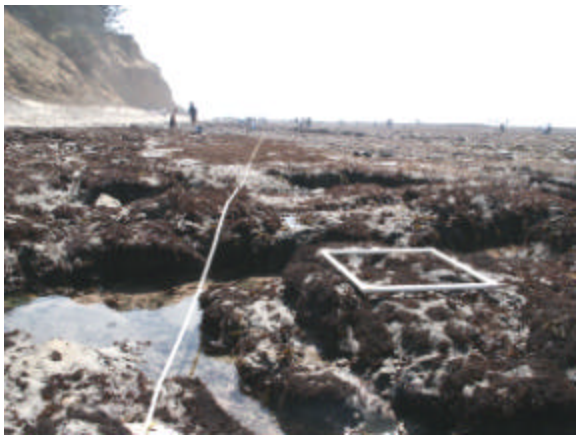
*San Mateo County Parks and Recreation Division*

# James V. Fitzgerald Marine Reserve: Resource Assessment



Moss Beach Reef, Fitzgerald Marine Reserve.

**November 17, 2004**

***Prepared for:***

San Mateo County Environmental Services Agency
Parks and Recreation Division
455 County Center
Redwood City, CA 94063

***Submitted by:***

TENERA Environmental

971 Dewing Ave., Suite 101, Lafayette, CA 94549
925.962.9769. FAX: 925.962.9758

225 Prado Rd., Suite D, San Luis Obispo, CA 93401
805.541.0310, FAX: 805.541.0421

ESLO2004-58.1

# Table of Contents

# List of Tables

# List of Figures

# Preface

The James V. Fitzgerald Marine Reserve (as of January 1, 2002) is classified by the California Department of Fish and Game as the James V. Fitzgerald State Marine Park (see below, *Section 6.0 – County Park Management*). This change was brought about by the re-classification of all marine protected areas in California into a common system of designations that reflects the levels of protection to the resources in the areas and the allowable and non-allowable uses. Previously, the names of California's marine protected areas included terminology such as 'refuges', 'reserves', and 'parks', but these terms were not consistently applied and did not reflect the level of protection. We anticipate that many people will continue to refer to the area as the James V. Fitzgerald Marine Reserve. However, in this report we use the new classification system, which is being used by the State's resource agencies. In addition, in the new classification system 'reserves' (i.e. State Marine Reserves) are fully protected from all extractive uses including fishing; hence, the term 'reserve' does not reflect the current level of resource protection in the James V. Fitzgerald Marine Reserve. Therefore, we will refer to the James V. Fitzgerald Marine Reserve as the James V. Fitzgerald State Marine Park or 'Park' in this report.

# Project Organization

**Project Manager**

Samuel Herzberg – San Mateo County Parks and Recreation Division

**Tenera Environmental**

Scott Kimura – Principal Investigator
John Steinbeck – Principal Investigator

Field Team
Jay Carroll
Joel Carter
Andrew Harmer
Steve Pengilley
Shelly Peters

**Scientific Advisor**

Steve Murray, Ph.D. – California State University, Fullerton, Biology Department

**Technical Advisory Committee**

Robert Breen – San Mateo County Parks and Recreation Division, Ranger at Fitzgerald; Friends of Fitzgerald
Mark Carr, Ph.D. – U.C. Santa Cruz, Biology Department
Susan Danielson – Save Our Shores
Mary DeLong – Friends of Fitzgerald, President
Sandy Emerson – Mid-Coast Community Council
Barbara Kossy – Neighborhood representative
Ralph Larson, Ph.D. – San Francisco State University, Biology Department
Steve Lonhart, Ph.D. – Monterey Bay National Marine Sanctuary
Bruce MacKimmie – Local sport fishing representative
Dave Moore – San Mateo County Parks and Recreation Division, Superintendent
Tom Niesen, Ph.D. – San Francisco State University, Biology Department; Friends of Fitzgerald
Pete Raimondi, Ph.D. – U.C. Santa Cruz, Biology Department; Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO)
Pietro Parravano – San Mateo County Harbor District
Jan Roletto – Gulf of the Farallones National Marine Sanctuary
Jennifer Vick – Golden Gate National Recreation Area

**Student Participation**

Aura DeMare – San Francisco State University
Nancy Levine – U.C. Berkeley

# Acknowledgments

This project could not have been completed without the assistance of many people. We would especially like to recognize the Friends of Fitzgerald organization. This volunteer organization, which is dedicated to enhance educational outreach and habitat preservation at the Fitzgerald State Marine Park, provided valuable assistance in successfully completing several components of the project. Many 'Friends' worked on the visitor count surveys. This work required nearly a daily presence at the Park, and would not have been completed without their assistance. Special thanks go to Tom and Linda Ciotti who helped with scheduling volunteers for the visitor counts. In addition, Justin Holl and Sara Kimberlin donated a considerable amount of time on computer entry of Park data.

We also relied on others to provide us with background and orientation to the Park, historical information, and access to Park records. Ken Vicknaire used knowledge gained from leading many classes to the Park to orient us on the ecological setting. Park Ranger Steve Durkin updated and summarized the Park's visitor attendance logs and furnished enforcement and surveillance records for this report.

Two students assisted in the project, and used their studies to partially fulfill college requirements. Aura DeMare (graduate studies, San Francisco State University) provided much of the Geographic Information System resource mapping and associated aerial photography. Nancy Levine (undergraduate studies, U.C. Berkeley) completed an owl limpet (*Lottia gigantea*) population study at the Park, which is summarized in this report.

All of the Technical Advisory Committee members for the project are also to be thanked for donating their time to help refine project objectives, study approaches, the resource assessment, and management considerations.

Lastly, Mr. Bob Breen, a former ranger at the Park, provided a wealth of information for this project gained from his long-term contributions to resource monitoring, enforcement, and education. Throughout his career, he was self-directed and realized at an early stage the importance of establishing documentation on attendance at the Park and data on biodiversity. His professional role at the Park will be missed, but his sharing of knowledge and interest for the health of the Park continues.

# Executive Summary

Intertidal areas along rocky shorelines have become increasingly popular attractions for tourists, students, and the general public because they provide easy access to a wide variety of interesting marine life in tidepools and other habitats, including shoreline areas for fishing. The intertidal zone is the portion of shore that becomes covered and uncovered with water with the changing tides. However, the increased numbers of visitors to these areas can result in environmental impacts through trampling, rock turning, mishandling organisms, and collecting.

## Study Purpose

This study was initiated as a result of concerns by the California State Department of Fish and Game (CDF&G) and the County of San Mateo (County) about the potential impacts from current levels of visitor use, potential increases in future visitor use, and the effectiveness of present management and regulations in protecting the health and viability of the marine life in the James V. Fitzgerald State Marine Park. The need for the study was one of the recommendations in the Fitzgerald Marine Reserve Master Plan (Master Plan) (Brady/LSA 2002), and was the basis for obtaining a grant from the National Oceanographic and Atmospheric Administration (NOAA) to support the project. Tenera Environmental (San Luis Obispo, CA) completed the study during the spring and summer of 2004. The study summarizes existing data on visitor use and marine life in the Park, provides new data on the distribution and abundance of marine life relative to visitor use, and offers suggestions for future monitoring and management of Park visitation to protect marine resources.

## Background

Formerly known as the James V. Fitzgerald Marine Reserve, the State Marine Park is located in San Mateo County and within the Monterey Bay National Marine Sanctuary. The Park is approximately 3 mi (5 km) long, and includes a complex of broad intertidal rock platforms and small pocket beaches. The San Mateo County Parks and Recreation (County Parks) and the California State Department of Fish and Game (CDF&G) share joint custodianship for the natural resources in the Park. CDF&G has regulatory authority within the Park below the mean high tide level, and County Parks has regulatory authority above the mean high tide level. County Parks has assumed the overall day-to-day protection of the Park's natural marine resources. State Marine Park regulations prohibit the collecting of algae (seaweeds) and invertebrates (e.g., abalone), but recreational fishing is allowed.

## Levels of Visitor Use

The Fitzgerald State Marine Park receives over 100,000 visitors each year, and is one of the most frequently visited rocky shorelines in California. There are several reasons for the high levels of visitation. The State Marine Park is within easy driving distance from dense metropolitan areas of San Francisco Bay. Above the mean high tide line, San Mateo County owns and maintains a parking lot with restrooms, a picnic area, and an access path that leads to the intertidal zone. The flat, rocky intertidal platforms nearby make it easy for visitors to access and explore tidepools. The most concentrated visitor use occurs along Moss Beach Reef adjacent to the main access path. Our census surveys and questionnaire poles substantiated that the main attraction of the Park is its natural resource values coupled with ease of access. Most visitors explore the richly diverse tidepools for education, relaxation, or simply out of curiosity. The Park is a particular strong attraction for school children, which can account for half of the attendance during spring.

## Study Approach

During spring and summer 2004, we conducted surveys with the Friends of Fitzgerald volunteer organization on visitor numbers and their activities, and obtained public input on use of the Park through a questionnaire. We also sampled the condition of the shoreline biological communities using standard biological sampling methods. The high use area of Moss Beach Reef at the main access trail was sampled and compared to areas located south in the proximity of Frenchman's Reef where visitor levels tend to be much lower. Our study included data analysis of a unique study done by County Park rangers of intertidal areas that have been periodically roped off from visitor access since 1994. These areas were compared with unroped areas exposed to visitor access.

## Findings

Our studies did not produce conclusive evidence that current levels of visitor use are negatively impacting the intertidal biota at the Fitzgerald State Marine Park, Moss Beach Reef in particular. This included algal and invertebrate assemblages, mussel beds, sea stars, and intertidal fishes. One of the most important findings was the variation in the numbers and types of plants and animals found over relatively small areas. This variation can result from a number of natural factors (e.g., substrate differences, wave exposure, biological community interactions), which can mask effects from visitor use. Therefore, in this study we could only attribute differences between areas of high and low use to the effects of visitor use if the differences involved a large number of species that were susceptible to collecting, handling, and trampling. Using these criteria, our studies did not detect any differences that could be conclusively linked to visitor use. Overall, we found the Moss Beach Reef intertidal zone to be as diverse and variable in species composition, abundance, and distribution as comparable areas with lower levels of visitor use.

However, this finding should be treated with caution, due to the short duration of the study and the absence of prior data enabling rigorous tests of impact hypotheses. Even though our studies were not able to detect statistically significant effects of visitor use, we do not conclude that there were no impacts. With over 100,000 people visiting the State Marine Park each year, there are undoubtedly impacts that likely occur on a constant basis from trampling, handling, and collecting. While our results showed that Moss Beach Reef was as diverse as areas with less visitor use, it could have been more diverse historically, and could have declined in diversity to levels similar to the areas we studied with less visitor use. There was no means to determine historical levels of species diversity, other than assuming that current conditions in low use areas represented natural conditions. Also, impacts have probably been reduced due to a bus reservation system started in 1994 to control visitor numbers, an increased number of docent-led school trips assisted by the Friends of Fitzgerald, and surveillance enforcement efforts by San Mateo County Park rangers, which has reduced the number of collectors and number of organisms collected over time. If not for these efforts, negative impacts could have been greater during our study and more apparent.

We hypothesized that the study of roped and unroped plots would yield some evidence of visitor impacts, but no strong conclusions could be drawn regarding the effectiveness of limiting visitor access as a means to increase the abundance of intertidal biota. We analyzed the data from the 1994 and 1998 study years and found that while the abundances of some species in the roped plots increased relative to the unroped plots, others decreased. The mixed results indicated that excluding visitors did not substantially alter the nature of the biological communities in the test plots. We sampled other areas of Moss Beach Reef exposed to visitor use, and found species that were actually higher in abundance in other unroped areas than in the roped test plots. This further demonstrated the presence of large spatial variation of marine life on Moss Beach Reef, which is why it was difficult to attribute any of the differences between the roped and unroped areas to different levels of visitor use.

Certain edible invertebrate species, such as black abalone and owl limpets, are at risk of depletion through illegal collecting. We found both species to be generally scarce in the Park, probably in part because of limited suitable habitat. If substantial collecting were to occur, the populations would be at risk of depletion.

According to Park rangers, black turban snails were among the species most commonly collected illegally. Of the areas that we sampled we found that black turban snails were least abundant on Moss Beach Reef (high use area), suggesting that the lower abundances may have been due to illegal collecting. However, by examining the shell size distribution among areas we found greater numbers of small individuals in the areas outside of Moss Beach Reef. Hence, the observed differences in turban snail abundance may have been related to spatial variation in recruitment within the Park and not to visitor impacts.

The recreational shore fishery at the Park remains popular even though the number of anglers per year has dropped by nearly 80% since records were first kept in the early-1970s. The Park is

unique in supporting a 'poke-pole' fishery for monkeyface eels and rock pricklebacks. Surfperch, lingcod, cabezon, greenling, and rockfish are also caught in the Park. Records collected by Park rangers for the period 1980-2002 revealed that 'catch per time spent fishing' for monkeyface eels and rock pricklebacks has been variable from year to year, but has declined slightly over time, first noted in data reported up through 1992 by HLA (1993). A decline also occurred in surfperch catches. However, occasional peaks in catch per time spent fishing for these species reveal that the area still provides good fishing opportunities. Fishing success has always been low for lingcod and cabezon because of their naturally lower abundances, but recent restrictions on catch sizes of these species throughout California have also contributed to lower overall catches. All of the fish species targeted by shore fishers have populations that extend over broad areas of the near- and offshore subtidal. Therefore, there is a low likelihood that areas closely fringing the Park could become fully depleted of fish through shore fishing activities alone, as movement of fishes from unfished areas could potentially replenish local populations. However, size measurements of the fishes caught were not obtained in the fisher interviews over time, so there is no information on how the quality of fish (weight and lengths) may have changed. A decline in fish lengths could be indicative of overfishing.

## Park Values and County Management Plans

In recognition that much of the Park use is related to educational activities, the Parks and Recreation Division of San Mateo County has been active in developing a comprehensive management plan (Fitzgerald Marine Reserve Master Plan (Brady/LSA 2002) to increase both educational opportunities and resource stewardship at the Park. Prior to this document, there has never been a guiding management plan for the Park. A Master Plan was proposed in the 1970s, but was never adopted. The current Master Plan was developed over the period 1997-2004, which included a number of environmental reviews and 17 public workshops and meetings. The adoption of the Master Plan by the County Board of Supervisors is scheduled for December 2004.

The current Master Plan approach focuses management actions on ways to foster marine science appreciation and greater awareness of the sensitivity of the marine life to visitor disturbances. Among the action items is the design and construction of a Marine Science Education Center at the Park to not only enhance visitor education but also to allow visitors to experience some of the shoreline resources without directly accessing the tidepools, thus potentially lessening negative impacts.

The following management considerations were developed with an expected change in use in mind and the same commitment to the Fitzgerald Marine Reserve Master Plan objectives in protecting the natural resources. Greater detail on management considerations is provided at the end of this report in **Section 7**.

The Marine Science Education Center could change how people use the area. Currently, peak visitation occurs for 1-3 hours around low tide during daylight hours coupled with nice weather. The Education Center could result in overall visitation levels in the area becoming spread over longer periods of the day, over more days, and independent of weather and tides.

A challenge in managing visitor attendance will be the Fitzgerald Marine Reserve Master Plan's goal of limiting visitor use to 500 people per day with a not-to-exceed maximum of 300 people on the shore at any given time, as past levels have frequently exceeded these limits. This 'carrying capacity' goal was recommended by HLA (1993), and the limits were incorporated in the Master Plan. The recommended limits were 'targets' for reducing visitor use, but were not expected to eliminate the concerns for visitor impacts and the need for management. In order to limit visitor levels to 500 people per day, school field trips could be limited to 300 students per day or lower, which would allow for an additional 200 non-school related visitors per day.

Because the Education Center could change how people use the area, new visitor counting methods may likely be needed to distinguish the numbers of people visiting the Center from those visiting the intertidal zone. Historically, numbers of people visiting the intertidal zone were estimated by counting cars in the parking lot. However, many people may only use the Education Center. Therefore, another method will be needed to distinguish counts of those visiting the intertidal zone from those only visiting the Center. For example, a turnstile or infrared counter at the head of the main access path would provide direct counts of people using the intertidal zone.

Many other rocky intertidal zones in California that are near urban areas also experience high levels of visitation. Resource managers in these areas are confronted with similar issues of balancing resource conservation with continued access. Accordingly, we feel that the planning and implementation of additional resource conservation measures at the Park to minimize impacts, including continued biological and visitor monitoring are warranted.

We suggest that San Mateo County actively collaborate with other agencies and groups with similar management goals to refine management objectives, action priorities, and monitoring methods. We include a set of management considerations in **Section 7** for collaborating with others to help ensure protection of existing resource conditions with the possible changes in visitation, future management changes, and operation of the Park.

Because over 99 % of the use in the State Marine Park is centered on education, an additional goal of the Fitzgerald Marine Reserve Master Plan is to have the area designated exclusively for this use by the CDF&G. An increased level of resource protection would exclude recreational fishing, which presently accounts for 1 % of the use in the Park. Restricting fishing would effectively change the State Marine Park to a 'no-take' area (i.e., State Marine Reserve). This change in status could only occur through the CDF&G Marine Life Protection Act (MLPA) process, which was established to create an improved network of marine protected areas in the State. The current MLPA process is focused on central California, and may include the James V. Fitzgerald State Marine Park.

# 1.0 Introduction

## 1.1 Purpose

The results of this project provide a quantitative description of species diversity and visitor use in the intertidal zone of the James V. Fitzgerald State Marine Park. The purpose of the project was to:

- Describe the historical status and trends of visitor use profiles and intertidal marine resources in the Park area.
- Identify what relationships exist between levels of visitor use in rocky intertidal habitats and potential visitor impacts (e.g., trampling, gathering, and fishing) on the condition of the Park's natural resources.

We also use the information contained in this report as the basis for a resource stewardship program to:

- Provide management options for limiting visitor impacts to the best extent practical in concurrence with the Fitzgerald State Marine Park's Master Plan objectives (Brady/LSA 2002).
- Provide a framework for a long-term monitoring plan to improve baseline data for future scientific research, and to evaluate the effectiveness of Master Plan objectives.
- Evaluate the match between the long-term goals and objectives of the San Mateo County Parks and Recreation and resource protection goals of the Marine Life Protection Act.

