortars "of both the boulder and bucket-shaped variety" at an exposed site near Glen Cove (CA-SOL-236). These were used for grinding acorns, buckeye kernels, and seeds (Johnson 1978; Levy 1978). A variety of arrowheads were also found at the site prior to Nelson's survey (Nelson 1907). Typically, these were made of stone or bone, although in some designs the arrow foreshaft served doubly as the head (Johnson 1978; Levy 1978). Chert, a mineral commonly used in the construction of arrow points, was mined in Ohlone territory (Levy 1978). The nearest obsidian deposits, used for making spears, knives, and arrowpoints, were quarried by the Southern Patwin along the east side of the Napa River, near Mt. Helena (Heizer and Treganza 1972).

In addition to providing a wealth of materials for shelter, clothing, watercraft, and other items of necessity, the Strait Region offered the native inhabitants a seemingly endless bounty of food resources. As with other California cultures, acorns were a primary staple of the local diet (Kroeber 1925; Gifford 1939; Baumhoff 1963; Johnson 1978; Levy 1978; Basgall 1987, McCarthy 1993). Coast live oak (*Quercus agrifola*) and valley oak (*Quercus lobata*) were heavily favored, since both produced an abundance of acorns (Levy 1978). Typically, acorns were pulverized into meal, leached with water, and then cooked into a mush, called *pinole* by the Spanish (Johnson 1978; Levy 1978; Cohen 1996). Though they were considered inferior to acorns, ground buckeye (*Aesculus californica*) seedlings were used in the manufacture of bread or mush (Bohakel 1977;

Johnson 1978; Levy 1978,). Grass seeds were also a significant staple, as were a variety of roots, shoots, bulbs, and berries (Bean and Lawton 1973; Bohackel 1977; Johnson 1978; Levy 1978).

Some of these food items were received by the early explorers as gifts or trade items. Canizares (1971), for example, received *pinole* and "edible seeds" in exchange for glass beads at Tormey. At a Huichiun village near San Pablo Creek, not far from the Strait, Font and Anza were presented with *cacomites*, "a little bulb or root almost round and rather flat" extracted from a species of iris, and *amole* (*Chlorogalum pomeridanum*), which Font described as "another root like a rather long onion" that tasted "a little like mescal" (Font 1930; Levy 1978). A day later, at the Tormey village, the explorers received *cacomites* and a long root called *chuchupate* (*Lomatium californicum*).

Presumably, the natives burned the grassy areas along the Strait to encourage the growth of these and other plants, but if this was indeed going on at the time of European contact, the early explorers made no mention of it. Anderson (1993) reports that many Californian tribes used fire to eliminate competitive shrubs and grasses, thus favoring the vegetative regrowth of tubers, bulbs, and corms. Baumhoff (1978) further suggests that fire was used in grasslands "both to control the growth of brush and promote the growth of seed-producing grasses and also to facilitate hunting". There is also evidence to suggest that burning was used to manipulate acorn resources (McCarthy 1993). Based on its widespread use by other cultures, Cohen (1996) speculates that the open grasslands and lack of brush that the Spanish explorers observed in the Strait Region may be due to indigenous fire management practices. Furthermore, the use of fire by other native tribes in the Bay Area, as noted by Crespi (1927), Costanzo (1911), Fages (1911), Kotzebue (1821), and others, would seem to increase the likelihood that the Strait Region tribespeople were inclined towards such practices as well.

More apparent than the use of fire to control or enhance resources is the importance of fishing to the native tribespeople. From his observations of communal fishing activities along the Strait, Font concluded that the natives "enjoyed plenty of excellent fish, among them being very fine salmon in abundance" (Font 1930). He also witnessed the natives catching a large fish, measuring six feet long and having "no scales, thick skin, and some spots like little stars and other figures, caused by some little bones which they had between the skin and the flesh." This was probably a sturgeon, for which the natives had devised a special fishing technique using a seine net (Cohen 1996).

Along with the fish species previously mentioned, locality and tide influence seemed to favor the obtainment of larger marine creatures. Although not a daily occurrence, whales would occasionally wash ashore in the Strait from the neighboring San Pablo and San Francisco Bays (Bohackel 1977). Beached carcasses were then cut into sections and shared among families or groups.

Shellfish also made up a portion of the local diet, as evidenced by the many shellmounds the natives left behind in the Strait Region and numerous other bayshore localities (Nelson 1909; Elasser 1957; Chavez 1977, Roop and Flynn 1984). The mounds, which consisted of large accumulations of shells, ash, stones, animal bones, and human burial remains, were subjected to careful quantitative and qualitative analysis early in the 20th century and again in the late 1940s and early 1950s in an attempt to estimate their antiquity (Greengo 1951; Heizer 1951). Bay mussel (*Mytilus trossulus*) and bent-nosed clam (*Macoma nasuta*) constituted the bulk of the shell material in mounds (Nelson 1909; Mayfield 1978). However, a variety of other mollusk species were also identified from early mound excavations; these included: California mussel (*Mytilis californianus*), cockle (*Cardium spp.*), limpets (*Acmaea spp.*), olive shell (*Olivella biplicata*), West Coast oyster (*Ostrea lurida*), and red abalone (*Haliotus rufescens*).

One of the first attempts to quantify the contents of Bay Area shellmounds was undertaken by Edward W. Gifford (1916). Gifford examined samples from 12 different shellmound sites, including the site at Glen Cove. From the Glen Cove (a.k.a. "Carquinez") samples, he found an abundance of shell fragments, an above average amount of ash, and only scant traces of fish and other vertebrate remains (Table 1). Gifford interpreted the relatively high proportion of ash to shell in the mound to mean that the inhabitants had used "more than the usual amount of wood", and had depended more on vegetable foods, which would leave no trace, than on the usual extent of shellfish. His interpretation of the Glen Cove site data is interesting, given that vegetable foods were an important part of the local diet; however, whether or not his conclusions can be extended to the entire Strait Region is still another matter. Both Font and Anza reported large heaps of mussel shells on the southwestern shore of the Strait, suggesting that shellfish were heavily integrated with the local diet (Anza 1930; Font 1930).

Waterfowl were also an important food source for the native inhabitants. Crespi received "two dead geese, dried and stuffed with grass to use as decoys in hunting others, large numbers being attracted this way" (Crespi 1927). Geese and ducks were typically lured to shore with stuffed decoys, and then trapped with nets (Levy 1978; Cohen 1996). Species commonly exploited in this manner included the Canada goose (*Branta canadensis*), snow goose (*Chen caerulescens*), white-fronted goose (*Anas americana*), mallard (*Anas platyrhynchos*), pintail (*Anas acuta*), shoveler (*Anas clypeata*), green-winged teal (*Anas crecca carolinensis*), and American coot (*Fulica americana*). In addition to waterfowl, a variety of land birds, such as mourning dove (*Zenaida macroura*) and California quail (*Lophortyx californicus*), were commonly eaten, as were many birds of prey (Levy 1978).

In many tribal localities throughout the Bay Area, the economic significance of mammals is apparent from shellmound excavations (Table 2). Given their proximity to good wildlife habitat, it may also be assumed that the people of the Strait Region hunted such things as deer, elk, antelope, rabbits, squirrels, and mice. However, since few sites in the Strait Region were given as careful and thorough an analysis as those at Ellis Landing and Emeryville, the extent of mammal usage by the natives is simply not known.

Spanish accounts are equally barren in this regard. Excepting Font's mention of the ceremonial hides at Tormey, little evidence of mammal exploitation was documented by the Spanish during their brief visit to the Strait Region (Font 1930). Mayfield (1978) suggests that the many gifts of plant food the Spanish explorers received from the natives points to a scarcity of resources. "If animal foods were more abundant," he contends, "then surely the Indians would have more freely given them to such impressive -- and threatening – guests." Alternatively, the absence of mammals from the local diet may be viewed less as an issue of resource scarcity than of energetic efficiency. Baumhoff (1963) seems to validate this point, stating that, among aboriginal Californians, land mammals were "of lesser importance than acorns, but ranked higher than fish in areas without good salmon streams." Since the people of the Strait Region were obviously blessed with concentrated runs of salmon, a wealth of acorns and other plant by-products, and other resources, it may be reasonable to conclude that they depended only secondarily on mammals as a food resource.

Depopulation

Following Spanish invasion and occupation in the late 18th and early 19th century, the seemingly harmonious existence of native Californians came to an end, and as a result, their populations plummeted. Rampant disease, high infant mortality rates, and malnutrion in missions, and military subjugation by the Spanish, have all been indicated in the decline of indigenous cultures (Cook 1943; Castillo 1978; Milliken 1995).

Within the Strait Region, population trends among the native tribespeople are difficult to determine, given that ethnologists had not even ventured into neighboring linguistic precincts until late in the 19th century (Levy 1978; Johnson 1978). By then, it may be assumed that the Strait Region was completely devoid of native inhabitants; thus, only generalized interpretations of their numbers, territories, and tribal affiliations can be posited from these early ethnological accounts.

The most objective figures come from mission baptismal records, in particular those of Mission Dolores in San Francisco. The mission, which Anza founded along the

Arroyo de los Dolores in 1776, served as the principal receiving center for natives from the North and East Bays (Scott 1985). Some of the congregants came from the Strait Region (Milliken 1995, Table 3). A total of 151 Karkins and 95 Huchiun-Augustos were recorded at the mission between 1787 and 1810. Add to that the small number of Huchiun-Augustos misidentified as Huichiun speakers, perhaps as few as five, and the number of natives recorded from the north side of the Strait would equal 100 people. The total number of residents recorded from both sides of the Strait, then, would be around 250 people.

Of course, these figures do not correspond at all well with the original estimates posed by Font, Anza, and Canizares. The explorers estimated that between 400 and 500 people occupied the village at Tormey alone (Anza 1930; Font 1930; Canizares 1971). This doesn't even account for the other three villages. Since the projected figures probably exceed the number of baptisms more than twice over, the mission records would seem to suffer from a considerable margin of error. However, as Cook (1957) points out, the number of baptisms represents the population size only in theory:

> *Disease, fugitivism to the deep interior, depression of birth rate, economic and social upheaval, military butchery, all took such a toll of the nonmissionized, or surviving, indians that certainly no more than one-half of the aboriginal number could have actually been baptized. At all events, the total number of baptisms represents a subminimal estimate of population.*

With this in mind, it seems fruitless to hazard an estimate for a population so poorly represented, at least in a quantitative sense, by early Spanish explorers. In addition, baptismal records only reflect the size of the mission population; they are of little value in estimating native populations at the time of initial contact. What can be surmised with a greater degree of certainty is that the people of the Strait Region vanished early in the 19^{th} century and left no further trace of their whereabouts. In their departure, they left behind a few shellmounds, some telling artifacts, and a balanced way of life that was quickly and quietly forgotten.

Hispanic Period

Early Explorations

The Spanish soldiers and monks who made the first recorded observations of the region came with the practical aim of locating suitable settlements, finding good transportation routes, and judging the availability and quality of local water supplies, pasturage, timber, and soil (Clarke 1959). In doing so, these observers provided a valuable, though incomplete, survey of the pre-settlement landscape.

Not all of their observations, however, are wholly reliable. Upon their discovery of San Francisco Bay in 1769, Don Gaspar de Portola and his immense band of soldiers, priests, Christian Indians, muleteers, and servants, believed they had found the harbor near Point Reyes where Francis Drake had anchored his boat, the *Golden Hind*, in 1579 (Scott 1985). Firm in their convictions that the diminutive harbor, named *Bahia de San Francisco* by Sebastian Rodriguez Cermeno in 1595, and the massive estuary were one and the same, Portola and his men gave the great bay what they thought was its rightfully christened name. Many years would pass before this misunderstanding would be corrected, and the two water bodies -- Drake's Bay and San Francisco Bay -- would be given their due distinction. Thus, in the spring of 1772, Pedro Fages, Father Juan Crespi, and a band of soldiers set out to explore what they believed to be the storied bay near Point Reyes, but was in fact San Francisco Bay, and proceeded up the eastern shoreline past the locations of the present-day cities of Oakland, Berkeley, and Richmond (Scott 1985).

On March 29, the explorers reached the western end of the Strait, and continued for some distance along its southern banks in the direction of Martinez. Along the way, Crespi described the area as follows:

> *In the whole distance we traveled on these hills there was not a single tree. The bed of the estuary is very deep and its shores precipitous; on its banks we did not see so much as a bush; and the water was so still it seemed to have no current* (Crespi 1927).

Crespi's unflattering depiction of the southern shore would remain the only detailed account of the Strait Region for several more years until 1775, when the brig *San Carlos*, under the command of Juan Manuel de Ayala, entered the Bay to survey its as yet uncharted waters (Galvin 1971). Ayala, who had begun the voyage as a junior lieutenant was hastily promoted due to a bizarre incident involving Commander Miguel Manrique (Cohen 1996). Apparently, Manrique had to be taken into port after he had reportedly lost in his mind, threatening the crew with six double-barreled pistols. In a regrettable act of bravery, Ayala picked up one of the pistols and accidentally shot himself in the foot, leaving him unfit to perform his survey duties. While Ayala remained onboard the *San Carlos* and recuperated from his injuries, he entrusted the actual reconnaissance of the Bay to first mate Juan Canizares (Scott 1985). During the next 44 days, while the *San Carlos* lay anchored in the Bay near Angel Island, Canizares made three voyages in the ship's longboat to the Bay's northern and southern interior.

On August 15th, Canizares entered the Carquinez Strait Region, noting that "the land makes a channel a mile and a half wide, of depth for sounding, and clear of obstructions" (Canizares 1971). Navigating east along the Strait he soon came to Southampton Bay, which he named Port of Assumption in honor of the Catholic feast. His praises for the bay are nothing short of extraordinary, considering that few ships of any size would anchor there today:

> *...the west side has a cove so spacious and deep, with plenty of wood and places to get water, and protected from all winds, that I judged it to be one of the best inland harbors that our sovereign possesses, large enough for anchoring a squadron of warship* (Canizares 1971).

Oddly, he seemed less favorably disposed to the shoreline lying east of Southampton Bay, which he found "barren, filled with grasshoppers, and unfit at anytime for settlement", than to the opposite shore, which he described as tree-covered (Canizares 1971). He further emphasized this fact on his 1775 map by showing an almost continuous stand of trees on the south side of the Strait, and no trees whatsoever on the north side (Fig. 6). Canizares' findings are interesting, if not confounding, given that Crespi had not noted so much as a single bush during his reconnaissance of the southern bank in 1772. However, his statements seem to some gain some credibility when compared with the reports of the Anza Expedition.

The expedition of Juan Bautista de Anza, which began in the fall of 1775, had a three-fold purpose: Firstly, to explore an overland supply route from Sonora to Monterey, secondly, to secure sites for a mission and presidio at San Francisco, and thirdly, to retrace the route that Crespi and Fages had blazed four years earlier into the northern regions of the Bay (Scott 1985). After completing the arduous trek to Monterey, Anza left for the Bay Area on March 23, 1776 with Father Pedro Font and a small entourage of soldiers, and arrived in the Strait Region on April 2 (Anza 1930; Font 1930; Beck and Haase 1974). The explorers continued along the southern shore towards Martinez, and as they did so, each gathered their diaristic impressions of the surrounding countryside.

From the vicinity of Crockett, Anza noted that the party had walked "two leagues east along the top of the hills close to the water, and one east-southeast", whereby they reached a canyon filled with "oaks and other trees" and ascended to "the tops of the hills near the water" (Anza 1930). He further described the region, which lay somewhere in the vicinity of Martinez, as "so improved in abundance of firewood, and timber of oak and live oak, that all its canyons are well provided with one and the other" (Anza 1930; Cook 1957).

In this regard, it would appear that Font saw things differently than Anza. At one point, he states: "The hills that form this channel are without trees..." (Font 1930). However, in relation to the northern side of the Strait, the accounts of Anza and Font are basically in agreement. Font, for example, states that the hills on the opposite side "appeared bald, with little grass, the earth being reddish in color," while Anza remarks that "in four leagues we have not seen a single tree".

If the accounts given by Crespi, Font, and Anza are allowed to stand on their own, then they are almost certainly confusing. However, when they are seen as fragments connecting a larger picture, a clearer pattern emerges. Cook's (1957) explanation of this pattern is as follows:

> *The implication of Anza's account and the rather specific statement by Font seem to support Crespi's description. There was little oak or other woody plant on the south shore west of what is now Port Costa. From there to Martinez the canyons held a fair growth of oak. In those areas not bearing oak, the primary plant cover was grass.*

With the view that wooded areas on the southern banks were found to the east of Port Costa, and grassy areas to the west, even Carnizares' account seems to be in basic agreement with the others, since it appears he was describing the portion that lay directly across from and to the east of Southampton Bay. It may be further concluded that his representation of the tree-lined southern side on his 1775 map is merely an error of scale, in which the rounded shoreline between Oleum and Port Costa is severely diminished, and the somewhat more linear shoreline between Port Costa and Martinez is grossly exaggerated.

Together, the accounts of the early Spanish explorers provide a clearer picture of what the region must have looked like prior to Euro-American settlement: a place with good wood and water, generous pasturage, and one of the best inland harbors in all of New Spain. Still, despite its many advantages, the explorers found the Strait Region generally unfit for settlement. As Cohen (1996) puts it:

They viewed the Strait itself as a barrier, frustrating their efforts to explore the country north to Point Reyes where Sebastian Cermeno, and probably Sir Francis Drake, had landed nearly two hundred years before.

Subsequent Exploratory and Punitive Expeditions

The Strait remained a barrier to the Spanish until early in the 19th century, when crossing it became a matter of urgency. This time it was not the call of the northern frontier that drew Gabriel Moraga and 17 soldiers to its banks in the spring of 1810; rather, it was the recent rise in hostile acts perpetrated against the Spanish by the Suisun tribespeople (CSCCHC 1977).

Beginning in 1807, the Suisuns launched a series of attacks on outposts of the Bay Area missions, resulting in property damage and the deaths of many neophytes. After each attack, the Suisun escaped reprisal by fleeing across the Carquinez Strait in rafts and taking refuge in Suisun Marsh (CSCCHC 1977).

The area north of the Strait offered the natives many advantages. Its remoteness from the missions at Santa Clara and San Francisco was favored by newly- escaped converts who sought freedom and a return to their native ways (Keegan 1989). Moreover, the common practice of stealing horses had made them even more successful in evading capture. In time, the Suisun had assembled a small but formidable calvary and could no longer be ignored by the Spanish.

In May 1810, Moraga's force crossed to the other side of the Strait by boat, and from there proceeded to the Suisun village of Sespesuya, where it was met by 125 warriors (CSCCHC 1977; Cohen 1996). After engaging in a fierce battle, the natives were driven into several village structures, where most of the occupants were killed by the Spanish. The remaining Suisuns committed a grizzly act of suicide, preferring to set one of their own dwellings on fire and die within rather than accept defeat by the Spanish (Keegan 1989).

