MALIBU LAGOON:
A Baseline Ecological Survey

Editors
B. Sean Manion
Jean H. Dillingham

Project Director
Jean H. Dillingham
for
Topanga-Las Virgenes
Resource Conservation District

Performed for
Los Angeles County,
Dept. of Beaches and Harbors
under SB 959
and
California State
Dept. of Parks and Recreation
under Grant #4-400-7171

cover by LD&A Marketing Communications

PREFACE

Approximately 67,000 acres - covering valleys and mountains, natural parklands and suburban developments - form the largest perennial drainage system within the Santa Monica Mountains. Altered through human intervention, the extensive Malibu Creek watershed terminates at Malibu Lagoon, one of the last remaining estuaries in Los Angeles county.

Lagoon wetlands are endangered ecosystems. Wetlands serve as vital components within regional hydrologic systems. Additionally, they are critical in maintaining resident biotic (plant and animal) assemblages and as stopover grounds for waterfowl and shorebirds migrating along the Pacific Flyway.

Renewed awareness of the environmental importance of wetland habitats has sparked governmental and individual conservation efforts. Restoration of these endangered ecosystems has a heightened level of priority among the public.

Malibu Lagoon has been heavily impacted by human use. It has been used as a general dump site by many, including Caltrans, and the original acreage has been diminished by urban development. However, since 1983, Malibu Lagoon has been undergoing the slow process of restoration, initiated and managed by the California State Department of Parks and Recreation (DPR).

Careful management by DPR, complimented by allowing natural restoration processes to occur, has resulted in a wetland resource of increased ecological and recreational value. The initial restoration stages consisted of recontouring and revegetating the previously degraded landscape for habitat reconstruction. Progress has been made toward fulfilling the ecological potential of this Lagoon.

The subject of this study is to gather baseline ecological and physical data of the Malibu Lagoon ecosystem. The Topanga-Las Virgenes Resource Conservation District (TLVRCD), as commissioned by the Los Angeles County Department of Beaches & Harbors and the State Department of Parks & Recreation, has measured and documented physical and ecological conditions for the full year cycle from May 1987 through June 1988. This is the first study of such wide scope undertaken for the Malibu Lagoon. Previous studies have concentrated on single faunal or floral groups and resultant information has been drawn upon for background and methodologies.

To facilitate wise management of environmental resources leading to positive change, TLVRCD believes that scientists, public officials and citizens must actively exchange information and ideas within a framework of comprehension, accessibility and community interest.

As this is a baseline study, to be used to compare present Lagoon conditions with future environmental change, TLVRCD has put emphasis on communicating to both the scientist and layperson. It is a research paper that adheres to scientific standards with an additional emphasis on interpretation to lay terms.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

This report reflects the efforts of many people besides the authors listed. Without the enthusiastic support of the following data collectors, our understanding of Malibu Lagoon would be sorely lacking.

Gaby de Benedictus
Lucienne Bouvier
Mark Darcy
Leo French
Nancey Helsley
Brian Hill
Pearl Hsiung
Brenda Huie
Robert Jensen Sr.
Kyle LaBrache
Annette Landreau
Mickey Long
Marcia Matz
Melissa Miller
Lyle Nichols
Kris Randall
Mike Reader
Debbie Shafer
Joel Washburn

These loyal observers were exceptionally dedicated and deserve special thanks:

Lois Boylen-Cota
Chuck Cleeves
Wendi Gladstone
Joyce Halley
Avis F. Keedy
Nelson Takayama
Lori Willis

For his continuing expertise and support in this project, we wish to extend our thanks to Bill Tippets, California Department of Parks and Recreation (DPR).

We also want to thank the Los Angeles County Fish and Game Commission and DPR for equipment used to collect data.

In addition, the following people gave of their expertise in various subject areas in order to assure that our analysis was as accurate and up-to-date as possible. Many thanks to:

Chapter 1.0: Darrick Danta, CSUN; Ruth Brodrick, TLVRCD

Chapter 2.0: Ed McComb, Jim Colbaugh and Scott Quaddy, Las Virgenes Municipal Water District; Larry Young, LA County Health Dept.; Chris Nagler, CA Water Resources Division

Chapter 3.0: Joy Zedler, SDSU; Phillip Rundel, UCLA; Bob Muns, Rancho Santa Ana; Avis Keedy; Richard Campbell, Rick Aguayo, and Mary Thoroughgood, USDA Soil Conservation Service; Wayne Ferren, Herbarium, UCSB

Chapter 4.0: Chuck Cleeves, Jon Sloan, CSUN

Chapter 5.0: Leslie Harris, USC Hancock Foundation; Chris Nordby, SDSU

Chapter 6.0: Chris Nordby, SDSU; Hans Kuch, Los Angeles County Museum of Natural History (LACMNH) Crustacean Lab

Chapter 7.0: Camm Swift and Marty Meisler, LACMNH Ichthyology Lab; Lyle Nichols, CSUN

Chapter 8.0: Kimball Garrett, LACMNH; Lois Boylen-Cota; Sanford Wohlgemuth and Tom Howell, LA Audubon

Chapter 9.0: Lesley Devine, TLVRCD Board President

And last, but certainly not least, the authors wish to extend special thanks to all Board members and staff at the Topanga-Las Virgenes Resource Conservation District office. Without the competent and enthusiastic support of these dedicated people, this report would never have seen publication.

Members of the Board

Lesley Devine, President
Dennis Washburn, Vice-President
David Gottlieb, Secretary
Jerry Douglas
Nancy Helsley

Staff

Elizabeth Douphner, Executive Officer
Pearl Sloan, Financial Officer
Melanie Beck
Ruth Brodrick
Mary A. Cohen

1.0 OVERVIEW OF MALIBU LAGOON

1.1 INTRODUCTION

This initial chapter provides background information on estuarine environments, describes the environmental setting, and briefly outlines the restoration process.

Malibu Lagoon is one of the last remaining estuaries in Los Angeles County. It is a small (5.2 hectares; 13 acres), shallow water embayment occurring at the terminus of the Malibu Creek watershed. The total land area plus the aquatic lagoon area is 14.7 hectares (36.1 acres). This lagoon is a remnant of a once more extensive group of estuaries within the southern California region from Point Concepcion to the international border with Mexico.

Southern California has a long history of human occupation and consequent landscape disturbance which continues to impact all estuaries in the region. Estuaries in southern California have been reduced in total acreage by more than 75% when compared with the original acreage of pre-European settlement. This extensive and continuous loss of estuarine habitat has awakened human awareness regarding the intrinsic values embodied within these ecosystems. For humans to uncover and discern the full value of estuaries, we must first begin the process of examination and study of these wetland environments. This allows us to acquire the specific knowledge and understanding leading to firm conclusions regarding the significance of estuaries as part of our global natural heritage.

At Malibu Lagoon the process of examination is underway. This Lagoon exhibits a mix of both natural and non-natural characteristics that make its study difficult, interesting, and critically important. The Malibu Lagoon ecosystem presently receives a combination of natural seasonal freshwater input and a substantial additional non-natural input of freshwater from imported sources. This environmental stress changes the biogeochemical conditions (i.e., salinity and freshwater balance) in the Lagoon and can challenge even adaptable organisms living within Malibu Creek and Malibu Lagoon. Identifying all of the non-natural water inputs and the pollutants they may contain and then assessing their cumulative effect upon the Lagoon's biota is beyond the scope and intent of this project. It is a research and management challenge for future studies.

An additional characteristic of Malibu Lagoon is that while it does contain highly variable levels of biological pollutants (i.e., coliform bacteria), it presently has no significant levels of toxic chemicals associated with industrial pollutants. This is an extremely positive factor in assessing the Lagoon's long-term restoration potential.

For current and future Lagoon management, determining the complex combination of natural and human-generated change is vitally important, especially its cumulative effect upon the Lagoon biota. This will potentially improve the quality of management decisions for the entire Malibu Creek and Lagoon ecosystems.

Adding to its ecological significance within southern California is Malibu Lagoon's important role as a stopover and wintering area for birds migrating along the Pacific Flyway. It also functions as an essential nursery habitat for some fish species, and is the southernmost stream in North America within the range of the anadromous steelhead (Oncorhyncus mykiss), a sea-run rainbow trout. Additionally, Malibu Creek and Malibu Lagoon play a critical role in the overall functioning of the local hydrologic system of the Malibu Creek watershed. Finally, Malibu Lagoon serves as a valuable educational and recreational resource for urban dwellers learning to understand and enjoy their shared inherited resources.

1.2 ESTUARIES IN THE ENVIRONMENT

Estuaries are interface regions (ecotones) between aquatic habitats of the earth's land masses and marine habitats of oceans or seas. Some are deep water complexes while others are shallow wetlands occurring at the lower elevational limits of watersheds (Ferren 1985). At this area of intermixing between fresh and salt water environments, where concentrations of sea derived salts are .05% or higher, a distinct ecosystem, the estuary, is found. Pritchard (1967) states that "An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which seawater is measurably diluted with freshwater derived from land drainage." Lagoons, however, are somewhat different, as they frequently do not maintain this free and continuous connection with the open sea.

Frequently, estuaries are geographically isolated from each other due to their unique physiographic formation requirements. Thus, they become "islands" of unique habitat-type surrounded by habitats of dissimilar type, either natural or human-made. When a distinct geographic area (i.e., an estuary) is isolated from other similar areas by either physical or biological barriers, levels of endemic or unique organisms tend to evolve (Ferren 1985). This situation, along with the present rarity of ecologically intact, unaltered examples of estuaries, increases the ecological significance of our global system of estuarine environments.

During the past 30,000 years sea level has risen approximately 130 meters as a result of the melting of major continental glaciers of the Pleistocene epoch. Geologically the world's estuaries are quite young, generally having been formed approximately 5,000 years ago when the seas reached their present level (Thurman 1975).

Globally, estuaries exhibit a wide variety of characteristic features of geomorphology, water circulation, biogeochemistry and ecology (Wolfe and Kjerfve 1986). A characteristic feature of estuary systems in southern California is that they are "frequently intermittent and exhibit unique characteristics relative to the majority of estuarine systems" (Onuf 1987, Zedler 1986).

Southern California estuarine ecosystems, such as Malibu Lagoon, are principally influenced by the following physical factors: tidal circulation, precipitation, freshwater runoff, evaporation, and wind (Ferren 1985). It is important to note that most of the world's estuaries are also influenced, to a significant extent, by human-generated alteration.

Salinity regimes in southern California estuaries are highly variable (Zedler & Nordby 1986), both temporally and spatially, depending upon factors such as local climate patterns, evaporation, seasonal ocean circulation, human-generated inputs, and intermittent major climatic perturbations (e.g., hurricanes, El Nino).

Estuaries located in southern California are usually termed intermittent in nature. This condition is principally due to the aridity of the environment which means that stream flow into estuaries will either completely cease or greatly decrease in volume each summer. For example, in southern California most of the annual precipitation falls in a few large winter storms (Rose 1982). When this seasonal precipitation tendency is combined with high spring, summer, and fall evaporation rates and watersheds of relatively small area with steep relief, the amount of surface or near-surface water can be quite low for prolonged periods (Onuf 1987). Since the majority of physical factors stated above which affect lagoon systems in southern California fluctuate widely, estuarine biota generally exhibit a high degree of physiological and behavioral plasticity in order to persist.

1.3 LOCATION

Malibu Lagoon is located in Los Angeles County, California, west of Malibu Pier (Fig. 1.1), latitude 34 degrees 1' 58" North and longitude 118 degrees 40' 50" West. Malibu Creek, which cuts North-South through the steep-sided Malibu Canyon gorge, empties into the Lagoon and contributes freshwater, sediments, nutrients, detritus, and human-generated inputs (urban runoff) into this Lagoon ecosystem. Malibu Creek is one of several streams which drain the coastal side of the Santa Monica Mountains. This mountain range is part of the east-west trending Transverse Range province in southern California (Fig. 1.2).

The Santa Monica Mountains of southern California stretch approximately 75 km (47 miles) westward from Griffith Park, in the City of Los Angeles, to Point Mugu in Ventura County. The width of this mountain range averages 12 km (7.5 miles), while elevations range from sea level to 948 meters (3,110 feet) above sea level at Sandstone Peak (Rose 1982). This coastal range with its varied topographic relief and climatic gradients harbors a diversity of habitats. Rugged steep slopes, deep moist canyons, and arid ridgetops characterize this Mediterranean-type ecosystem.

These mountains represent a unique mix of land ownership. In 1978, the Santa Monica Mountains National Recreation Area was established in an effort to preserve parklands, while maintaining general multiple-use goals. Within the area legally bounded by the National Recreation Area, land is owned by Federal, State, and County agencies, as well as private camps, homeowners, and other land-holding agencies. Malibu Lagoon is part of Malibu Creek State Park within the National Recreation Area.

1.4 CLIMATE

The Santa Monica Mountains, including Malibu Lagoon, are characterized by mild, wet winters and hot, dry summers. Amounts of precipitation vary widely: The Santa Monica pier receives approximately 330 mm annually; while approximately 635 mm fall at the Topanga Canyon fire station. The distribution of rainfall is influenced primarily by the distance from the Pacific Ocean and the sudden steep topographical relief of the mountains. Precipitation, therefore, is generally greater in the mountains than inland flatlands, usually ranging from 450-650 mm annually (Plantrich 1986).

Onshore and offshore breezes are an integral part of this coastal ecosystem, for they influence patterns of frequent coastal fog invasion, which can penetrate deeply within the canyon systems. These moisture laden fogs are important to much of the native vegetation within its influence, particularly during the dry summer months. Being near the ocean and exhibiting a diverse physical relief, the Santa Monica Mountains display a great variety of microclimatic conditions. These conditions are primarily influenced by differences in the slope, slope aspect, elevation, soil type, fire history, rainfall patterns, proximity to the coast (thus, changes in fog/moisture intrusion) and existing vegetation on each site (Rose 1982).

1.5 MALIBU CREEK WATERSHED

The Malibu Creek watershed is the largest perennial drainage system within the Santa Monica Mountains, comprising a total of approximately 27,115 hectares (67,000 acres) (Tjaden 1978). Malibu Lagoon forms at the terminus of Malibu Creek, a typical result of the fluvial processes of stream erosion, transportation, and deposition of sediments. The most significant fluvial (running water as a land-forming agent) processes occur during winter, when seasonal storms create intense flooding of stream channels within these mountains (Rose 1982). These winter floods erode and carry the vast majority of the total yearly sediment load of streams in the Santa Monica Mountains. Precipitous slopes characterize this watershed and are a major factor influencing runoff velocity and erosion. Geologic composition of these steep, rugged slopes is massive, hard tertiary rock, mainly of the Sespe sandstone formation. Deep canyons, such as Malibu Canyon, are believed to be formed entirely from erosion, rather than fault displacement (Sharp 1978). Soils on these slopes are highly erodible (USDA Soil Conservation Service 1967) and contribute heavily to the dynamic nature of Malibu Lagoon. During late spring, summer, and fall, local streams experience a gradual decline of water discharge, which corresponds with local precipitation patterns, temperatures, and evaporation rates. This temporarily changes Lagoon conditions and further challenges the overall adaptive resilience of organisms living there.

Malibu Creek is classified as a stream in its "youthful" stage. Streams of this type are characterized by high velocity and energy, and a low sediment load relative to its total sediment load capacity (McIntyre 1985). Stream slope, velocity, water volume, and available erodible materials determine, in part, the sediment load, which is deposited in increasing increments as water is slowed by various physical impediments. Malibu Creek, especially during storms, becomes a formidable channel cutting machine that deposits much of its sediment load as it nears and finally reaches the Lagoon. As the creek nears the sea, stream slope declines and consequently its velocity begins to decrease. When streamwaters finally enter the sea its velocity abruptly decreases as it "backs up," and sediment deposition increases in the slow water. This fluvial process contributes significantly to the formation and dynamic nature of the Malibu Lagoon environment. It is a process governed principally by geologic and climatic conditions, and increasingly by humans.

Historic annual hydrologic and sediment cycles are currently disrupted by excessive non-seasonal imported domestic water released into many local streams (Rose 1982), including Malibu Creek. Within the Malibu Creek watershed the majority of non-seasonal domestic water release is from the Tapia Water Reclamation Facility of the Las Virgenes

Municipal Water District. Tapia is a tertiary wastewater treatment plant and presently releases about 8-10 million gallons of water per day (MGD) into Malibu Creek from October through June. These non-natural water sources can exert extreme stress upon much of the native biota (plants and animals) inhabiting the Malibu Creek and Malibu Lagoon ecosystem. In an attempt to present a comprehensive and contextually relevant study of Malibu Lagoon, management considerations regarding excess domestic water input will be addressed in the final chapter.

1.5.1 SOILS

Soils occuring within the general Malibu Lagoon area are typical of a coastal valley floor alluvial landform. The following soils predominate this sloping alluvial fan: Elder sandy loam, Sorrento loam, Riverwash, and Coastal Beach.

Elder sandy loams are deep, well-drained soils that develop on level to moderately (9%) sloping alluvial fans and valley floors. They are mildly to moderately alkaline, and comprise approximately 0.4 percent of the total Malibu area.

Sorrento loam is also a deep, well-drained soil, typical of alluvial landforms. These soils occur on 0-2% slopes. The pH is slightly acid to neutral. This soil type represents 0.4% of the Malibu area.

Riverwash is a miscellaneous land-type consisting of deposited sand, gravel, and stones with some silt and clay. As its name implies, Riverwash occurs in stream channels.

Coastal Beach (miscellaneous land-type), is comprised of sandy, stony, or cobbly coastal beaches and related landward sand dunes. It is important to note that due to urban development, none of the historic sand dune habitat remains at Malibu Lagoon. Beaches total about 0.7% of the land in Malibu (U.S.D.A. Soil Conservation Service 1967). Other soil types, not generally found in the Malibu Lagoon area, comprise the other approximately 98.5% of soils found in the Malibu area.

1.6 CULTURAL HERITAGE

Although it is beyond the scope of the present study to detail the early cultural heritage of the Malibu Lagoon area, it is important to acknowledge its significance within the contextual framework of Malibu Lagoon.

Hunting and gathering societies have long occupied southern California. The archaeological records indicate a trend towards greater cultural complexity in the course of early occupation (Leonard 1971, Lundberg 1965, Grant 1978).

The earliest substantial evidence of human occupation in the Santa Monica Mountains is from approximately 5500-5000 B.C. These people are believed to have migrated into coastal southern California about 7000-6000 B.C. (Leonard 1971).

Four coastal areas within the Santa Monica Mountains have been identified as major sites of early occupation. The Sweetwater Mesa site near the mouth of Malibu Canyon overlooking Malibu Lagoon is identified as a major area of occupation. Carbon 14 analysis dates the site at 6310 plus or minus 100 B.P. and 6870 plus or minus 100 B.P. (Leonard 1971).

Cultures of the early prehistoric periods tended to use less of the resource base than later cultures inhabiting the same geographic area. This coastal zone of occupation exhibits a very high resource diversity, year-round productivity, and abundance of flora and fauna (Leonard 1971), which later cultures, such as the Chumash, utilized more extensively than earlier inhabitants.

The Chumash Indian culture belongs to a broad linguistic and cultural-geographic assemblage of people, known as Hokan, who were dispersed throughout various portions of California (Kroeber 1976, Landberg 1965). The southeasterly coastal range extent of known Chumash culture is the rancheria of Humaliwu adjacent to Malibu Creek in Malibu Canyon (Grant 1978). There are believed to be at least six to eight linguistic divisions within the Chumash culture, with the coastal Chumash divided into three. The Ventureno geolinguistic group occupied the coastal area between Ventura and Malibu Canyon (Grant 1978, Kroeber 1976).

Malibu Creek and Malibu Lagoon have a rich cultural and biological heritage. The full potential for education, recreation and restoration in this area has yet to be tapped.

1.7 PRE-RESTORATION

The deposition of sand, gravel, cobbles, and muds forms a delta, comprising Malibu Lagoon and the immediate surrounding lowland environment. Before modern development the Malibu Lagoon ecosystem was significantly larger than at present. The spectrum of plant and animal species exhibited a greater species richness and abundance in pre-modern development times. For instance, many native species of flora disappeared because of development; consequently, exotic and weedy species became established.

Discussing pristine or undisturbed conditions of a geographic area, especially in southern California, often in reality becomes a discussion of the "degree of disturbance." As stated earlier, Malibu Lagoon and its adjacent areas were occupied and its resources utilized by humans for approximately 5000 years. However, the resources used by early inhabitants were inherently conserved or protected on a sustained-yield basis. Early permanent inhabitants did not or could not strip the resource base faster than it could be reproduced and maintained through natural biological vigor.