## 1.2 Background

The James V. Fitzgerald State Marine Park was created as the James V. Fitzgerald Marine Reserve in 1969 through legislative action. Beginning in about 1908, when the Ocean Shore Railroad was constructed through the town of Moss Beach, the reefs of the Moss Beach area were widely used for gathering food. In the 1960s, San Mateo County managers realized that continuing population growth in the area and the harvesting of marine organisms from the rocky reefs had the potential to deplete local marine populations. Accordingly, San Mateo County proposed that the State of California acquire the Moss Beach reefs as a state reserve in recognition of the need for increased resource management and protection. The reserve (Park) was named after a former chairman of the San Mateo County Board of Supervisors.

The Fitzgerald State Marine Park is located in Moss Beach, California, approximately 17 miles (27 km) south of San Francisco (**Figure 1-1**). The Park is approximately 3 miles (5 km) long and extends 1,000 ft (305 m) offshore from the mean high tide line to include subtidal habitats to


**Figure 1-1**. Location of the State Marine Park and coastal segments used in visitor surveys. Arrows indicate access paths.

depths of approximately 20 ft (6 m). The Park has long been recognized for its extensive reef systems (**Figure 1-2**) and for being among the most biologically diverse habitats in California. It has been and remains a popular area for school groups, tourists, and the general public, and offers a variety of opportunities for education, scientific research, relaxation, and recreation. Indeed, a large part of its biological recognition stems from the amount of research completed in

the area. For example, many 'type specimens' in museums and herbaria that were used for original descriptions of species were collected from the reefs of Moss Beach (Smith 1969, Smith and Carlton 1975, Abbott and Hollenberg 1976, Sparling 1977, Morris et al. 1980).

The proximity of the Park's rocky intertidal habitats to the densely populated areas of San Francisco Bay is a large reason for the extraordinarily large numbers of visitors. It is estimated that approximately 100,000 people visit the Park each year. Population growth in San Mateo County and the surrounding communities is expected to further increase (**Figure 1-3**), and coastal tourism in the area will likely continue to rise resulting in increased visitor use. School field trips to the Fitzgerald State Marine Park and other rocky shore areas will also likely increase, as marine science education is included in curricula at all school levels. Due to the high visitation and public interest in the area, there has been a concern that the diversity and abundance of the intertidal marine biota in the Park has become degraded, or is at imminent risk of becoming significantly degraded as a direct result of visitor impacts.

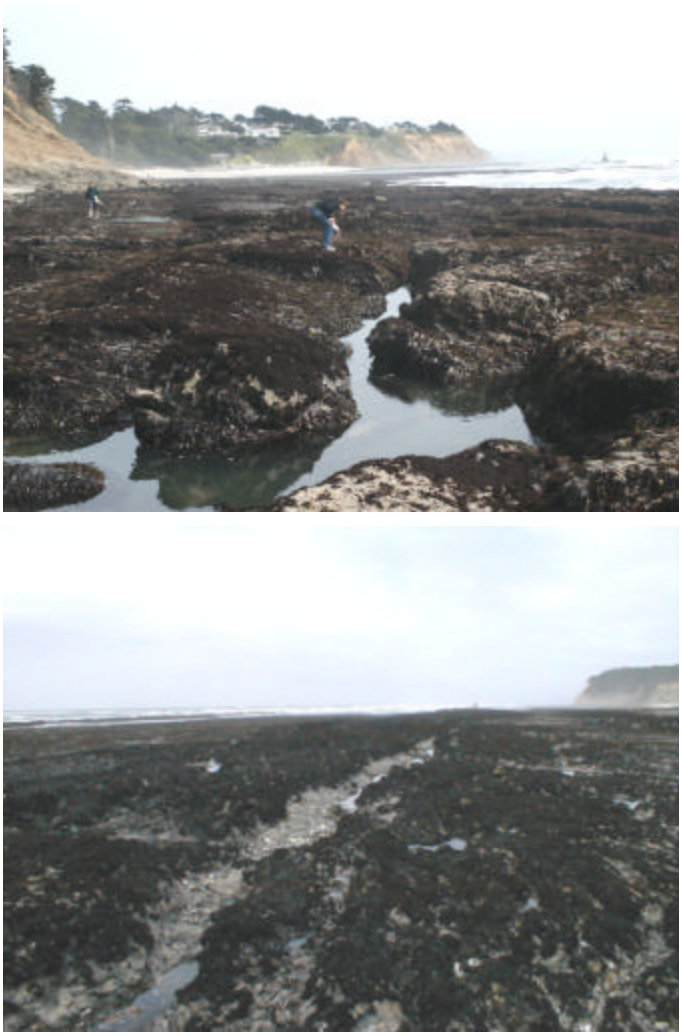


**Figure 1-2**. Wide bench platforms characterize the Fitzgerald State Marine Park intertidal zone. Top photo is view of Moss Beach Reef looking south. Bottom photo is Distillery Reef looking north.

## 1.3 Rationale for the Study

While the Park's shoreline is a very popular area for a variety of reasons, the most popular activity in the Park is tidepool exploring. However, the large numbers of visitors can both knowingly and unknowingly harm shoreline habitats and intertidal biota.

Visitor impacts can occur from a variety of activities. The most widespread impact occurs from trampling, where people walking on the rocky intertidal reefs crush and dislodge algae and invertebrates. Impacts also occur when people remove and handle organisms. Handling can

cause stress to the organisms, and mortality can result not only from high levels of stressful handling, but also when organisms are not returned to appropriate habitats. Turning rocks to inspect under-substrate biota also can crush organisms and expose the species underneath to stressful bright sunlight and desiccation. Many species that live under turnable substrates require constant moisture and shade to survive. Many other types of organisms live in cracks, crevices, and under shady overhangs to reduce desiccation stress when the tide recedes. These organisms can be harmed if not properly returned to these types of habitats. Collecting obviously removes species from their habitats on a permanent basis. Poaching is another concern, in which edible species, such as abalone, owl limpets, and mussels, are illegally harvested for consumption, bait, or sale. People may be unaware that their actions can have impacts on species populations and that their activities often are unlawful.

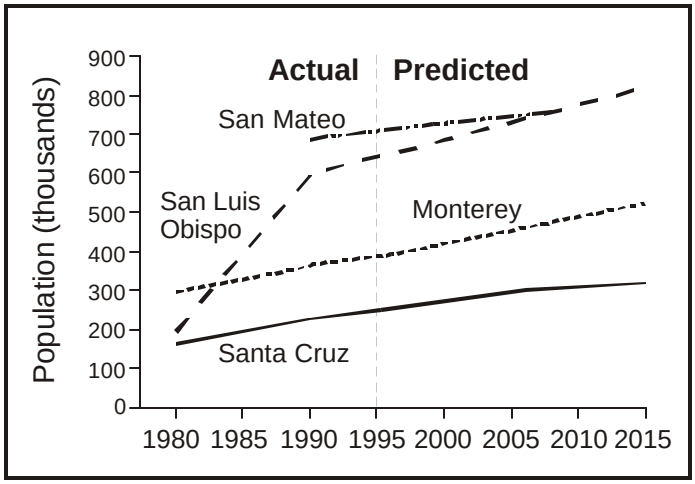



**Figure 1-3**. Actual and predicted population growth for San Mateo County and neighboring counties. (source: http://www.mbnms.nos.

While it is recognized that impacts from trampling and collecting at the Fitzgerald State Marine Park have occurred, and continue to occur, the magnitude and spatial scale of these impacts have yet to be rigorously assessed. A previous study done by Harding, Lawson, and Associates (HLA 1993) included a review of Park information and data collected by Mr. Robert Breen (head ranger, retired). The study also included the results from observations by HLA. Their conclusion was the intertidal zone at the Park was being degraded by visitor use. The HLA (1993) conclusion was based on low abundances of organisms that would be expected to be abundant, low abundances of certain fauna that live mainly underneath cobbles and small boulders (under-rock fauna), and apparent trampling impacts on algal species.

The Park is also a popular site for poke-pole fishing, mainly for monkeyface eels (*Cebidichthys violaceus*) and rock pricklebacks (*Xyphister mucosus*) (**Figure 1-4**). HLA (1993) presented Park data on shore catch statistics for these two species (1972 to 1991), which indicated a decline in catch-per-unit effort. New data are available (through 2003), and the updated findings are presented in this report.

The potential of continuing impacts, due to the variety of visitor uses, created the need for further studies on the status of the James V. Fitzgerald State Marine Park to provide information to the San Mateo County Parks and Recreation Division. This information will be used to finalize management goals presented in the Fitzgerald Marine Reserve Master Plan (Brady/LSA 2002) to

ensure a balance between human use and the protection of the area's natural marine resources. The Master Plan, which should be adopted by the San Mateo County Board of Supervisors in December 2004, was developed over the period 1997-2004, and involved 17 public workshops and meetings to complete.

This report includes analyses of historical data not previously reported, including Park data collected since the HLA report. New studies were also completed specifically to supplement and broaden the knowledge of baseline conditions of the intertidal marine populations in the Park.

**Figure 1-4**. Poke-pole fishers north of the main access.

## 1. 4. Environmental Setting

### Access

The Park is convenient to visit not only because it is immediately off coastal Highway 1, but it also has a parking lot that can accommodate 39 cars, a picnic area, restrooms, and a direct path to the shore. The locations of all established paths to the intertidal zone in the Park are shown in **Figure 1-1**. The main path at the parking lot gently slopes from the parking area to the shore, and is the easiest path to access the intertidal zone for many people (**Figure 1-5**). The path runs along the top of the bank of San Vicente Creek. It is maintained and has seating areas, signs, refuse cans, and a stairway down to the bank of San Vicente Creek. The base of the path terminates at the entrance to the sandy beach backing Moss Beach Reef. Access to the reef is achieved by using a series of broken concrete slabs that provide dry footing when crossing over the creek (**Figure 1-5**). The beach that backs the Moss Beach Reef platform is used for walking

**Figure 1-5**. Main access path and crossing over San Vicente Creek.

and picnicking, and an expansive low-relief, rock platform extending off the beach provides for safe walking across the intertidal zone to explore tidepools and view intertidal organisms.

There are several other paths in the Park that lead to the intertidal zone, but these receive less use. These paths are used mainly by local residents, since they originate in the neighborhoods around the Park and parking is generally limited to the narrow streets in the area. These trails are not maintained, but remain open due to levels of usage that prevent them from being overgrown by vegetation.

**Figure 1-6**. Neighborhood footpath north of the main access.

**Figure 1-7**. Access from California Street to Seal Cove beach.

The most northern neighborhood footpath that leads to the intertidal zone in the Park occurs north of Reef Point (**Figure 1**). The path is very narrow and steep, and is marked with a sign saying 'danger'. The path leads to a small pocket sand beach. Another neighborhood path (**Figure 1-6**) meanders down the small drainage of 'Sunshine Creek' (**Figure 1**), and terminates just north of the main access. A footpath to the south of the main access is used to access Seal Cove beach, located south of Moss Beach Reef. The trailhead for this path originates within Park property at the north end of Seal Cove beach (**Figure 1-7**). However, this path is also used mainly by local residents because there is no parking nearby. A trail at the south end of Seal Cove Beach originates at the Distillery Restaurant parking lot. While parking is available there, the path is relatively steep, and there is a warning sign for anyone using that path (**Figure 1-8**). The next trail is located immediately south of the Distillery Restaurant parking lot, but was largely overgrown with vegetation during the study. Two footpaths are present near the southernmost end of the Park (**Figure 1-9**), which provide access to Ross's Cove, an area located immediately north of the Pillar Point headland. An unpaved parking lot is over the bluff shown in **Figure 1-9**. The lot is near Pillar Point Marsh. The parking lot accommodates approximately 30 vehicles. Many who park there, however, use the sand beach areas on the south side of the Pillar Point headland, rather than Ross's Cove. The lot, however, provides a place for people to park their cars and walk over the cliff bluff to Ross's Cove, a distance of approximately 0.5 mi

(0.8 km) from the parking lot. There are likely other footpaths to the intertidal zone that have been created by local residents, but these are more obscure and more difficult to traverse.


**Figure 1-8**. Path from Distillery Restaurant parking lot to Seal Cove beach. The sign warns of extreme danger and states that this access is closed and to use California Street access.

## Shoreline Geomorphology

The intertidal shoreline of the Fitzgerald State Marine Park is mainly a system of expansive elevated rock bench platforms backed by tall cliffs. The geology of the shoreline is mostly of two types, separated by the Seal Cove fault that bisects the shore near Reef Point (**Figure 1-1**). The majority of the Park's shoreline occurs south of Reef Point, and is characterized by 300-600 ft (91-182 m), wide, flat, rocky platforms (**Figure 1-2**). These rocky platforms and the sea cliffs that back the shore are composed of sandstone, siltstone, and mudstone (Tertiary-Pliocene-Purisima formation) and are highly prone to erosion. Erosion rates of the sea cliffs have been as high as 1-4 ft (0.3-1.2 m) per year in some places (Brady/LSA 2002), resulting in landslides (**Figure 1-10**) and even the collapse of homes built close to the bluff. Seawalls and rock armoring are used in some places to protect shoreline property boundaries. In contrast, the shoreline north of Reef Point is composed mostly of granodiorite (hard substrate) rock outcops that are high in relief (**Figure 1-11**). The steep rocks provide little in the way of an intertidal zone and, therefore, the shoreline north of Reef Point receives less visitation, except for a small pocket beach used by local residents. Also, some people may fish from the tall rocks.

**Figure 1-9**. Footpaths from Pillar Point Marsh parking lot that is opposite the bluff. (source: Californiacoastline.org)

Most of the Pillar Point headland at the south end of the Park is not within the Park boundaries (**Figure 1-1**). While the Fitzgerald State Marine Park is well known for its expansive reef systems and biodiversity, the Pillar Point headland is world-renowned as a famous surf spot. 'Mavericks' at Pillar Point is famous for some of the largest waves in California. In addition to

surfers who paddle to catch waves, there are also tow-in surfers that use personal watercraft (jet-skis and waverunners) to catch waves.

**Figure 1-10**. Recent landslide onto Moss Beach.

## Upland Property and Pillar Point Marsh

The Park also includes approximately 32 acres (13 ha) of cliff bluff above the mean high tide level. Walking trails with scenic lookout points on the cliff bluffs above the intertidal zone extend throughout most of the distance of the Park. Pillar Point Marsh (41 acre, 17 ha) near the south end of the Park is a recent addition to the Park, acquired in 1997 (**Figure 1-1**).

**Figure 1-11**. Coastline north of Reef Point characterized by high relief rocks.

# 1.5 Current Resource Management

Presently, the San Mateo County Parks and Recreation Division (County Parks) and the California Department of Fish and Game (CDF&G) share joint custodianship of the Park's natural resources. County Parks has jurisdiction of Park shoreline areas above the mean high tide line, and the areas above this line (32 acres, 13 ha) are currently classified as a County Park. CDF&G has jurisdiction for the marine resources below the mean high tide line, which encompasses the Fitzgerald State Marine Park. The Monterey Bay National Marine Sanctuary (MBNMS) has primary jurisdiction of the geological features in the sanctuary, including resource management oversight. This includes the Fitzgerald State Marine Park up to the mean high tide level. In 2004, the Gulf of the Farallones National Marine Sanctuary (GFNMS) was made the sanctuary manager of the MBNMS north of the San Mateo/Santa Cruz County line where the Fitzgerald State Marine Park is located.

Numerous regulations at the Fitzgerald State Marine Park were enacted to help preserve the natural diversity of marine life and Park habitats. All of the marine biological resources in the Park are protected from collecting through existing CDF&G regulations (**Table 1-1**). The collecting of algae and invertebrates, including substrates, within the Park for recreational and commercial purposes, is prohibited, but some collecting of marine species for education and research is allowed with a scientific collecting permit issued by the CDF&G. Recreational fishing is also allowed with a valid fishing license from the CDF&G. Any alteration to the substrates in the Park requires a permit issued by the GFNMS. The Fitzgerald State Marine Park is also within a California State Water Resources Control Board Area of Special Biological Significance (currently a State Water Quality Protection Area, see below *Section 6.2 – State Marine Resource Management*). This designation affords special protection to the Park (and other State Water Quality Protection Areas) through the prohibition of point-source waste discharges.

While multiple agencies have regulatory authority over the Fitzgerald State Marine Park, San Mateo County Parks has taken on the responsibility of monitoring and managing the day-to-day use and protection of the Park's marine resources. County Park rangers are present on a daily basis to provide surveillance and enforcement, including marine education outreach to visitors. Other groups also assist with resource stewardship, but not in the form of regulatory protection and enforcement. Volunteer docents (Friends of Fitzgerald, a non-profit education outreach organization) assist in field trips and provide onsite marine science education, on nearly a daily basis during the school term. The Gulf of the Farallones National Marine Sanctuary also contributes to education outreach, seal monitoring, and beach watch programs.

**Table 1-1**. Current CDF&G regulations for the Fitzgerald State Marine Park. (source: www.dfg.ca.gov/mrd/mlpa/mpa.html)

| Species Allowed for Recreational Take | Species Prohibited for Recreational Take | Species Allowed for Commercial Take | Species Prohibited for Commercial take |
|---|---|---|---|
| Rockfish (family Scorpaenidae), lingcod, surfperch (family Embiotocidae), monkeyface eel, rock eel, white croaker, halibut, cabezon, kelp greenling, and smelt (Families Osmeridae and Atherinidae) | All marine aquatic plants; All invertebrates; All fishes except rockfish (family Scorpaenidae), lingcod, surfperch (family Embiotocidae), monkeyface eel, rock eel, white croaker, halibut, cabezon, kelp greenling, and smelt (Families Osmeridae and Atherinidae) | None | All |

## 1.6 Study Approach

Assessments of visitor impacts are often made from studies that are started after the impacts have already been occurring for some time. Since there is no baseline describing pre-impact conditions, these studies rely on comparisons with reference areas that have reduced levels of impact or no impact. However, this approach has many limitations because areas being compared probably had differences that existed prior to any impacts. This is a particular problem in rocky intertidal studies where it is often difficult to find comparable reference/control areas, due to the highly variable environment. Differences between areas can exist due to habitat differences (e.g., wave exposure, substrate composition, habitat relief) and historical disturbances (e.g., storms, landslides), which are not related to the impact being studied (e.g., visitor impacts).