After he himself had led an expedition through the Strait and up the Sacramento River to battle a group of hostile natives in 1813, Luis Arguello, commander of the San Francisco Presidio, sent Lieutenant Jose Sanchez on a quest similar to Moraga's in 1817, ordering Sanchez and his men to cross the Strait and subdue the rebellious Suisuns. Upon meeting a contingent of Suisuns at Benicia, the Spaniards quickly repelled the natives with their superior weaponry and forced them to flee to a permanent village site near Suisun City (CSCCHC 1977). Sadly, the battle ended no less pleasantly than Moraga's did seven years earlier. Facing certain defeat, the natives again retreated to their huts and set themselves on fire.

The expeditions of Moraga and Sanchez did much to subdue the Suisun tribelets north of the Strait Region, a fact that is evidenced by the large number of Suisun baptisms recorded after 1810 (Keegan 1989). But the forays were also helpful to the Spanish in another way. By effectively opening up the *frontera del norte*, the expeditions enabled the Spanish to explore new mission territory and to colonize the region lying north of the Bay.

Around the time of the military raids in Suisun City and Benicia, a series of exploratory endeavors were also carried out by the Spanish in the interior of northern California. Though all of them passed through the Strait Region enroute to the Central Valley, little of substance can be derived from their accounts. These include explorations of the Sacramento and San Joaquin Rivers by Fray Jose Viader and Gabriel Moraga in 1810, by Father Ramon Abella and Jose Sanchez in 1811, and by Abella, Arguello, and Father Narcisco Duran in 1817 (Cook 1957, 1976). A final expedition of note was that of Arguello, who in 1821 crossed the Strait with 70 men to investigate rumors of an American colony in the Sacramento Valley (Schenck 1926; Cutter 1950; Arguello 1992; Cohen 1996).

Land Grants

When Mexico won its independence from Spain on September 16, 1821, a new system of governance and land ownership emerged, one that would lead to the creation of feudal baronies lasting well into the Euro-American Era (Haase and Beck 1974). During the Spanish period, the mission had served as the main vehicle by which Spain could advance its frontier. By exploiting the labor of a large native workforce, Spain had transformed the missions into centers of production and trade, thus diminishing the need for private land enterprises in California. All told, fewer than 30 concessions were made for the settlement and use of a specified tract of land, and in each case the title had remained with the crown.

The Mexican government was more liberal with respect to the use of lands by private individuals, and far more important, Mexican land grants conveyed full title (Burcham 1957). Before the grant was made official, however, a claim for land was filed by petition to the governor of the territory (Collier 1983). The petition was accompanied by a diseno, a crude map of the area in question. After investigation of the property by a local official, a report was issued either approving or denying the petition. Approved claims required that the grantee occupy the land in person or appoint a representative; erect a permanent building; move livestock onto the land; and build a fence or corral without blocking access to pre-existing roads or trails. Many rancheros neglected one or more steps required by Mexican law to finalize ownership. However, the invalidation of a grant, when it occurred, did not necessarily return the land to the public domain (Haase and Beck 1974; Collier 1983).

Under such a system, the Strait Region was parceled out to various owners, and was divided amongst five grants of varying sizes (Table 4). In 1823, Rancho El Pinole was granted to Ignacio Martinez, Commandante of the presidio of San Francisco (Davis 1965). During a shift of governorships in 1834, Martinez was required to show title to his property, but failed to turn up the necessary paperwork (Purcell 1940). Unable to support his claim, he filed a subsequent petition in 1837 to Governor Juan Bautista Alvarado for the three square leagues (around 13,000 acres) originally granted, plus an additional square league to support his growing cattle operation (Collier 1983). The tract included the present site of the City of Martinez west of Alhambra Creek, as well the southeastern shore of San Pablo Bay from the vicinity of Crockett to near Point Pinole.

Upon confirmation to Martinez's heirs in 1854, the property stood at just under 18,000 acres (Purcell 1940).

Rancho Canada del Hambre y Las Bolsas, a lesser-sized grant spanning the shoreline from Crockett to nearly Martinez, was conferred to Teodora de Soto in 1842. From the beginning, de Soto's claim to the more than 13,000-acre property was fraught with controversy, and soon led to one of the most puzzling Mexican land cases in Contra Costa County's history (Collier 1983). The case remained in litigation for a number of years, but when the legal fog finally cleared in the mid-1800s, the grant was again confirmed to de Soto.

In 1844, William Welch, a former Scotch sailor, secured title to a tract of land known as Rancho Las Juntas between present-day Walnut and Alhambra Creeks (Fink n.d.). The Spanish name *Juntas* referred to the junction of several streams at the northern end of the property. From there the narrow tract extended south to the Strait, where it would later comprise a portion of the City of Martinez (Historic Record Company 1926). Though Welch's grant proved highly amenable in terms of settlement, his primary motivation for acquiring the property had been for grazing cattle. After receiving the grant of around 13,000 acres, he entrusted the daily operation of the ranch to a majordomo, while he himself resided in San Jose, and later in the Walnut Creek area, with his family (Purcell 1940; Collier 1983).

The other side of the Strait was divided, rather unequally, between two grants. Victor Castro, son-in-law of Ignacio Martinez, was granted the 900-acre Isla de la Yegua (Mare Island) in 1841, and in 1844 General Mariano Vallejo received a grant of 84,000 acres for Rancho Soscol that covered the remainder of the northern shore (Gregory 1912; Smilie 1975; Dillon 1980). Portions of the claim, which was later rejected, would provide the sites for both Benicia and Vallejo. In addition to its original name, *Soscol*, which it took from a Patwin village of the same name, Vallejo's enormous tract was referred to as El Rancho Nacional, because it provided beef cattle for soldiers (Dillon 1980).

According to William Heath Davis, author of "Seventy Five Years in California", El Rancho Nacional "had about fourteen thousand head of cattle and a large number of horses." While Nacional was the largest ranching operation in the region, it was by no means the only outfit of its kind. At its peak, Rancho El Pinole contained over 3,300 head of cattle, 480 horses, and about 600 sheep, and Rancho Las Juntas was roamed by over 1,000 cattle (Fink n.d.;Vovsi 1969).

In most cases, the densities of livestock in these areas probably exceeded the limits of prudence. However, under Mexican rule, ranchos having a large appropriation of cattle were quick to prosper. This was due to Mexico's easement of trade restrictions against foreign countries, which in turn stimulated the exportation of hides and tallow, the principal commercial products of California ranchos (Hutchinson 1969). These were mostly sold to trading vessels out of New England and Middle Atlantic ports, where hides were made into leather, and tallow into soap and candles.

Exploitation of Native Mammals

The appetites of foreign and domestic markets for fur, meat, hides, and tallow also led to the exploitation of many native mammals in the region. As early as 1828, trappers from the Hudson Bay Company penetrated into the interior valleys and tidewater regions of northern California from a company post at Fort Vancouver (Thompson 1957; Dillon 1980). The interest of these trappers was primarily in beavers and fresh-water otters, of which they found plenty in the Delta and in the marshes lining Suisun Bay. Each year, until 1843, the members of the so-called Buenaventura Brigade set out from Fort Vancouver and made their way down the Sacramento River to the Bay in search of pelts (Dillon 1980). A number of these brigades -- led by Peter Ogden, Alexander McLeod, Michael Framboise, and John Work -- wound up in the marshes east of Benicia; however, the majority concentrated their efforts in the Delta region, where inland furbearers were said to be especially numerous (Skinner 1962).

Another commonly exploited game animal at that time was the elk (*Cervus sp.*). Between the years of 1840 and 1843, William Heath Davis (1929) recalls seeing as many as "two or three thousand" elk on Mare Island. So numerous were these herds that, according to Davis, they had taken to swimming back and forth across the Strait between the mainland and the island. His account of this phenomenon is as follows:

> *... I remember one occasion, when on the schooner Isabella, of sailing through a band of these elk, probably less than a thousand, which were then crossing from Mare Island to the mainland. It was a grand and exciting scene. The captain of the boat wanted to shoot at some of them, but I prevented him from doing so*

because we could not stop to get game on board and I did not like to see elk wantonly destroyed.

The elk population on Mare Island, says Davis, soon fell prey to the local rancheros that would "go out to the haunts of the elk and capture them by lasso, which was used by them on all occasions, and, after killing the animals, secure the hides and tallow on the spot, leaving the carcasses."

While congregations of this sort were probably extremely rare, the region undoubtedly held a generous supply of wild game. Some of the more prominent species at this time were black-tailed deer (*Odocoileus hemionus columbianus*), pronghorn antelope (*Antilocapra americana*), and grizzly bear (*Ursus californicus*) (Skinner 1962).

<u>Introduced Plants and Their Agents</u>

During the Spanish and Mexican Periods, the Strait Region also supported vast areas of free range. The exact nature and composition of these resources is not known. However, it can be assumed that native bunch-grass perennials such as needlegrass, bluegrass (*Poa sp.*), oatgrass (*Danthonia sp.*), junegrass, and melicgrass were once more abundant in the region than they are today, and that a variety of factors figured in their decline (Clarke 1952).

Some have suggested that California's native bunchgrass communities were experiencing a downward trend well before the arrival of Europeans. Edwards (1992), for example, suggests the native bunchgrass associations had achieved a relict state by the end of the Pleistocene, around 18,000 to 10,000 years ago. This he attributed to extreme temperature fluctuations and the subsequent extinctions of coevolved megafauna such as mammoths (*Mammanthus sp.*), horses (*Equus sp.*), large camels (*Camelops sp.*), and bison (*Bison sp.*). Huenneke and Mooney (1989) further suggest that changes in precipitation may have been a factor in the decline, noting that Mediterranean climates worldwide tend to lend themselves to shrub steppe or sclerophyllous vegetation, while areas adapted to summer rainfall regimes are more likely to support major expanses of grassland. Given that California in the late Pleistocene was apparently cooler and moister than it is today, the climate was at one time probably much more favorable with regard to grasslands in general (Huenneke and Mooney 1989).

If, as these authors claim, the native bunchgrass communities were fragile to begin with, then the arrival of Europeans only hastened their demise. Evidence from plant materials in adobe bricks indicates the probable introduction of at least 18 species of exotic weeds prior to and during the Mission Period (1769-1824) (Hendry 1931; Hendry and Kelly 1925; Hendry and Bellue 1936; Clarke 1952; Burcham 1957). Among these were wild oats (*Avena sp.*), filaree (*Erodium cicutarium*), curly dock (*Rumex crispus*), sow thistle (*Sonchus oleracea*), foxtail (*Hordeum murinum*), bur clover (*Medicago hispida*), black mustard (*Brassica nigra*), pigweed (*Chenopodium album*), wild beet (*Amaranthus retroflexus*), and Queen Anne's lace (*Daucus carota*).

The introduction of domestic livestock created still another problem. Grazing by cattle, horses, sheep, and goats destabilized the original plant cover, setting the stage for invasion (Burcham 1957). Many small plants and seedlings were destroyed by trampling and ground compaction, especially perennial grasses, which were extremely sensitive due to their root system (Ferguson 1983). Once the root system was injured, the above-ground portion of the plant was unable to obtain sufficient nutrients or water, and eventually died, or persisted in a weakened condition.

Under the enormous weight and strain of these domestic grazers, soil porosity and permeability also changed. Once the texture of the soil had been altered, infiltration by rainfall was severely diminished, and the soil was unable to retain or store water. As water failed to percolate into soil, sediment and surface water runoff filtered into local creeks, extending the damage to entire watersheds (Ferguson 1983).

The root of the problem laid in the range husbandry practices of the day. Livestock were generally left untended and unfenced, which allowed them to congregate in areas where water and forage were in sufficient supply and terrain was necessarily unchallenging (Burcham 1957). In areas receiving intensive use, the more desirable native perennial species diminished rapidly and were replaced with less desirable native annuals. In time, conditions were equally favorable for invasions by alien species. "The majority of these, states Burcham (1957) "were almost identical with native annual species in general growth habits and reponses; moreover, they developed in regions having climates similar to California, having survived for centuries on lands grazed heavily by domestic livestock, where all but the most aggressive genetic strains were eliminated." The process of replacement was further aided by the fact that perennial bunchgrasses, which grew in clumps, were vulnerable to invasion from within. Bare areas between the clumps afforded spaces where invaders could become established in small numbers, and from which they could spread under favorable conditions (Burcham 1957).

In the Strait Region, one introduced species in particular flourished under these conditions: wild oat (*Avena fatua*). During his visit to California in the summer of 1841, Charles Wilkes, American commander of the H.M.S. Sulphur, visited the region and noted that "the hills are thickly covered with wild oats which were ripe, and the landscape had that peculiar golden hue before remarked. The contrast of this and with the dark green foliage of the scattered oaks heightens the effects, which, although peculiar, is not unpleasing to the sight." (Wilkes 1845). *Avena* grew so vigorously during the rancho period, in fact, that J.P. Frazer-Munro (1882), an early Contra Costa County historian, claimed that the local horse trails "twisted through the growth of wild oats that reached, on every side, as high as the head of a passing equestrian." Across the way, in Solano County, wild oats had settled in equally well on the hills above the Strait, occurring intermittently with native grasses. Wood, Alley, and Co (1879) noted that most of the hills in the county were covered with "a dense growth of 'bunch grass' and wild oats, the former growing upon the summits and the north sides of the highest peaks....".

Decline of the Ranchos

If nothing else, these accounts attest to the aggressive and vigorous nature of exotic plant life during the Mexican period. Still, it was not the embattled landscape but social and political turmoil that spelled doom for the ranchos. The real troubles began with the 1848 Treaty of Guadalupe Hidalgo, which ended the Mexican-American War and ceded California to the United States. Despite the treaty's promise to protect the inviolability of Mexican land grants, rancheros throughout California were soon divested of their properties by Anglo squatters and speculators, and a thorny if not outright hostile legal system (Wollenberg 1985).

This process was helped in a large part by the Land Law of 1851, which established a commission to resolve disputes over property rights, requiring those who owned land to appear before the commission and show proof of their claims. The commission was generally fair, but owing to its members' lack of fluency in Spanish and incompetence in Mexican land law, the process was often delayed and produced eccentric decisions (Pitt 1966). As a final recourse, disputed rulings could be appealed to the federal courts, but such cases dragged on for years, taking an average of 17 years from the filing of the original claim to the final court decision (Wollenberg 1985). Burdened by excessive legal fees and property taxes, and unable to evict squatting Gold Rush immigrants from their lands, many rancheros were forced to sell off their claims, often before the courts had rendered their final verdicts.

In this way the region changed hands yet again. The Strait's vacant, oat-covered margins soon gave way to discrete settlements, and the hide and tallow trade, once the mainstay of the local economy, was soon abandoned in favor of greener entrepreneurial pastures. In a matter of years, the Strait Region would gain prominence as the seat of both county and state governments, a military outpost, and a major commercial port. In short, the region would develop rapidly following European-American settlement. But change would not come without a price.

CHANGES FOLLOWING EUROPEAN-AMERICAN SETTLEMENT

Settlement and Economy

Routes to Gold Country

With James Marshall's discovery of gold on the American River on January 24, 1848, a veritable stream of humanity poured into the northern half of California seeking fortune in the gold fields. Some sailed from San Francisco to the Carquinez Strait, and from there continued up the inland waterway to Sacramento. Others reached the gold fields by more cumbersome means, following one of the principal overland routes. Travelers attempting to reach the gold country from the peninsular side of San Francisco Bay had to cross the Golden Gate to Sausalito by launch (Rigdon 1923). Another route passed around the southern end of the Bay and continued through the Livermore Pass to the Strait. Upon reaching the Strait at Martinez, travelers boarded a ferry boat and were transported across to Benicia (Woodruff 1947).

In September of 1849, a four-mule stage line was established between Benicia and Sacramento (Allan 2002). The line connected to a sloop from San Francisco, and was for a brief time the principal means of travel between San Francisco and the gold country. As demand for faster and more reliable transportation increased, the sloop was succeeded by numerous steam-powered side-wheelers.

Pioneer Towns

From an early date, the Strait Region seemed ideally positioned for settlement. Some forward-thinking individuals recognized this fact immediately, and through no small effort on their part towns of considerable size and importance began to blossom along its shores.

One of the earliest settlements to bear fruit was Benicia. The town was founded by Robert Baylor Semple, an immigrant from Kentucky, after he and several other members of the 1846 Bear Flag Expedition raided the garrison at Sonoma and took General Mariano Vallejo prisoner (Dillon 1980). Soon after the incident, Semple persuaded Vallejo to deed him a part-interest in Rancho Soscol, and received a five-mile parcel of land along the Strait. By 1848, Semple and his partner Thomas Larkin, the U.S. consul to Mexico, had sold over 200 lots, and Semple had begun the ferry service between Martinez and Benicia. Through the combined energies of Semple and Larkin, the town developed steadily over the next couple of years and by 1850 had grown to nearly 600 people (Bureau of Census 1850).

That same year, Lieutenant Colonel Silas E. Casey established Benicia as the site of the first U.S. arsenal on the Pacific Coast, and the California Legislature appointed the fledgling town seat of the Solano County government (Keegan 1950). Benicia received an additional boon three years later, in 1853, when the State Legislature moved to the City Hall building (Cohen 1996). Sadly, though, Benicia's unique partnership with institutions of higher government ended almost as quickly as it had begun. A year later, the state capitol was relocated to Sacramento, where it has remained ever since, and in 1858, the county seat moved to Fairfield.

Vallejo's bid for political prominence was equally disappointing. The city's biggest advocate was General Vallejo himself, who offered 156 acres of land for the town site, as well as an additional sum of $370,000 for public buildings, including a state capital building costing $125,000 (Keegan 1989). The General's promises, however, never materialized. After a year of putting up with inadequate housing and meeting facilities, the legislators decided to move the capital to Sacramento, but were chased back to Vallejo again two months later when a freak flood overwhelmed the banks of the American River. Vallejo's second term as capital would prove to be its last, and in 1853, Benicia would become the new, albeit temporary, home of the state's curiously nomadic government (Keegan 1989).

Despite its abandonment by the legislature, the City of Vallejo grew to nearly 1,500 residents by 1860 (Bureau of Census 1860). This was in large part due to the establishment of the Mare Island Naval Yard in 1854, and later by grain processing and shipping activities (Cohen 1996). The city's early growth was also fostered by a reliable transportation system. Beginning in 1852, a small sloop sailed monthly between Vallejo and San Francisco. A few years later, a steamer began regular service between San Francisco and Napa, with stops at Vallejo (Allan 2001).