Modern development in the 1900's began the process of ecological degradation as the Lagoon area and adjacent land were used as a general fill site, Caltrans dump site, and area of urban development. Additionally, areas have been sprayed with a mixture of 80% diesel oil and 20% pesticide, called Golden Bear IIII (Tjaden 1978), in order to combat a perceived mosquito problem.

1.8 RESTORATION PROCESS

In April 1978 the California State Department of Parks and Recreation (DPR) issued an environmental impact report and resource management plan for Malibu Lagoon. This report states policies and objectives of the DPR regarding Malibu Lagoon and provides policies for the preservation, interpretation, and public use of the natural and cultural resources of this State Park. The DPR's goal was and currently is "...to preserve and restore as much of the natural landscape and biotic communities as possible, while providing facilities to make the outstanding resource values found here available to the public for its enjoyment." (Tjaden 1978).

Prior to restoration, the site was comprised of landfill, native and non-native vegetation, and two baseball fields (Fig. 1.3). After planning by DPR and cooperating researchers, the restoration process began in 1983 when DPR contoured the land and excavated three channels approximately 30 feet wide with sloping mudflats rising to proposed Pickleweed (<u>Salicornia virginica</u>) marshes and upland habitat (Fig. 1.4). Where necessary, due to grading, the area was re-vegetated with native vegetation along an elevational gradient consistent with known data regarding this and other estuarine systems. The Post-restoration (post-grading and re-planting) management recommendations proposed and implemented by DPR include, but are not limited to, the following:

1. Construction of a series of bridges and trails in order to facilitate beach access. This also serves to keep human traffic from cumulatively impacting the delicate and limited ecosystem.

2. Managing water levels within the Lagoon by periodically breaching the sandbar with the Department of Parks and Recreation's bulldozer when water levels reach 1.07 meters (3.5 feet), for the purpose of reducing extensive periods and levels of water impoundment. This will

reduce mosquito breeding success, and possible flooding of Malibu Colony septic tank drain fields, which may become a source of pollution.

Research by Topanga-Las Virgenes Resource Conservation District (TLVRCD) is centered on documenting the current physical and ecological conditions at Malibu Lagoon, thus facilitating management of this ecosystem. The District's project was a one-year ecological study that began in May 1987.

1.8.1 ENVIRONMENTAL EDUCATION AND INTERPRETATION AT MALIBU LAGOON

The interpretive goal of the Department of Parks and Recreation at Malibu Lagoon State Beach is to "...provide visitors with awareness and appreciation of the significant recreational, natural, and cultural resources...(Tjaden 1978)" In order to facilitate this educational goal the TLVRCD in 1985 entered into a cooperative agreement with DPR and began implementation of the Malibu Lagoon Marine Science School Program. These environmental education programs provide school children with a "hands-on" learning experience. In addition, students actually assist in selected portions of our ongoing research as they learn about estuarine ecosystems. We see this student participation as a significant investment towards a bright future in the intelligent conservation of our shared ecosystems.

1.9 OUTLINE OF CHAPTERS

This report is organized as follows. Chapter Two discusses the spectrum of water quality parameters that were measured and analyzed. Chapter Three includes the vegetation survey along the Lagoon's elevational profile. The fourth chapter describes sediment profiles found in the Lagoon and relates this data to the distribution of infauna found within the sediments. Chapter five identifies and quantifies benthic infauna (Polychaete worms and Jacknife clams) found in sediment samples in Malibu Lagoon. Chapter Six discusses the epifaunal organisms, (shrimp and crabs) that were surveyed. Chapter Seven examines diversity and population trends for fishes of the lagoon from five sampling (seining) stations within the Lagoon. Chapter Eight provides species occurrence lists and general seasonal population trends of birds using Malibu Lagoon. The final Chapter provides a summary of the Lagoon status with site-specific considerations for future management of Malibu Lagoon as an integral functioning component of the Malibu Creek watershed.

1.10 LITERATURE CITED

Day, J.H. 1980. "What is an Estuary?" South African Journal of Science, 76: pp. 198.

Ferren, W.R. Jr. 1985. Carpenteria Salt Marsh Environment, History, and Botanical Resources of a Southern California Estuary. Herbarium Dept. of Biological Sciences, University of California, Santa Barbara, Publication No. 4, pp. 300.

Grant, C. 1978. In Handbook of North American Indians. Ed. R.F. Heizer: pp. 505-520.

Hasz, L. 1982. "Malibu Lagoon: A Local Resource." California State University Northridge, Unpub. pp. 10.

Hudson, T. and Blackburn, T.C. 1979. The Material Culture of the Chumash Interaction Sphere. Vol. 1. Ballena Press, Los Altos, California. pp. 386.

Kjerfve, B. 1986. Comparative Oceanography of coastal Lagoons. In Estuarine Variability. Ed. D.A. Wolfe. Academic Press, Inc., Orlando, New York, London. pp. 63-83.

Kroeber, A.L. 1976. Handbook of the Indians of California. Dover Publications, Inc., New York. pp. 995.

Landberg, L.C.W. 1965. The Chumash Indians of Southern California. Southwest Museum papers No. 19, Highland Park, Los Angeles, California. pp. 158.

Leonard, Nelson N. III 1971. Natural and Social Environments of the Santa Monica Mountains (6000 B.C. to 1800 A.D.). Dept. of Anthropology, University of California, Los Angeles. pp. 97-135.

McIntyre, M.P. 1985. Physical Geography. John Wiley and Sons, New York. pp. 534.

Onuf, C.P. 1987. The Ecology of Mugu Lagoon, California: An Estuarine Profile. U.S. Fish and Wildlife Service Biol. Rep. 85 (7.15). pp. 122.

Pielou, E.C. 1975. Ecological Diversity. John Wiley and Sons, New York, London. pp. 165.

Plantrich, R. 1986. Fire Management Plan/Santa Monica Mountains National Recreation Area. U.S. Dept. of the Interior/National Park Service. pp. 103.

Pritchard, D.W. 1967. What is an Estuary: Physical Viewpoint. In Estuaries, Ed. G.H. Lauff. Am. Assoc. Adv. Sci., Washington, D.C. pp. 757.

Reid, G.K. and Wood, R.D. 1976. Ecology of Inland Waters and Estuaries, Second Edition. Van Nostrand Company, New York, Toronto, London. pp. 485.

Rose, P.W., Ochsner, D.C., Klubnikin, K. Plantrich, R., and Thomas, T.W. 1982. Draft Natural Resource Management Plan/Environmental Assessment. Santa Monica Mountains National Recreation Area, U.S. Dept. of the Interior/ National Park Service. pp. 322.

Sharp, R.P. 1978. Geology Field Guide Southern California. Kendall/Hunt Publishing Company, Dubuque, Iowa. pp. 208.

Thurman, H.V. 1975. Introduction to Oceanography. C.Merrill Publishing Company, Columbus, Ohio. pp. 441.

Tjaden, A., Roberts, J. and Pierce, K. 1978. Malibu Lagoon State Beach Resource Management Plan, General Development Plan, and Environmental Impact Report. State of California Department of Parks and Recreation. pp. 33.

U.S. Dept. of Agriculture--Soil Conservation Service 1967. Soils of the Malibu Area--California; With Farm and Non-farm Interpretations. USDA and SCS in cooperation with Topanga-Las Virgenes Soil Conservation District and Los Angeles County Dept. of the County Engineer. pp. 34.

Wolfe, D.A. and Kjerfve, B. 1986. Estuarine Variability: An Overview. In Estuarine Variability. Ed. D.A. Wolfe. Academic Press, Inc., Orlando, New York, London. pp. 3-17.

Zedler, J.B. and Nordby, C.S. 1986. The Ecology of Tijuana Estuary: An Estuarine Profile. U.S. Fish and Wildlife Services Biol. Rep. 85 (7.5). pp. 104.

Zedler, J.b. 1982. The Ecology of Southern California Coastal Salt Marshes: A Community Profile. U.S. Fish and Wildlife Service. FWS/OBS-81/54. pp. 110. [Second printing with corrections 1984].

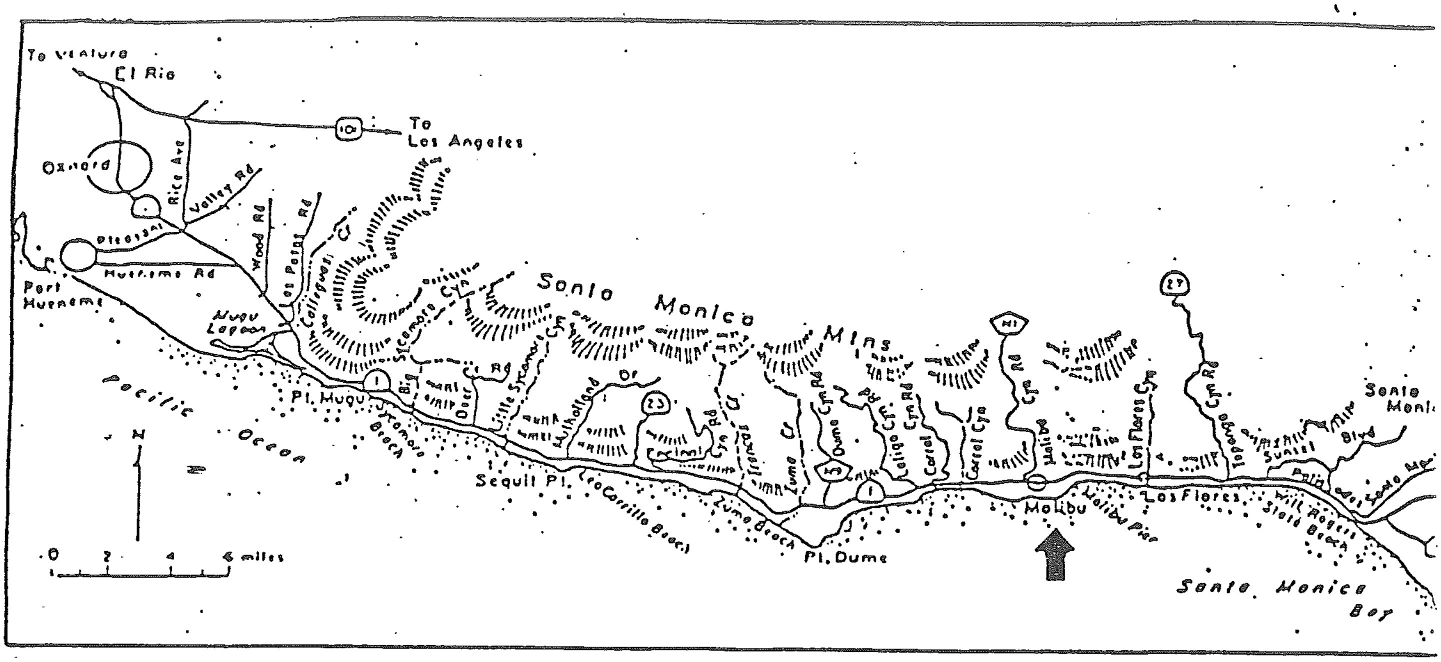


Figure 1.1 Santa Monica to Oxnard, arrow points to Malibu Creek Watershed.

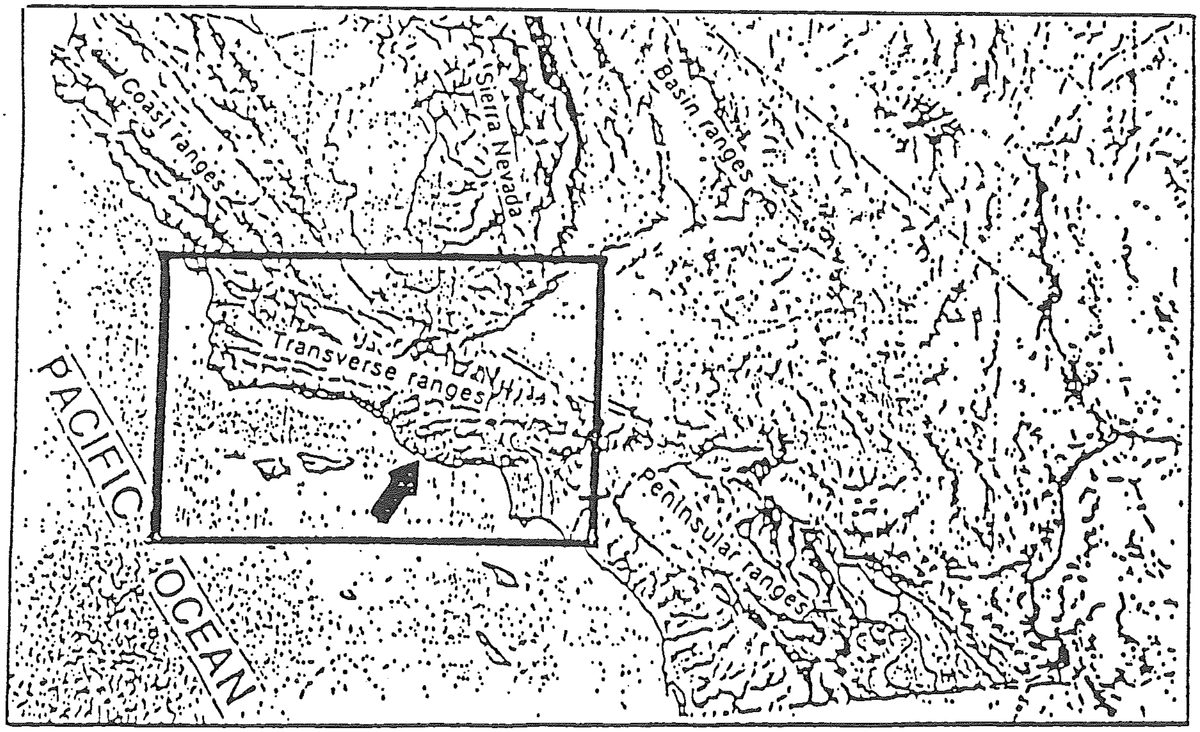


Figure 1.2 Transverse Ranges, arrow points to Santa Monica Mountains.

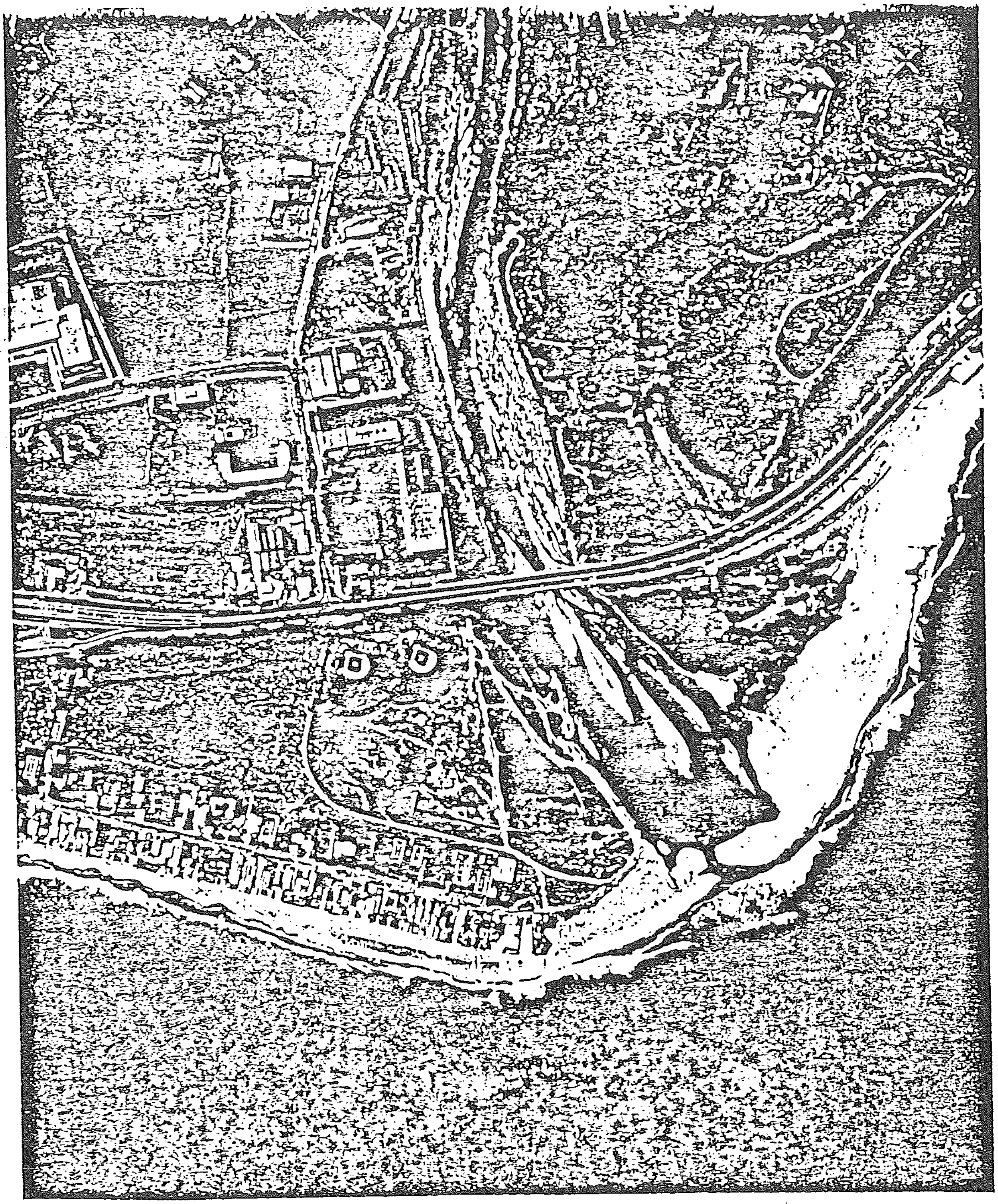


Figure 1.3 Pre-restoration of Malibu Lagoon
Aerial Photo, MAY 1973

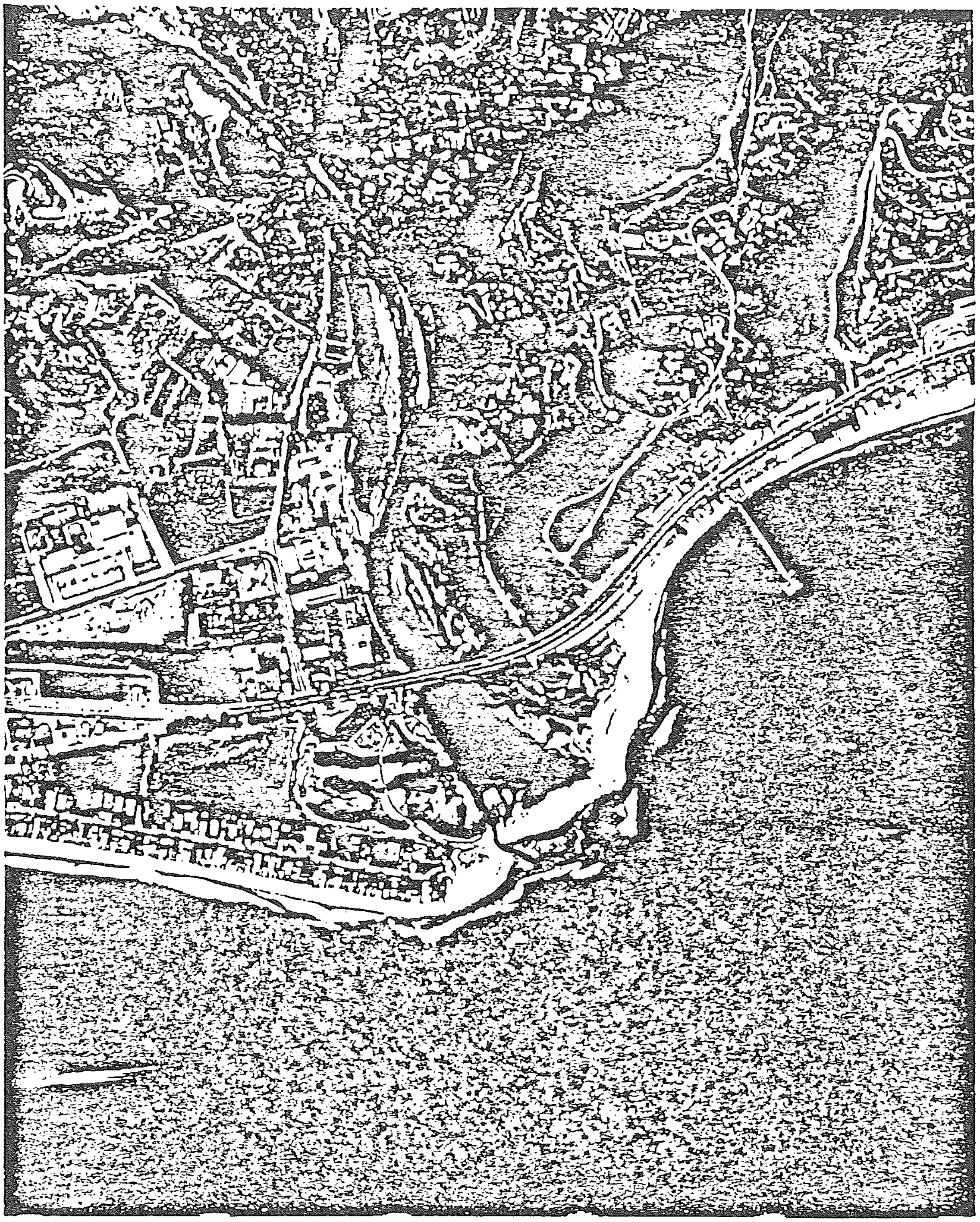


Figure 1.4 Malibu Lagoon after restoration

2.0 PHYSICAL AND CHEMICAL PARAMETERS OF MALIBU LAGOON

2.1 INTRODUCTION

Physical and chemical parameters associated with water quality exert a major influence on biological activity in an aquatic ecosystem. It is critical to the understanding of the Malibu Lagoon ecosystem that these variables be monitored and correlated with major physical and chemical occurrences (events) at the Lagoon.