A more robust study design for impact studies includes data collected concurrently in control and impact areas before, during, and after the impact has occurred (Stewart-Oaten et al. 1986, Schiel et al. 2004). This provides a quantitative baseline to measure changes in impact areas relative to changes in control areas. However, this type of study requires commitment of substantial resources to a long-term study and the foresight to institute a study program prior to the occurrence of the impact. Numerous robust statistical methods are available for this type of study to compare species abundances in impact areas relative to their abundances in non-impacted, control areas.

Another type of study design to specifically determine visitor impacts would be to exclude visitor use from an area of prior use and monitor responses in the marine community relative to un-manipulated controls. This type of field experiment can provide strong evidence for visitor impacts if differences are detected between treatments. However, this type of study also requires commitment to a long-term study, and can be plagued by habitat differences resulting in biological differences between open and exclusion areas.

Senior Park ranger Robert Breen (retired) began a manipulative field experiment in 1994 on Moss Beach Reef, the area with the highest visitor use. Two 10 m x 10 m plots were randomly selected on Moss Beach Reef with each 100 $m^2$ plot fixed by installing corner bolts into the substrate. At every daytime low tide, Park rangers roped off each plot using yellow polypropylene line attached to the corner bolts (**Figure 1-12**). The yellow line laid on the substrate, and formed a 100 $m^2$ square area. The roped plots were periodically sampled

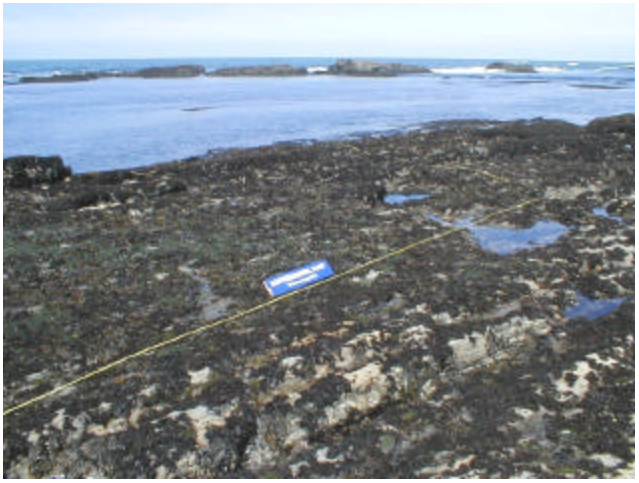


**Figure 1-12**. Park roped area (10m x 10m) on Moss Beach Reef.

over time from 1994 through 2001. Within each roped plot, five 1 $m^2$ quadrat locations were initially randomly selected and then fixed, using bolts. Each roped plot had in place an adjoining unroped area of equal size in which five 1 $m^2$ quadrat locations were also sampled. An additional 100 $m^2$ roped plot was established in a mussel bed on Moss Beach Reef with two unroped mussel plots of the same size located nearby on Moss Beach Reef.

The data from this sampling design have never been rigorously analyzed. As part of this study, we analyzed these data and present the results for the first time. To augment this study, we completed other field studies in high use areas (Moss Beach Reef) to develop a database to specifically compare species composition and abundance between the roped and unroped plots to other high use areas on Moss Beach Reef. We also studied specific species (owl limpets and prickleback eels) known to be extracted by Park visitors, and completed visitor shoreline counts (census surveys) to identify current patterns of visitor use and activity in different areas of the Park.

We completed other supplemental studies that consisted of sampling areas of high use on Moss Beach Reef and areas of lower visitor use downcoast but still within the Park. In our supplemental studies, however, we expected that it would be difficult to conclude that visitor use contributed to any differences observed between areas. This was because we expected to find large spatial variation in species composition and abundance within and between areas that might not be due to visitors. For example, a difference in a single species found between areas in these supplemental studies would not provide strong evidence to conclude that the difference was caused by visitor use. In this type of study design, differences between areas in a large number of species needed to be detected to provide strong evidence of visitor impacts.

## 1.7 Scope of Work

The present study consisted of visitor use surveys combined with biological sampling that involved analysis of existing data and records and new studies to fill knowledge gaps.

### Visitor Use Surveys

#### Analysis of Existing Data

- Update of annual attendance records (Park data)
- Compilation of surveillance and enforcement reports (Park records)

#### New Studies

- Census counts of people in the intertidal zone throughout the Park made during low tides (spring-summer 2004)
- Visitor questionnaire surveys for park management

## Biological Surveys

### Analysis of Existing Data

- Park data for the roped and unroped plots
- Shore fishing catch statistics

### New Studies

- Sampling and analysis of impacts with distance from the main access based on transect and quadrat sampling data
- Sampling and analysis of tidepool biota in high and low use areas
- Sampling and comparison of additional unroped plots to the Park plots
- Sampling of Park plots for changes in mussel abundances and geographic information system (GIS) mapping of mussel beds
- Sampling of Park plots for changes in sea star abundances
- Owl limpet survey of population densities and shell size distributions
- Sampling and analysis of under-rock fauna in high and low use areas using transect and quadrat sampling methods
- Eel recruitment sampling using transect and quadrat sampling methods to assess habitat utilization
- GIS mapping and analysis of substrate habitat classifications in the Park and comparison to other shores in San Mateo County

## Other Potential Human Influences

Tasks to assess other human influences that potentially affect the marine resources at the Park were included in the study:

- San Vicente Creek water quality
- Sewage
- Oil spills
- Tow-in surfing
- Low flight aircraft
- Desalination Plant

## 1.8 Report Organization

The tasks are reported individually in their appropriate sections and each task description includes a purpose statement, rationale, background, methods, results, and discussion subsections:

- **Section 2.0 - Visitor Use Descriptions:** This section describes Park attendance records through summer 2004, description of how visitors tend to be distributed along the shore, and results from our visitor questionnaire surveys. This section includes a compilation of collecting citations and warnings logged by Park rangers. Visitor numbers are also compared to other popular intertidal areas in California.
- **Section 3.0 – Biological Descriptions:** This section contains the sampling results and findings from our biological surveys and analysis of existing biological data collected by Park rangers.
- **Section 4.0 – Other Potential Human Influences:** This section contains a description of potential risks to marine life from factors other than visitor use in the intertidal zone.
- **Section 5.0 – Integrated Discussion of Visitor Use and Biological Impacts:** This section incorporates the findings from all of the studies to evaluate potential impacts related to all human influences.
- **Section 6.0 – County Park Management and the Marine Life Protection Act Process:** This section describes how County management goals and objectives for the Fitzgerald State Marine Park align with the goals and objectives of the Marine Life Protection Act.
- **Section 7.0 – Management Considerations:** This section describes components for future Park operations, monitoring, and evaluation.
- **Section 8.0 – Literature Cited:** This section contains all of the references used in the report.

# 2.0 Visitor Use Descriptions

## Approach

Several tasks were completed to develop a description of visitor use in the Fitzgerald State Marine Park. The study approach and findings are described below for:

- Attendance levels
- Visitor distribution
- Visitor activities
- Personal visitor information
- Surveillance, collecting violations, and advisories
- Comparison of visitor attendance with other areas

## 2.1 Attendance Levels

### Purpose

Park rangers have kept daily logs of total attendance at the Park since 1969. We reviewed available data to provide a description of attendance levels from 1969 through 2003.

### Background

Records of the actual numbers of people who visit intertidal zones are rare, as acquiring and maintaining these types of records requires some form of continuous system to account for visitor use in the intertidal zone. Many parks and reserves have entry gates that allow visitors to be counted as they arrive, but most areas have other attractions, in addition to the rocky intertidal zone, that bring people to the park or reserve (e.g., hiking trails, picnic areas, wildlife). There are few locations where the primary attraction is the rocky intertidal zone. As a result, a total attendance number for areas with multiple attractions would tend to be an over estimate of the number of visitors just visiting tidepools or rocky intertidal areas. Many areas also have school visit registration systems that allow them to track the numbers of students utilizing an area, but these numbers alone would tend to underestimate the total numbers of visitors because the counts do not include unscheduled visits by the general public whose members arrive by car, bike, and foot. Also, many areas have multiple access points that are not monitored, and many popular intertidal areas do not have the staff or means to monitor use. Therefore, long, continuous records of visitor use of shoreline areas are generally not available and numerous assumptions must be considered when interpreting the available data.

Surveys of the numbers of people on the shore can also be used to estimate total numbers of visitors for an area. If these surveys are to target intertidal visitation, they are most often done at low tide when visitors have access to the lower intertidal areas and tidepools. The numbers from these surveys can then be extrapolated to estimate total visitor use. However, total attendance levels derived using this approach can produce misleading results, as most surveys do not account for visitor turnover throughout the day or changes in numbers due to tidal conditions, weather, the day of the week, and time of year. Although surveys could be designed to account for all of these potential factors, they are time consuming and require considerable resources to complete. Consequently, estimates based on survey methods can only, at best, provide a rough approximation of visitor attendance (Tenera 2003).

The database on visitor attendance at the Fitzgerald State Marine Park is unique and was made possible by several factors. First, almost all of the Park's visitors tend to visit the rocky intertidal zone since it is the main attraction. Second, the Park has a main parking lot located at the primary access point to the shoreline. Although there are other access trails to the Park's beaches, very few people use these trails, which mostly serve the people in the neighborhood who know their locations. Even though the Park does not have a ticketing system for parking, because parking at the Park is free, one of the daily duties of the Park rangers has been to count the numbers of cars in the parking lot. This has allowed car counts to be used as an index of visitor use and these data can be extrapolated to provide an estimate of the numbers of visitors to the Park's rocky intertidal zone.

## Methods

Since 1969, Park rangers have logged total attendance records. The numbers of vehicles in the main parking lot have been counted daily to provide an estimate of total daily attendance. The numbers of people arriving at the Park on school visits have been counted separately.

Each day, the parking lot is monitored on several occasions, and the maximum number of public vehicles observed is recorded. This maximum vehicle number is multiplied by two and that product multiplied by five to provide a daily estimate of the number of public visitors to the Park. The 'two' represents the number of passengers per vehicle. The 'five' was developed by Park rangers as a factor and multiplier to account for turnover in cars, walk-ins, and bike-ins, and was selected based on continuous observations and counts throughout the day to obtain actual estimates.

Park rangers also record the number of people arriving at the Park on school visits by bus, van, and car. School visits in cars and vans are treated separately from the car counts for the general public. The actual numbers of people with schools and groups are added to the attendance estimates for the general public to provide a total attendance record for the day.

This method of estimating total daily attendance may be criticized, due to the assumptions used in the multipliers in the formula, which were derived without a thorough analysis. However, the

rangers who have worked at the Park for many years derived this formula and believe it to be a reasonably accurate in representing the extent of visitor use (R. Breen and S. Durkin, pers. com.). These rangers have compared this method of estimating daily attendance on several occasions with general counts and visual interpretation of visitors for the day, and both numbers were within approximately 15 % of each other (R. Breen and S. Durkin, pers. com.). Nevertheless, the Park's method of estimating visitor numbers provides values for attendance that are probably within an order of magnitude of actual levels, and can serve as an excellent index of changes in visitor attendance levels over time since data have been consistently taken with this methodology since 1969.

## Results

Total annual attendance estimates, including the component of these visits designated as group visits, are portrayed for 1969-2003 in **Figure 2-1**. Only the records that were readily available are shown. Some records remain in archived storage, and were not accessible. Since 1969, estimates of annual attendance have risen, peaking slightly over 132,000 people in 1997. From 1997 through 2003, annual attendance estimates dropped to approximately 100,000-110,000 people per year.

Group visits have been normally associated with school trips (elementary through college). Group visits have totaled approximately 20,000 people per year (**Figure 2-1**), but were higher in the 1980s (data not shown), peaking near 30,000 people per year (R. Breen, pers. com.). The decrease in school visits since the 1980s is thought to be associated with reductions in school budgets to support class field trips (R. Breen, pers. com.).

Total attendance levels tend to be highest during the year in spring when school visits can account for approximately one-half of the visiting population (**Figure 2-2**). Visits by school

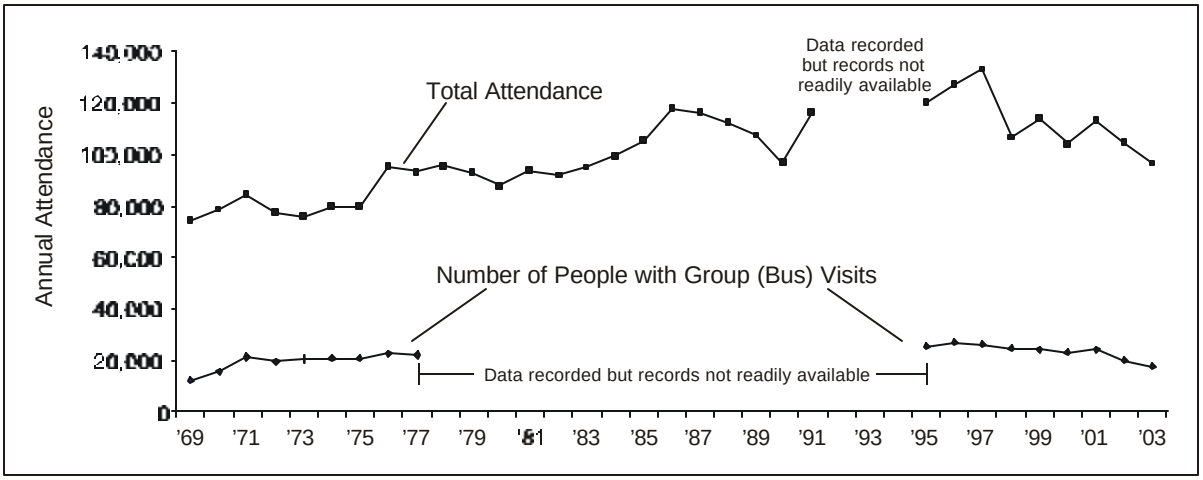



**Figure 2-1**. Changes in annual attendance at the Fitzgerald State Marine Park. School visits are portrayed as a component of total annual attendance.

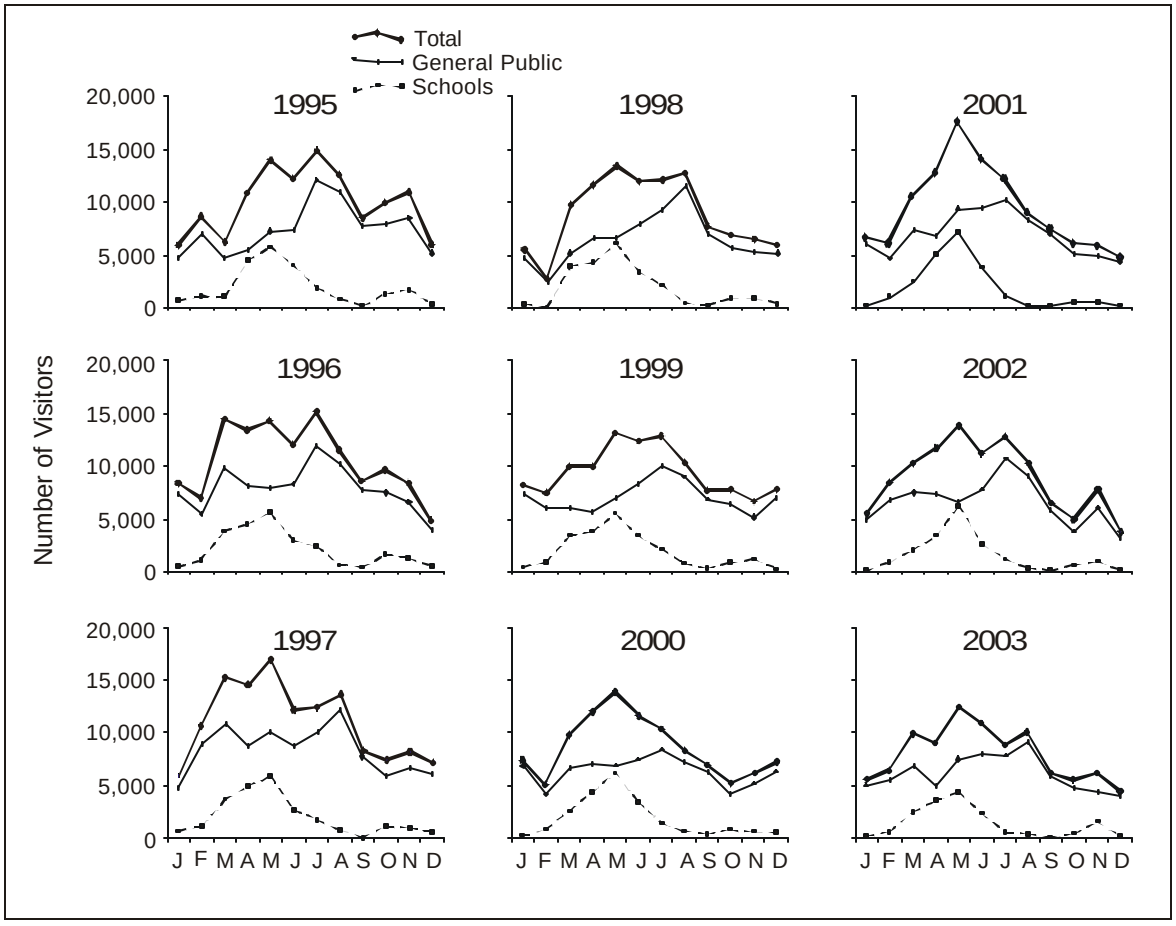



**Figure 2-2**. Monthly variations in public and school attendance.

groups are more common during the spring because there is generally good weather and the lowest low tides occur during daylight during these months. During summer, the number of school visits decreases but tourism increases at the Park (**Figure 2-2**). Although daily peak attendance can be similar between spring and summer, overall attendance in summer is slightly lower because the increase in summer tourism is generally not as great as the decline in school visits. Visitor levels tend to be lowest in winter.