Transportation can also be credited with the founding of Martinez, for it was there that Semple's Ferry made its landing on the southern shore of the Strait (Allan 2002). In 1849, Colonel William Smith, acting as an agent for the heirs of Ignacio Martinez, established a town site at the location of the ferry landing. Smith commissioned a survey of 120 acres within the existing boundaries of Rancho El Pinole, and subdivided the property west of Alhambra Creek (Gregory 1912). Additional lots were surveyed on the east side of the creek, in Rancho Las Juntas, by the heirs of William Welch. When Martinez was designated the seat of Contra Costa County in 1850, the town was assured of future growth (Allan 2002). It soon gave rise to numerous businesses, stores, and hotels providing services to ferry passenger, and would later provide a site for salmon canneries, grain storage and processing facilities, and oil refineries (Historic Record Company 1926; Smith and Elliot 1952; Perry et al. 1986; Cohen 1996).

Two miles west of Martinez was the town of Eckley. Established in 1870, the town was named and built for Commodore Eckley, a millionaire grain shipper and sportsman (EBRPD 1992). Eckley purchased the site to serve as his personal yacht harbor, and later sold the shoreline property to the Grangers Business Association, which in turn built a large grain storage warehouse along the waterfront. Following his death in 1896, Eckley's widow leased the land to the Carquinez Bricks and Tile Company. Brick production began in 1907 and continued until August 1914 when the company terminated its lease and went out of business (EBRPD 1992).

An even more impressive industrial center developed near the water's edge at Big Bull Valley. Renamed Port Costa by the Central Pacific Rail Road, the soon-to-be town site began to pick up steam, literally, when Central Pacific completed its ferry terminal at the mouth of the valley in 1879 (Cohen 1996). A year later, George W. McNear began the Port Costa Warehouse and Dock Company, which consisted of an immense 2,300-

foot-long wharf and two warehouses, one 700 feet long and the other 1,000 feet long (Murdock 1977). This was followed by a number of other warehouses of varying capacities, including the California Wharf and Warehouse and the gargantuan complex owned by the Nevada Warehouse and Dock Company. Encouraged by the favorable business climate in the area, McNear eventually acquired a large strip of frontage along the Strait, part of the 4,000-acre Piper Ranch property, and laid out the town of Port Costa (Collier 1983). In the early years of the town, tidewater reached into the valley for nearly 300 yards, and the block-long business section ran roughly parallel to the Strait and stood on pilings above the water. Due to its relative inaccessibility by land, the town had fewer than 300 permanent residents at any one time, but is purported to have held as many as 3,000 sailors, railroad employees and stevedores at the height of the grain shipping season (Emanuels 1986).

Unlike Port Costa's industrial roots, the town of Crockett traces its origins to John B. Crockett, a lawyer, who in 1850 came to possess 1,800 acres of the original Rancho Canada del Hambre y Las Bolsas grant as payment for counsel in a land grant case (Keith 1939). Beginning in 1867, Crockett entered into a partnership with Thomas Edwards, Sr., a recent Welsh immigrant, to develop a portion of the waterfront (Cohen 1996). Edwards built a house and operated a farm there until the early 1870s, when he took up residence in San Francisco (Keith 1939). Edwards later purchased a share of the property and proceeded to lay out a 31-acre townsite, which he named Crockett. Among the many industries that would come and go in the town of Crockett were Heald's Agricultural Works, a foundry specializing in machine parts, and the Starr Flour Mill, both established in 1882 (Staehle 1945). The mill was later converted into a sugar refinery that was acquired by the California-Hawaiian Sugar Refining Company.

The remaining share of John Crockett's land was bought out by John T. Strentzel, an Alhambra Valley orchardist (Emanuels 1986). At about the same time that Edwards was putting the finishing touches on Crockett, Strentzel had laid out a town and named it Valona. Many years later, another town by the name of Crolona would develop in connection with the C&H factory. The town, which sat halfway between Crockett and Valona, existed largely for the benefit of the factory employees and included a men's club, a laundry facility, and several homes for company executives (Emanuels 1986).

Industry also put the towns of Selby, Tormey, and Oleum on the map. The towns were founded on land belonging to brothers John and Patrick Tormey, who in 1865 bought 7,000 acres of Rancho El Pinole from the heirs of Ignacio Martinez (Cohen 1996). The land was then dually divided, with Patrick taking the shore of San Pablo Bay as his share. Twenty years later, Thomas Selby, a successful lead manufacturer from San Francisco, bought the land and built his first blast furnace along the shoreline (Emanuels 1986). More furnaces were added over the years, and before long, Selby had the largest smelter of lead, silver, and gold ores in the world. The towns of Selby and Tormey grew up around the smelter, principally as housing communities for its employees, and the town of Oleum emerged later, in 1895, in connection with the Union Oil Company refinery (Purcell 1940).

Grain Farming

Although wheat was grown in California from the time of the missions, extensive cultivation did not begin until the 1850s (Lewis 1984). In those days, grains were, in part, grown to avert a looming ecological crisis in many of the regions surrounding San Francisco Bay. Cattle raising had expanded rapidly during the Mexican Period (1823-1844), and by 1855 the number of cattle and other livestock had increased to the point that natural pasturage could no longer support the herds (Goodan and Shatto 1948). In 1847, Elam Brown, who is generally credited with being Contra Costa County's first grain farmer, undertook a trial planting of grain on the Rancho Acalanes grant near what would later become the town of Lafayette (Purcell 1940; Akers 1971). The planting eventually yielded 105 bushels of barley and 150 bushels of wheat per acre. Initially, Brown and other pioneer farmers in the region drew upon their prodigious grain yields to supplement natural forage, but with the rising demand for wheat in Europe, grain soon supplanted cattle as the primary economic staple (Goodan and Shatto 1948).

Following Brown's lead, a number of early settlers in the Strait Region turned their attention to wheat farming. Charles and Lafayette Fish and William Hook, who arrived in the county in the early 1850s, bought plots of land to the south and east of Martinez and dedicated large acreages to wheat (Perry et al.1986). William B. Frazer also acquired a half section of land on the east side of the city, where he grew wheat and tended livestock, and Martin Woolbart engaged in stock and grain farming on Bull's Head Point. The same activities were undertaken by James McHarry and James Stewart in the vicinity of Franklin Canyon (Perry et al.1986).

On the opposite end of the Strait, brothers John and Patrick Tormey, who eventually came to own more than 7,000 acres of the Martinez family grant, put large areas of land to grain farming and pasture. Thomas Edwards, who through his partnership with John B. Crockett was among the first to settle the Rancho del Hambre y Las Bolsas grant, also raised wheat in the vicinity of what would later become the town of Crockett (Keith 1931). Staehle (1945) claims that Edwards farmed more than 1,800 acres "and had practically all of it planted in cereal". However, given that Edwards had only settled on a portion of John Crockett's land, which in its entirety was 1,800 acres, this figure appears to be highly inflated.

Early Grain Ports

For a time, the principal wheat servicing and distribution center for much of the region was the town of Pacheco, which was located at the head of navigation on Pacheco Slough (Goodan and Shatto 1948). The town was several miles from Martinez; yet it maintained an especially deep tidal connection to Suisun Bay. At high tide, boats of up to six foot draught were able to navigate up the estuary to Pacheco to load wheat (Akers 1971). Many of these vessels were bound for distant ports in northwestern Europe.

Pacheco dominated as a grain port until the late 1860s, when the town succumbed to a series of natural disasters, including several fires, a flood, and an earthquake (Akers 1971). Pacheco's loss, however, was Vallejo's gain. In the years that followed, the grain trade from Vallejo increased handily, and many ships bound for foreign ports loaded from its harbor. Vallejo's success was further assured by the construction of a railroad spur in 1868 that connected it to Sacramento, and by the Starr flour mill in south Vallejo (Cohen 1996).

Over the next decade, the Strait Region continued to hold its own as a center for grain shipping and storage. The advantages that favored Vallejo as a grain port eventually came to favor Benicia as well, though it never gained the importance of its western neighbor (Akers 1971). Across the way in Contra Costa County, as Pacheco fell into decline, Martinez became the only port of any real consequence on the southern shore of the Strait. This would change, however, as new ports were established along the precipitous shore west of Martinez, where the proximity of deep water to dry land permitted more access to navigation than did other Bay Area entry points that were exposed at low tide (Grossinger and Brewster 2003). .

The Railroad and the Expansion of the Grain Industry

The joining of the rails of the Central Pacific and Union Pacific Railroads at Promontory Point, Utah, in 1869 is generally acknowledged as the event linking California to the rest of the nation (Snyder 1988). Yet, because the Bay and its arms continued to pose a significant barrier, both freight and passengers faced a circuitous route within California in order to reach San Francisco. One possible route involved travel by rail from Sacramento to Vallejo, from which point steamers connected with San Francisco. Another line ran from Stockton and over Altamont Pass to Oakland and connected to a line heading south towards San Jose, which eventually terminated at San Francisco; however, as this proved to be a long and laborious journey, Central Pacific soon turned its attention to creating a shorter main line between Sacramento and Oakland, one that would eliminate the need for travel over Altamont Pass (Stachle 1945).

By 1878, Central Pacific completed a rail line along the shore of San Francisco Bay from Oakland to Tracy (Snyder 1988). Another length of track was laid from Fairfield to Benicia through Suisun Marsh. Ferry slips were subsequently erected at Port Costa and Benicia, and an enormous train ferry, called the *Solano*, began service between the two points in 1879 (Woodruff 1947). The vessel, which at 424 feet long was the world's largest at that time, was capable of carrying two locomotives and a full freight train of 48 cars, or a full passenger train of 24 cars on a single run (Snyder 1988). With this service in place, the rail trip from Sacramento to San Francisco was reduced by more than 60 miles. The completion of these rail lines also transformed Port Costa, once a nearly uninhabitable site marked by steep bluffs and a constricted shoreline, into one of the most important grain centers in all of California (Cohen 1996). With the ferry plying regularly between the two rail routes, trains were now able to deliver and receive grain at Port Costa from all parts of inland California (Akers 1971).

To take advantage of this opportunity, facilities for grain storage and processing were hastily constructed along the southern shoreline. Soon, the entire waterfront from Crockett to Martinez was covered with wharf franchises. These included the Starr Flour Mill and Pacific Coast Warehouse Company facilities at Crockett; California Wharf and Warehouse Company, Port Costa Warehouse and Dock Company, and Nevada Warehouse and Dock Company facilities in Port Costa; The Granger's Business

Association facility at Eckley; and the Granger's Warehouse facility at Martinez (Cohen 1996).

The amount of wheat that passed through these franchises in the early years easily surpassed the competition. In 1881, grain stored at the Contra Costa County facilities reached a new high, and in this same year more ships left from the southern shore of the Strait than sailed from San Francisco or Vallejo (Akers 1971). From the years 1881 to 1882, about two-thirds of the ships carrying grain from San Francisco Bay were loaded at Port Costa (Cohen 1996, Table 5). In 1884, Port Costa shipped as much as 52% of the grain, and in 1887, it loaded nearly 80% of the grain ships in the Bay Area (Saunders 1960; Akers 1971).

Decline of the Grain Industry

The fall of wheat prices brought about by competition from other countries, ignorance of farmers regarding sustainable farming methods, and the discovery of more profitable products were all reasons for the gradual decline in grain production throughout the state (Akers 1971). Though the amount of wheat leaving the Carquinez grain ports had generally decreased after 1890, it was especially noticeable by the turn of the century, when the amount of wheat acreage in California dropped by nearly 40 percent. Whereas local grain ports sent millions of tons of grain in hundreds of ships in the 1880s and 1890s, after the turn of the century, only a few ships were seen entering the ghostly harbor along the Strait (Akers 1971).

Decline was followed by deterioration. The mill in Crockett and the warehouses at Port Costa were closed and eventually abandoned (Cohen 1996). On May 10, 1910, Nevada Dock, one of the most enduring symbols of the wheat era, burned to the waterline and was never rebuilt (Murdock 1977). The same fate befell the California Company's warehouse in 1924. Spared from fire, other facilities were simply left to rot, whereupon, they frequently fell victim to the Atlantic shipworm (*Teredo navalis*), a saltwater woodborer that feeds on pilings. Sadly, the halcyon days of the wheat era would never return to the Strait Region. But as Mae Fisher Purcell (1940) reminds us, "the wheat era was not all in vain. The origin of some big fortunes of today and some smaller ones began with wheat."

Other Early Land Uses

In terms of their impact on the landscape, few early land uses in the Strait Region could match the intensity of grain cultivation, storage, and processing. Still, not all of the local economies depended solely on the production of grain for their survival. Some areas along the Strait were blessed with unusual natural advantages, such as particularly fertile soils or especially forgiving micro-climates. Others developed merely as a matter of luck, and grew unexpectedly from the seeds of innovation or from pure geographical chance.

The fruit culture in the Alhambra Valley is one example. Until the 1880s, wheat production had predominated throughout much of the valley (Perry et al. 1986). One notable exception was John T. Strentzel, the president of the Alhambra Grange, who by

1860 had planted an enormous variety of fruit trees, including countless varieties of peaches and pears, on his property south of Martinez (Akers 1971). The following years saw many other local residents do the same, and by 1875, with Alhambra Valley orchardists at the helm, Contra Costa County became a leading producer of fruit crops. That year, the county reported as many as 40,000 apple trees, 20,000 peach trees, 3,500 mulberry trees, 1,250 apricot trees, 1,000 orange trees, 500 prune trees, 100 olive trees, 50 lemon trees, and more than 600,000 grape vines (Purcell 1940).

By 1884, cultivation of fruit and nut crops attained the same importance for the valley's economy as had grains (Perry et al.1986). Much of the countryside surrounding Martinez was planted to orchards, and the trend persisted until even the steepest hillsides bore fruit and nut trees. Above the city to the west, cherries, apples, oranges, and grapes were planted in the vicinity of what is now Rankin Park. Another 200-acre orchard, belonging to Henry Raap, was located on the present Alhambra Avenue extension between H Street and Highway 4 (Perry et al.1986).

By 1885, due to the railroad connection, Port Costa had surpassed Martinez as a local grain shipping port. Nevertheless, the loss of grain storage revenue did not quiet the activity at the Martinez junction. A cannery was built along Granger's Wharf, and a number of fruit packing sheds were subsequently erected below Muir Station on Alhambra Way. These were located at the terminus of a spur track extending from the main line. The sheds were occupied for many years by the Pioneer Fruit Company which handled the bulk of the agricultural output from the Alhambra Valley. By 1920, an average of 150 carloads of pears, 30 of grapes, and 20 of apricots and plums were shipped annually by the company (Perry et al.1986).

Commercial wine production in the valley reached an early peak between 1885 and 1890; consequently, many small acreages on the hillsides above Martinez were given over to vineyards. By 1890, a number of wineries were in operation, including the Christian Brothers, an educational institution affiliated with the Roman Catholic Church that had been an early producer of sacramental wines before it turned to commercial winemaking (Carroll 1985; Perry et al.1986). Local vineyards continued to prosper until the enactment of the 18th amendment, Prohibition, in 1918. After its repeal in 1933, only one winery survived, though a second winery continued its endorsement of wine from other sources until 1938 (Perry et al.1986).

Elsewhere in the Strait Region, industries cursed with ephemerality or blessed with longevity clamored along the busy shoreline. The Starr Flour Mill in Crockett began its milling operations in 1891; however, due to circumstances beyond its control -- namely, England's competing demand for grains, general decreases in wheat production, overspeculation, and fraudulent practices in the grain market and in shipping -- the mill was forced to close a mere three years after it had began operation (Stachle 1945).

A few years later, in 1897, a group of investors purchased the mill and converted it to a beat sugar factory, which operated under the name of California Beet Sugar Refining Company. In 1900, the company leased about 10,000 acres to Contra Costa County, Solano, and Sonoma Counties for the planting of sugar beats (Keith 1939).

Seemingly everything was done to stimulate an interest in the sugar beat industry; yet, due to poor results the company had to cease its operations in 1903 (Stachle 1945).

The last chapter in the life of this failure-prone factory began in 1905, when it was purchased by the Sugar Factors Company of Honolulu (Keith 1939). The Californian and Hawaiian Sugar Refining Corporation, as it is now known, began its refinery operation in 1906 and has been in almost continuous operation ever since (C&H n.d.). Today, the C&H refinery composes the largest refinery of its type in the United States and one of the two or three largest in the world. It typically refines 2,800 to 3,000 tons of raw sugar per day and 650,000 to 700,000 tons per year, a large percentage of it coming from Hawaii, Australia, the Philippines, and other Pacific sources. Another Starr legacy, the General Mills plant at Vallejo, currently occupies the site where the Starr Flour Mills was built in 1869. The mill went bankrupt in 1894, was bought by George McNear in 1895, then by Sperry Flour Co. in 1910. The property fell under its current ownership sometime in the 1960s (Cohen 1996).

Along with flour mills, a number of salmon canneries also operated along the shores at an early date. These included a cannery in Benicia, which opened in 1880, and two in Martinez, which opened in 1882 (Historic Record Company 1926; Skinner 1962; McEnvoy 1986; Cohen 1996). The canning industry in the Strait Region grew and reached its peak in the early 1880s with annual salmon landings of around 10 million pounds, most of which were shipped in tins to Australia, England, and the eastern states (Emanuels 1986; Skinner 1962; McEnvoy 1986; Cohen 1996).

Though the salmon pack dropped precipitously in the same decade and never regained its former volume, many canneries continued to operate without salmon into at least the 1950s, instead packing roe from locally-caught shad, oysters grown in Tomales and Drakes Bay, and sardines from Monterey (Cohen 1996). Alongside these canneries, a number of reduction plants were also put into service to render sardines and offal to meal and oil (Scofield 1954).

A final enterprise of note is that of the Selby Smelter, which Thomas Selby began in the 1880s. Throughout its history, local residents complained bitterly of pollution from the smelter, alleging that illness, damage to crops, and even the deaths of livestock were all due to its fumes (Holmes et al. 1915). When the plant closed in 1971, a slag pile later determined to be hazardous waste was left on the shore, and numerous reports of lead contamination have since been linked to the smelter (Rabinowitz and Wetherill 1972; Ritson et al. 1998; Cohen 1996)

The Contemporary Urban Landscape

Today the characteristic industry of the Carquinez shore is oil refining (CSRCC 1998). Early refineries were connected by pipelines to oil fields in Coalinga and the Kern-Midway field near Bakersfield (Rigdon 1923). The refineries have since expanded in number, and currently include terminals at Benicia, Martinez, Ozol, Crockett, and Selby (USACE 2000). According to Cohen (1996), these provide 72 percent of the Bay Area's refining capacity and 58 percent of its storage capacity. Most now receive crude oil tankered in from Alaska with additional crude oil and petroleum products either piped in or shipped from southern Californian oil fields and refineries (Gleason 1958; Perry et al.1986; Chambers Group 1994; Cohen 1996).