Malibu Lagoon represents a complex hydrologic environment affected by the physiography, tidal inundation and influx of fresh water from Malibu Creek. Only by repeated sampling can insight into how all these factors are related, as well as their effect on the biota, be determined.

2.2 OBJECTIVES

The main objective is to correlate changes in the physical and chemical parameters of the Lagoon to biological events and overall activity. Flora and fauna of estuarine ecosystems depend on some degree of variability in their environment. Where biological and biochemical limits occur for different species in Malibu Lagoon is of great importance when considering future restoration and management plans.

In addition to recording normal fluctuations of salinity, temperature, dissolved oxygen, pH, turbidity and water depth, special events that occur are also documented. These include storms, sewage spills, heavy influx of freshwater released from the Tapia Water Reclamation Facility, and closure of the mouth of the Lagoon. To determine whether chemical pollutants were present, water samples were sent for analysis to the UCLA Biomedical and Environmental Studies Lab.

The physical and chemical parameters are recorded weekly, with additional information on salinity, pH, and temperature, as well as general Lagoon conditions added biweekly by student groups visiting the Lagoon. Student data have been collected since October 1986, and although it probably contains some errors, they still provide a solid basis of information concerning water quality fluctuations over time. In addition, a twenty-four hour continuous survey of Lagoon conditions was conducted in May, 1988 to provide insight into the daily cycle of the Lagoon.

In trying to incorporate an historical perspective, data from pre-restoration and current stations monitored by Tapia are considered, as well as that gathered immediately following the initial restoration (1983) by Lynn Hasz, a graduate student at CSUN.

2.3 METHODOLOGY

2.3.1 PHYSICAL AND CHEMICAL PARAMETERS

Grab samples of both surface and bottom water are collected at 3-5 stations in the Lagoon when depths are 50cm or greater. In shallow areas, only a mid-level sample is collected (Map A). Data are collected weekly by project researchers. At each station the following methodology is used to collect data.

SALINITY: Using a calibrated Atago (S/Mill) hand held refractometer, salinity is measured to the nearest part per thousand (ppt). This instrument is calibrated from 0-100%. Sample water is placed on the instrument and read by 3 people, to insure accuracy. Accurate readings depend on temperature calibration, thus allowing for a 2-4 ppt error.

TEMPERATURE: Water temperature is determined using an immersion thermometer and recorded in degrees Celsius.

Air temperature is measured with the Yellow Springs Instrument (YSI) Model 057 dissolved oxygen meter in degrees Celsius.

pH: Tri-reagent ColorpHast pH strips are dipped in the sample and read. These values are accurate to the nearest whole number.

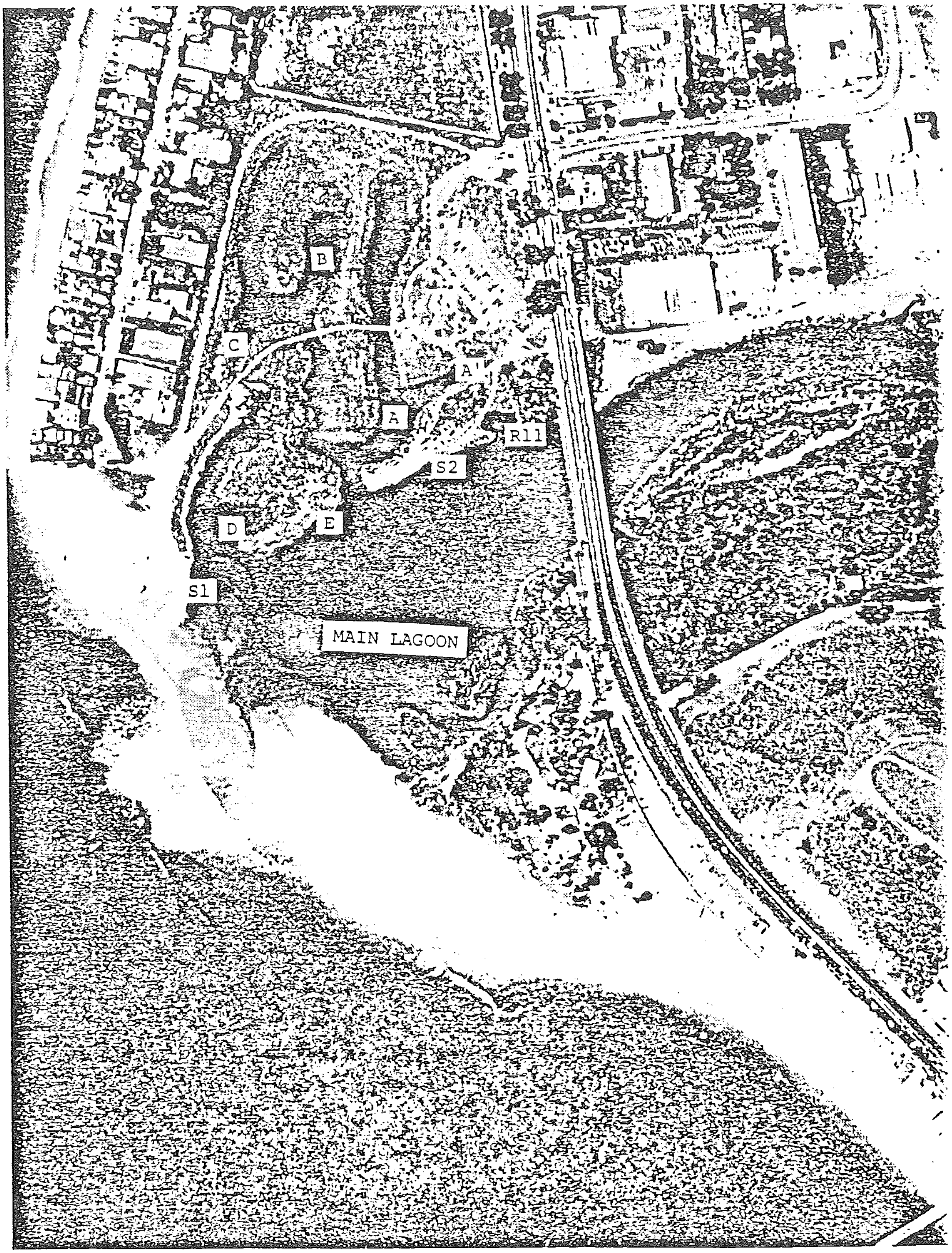
DISSOLVED OXYGEN: Using a YSI Model 057 dissolved oxygen meter calibrated for temperature and salinity, the probe is immersed in the water, moved slowly back and forth (1 ft/sec) and allowed to steady. Readings are in milligrams/liter and accurate to the nearest 0.2 mg/l. The probe is held first near the surface and then near the bottom, or mid-level in shallow areas.

TURBIDITY: Using a LaMotte test kit, turbidity is measured in Jackson Turbidity Units (JTU), which is accurate to the nearest 5 JTU.

2.3.2 STUDENT GENERATED PHYSICAL DATA (Malibu Lagoon Tours)

Twice a week from October to June and once a week during the summer months, visiting student groups recorded the salinity and temperature of the surface and bottom water at two locations in the Lagoon (Map A: S1 and S2). Salinity is measured using a LaMotte salinity test kit, in parts per thousand. Temperature is collected using an immersion thermometer in degrees Celsius. Beginning in September 1987, the students also collected the pH at these two stations once a week using Tri-reagent ColorpHast test strips. Due to the

MAP A Study Stations at Malibu Lagoon



numbers of observers and data collectors, these data may be less accurate. However, it does document the wide variation of salinity and temperature found on a short-term basis, as well as indicates seasonal trends.

2.3.3 TRACE ELEMENT ANALYSIS

Once a month in conjunction with other data collection, water samples are collected and sent to the UCLA Biomedical and Environmental Studies Lab for analysis. These samples are taken from five stations in the Lagoon (Map A). They are tested for levels of cation and anion presence, which would indicate the presence of toxic chemicals in the Lagoon.

2.3.4 TOTAL COLIFORM COUNTS, LA COUNTY DEPARTMENT OF HEALTH

Data obtained from the LA County Health Department includes the total coliform counts found at their sample station, which is on the Surfrider Beach, halfway between Malibu Pier and the Adamson House. Samples are taken there once a week, although from May through November 1987, data was only collected monthly. No total coliform samples are taken within the Lagoon itself. Total coliform is measured in units of MPN (Most Probable Number).

2.3.5 TAPIA WATER RECLAMATION FACILITY

This tertiary water treatment plant of the Las Virgenes Municipal Water District is located approximately five miles upstream on Malibu Creek. As part of their own monitoring program of Malibu Creek, data on the water quality both upstream and downstream of the plant is recorded once a week. Adjacent to Malibu Lagoon two water quality monitoring stations are located on both the upstream (at Cross Creek Road, station "R4") and downstream sides of the Pacific Coast Highway bridge. Tapia Station R11 is quite close to student site 2, as well as to Station E (Map A), as designated by the Resource Conservation District observers.

2.3.6 24 HOUR LAGOON SURVEY

The objective of this sub-section of the study was to observe conditions in the Lagoon continuously for 24 hours in order to better understand the daily cycle of the Lagoon, as well as changes occurring due to the arrival of fresh water released from Tapia. By monitoring changes in water level, salinity, temperature, pH, dissolved oxygen, turbidity, and also trying to determine current flow through different channels of the Lagoon, a perspective on water movement, flow rates, and turnover of water in the channels might be obtained. See Map A for locations. At the time of the study, the Lagoon entrance was closed by a sand bar. Therefore, ocean influences were not seen until the entrance was bulldozed open at the end of the 24 hour watch.

2.4 OBSERVATIONS

Variability is the most noticeable factor in water quality at Malibu Lagoon. As was noted during the 24 hour survey, once the entrance was opened, even though the tide was theoretically rising, almost the entire Lagoon emptied out within two hours. The water quality parameters reflected this dramatic change and showed that for the times the entrance is silted shut, the primary influence in the Lagoon is the incoming freshwater from Tapia. This can cause flooding over much of the peninsula area between channels and allows the Lagoon to assume characteristics often found in enclosed bodies of water, such as increased temperatures, reduced dissolved oxygen and low salinity.

Generally, pH remained in the range of 6.5 - 9.5 at all stations throughout the year (Fig. 2.1), with an average of 7.3. A few peaks occurred in October and February. These same dates are a time of unusual readings of all water quality parameters in the Lagoon. Interestingly, the highest recorded pH was in B Channel, which is very shallow and typically shows exposed mud at low tide. Could it be that the nutrients trapped in the sediments are influencing the water quality here? It is also possible that residual "suds" raise the pH after the Lagoon has drained. pH levels recorded by Tapia at their station (R11) near the PCH bridge were consistently higher than those found elsewhere in the Lagoon. Sewage has a pH of around 8, and the effluent leaving the Tapia plant is between 6 and 6.5. The large amount of bird guano, which is high in uric acid, may serve to lower the pH in the other more widely utilized roosting areas.

In analyzing the trends over the year (Fig. 2.2), it appears that salinity increases at the end of each month, corresponding to a tidal cycle of low high or neap tides. This could also be tied to the pattern of salt water intrusion. Average ocean water has a salinity of 34-36 ppt. Salinity in B channel exhibited a wide range, from 0-34 ppt with an average of 19.1 ppt. There is a well defined salt lens present in the deepest channel (C station), where extremes tied to the tidal cycle. Surface samples at C station ranged from 2-35 ppt with an average of 17.6 ppt, while bottom samples ranged from 6-37 ppt, with an average of 23.4 ppt. The salinity at E station, located in the main body of the Lagoon is typically less saline, but also shows well developed layering and variability, dependent on the condition of the Lagoon entrance. Surface samples here can be as low as 0 ppt, but usually were a little more saline (34 ppt), and

Fig. 2.1 Average monthly pH of Stations A, B, C, D, E, Malibu Lagoon, 1987-1988.

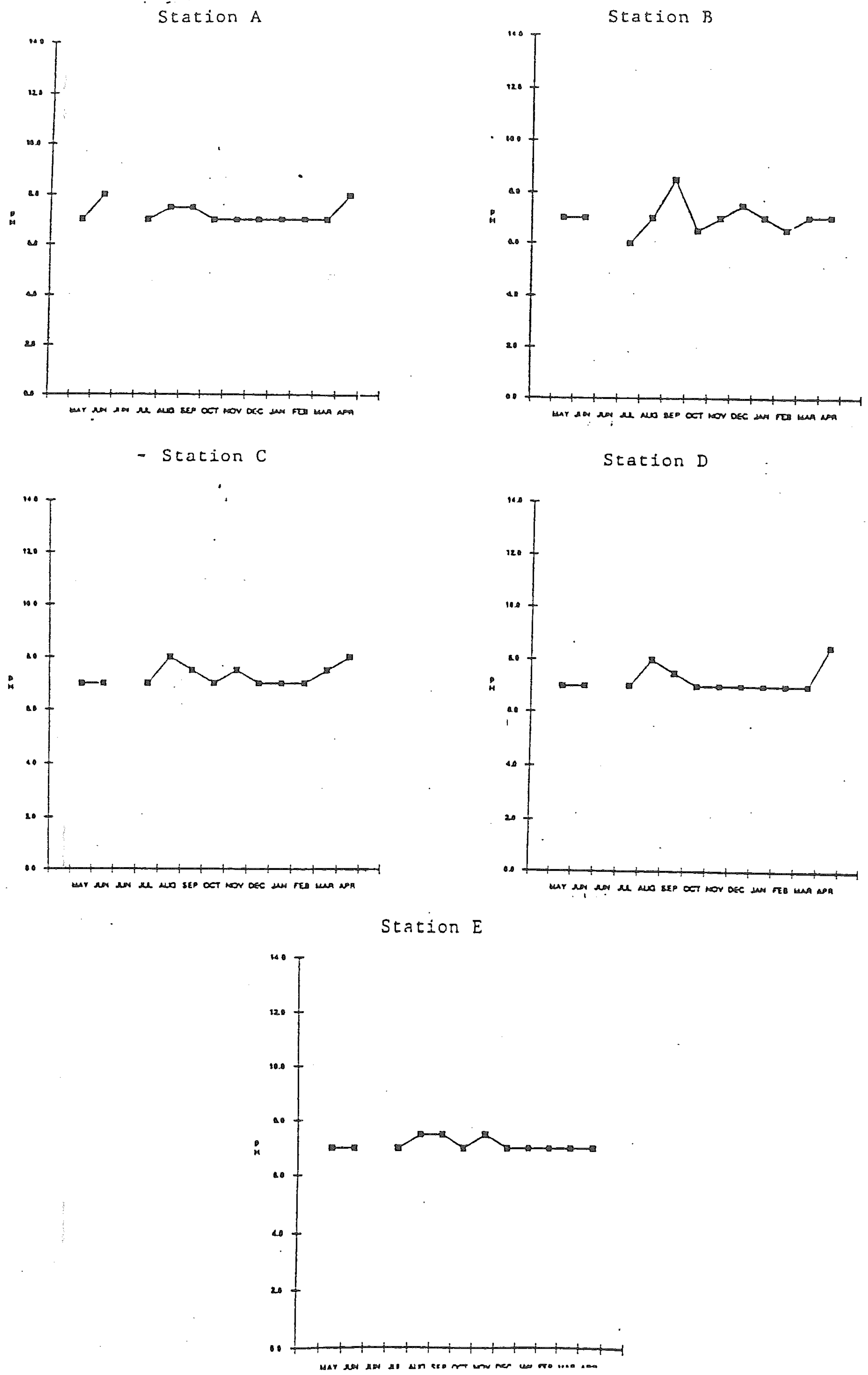
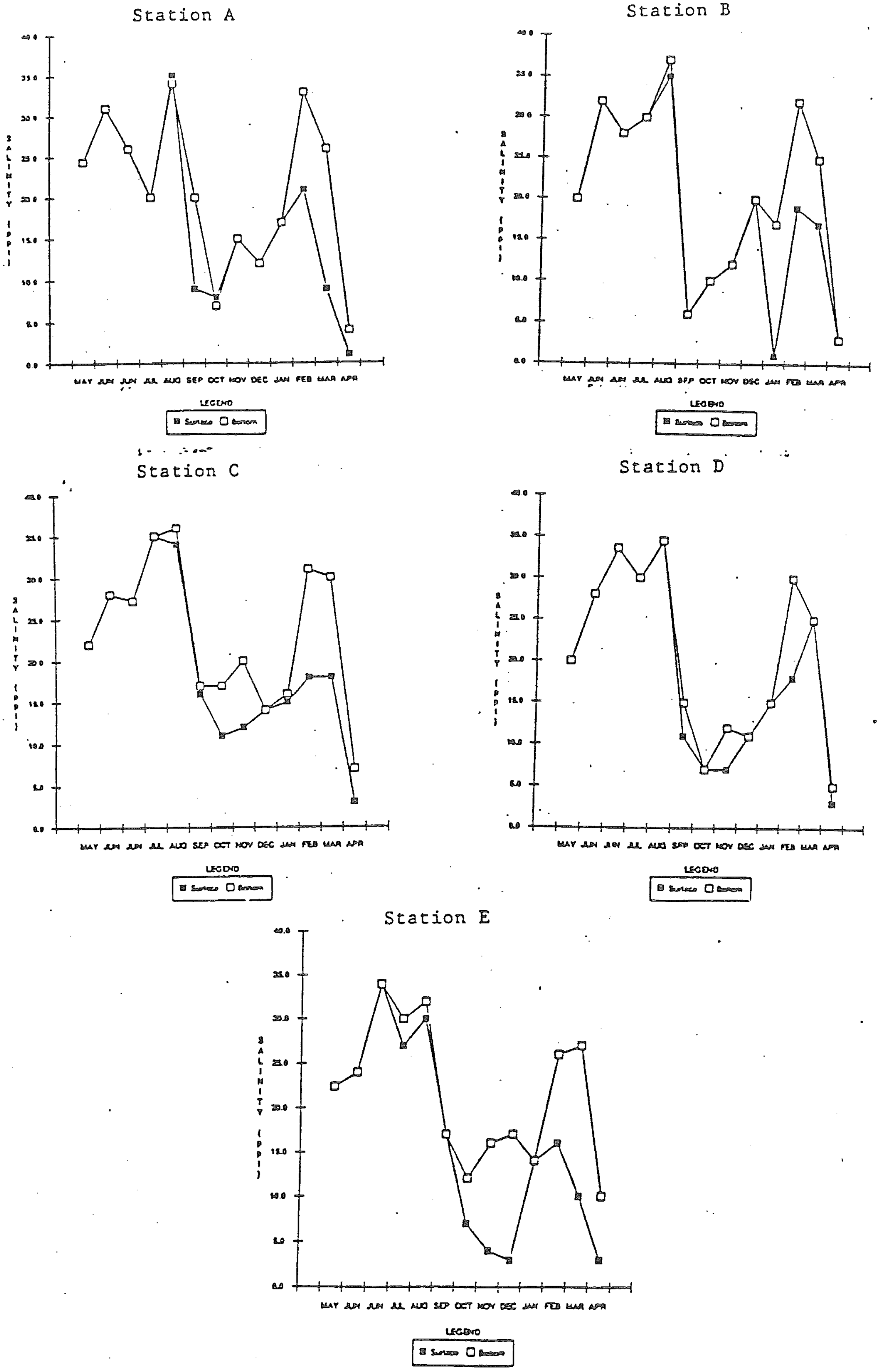


Fig. 2.2 Average monthly salinity (ppt) of Stations A, B, C, D, E, Malibu Lagoon, 1987-1988.