A Master Plan objective for the Park is to limit total daily attendance to 500 people with a limit of 300 people at any given time. In the past, daily attendance commonly exceeded 500 people per day, particularly in spring (**Table 2-1**). Visitor census surveys conducted as part of this study have also shown that the number of simultaneous visitors has exceeded 300 people on a number of occasions (**Figure 2-3**). These results can be used to assess the Master Plan objective of limiting visitation on the shore to 300 people at any given time. The most appropriate shoreline area for this assessment is the combined area of Moss Beach Reef and Surfgrass Flats, as these

**Table 2-1**. Number of days that visitor attendance exceeded 500 people. (ND = no data)

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Jan** | 3 | 7 | 2 | 1 | 6 | 5 | 3 | 3 | 2 | 6 |
| **Feb** | 5 | 3 | 9 | 0 | 4 | 2 | 1 | 4 | 4 | 4 |
| **Mar** | 2 | 13 | 12 | 9 | 7 | 6 | 7 | 6 | 8 | 12 |
| **Apr** | 10 | 13 | 18 | 11 | 9 | 9 | 12 | 8 | 6 | 9 |
| **May** | 15 | 14 | 21 | 12 | 17 | 14 | 21 | 15 | 13 | 20 |
| **Jun** | 11 | 10 | 9 | 12 | 12 | 10 | 12 | 12 | 8 | 10 |
| **Jul** | 14 | 15 | 10 | 10 | 7 | 3 | 8 | 8 | 4 | ND |
| **Aug** | 7 | 6 | 11 | 7 | 4 | 3 | 6 | 4 | 5 | ND |
| **Sep** | 4 | 4 | 3 | 6 | 5 | 3 | 6 | 3 | 3 | ND |
| **Oct** | 6 | 6 | 5 | 3 | 6 | 2 | 3 | 1 | 2 | ND |
| **Nov** | 7 | 4 | 5 | 3 | 3 | 3 | 1 | 5 | 2 | ND |
| **Dec** | 3 | 1 | 4 | 4 | 2 | 3 | 0 | 1 | 1 | ND |

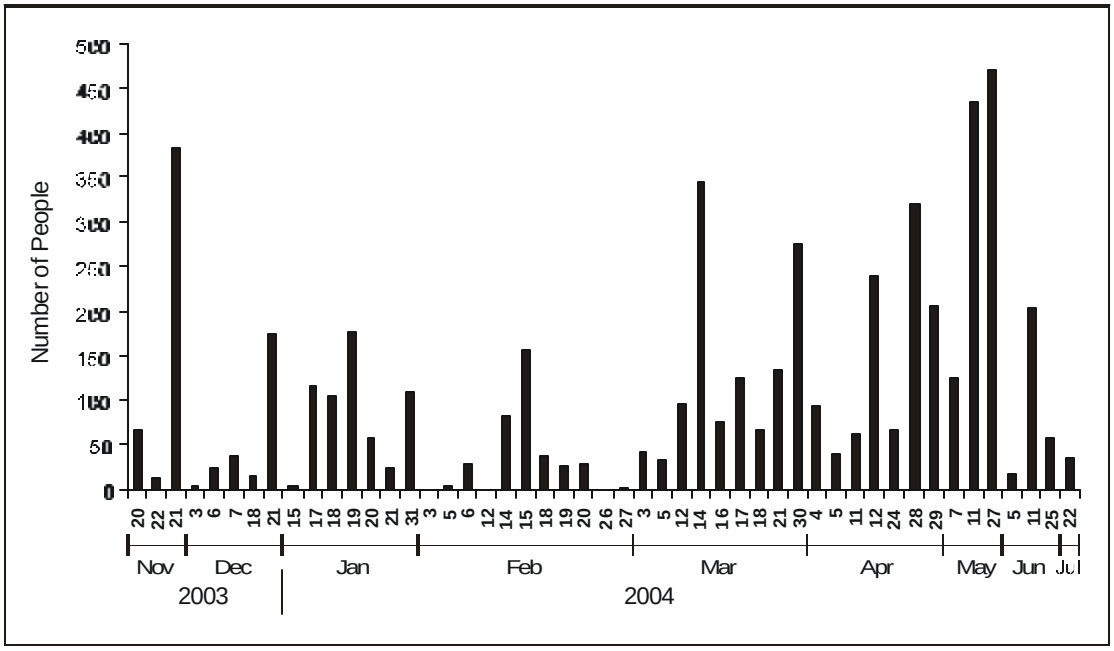



**Figure 2-3**. Total number of people counted on Moss Beach Reef and Surfgrass Flats in each of the census surveys.

areas receive the highest use (see below, *Section 2.2 – Visitor Distribution*). The days when the number of visitors exceeded 300 were all weekdays when school visits occurred simultaneously with periods of high public use. Total counts for all other sections of the Park (combined) at any given time were always less than 300 people, the largest being 50 people.

The results of the visitor census surveys were used to estimate the total number of days that visitor use could have exceeded 300 people per day. We assumed that weekdays in spring are the most likely days when total visitor use can exceed 300 people from combined school groups and public use. We completed 14 census surveys on weekdays in spring, and counted greater than 300 people on Moss Beach Reef and Surfgrass Flats in four of the 14 surveys (29 % of the surveys). Therefore, if there are 60 weekdays in spring, we estimate that there could be 17 days (29% of 60) when total visitor use could exceed 300 people. This estimate was only based on the spring months when visitor levels were highest. This is probably an underestimate since visitor levels can also be high during the summer and other days, such as holidays, that result in large numbers of public visitors to the Park.

## Discussion

The same methods to estimate visitor attendance at the Fitzgerald State Marine Park have been used consistently on a daily basis since 1969 allowing descriptions of long-term changes in visitor attendance by both the general public and schools. Minimum numbers of approximately 80,000 people per year occurred in the 1970s and 1980s, but attendance then rose to consistent levels of about 100,000 people per year, with a peak of over 130,000 people in 1997. A slight decrease in visitor attendance occurred after 1997, but visitor numbers were still near 100,000 people per year.

Although the reason for this decrease in visitor use over the past several years remains unknown, a possible explanation is the change in the signage for the Park on Highway 1. A large billboard advertising the Park was damaged in an automobile accident around 1997/98. The sign was removed and replaced by a smaller sign. The decrease in visitor attendance since 1997 could have been due, in part, to the replacement of the large billboard with a less visible sign. Other possible factors include fewer class visits, due to reductions in school budgets and less media and news coverage on the Park's attractions (R. Breen, pers. com.).

The estimates do not include counts of visitors that may have entered the Park using other access points and, therefore, surely underestimate the total annual attendance levels for the entire Park. However, our surveys of visitor use showed that the number of visitors to other areas of the Park tend to be much lower than Moss Beach Reef (see below, *Section 2.2 – Visitor Distribution*). Although the total annual attendance estimates are most likely to be underestimates of the total number of visitors, we believe that our estimates would not be increased substantially by including visitors from other parts of the Park.

A goal described in the Fitzgerald Marine Reserve Master Plan is to limit total daily attendance on Moss Beach Reef to 500 people per day with a limit of 300 people at any given time. This level was based on a recommendation from a previous study (HLA 1993). There was no basis for the number other than to serve as a 'target' to lower visitor use. Prior to 1994, as many as 40 buses arrived at the Park on a single day (R. Breen, pers. com.). The bus reservation system employed since 1994 was implemented to avoid this high level of use, and the associated problem of vehicle congestion in the parking lot and adjoining neighborhoods. The reservation system schedules school bus visits to avoid exceeding 500 visitors per day from schools or other group visits. However, the system has no controls on levels of visitation by the general public. In addition, unscheduled groups may also arrive at the Park, increasing group visitor levels above the goal of 500 (R. Breen, pers. com.). The unannounced group visits have been included in the daily counts by the rangers, and have contributed to pulses of visitor use exceeding 500 people per day, and probably the 300 maximum at any given time.

Our census surveys also documented occasions when the total number of people in shoreline areas near the main access points (Moss Beach Reef and Surfgrass Flats) exceeded 300 people. Since the surveys were relatively infrequent, there were likely many additional days when total visitation on Moss Beach Reef and Surfgrass Flats exceeded 300 people at any given time, especially during the spring when we estimated the total numbers of visitors can exceed 300 people on 29% of the weekdays.

Historically, up to 2,000 people per day visited the Moss Beach Reef intertidal zone. This occurred on weekends and holidays during periods with good weather and tide conditions. In more recent years, peak levels have dropped to a maximum of about 1,000 people per day (R. Breen, pers. com.). During these days, the number of visitors during any time period likely exceeded the goal of 300. The decline in overall peak numbers from historical levels is probably the result of the group reservation system. In July 2004, the reservation system was made more stringent. Any group with greater than 10 people is now required to have a reservation to visit the Park. This was intended to further limit (group) visitor use, and was done because measures to limit access for the general public have been difficult to implement.

In conclusion, the information on visitor attendance demonstrates that other management measures need to be explored and implemented to meet the objective of 500 people per day with a limit of 300 people at any time. Although group visits can be managed, access to the Park remains open to the general public, and public use and unscheduled group visits can easily exceed the visitor limits. While methods for estimating total attendance have been used with success, and can be continued, future management measures should include methods to monitor the instantaneous 300 people limit. Although there will always be the potential that unscheduled group visits will cause attendance levels to exceed Park limits, the frequency of unscheduled group visits should decline as more and more groups become aware of the group reservation system. The Park could also encourage unannounced trips to redirect their visit for the day to other coastal areas. To avoid these situations, the Park should develop a program to inform all

school districts and tourist charter companies within the counties surrounding San Mateo County of new policies that involve the group reservation system for the Park.

## 2.2 Visitor Distribution

### Purpose

Visitor census surveys were completed to describe patterns of visitor distribution in the Fitzgerald State Marine Park intertidal zone.

### Background

Visitor use in different sections of the Park shoreline were previously classified as heavy, moderate, and low (HLA 1993). The categories were based on field observations made in a limited number of surveys without actual numbers of people reported. In our study, the Friends of Fitzgerald organization counted people on the shore and developed a database on the distribution of people along the Park shoreline.

The surveys were conducted to determine the distribution along the shoreline of the visitors that were at the Park at that time. The data were primarily used to determine the areas of the shoreline that receive heavy, moderate, and low use, and to validate that our biological sampling stations corresponded to areas of 'high' and 'low' use. The numbers were not collected to derive total daily estimates of people on the shore, since they only represented the numbers of visitors during a limited time period.

### Methods

The approximate 3 mi (5 km) shoreline of the Fitzgerald State Marine Park was divided into 11 segments extending from the northern to the southern boundaries of the Park (**Figure 1-1**). These segments were separated and identified by geographical features (mainly headlands), and ranged in length from 173 m to 916 m (189 yd to 1,002 yd). Geographic features determined the length of each segment with the criterion that there was no fundamental change in the nature of access along each shoreline length. For example, a segment with difficult access to the intertidal zone (steep drop off from the cliff to the ocean) was separated from an adjoining segment with easier shore access provided by, for example, a footpath. The Moss Beach Reef area, located at the terminus of the main access, was subdivided into three segments to obtain better resolution on the distribution of people along this portion of the shore.

Counts of people were made from the cliff top for each segment. Numbers were recorded in 'snapshot' counts. It took about two-hours to walk the length of the Park to make all of the 'snapshot' counts. The surveys were done during days when the weather was appropriate for

visiting tidepools, and during tide levels at or below about +1.5 ft mean lower low water (MLLW). Days when people would not tend to visit the tidepools were not surveyed, which included days of rain, heavy fog, low temperatures, high winds, and high tides.

Forty-nine surveys were completed over a nine-month period (November 20, 2003 to July 22, 2004). In each survey, people were counted in each segment. People on the sandy beaches were counted separately from those on the rock bench platforms. The width of the bench platforms varied between segments. Therefore, the width of the rock bench platform in each segment was divided into three zones, and the people counted in each zone as follows:

- Upper bench (near the cliff bases)
- Mid-bench (mid-section of the bench platform characterized by foliose algae)
- Lower bench (near the outer edge of the bench platforms)

The surveys were made on foot using binoculars by observers who walked the entire shoreline of the Park. Counts of harbor seals and people fishing from the shore and the numbers of fishing boats working in nearshore waters were also included in the surveys. Weather and sea state were also recorded.

Volunteers from the Friends of Fitzgerald, a non-profit, marine science education outreach organization, completed all of the visitor surveys. Due to the use of volunteers, the actual survey days were based on volunteer availability. Under ideal circumstances, visitor use surveys would be completed to account for differences due to the day of the week, holidays, seasons, time of the day, tidal levels, weather, etc. (Underwood and Kennelly 1990). Under these circumstances, the data could be used to provide more accurately based estimates of visitor use. Although not conforming to this ideal sampling scheme, the surveys were completed at various times of the day to correspond to the low tide for the day and included weekends and weekdays. Since the results were only used to provide relative counts of people for locating the biological sampling in areas with high and low visitor use, the surveys did not need to be completed during all types of weather conditions and tidal levels.

## Results

### Distribution of People Along the Shore

A total of 5,873 people was observed in the surveys. Counts for each segment were corrected for length of shore in order to compare numbers of people among the segments, which differed in their lengths. As expected, the main access had the largest influence on the overall distribution of people in the Park. People were most concentrated on Moss Beach Reef, particularly in the two segments immediately south of the main access (**Figure 2-4**). Surfgrass Flats was another commonly used area, although the number of visitors was less than the Moss Beach Reef

segments, which were closer to the main access to the Park shoreline. Visitor use was much lower in all the other segments.

## Distribution of People Across the Shore

Most of the people were on the sandy beaches backing the rock bench platforms and on the upper and middle zones of the rock bench platforms (**Figure 2-5**). The numbers were much lower on the outermost lower zone on the rocky bench platforms. The number of people in the outer zone was highest in Segment 1c (Moss Beach Reef) and Segment 2 (Surfgrass Flats). The southernmost region of Moss Beach Reef is Segment 1c. The rock bench platform there rises slightly in elevation. Consequently, people are able to venture closer to the water without getting wet. Surfgrass Flats is relatively protected from waves, which also allows visitors to venture out near the waterline without the fear of getting wet during low tides. Although Segment 1b on Moss Beach Reef was directly off the main entry to the beach, access to the outer edge of the reef in that segment is restricted (by cones placed at low tide) to prevent people from encroaching on the harbor seal haulout directly offshore (**Figure 2-6**). There is also a broad, low-elevation surge channel directly off the main access to the shore that separates the outer edge of the bench platform from the inner region. Therefore, the seaward edge of the rocky bench in Segment 1b is often inaccessible, except during extremely low tides.

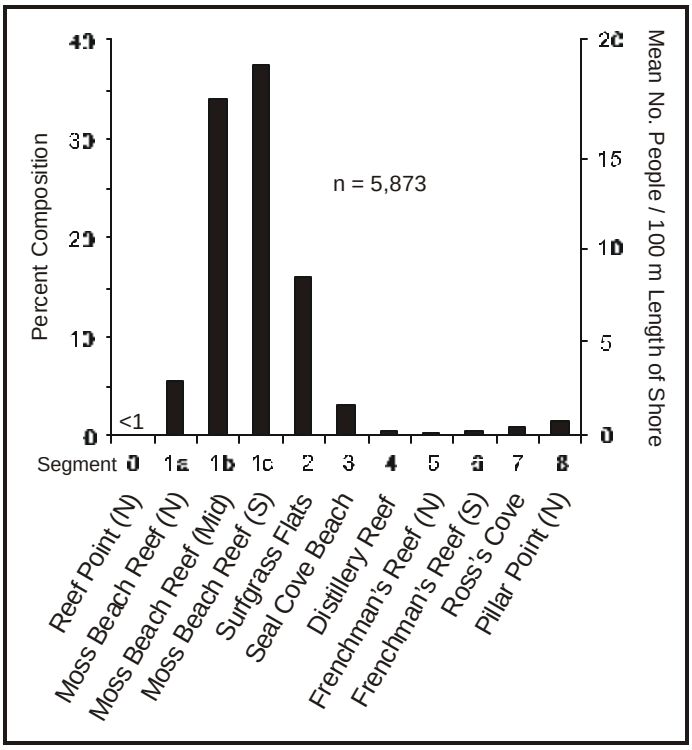



**Figure 2-4**. Overall distribution of people in the Fitzgerald State Marine Park corrected to 100 m length of shore. (Surveys = 49, and excludes fishers, surfers, and kayakers.)

The distribution of people across the shore in other segments was largely determined by the presence of a sandy beach. For example, the area north of Reef Point has a small sandy beach with access from the local neighborhood. While rocks surround the area, they are very steep and not very accessible for exploring tidepools (**Figure 1-10**). The main attractions at Seal Cove Beach and Ross's Cove are the large sandy beach areas that are used for picnicking, sunbathing, and walking dogs, all non-tidepooling activities. Other areas (e.g., Distillery Reef and Frenchman's Reef) have less beach area, plus they are more difficult to access.