Along with industry, significant changes in transportation have also altered the appearance of the Strait Region. Until 1927, the Strait could only be traversed by a series of ferries. In addition to the ferry line between Port Costa and Benicia previously mentioned, a number of other lines ran between makeshift harbors in the Strait Region. These included the following routes: Martinez-Benicia; Martinez-Benicia Arsenal; Vallejo-Rodeo; South Vallejo-Vallejo Junction; Crockett-Morrow Cove; Vallejo-Mare Island Navy Yard (Cohen 1996). In 1976, ferry service resumed between Vallejo and San Francisco after an absence of 49 years (Allan 2001).

The year 1927 marked the historic completion of a bridge between Crockett and Vallejo. An engineering feat of the time, the Carquinez Strait Bridge provided the final link in the Pan-American Highway, connecting Canada with Mexico (Allan 2001). The state took over operation of the bridge in 1940, and in 1958, with traffic from Interstate 80 on the rise, it completed a parallel span 200 feet to the east to relieve congestion (Cabanatuan 2003b). The bridge was only recently succeeded by the Alfred Zampa Memorial Bridge, which lies to the west of the former bridges. Completed in November 2003, this massive suspension bridge is currently being used to handle southbound traffic, while the 1958 bridge conveys traffic headed north (Cabantuan 2003a; Chui 2003). The predecessor to both, the 1927 cantilever span, is deemed too old and costly to maintain, and has been scheduled for demolition (Cabanatuan 2003a).

On the opposite end of the Strait, two other bridges of note connect Martinez with Benicia. When completed in 1930, the Southern Pacific Railroad Bridge was the longest and heaviest double track bridge west of the Mississippi River, and boasted a load-carrying capacity greater than that of any bridge in the U.S. (Snyder 1988). Seventy-four years later, the bridge continues to retain a high degree of integrity, as diesel locomotives and high-capacity freight cars have replaced the steam engines and smaller cars of its early years. A parallel highway bridge carrying Interstate 680, the George Miller, Jr. Memorial Bridge, was completed on its downstream side in 1962.

Patterns of settlement have also changed dramatically over the past 150 years. The historic street grids comprising the town center in places like Benicia, Vallejo, and Martinez reflect a mercantile orientation (City of Benicia 1999). The mix of commercial uses in these towns once reflected the practical needs of daily life. Businesses were typically concentrated in a smaller area to accommodate people traveling on foot. By contrast, the curvilinear and auto-oriented street patterns that exist today reflect a suburban pattern of settlement.

The current pattern of suburbanization in the region began in the 1940s and has been on relative par with the rest of the Bay Area ever since. Referring to the parallel growth of the Ygnacio Valley, which lies just south of the Strait Region, Goodan and Shatto (1948) identified a number of early factors contributing to local growth. Among these are the expansion of neighboring Bay Area cities, population pressure during World War II, increases in income during the war years, the almost universal use of the automobile as a means of mobility, and the Californian ideal of living remotely, though not too remotely, from the city. To these can be added the completion of the aforementioned bridges, which have increased the flow of traffic and commerce to both shores of the Strait.

As is typically the pattern with most Bay Area communities that have expanded inland from the waterfront, an increasing number of subdivisions are appearing in the hills above the Strait. Local topography has to some extent restricted the expansion of development in the Strait Region. The most effective means of controlling development, however, has been through land preservation.

The largest area of public land in the region is the Carquinez Strait Regional Shoreline. A property of the East Bay Regional Parks District, it comprises 2,843 acres of bluffs and shorelines between Crockett and Martinez, as well as land-banked acreage between Highway 4 and Cummings Skyway (EBRPD 2002). Other important conservation areas in the Strait Region include the string of shoreline parks that extend from Sears Point Bridge to Dillon Point, owned and managed by the Greater Vallejo Recreation District, and the Benicia State Recreation Area extending from Dillon Point to the eastern edge of Southampton Bay, which is overseen by the California Department of Parks and Recreation (Cohen 1996). In addition to these, the Mare Island Naval shipyard, which closed in 1996, is also likely to benefit from conservation measures in the near future. The area, which includes 2,400 acres of mudflats, 920 acres of tidal marsh, and 510 acres of diked marsh, is currently slated to become part of the San Pablo Bay Wildlife Refuge (City of Vallejo 1993, 1994; Cohen 1996).

Flora and Fauna

Terrestrial Habitats

Despite such measures, none of the lands currently preserved as open space are truly free from the effects of human influence. The continued propagation of exotic range flora during the 19th century, principally as a result of overstocking, accounts for the astonishing variety of non-native annual grasses that have taken up residence on the undeveloped hillsides, including such species as wild oats, brome, ryegrass, foxtail, wild barley, silver hair grass, annual bluegrass, and dogtail grass (CSRCC 1998). These have steadily displaced or marginalized native species, such as needlegrasses, wildryes, melic grasses, june grasses, oatgrasses, and bluegrasses.

Along with promoting non-native species, intensive grazing would have also tended to protect against the potential expansion of native scrub and wooded habitats (McBride 1969). As can be seen in the recent photograph from the west slope of Big Bull Valley, currently under management by EBRPD, the once open grasslands are now interrupted by extensive patches of shrub vegetation. Whereas, historically this area was composed exclusively of grass cover, it is now occupied by dwarf stands of coyote brush and poison oak (Figs. 7a and 7b).

The opposite slope, which once supported little tree cover, is now covered by scattered stands of non-native blue gum eucalyptus (*Eucalyptus globulus*). This species was originally brought to California in the early 1850s to serve as a windbreak and shade tree (Saunders 1926). Its establishment near Port Costa in the late 19th century has generally been attributed to the town's founder, George McNear, who had the trees planted on the hills west of town in order to have the land re-zoned as forest property (Murdock 1977). From an analysis of aerial photos taken both in1929 and in 1993, it appears that the area has been cleared of numerous plantings within the past 75 years and is now transitioning into native woodland/scrubland habitat (Fig 8a and 8b).

The densely populated stands of native live oak, bay laurel, and buckeye that grow on the Strait Region's north-facing slopes and canyons are another modern feature of the landscape. At the time of European contact, the southern shore of the Strait was completely barren from the shore of San Pablo Bay to present-day Port Costa. A telling statement to this effect was made by Crespi, who observed: "In the whole distance we traveled on these hills there was not a single tree" (Crespi 1927). Canizares' 1775 map more or less validates this statement, as it gives the appearance that the curved shoreline west of Port Costa is utterly devoid of trees.

Given that the area is now at least partially tree-covered, it would appear that a dramatic transformation has since taken place. Comparative analysis of the 1929 and 1993 aerial photosets indicates that, even within this relatively short time period, woody vegetation along the southern shore has expanded rapidly into the grasslands. This expansion can probably be attributed to historic changes in land use, such as the cessation of burning and grazing. In some instances, formerly cleared woodlands have simply grown back, as has occurred in the hills west of Martinez, where vineyards once predominated (Figs. 9a and 9b).

That trees appear at all on the northern shore of the Strait is something of a minor miracle. Early Spanish accounts during the years 1775 and 1776 reveal that the region lying immediately north of the Strait was, at that time, completely devoid of woody vegetation. Canizares' 1775 map depicts the northern bank as a barren, treeless expanse, the only trees being those that rimmed Suisun Bay or lay opposite it on the generously-wooden southern bank. In his report to Captain Ayala, he described the hills that lay east of Southampton Bay as "barren, filled with grasshoppers, and unfit at anytime for settlement" (Canizares 1971). A similar impression of the northern hills was also conveyed by Font and Anza, who saw not so much as a single tree on the northern side of the Strait (Anza 1930; Font 1930). Even the grass cover seemed strangely lacking, as is evidenced by Font's remark that the hills appeared "...bald, with little grass, the earth being reddish in color" (Font 1930).

Today, wooded areas appear along the entire length of the northern shore. Along with the general increase in tree plantings associated with urban growth in the cities of Benicia and Vallejo, a number of suburban housing developments have crept into the hills, their rectangular-shaped lots and curvilinear streets adorned with countless varieties of exotic trees, shrubs, forbs, and grasses. Soil disturbances stemming from development have also spawned an array of weedy invaders, such as Italian ryegrass (*Lolium multiflorum*), ripgut grass (*Bromus diandrus*), pampas grass (*Cortaderia selloana*), wild oats, sweet fennel (*Foeniculum vulgare*), scotch broom (*Cytisus scoparius*), wild radish (*Raphanus sativus*), poison hemlock (*Conium maculatum*).and various types of mustards (*Brassica sp.*), mallows (*Malva sp.*), vetches (*Vicia sp.*), and starthistles (*Centaurea sp.*)

Clumps of native coyote brush scrub (*Baccharis pilularis*) are also scattered throughout the grasslands and along road margins, levees, and the upper edges of marshlands (Abergast and Newton 1974; CDPR 1991; Noss et al. 2000).

In some cases, increasing development pressure in the valleys and foothills of the Strait Region has even led to the diminishment of native species. In its Inventory of Rare and Endangered Plants, the California Native Plant Society (CNPS 2004) has assigned a number of locally-occurring species to List 1B (rare, threatened, or endangered in California and elsewhere). These include the Diablo fairy-lantern (*Calochortus pulchellus*), Diablo helianthella (*Helianthella castanea*), western leatherwood (*Dirca occidentalis*), robust monardella (*Monardella villosa ssp. globosa*), and Congdon's tarplant (*Centromadia parryi ssp. congdonii*).

Many native mammal populations have diminished in size or have disappeared completely since Euro-American settlement. Grizzly bear encounters were a common occurrence in the Strait Region up until the mid-1800s (Skinner 1962). They were so common, in fact, that General William Sherman, who was for a brief while stationed at the arsenal in Benicia, recalled an incident in 1849 in which a grizzly bear was actually seen swimming in the Strait (Smith and Elliot 1952). Following Euro-American settlement, ranchers and sport hunters greatly reduced the numbers of grizzlies in the Bay Area, until by 1900 the fearsome predator had all but disappeared (Skinner 1962).

The black bear is another conspicuous predator that has been extirpated from the region. Though they were hunted no less savagely than grizzlies, black bears continued to dwell in the region up to the 1940s (ACWPG 2001). The last remaining black bear in Contra Costa County was hit and killed by a car on San Pablo Dam Road in 1965.

Other mammals figuring prominently into local hunting lore, such as elk, pronghorn antelope, and black-tailed deer, were hunted relentlessly during the early years of Euro-American occupation (Skinner 1962). By the late 19th century, with urban encroachment and hunting on the rise, elk and antelope were driven from the Bay Area. Black-tailed deer, however, continue to be quite common in the Strait Region and can often be seen grazing on local hillsides (EBPRD 1992).

Aquatic Habitats

Beginning in the 1850s, large areas of the Bay's tidal marshes and mudflats were filled, diked, or drained (Goals Project 1999). Significant changes to the Strait's wetland areas began during the height of the grain-era in the late 1870s. Railroad construction resulted in the filled soil and riprapped edges that now border much of the southern shoreline (CSRCC 1998). Fill to accommodate roads, wharfs, and urban frontages further taxed these resources, while in other places, like Southampton Bay, sedimentation converted some formerly subtidal areas to tidal flats, effectively creating new intertidal habitat (USACE 1965; McClure 1972; Madrone Associates 1977).

As a result of these changes, which will be discussed in greater detail in the next section, virtually all of the remaining aquatic habitats in the Strait Region now harbor an extensive array of invasive weeds. Representative saltmarsh species such as cordgrass, pickleweed, and salt grass; brackish species such as jaumea, tule, and common reed; and freshwater species such as cattail and alkali bulbrush are all competing with non-native plants for marsh habitat (Arbegast and Newton 1974; Madrone Associates 1977; Grossinger et al. 1998). Common exotics include pigweed (*Chenopodium macrospermum var. farinosum*), brass buttons (*Cotula coronopifolia*), peppergrass (*Lepidium latifolium*), glasswort (*Salsoda soda*), narrow-leaf cattail (*Typha angustifolia*), curly dock (*Rumex crispus*), and spergularia (*Spergularia media*).

Of these habitats, brackish tidal marshes in the Strait Region are particularly vulnerable to invasion. A number of rare marsh plants reside in these habitats, including Suisun Marsh aster (*Aster lentus*), Delta tule pea (*Lathyrus jepsonii var. jepsonii),* soft bird's-beak *(Cordylanthus mollis spp. mollis), and* Mason's lilaeopsis *(Lilaeopsis* masonii). All of these are sufficiently rare to be assigned to the CNPS's 1B list (CNPS 2004). The first two species mentioned are species of special concern in California, while the latter two species are currently listed as State Rare. Mason's lilaeopsis has also been designated a federally endangered species (CDFG 2000).

Of particular consequence to these species is pepperweed (*Lepidium latifolium*), a perennial Eurasian herb that grows on beaches, tidal shores, saline soils and roadsides throughout most of California (Hickman 1993; Young and Turner 1995; May 1995; Young et al. 1997; Grossinger et al. 1998). The plant's success is due to the fact that it produces large amounts of seed, can reproduce rhizomatously, and is tolerant of a broad range of environmental conditions (Trumbo 1994; May 1995). The Bay-Delta Oversight Council (1994) warns that, when present in brackish tidal marsh, the plant could potentially outcompete or displace soft bird's-beak and Mason's lilaeopsis. Currently, relatively large *Lepidium* colonies, on the order of 0.1 to 0.2 acres, are found in the marshlands lining the bayward side Mare Island (Grossinger et al. 1998). A smaller population also occurs at Southampton Bay.

Another non-native species of concern is saltmeadow cordgrass (*Spartina patens*). Native to the eastern United States from Maine to Texas, *S. patens* was first reported from Southampton Bay by Munz (1968). Currently, a small patch of *S. patens* is present on the eastern side of Southampton Marsh where it may be encroaching on a patch of *Cordylanthus mollis* sp. *mollis* (Grossinger et al.1998). Though it is relatively restricted in distribution in the Strait Region, based upon physical parameters alone, *S. patens* could potentially occupy the mid-to-high elevational zone of marshes across a wide range of salinities, making it a possible threat to neighboring marshland habitats.

Degradation of tidal mash habitats has further impacted several local species of mammals and birds. Both the salt marsh harvest mouse, a state protected and federally endangered species, and the Suisun shrew, a California species of special concern, occur in tidal marshes in the Strait Region, where they continue to be threatened by human or human-caused activities such as the filling of marshes, discharges from sewage treatment plants, invasion by introduced non-native species, and pollution from urban and industrial sources (CDFG 2000).

Such impacts have also dealt a severe blow to the California black rail and the California clapper rail, both of which reside in the Strait Region. Currently, the black rail is found in brackish marshes adjacent to Suisun and San Pablo Bay. The clapper rail has been reported frequently in the marshes at Mare Island, and rarely at Southampton Marsh (Chapman 1977; Madrone Associates 1977; City of Vallejo 1993, 1994; Cohen 1996; CSRRC 1998). Both species are fully protected in the State of California, but only one, the clapper rail, is listed as federally endangered (CDFG 2000). Other protected bird species known to occur in the Strait Region include the salt marsh common yellowthroat (*Geothlypis trichas sinuosa*) and the Suisun sparrow (*Melospiza melodia maxillaries*) (CSRRC 1998). They are currently listed as California species of special concern (CDFG 2004).

Physical Resources

Waterfront Development

Along with its impacts on natural resources, urban growth has had a particularly dramatic effect on the appearance of the Carquinez Strait shoreline. As was mentioned earlier, the laying of the Central Pacific railroad tracks resulted in the strip of filled land that presently spans the length of the southern shoreline. Its impact on the landscape has undoubtedly been enormous, but even more intriguing is the extent to which the waterfronts in cities such as Benicia, Vallejo, and Martinez have changed since European-American settlement.

Though one wouldn't know it today, the city of Vallejo was once divided in two parts. Historically, the southern extent of the town, called South Vallejo, rested on a gentle, north-facing slope bordered to the west by Mare Island Strait and to the north and east by a large bay and a contiguous strand of marshland that extended inland for almost a mile (Fig. 10). Across the bay from this settlement was the larger town of Vallejo. For a time, both the bay and the marsh posed a considerable barrier to travel between the two cities. However, by the 1860s, the California Pacific Railroad had laid a railroad spur extending from Napa Junction to South Vallejo, and eventually to the Starr Flour Mill, providing a fast and reliable means of travel (Keegan 1989).

Later, two bridges were constructed. These linked the city with roads oriented to the north and west. One of these straddled the bay, in line with present-day Sonoma Boulevard, while the other crossed the marsh to the east, on a parallel path with present-day Lemon Street. As can be seen in the topographical map from 1901 (Fig.11a), the marsh and bay were still more or less intact by the turn-of-the-century. By 1914, however, attempts at filling the bay were already well under way (Southard, pers. comm.). Figures 11b, 11c, and 11d show the gradual progression of urban infill in South Vallejo during the years 1940, 1950, and 1959.

By comparing ground photos of the area -- one taken in the late 19^{th} century, the other taken this year -- the change becomes obvious. Whereas, previously, Vallejo residents had looked across the bay to South Vallejo (Fig. 12a), now no such view exists. This is largely due to a massive urban renewal effort in the 1960s and '70s that transformed Vallejo's waterfront into a haven for recreation (WRT 2000). The present view looking south is currently obstructed by an esplanade, as well as other recent additions to the waterfront (Fig.12b).

Despite losing its connection to the tide, the marsh lingered in place for several more decades. A 1920s photo taken at the marsh's edge, now the intersection of Curtola Parkway and Sutter Street, is especially revealing (Fig. 13a). This area has been completely transformed by urban development, as can be seen in a recent comparison photo (Fig. 13b). The last remaining vestige of these former tidelands is Lake Dalwigk, a small, tule-filled lake that is located near the intersection of Curtola Parkway and Lemon Street (Fig. 14). The lake, which was carved from former marsh habitat in the 1950s and now extends several feet below the original elevation of the marsh, is currently being used as stormwater retention basin by the Vallejo Sanitation and Flood Control District (Betourne, pers. comm.).

Like Vallejo's waterfront, Benicia's urban frontage took decades to solidify. When the town was originally platted in 1847, it was laid out in a rectangular grid that extended into the water (City of Benicia 1999). As a result, many streets along the waterfront were separated by fingers of tidal marshland. Over time, as can be seen by comparing topo maps from 1901 and 1980, these areas were gradually filled in (Figs. 15a and 15b). Near the end of World War II, a group of historic waterfront buildings near the First Street Pier were deemed a public safety hazard by the city and were gradually demolished (Angstadt, pers. comm.). The land beneath them has since been restored to tide. This transformation can be readily seen in two comparison views of the waterfront - one from the early 1900s, the other from this year (Figs.16a and 16b).