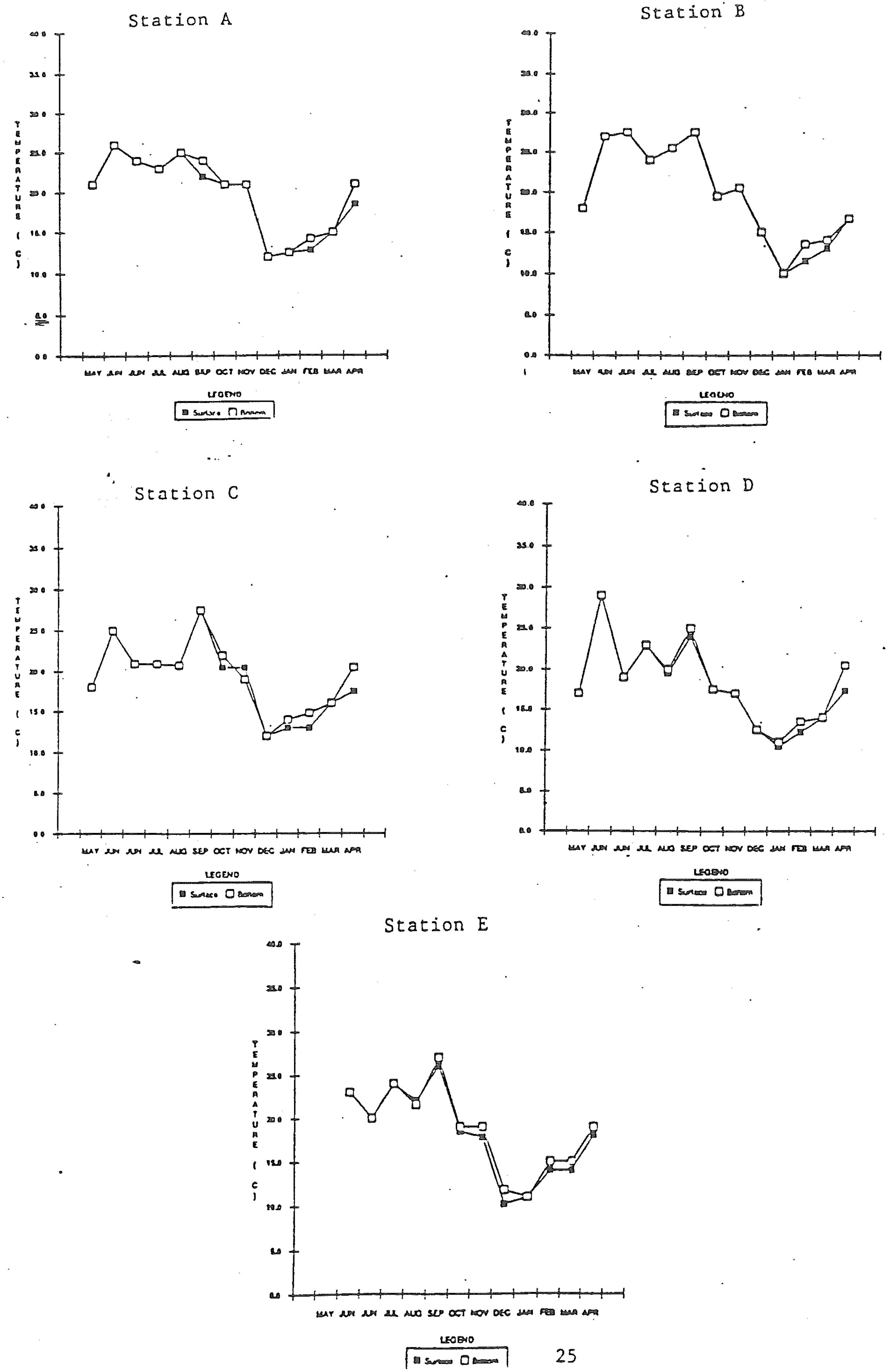
averaged a slightly higher reading of 19.3 ppt. These values stress the significance of fresh water input on the Lagoon ecosystem. It was also determined towards the end of the survey that the salinometer needed continuous re-calibration to reflect temperature change, thus potentially allowing a range of error of as much as 2-4 ppt in all data.

Another widely variable component of Lagoon water quality is the water temperature. This is to be expected, due to the shallow nature of the area and the strong influence of weather conditions. There are, however, a few noticeable trends. Over the year, the temperature increases through the summer and fall, only to decline in the winter beginning around early December (Fig. 2.3). Typically B station remains the warmest (average 19.4 C), and E station is more mixed with less obvious differences between surface and bottom temperatures. Station C often illustrates an interesting temperature inversion, with warmer water on the bottom. This condition is observed most frequently when data is collected prior to an incoming tide, or when the Lagoon entrance is closed. This may be an effect of water circulation patterns when the sand bar at D station blocks water movement in and out of the channel. A strong separation of temperature between surface and bottom water masses is characteristic. The general range of temperatures in Malibu Lagoon is between a low of 10 C and a high of 26.5 C, with an average of 18.5 C.

The levels of dissolved oxygen in the Lagoon show seasonal variability, with lowest levels occurring in the fall and early winter followed by steadily increasing levels through late winter and spring (Fig. 2.4). In keeping with trends shown by other parameters, dissolved oxygen levels at B Station tend to remain within a range of 4.6 to 14.2 mg/l, with an average of 10.6 mg/l. At C station, the range is slightly different (5.6-13.0 mg/l) and shows some variability in surface to bottom highs and lows. At times, the surface levels are higher than those on the bottom, and other times lower. The levels at E station tend to be consistently a little higher (2.1-20.0 mg/l), with a surface average of 11.2 mg/l and bottom average of 14.3 mg/l. This is no doubt related to the fact that ocean water is characteristically high in dissolved oxygen and is a result of the tidal intrusion and the effects of wind mixing.

Turbidity ranged between 10-20 JTU on the average at all stations (Fig. 2.5). One notable exception occurred in January, when all stations showed a dramatic increase with an extreme of 150 JTU at station C. This correlates to a period of heavy rains in the beginning of the month. It also points to the impact of floatables such as suds and debris, and road runoff from the vicinity of Malibu Colony which enter the Lagoon in the channel near C station, as well as farther back in all the channels.

Fig. 2.3 Average monthly temperature (°C) of Stations A, B, C, D, E, Malibu Lagoon, 1987-1988.



Station A

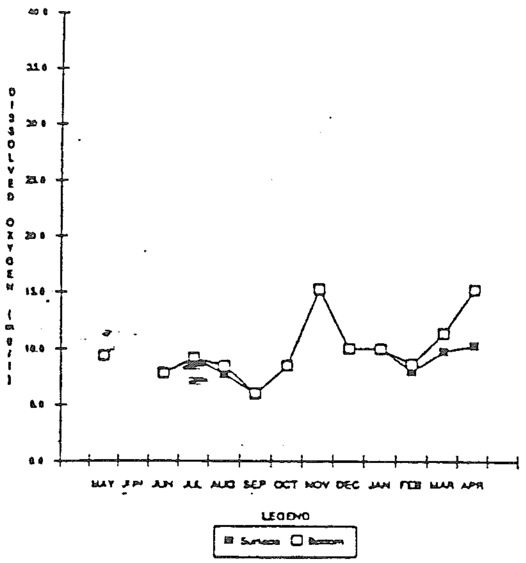
Station B

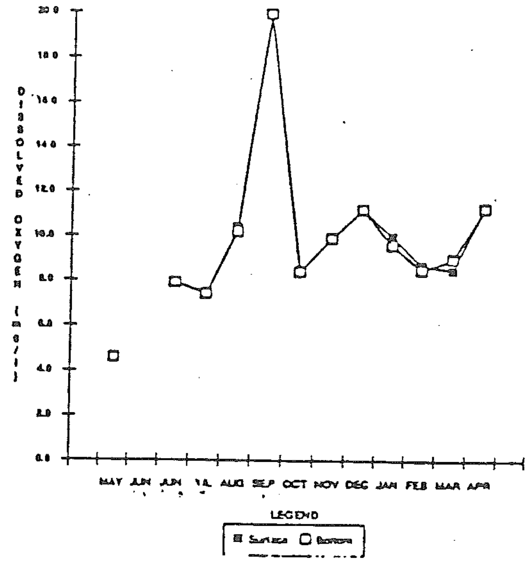
Station C

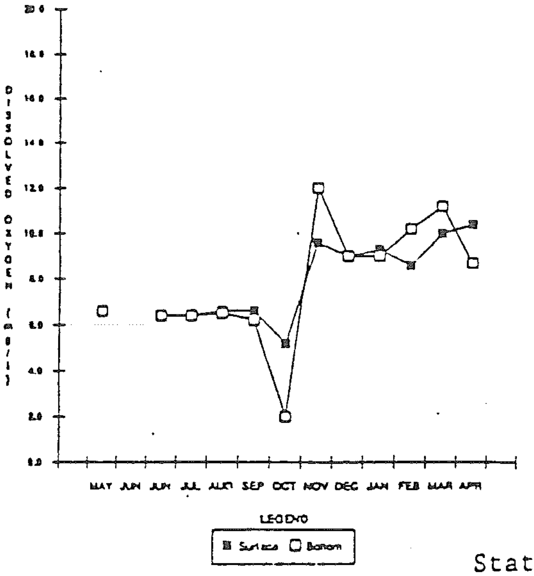
Station D

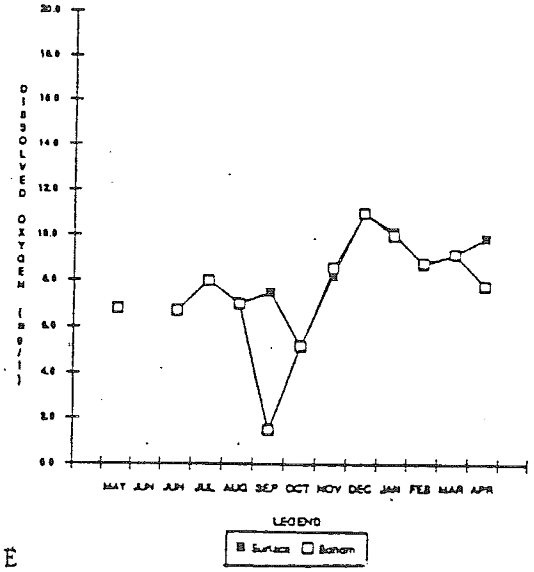
Station E

Fig. 2.4 Average monthly dissolved oxygen (mg/l) of Stations A, B, C, D, E, Malibu Lagoon, 1987-1988.


Station A


Station B


Station C


Station D

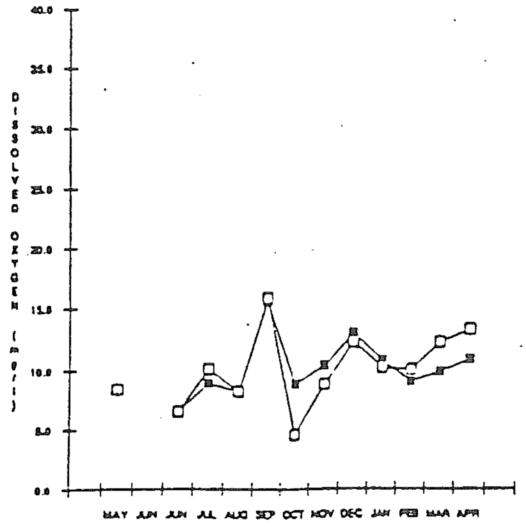
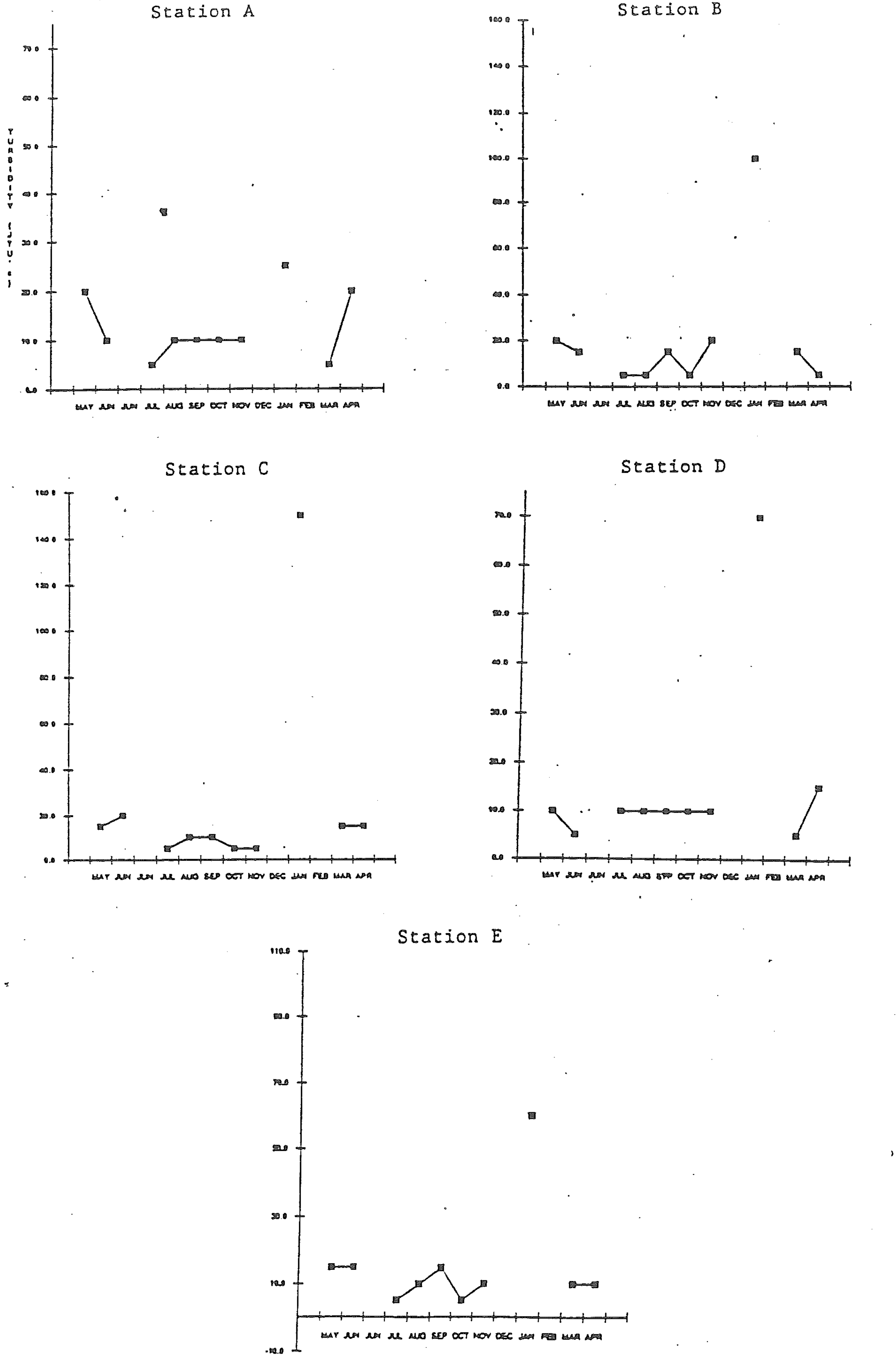

Station E

Fig. 2.5 Average monthly turbidity (JTU) of Stations A, B, C, D, E, Malibu Lagoon, 1987-1988.


Station A

Station B

Station C

Station D

Station E

Data collected over the past two years by the students participating on Malibu Lagoon School Tours substantiates the wide variability of temperature and salinity noted during this project. The locations where students collected data correspond roughly to Stations D and E. Station D is close to S1, and E is close to S2, but closer to the entrance (Map A). As can be seen in Figures 2.6 and 2.7, the trends recorded for both salinity and temperature are similar to those shown for Stations D and E. Frequent data points spread over a wider range of tidal stages add important detail to the less frequent data collection called for by this project.

The data collected by the Las Virgenes Municipal Water District, the agency responsible for monitoring the Tapia Water Reclamation Facility, seen on Figure 2.8, also confirms the trends of other observations. It should be noted that water released by Tapia consistently meets or exceeds the standard criteria levels for water quality. The only exceptions are some occasionally higher levels of dissolved oxygen, and slightly higher values for pH, which still remain within accepted safe levels, but are at the high end of the range. It appears that the quality of fresh water entering Malibu Lagoon from the Tapia plant and Malibu Creek is not adversely affecting the condition of the main Lagoon. However, the high volume of fresh water has a tremendous impact on the ecosystem.

Several elements (B, Ca, Co, Cu, K, Li, Mg, Mn, Mo, Na, Ni, P, Se, V, Zn) are considered essential for healthy growth of plants and animals, unless they exceed a certain amount. Above certain levels, some elements such as copper and magnesium become toxic. In Malibu Lagoon, all of these are found in concentrations which are within the limits set by the Water Quality Criteria, or are lower. Cobalt, lithium, and vanadium are needed for healthy microorganism and algae growth, and the low levels of these might warrant further investigation. If anything, the concern should be for the low levels of those elements necessary for maintaining healthy plants and animals. Manganese is of particular concern, as it is consistently below the lower limits of the range set for the health of the biota.

Of the other elements which are considered to be nonessential for growth, only titanium is toxic to both plants and animals when high levels are present. Selenium and copper are unique in that they are potentially toxic to animals when found in high concentrations, but are necessary in small amounts. Im Malibu Lagoon, they are all found within acceptable limits.

The general trend is that the levels of many elements increases in the summer months, with samples from E station consistently lower than those found in the rest of the Lagoon. This could be due to the circulation patterns in the Lagoon,

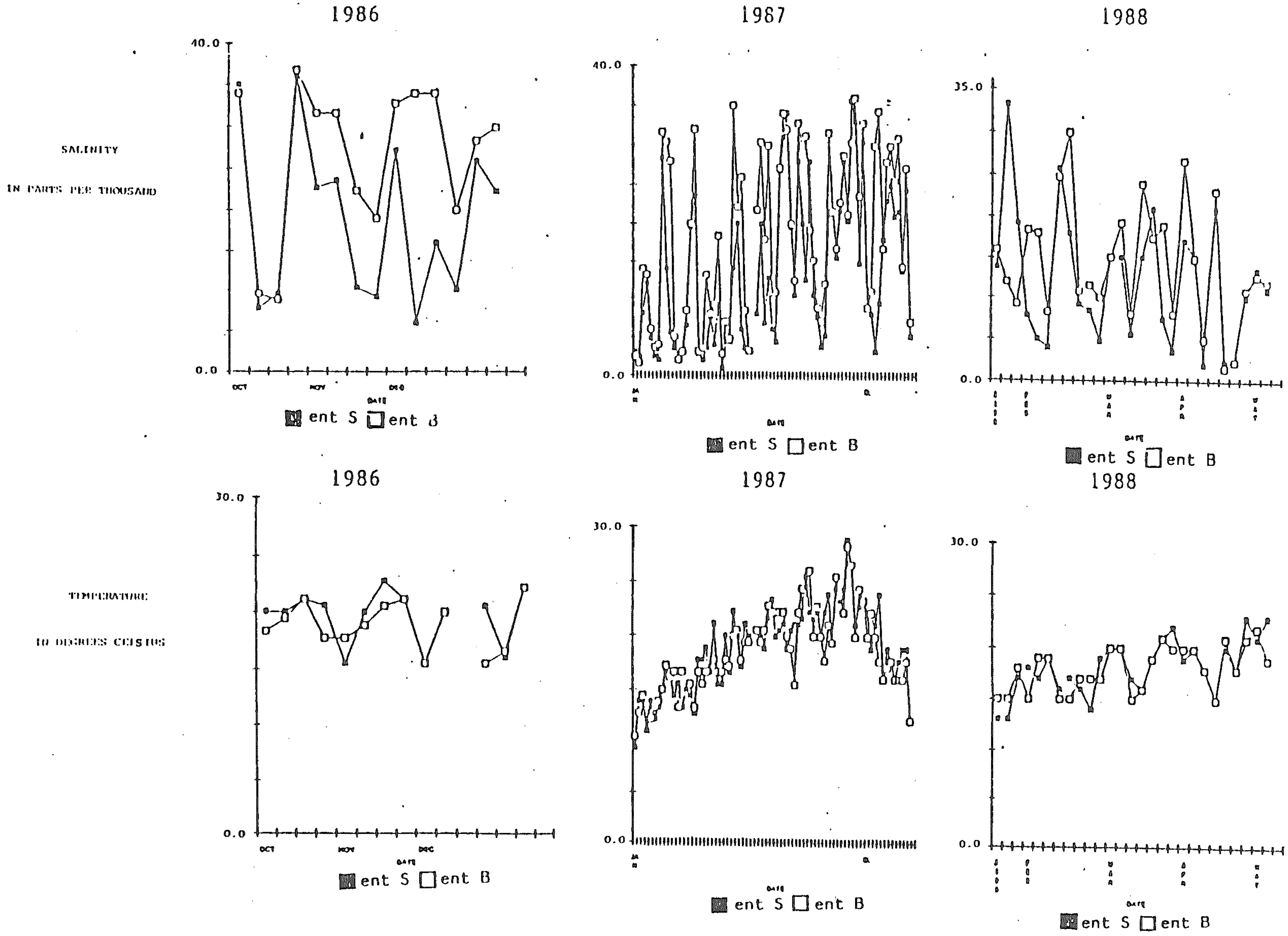


Fig. 2.6 Entrance Salinity (ppt) and Temperature (°Celsius) surface and bottom samples from Malibu Lagoon School Tours 1986-1988 (Site S1).