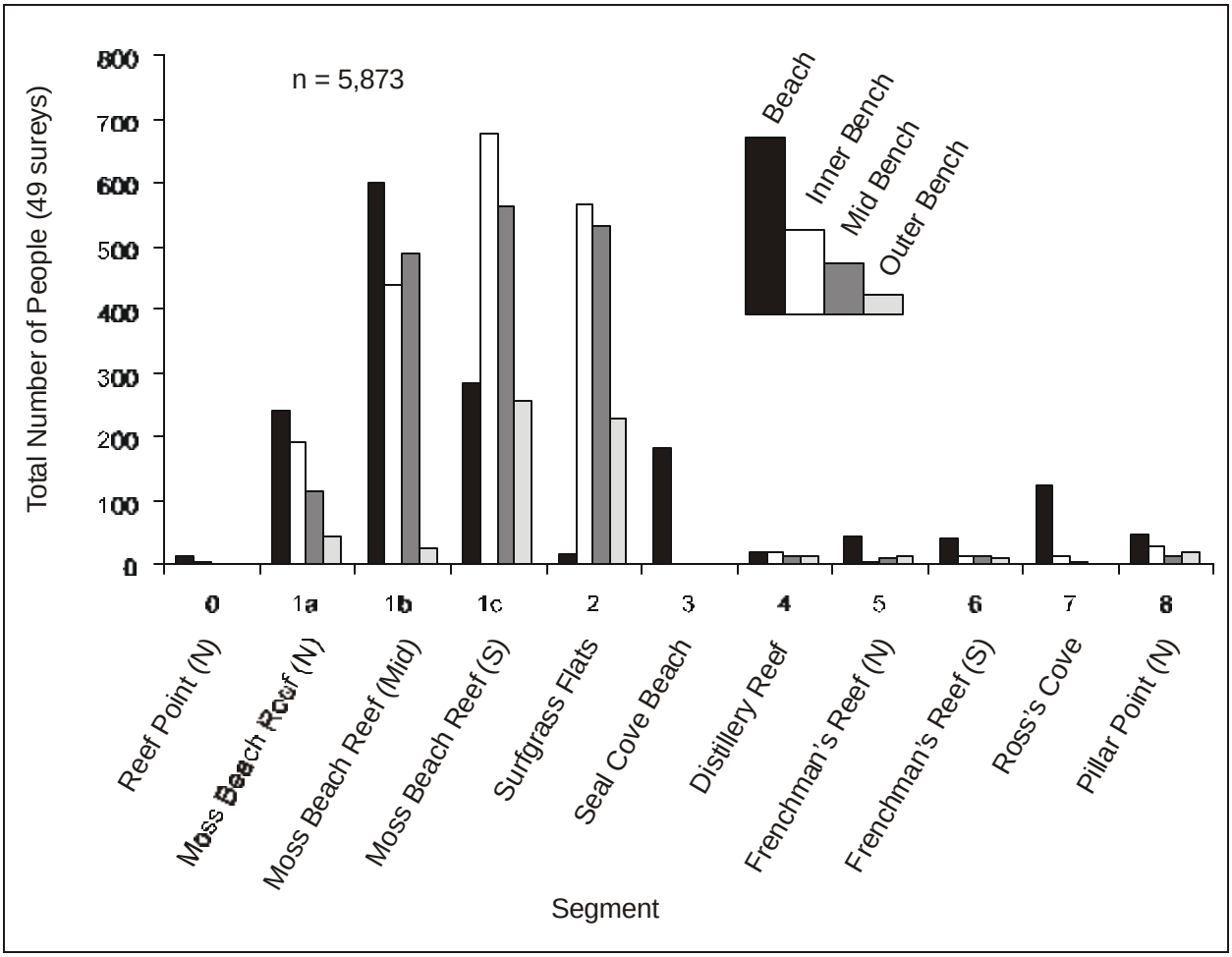



**Figure 2-5**. Distribution of people along and across the shore in the Fitzgerald State Marine Park, excluding fishers, kayakers, and surfers.

## Discussion

A purpose of these surveys was to obtain data on visitation throughout the Fitzgerald State Marine Park in order to locate our biological sampling stations in areas of 'high' and 'low' visitor use. These data could then be use to set up a study to determine if any effects of increased use could be detected. The locations and assumptions of our biological sampling acknowledge that the entire Park is accessible, and that it is highly unlikely that any area has been completely r

emoved from visitor impacts. The results of the study demonstrated that access, including parking, strongly influences how people tend to be distributed along the shore.

## Distribution of People Along the Shore

The results of the surveys supported our expectation that the Moss Beach Reef area was the area with the highest visitor use, particularly the segments immediately south of the main access to the Park shoreline (**Figure 2-4**). Levels of use were also high at Surfgrass Flats (Segment 2). Levels of use in other segments were much less with Segment 3 (Seal Cove Beach) and Segment 7 (Ross's Cove), and Segment 8 (Pillar Point north) having similar levels of use with over 100 total visitors for the 49 surveys. The last two areas are accessible from trails down the cliffs after an approximate 0.5 mi (0.8 km) hike over the bluff from the Pillar Point Marsh parking lot. Therefore, these areas require more effort to visit than Moss Beach Reef. Seal Cove Beach is accessed via a footpath that originates on Park property. Neighborhood residences are the primary users of Seal Cove Beach, because there is no parking lot in close proximity.

**Figure 2-6**. One cone forming a line of cones on Moss Beach Reef to deter access to the seal haulout on Nye's Rocks. Harbor seals are in the background.

Sections 4, 5, and 6 were south of the Distillery Restaurant, and included Distillery Reef and Frenchman's Reef. These segments do not have easily accessible paths to the intertidal zone, and were found to have the lowest visitor levels. Because of low visitation and the similar nature of the rocky benches to more heavily used portions of the Park's shoreline, Section 4 (Distillery Reef) was the area where we conducted our reference/control biological sampling (see *Section 3.0 – Biological Descriptions*).

## Distribution of People Across the Shore

We found most people in the Park utilized all the zones across the shoreline, except in areas where the lower zone was exposed to wave surge. Only where the rock bench platforms were relatively protected from surf conditions did people wander out to the most seaward edges of the platforms. The presence of sandy beaches also had a large influence on concentrating visitor in the upper intertidal zone along the beach.

We found that even during relatively 'poor' low tide conditions (approx. +1 ft MLLW) that large areas of the rock bench platform were still exposed for exploring tidepools, but for shorter periods of time. Consequently, there are many times of the year when the areas on the rock bench platforms are exposed to potential visitor impacts.

The potential for visitor impacts on exposed rock bench platforms is much greater than on intertidal areas that are steeply sloped and composed of boulders, cobbles, and high relief rocks

that are more difficult to traverse. These characteristics limit visitor access, due to the more difficult footing and greater chances of getting wet (Clowes and Coleman 2000, Tenera 2003). Consequently, potential visitor impacts in these intertidal areas tend to occur within a narrower band in the upper intertidal zone. In contrast, elevated rock bench platforms, such as those in the Fitzgerald State Marine Park, tend to be exposed to potential visitor impacts over a broader area.

## 2.3 Visitor Activities

### Purpose

Observations and records of visitor activities were made during the census surveys to quantify the activities of people visiting the Park's intertidal zone.

### Background

People will engage in a range of activities in the rocky intertidal zone, from passively standing, walking, and looking, to turning rocks, handling, and collecting animals. We recorded observations on visitor activities to acquire baseline data on the frequencies of these types of behaviors.

### Methods

The activities of people on the rock bench platforms and on the beaches observed by the Friends of Fitzgerald in the census surveys were classified into non-extractive and extractive activities:

Non-Extractive

- 'Picnicking' (chairs, ice chests, and/or umbrellas on the sand beaches)
- 'Passive' (standing, kneeling, walking, observing without turning rocks)
- 'Active' (handling organisms, rock turning)

Extractive

- Fishing

### Results

The 5,873 people observed in the surveys included 155 people picnicking on the beaches and 41 shore fishers. Of the remaining 5,677 people on the shore, 28 % of them were engaged in some form of 'active' tidepool activity at the time of observation (e.g., handling or touching organisms, lifting rocks) versus a 'passive' activity (e.g., looking, walking, standing). Shore fishers represented less than 1 % of the total visitors observed, and were observed in all areas of

the Park, with the exception of Seal Cove Beach, Ross's Cove, and the area immediately offshore of the main access.

Observations of inappropriate activities were noted independent of the present study. These included harassing the harbor seals that frequent the Moss Beach Reef area, carving into the soft sandstone cliffs, and climbing on the unstable cliffs along the shore.

### Discussion

Although the census surveys did not provide a comprehensive evaluation of visitor activities, it did indicate that the overwhelming majority (> 99%) of the activities in the Park were non-extractive. In constrast, less than 1 % of the people observed were fishers. Twenty-eight percent of the people observed in the rocky intertidal zone was engaged in some form of tidepool exploring, which included handling or touching organisms. The actual percentage of people engaged in this activity is probably much higher, since we expect that most people who traverse the intertidal zone will eventually be involved in some form of active involvement in touching and handling organisms when exploring tidepools. Our observations of people engaged in 'active' tidepool exploring (28%), however, is similar to that found by Addessi (1994) in San Diego where she noted that approximately 20 % of the visitors observed at any given time were actively involved in exploring the intertidal, which included turning rocks.

The potential impacts to the intertidal community from tidepool activities, aside from trampling effects, will depend on the severity of the action and the frequencies with which they occur. Although the action of someone picking up an animal and then replacing it is a form of collecting, it is less severe than someone carrying the animal to a different location or collecting it and removing it from the Park. Records of illegal collecting from Park records are presented in **Section 2.5**.

During the census surveys, Friends of Fitzgerald docents documented only three incidences of illegal collecting. When one of the people involved in the collecting was questioned by one of the docents, the person did not even know what organism he had collected, but collected it because it was 'interesting'. We did not observe illegal collecting, but observed improper tidepool etiquette during our sampling. In addition, docents have observed children carving letters and objects into the cliff base.

## 2.4 Questionnaire Information

### Purpose

Visitors were interviewed using a questionnaire to obtain a variety of information from the people who visit the Park. The questions included the purpose of the visit, knowledge of the

marine resources, understanding of conservation, opinions on Park amenities and areas for improvement, including Park operation and management.

## Background

Planners and managers seek ways to include public input in decision-making. This is especially important when the public is the principal user group. Public input helps to guide and prioritize areas needing improvement. Information from a questionnaire survey is one way to obtain public input.

The majority of people who use the Park include residents, tourists, and school groups. Interviews were conducted with residents and tourists. Interviews with school groups were not included because the needs of school groups are being addressed separately in the curricula planning and design of a proposed new interpretive center at the Park. The Acorn Group completed a questionnaire survey in 2004, largely to acquire input for the interpretive center.

## Methods

Friends of Fitzgerald volunteers took opportunities during the census surveys to complete the individual questionnaires. All surveys were completed in the Moss Beach Reef area near the main access. The interviewees were not selected at random, but were chosen as opportunities arose.

## Results

The Friends of Fitzgerald interviewed 39 individuals in the field. The following provides an overview of the results that includes information on demographics, purpose of visit, and input most directly related to Park operation, maintenance, amenities, and conservation awareness.

### Demographics

Only two of the 39 interviewees did not live in California. The other 37 all lived locally or in the general San Francisco Bay area.

### Purpose of Visits

When given a multiple-choice list for primary purpose of their visit, the number one answer was ‘to visit the tidepools’ (**Figure 2-7**). This is similar to the results obtained in the Acorn Group questionnaire (unpublished data).

## Time, Frequency, and Duration of Visits

The survey indicated that people typically spend about 1-3 hours visiting the tidepools when at the Park. Many of those interviewed indicated that they visit the Park multiple times each year, and some local residents visit the Park's intertidal zone up to 60 times per year. Most respondents said they time their visits to coincide with low tides.

## Ideas for Park Improvements

The majority of respondents chose 'no ideas' for Park improvements (**Figure 2-8**). The second most common answer for improvement was to increase educational outreach. The third most common suggestion was the need for more parking. All other responses were related to other types of improvements related to restrooms, access paths, signs, benches, etc.

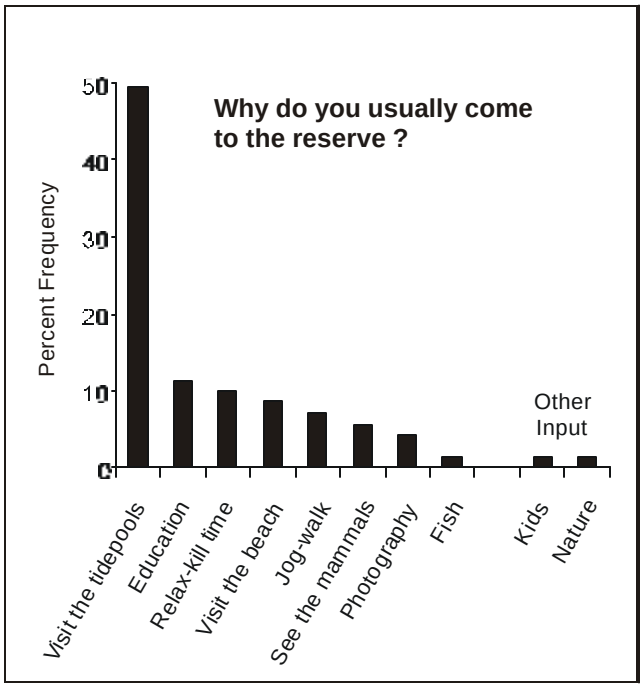



**Figure 2-7**. Primary purpose of visit stated by 39 interviewees.

## Areas Most Visited

The majority of respondents stated that Moss Beach Reef was the area that they visited most often. However, these responses were biased, as all of the interviews were completed at Moss Beach Reef. Seal Cove Beach and Ross's Cove are two other popular areas in the Park (see *Section 2.1 – Visitor Distribution*). Neighborhood residences are the primary users of Seal Cove Beach. Ross's Cove is also commonly visited with the primary purpose likely being the use of its large sandy beach.

## Awareness of Signs and Regulations on Resource Protection

Nearly all respondents said they were familiar with the signs and regulations at the Park, since most of them had been to the Park before. One respondent indicated that the signs were becoming faded and in need of replacement and upgrading.

## Observations of Inappropriate Tidepool Behaviors

The majority of respondents stated that they do not see or notice illegal collecting occurring when they visit the Park. However, six respondents stated that they see shells being taken on nearly every visit. Several have also seen children carving on and climbing the cliff faces.

## Beach Picnicking

Two-thirds of the respondents stated that they would be supportive of no picnicking on the beaches, provided that picnic areas were established and improved in other areas of the Park.

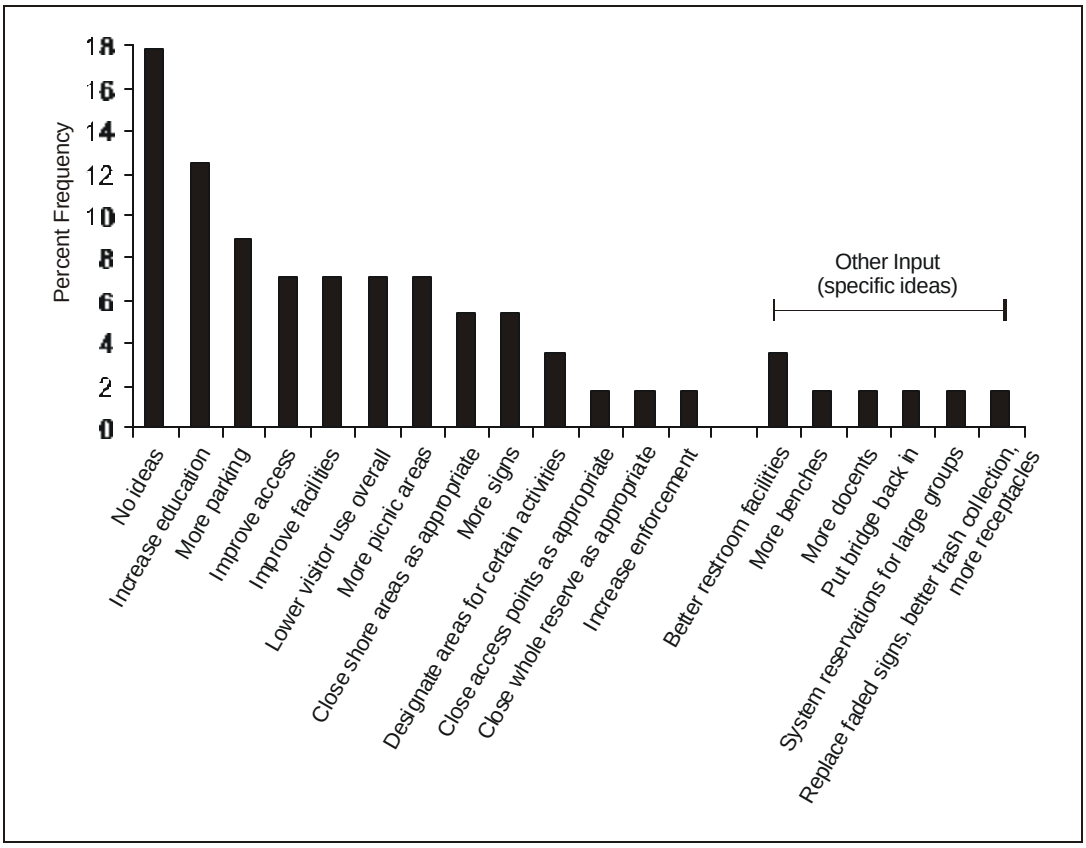



**Figure 2-8**. Answers for Park improvements from 39 interviewees.

## Institution of Access Fees

Respondents were about equally divided between supporting and not supporting an access fee. About half responded that they would support an access fee, while the other half stated that they would not be in favor of an access fee. However, the majority responded that if an access fee were instituted that the fee would not deter them from visiting the Park. One respondent suggested including a family fee (discount).

## Group Reservation Requirement

Similar to the bus reservation system, a management objective stated in the Fitzgerald Marine Reserve Master Plan (Brady/LSA 2002) includes a group reservation requirement for groups as small as four people. When asked, interviewees were about equally divided in their support of a group reservation requirement to help limit visitor numbers. However, a group of four would be equivalent to one family, which was concluded by Park management to be too stringent to warrant a reservation, and would not likely be enforceable. In July 2004, Park management instituted a group reservation requirement for groups greater than 10 people (**Figure 2-9**).

### Public Views on Biological Changes

Very few people (9) had any personal input on types of biological changes that have occurred in the Park. The majority of these few people indicated that species abundances were declining. However, one person believed that sea stars had increased in abundance, in comparison to two people who specifically stated that they believed that sea stars had decreased in abundance. These types of conflicting statements make it difficult to incorporate anecdotal information into resource assessments.


**Figure 2-9**. Sign notifying that reservations are required for groups of 10 or more.

## Discussion

Our results characterizing the viewpoints of the general public on the Park are limited, as only 39 people were interviewed. As expected, however, the questionnaires revealed that the people who visit the Park are mainly those who live nearby or in the San Francisco Bay area. The responses clearly indicated that people enjoy the Park, and will return on multiple occasions, indicating that management actions to preserve the marine resources and improving Park amenities are highly valued. Approximately half of the interviewees stated that their primary purpose of coming to the Park was to visit the tidepools. The other people stated other reasons (e.g., walking, photography, picnicking, etc.). However, it is likely that this latter group of people also visit the tidepools during their visits. The responses indicate that the primary activities in the Park are overwhelmingly non-extractive in nature, and the resources that make the Park attractive to these users should be protected.