As with many other localities in the Strait Region, wharves have been splitting the Martinez harbor since the time of the Gold Rush. A 1901 topographical map indicates that two wharves existed at the turn of the century (Fig. 17a). The first attempt at developing the Martinez waterfront, however, was the construction of a municipal pier and ferry slip in 1927 (McClure 1972). The ferry became an important link in the state highway system. The pier, on the other hand, fell well short of its intended purpose. Heavy shoaling had reduced the water depth at the face to 1.4 feet, thus prohibiting its use as a public boating facility (McClure 1972).

In 1934, after an early attempt at dredging proved unsuccessful, the pier was extended to a length of 803 feet to secure enough deep water for a yacht harbor. The harbor operated successfully for some years but persistent shoaling eventually caused it to be abandoned. Work on the existing harbor began in the summer of 1960 (USACE 1965). An area of about 50 acres was dredged to a depth of 9 to 10 feet, allowing for the construction of 364 new berths.

The marina (now with 423 berths) currently shares the harbor with the Martinez Refinery Wharf (USACE 2000; Fig.17b). The 343-acre Martinez Regional Shoreline, managed by EBRPD, lies just to the west of the wharf and includes the tidal flats around the marina and the wetlands near the outlet of Alhambra Creek.

Shoaling

Besides urban development, probably the single most important historical factor affecting the current character of the Carquinez Strait shoreline is the transport and deposition of sediment. In terms of its utility, sediment is both good and bad. While, on the one hand, it has been of considerable benefit in increasing marsh habitat and protecting it from further erosion, on the other, it is a constant impediment to boat access and berthing, and often must be maintained through the use of expensive dredging (Abergast and Newton 1974).

Historically, the progression of shoaling at Martinez Marina has followed the progression of structures (McClure 1972). The mudflats between the Martinez Refinery Wharf and the marina, and the flats west of the municipal pier, are the direct result of eddying caused by these two structures (Abergast and Newton 1974). In 1938, a civil engineer named R.L. Vaughn reported that the 30-foot depth contour off Martinez had been more or less stationary for 75 years, yet shoreward of this contour persistent shoaling has continued to the present day, casting a muddy "shadow" on the downstream side of the wharf and pier (Vaughn 1938, as cited in McClure 1972; McClure 1972; Abergast and Newton 1974).

Examination of other areas along the Carquinez Strait shows similar shadowing effects in open waters. The effect is particularly pronounced along the western shore of Mare Island. According to McClure (1972), U.S. Coast and Geodetic Survey (USC&GS) hydrographic charts indicate that after the construction of a barrier parallel to the current, sedimentation increased to such a degree between 1947 and 1966 that the shoreline advanced about one mile.

A study comparing depth changes in Southampton Bay over a period of 100 years was also conducted by the U.S. Army Corps of Engineers (USACE 1965). Using a series of USC&GS charts from the years 1857, 1886, 1922, 1940, 1950, and 1957, changes to the bay were revealed by comparing the location of MLLW lines and offshore depth contours over time. The Corps' study found that the MLLW, one-fathom, and two-fathom contours had made significant advances toward the main channel of the Strait between the years 1857 and 1886. About 80 percent of the surface area of Southampton Bay was heavily shoaled at this time having received about 8,730,000 cubic yards of material. In the ensuing years, shoaling continued in the bay, though at a reduced rate, until by the 1940 only minor amounts of material were received.

One of the mechanisms that accounts for this pattern of shoaling in Southampton Bay and other places in the Strait Region can be traced back to Gold Rush. According to Atwater et al. (1979), the rapid build-up of sediment during the late 19^{th} century probably resulted from contemporaneous hydraulic mining activities in the Sierra Nevada. Between 1853 and 1884, gold miners washed millions of cubic yards of sediment into Sierran streams. This debris eventually filtered down into the estuary and caused massive shoaling of subtidal areas in Suisun Bay and San Pablo Bay (Gilbert 1917). A similar pattern of accretion also occurred in the Carquinez Strait, though on a smaller scale. Gilbert (1917) estimated that between the years 1861 and 1890 as much as 40,000,000 cubic yards of sediment accumulated in the Carquinez Strait as a result of hydraulic mining, around 63 percent of that received during the same time period in Suisun Bay and around 11 percent of the total volume of sediment received contemporaneously in San Pablo Bay (Table 6).

It can also be assumed that a certain amount of residual exchange occurs as a result of artificially reversed flow in the estuary. McClure (1972) offered the following explanation for continued shoaling in the Strait after the abandonment of hydraulic mining:

> *When hydraulic mining was abandoned in California, a major source of silt in the rivers feeding San Francisco Bay was eliminated. Indirectly, though, mining provided a substitute. Stored on the bottom of San Pablo Bay are tens of feet of the same fine silt that washed down during the gold rush. This silt was undisturbed as long as the natural flow pattern of the river through the bay to the Golden Gate was preserved. With the restriction of the natural flow pattern by the building of dams, began a tendency to reverse the original flow. Now, with each tide that encroaches on the previously fresh water Carquinez Straits comes some of the silt that the tide has scooped up from San Pablo Bay.*

Additional sources of sediment include runoff from farmlands and urbanized uplands, and dredged channel and harbors (Gilbert 1917; Knott 1973; Atwater et al. 1979). Along with residual debris from San Pablo Bay and the natural sediment load carried downstream to the estuary from the Sacramento and San Joaquin Rivers, deposition stemming from contemporary land uses continues to shape the harbors of the Strait Region.

Pollution

Since the arrival of European-Americans, human activities have led to the fouling of waters, contamination of soils, and general pollution of the airspace around the Strait Region. A detailed analysis of these problems goes beyond the intended scope of this research project; however, brief mention will be made of the major pollutants and their sources.

Toxic materials have been released into the estuary since the early days of the gold rush, when large quantities of mercury were used to extract gold from ore (Monroe and Kelly 1992; Cohen 1996). Reductions to freshwater inflows in the past century, primarily due to state and federal water projects, have further amplified the effects of contaminated sediments by reducing the magnitude of periodic flushing events (Conomos 1979; Nichols et al. 1986; Kennish 1992; Ostrowski 2001). Recently, industrial, municipal, and agricultural discharges have led to elevated concentrations of trace elements in the sediment and water column (Gordon 1980; Flegal et al. 1991; Smith and Flegal 1993; Abu-Saba and Flegal 1995; Rivera-Duarte and Flegal 1997; Hornberger et al. 1999; Ostrowski 2001).

Many of these contaminants have been traced to point-source pollution in the Strait Region. Municipal and industrial discharges of trace metals such as arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc have been associated with wastewater outfalls from the Vallejo Sanitary and Flood Control District, Benicia Public Works Department, Central Contra Costa County Sanitation District, C&H Sugar, Shell, Tosco, Exxon, and Unocal (Gunther et al. 1987; Davis et al. 1991).

Ostrowski (2001) has also identified significant concentrations of copper and nickel in the vicinity of the former Mare Island Naval Reserve, where metals were used extensively in ship-building activities (including metal plating and the use of copper-based anti-fouling paints).

Historically, the largest source of air pollution in the Strait Region was the Selby Smelter. On March 14, 1905, the residents of the city of Benicia brought an injunction against the smelter for what they believed were unhealthful levels of sulphur dioxide in the air, claiming that airborne contaminants from the smelter fouled their crops and poisoned their livestock (Holmes et al. 1915). An independent commission of scientists was formed to formally investigate these complaints; however, after conducting a battery of rigorous tests, the commission determined that "the Selby smelter by emission into the atmosphere of sulphur dioxide from its plant does not maintain a nuisance in the southern portion of Solano County, Cal...." (Holmes et al. 1915).

Nevertheless, evidence of contamination was hard to ignore. Photos of sulfuric acid burns on native vegetation near the smelter were particularly revealing (Fig.18a). Livestock photos also indicated a cause for concern. One of the commission's photos shows a horse with flaring nostrils, a characteristic of "roaring", caused by paralysis of the diaphragm (Holmes et al. 1915, Fig. 18b). Cases of roaring in the so-called "Selby Smoke Zone" were commonly attributed to lead poisoning and probably resulted from the ingestion of foliage contaminated with lead fallout from the smelter. In 1937, American Refining and Smelter Company, Selby's successor, built a 606-foot-tall smokestack to waft the fumes higher into the air (Emanuels 1986). Despite this measure, Solano County livestock continued to show signs of exposure to toxic fumes. In the last two decades of the smelter's operation, over 40 horses died from chronic lead poisoning in adjacent pastures (Rabinowitz and Wetherill 1972).

Besides atmospheric deposition, soil contamination appears to be another side-effect of the smelter's operation. Using lead concentration and isotopic analyses from sediment cores in San Pablo and Richardson Bay, Ritson et al. (1998) detected a noticeable shift in the lead isotopic compositions of sediment deposited in the late 1800s and early 1900s, which they say coincided with the operation of the Selby Smelter. Lead contamination of soils in this horizon predates another possible large lead source, leaded gasoline, which did not come into widespread use until after 1923 (Chow and Johnstone, 1965; Ritson et al. 1998). Thus, Ritson et al. (1998) concluded that among the sediments sampled that were deposited before 1923, the Selby Smelter was "the most likely source of lead". The smelter has also been linked to the appearance of contaminated soils on the north shore of the Strait (Cal-EPA 1993; Cohen 1996).

After its closure in 1971, the smelter left behind about 1.8 million cubic yards of slag, containing arsenic, lead, copper, zinc, cadmium, chromium, nickel and other metals (Lochner 2004). The Selby Slag Site, which includes 66 acres of shoreline and marsh, was added to the state Superfund site cleanup list in the 1980s and is currently under the remediation oversight of the Department of Toxic Substances Control (Lochner 2004). As an interim remedial measure, the site was sealed with an asphalt cap in the early 1990s and has remained in this state to the present day, as can be seen in comparison aerial views from 1929 and 1993 (Figs 19a and 19b). Remediation efforts in the vicinity of the site are currently focusing on the presence of petroleum hydrocarbon and Methyl Tertiary Butyl Ether (MTBE) in the soil and groundwater (CRWQCB 2004). This new source of contamination is believed to be associated with the operation of the Shore Terminal Facility, located to the west of the Selby Slag Site (Lochner 2004).

CHAPTER 5
CONCLUSIONS

The transformation of the Carquinez Strait Region from what was once a sparsely wooded savanna to what is now a cluster of urban areas surrounded by dense woody vegetation has been so complete that it might seem pointless to study its change. However, since historic human activities have undoubtedly influenced the extent and pattern of landscape change, and consequently the viability of natural and physical resources, the process by which the transformation occurred cannot be overlooked. Gaining a historical perspective on the underlying processes of landscape change can provide new insight and make significant contributions to science and policy (Black et al. 1998).

Looking back through time, for example, one can see an appreciable difference in the quality of upland habitats in the Strait Region. Whereas, historically, the hills were covered with native perennial bunchgrasses, today they are overrun with non-native annual species, many of them introduced during the Spanish Period. A number of upland forb species have declined as well, their preferred habitats lost to road construction, development, and encroachment by non-native weeds. Recent increases in woody vegetation, particularly on the south side of the Strait, indicate a change in the overall disturbance regime, probably as a result of the modern movement towards fire suppression, the cessation of grazing, and the revegetation of formerly cleared areas.

The quality of wetlands habitats in the Strait Region has also been severely compromised. Due to human activities such as the filling of marshes, discharge from sewage treatment plants, and pollution from urban and industrial sources, the wetlands now host a variety of rare, threatened, and endangered species. The recent emergence of aggressive weedy species, such as pepperweed and saltmeadow cordgrass, in the marshes off Mare Island and in Southampton Bay is of particular concern for the future management of the few remaining populations of soft bird's-beak and Mason's lilaeopsis.

Given that so much of the habitat was modified or lost during the past two centuries, the historic extent of these wetland areas can only be surmised. Analysis has shown that the greatest net loss of wetland habitat in the Strait Region was the tidal marsh in Vallejo, which formerly extended inland for nearly a mile. Reclamation of the bayfront in the early 1900s essentially isolated the marsh, cutting it off from the tide. The marsh has since been filled, paved over, and for the most part, forgotten.

A similar transformation occurred in Benicia, where much of the former wetland habitat along the waterfront was filled in to make room for urban expansion. Unlike the pattern of irreversible change at South Vallejo, however, some of these areas have since been restored, although perhaps only as a consequence of city's efforts to purge its waterfront of hazardous, decaying structures.

Elsewhere, as in Martinez, formerly subtidal areas have gradually accreted, effectively creating a net gain of tidal habitat. Evidence suggests that an enormous influx of hydraulic mining debris from the years 1853 to 1884 is largely responsible for the current pattern of shoaling in the Strait Region. Continued shoaling is related to the existence of manmade projections along the shorelines, such as the wharf and pier at Martinez and the jetty on the southern tip of Mare Island; to disturbed sediment from dredging and urban runoff; to the natural sediment load that enters the estuarine system from upstream sources; and to the exchange of residual deposits from San Pablo Bay during reverse flow events.

Another consequence of land use in the Strait Region is pollution. As has been shown in the case of the Selby Smelter, the effects of pollution have been far-reaching. Airborne pollutants early in the 20th century were shown to cause damage to native vegetation downwind from the plant, and were believed to be responsible for the deaths of horses and other livestock in Benicia. Further evidence has shown that lead-contaminated soils in both Suisun and Richardson Bays can be traced directly to the Selby Smelter, raising the possibility that contamination from the smelter has reached an estuary-wide scale. Though polluted discharges have thankfully decreased in recent years with tighter regulatory measures and more efficient control technologies, information on the historic vectors of contamination are largely lacking and are highly relevant to current issues of environmental quality both locally and throughout the Bay Area.

This study has shown that landscape changes in the Strait Region have rarely been gradual or linear in nature; they are episodic and have often been the result of changes in economy and technology. Just as the hide and tallow trade stimulated the conversion of the natural pasturage, so too did the global demand for wheat cause the profound transformation of the Strait Region both in terms of settlement and land use. Further changes in technology, such as the completion of the transcontinental railroad and the construction of Strait Region bridges, has permitted greater accessibility, led to greater economic efficiency, and has facilitated the current intensified pattern of land use that is seen in the Strait Region today. Each transition has been accompanied by changes in physical and biological conditions, and has led to significant shifts in composition, or, in some cases, to the extirpation of certain species altogether. Whether these changes are deemed favorable or not, studies such as this provide new insights on regional landscape change and offer critical information upon which land and resource management decisions can be based.

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APPENDIX 1: FIGURES

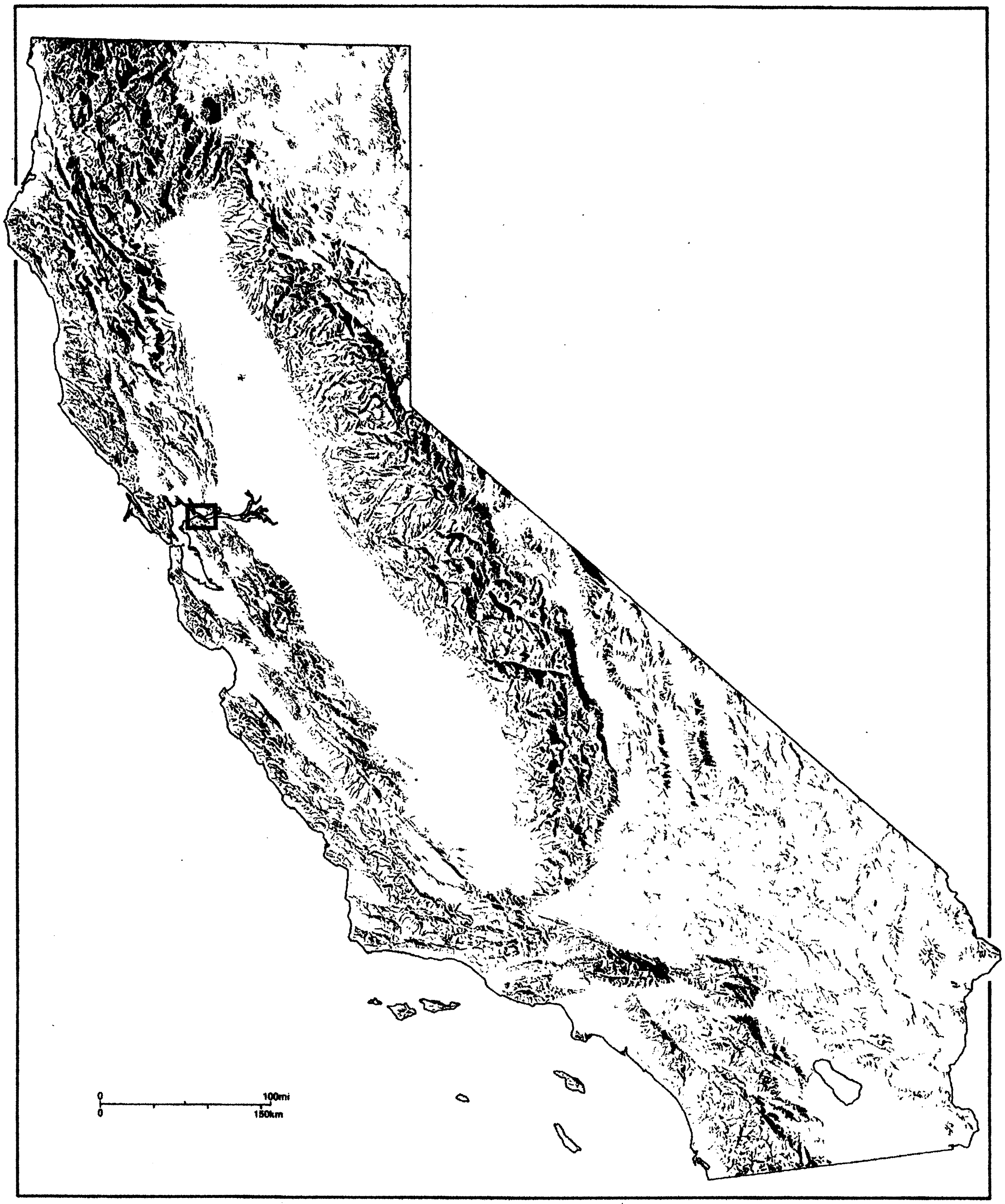

Figure 1. Map showing the location of the Carquinez Strait Region in California.
Source: Hornbeck 1983.