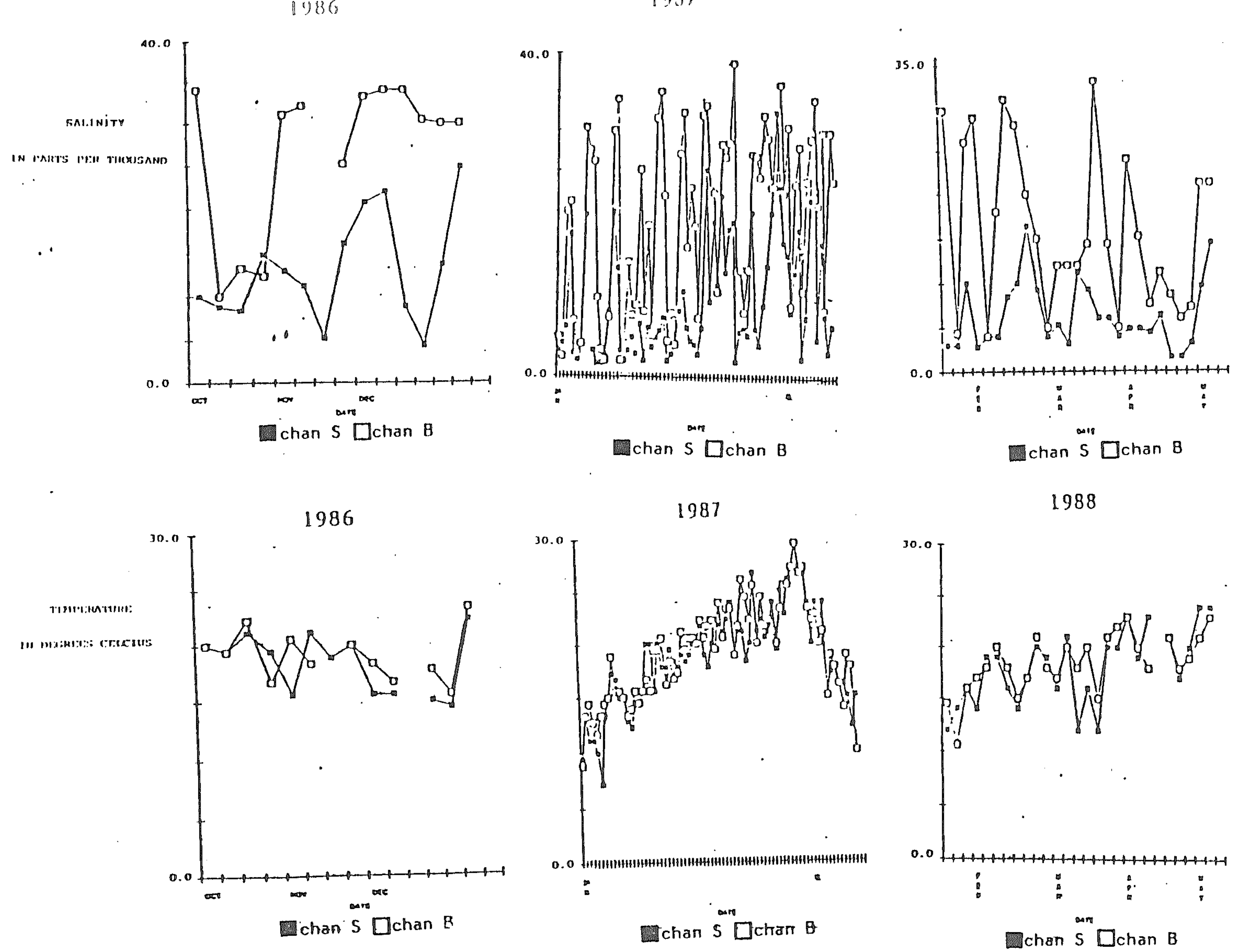


Fig. 2.7 Channel Salinity (ppt) and Temperature (Celsius) surface and bottom samples from Malibu Lagoon School Tours (Site S2).

Fig. 2.8 Table of Water Quality Data, monthly averages of samples from Site R11 (near the PCH bridge), collected by Tapia Wastewater Treatment Plant, 1987-1988.

Date	Temperature (C)	pH	Dissolved Oxygen (mg/l)	Turbidity
1987				
May	23.5	8.1	13.4	2
June	24.4	8.1	9.8	4.7
July	26.8	7.9	12.6	1.7
August	24.7	8.0	9.1	1.5
September	23.4	7.8	10.2	2.2
October	21.3	8.1	10.4	1.5
November	18.0	8.0	10.3	15.0
December	13.9	7.6	11.6	6.5
1988				
January	13.7	8.2	12.2	10.0
February	16.0	8.0	13.1	2.8
March	18.1	8.0	11.8	4.4
April	19.9	8.2	9.9	1.6
May	20.9	8.2	12.1	3.7
June	23.7	8.6	16.2	4.0

*Note: Dissolved oxygen levels lower than 7mg/l are considered to be in violation of limits set.

which allow water in the back channels to sit for longer periods than that in the main body of the Lagoon. It is also known that many of these elements precipitate out of solution when levels of dissolved oxygen increase, and therefore are more likely to be in solution during summer months when dissolved oxygen levels are lower.

Total coliform bacteria data is collected by Tapia near the PCH bridge (site R11), as well as at other stations both upstream and downstream from the plant. These, in addition to the data collected weekly by the LA County Department of Health outside the Lagoon on the surfing beach were collated with the intention of illustrating any relationship between levels of coliform in the Lagoon and those on the beach (Figure 2.9). If these data are examined with relation to tidal stage, rainfall and Lagoon entrance closure, a few trends begin to appear, but much still remains unclear.

First, it should be noted that total coliform levels as measured on the Surfrider Beach rose above levels considered safe for body contact (500 MPN/100ml), only 3 times during the 1987-88 survey. When this occurred in December 1987, the Lagoon levels recorded by Tapia were lower than those on the beach. In both January and March, the Lagoon (R11) levels were higher. In each case, these levels occurred after a period of heavy rainfall. The average count along the beach for the 14 months of the survey was 209 MPN/100ml. This is not surprising, since coliform bacteria cannot survive the high salinity of ocean water and die off rapidly upon exposure.

In the area of the Lagoon where samples were collected by Tapia (Site R11 near the PCH bridge), the total coliform levels were extremely variable, with an average of 1100 MPN/100ml. A week to week change of 100 MPN/100ml to over 2000 MPN/100ml was not uncommon. The extreme peaks always followed rainfall, but did not seem to be directly tied to Lagoon closure. Tidal influences were much stronger, with high counts during or following spring tides. Occasionally there were also high levels during mid-cycle or neap tipes, but these were always in association with entrance closure or heavy rainfall.

Overall, total coliform counts seem to be higher in the winter months when there is greater rainfall. It is interesting to note that there were also occasions when total coliform levels in the Lagoon were lower than those on the beach, and in both cases this was during spring tides, with an open Lagoon entrance. Sampling the levels of bacteria in other areas of the Lagoon, particularly C channel near the drainage pipes, and the main Lagoon would provide further insight into where the bacteria source is, and how water circulation within the Lagoon affects total coliform population peaks and declines. It is noted in the original restoration plan (LA County Department of Regional Planning 1982).

DATE 1987	TAPIA Site R11	LA COUNTY Surfrider Beach	ENTRANCE	TIDE
May 5	1000		-	mid
12	200	20	-	spring
19	3300		-	mid
26	<100		-	neap
June 2	1400		-	mid
9	1600	20	C	spring
16	900		-	mid
23	300		-	
30	1700		-	neap
July 7	800		-	mid
14	1100	300	-	spring
21	400		-	
28	-		-	
Aug. 4	<100		C	mid
11	<100	<20	O	spring
18	100		-	mid
25	100		C	neap
Sept.1	<1000		-	mid
8	500	300	-	spring
14	>1600/<500		-	mid
22	500		-	neap
29	3000		C	mid
Oct. 6	500		-	spring
*13	1750	40	O	mid
*19	500		barely O	neap
27	2400		-	mid
Nov. 3	3500	500	O	spring
10	1000	40	O	mid
16		110	-	
23		80	-	neap
24	1000		-	
30		40	-	spring
Dec. 1	1250		O	
7		1100	O	mid
8	1000		O	
*14		<20	O	
*15	2250		O	
*22	750	110	O	neap
29	1250	500	O	mid

DATE 1988	TAPIA Site R11	LA COUNTY Surfrider Beach	ENTRANCE	TIDE
Jan. *4		130	O	spring
*5	1750		O	
11		170	O	mid
12	1750		O	
19	1300	1100	O	neap
25		20	-	mid
26	500		-	
Feb. 1		130	-	spring
2	3700		-	
8		40	-	mid
9	1000		-	
16	2800		O	neap
22		130	-	mid
23	500		-	
*29		1300	O	mid
Mar. 1	1700		-	spring
7		70	-	
8	500		-	mid
14		20	-	neap
15	150		-	
21		40	-	mid
22	300		-	
28		300	-	
29	200		-	spring
Apr. 4		500	-	
5	1850		-	
11		20	O	mid
12	50		C (opened 13th)	
*18		300	O	neap
*19	300		O	
*25		170	O	mid
*26	500		O	
May 2		40	O	spring
3	TNTC		O	
9		<20	O	mid
10	2300		O	
16		20	O	neap
17	1000		O	
23		220	O	mid
24	TNTC		O	
31	1900	20	C	spring
June 6		130	O	mid
7	<100		O	
13		40	-	neap
14	1250		-	
20		130	-	mid
21	900		-	
27		80	-	spring
28	150		-	

NOTE:
* indicates day of rainfall
TNTC = Too numerous to count
- indicates that no specific note was made of entrance condition
MPN = Most Probable Number

Fig. 2.9 Table of total coliform bacteria counts (MPN/100ml) from Tapia Water Reclamation Facility and Los Angeles County Department of Health, correlated to tidal stage and precipitation, and status of Lagoon entrance, 1987-1988.

1982) that improperly maintained septic systems drain into the Lagoon when the water table rises. More information is needed in order to more clearly understand the relationship of coliform counts in the Lagoon to those found along the beach.

A few trends appeared during the 24 hour survey of the Lagoon which documented more completely the daily cycle. As might be expected due to photosynthesis, levels of dissolved oxygen rose during the day to a high of 14 mg/l around 6:00pm, and fell during the night to lows of around 7 mg/l (Figure 2.10). The closed entrance at the time of the survey meant that the water level in B channel reached a high of 5.2 ft before the bulldozer arrived. There was a temperature inversion with differences of up to 7 degrees between colder surface water and warmer bottom water, probably due to the continuous influx of fresh water from Malibu Creek. One diurnal cycle documented was that of pH, which went from a consistent daytime reading of 8.5 to a nighttime low of 6.5 (Figure 2.11). The following day it returned to 8.5 at the same time the entrance was opened and the Lagoon emptied.

2.5 DISCUSSION

Salinity and temperature are normally quite variable in an estuarine situation as a result of tidal influences. At Malibu Lagoon this situation is further complicated by unnatural and irregular influx of large volumes of fresh water from the Tapia Water Reclamation Facility of the Las Virgenes Municipal Water District and the constantly changing status of the mouth of the Lagoon. As compared to other Southern California estuaries, the low salinities found at Malibu Lagoon put it in the class of brackish, not salt water marshes (Zedler 1982). Due to an agreement with Southern California Edison, the Las Virgenes Municipal Water District releases excess water during off-peak hours, thus inundating Malibu Creek with large amounts of water in short time periods. Tapia has no way of holding excess water for extended time periods (i.e. more than a day) in order to release it on a more consistent basis, except in their percolation ponds. Instead, when they are unable to sell reclaimed water, Tapia discharges large volumes into Malibu Creek. This often occurs during the winter, when precipitation already increases the volume of water in the Creek naturally. The results of this irregular flooding most noticeably affects the distribution and health of various plant species in the Lagoon, but also the animals. Most common estuarine plants require short intervals of low salinity in order for seed germination and establishment to occur. These natural "windows" are normally provided by seasonal rainfall. At Malibu Lagoon, the normal seasonal pattern is lost and a more erratic pattern imposed, resulting in a non-zonated pattern of vegetative distribution. Animals normally found in estuarine habitats tend to tolerate

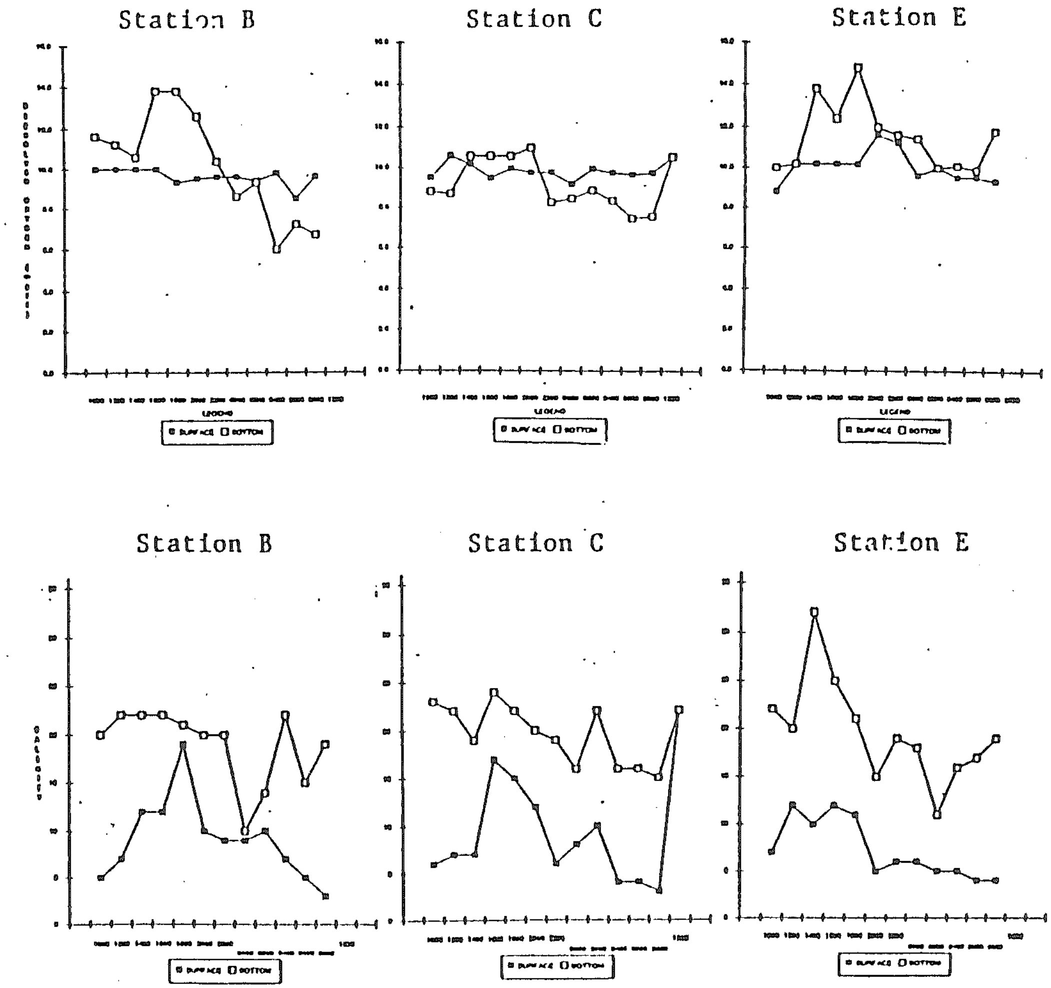


Fig. 2.10 Dissolved Oxygen (mg/l) and Salinity (ppt) from Stations B, C, E, Malibu Lagoon 24 Hour Survey, 31 May - 1 June 1988.

Malibu Creek indicates that the level of these nutrients decreases as the water flows downstream, but still meets the low threshold needed to foster algae growth. The water released from the tertiary plant is 97% clean, but does retain nitrates and phosphates in solution. The study done in 1983 by Lynn Hasz recorded such low levels that data was no longer collected after several months. The levels found today are an unknown which needs to be included in future studies.

As is typical, this study seemed to generate more questions than it answered. Now that there is a comprehensive database, continued data collection could potentially provide better answers. Data concerning the impact of the Pepperdine sewage treatment plant, as well as that of the commercial area along Cross Creek Road is needed to complete the picture. Water quality is absolutely critical to the overall health of the Lagoon, and it is important that future studies incorporate information on levels of nitrates and phosphates in an attempt to determine the levels of these compounds introduced by runoff and septic tank overflow. Further investigation of water circulation may explain the distribution of benthic organisms and plant species. Based on the observations taken during this year, fresh water influx is a greater factor in the ecosystem than is salt water. What changes might occur as a result of more regular entrance maintenance? Would the creation of percolation/retention ponds mitigate the volume of water coming down the Creek? How might we encourage a greater diversity of benthic organisms? What will happen to the established system if the channels are re-graded and connected? Clearly there is much yet to discover.

2.6 SUMMARY

1. Salinity, temperature, dissolved oxygen, and pH vary tremendously in Malibu Lagoon, sometimes with extremes occurring in short time spans.

2. Malibu Lagoon is more characteristic of a brackish water ecosystem rather than salt water, and has a low diversity of invertebrates and fish, characteristic of estuaries receiving high volumes of fresh water input.

3. Distribution of plants and animals is reliant upon the physical and chemical parameters of the watershed. Changes in the water quality could potentially affect the entire ecosystem.

4. Freshwater input from the Tapia Water Reclamation Facility is of high quality, but does affect the overall water quality when impounded by closure of the Lagoon entrance. This potentially provides good growing conditions for coliform bacteria.

5. Department of Parks and Recreation frequently does not immediately open the Lagoon entrance when levels reach 3.5 ft. The impounded water stresses the septic systems of nearby homes and businesses by raising the water table. It is possible that the elevated water table results in sewage overflow into the Lagoon.

6. High coliform bacteria counts are frequently found in streams associated with urban areas. The counts along Malibu Creek are high above the Tapia Water Reclamation Facility, less than 2 MPN/100ml for water released from Tapia, and high again in Malibu Lagoon where impounded water provides ideal growing conditions. Non-point sources of pollution along the Creek need to be identified. The homes and businesses located along Malibu Creek and Malibu Lagoon are potential sources of this pollution.

7. No chemical toxics were found in Malibu Lagoon.

8. Further studies of coliform sources, water circulation patterns, and overall water quality are needed to provide a more complete understanding of the ecology of the watershed.

LITERATURE CITED

Denny, Dr. Christopher. 1988. (personal communication) UCLA School of Medicine.

Gough, L. P. et al. 1979. Element Concentrations Toxic to Plants, Animals, and Man. U.S. Geological Survey Bulletin 1466. pp.80.

Hasz, L. 1983. Malibu Lagoon: A Local Resource. CSUN. unpub. pp.10.