The questionnaires also indicated that many people want the Park to be improved. Suggestions included improved access, restrooms, garbage receptacles, signs, picnic areas, and parking. The restrooms have been recently upgraded. Access across San Vicente Creek would require a bridge or permanent concrete pillars/footings (stepping structures) placed in the creek bed to allow water to bypass and allow for foot traffic without the fear of stepping into the creek. Modifying the crossing over San Vicente Creek would require an extensive permitting process, as a wetland might be involved. Improving signage at the Park is the most technically feasible improvement. Increasing the number and maintenance of garbage receptacles could also easily be accomplished.

An important suggestion from the public was to increase the number of public parking spaces. Public parking may become more limited with the development and operation of the marine science interpretive center, which is planned to be constructed in the existing parking lot. Parking spaces will also be needed for the center employees. Bus parking may become a larger problem, as school groups, including the general public, will now have the interpretive center as another attraction to the Park, in addition to visiting the tidepools. Reducing the availability of parking on County property could increase parking along the neighborhood streets .

Potential parking problems could be reduced with the addition of an offsite parking lot. An offsite parking lot nearby could be used for buses (and cars) for temporary parking while people visit the Park. A shuttle van service between the offsite lot and the Park could be provided, as well. To encourage offsite parking (for the general public), a parking fee could be charged for use of the main parking lot, while there would be no fee for parking in the offsite lot or use of the shuttle service.

It is our opinion that the management recommendation to restrict picnicking on the beach may become contentious. While beach picnickers represent only a fraction of the total visiting population, picnicking on the beach is likely the sole purpose of many people for visiting the shore. Furthermore, we believe it would be very difficult to enforce a no-picnicking rule, since it would be difficult to distinguish picnicking from other passive beach activities.

A 'no ice chests' rule may be more enforceable to limit beach picnickers. This type of rule is employed at other locations, but usually to support on-site concessionaires and to control alcohol. Another means to curtail beach picnickers might be to provide warning signs that the cliffs backing the shore are highly prone to erosion and landslides. During all of our field visits, we witnessed and heard rock falling from the cliffs. In one instance, a rock (soccer ball size) fell within about 15 ft of a beach picnicker on Moss Beach. In addition, children should be strongly discouraged from climbing and carving the cliffs. Warnings about the unstable cliffs should be posted at all access points and along the base of the cliffs.

## 2.5 Surveillance, Collecting Violations, and Advisories

### Purpose

This section presents a description of surveillance and enforcement in the Park and a review of available collecting citations and advisories.

### Background

Enforcement and advisory records provide information on illegal collecting, the species collected, and types of inappropriate tidepool behaviors. These types of data were available only

because of the daily presence of Park rangers and their record keeping. Nevertheless, the number of documented infractions observed by Park rangers will always be underestimated because of infractions that occur after they have left the Park.

## Methods

The Park records on collecting citations and observations were made available for our review and are described below. The California Department of Fish and Game (CDF&G) is also a key enforcement agency responsible for the protection of marine resources and keeps records of infractions. However, CDF&G enforcement records were not available for our review, because these records are confidential.

## Results

Based on Park ranger records, there has been a steady decline in the number of people caught illegally collecting since 1969 (**Figure 2-10**). While it is recognized that not all perpetrators are caught, the consistent observations of the rangers can be used to determine whether a general trend in the frequency of illegal collecting has occurred. Illegal collecting includes poachers who were intentionally harvesting organisms for consumption, plus the general public and school visitors who were found collecting organisms for curiosity, souvenirs, and education (casual collecting). Citations were issued in only the most overt cases of collecting; in most cases only an oral advisory was issued.

The decline in the number of collectors has resulted in an overall decline in the number of organisms collected (**Figure 2-10**). Mollusks, particularly mussels, limpets, and turban snails, were the most common species collected (**Table 2-2**). Other species commonly collected included crabs and sea stars.

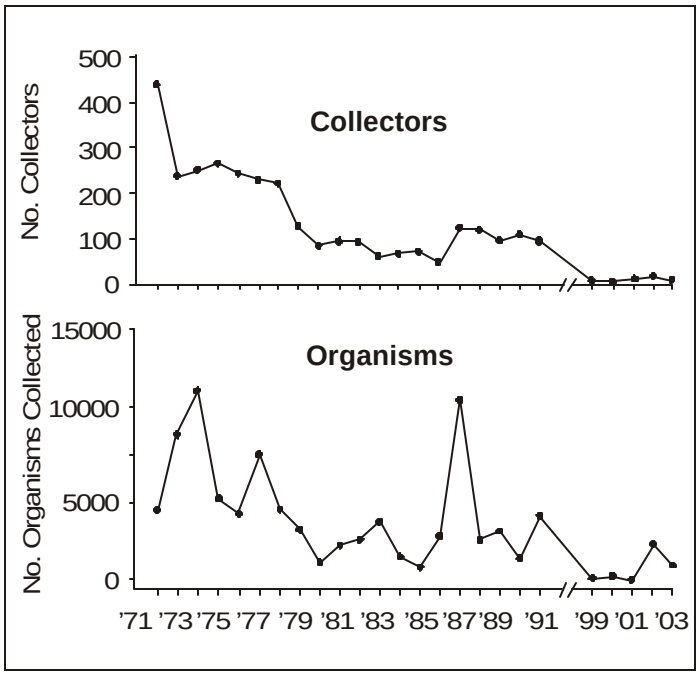



**Figure 2-10**. Changes in numbers of collectors and estimates of the total number of organisms illegally collected.

## Discussion

Although every instance of inappropriate tidepool behavior cannot be stopped before it has happened, there is, in general, an effective

**Table 2-2**. Summary of collecting violations (Park ranger records: 1999-2004).

| Date | Collectiors | Turban Snails | Limpets | Urchins | Mussels | Hermit Crabs | Tidepool Fishes | Rock Crabs | Sea Stars | Anemones | Shore Crabs | Abalone | Nudibranchs | Porcelain Crabs | Other Gastropods | Isopoda | Worms | Barnacles | Sponges | Tunicates | Shells | Algae | Rocks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/31/99 | 1 | | | | | | | 1 | | | | | | | | | | | | | | | |
| 7/10/99 | 1 | 15 | 3 | | | 10 | | | | 1 | | | | | | | | | | | | | |
| 7/11/99 | 1 | 7 | 11 | | 7 | 45 | | | | | | | | | | | | | | | | | |
| 7/27/99 | 5 | 75 | | | 7 | | | | | | | | | | | | | | | | | | |
| 8/21/99 | 3 | 100 | | | | | | | | | | | | | | | | | | | | | |
| 8/25/99 | 2 | 10 | | | | 10 | | | | | | | | | | | | | | | | | |
| 8/28/99 | 2 | 6 | | | | 5 | | | | | | | | | | | | | | | | | |
| 12/23/99 | 2 | | 2 | | 5 | | | | | | | | | | | | | | | | | | |
| 12/24/99 | 4 | | 3 | 1 | 15 | | | | | | | | | 2 | 1 | 1 | | | | | X | | |
| 1/20/00 | 1 | 25 | | | 3 | | | | | | | | | | | | | | | | | X | |
| 3/16/00 | 2 | | 1 | 256 | | | 12 | | 2 | 1 | | | 7 | 1 | | | 1 | | X | X | | | |
| 4/1/00 | 2 | | | | | | | | 2 | | | | | | | | | | | | | | |
| 4/10/00 | 1 | 35 | | | | | | | | | | | | | | | | | | | | | |
| 4/27/00 | 1 | 2 | | 3 | | 2 | 1 | | 1 | | 2 | 1 | | | | | | | | | | | |
| 6/4/00 | 1 | 2 | | | | | | 1 | 2 | | | | | | | | | | | | | X | |
| 7/4/00 | 1 | 11 | | | | | | | | | | | | | | | | | | | | | |
| 7/24/00 | 1 | | | | | | | | | | 1 | | | | | | | | | | | | |
| 9/3/00 | 3 | | | | | | | | | | | | | | | | | | | | | X | |
| 12/10/00 | 1 | | | | | | | | | 1 | | | | | | | | | | | | | |
| 1/11/01 | 1 | 41 | 3 | | | 5 | | | | | | | | | | | | | | | | | |
| 3/5/01 | 1 | 20 | | | | | | | | | | | | | | | | | | | | | |
| 4/2/01 | 1 | | | | | | | | 1 | | | | | | | | | | | | | | |
| 5/12/01 | 2 | 15 | | | | 10 | | | | 1 | | | | | | | | | | | | X | |
| 5/14/01 | 2 | 8 | | | | 10 | | | | | | | | | | | | | | | | X | |
| 5/19/01 | 2 | | | | | | | | 1 | | | | | | | | | | | | X | | X |
| 5/21/01 | 1 | | | | | | | 1 | | | | | | | | | | | | | | | |
| 5/26/01 | 3 | 4 | 5 | 5 | | | | 5 | 2 | 3 | | 6 | | | | | | | | | X | | |
| 6/16/01 | 15 | 1 lb | 5 | | | 25 | | | | | | | | | | | | | | | | | |
| 3/12/02 | 6 | 252 | 52 | | 59 | 17 | | | | | | | | | | | | X | | | | X | |
| 6/24/02 | 5 | | 19 | | | | | | | | | | | | | | | | | | | | |
| 7/6/02 | 6 | 50 | | | 30 | | 7 | | | | | | | | | | | | | | | X | |
| 7/7/02 | 3 | | | | 10 | | | | | | | | | | | | | | | | | X | |
| 7/14/02 | 3 | | | | | | | | | | | | | | | | | | | | | X | X |
| 7/28/02 | 3 | 1331 | 431 | | | | | | | | | | | | | | | | | | | | |
| 8/25/02 | 1 | | | | | | | | | | | | | | | | | | | | | X | |
| 9/1/02 | 6 | 20 | | | 14 | | | | | | | | | | | | | | | | | X | |
| 11/27/02 | 1 | | | | | | | 3 | | | | | | | | | | | | | | | |
| 1/1/03 | 1 | 12 | | | | | | | | | | | | | | | | | | | | | |
| 3/11/03 | 2 | | | | | | 1 | | | | 4 | | | | | | | | | | | | |
| 3/28/04 | 4 | | | | 15 lb | | | | | | | | | | | | | | | | | | |
| 4/8/03 | 2 | 50 | | | | | | | | | | | | | | | | | | | | | |
| 4/19/03 | 2 | | | | 35 lb | | | | | 1 | | | | | | | | | | | | X | |
| 5/26/03 | 2 | 50+ | | | | | | | | | | | | | | | | X | | | X | X | X |
| 10/23/03 | 4 | | | | | | | | | | | | | | | | | | | | | | |
| 1/19/04 | 2 | | | | lrg bag | | | | | | | | | | | | | | | | | | |
| **Total** | **116** | **2091** | **535** | **265** | **150** | **139** | **21** | **11** | **11** | **8** | **7** | **7** | **7** | **3** | **1** | **1** | **1** | | | | | | |

network of presence, surveillance, and enforcement in the Park that has likely helped to lower potential impacts from visitor activities over time. Park rangers are present daily, and Friends of Fitzgerald docents assist in providing a presence at the Park.

There are several other possible reasons for the data depicting an overall decline in collectors and numbers of organisms taken. The general public might have gained an overall greater appreciation for marine resource conservation from educational outreach efforts, literature, and television. Poaching may have decreased, due to stiffer fines, the possibility of imprisonment, and lack of tolerance to collecting by enforcement agencies. In addition, significant numbers of poaching incidents may still occur in the Park, but poachers are more adept at avoiding being caught. Another reason may be that the area is no longer a good source area for poaching, due to a decline in the quality and abundance of organisms.

While enforcement and advisory records provide documentation on unlawful and inappropriate actions in the intertidal zone, the records, however, only represent a portion of the inappropriate actions that likely occur. Enforcement staff and docents, including informed citizens, are not present at all times in all places. Furthermore, some form of inappropriate tidepool behavior can eventually be seen during any prolonged observation of the area.

Southern California rocky shorelines that are popular visitor destinations have larger records of citations and advisories than the Fitzgerald State Marine Park. The advisories issued by lifeguards at many places in Orange County have averaged 25,532 annually over two years (Murray et al. 1999). This high number is due to the on-site presence of lifeguards for most hours of the day during summer months, and the high numbers of visitors to the shore. However, the lifeguards are generally not present in the field during the fall and winter months when low tides occur during daylight hours and tidepool visitation is also high. Consequently, many more incidences have likely gone undetected. The high number of incidents and advisories is not unusual because, in these areas, an average of nearly one individual every 10 minutes has been observed engaged in some form of inappropriate tidepool activity (Murray et al. 1999).

CDF&G scientific collecting reports are also another source of information on organisms removed from their habitats. This form of collecting is legal, however, and is regulated under the scientific collecting permit issued to an individual by the CDF&G. Holders of scientific collecting permits are required to submit a report of the organisms collected every two years upon expiration of their permit. However, the collecting reports are not archived in a way that allows the data to be retrieved by location. Consequently, it is largely impossible to construct a complete database on past amounts of scientific collecting in the Park, or any other location.

# 2.6 Comparison of Visitor Attendance with Other Areas

## Purpose

The purpose of this portion of the study was to compare visitor numbers at the Fitzgerald State Marine Park with other popular intertidal areas, which are easily accessible.

## Background

People frequent other rocky intertidal areas in California in addition to the Fitzgerald State Marine Park. Many of these areas also experience heavy use because, like the Fitzgerald State Marine Park, they have parking lots that are close to the shore with walking trails leading to the intertidal zone, and are close to urban areas. Several of these shoreline areas were compared in a previous assessment of visitor use (Tenera 2003). Below we summarize the information described by Tenera (2003) to describe numbers of visitors among areas with similar access and coastal resources.

## Methods

We compiled estimates of visitor attendance for other areas from a number of sources; referred to by the names used prior to the State's re-classification of MPA types:

- Point Pinos (Monterey County): source/ Tenera 2003
- Natural Bridges State Beach (Santa Cruz County): source/ Martha Nitzberg, Education Outreach Specialist
- Point Lobos State Reserve (Monterey County): source/ Pat Clark-Gray, Monterey State Parks; Chuck Bancroft, Ranger
- Little Corona del Mar (Orange County): source/ Cheri Schonfeld, Marine Life Refuge Supervisor
- Crystal Cove Marine Life Refuge (Orange County): source/ Winter Bonnin, State Park Interpreter
- Dana Point Marine Life Refuge (Orange County): source/ John Lewengrub, Marine Life Refuge Project Manager
- Cabrillo National Monument (San Diego County): source/ Engle and Davis (2000)

Total annual attendance estimates were used for comparison to provide a generalized representation of overall visitor use. Other types of attendance estimates may be used to compare areas (such as maximum daily attendance levels), but these were judged to be unreliable for

comparison purposes. For example, some areas may experience equivalent maximum daily levels of attendance during holidays or during the lowest tides of the year, but total annual attendance may be substantially different and, therefore, more relevant for comparison purposes.

Annual visitation levels for other areas were obtained from literature accounts and through interviews with associated management staff. We found that some areas had programs with visitor counts that had been compiled or a sufficient number of field observations completed to derive general estimates of total annual visitor attendance. The annual attendance level for each area was adjusted for shoreline distance, in order to compare visitor densities based on a common shoreline span (100 m of shore). The distance of the shoreline most affected for each area was based on an approximation made by staff or the distance measured from maps.

## Results

### Fitzgerald State Marine Park Annual Visitation

While Park records indicate that visitor use at the Fitzgerald State Marine Park peaked at over 130,000 people in 1997, we chose to use 100,000 people per year as an overall value of recent annual attendance at the Park.

### Annual Visitation at Other Areas

Annual attendance estimates among all areas are compared in **Figure 2-11** with the information summarized in **Table 2-3**. The numbers are for general comparisons only, because different methods were used to estimate total annual visitor attendance. The visitor estimates in **Figure 2-11** and **Table 2-3** are all based on the numbers of visitors in the intertidal zone. If our estimates included people on cliffs and on walking trails, annual attendance estimates would be greater for some areas (e.g., Point Pinos).

The Fitzgerald State Marine Park, Little Corona del Mar in Orange County, and the Cabrillo National Monument in San Diego County appear to have the highest numbers of visitors per year per length of shoreline (**Figure 2-11**).