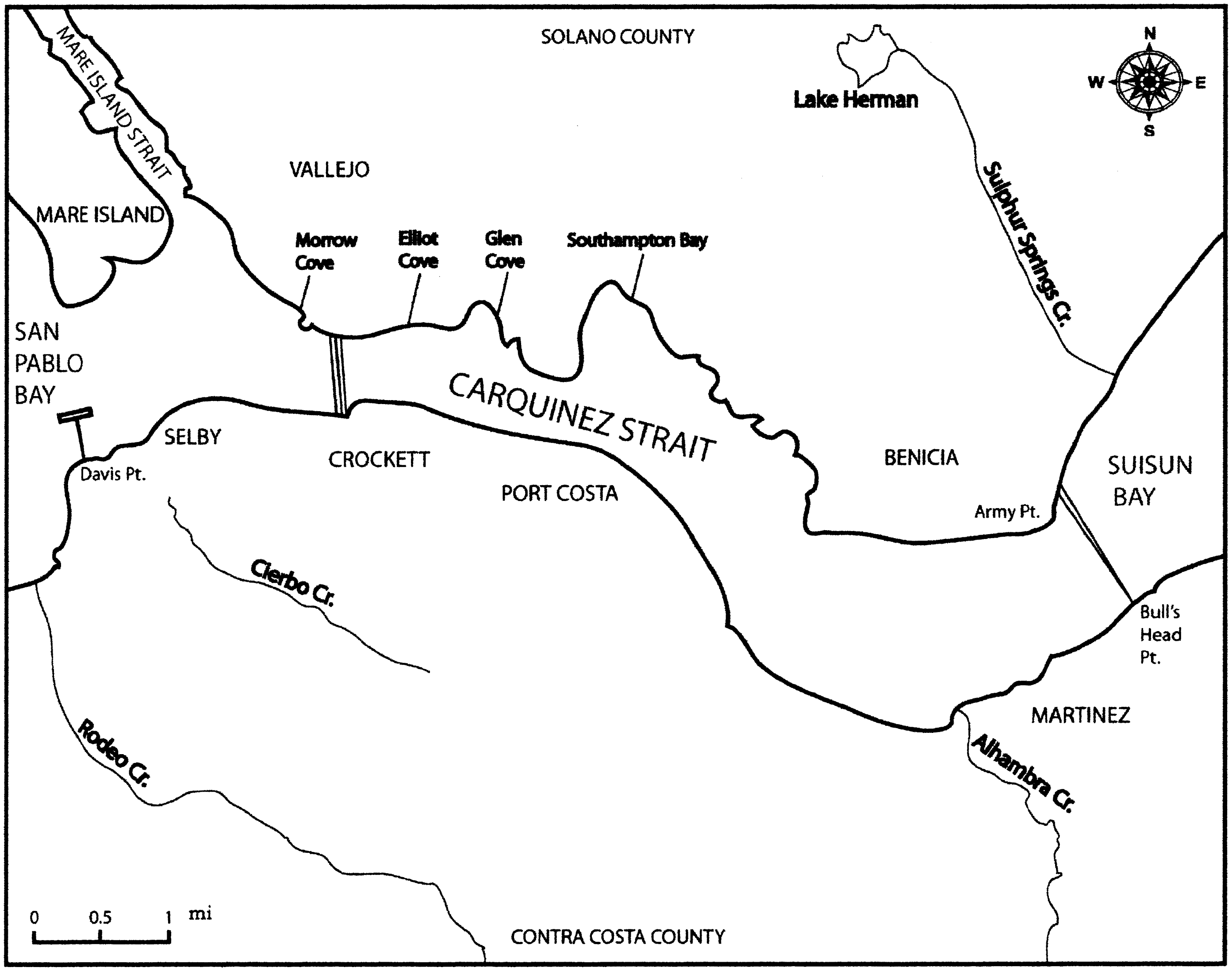

Figure 2. Map of the Carquinez Strait Region.

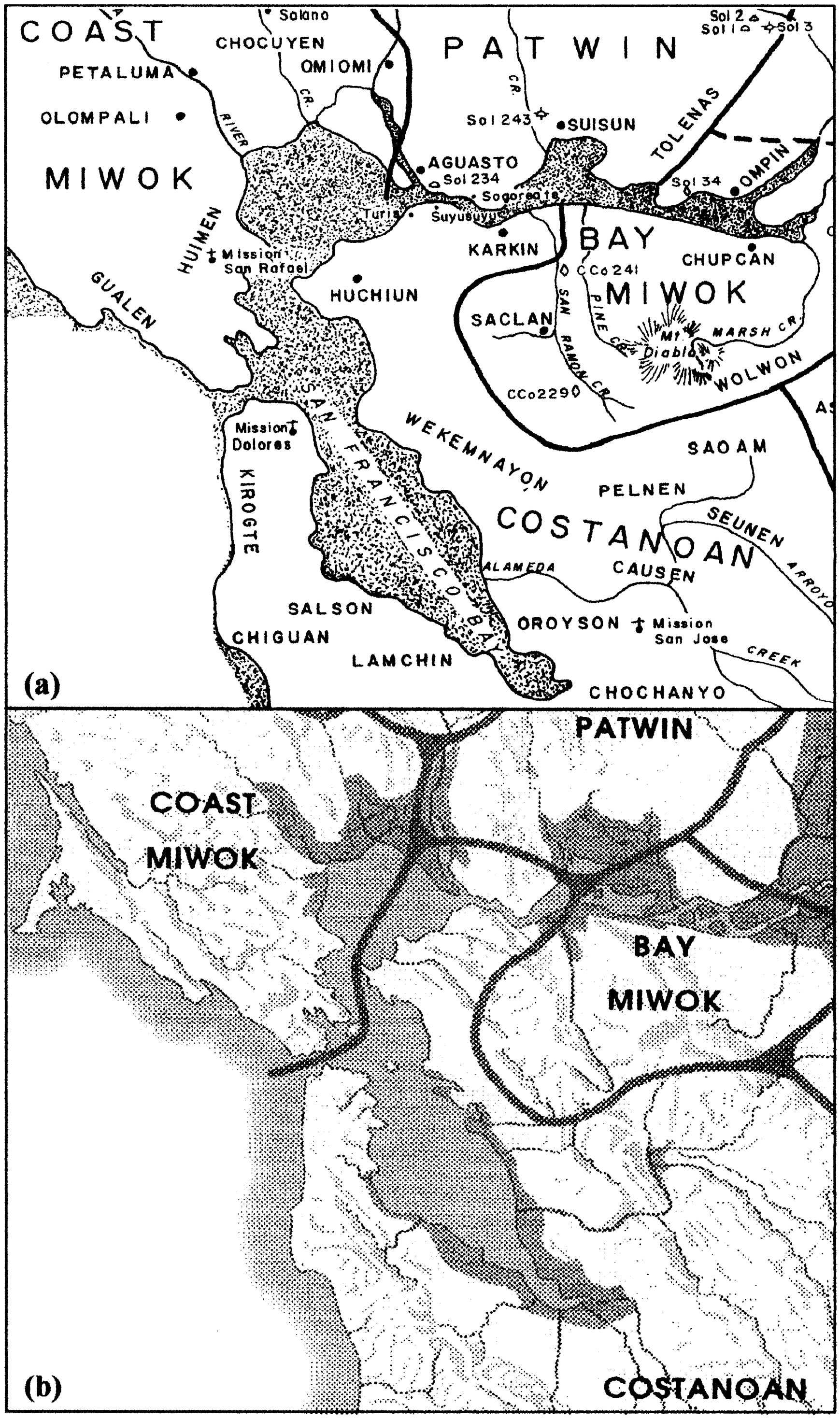

Figure 3. Native American linguistic boundaries in the Bay Area as conceived by (a) Bennyhoff and (b) Milliken. *Sources*: Bennyhoff 1977; Milliken 1995.

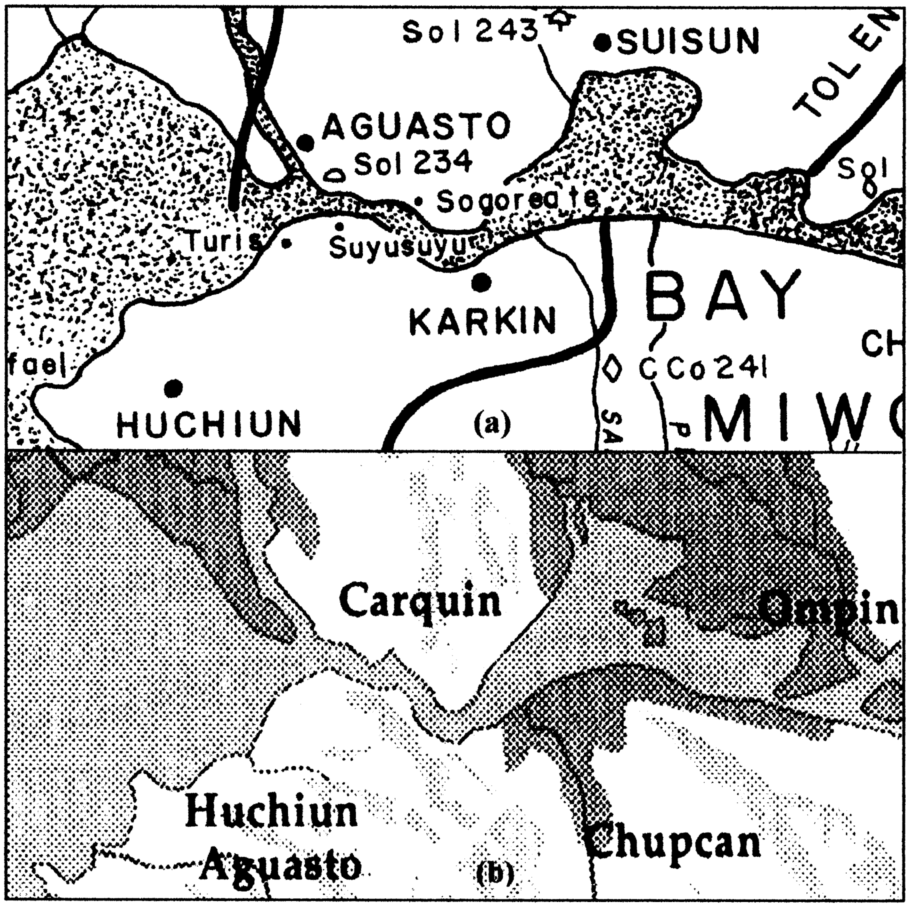

Figure 4. Tribal territories in the Strait region, as conceived by (a) Bennyhoff and (b) Milliken. *Sources*: Bennyhoff. 1977; Milliken 1995.

Figure 5. Villavicencio's 1781 map of San Francisco Bay. The letter "O" denotes the locations of village sites. *Source*: Galvin 1971.

Figure 6. Canizares' 1775 map of San Francisco Bay. *Source*: Galvin 1971.

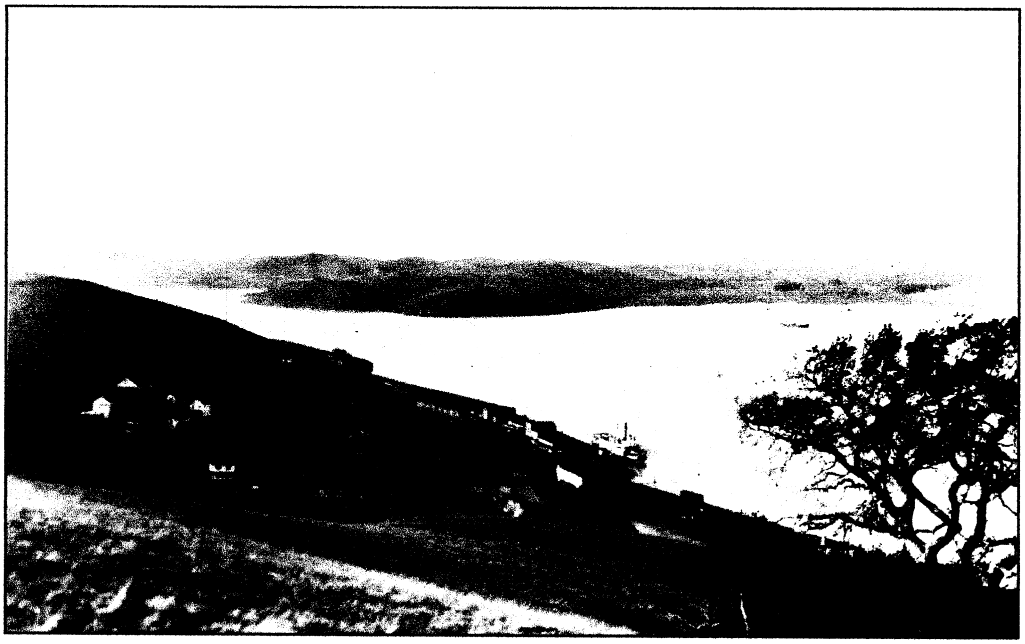

Figure 7a. Early photo (circa 1910) of Port Costa. Photo courtesy of the Contra Costa History Center.

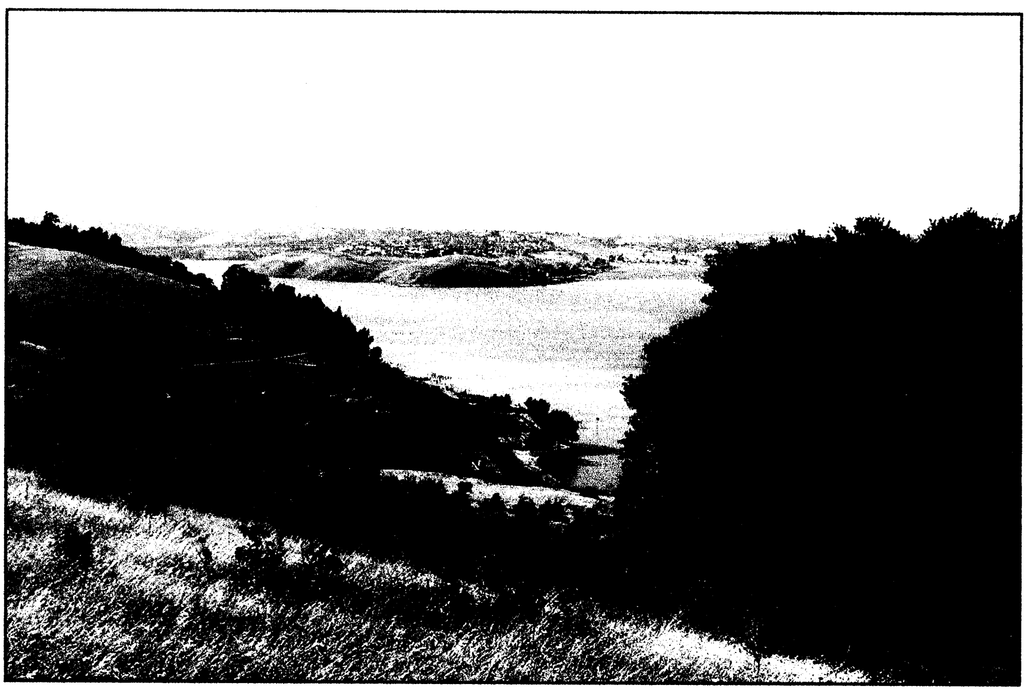

Figure 7b. Similar view in 2004. Photo by author.

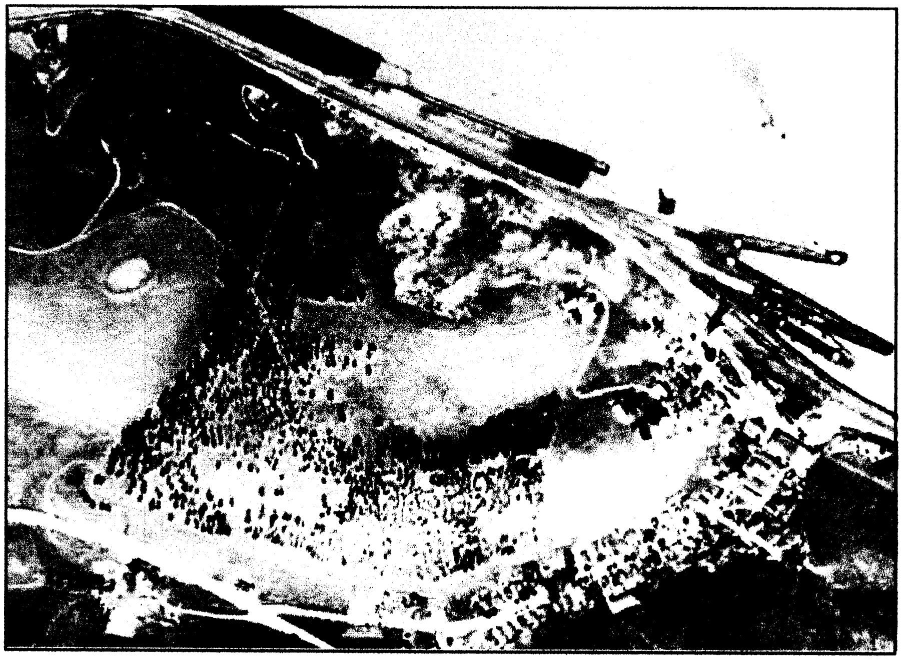

Figure 8a. Early aerial photo (circa 1929) showing the eucalyptus grove near Port Costa. *Source*: Berkeley Digital Library SunSite 2004a.

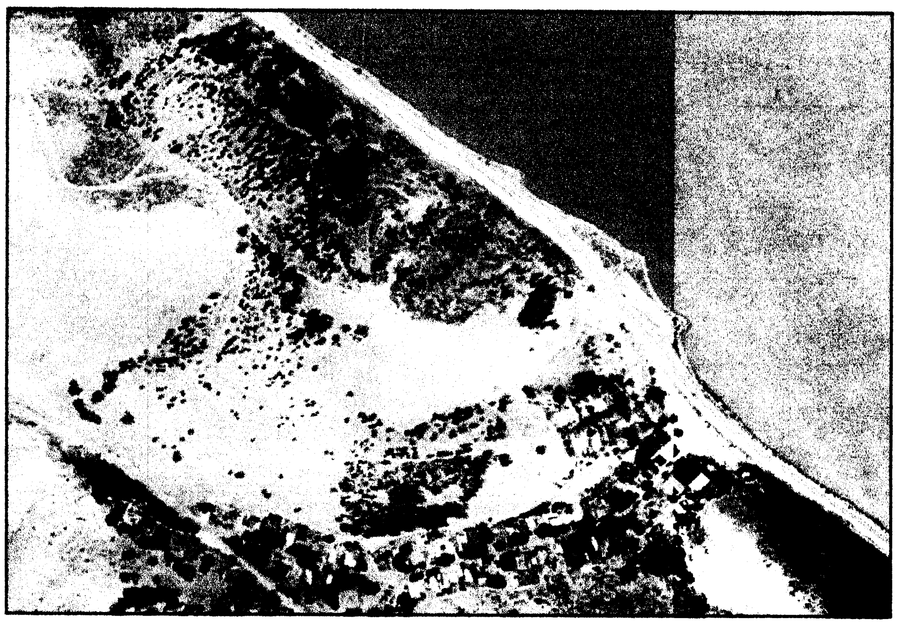

Figure 8b. Similar view in a 1993 aerial photo series. *Source*: California Spatial Information Library 2004.