L.A. County Department of Regional Planning. 1982. Proposed Malibu Local Coastal Plan: Research Analysis and Appendices. Coastal Studies Section.

Las Virgenes Municipal Water District Malibu Creek Monitoring Program. Monthly Summaries, May 1987 - June 1988.

Mitchell, M. and Stapp, W. 1986. Field Manual for Water Quality Monitoring. Thompson-Shore Printers. pp.10-64.

Nordby, C. and Covin, J. 1988. Physical-Chemical and Biological Monitoring of Los Panasquitos Lagoon. Los Penasquitos Lagoon Foundation.

Rand, M. C., ed. 1976. Standard Methods for the Examination of Water and Wastewater. 14th Ed. American Public Health Association. pp.99, 135, 715.

Tjaden, A., Roberts, J., and Pierce, K. 1978. Malibu Lagoon Surfing Beach Resource Management Plan, General Development Plan, and Environmental Impact Report. State of California, Department of Parks and Recreation.

Trussell, R. R. et al. 1980. Las Virgenes Municipal Water District, Triunfo County Sanitation District Malibu Creek Study 1979. James M. Montgomery, Consulting Engineers, Inc. pp.3:1-36.

Zedler, J. B. 1982. The Ecology of Southern California Coastal Salt Marshes: A Community Profile. U. S. Fish and Wildlife Service FWS/OBS-81/54. pp.110.

Zedler, J. B., Koenigs, R., and Magdych, P. 1984. Freshwater Release and Southern California Coastal Wetlands. San Diego Association of Governments. pp.51.

Zedler, J. B. and Nordby, C. 1986. The Ecology of Tijuana Estuary: An Estuarine Profile. U.S. Fish and Wildlife Services Biological Report 85 (7.5). pp.104.

3.0 VEGETATIVE SURVEY OF MALIBU LAGOON

3.1 INTRODUCTION

Over the years, Malibu Lagoon has experienced a great many changes which have dramatically altered the natural flora of the area. When the Lagoon was used by the Chumash Indians, particular plant species were husbanded for use in basketmaking and food. The Indians were known to utilize the area, so that even prior to the historical period, the Lagoon has been a somewhat altered ecosystem.

The value of the Lagoon vegetation and its ability to recycle wastes, buffer against the ravages of storms and stabilize the coastline is one of the main reasons for conducting this study. However, in recent history Malibu Lagoon has met with many changes. Most recently, it was filled in to provide space for baseball fields and parking lots. In 1982-83, a restoration project began which entailed removal of much fill, comprehensive re-grading and landscaping, with the inclusion of trails and visitor use areas.

In the five intervening years, recovery has resulted in the re-establishment of vegetation and reintroduction of some the more characteristic estuary animals. In trying to evaluate the success of the Phase I restoration, as well as maximize the possibility of further enhancement when Phase II begins, a comprehensive survey of the Lagoon vegetation was necessary.

3.2 OBJECTIVES

The distribution and diversity of vegetation in Malibu Lagoon are of great interest, especially within the context of further restoration. A comprehensive survey of vegetation was conducted in September 1987, and repeated again in April 1988. These months were selected as they are indicative of the end of one growing season, prior to the fall rains, and the start of another. The survey consisted of several components.

First, a preliminary botanical inventory was carried out. The list of all species found in the area was compiled and verified by experts. Specimens were collected and prepared to form the basis of an herbarium collection. In the spring, further data were collected for those species dormant or not identifiable in the fall. A list of flora has been compiled for visitors to Malibu Lagoon.

Second, in order to monitor changes in the transitional vegetative zones over time, three permanent transects of the back-channel area in a NE - SW orientation were established. Repeated surveys in these fixed locations should provide a long-term, quantitative index of community structure and dynamics, soil salinity, elevation changes and habitat preferences. These transects were repeated in April 1988, and will be available for continuing surveys in the future.

Third, the data will be used to determine ways of encouraging and enhancing the return of native estuarine vegetation in the Lagoon.

3.3 METHODOLOGY

3.3.1 BOTANICAL INVENTORY

A preliminary list of all species present in the Lagoon was compiled by repeated surveys covering the entire area in September 1987 and April 1988 (Figure 3.1). Questionable specimens were collected and their identification verified by Bob Muns (Rancho Santa Ana Botanic Garden) and Wayne Ferren (UCSB). These surveys concentrated solely on vascular plants. Taxonomy and nomenclature is according to Ferren, 1985 and Munz, 1974.

At the time of reconstruction in 1979-82, several methods were used to landscape the area following grading. In addition to re-seeding the Salicornia virginica originally from the Lagoon, several species endemic to the Channel Islands were introduced according to the plans of the landscape architect. The inventory takes into account all natives, introduced natives, and opportunistic exotic invaders that have self-seeded, or were contaminants of the hydro-seeding process.

Herbarium specimens were also collected for use in educational programs, as well as to provide a historical perspective of the estuary documenting the species present. These specimens are stored at the office of the Topanga-Las Virgenes Resource Conservation District.

3.3.2 ELEVATION PROFILE

Three 100 meter transects of the back-channel area in a NE - SW direction were established (Figure 3.2).

- AIZOACEAE
  - Carpobrotus edulis
  - Gasoul crystallinum
  - G. nodiflorum
  - Malephora crocea
  - Tetragonia tetragoniodes
- AMARANTHACEAE
  - Amaranthus albus
- ANACARDIACEAE
  - Schinus terebinthifolia
- APIACEAE
  - Apium graveolens
  - Corium maculatum
  - Foeniculum vulgare
- ARECACEAE
  - Washingtonia
- ASTERACEAE
  - Achillea
  - Ambrosia chamissonis
  - A. psilostachya
  - Artemisia californica
  - A. dauglasiana
  - Baccharis glutinosa
  - B. pilularis consanguinea
  - Centaurea melitensis
  - Chrysanthemum coronarium
  - Cirsium californicum
  - Conyza bonariensis
  - C. canadensis
  - Coreopsis gigantea
  - Cotula coronopifolia
  - Cynara carduncultus
  - Heterotheca grandifolia
  - Hypochoeris glabra
  - Jaumea carnosa
  - Latuca serriola
- ASTERACEAE
  - Malacothrix saxatilis
  - Picris echioides
  - Senecio vulgaris
  - Silybum marianum
  - Sonchus oleraceus
  - Xanthium strumarium
- BETULACEAE
  - Alnus rhombifolia
- BORAGINACEAE
  - Heliotropium curassavicum
- BRASSICACEAE
  - Brassica geniculata
  - Cakile maritima
  - Lepidium latifolium
  - L. oblongum
  - Lobularia maritima
  - Raphanus sativus
- CAPRIFOLIACEAE
  - Sambucus mexicana
- CARYOPHYLLACEAE
  - Spergularia bocconii
  - S. marina
- CHENOPODIACEAE
  - Atriplex lentiformis
  - A. patula hastata
  - A. semibaccata
  - Atriplex sp.?
  - Bassia hyssopifolia
  - Beta vulgaris
  - Chenopodium album
  - C. ambrosioides
  - C. murale
  - Salicornia virginica
  - Salsola iberica
- CONVOLVULACEAE
  - Calystegia macrostegia
  - Cuscuta salina
- CUPRESSACEA
  - Cupressus
- CYPERACEAE
  - Cyperus alternifolius
  - Scirpus acutus
  - S. californicus
  - S. robustus
- EUPHORBIACEAE
  - Euphorbia terracina
  - Euphorbia sp?
  - Ricinus communis
- FABACEA
  - Lotus scoparius
  - Medicago polymorpha
  - Melilotis albus
  - M. indicus
  - Trifolium pratense
  - T. repens
  - Vicia villosa
- FRANKENIACEAE
  - Frankenia grandiflora
- GERANIACEAE
  - Erodium cicutarium
  - E. moschatum
- HYDROPHYLLACEAE
  - Phacelia ramosissima
- JUNCACEAE
  - Juncus sp.
- JUNCAGINACEAE
  - Triglochin concinnum
- LAMIACEAE
  - Marrubium vulgare
  - Stachys rigida
- MALVACEA
  - Malacothamnus fasciculatus
  - Malva nicaeenis
  - Malva parviflora
- MYOPORACEAE
  - Myoporum laetum
- MYRUCACEAE
  - Myrica californica
- PAPAVERACEAE
  - Eschscholzia californica
- PINACEAE
  - Pinus sp?
- PLANTAGINACEAE
  - Plantago coronopus
  - P. lanceolata
  - P. major
- PLUMBAGINACEAE
  - Limonium californicum
- POACEAE
  - Arundo donax
  - Bromus diandrus
  - B. mollis
  - B. rubens
  - B. wildenovii
  - Cortaderia atacamensis
  - Crypsis niliacea
  - Cynodon dactylon
  - Distichlis spicata
  - Echinochloa crusgalli
  - Elymus condensatus
  - Festuca
  - Hordeum murinum
  - Hordeum sp.
  - Leptochloa uninervia
  - Lolium perenne
  - Oryzopsis miliacea
  - Parapholis incurva
  - Pennisetum clandestinum
  - Polypogon monspeliensis
  - Sorghum halepense
- POLYGONACEAE
  - Erigonum giganteum
  - E. fasciculatum
  - Polygonum aviculare
  - Rumex conglomeratus
  - R. crispus
- PRIMULACEAE
  - Anagallis arvensis
- ROSACEAE
  - Lyonothamnus floribundus
  - Prunus lyonii
- SALICACEAE
  - Salix hindsiana
  - S. lasiolepis
- SCROPHULARIACEAE
  - Galvezia speciosa
  - Veronica anagallis-aquati
- SOLANACEAE
  - Lycopersicum esculentum
  - Nicotiana glauca
  - Solanum douglasii
  - S. nodiflorum
- STERCULIACEAE
  - Fredmontodendron sp.
- URTICACEAE
  - Urtica holosericea

Figure 3.1 Flora of Malibu Lagoon, 1987-1988

3.4 OBSERVATIONS

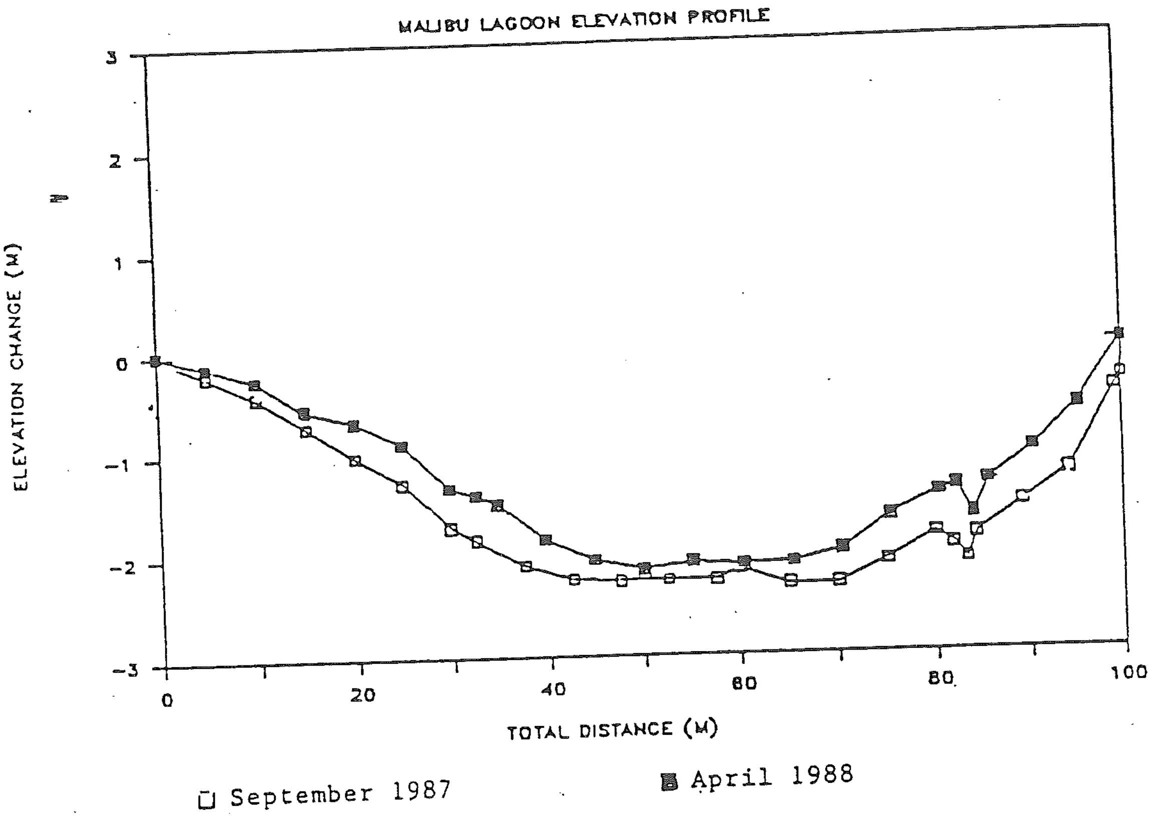
The botanical inventory revealed a total of 133 species of vascular plants in Malibu Lagoon (Figure 3.1). In addition to the native estuarine species, a wide variety of naturalized exotics and non-estuarine natives are also found at the Lagoon. This opportunistic growth has produced an ecosystem with little resemblance to less disturbed, zonated Southern California coastal salt marshes. It is important to note that Malibu Lagoon currently receives influx of large volumes of fresh water from the release of reclaimed waste water by the Tapia Water Reclamation Facility, which is located upstream on Malibu Creek. This surely plays a dominant role in the distribution of plants in Malibu Lagoon.

Another key factor influencing species distribution is their elevation with respect to incoming waters, both fresh and salt. Gradient along the channels is an important factor in determining the rate and extent of inundation. Normal slope is less than 0.7% in most estuaries (Zedler 1982). At Malibu Lagoon, the banks are steeper, and although they have moderated over time, they only become mud flats at the very ends of the back channels. The elevation profiles documented increased sedimentation during the winter of 1987-88, with an average increase of 18 cm (Figure 3.3). Channel A is included in the transects, and the width of the channel, as well as its depth indicate slow filling due to sedimentation. This effect may also be enhanced by the continued spread of the California Bullrush (Scirpus californicus) stands in the channel.

The distribution of species in less disturbed estuaries demonstrates a zonation based on the salt tolerance of the dominant species and their ability to withstand inundation. At Malibu Lagoon, the combined factors of restoration landscaping producing steep banks and higher than normal levels of fresh water have caused the natural zones to disappear. It has also been found in other areas that a period of little or no flow is as important a factor as periodic increased flow (Zedler, Koenigs and Magdych 1984). Thus the distribution is very mixed and the data is not sufficient to determine which of the many factors, or combinations thereof, are responsible.

The plot surveys and soil salinity data indicate that although the vegetation is disturbed, the underlying order could be related to salinity. Most estuarine species tolerate a range of between 15 and 50 ppt, with each species showing preference for a more narrow range. There are three dominant halophytes (salt tolerant species) at Malibu Lagoon: Distichlis spicata, Jaumea carnosa, and Salicornia virginica.

Fig. 3.3 Elevation profiles of transect #1, Malibu Lagoon, September 1987 and April 1988.



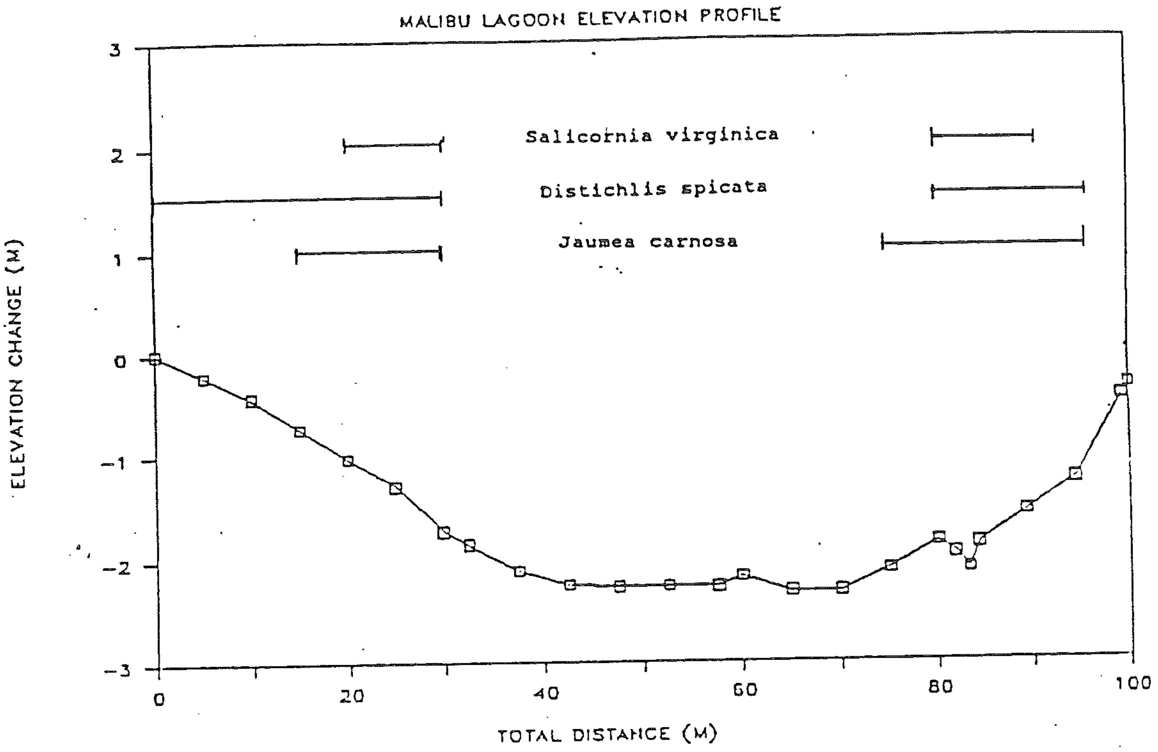
Under conditions common in other salt marshes, pickleweed (Salicornia virginica) is often the first emergent plant to establish dominance due to its perennial habit, vegetative reproduction, and ability to tolerate hypersaline soils. At Malibu Lagoon, the area surveyed NW of the visitor path appears to foster the growth of Jaumea carnosa and Distichlis spicata more than the pickleweed (Figure 3.4). This could be a reflection of the soil composition, which is mostly sand and fill, slowly being covered by decayed organic sediments carried by the water. It also could indicate that fresh to brackish water is more commonly present. Distribution of pickleweed follows points of higher soil salinity. It is not common in less saline areas. Salinity data for that channel was not collected, but in the adjacent channel (B), the range was from 0 to 34 ppt, with an average of 19.1 ppt. Despite the fact that pickleweed is usually larger in size than either of the other two dominant species, the data indicate that it was not only less numerous when counting individuals, but also when comparing percent cover (Figure 3.5). Over the winter months, the pickleweed appeared to die off, and during the April survey most plants were dried, with growth only at the tips.

Consequently, Jaumea carnosa and Distichlis spicata vie with each other for dominance. They too are found in hypersaline soils, but most often occur in less saline places. Perhaps the lower salinities found at Malibu Lagoon gives them the competitive advantage over pickleweed. This is somewhat unusual as Jaumea carnosa usually has difficulty competing with pickleweed. Pickleweed generally requires only a brief window of fresh water in order for its seeds to germinate, but if this period is extended, the germination rate is not as high (Zedler, Koenigs and Magdych 1984). Jaumea, on the other hand, germinates well in fresh water, and this may explain its relative competitive advantage at Malibu Lagoon.