While annual attendance at the Fitzgerald State Marine Park has been reported to be approximately 110,000-135,000 visitors per year along approximately 500 m of shoreline by Breen (1998), we chose 100,000

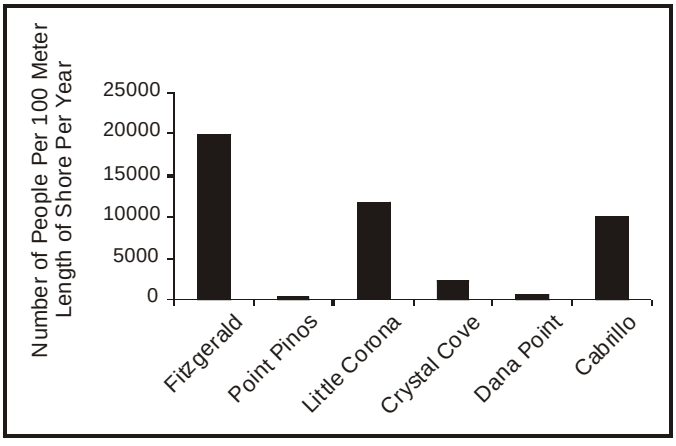



**Figure 2-11**. Comparison of annual attendance among popular intertidal areas in California.

**Table 2-3.** Annual attendance among popular rocky intertidal areas in central and southern California. (Note that the areas and names are those used prior to the State's re-classification of MPA types.)

| Unit (County) | Estimates of Attendance | Length of Rocky Shore Most Visited | Data Source | Methods | Comments |
|---|---|---|---|---|---|
| Fitzgerald Marine Reserve (San Mateo Co.) | 100,000+ total visitors/year | 500 m (0.31 mi) | Park records | Counts of buses, cars, and walk-ins. | General public use exceeds school use. Limit Goal: 300-500/day |
| Point Pinos (Monterey Co.) | 30,000 – 50,000 per year | 1.3 km (0.80 mi) | Annual attendance extrapolated from data collected in the present study and from data in Clowes and Coleman (2000) | Data from extrapolations. | Use high, but not as high as other areas. Attendance probably closer to 50,000 people/yr |
| Natural Bridges State Beach (Santa Cruz Co.) | Approx. 200,000/yr visit the beach and park but unknown numbers visit the rocky intertidal<br>Approx. 4,000 students/yr visit the intertidal zone through docent-led education programs | 0.4 km (0.25 mi) | Martha Nitzberg (Education Outreach Specialts, pers. com.) | Tallies of cars and entry passes. | No estimates of total visitor use for intertidal zone, although considered high. |
| Point Lobos State Reserve (Monterey Co.) | Daily Intertidal Use<br>Max: 20-25 people/any time<br>Total: 50-75 people/day<br>30,000-50,000 total visitors/year, but few go into the intertidal | Weston Beach: 100 m (0.06 mi) | Pat Clark-Gray (District Interpretive Specialist, Calif. State Parks, Monterey District, pers. com.)<br>Chuck Bancroft (Park Ranger, Point Lobos, pers. com.) | Numbers from gate records of groups, cars, walk-ins. | Intertidal use mainly at Weston Beach.<br>Most use is nature trails. |
| Little Corona Marine Life Refuge -Robert E. Badham Marine Life Refuge- (Orange Co.) | 2000-01: 7,800 in classes plus 7,800 not in classes<br>2001-02: 6,000 in classes plus 6,000 not in classes<br>2002-03: 4,000 in classes plus 1,000 not in classes<br>Summer wkends: 500-1000/day<br>Summer wkdays: 500-800/day<br>Historical max: 1,200-1,500 in classes/day<br>No estimates of total visitors/year | 0.8 km (0.50 mi) | Cheri Schonfeld (Marine Life Refuge Supervisor, City of Newport Beach, pers. com.) | Numbers from school visits that go through reservations and the marine science program. | Attempting to lower visitor use each year.<br>General public use well exceeds school use.<br>Limit: Goal: 200-300/day |
| Irvine Coast Marine Life Refuge -Crystal Cove- (Orange Co.) | 1996: 7,690 in classes<br>2003: 9,000 in classes (anticipated)<br>Multiple access points<br>No estimates of total visitors/year | 4.0 km (2.5 mi) | Winter Bonnin (State Park Interpreter, Crystal Cove State Park, pers. com.) | Numbers are from school visits that go through reservations and the marine science program. | Scheduled bus visits are nearly booked for the year by mid-Feb. |
| Dana Point Marine Life Refuge (Orange Co.) | 1,000-2,000 students/yr via the Ocean Institute interpretive program. More students via other programs.<br>Up to 4,000 total visitors/day during good days with 600 people in smaller groups<br>One main access<br>100,000 total visitors/year, based on extrapolations from visitor counts collected 5 years ago | 1.2 km (0.75 mi) | John Lewengrub (Project Manager, Dana Point Marine Life Refuge, pers. com.) | Total annual visitor counts based on extrapolated data from visitor census surveys from planned programs. | Visitor count surveys are not as numerous as five years ago.<br>Beginning a tidepool biological monitoring program. |
| Cabrillo National Monument (San Diego Co.) | 1990-95: Max. 384 people/day<br>100,000 total visitors/year | 1 km (0.62 mi) | Engle and Davis (2000) | Annual attendance extrapolated from data in Engle and Davis (2000). | Most use concentrated in Area 1 (300 m).<br>Most counts made during minus tides. |

people per year as the number for Fitzgerald State Marine Park to be compared with other areas, because total attendance has decreased slightly from the highest values reported by Breen (1998). We estimate that the intertidal area at Cabrillo National Monument also has approximately 100,000 visitors per year. We derived this estimate from extrapolating census counts of people made by Engle and Davis (2000). They counted people in 288 surveys from 1990 through 1995. The annual estimate for the Cabrillo National Monument is likely high because most counts were made during minus tides when visitor use was probably greatest. The annual attendance for Point Pinos was calculated by extrapolating visitor counts in the shoreline made by Clowes and Coleman (2000) and Tenera (2003), as this was the only means to determine annual attendance levels.

Annual visitor estimates were not available for most areas in Orange County because they did not have census programs (**Table 2-3**). The most definitive information was on school bus visits organized through the local education outreach programs. However, many visitors arrived independently, and there were no reliable data on shoreline use by the general public. Despite the lack of reliable data, it was roughly estimated that approximately one million people visit the seven Orange County marine protected areas (MPAs) collectively over the course of a year (John Lewengrub, Project Manager, Dana Point Marine Life Refuge, pers. com.). Therefore, well over 100,000 people on average may visit each of the seven Orange County MPAs each year. We used the value of 100,000 people per year for each of the two Orange County MPAs in **Figure 2-11**. Point Lobos has tended to have the smallest numbers of people visiting the intertidal zone. Most people stay on the nature trails located above the intertidal zone (Chuck Bancroft, Park Ranger).

## Discussion

Based on numbers of people per unit of shoreline, the Fitzgerald State Marine Park ranked among the highest visited areas among popular intertidal sites in California. The high attendance at the Park is likely associated with its proximity to the densely populated San Francisco Bay area and its historical identification as an accessible intertidal site. Furthermore, the rocky intertidal zone at the Fitzgerald State Marine Park consists of a flat rock bench platform. The low topographical relief provides for a convenient and safe tidepooling experience compared to steep rocks at many other places (e.g., Point Pinos). This combined with the parking lot and restroom facilities likely account for the popularity of the Fitzgerald State Marine Park.

The high attendance in southern California is likely associated with consistently nicer weather, compared to areas in central California, and the proximity of the areas to large urban regions. In addition, there is a scarcity of rocky habitats to visit in the southern California region, which tends to concentrate visitors interested in tidepools at only a few sites. Natural Bridges State Beach in Santa Cruz County is another area that receives high visitor use, although there are no reliable estimates on the numbers of people that visit the rocky intertidal zone annually (Martha Nitzberg, Education Outreach Specialist, pers. com.). High attendance at Natural Bridges State Beach is likely associated with convenient parking, ease of access, and the adjoining upland State Park.

# 3.0 Biological Descriptions

## Approach

The purpose of our study was to determine if intertidal areas were being impacted by visitor use and to provide data on the current conditions of the biological communities for use as a baseline for future studies. Our biological studies were completed in spring-summer 2004. To optimize resources, we chose to concentrate our sampling during a single survey period, with the largest number of replicate sites practical, rather than conduct several less detailed surveys over a longer time period. The following surveys were completed:

- A gradient study to determine whether algal and invertebrate abundances change with distance from the main visitor access to the State Marine Park,
- A tidepool study of algal, invertebrate, and fish abundances,
- A study to determine effects of visitor use on algae and invertebrates using data from the Park's roped and unroped study plots,
- A study to determine if the Park's roped and unroped plots are representative of other areas on Moss Beach Reef,
- A study to determine effects of visitor use on mussel beds between roped and unroped plots,
- GIS mapping of mussel bed areas,
- A survey of sea star (*Pisaster* spp.) abundance and comparison to historical data,
- A survey of owl limpet (*Lottia gigantea*) shell measurements,
- A survey of monkeyface eel and rock prickleback recruitment on Moss Beach Reef and Distillery Reef,
- A finfish fishery resources study,
- A GIS analysis of the shoreline habitat of Fitzgerald State Marine Park and comparison with other areas of the San Mateo County outer coast.

No organisms were sacrificed during the course of our studies in order to minimize impacts. If organisms could not be identified in the field, species' characteristics were recorded and used to identify the organisms in the laboratory.

## Study Areas

All intertidal areas in the Fitzgerald State Marine Park are susceptible to some level of visitor impact, because all areas are relatively accessible. Therefore, we used our visitor census observations (see *Section 2.0 – Visitor Use Description*) to verify that the areas we sampled for comparisons were located in areas with high and low visitor use.

Moss Beach Reef, the area from the main access south to Cypress Point (**Figure 3-1**) was the area with the largest numbers of visitors. Biological sampling was not conducted in the less-visited areas north of the access where the intertidal zone is less accessible because it is composed of large relief rock ridges and surge channels (see *Section 1*.5 - *Environmental Setting*). Fewer visitors use this area because the footing is not as safe as the rock bench platforms (Moss Beach Reef), and the docents always direct groups south from the main access. We also did not sample Nye's Rocks (**Figure 3-1**), because this is a haulout site for harbor seals.

All of our reference/control areas were on Distillery Reef (**Figure 3-2**) and Frenchman's Reef-South (**Figure 3-3**) where we found visitor use to be very low. In all areas, we sampled the upper and mid-bench intertidal zones on the rock platforms. The outermost fringes of the platforms were not sampled because of difficulties inherent in sampling this area, which is subject to more wave surge and is less often exposed during low tide than the areas on the reefs. Our census surveys verified that these areas have fewer numbers of visitors due to the difficult and dangerous access. The coordinates for all sampling locations are presented in **Table 3-1**.

## Analysis

In this report, we refer to organisms as 'taxa' or 'species'. Taxa is a more general term that refers to several species that may be grouped together because they are closely related. We describe patterns and trends for single taxa using graphs and tables. Where appropriate, we analyzed the data using multivariate statistics, which were used to describe the patterns of variation in the biological communities. Multivariate analysis provides a powerful means to examine patterns and trends for all of the taxa in a single analysis. The following describes our statistical approaches.

The patterns of variation in the communities were analyzed using non-metric multi-dimensional scaling (MDS), a multivariate method for ecological analysis available in the PRIMER multivariate ecological statistical package (PRIMER-E Ltd. 2001). The Bray-Curtis measure of dissimilarity was used in all MDS analyses. The MDS analysis involves iteratively configuring the samples in the analysis to maximize the rank correlation between the distances in the MDS configuration and the original Bray-Curtis dissimilarities (Clarke and Warwick 2001).

Differences between the groups identified in MDS were analyzed using the ANOSIM procedure in the PRIMER package. When statistical differences were detected between groups, the SIMPER procedure in PRIMER was used to determine the species that contributed to the differences and patterns in the MDS.

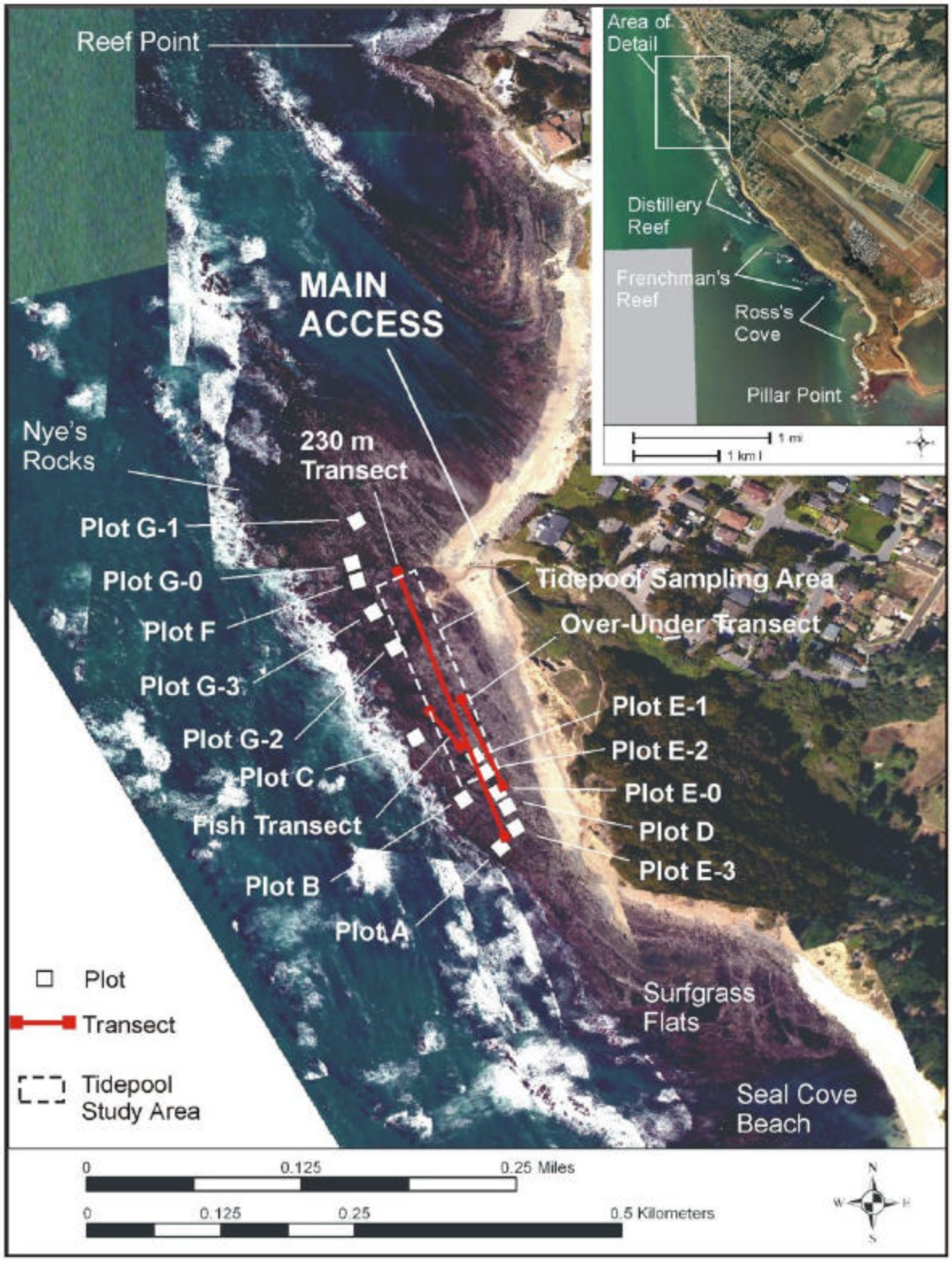



**Figure 3-1**. Sampling locations on Moss Beach Reef.

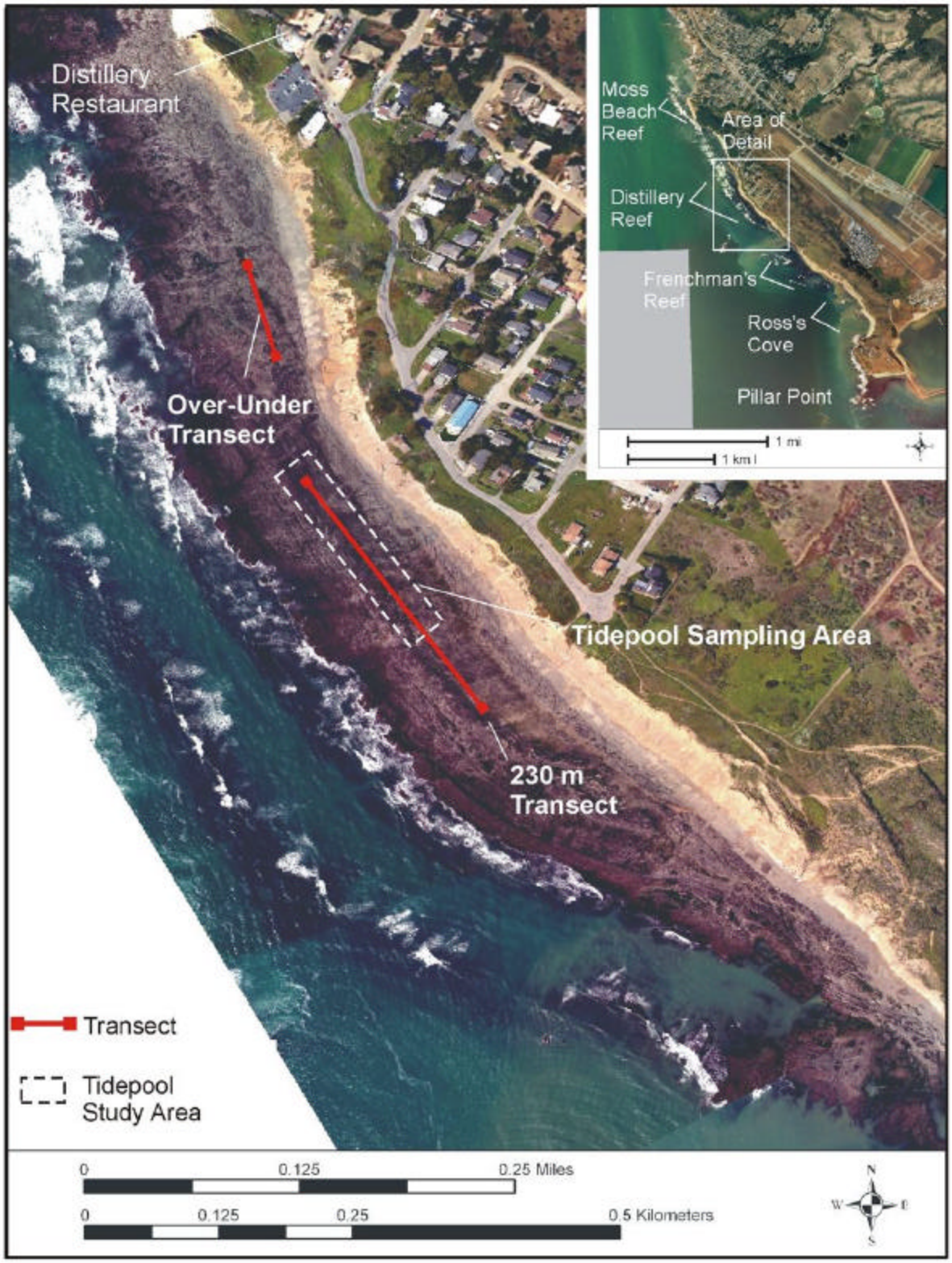



**Figure 3-2**. Sampling locations on Distillery Reef.


**Figure 3-3**. Sampling locations on Frenchman's Reef.

**Table 3-1**. Sampling locations for plots and transects.

| Study | Long. (NAD83) | Lat. (NAD83) | Location | Attribute |
|---|---|---|---|---|
| PLOT A | 122.51742 | 37.52200 | Moss Beach Reef | Middle |
| PLOT B | 122.51797 | 37.52242 | Moss Beach Reef | Middle |
| PLOT C | 122.51836 | 37.52280 | Moss Beach Reef | Middle |
| PLOT D | 122.51746 | 37.52216 | Moss Beach Reef | Middle |
| PLOT E-0 | 122.51754 | 37.52223 | Moss Beach Reef | Middle |
| PLOT E-1 | 122.51776 | 37.52242 | Moss Beach Reef | Middle |
| PLOT E-2 | 122.51768 | 37.52234 | Moss Beach Reef | Middle |
| PLOT E-3 | 122.51737 | 37.52212 | Moss Beach Reef | Middle |
| PLOT F | 122.51817 | 37.52401 | Moss Beach Reef | Middle |
| PLOT G-0 | 122.51827 | 37.52408 | Moss Beach Reef | Middle |
| PLOT G-1 | 122.51830 | 37.52426 | Moss Beach Reef | Middle |
| PLOT G-2 | 122.51796 | 37.52367 | Moss Beach Reef | Middle |
| PLOT G-3 | 122.51803 | 37.52392 | Moss Beach Reef | Middle |
| Over-Under Transect | 122.51763 | 37.52323 | Moss Beach Reef | Origin |
| Over-Under Transect | 122.51733 | 37.52236 | Moss Beach Reef | Terminus |
| Over-Under Transect | 122.51281 | 37.51582 | Distillery Reef | Origin |
| Over-Under Transect | 122.51271 | 37.51539 | Distillery Reef | Terminus |
| Fish Transects | 122.51781 | 37.52279 | Moss Beach Reef | Origin |
| Fish Transects | 122.51752 | 37.52254 | Moss Beach Reef | Terminus |
| Fish Transects | 122.50692 | 37.50767 | Frenchman's Reef | Origin |
| Fish Transects | 122.50655 | 37.50734 | Frenchman's Reef | Terminus |
| 230 m Transect | 122.51800 | 37.52405 | Moss Beach Reef | Origin |
| 230 m Transect | 122.51735 | 37.52200 | Moss Beach Reef | Terminus |
| 230 m Transect | 122.51270 | 37.51452 | Distillery Reef | Origin |
| 230 m Transect | 122.51135 | 37.51264 | Distillery Reef | Terminus |

# 3.1 Gradient Study

## Purpose

The purpose of this study was to determine whether a gradient of change in the biological communities could be detected on Moss Beach Reef that could be correlated with increasing distance from the main access path southward. This type of study would be appropriate if there were decreased numbers of visitors with increasing distance from the main access point. However, results of our visitor counts showed that the entire area was visited nearly equally.