Figure 9a. Early aerial photo (circa 1929) showing vineyard areas west of Martinez. *Source*: Berkeley Digital Library SunSite 2004a.

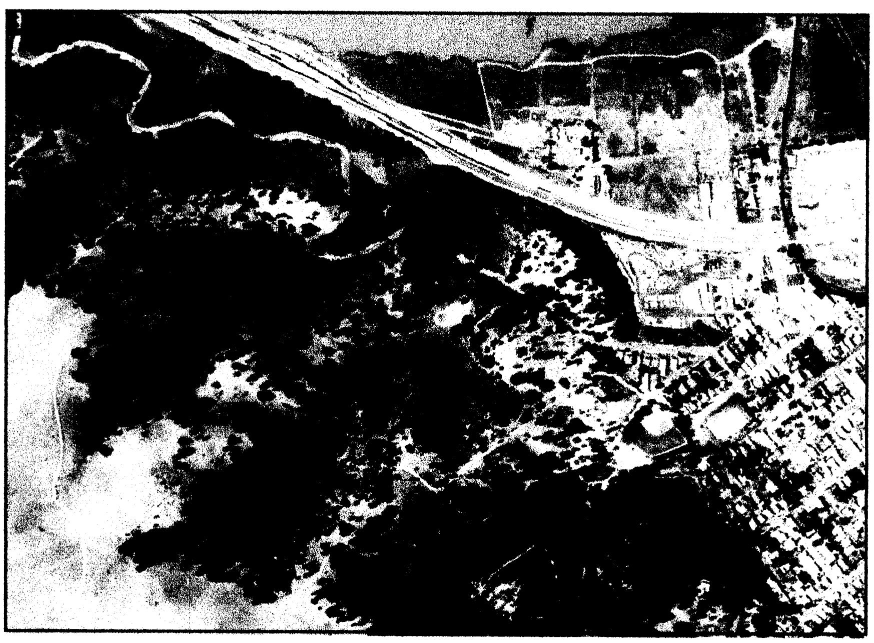

Figure 9b. Similar view in a 1993 aerial photo series. *Source*: California Spatial Information Library 2004.

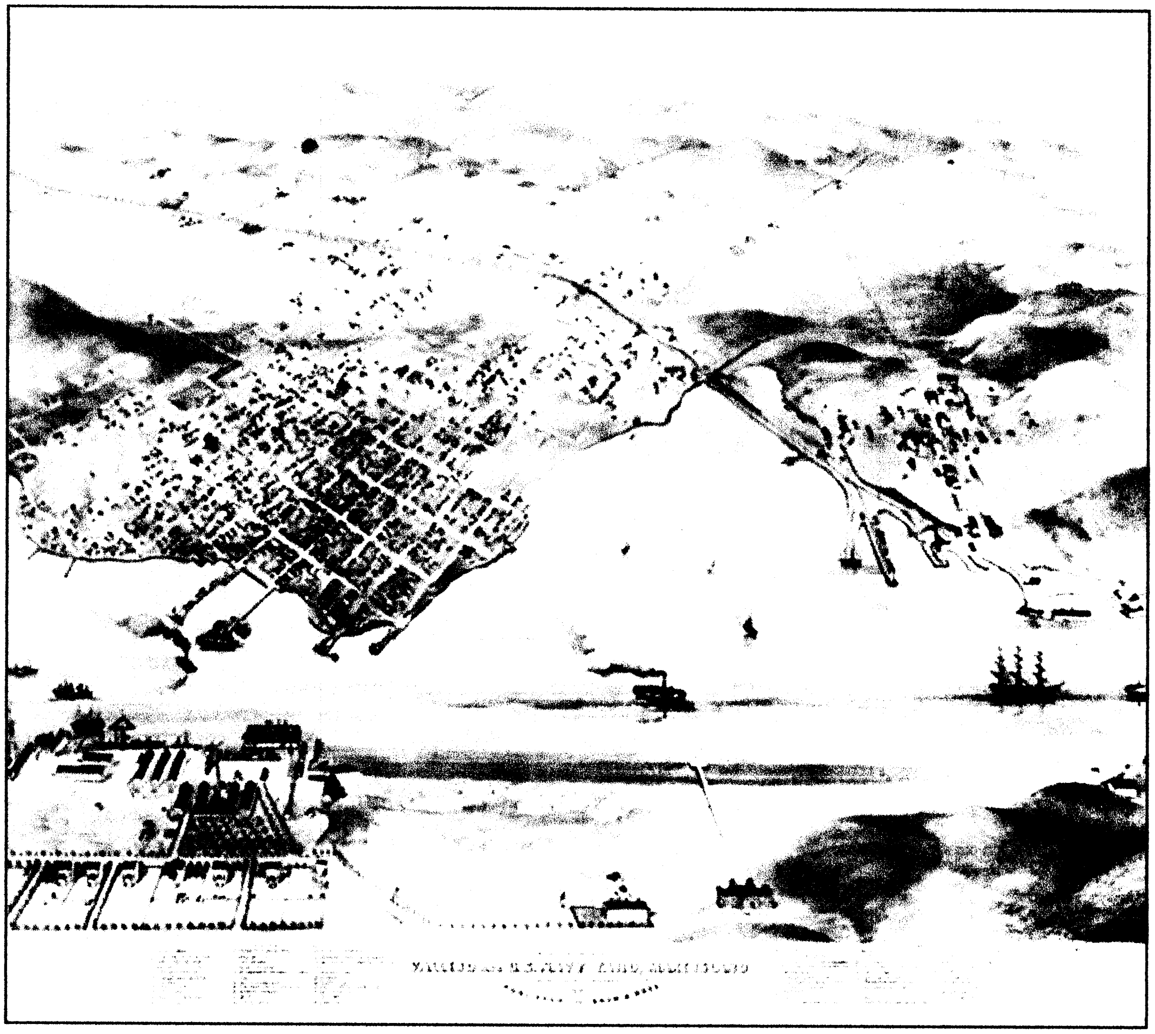

Figure 10. Early map (circa 1871) of the bay and marsh in South Vallejo. *Source*: Wallace Roberts Todd Planning and Design, Inc. 2004.

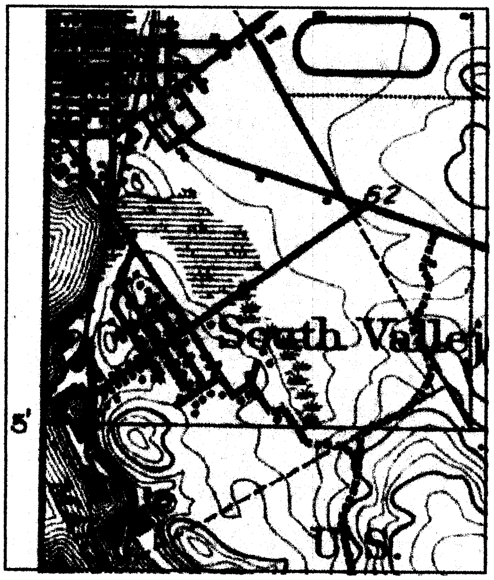

Figure 11a. Early topographic map (circa 1901) showing the tidal marsh in South Vallejo. *Source*: Berkeley Digital Library SunSite 2004b.

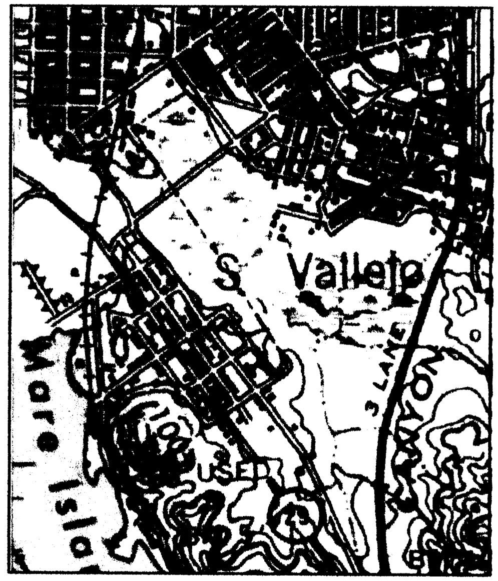

Figure 11b. Similar view in a 1940 USGS topographic map. *Source*: Berkeley Digital Library SunSite 2004c.

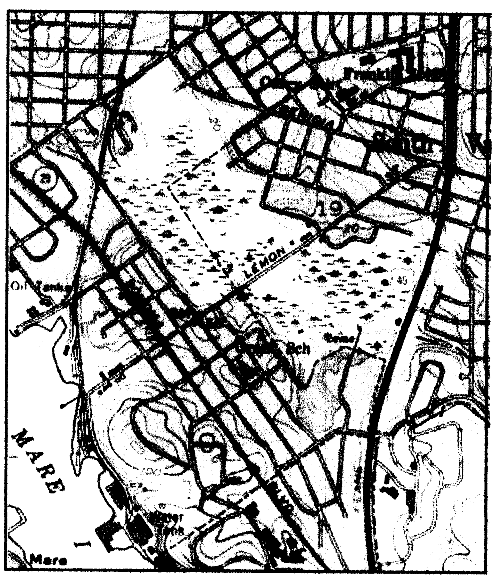

Figure 11c. Similar view in a 1950 USGS topographic map. *Source*: Berkeley Digital Library SunSite 2004d.

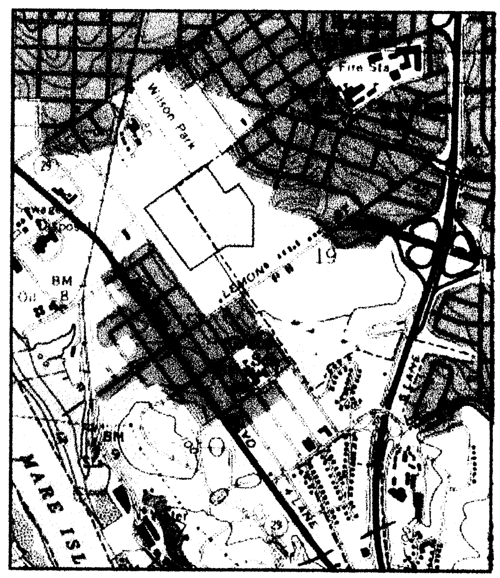

Figure 11d. Similar view in a 1959 USGS topographic map. *Source*: Berekeley Digital Library SunSite 2004e.

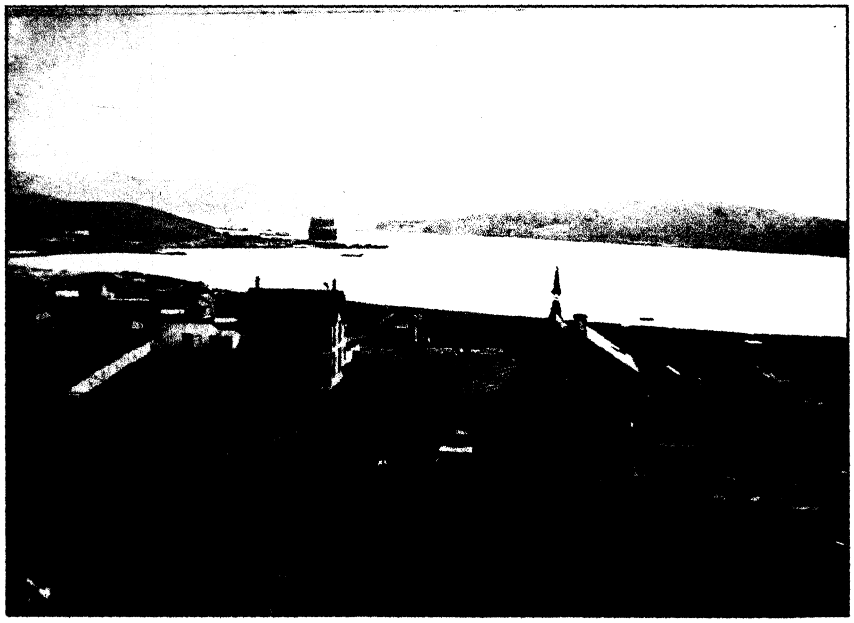

Figure 12a. An early photograph of Vallejo, South Vallejo, and the bay in between, taken sometime prior to 1870. The Starr Flour Mill can be seen in the distance. Photo courtesy of the Vallejo Naval and Historical Museum.

Figure 12b. Similar view in 2004. The old Starr Flour Mill site is currently occupied by a General Mills plant (white building, left of center). Photo by author.

Figure 13a. Early photo of the marsh, probably taken in the 1920s. Sutter Street can be seen on the upper left-hand side of the photo. Photo courtesy of the Vallejo Naval and Historical Museum.

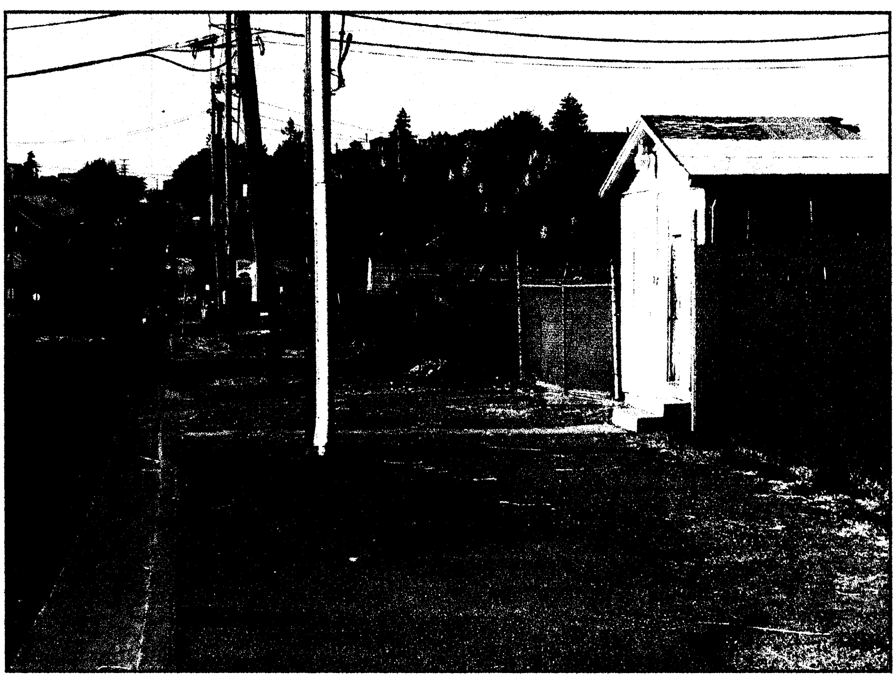

Figure 13b. Similar view in 2004. Photo by author.

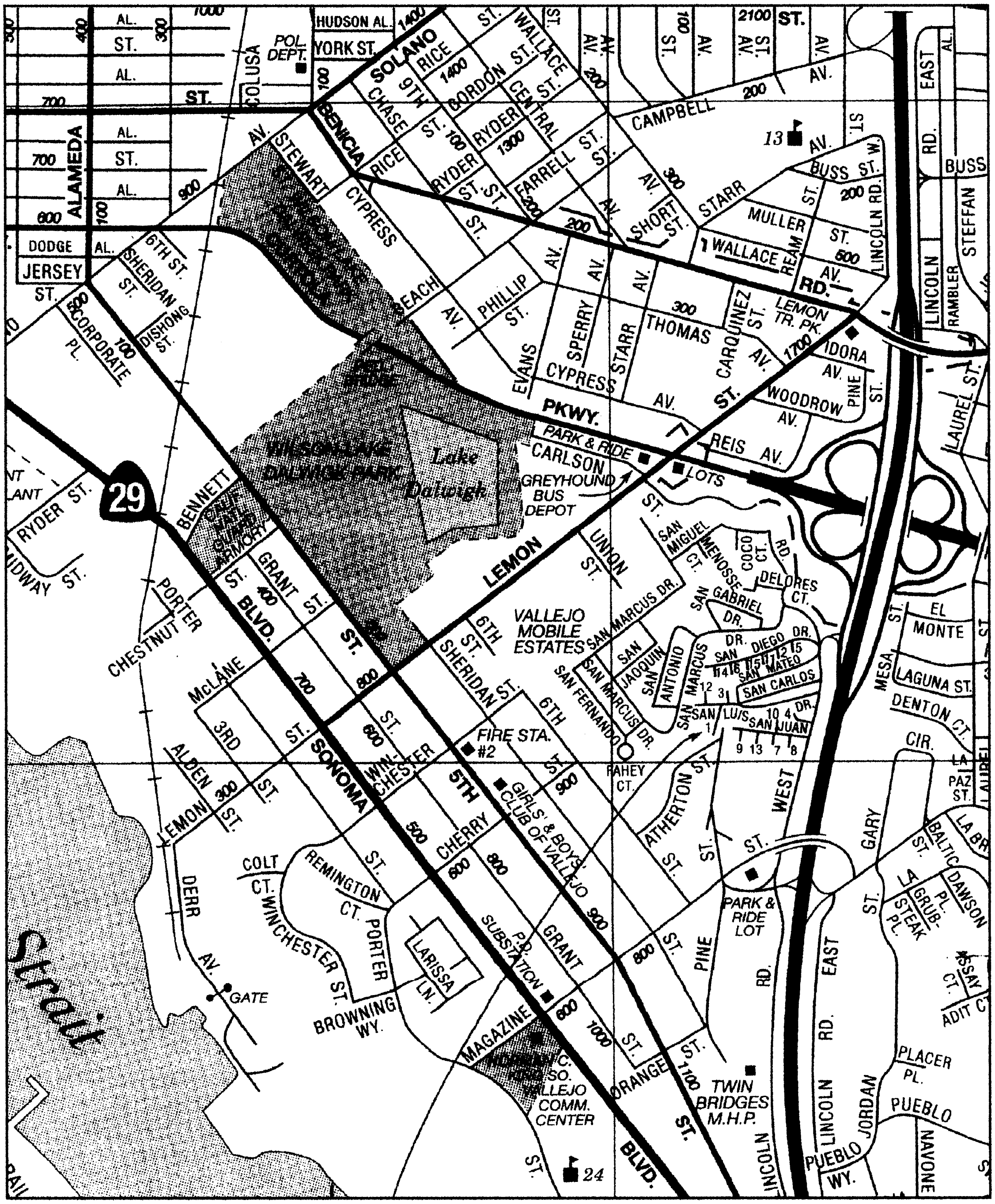

Figure 14. Current street map of Vallejo showing Lake Dalwigk. *Source*: American Automobile Association 2003.