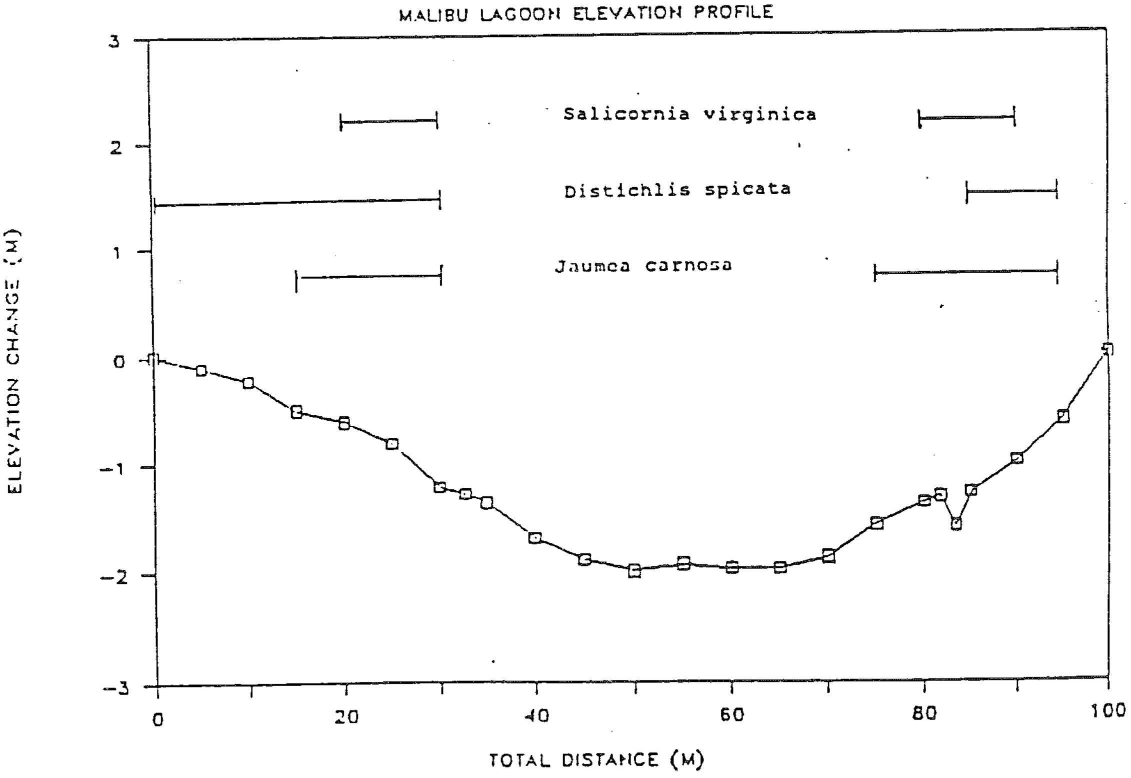
An interesting observation was that the parasitic plant Dodder (Cuscuta salina) covered large areas of Jaumea, and only rarely any other species. In areas where pickleweed and Jaumea were mixed, this was especially obvious. The reason for this preference is unclear, but warrants further investigation. Typically, salt marsh dodder is associated with pickleweed.

Distichlis spicata generally prefers less tidal inundation and sandy soils that provide good drainage. It may be that the fill left from the pre-restoration period has not yet been converted into more finely textured hypersaline soils, and still retains better drainage potential due to the high sand and gravel content.

Fig. 3.4 Relative distribution of three dominant halophyte species (*Jaumea carnosa*, *Distichlis spicata*, *Salicornia virginica*) in Malibu Lagoon, September 1987 and April 1988.



SEPTEMBER 1987



APRIL 1988

Fig. 3.5 Percent cover and total number of individuals for three dominant halophytes, Malibu Lagoon, 1987-1988

Total number of individuals
(0.25 meter square)

Transect	#1		#2		#3	
Species	Sept.	Apr.	Sept.	Apr.	Sept.	Apr.
Distichlis spicata	465	213	636	308	308	277
Jaumea carnosa	397	159	510	251	503	408
Salicornia virginica	35	22	154	28	220	116

Mean Cover By Class (Zedler)
(0.25 meter square)

Transect	#1		#2		#3	
Species	Sept.	Apr.	Sept.	Apr.	Sept.	Apr.
Distichlis spicata	4.8	5.2	4.1	4.4	3.4	3.5
Jaumea carnosa	4.6	5.1	3.5	4.0	3.8	4.5
Salicornia virginica	4.0	3.25	2.6	2.5	2.6	2.6

Note: Only 0.25 of the 1 meter square value for transect #1 was included in these figures.

PERCENT COVER BY CLASS (Zedler)

1	less than 1%	4	26-50%
2	less than 5%	5	51-75%
3	6-25%	6	76-100%

Visually, pickleweed appears to be the most dominant species in the Lagoon, especially in the area between the trail and the main Lagoon. No quantitative data is available to support that observation, but it would be interesting to pursue. Despite apparent visual dominance, it has been shown to be the least common of the 3 dominant halophyte species in the transected area.

Of the 133 species found at Malibu Lagoon, only a total of 39 were counted in the transects, which indicates their limited distribution, and the curious dispersal pattern of species. The number of species varied both seasonally and within transects. A total of 3 species were noted only in September, and 12 only in April (Figure 3.6). This data reinforces the need to repeat the transects at different seasons in order to obtain a more comprehensive understanding of the plant community.

In September, only 8 of the total species counted (20) were common to all 3 transects. Sixteen species were found in only one transect, and transect #2 had the lowest overall number of species (9). The April survey recorded a total of 35 species, of which 26 were common to all three transects. Again, transect #2 had the lowest diversity in comparison to that found in #1 and #3, which could be due to the wide salt pannes and dryness of the center part of the peninsula.

The majority of species found are naturalized exotics and other native plants normally not found in estuaries. Malibu Lagoon has a very small number of estuarine species in comparison with those found in other Southern California salt marshes (Figure 3.7). These two facts are important points to be considered when planning further restoration of the Lagoon. Eradication of all exotics would be costly and difficult, but a management plan that allows for the enhancement of native estuarine species needs to be established.

Perhaps the major variable effecting both distribution and growth of plants in Malibu Lagoon is the soil salinity (Figure 3.8). As might be expected, the salinities were much lower in April following the winter rains. The range in September was from 0.448 ppt near the trail to 34.56 ppt across the channel near the driveway by the entrance kiosk, with an average of 11.6 ppt. In April, the higher peninsula area remained fairly constant at 0.512 ppt, but the salinity increased noticeably at the other end of the transect to 27.52 ppt, with an overall average of 6.84 ppt. Greater variety of species was noted in areas with soil salinities of less than 15 ppt, which corresponds to the first 30 meters of the transect. Highest salinities corresponded to salt pannes found along the transect where there was little or no vegetation. The salinity of soil samples taken from

Fig. 3.6 Species found in all transects, Malibu Lagoon, 1987-88

SPECIES	FALL	SPRING	CSM	NATIVE	NATURALIZED EXOTIC
Ambrosia psilotachya	x	x		x	
Anagallis arvensis		x			x
Atriplex lentiformis	x			x	
A. patula hastata	x	x			x
A. semibaccata	x	x			x
A. species?	x	x			
Avena fatua	x	x			x
Baccharis glutinosa	x	x		x	
B. pilaris		x		x	
Bromis diandrus	x	x			x
B. mollis	x	x			x
B. wildenovii		x			x
Chrysanthemum coronarium		x			x
Conzya sp.		x			
Coreopsis gigantea	x			x	
Cressa truxillensis		x		x	
Cuscuta salina	x	x	x		
Cynodon dactylon	x	x		x	
Distichlis spicata	x	x	x		
Enteromorpha intestinalis (*)	x	x	x		
Festuca sp.	x	x			x
Foeniculum vulgare	x	x			x
Frankenia grandiflora	x	x	x		
Gasoul nodiflorum		x			x
Gnaphalium sp.		x		x	
Hypochoeris glabra		x			x
Jaumea carnosa	x	x	x		
Lolium perenne		x			x
Lotus scoparius	x			x	
Medicago polymorpha		x			x
Melilotus indicus	x	x			x
Parapholis incurva	x	x			x
Pennisetum clandestinum	x	x			x
Picris echoides	x	x			x
Polygonum aviculare		x			x
Salicornia virginica	x	x	x		
Scirpus californicus	x	x	x		
Sonchus oleraceus	x	x			x
Spergularia marina	x	x	x		

(*) drift algae consistently found along channel banks
CSM - Coastal Salt Marsh Species

Fig. 3.7 Comparison of Southern California coastal salt marsh vegetation, prepared by Bob Muns, with information from Zedler, 1982.

		Coastal Salt Marshes Coastal Salt Marsh Species	TIJUANA ESTUARY	TORREY PINES SALT MARSH	UPPER NEWPORT BAY MARSH	BOLSA CHICA SALT MARSH	BALLONA WETLAND	MALIBU LAGOON	POINT MUGU LAGOON MARSH	CARPINTERIA SALT MARSH
Spike Rush	HIGH MARSH	JUNCUS ACUTUS	●	●	●	●			●	●
Goldfields		LASTHENIA GLABRATA	●	●					●	●
Alkali Weed		CRESSA TRUXILLENSIS	●	●	●		●		●	●
Salt Bush		ATRIPLEX WATSONII	●		●	●			●	●
Pickleweed		SALICORNIA SUSTERMINALIS	●	●	●	●	●		●	●
Salt Marsh Bird's Beak		CORDYLANTHUS MARITIMUS	●		●				●	●
Sea Lavender		LIMONIUM CALIFORNICUM	●	●	●	●		○	●	●
Shore Grass		MONANTHOCHLOE LITTORALIS	●	●	●	●			●	●
Alkali Heath		FRANKENIA GRANDIFOLIA	●	●	●	●	●	●	●	●
Succulent Arrow Grass		TRIGLOCHIN CONCINNUM	●		●			●	●	●
Sea Blite		SUAEDA CALIFORNICA	●	●	●	●	●		●	●
Salt Grass		DISTICHLIS SPICATA	●	●	●	●	●	●	●	●
Salt Marsh Dodder		CUSCUTA SALINA	●	●	●	●		●	●	●
Jaumea		JAUMEA CARNOSA	●	●	●	●	●	●	●	●
Saltwort	LOW MARSH	BATIS MARITIMA	●		●	●			●	
Annual Pickleweed		SALICORNIA BIGELOVII	●		●	●			●	
Pickleweed		SALICORNIA VIRGINICA	●	●	●	●	●	●	●	●
Cordgrass		SPARTINA FOLIOSA	●		●	●			●	

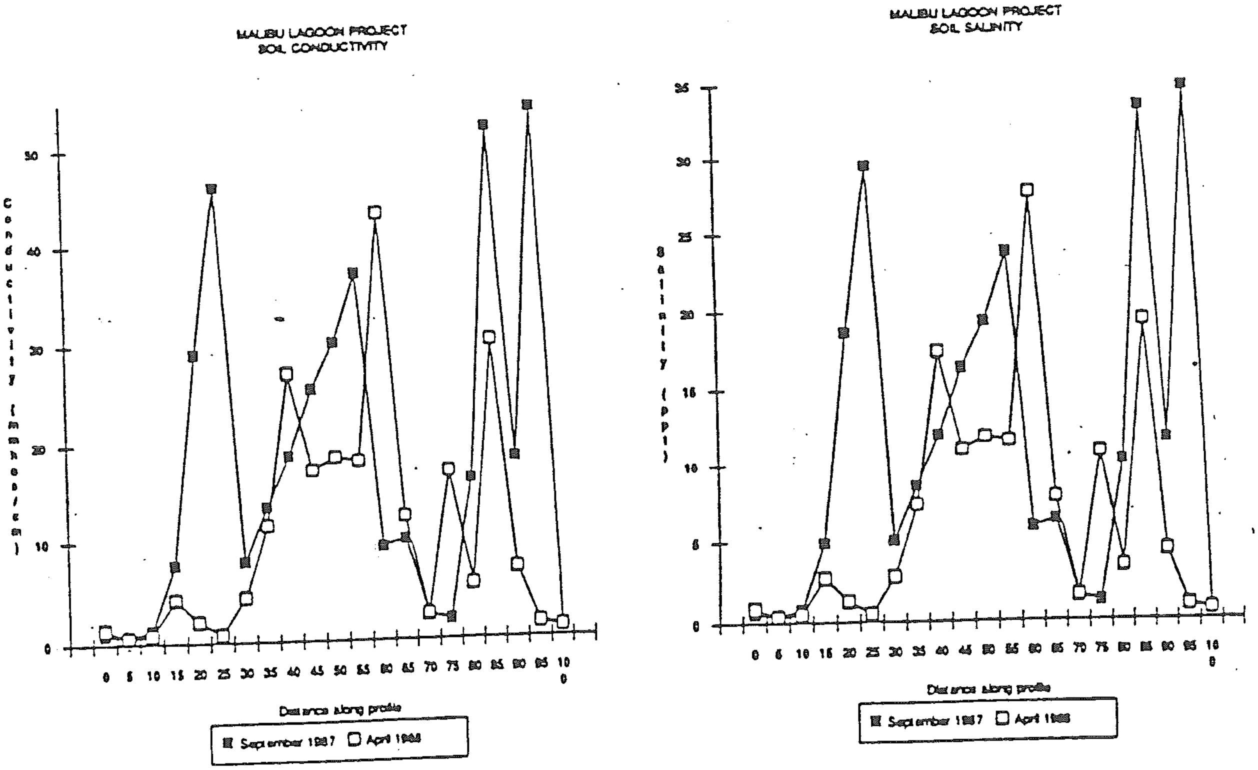
COMMON NAME

Fig. 3.8 Soil conductivity (mmhos/cm) and salinity (ppt) of transect #1, Malibu Lagoon, September 1987 and April 1988.

	September		April	
Distance Along Profile (Meters)	Conductivity (mmhos/cm)	Salinity (ppt)	Conductivity (mmhos/cm)	Salinity (ppt) --
0	0.9	0.57	1.4	0.896
5	0.7	0.448	0.6	0.384
10	1.2	0.768	0.8	0.512
15	7.6	4.864	4.2	2.688
20	29	18.56	2	1.28
25	46	29.44	0.8	0.512
30	7.8	4.992	4.3	2.752
35	13.3	8.512	11.4	7.296
40	18.6	11.904	27	17.28
45	25.4	16.256	17.1	10.944
50	30	19.2	18.4	11.776
55	37	23.68	18	11.52
60	9.1	5.824	43	27.52
65	9.8	6.272	12.1	7.744
70	2.4	1.536	2.4	1.536
75	1.9	1.216	16.8	10.752
80	15.9	10.176	5.2	3.328
85	52	33.28	30	19.2
90	18.1	11.584	6.7	4.288
95	54	34.56	1.4	0.896
100	1	0.64	1	0.64

* Questionable sample number due to difficulty reading sample label.

-- Conversion: mmhos/cm x 640 = ____mg/liter / 1000 = ____ppt



the channel did not change markedly over the winter season, possibly indicating a relatively stable interstitial environment.

3.5 DISCUSSION

It is known that two major limiting factors affecting distribution and density of estuarine vegetation are soil salinity and elevation along a tidal gradient. Due to the dredging of the steep-banked channels in Malibu Lagoon at the time of restoration, there has been a remarkably opportunistic recolonization, showing little zonation common to an undisturbed system. Normally, a 0.7% slope is needed to provide the periodically inundated substrates which foster more regular zonation patterns (Zedler 1982). Because some planting was done of both native and non-native species, there is a large diversity of species. According to the preliminary list, there are a total of 133 species represented in the area. Of these 5.3% are native to estuarine habitats, 29.7% are natives, but planted as part of the landscaping effort, and 65% are introduced species which seed themselves.

The influence of varied water levels and the erratic circulation pattern of the Lagoon channels also has a strong influence on the distribution of species. During times when the mouth of the Lagoon is closed, freshwater levels can get high enough to seriously effect more halophytic species such as pickleweed (Zedler 1982), as well as those whose root systems require periodic drying out. One other important consideration is the quality of the water in this system. During times of heavy rains and high tides, waste water from the storm drains and septic systemss of nearby houses have been observed in the back channels. The long term effects of introducing these nutrients, especially nitrates and phosphates, and other possible pollutants is unclear.

Freshwater outflow from the Tapia Water Reclamation Facility represents another problem. The volume of water released varies seasonally, which makes for erratic inundations of silt and other sediments, as well as nutrients such as nitrates and phosphates. When high volume corresponds to spring tides and the closure of the Lagoon entrance, the water level in the Lagoon rises dramatically. More consistent monitoring of the Lagoon water levels, fresh and salt, in the future will help explain patterns of vegetation distribution and density.

Inundation of fresh and salt water in turn influences the residual salinity of the soils. The normal ranges for Southern California estuaries extends from the 45 ppt usually found during the dry season/years, to a range of 15-20 ppt during the rainy season, to lows of 0-20 ppt in wet years (Zedler 1986). At Malibu Lagoon the data for September indicate a range of 0.44 ppt in the higher elevations to 34.5 ppt found in a small depression near the furthest edge of the back-channel, with a range of 0.57 ppt to 27.52 ppt in April. The soil salinity along the transect showed wide variation and repeated surveys need to be done before any consistent patterns along the transect will emerge. This data does correlate to the overall water quality information which would categorize Malibu Lagoon as a brackish, rather than salt marsh ecosystem.

Distribution of vegetation follows some unusual patterns as a result of high levels of disturbance. Starting at the higher elevations, species common to more upland habitats (roadsides, coastal scrub, cultivated areas, disturbed coastal habitats) dominate. Shrubs such as _Atriplex_ (sp.) and _Baccharis glutinosa_ are common. These plants are associated with exotic grasses and dry soils. The dominant vegetation for these areas consists of the grasses.

Moving towards the lower elevations from the upland area, it becomes clear that three halophytic species dominate the area, _Distichlis spicata_, _Jaumea carnosa_, _Salicornia virginica_. Despite the fact that visual observations would lead one to conclude that _Salicornia virginica_ is the dominant species, this proved false when actual counts were made. These plants are larger and woody, so that they are more obvious, but the truly dominant halophyte of Malibu Lagoon is _Jaumea carnosa_. The extended periods of fresh water inundation and steeper bank gradients seem to have provided a competitive advantage for germination and establishment of this species.

Along the channel banks, mats of drift algae (_Enteromorpha intestinalis_) were common. Periodic algal blooms occurred, but how these are related to nutrients provided by wastewater is not clearly documented. Several large stands of _Scirpus californicus_ are found along the NE banks. These were planted during the restoration process and their spread through the channel needs to be closely monitored. They provide necessary nesting habitat for numerous birds, but could overtake the whole channel if not managed.

Also conspicuously absent from any area in the Lagoon is Spartina foliosa, commonly known as Salt Marsh Cordgrass. This could be the result of numerous factors such as extreme soil salinity, insufficient tidal circulation, or erratic freshwater influx. It is not known whether Malibu Lagoon ever had any Cordgrass, but certainly the heavy manipulation of estuaries by man has had a tremendous impact on the presence of this species in other estuaries.

Consistent monitoring along these transects should be very interesting, as Malibu Lagoon seems to be somewhat different from other Southern California estuaries in its vegetative pattern. How long will Jaumea carnosa and Distichlis spicata dominate? How does the water circulation through the Lagoon effect growth along the channels? What is the average salinity of the water in the back channels? What effects do the nutrients from run-off have on growth rates of different species? There is still much to learn, and continued monitoring following Phase II of the restoration is essential.

Malibu Lagoon, like other estuaries, is a vital part of the entire ecosystem of the coast. As the press of humanity increases, it becomes even more important to maintain estuaries, not only for recreation and as wildlife habitat, but also because of the important role they play in recycling wastes naturally, enhancing watersheds and providing a buffer against storms. The flora of Malibu Lagoon are an essential basis for the stability of the entire Lagoon, and greater understanding of how the system functions will allow a well informed and useable management plan to be formulated.

3.6 SUMMARY

1. The reconstructed topography of Malibu Lagoon created steep channel banks which have been slowly filling in over the past 5 years to allow more natural tidal inundation patterns to return.

2. High volumes of fresh water influence the distribution of plant species, favoring those with greater tolerance to brackish rather than salt water.

3. There are 133 species thus far recorded at Malibu Lagoon. Of these, only 5.3% are native estuarine species. The majority (65%) are introduced and self-seeding exotics. Only 29.7% are native California species.

4. In contrast to other Southern California estuaries, Jaumea carnosa and Distichlis spicata are more prevalent than the more typical Salicornia virginica. Dodder (Cuscuta salina) preferentially parasitizes Jaumea. There is no evidence that any species of Spartina was present in Malibu Lagoon.

5. Future management of the Lagoon needs to carefully control introduced exotics and enhance the re-establishment of native estuarine species. Further information is also needed about the effects of nutrients introduced by runoff and water circulation patterns.

6. Malibu Lagoon provides a natural laboratory to document the restoration succession and patterns of vegetation in a disturbed ecosystem.

7. The flora of Malibu Lagoon is essential to the integrity of the ecosystem and allows the estuary to continue to act as a natural buffer zone against storms, recycle wastes and provide food, shelter and nursery areas for numerous organisms.

3.7 LITERATURE CITED

Ferren, W.R. 1985. Carpentaria Salt Marsh: Environment, History, and Botanical Resources of a Southern California Estuary. University of Southern California, Publication #4.

Ferren, W.R. 1988. personal communication to Jean Dillingham.

Muns, R. 1988. Flora of Malibu Lagoon. unpubl. pp. 4.

Munz, P. 1974. Flora of Southern California. University of California Press. pp. 1086.

Raven, P. H. et al. 1986. Flora of the Santa Monica Mountains, California. 2nd Ed. Southern California Botanists Special Publication No. 2. 181pp.

Richards, L.A. 1954. Diagnosis and Improvement of Saline and Alkaline Soils. U.S. Department of Agriculture. Agriculture Handbook No.60.

Zedler, J.B. 1984. Salt Marsh Restoration: A Guidebook for Southern California. La Jolla, CA: Sea Grant College Program, Institute of Marine Resources, University of California. pp.2.

Zedler, J.B. 1982. The Ecology of Southern California Salt Marshes: A Community Profile. U. S. Fish and Wildlife Service FWS/OBS-81/54. 110pp.

Zedler, J.B. and Nordby, C. 1986. The Ecology of Tijuana Estuary, California: An Estuarine Profile. U. S. Fish and Wildlife Services Biological Report 85(7.5) 104pp.

Zedler, J.B., R. Koenig and P. Magdych. 1984. Streamflow for the San Diego and Tijuana Rivers. San Diego Association of Governments. 51pp.

4.0 SEDIMENT SURVEY

4.1 INTRODUCTION

Sediments and currents, both in an estuary and along the beach, control those morphologic features which characterize any estuary. Deposition of sediments plays a crucial role in the distribution of benthic invertebrates. Most species are adapted to living within a narrow framework of sediment size and composition. The rate and type of sedimentation contributes to the establishment of benthic populations and their longevity (Komar 1976). At Malibu Lagoon, scouring and deposition of both fine and coarse sediments have led to the development of mud flats, tidal islands, sand bars, and relatively deep channels. These morphologic features control both the distance of salt wedge intrusion and the rate of tidal flushing.

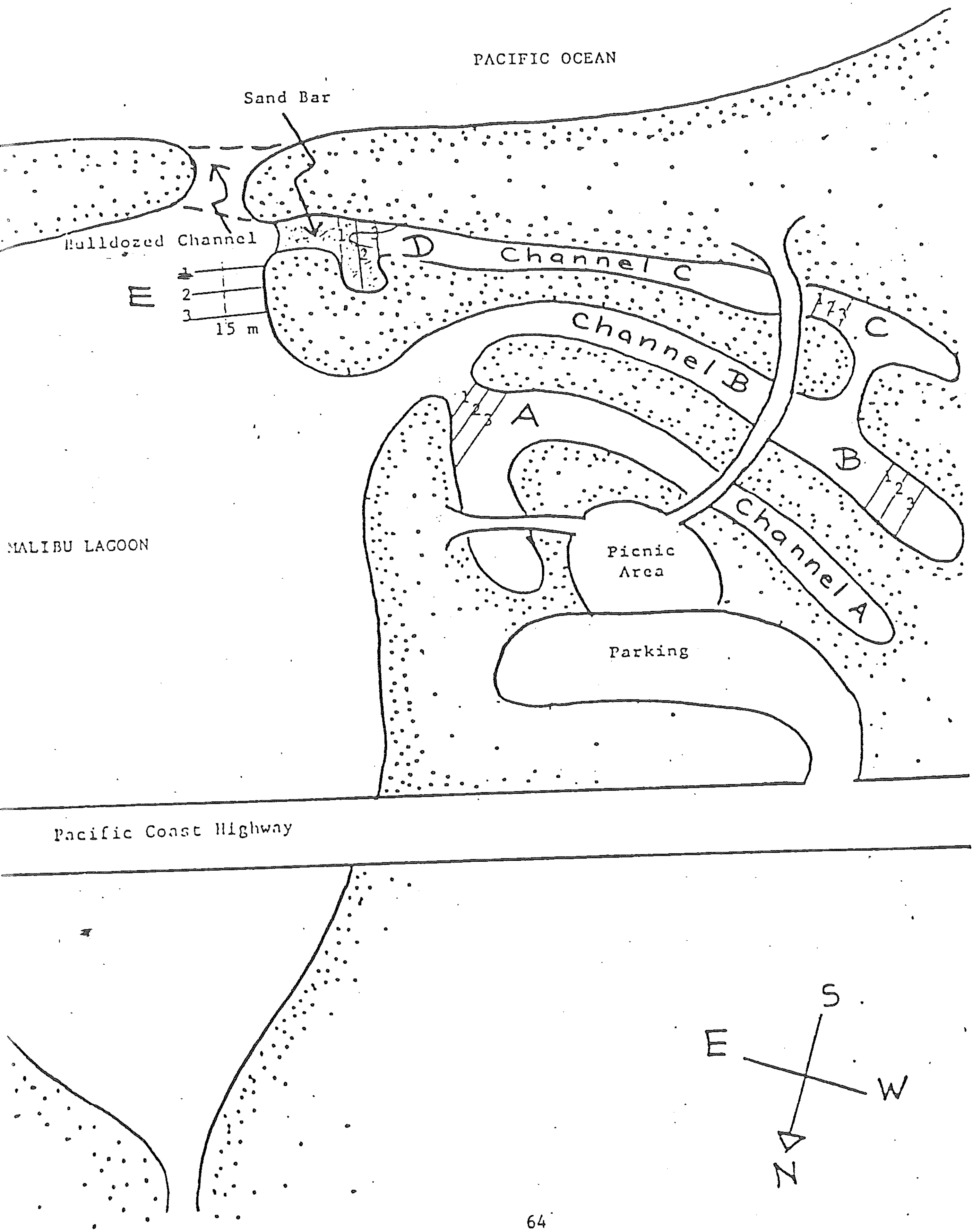
In 1983, approximately 36 acres of the Lagoon were restored. This included most of the study area where channels were dredged with U-shaped cross section and steep sloping banks. In the five year period since restoration the Lagoon has changed only slightly in morphologic features, with partial to complete infilling of the channels.

This is in sharp contrast to the Lagoon before restoration. Historically the study area was a flood plain, a vast consolidated upland area with features that contained grasses and small shrubs. The wetland area was significantly larger, and in the area of the present-day Malibu Colony was a large sand dune. Drainage from an extensive watershed flowed into the year-round Malibu Creek, characterized by very low flow during the summer months which allowed a sand spit to seal the ocean entrance. During winter storm periods, this entrance would be forced open by high water flows from the creek.

4.2 OBJECTIVES

The main objective of this survey is to study the distribution of sediments in the Lagoon as a measure of the recovery process after the 1983 restoration, when newly constructed clay-bottomed channels were free of any sediments. A second objective is to measure changes in sediment depth and composition in the Lagoon over time. By classifying and measuring sediments in core samples along different gradients at the Lagoon, a better understanding of this ecosystem may result.

MAP 4 A: SEDIMENT SAMPLING STATIONS AT MALIBU LAGOON



4.3 METHODOLOGY

All data is collected bi-monthly at five stations (A-E) located throughout the Lagoon (Map 4A). Surveys were made in November 1987 and January, March, and September 1988. Stations A, B, C, and D were sampled across an entire channel. Station E was sampled for at least 30 m into the main Lagoon. During each survey only one transect was made at each of the stations. In order to not unduly damage these soft sediment habitats the transects were offset by 20 feet for each survey. This offset is not believed to have biased the results since the stations appeared to be relatively uniform between transect lines. In all cases the western-most transect is labeled 1, with transect numbers increasing to the southeast. Three different transects were made at each station.

Samples are taken at 5 meter intervals from a fixed point on both banks, beginning and ending at the edge of the vegetation. A large core device, 15.6 cm in diameter and 61.5 cm long, is used to collect the sample (Fig. 4.1). This sample is examined and described. Information recorded includes: total depth, presence and width of any layers, a qualitative description of grain size and composition (organic vs. inorganic) and the presence of organisms.

At each of the sampling locations, a metal meter stick is manually pushed into the sediment as far as it will go. During the 1983 Lagoon restoration the channels were cut out of consolidated clays (Hasz 1983) which are essentially impenetrable by hand. Therefore, this technique provided an approximate measure of sedimentation over time. These measurements also give some indication of recent patterns of sedimentation or erosion.

4.4 OBSERVATIONS

The main Lagoon substrates are composed mainly of coarser grained sediments, mostly smaller cobble, gravels, and sands. At edges of the peninsulas on the west side of the Lagoon are short, almost vertical banks composed of clay, which were formed during the restoration process. Vegetation in this area is on top of the flat peninsulas, and none is evident along the shoreline. The seaward edge of the Lagoon is bordered by a spit composed of beach sands.

Stream flow from storms, and from tertiary treated sewage wastewater generated by the Tapia Water Reclamation Facility, maintained an open entrance throughout the winter months. Major storms in late October and December 1987, and in January 1988 scoured a channel through the Lagoon, maintaining an entrance until mid-April. A late arctic storm in April again flushed out the entrance channel, yet the entrance to the

Fig. 4.1 Diagram of sampling device used at Malibu Lagoon for sediment and invertebrate infauna surveys.

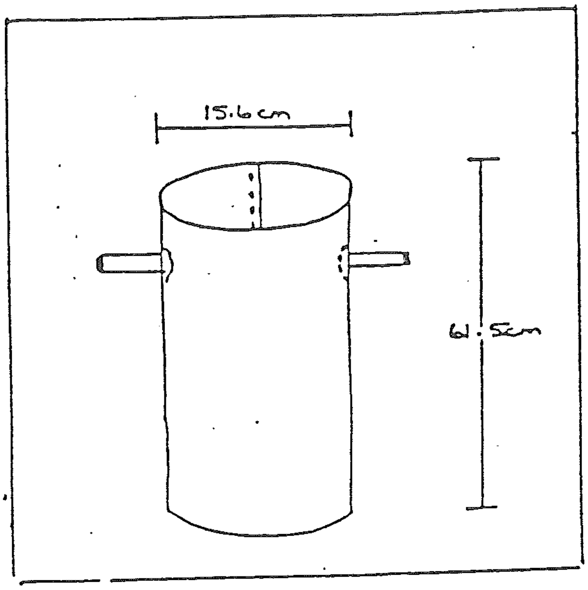


Fig. 4.2 Average amount of sedimentation in channels at 5 stations within Malibu Lagoon since 1983 restoration; includes changes in sedimentation patterns, Nov. 1987 - Sept. 1988.

STATION	AVER. SED. DEPTH (cm)	CHANGES IN SEDIMENTATION PATTERNS
A	40	-
B	43	-
C	36	-
D	extremely variable	15 m-wide sandbar formed beginning in October 1987 blocks water circulation in Channel D (Map 4 A) when water levels are below 2.75 ft.
E	*24	Winter 1987 storms eroded sandbar beyond 15 m from shore, by approximately 21 cm.

* average depth, 5-15 m from shore

Lagoon was closed after only three days. From this period on, California Department of Parks and Recreation (DPR) has experienced difficulty in maintaining an open entrance, with six closures noted in just eight weeks. When Lagoon water levels exceed 3.5 ft, DPR is mandated to open the entrance to the Lagoon near Malibu Colony. The longshore transportation of sand along the ocean beach and tidal action bring sand through the entrance, where it is deposited in slower moving water in areas near the entrance. Tidal action also brings in organic material, in the form of drift coastal algae, which is deposited both in the main Lagoon and inlet channels.

When left unmanaged, the sand bar at the entrance gradually moves eastward, toward Malibu Pier. Beginning in October 1987, when a deep water channel existed at the managed entrance location, a meander began to develop in the channel, with the formation of a sand bar on the west side. By the beginning of December, the sand bar had increased substantially to the east (approximately 600 m from a marked signpost), and the channel showed a strong oxbow configuration. In early May, this natural entrance was filled with sand by Los Angeles County Lifeguards, followed by a new entrance, cut at the former "managed site" near Malibu Colony.

Station E, the only study site within the main Lagoon, appears to be subject to alternating periods of rapid deposition and erosion. A sand bar of medium to coarse grained sand had been previously deposited along the west shore of the Lagoon. This sand bar extended at least 45 m eastward across the Lagoon. It was maintained from September 1987 through January 1988. Between January and March 1988 extensive erosion occurred, removing that portion of the sand bar which extended more than 15 m from shore. The thickness of sediments at distances greater than 15 m from shore decreased by approximately 21 cm.

All of the stations within the dredged channel system (A, B, C, and D) showed a significant amount of infilling since the 1983 restoration (Figure 4.2)

Station D, at the entrance to Channel C is the site nearest the ocean entrance and has been subjected to rapid deposition. Much of the channel was infilled between the January and March 1988 surveys, with sands overlaying sediments composed of fine sand mixed with some mud. The development of a small sand bar, 15 m in width, at the entrance to this channel (Map 4A) in October 1987 has affected the patterns of water movement when the levels in the Lagoon are below 2.75 ft. At lower water levels, water on outgoing tides must exit from the B channel. Drift coastal algae is often deposited, adding pockets of organic material. Sediment depths have increased in this channel by about 18 cm on the north side, and <u>Salicornia virginica</u> has begun to colonize this area.

Station C has the most diverse sediments of the survey. These vary from light colored beach sands to highly organic black silts and muds. A large amount of sedimentation has occurred here since the 1983 restoration, averaging 36 cm at the center of the channel. However no measureable changes occurred during this study. Drift coastal algae is often carried as far up as this study site.

The furthest study site from the main Lagoon and the channel entrance is Station B. This is the best example in the Lagoon of a mudflat. Sediments are deep, mostly unconsolidated fine, organic muds in the center of the channel, grading into some coarser silts and fine sands near the edges of the salt marsh vegetation. This vegetation, dominated by Jaumea, is encroaching into the channel, approximately 2 m on the north side and almost 4 m on the south side. Sediment thickness at this location has not changed significantly during this study. The average thickness of sediments deposited since 1983 in the center of the channel was 43 cm. There is a shallow, but well-defined channel for water in the middle of the inlet. At low tide, the mud-flat is usually exposed. Elevations of the peninsula between channels B and A has also increased, with an average of 18 cm more sediments noted in the April 1988 vegetative survey than was recorded in September 1987.

Station A is near the exit of two small inlets which enter the main Lagoon. This study site is composed of highly organic fine muds and clay. Drift algae and holdfasts are regularly carried, and deposited in this channel by tidal currents. The average thickness of the sediment in the center of the channel at Station A was 40 cm.

Water circulation patterns in the Lagoon remain largely unstudied. Observations made during a 24 hour survey in June 1988 indicate that when the entrance to the Lagoon is opened by the bulldozer, water flows faster out of Channel C than from Channel B. Flow out of both channels have been clocked at a 1 inch drop in water level in slightly less than 2 minutes. It is only when water levels in the Lagoon drop below 2.75 ft. that circulation patterns in the inlet channels change. At that point the sand bar at the mouth of Channel C is exposed, and water from all the inlets must flow out Channel B.

4.5 DISCUSSION

From these surveys, trends in sedimentation patterns and distribution of sediments, including sand spit growth along the beach, have been noted. The general circulation patterns observed may affect the distribution of sediments throughout the Lagoon.

Sedimentation patterns reflect both the patterns of water movement and the velocity of flow. As expected, faster moving water near the creek and ocean entrance results in the deposition there of coarser particles (cobble, gravel, and sand). Slow flowing water carries fine sediments (mud, silt, fine sand) into the inlets. The addition of drift coastal algae was noted in all study sites except Station B and provided material which is eventually incorporated into sediments as a major organic component. Water circulation patterns in the Lagoon remain to be studied if the sedimentation patterns are to be fully understood. For instance, the building of a sand bar at the entrance of C channel has significantly altered water flow patterns in the B and C inlets, directing all flow through channel B when water levels are below 2.75 ft. The result is that water often stagnates at Station D.

Sediments carried during storm activity and by large volumes of fresh water from the Tapia facility most likely accelerate the rate of downstream deposition. As stream discharges increase, the sediment load which a stream can carry increases proportionally (Lutgens and Tarbuck 1986). Measurements of the present carrying capacity of Malibu Creek and downstream sedimentation in Malibu Lagoon need to be made. Management of an ocean entrance to maintain water quality in the Lagoon throughout the year has surely increased the rate of deposition of both sand and organic material (drift algae) near this managed entrance. During periods of natural closure, from April until the first winter storms occur, no deposition would be expected to occur by ocean transport.

During periods of closure, water continues to enter the Lagoon from the Tapia plant and from Creek drainage. Due to difficulty in getting the one bulldozer to the Lagoon to open the entrance when water levels reach the mandated 3.5 ft, water volumes in the Lagoon are often high, reaching levels as high as 5.2 ft. The management of the position of the entrance has been debated among homeowners in the Malibu Colony and the surfing community, and the L.A. County Department of Beaches and Harbors, who provide lifeguard services for the outer beach. The natural entrance to the Lagoon, which is to the east of the managed entrance, prevents lifeguard vehicles from reaching the lifeguard tower near Malibu Colony. The provision of an emergency vehicle at this site would end any need for management of the entrance for emergency lifeguard services.

Since water exits rapidly upon opening of the entrance, fine sediments may be carried away. Station B is least affected by the rapid drop in water levels as the shallow configuration of its channel holds low volumes of water. The deeper channel configuration found at Stations A, C, and E can carry larger volumes of fast-moving water, and has the potential of moving greater amounts of sediment. The scouring capacity of water was exemplified by the rapid erosion of the sand bar at Station E in the main Lagoon in January 1988, when a major storm occurred in conjunction with a very high tide. Waves were breaking into the Lagoon. The storm cut a channel through the beach berm and the water level dropped quickly with the rapidly outgoing tide (about 1 in/5 min). The scouring we observed at Station E is likely to have occurred during this period.

The compromise position of the entrance has clearly affected sedimentation patterns in the Lagoon. Deposition of beach sand will always occur at the mouth of the Lagoon. Any channel located near an ocean entrance will quickly fill with sediment. Therefore, the position of the Lagoon entrance cannot be near a restored channel if that channel and associated water circulation patterns are to be maintained. For proper management of Malibu Lagoon the choices are to move the main Lagoon entrance eastward, or alter the channel configuration.

Historic patterns of sedimentation and water flow in the Lagoon indicated a slow progression of infilling which was also noted in this study. It is likely that increased water flow from the Tapia facility will accelerate this process. A management plan needs to be developed by the agencies and organizations who affect the entire watershed so that a comprehensive management plan can be developed for the future. What occurs upstream and along the beaches clearly affects the Lagoon.

4.6 SUMMARY

1. The rather deep channels designed and built during the 1983 Lagoon restoration project are filling with sediment. Grain size of the sediment varies with water velocity and volume in each channel.

2. Beach sands are deposited inside the mouth of the Lagoon. Because of the proximity of the Lagoon's managed entrance to Channel C these deposits are filling the opening to this inlet (Map 4A).

3. The Tapia Water Reclamation Facility plans to increase its discharge of tertiary treated waste water into Malibu Creek. The resulting increase in water flow will increase the volume of sediments deposited in the Lagoon by an unknown amount.

4. Opening of the entrance needs to be timed to coincide with an outgoing high tide for the entrance to remain open for any time. To minimize the removal of sediments, water levels should not be permitted to rise above the mandated 3.5 ft. More regular opening, or a permanent method of regulating water flow to the Lagoon needs to be considered in the final management plan.

5. This study has only touched on the information needed concerning sedimentology and patterns of water circulation in Malibu Lagoon. Future studies should include:

- a. direct measurement of depositional and/or erosional rates
- b. circulation patterns within the Lagoon
- c. salt wedge intrusion
- d. beach berm height
- e. mapping the natural migration of the Lagoon entrance over time
- f. monitoring the volume of water in Malibu Creek

6. The management of the entire watershed by those agencies and organizations affecting it are clearly needed if Malibu Lagoon is to become a functional estuary.

LITERATURE CITED

Davis, R.A, Jr. 1983. Depositional Systems- A Genetic Approach to Sedimentary Geology. Prentice Hall.

Hasz, L. 1983. Malibu Lagoon: A Local Resource. CSUN. unpublished. pp.10.

Kennett, James. 1982. Marine Geology, pp. 286-298. Prentice Hall. pp.787.

Komar, Paul, D. 1976. Beach Processes and Sedimentation, pp.203-223. Prentice Hall.

Lutgens, Frederick K. and Edward J. Tarbuck 1986. Essentials of Geology, 2nd edition, Charles E. Merrrill Co. pp.346.

Nordby. C. and J. Covin 1988. Physical, Chemical and Biological Monitoring of Los Penasquitos Lagoon. Los Penasquitos Foundation. Unpublished.

U.S. Congress, Office of Technology Assessment. Wastes in Marine Environments, 1987. OTA-O-334 (Washington, D.C.; U.S. Government Printing Office. pp.304.