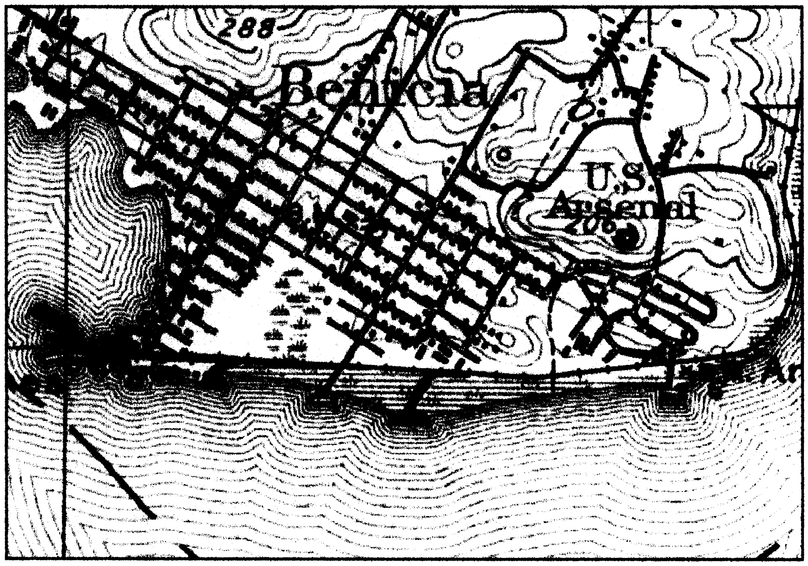

Figure 15a. Early topographic map (circa 1901) showing the Benicia waterfront. *Source*: Berkeley Digital Library SunSite 2004b.

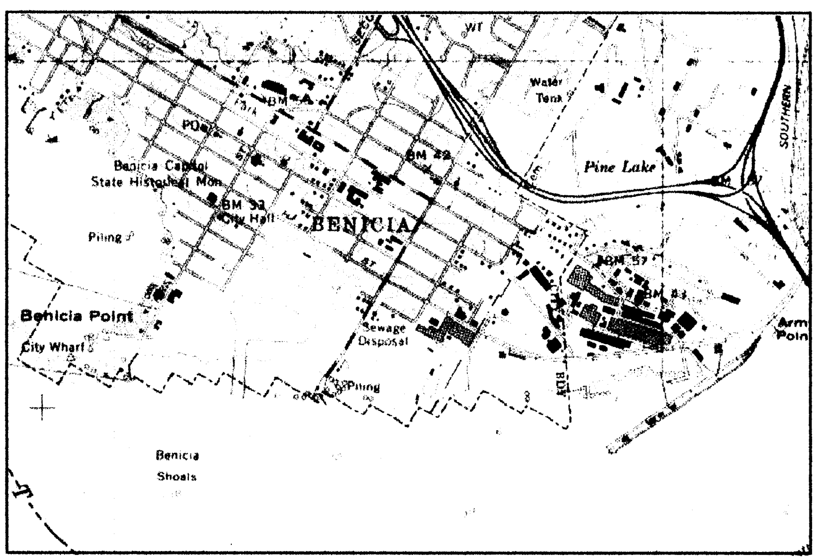

Figure 15b. Similar view in a 1980 topographic map. *Source*: Berkeley Digital Library SunSite 2004f.

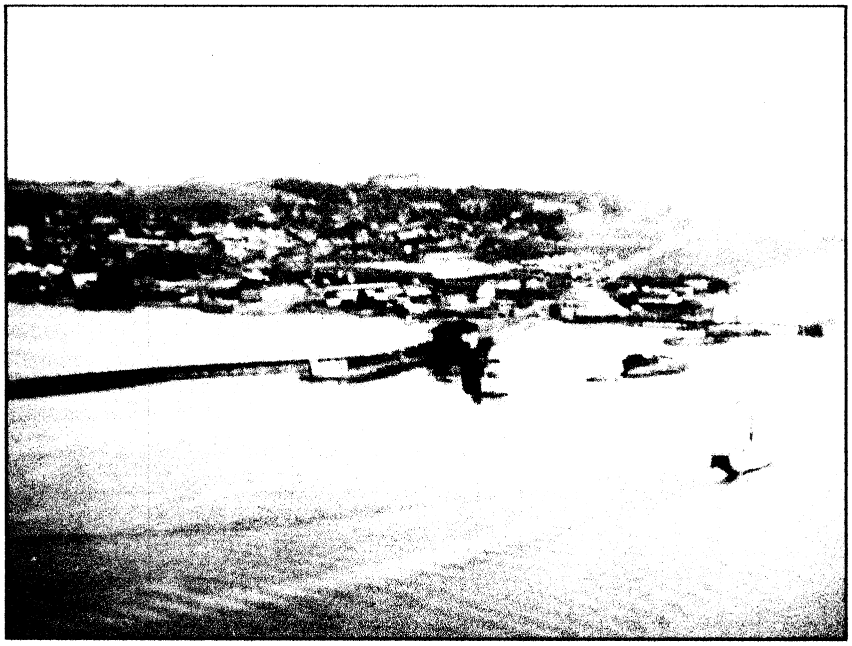

Figure 16a. Early photograph of the Benicia waterfront, taken sometime before 1930. The First Street Pier is at center. Photo courtesy of the Benicia Historical Museum.

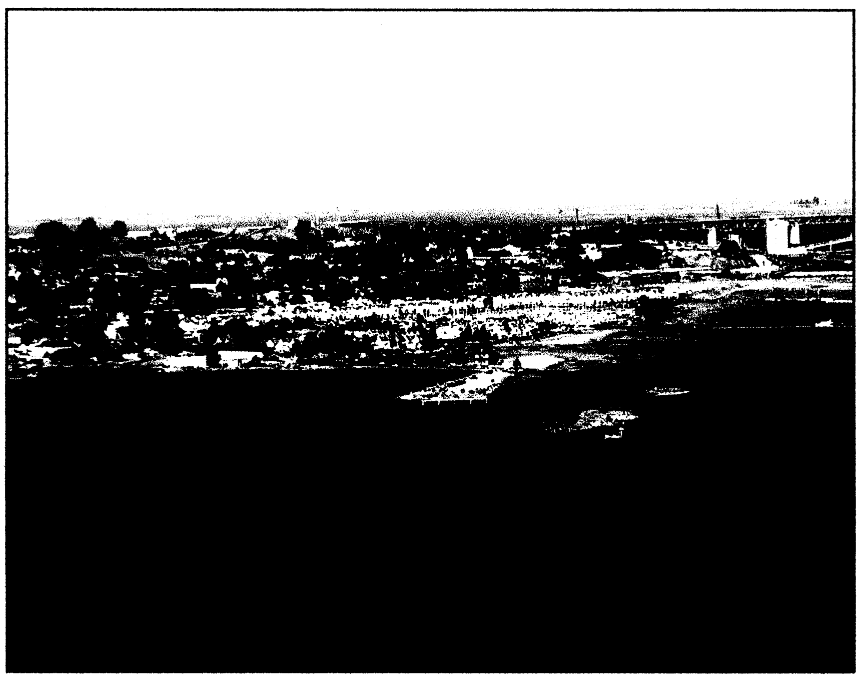

Figure 16b. Similar view in 2004. Photo by author.

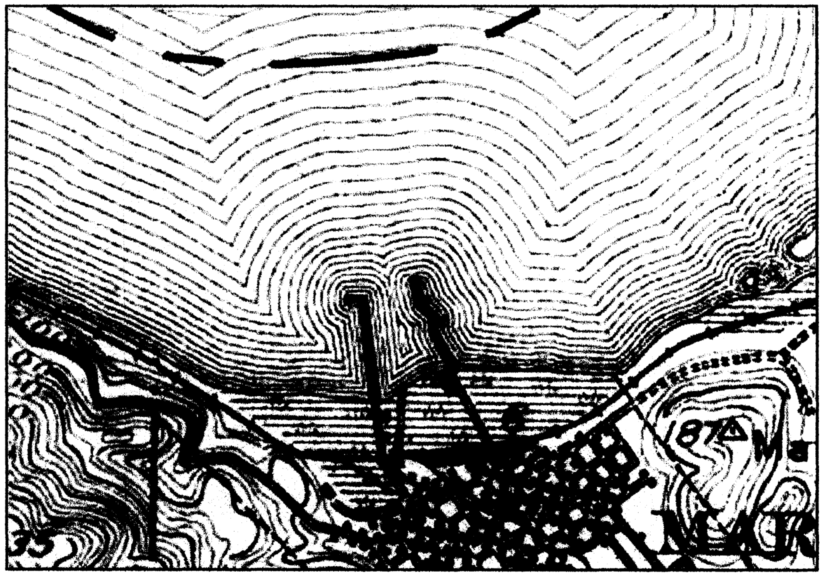

Figure 17a. Early topographic map (circa 1901) showing the Martinez waterfront. *Source*: Berkeley Digital Library SunSite 2004b.

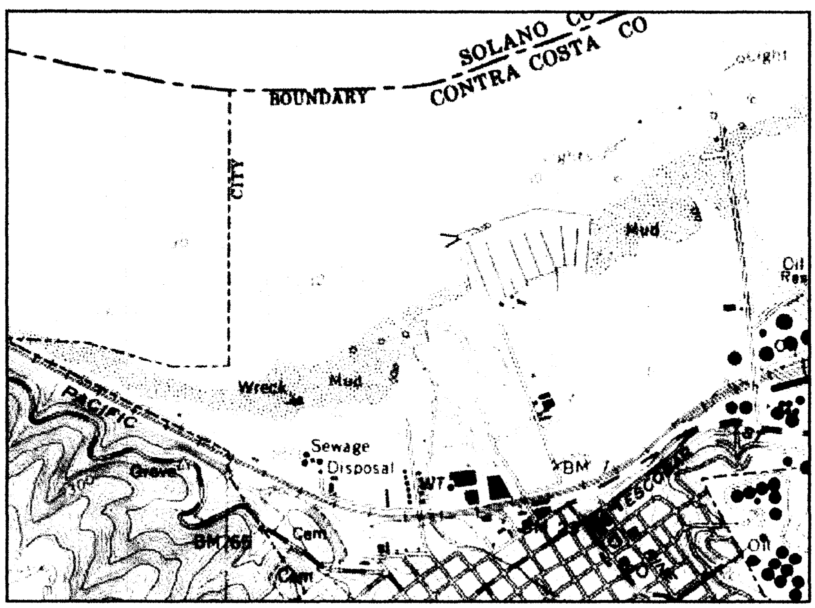

Figure 17b. Similar view in a 1980 topographic map. *Source*: Berkeley Digital Library SunSite 2004f.

Figure 18a. Photo of leaves exposed to sulfuric acid fumes from the Selby Smelter. *Source*: Holmes et al. 1915.

Figure 18b. Photo of a horse exposed to lead pollution from the Selby Smelter. The flared nostrils, shown here, are a symptom of acute lead poisoning. *Source*: Holmes et al. 1915.

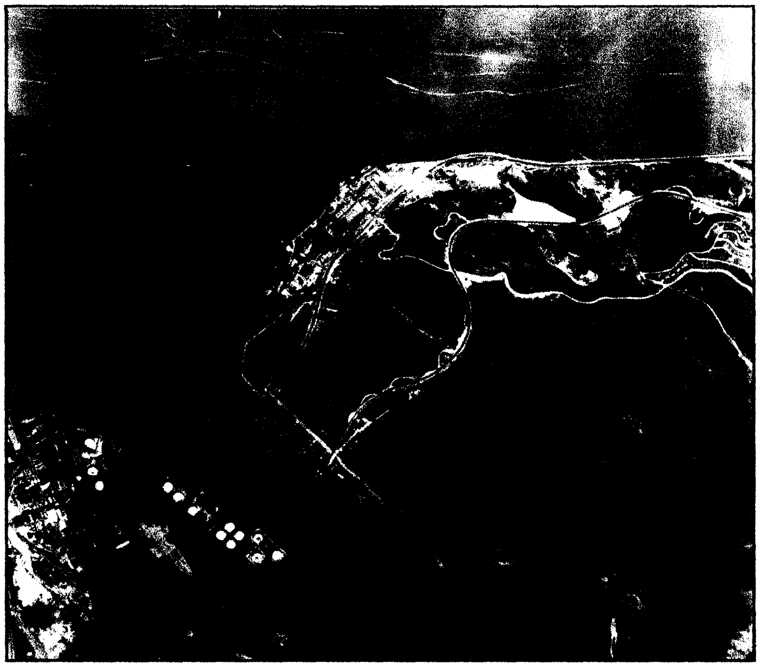

Figure 19a. Early aerial photo (circa 1929) showing the Selby Smelter. *Source*: Berkeley Digital Library SunSite 2004a.

Figure 19b. Similar view in a 1993 aerial photo series. *Source*: California Spatial Information Library 2004.

APPENDIX 2: TABLES

Table 1. Main constituents of San Francisco Bay shellmounds.*

Mound	Fish remains	Other vertebrate remains	Shell	Charcoal	Ash	Rock	Residue
Sausalito	0.008	0.015	54.44	0.055	4.21	23.5	17.77
Greenbrae	0.008	0.004	65.4	0.108	12.73	8.9	12.61
San Rafael	0.008	....	53.93	0.047	24.66	6.1	15.26
Carquinez	**0.01**	**0.025**	**55.34**	**0.175**	**26.5**	**3.8**	**14.2**
Ellis Landing	0.034	0.043	69.3	0.294	13.99	5.1	11.05
West Berkeley	0.069	0.069	52.53	0.123	23.76	4.9	18.51
Emeryville	0.186	0.031	59.86	0.237	13.47	8	18.26
Castro	0.008	0.076	25.99	0.898	9.47	8.8	54.72
San Mateo	0.005	0.11	59.09	0.173	11.2	18.5	10.98
San Mateo Point	....	0.185	58.5	0.05	6.04	16.2	19.06
San Francisco	0.1	0.15	57	0.02	15.9	1.4	25.43
Half Moon Bay	0.003	0.033	56.46	0.01	4.19	5.2	34.06
Eureka	0.01	....	68.47	0.21	12.08	....	19.23
Gunther Island	0.016	0.077	15.62	0.3	1.81	0.88	81.29
Point Loma	....	....	28.94	0.6	4.09	1.2	65.19
Average mound	0.31	0.055	52.07	0.22	12.27	7.5	27.84
Average S.F. Bay mound	0.04	0.064	55.59	0.198	14.72	9.6	19.8

Source: Gifford 1916.

*Values represent the average percent of each sample taken.

Table 2: Mammal remains found at San Francisco Bay Area archaeological sites.

Common Name	Scientific Name
Dog/coyote	*Canis sp.*
Gray fox	*Urocyon cinereoargenteus*
Black bear	*Ursus americanus*
Grizzly bear	*Ursus arctos*
Raccoon	*Procyon lotor*
Badger	*Taxidea taxus*
Beaver	*Castor canadensis*
Long-tailed weasel	*Mustela frenata*
California ground squirrel	*Spermophilus beecheyi*
Black-tailed jackrabbit	*Lepus californicus*
Botta's pocket gopher	*Thomomys bottae*
Striped skunk	*Mephitis mephitis*
Sea otter	*Enhydra lutris*
Mountain lion	*Felis concolor*
Bobcat	*Lynx rufus*
Gill's bottle-nosed dolphin	*Tursiops gillii*
Grampus	*Grampus griseus*
Harbor Porpoise	*Phocoena phocoena*
Gray whale	*Eschrichtius robustus*
Northern fur seal	*Callorhinus ursinus*
Stellar's sea lion	*Eumetopias jubatus*
California sea lion	*Zalophus californianus*
Harbor seal	*Phoca vitulina*
Elk	*Cervus sp.*
Black-tailed deer	*Odocoileus hemionus*
Pronghorn antelope	*Antilocapra americana*

Sources: Nelson 1909; Simons 1992.

Table 3. Yearly baptisms of three tribes at Mission Dolores.

Year	Huchiun	Huchiun-Aguasto	Karkin
77			
78			
79			
1780	1		
81			
82			
83			
84			
1785			
86	1		
87	10		1
88		1	
89	2		
1790			
91	5		
92	33		
93	1		
94	165		
1795	5		3
96	2		
97	2		
98			
99			
1800	14		
01	65		
02	5		4
03	44	18	
04	5		7
1805	22	43	1
06	2		
07			
08		3	1
09		23	99
1810		7	33
Total	384	95	151

Source: Milliken 1995.

Table 4. Mexican land grants in the Strait Region.

Year	Rancho	Area (acres)	Grantee
1823	Rancho El Pinole	~13,000	Ignacio Martinez
1841	Isla de la Yegua (Mare Island)	~900	Victor Castro
1842	Rancho Canada del Hambre y Las Bolsas	~13,000	Teodora de Soto
1844	Rancho Las Juntas	~13,000	William Welch
1844	Rancho Soscol*	~84000	Mariano Vallejo

Sources: Gregory 1912; Historic Record Co. 1926; Purcell 1940; Davis 1965; Smilie 1975; Dillon 1980; Collier 1983; Fink n.d.

* Claim was later rejected.

Table 5. Number of ships loading wheat at California ports: 1868-1881.

Crop Year	San Francisco	Oakland	Vallejo	Other	Total
1868-69	171	....	4	....	175
1869-70	163	....	31	....	194
1870-71	71	16	36	....	123
1871-72	24	12	7	....	43
1872-73	189	106	44	....	339
1873-74	94	77	76	....	247
1874-75	116	82	63	4	265
1875-76	75	35	64	....	174
1876-77	114	85	103	5	307
1877-78	58	14	37	....	109
1878-79	142	62	65	....	269
1879-80	118	37	118	....	273
1880-1881	103	33	97	124*	357

Sources: *Pacific Rural Press*, July 1881, 82, as cited in Cohen 1996.

*Includes 84 ships at Port Costa, 31 at Benicia, and 1 at Martinez.

Table 6. Estimated volumes of hydraulic mining debris deposited in the San Francisco Bay Estuary:1849-1914.

Body of water	Dates of surveys	Volume deposited between dates of survey (Cubic yds.)	Volume of deposits 1849-1914 (Cubic yds.)
Suisun Bay	1867-1886	64,000,000	200,000,000
Carquinez Strait	1861-1890	40,000,000	50,000,000
San Pablo Bay	1857-1897	366,000,000	570,000,000
San Francisco Bay	1856-1896	196,000,000	326,000,000
Bay total	....	....	1,146,000,000

Source: Gilbert 1917.