# Background

Gradient analysis is one approach to impact assessment when no baseline data or suitable reference areas exist. Increased abundances of organisms or community changes with distance away from a main access point would provide evidence of visitor use effects, given that all other environmental factors were equal. The area from Fitzgerald State Marine Park's main access southward to Cypress Point (**Figure 1-1**) was chosen as the site for a gradient study because the length of time that visitors explore tidepools was expected to be greatest nearest the main access point within this region. However, our visitor census surveys showed that visitors tended to be equally spread throughout the Moss Beach Reef region from the main access south to Cypress Point (see *Section 2.0 – Visitor Use Description*). We therefore sampled Distillery Reef in the same fashion to provide a control/reference for the Moss Beach Reef transect.

# Methods

## Sampling

A 230 m transect was deployed parallel to shore on Moss Beach Reef, beginning near the main access in the upper intertidal zone (approx. +3-4 ft MLLW) (**Figure 3-1**). At each 10 m interval (beginning at meter 0) along the 230 m shoreline transect, a 10 m transect was deployed in an offshore direction (**Figure 3-4**). Three 0.25 $m^2$ quadrats were randomly positioned along each 10 m transect in areas that contained flat rock habitat. Tidepools, puddles, ledges, cobbles, and boulders were not surveyed in order to minimize effects of habitat variation.

In each quadrat, the percent cover was visually estimated for algae, sessile invertebrates, and bare rock, and motile invertebrates were counted. The three quadrats provided three samples for averaging species abundances for each 10 m transect segment. We also used the same methodology to sample Distillery Reef for comparison, an area with fewer visitors and presumably visitor impacts (**Figure 3-2**).

## Analysis

Algal and invertebrate data were analyzed separately using multi-dimensional scaling (MDS). Bray-Curtis measures of dissimilarity based on average abundances from the three quadrats were used in the MDS analyses. Data from the two areas were analyzed together to contrast their community patterns and to determine if any statistically significant differences between the community patterns could be detected. ANOSIM was used to

**Figure 3-4**. Sampling using 0.25 $m^2$ quadrats.

determine if there was a statistical difference between communities from the two areas, while the species that contributed to any observed differences were analyzed using the SIMPER procedure.

The data from each area were also analyzed separately using MDS. The presence of a linear pattern of variation along each transect was analyzed using the RELATE routine in PRIMER. This analysis helped identify patterns that might have been related to variation in levels of visitor effects along the transect. The analysis is done by comparing the rank correlation between a linear pattern and the Bray-Curtis distances among transect segments with a set of correlations between a linear pattern and a set of distances based on random permutations of the stations. The statistical significance of the rank correlation from the original data is based on the percentage of values it exceeds, in comparison with values from the full set of random permutations. If visitor use was affecting the communities at Moss Beach Reef the analysis might detect a significant change in the communities with increased distance from the main access trail near the parking area. In contrast, no pattern of change along the transect would be expected to occur at Distillery Reef.

The algal data analyzed with MDS, which included only foliose, non-crustose taxa, were square root transformed to reduce the weighting of algae with large abundances in the analysis. Invertebrate data were log transformed to reduce the scale differences between count and percent cover measures of taxa abundances.

## Results

### Overview

The composition of the algal communities along the Moss Beach and Distillery Reefs transects was different even though the average total upright algal cover and number of taxa were similar between transects (**Figure 3-5**). Moss Beach Reef had higher abundances of *Neorhodomela larix*, while abundances of *Endocladia muricata* and *Cryptosiphonia woodii* were higher at Distillery Reef. The total number of taxa at both locations was much less than what would be observed at other popular intertidal areas such as Point Pinos in Pacific Grove where the increased heterogeneity of the substrate allows for greater species diversity (Tenera 2003). Total upright algal cover at Moss Beach decreased with distance from the main access (**Figure 3-6**). A similar pattern occurred along the Distillery Reef transect where total upright algal cover declined slightly in a downcoast direction from the transect origin to transect terminus. Numbers of algal taxa were similar along each transect.

Invertebrate taxa richness (mean no. taxa / 0.25 $m^2$) was slightly greater on the Distillery Reef transect (**Figure 3-7**). Black turban snails (*Tegula funebralis*) were slightly more abundant along the Distillery Reef transect (**Figures 3-7 and 3-8**) than the Moss Beach Reef transect. The mean number of taxa per quadrat did not show any pattern of change along Moss Beach Reef related to increasing distance from the main access (**Figure 3-8**). Black turban snails did appear to increase

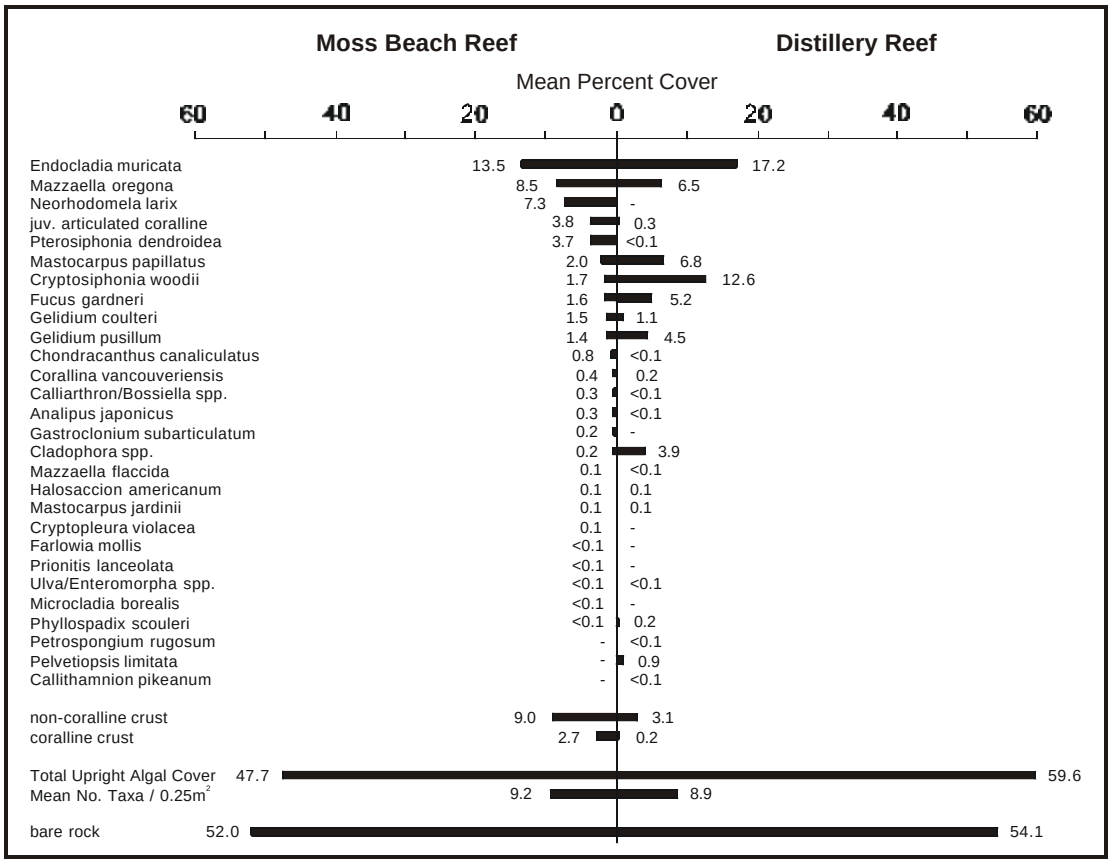



**Figure 3-5**. Algal abundances in the 230 m transects on Moss Beach Reef and Distillery Reef.

along the first 50-60 meters of the transect, but their abundances at the end of the transect, farthest from the main access, were similar to abundances near the main access (**Figure 3-8**).

## Algal Analysis

The MDS results showed greater variation among transect segments at Moss Beach compared to Distillery Reef (**Figure 3-9a** and **b**). A significant difference was detected between areas (ANOSIM R-Value=0.29, $p<0.01$), which was likely due to the high similarity among transect segments at the Distillery Reef site, relative to the Moss Beach segments.

SIMPER analysis showed that the algal communities at both sites were dominated by a small number of algal species; seven algal species at Moss Beach and five at Distillery Reef (**Table 3-2a** and **b**). The larger number of taxa accounting for the similarity among transect segments at Moss Beach probably helped explain the increased variability and reduced average similarity (25%) among transect segments relative to Distillery Reef (average similarity = 42%). Despite the difference in average similarity between areas, the total average number of foliose algal taxa and percent algal cover were extremely similar between sites (**Table 3-3**). The

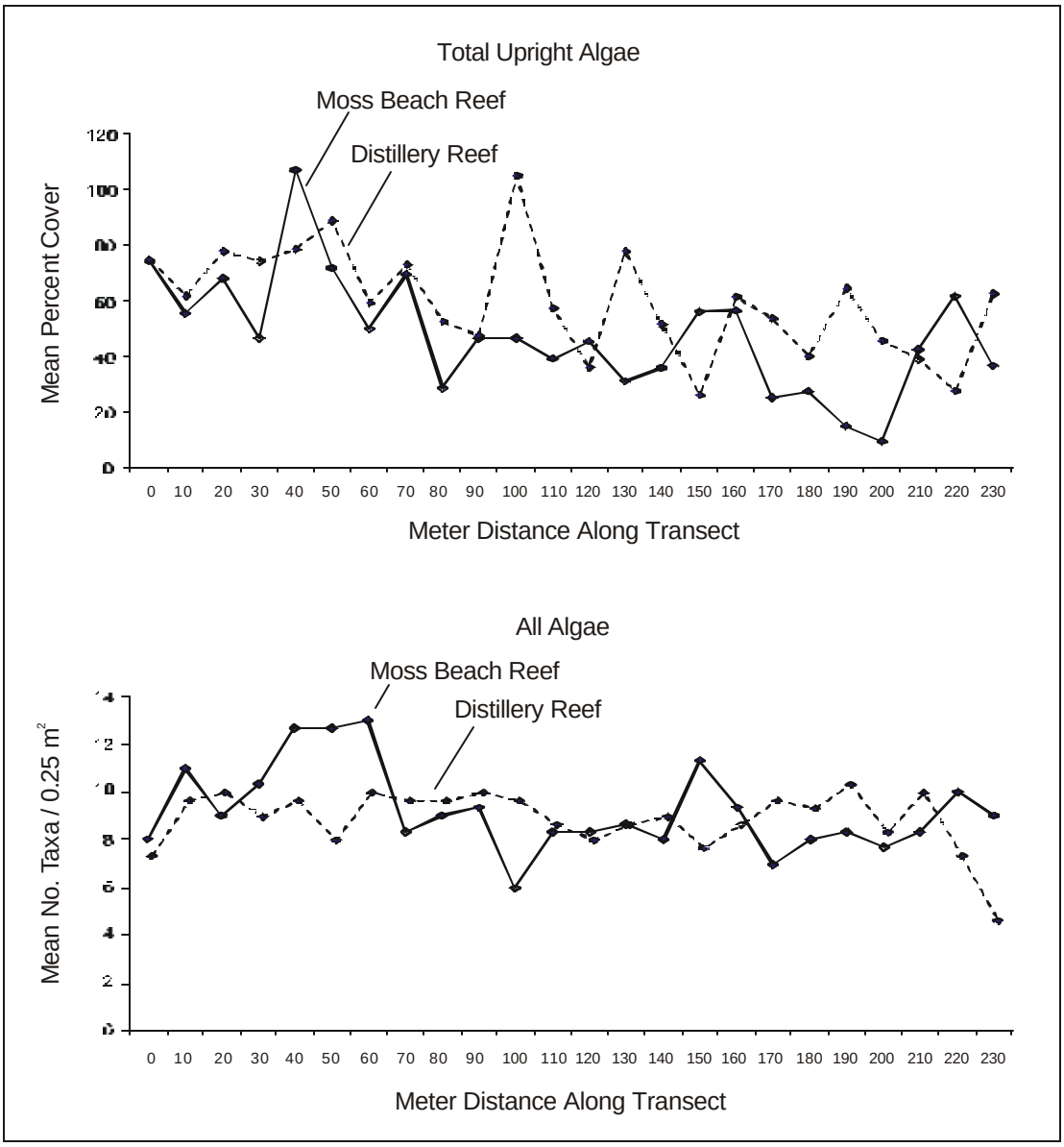



**Figure 3-6**. Upright algal abundances along the 230 m transects on Moss Beach Reef and Distillery Reef.

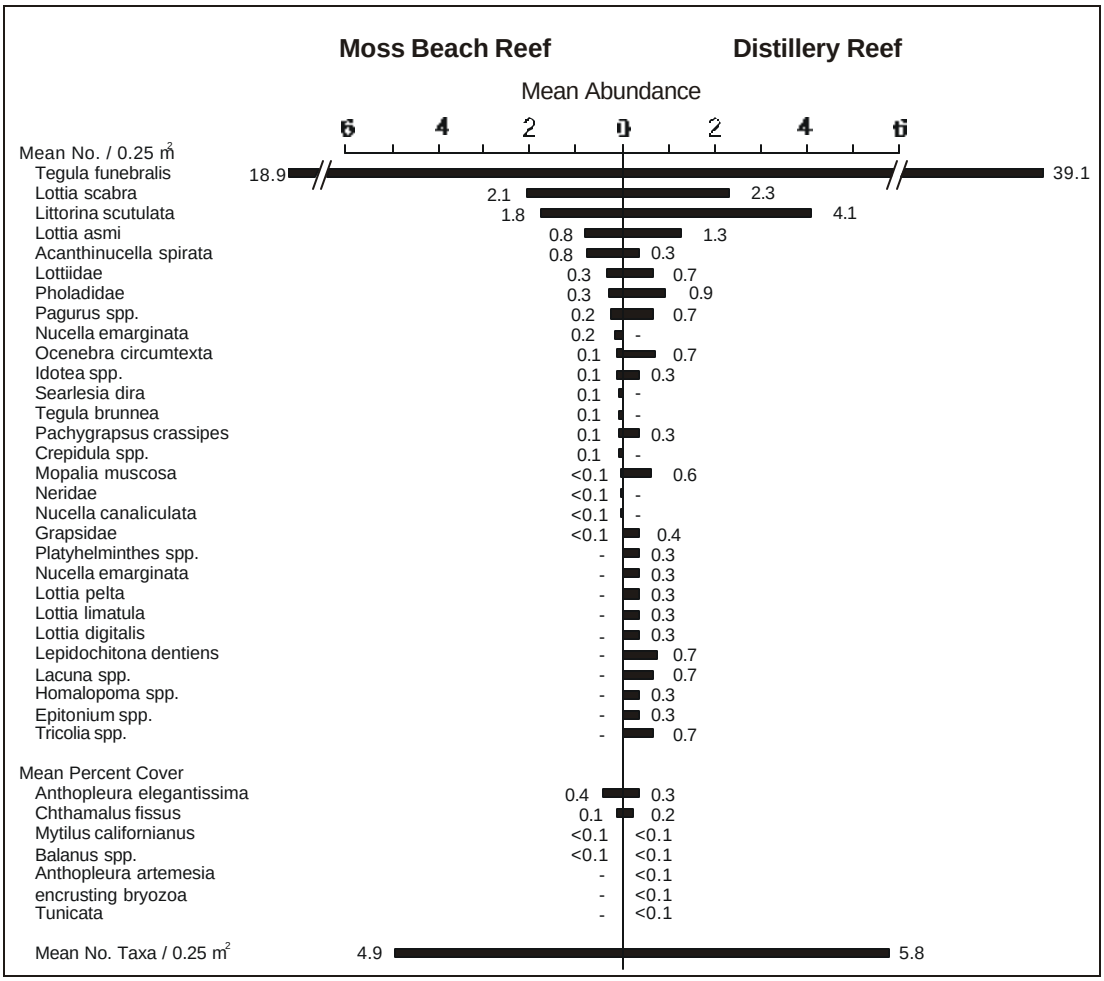



**Figure 3-7**. Invertebrate abundances in the 230 m transects on Moss Beach Reef and Distillery Reef.

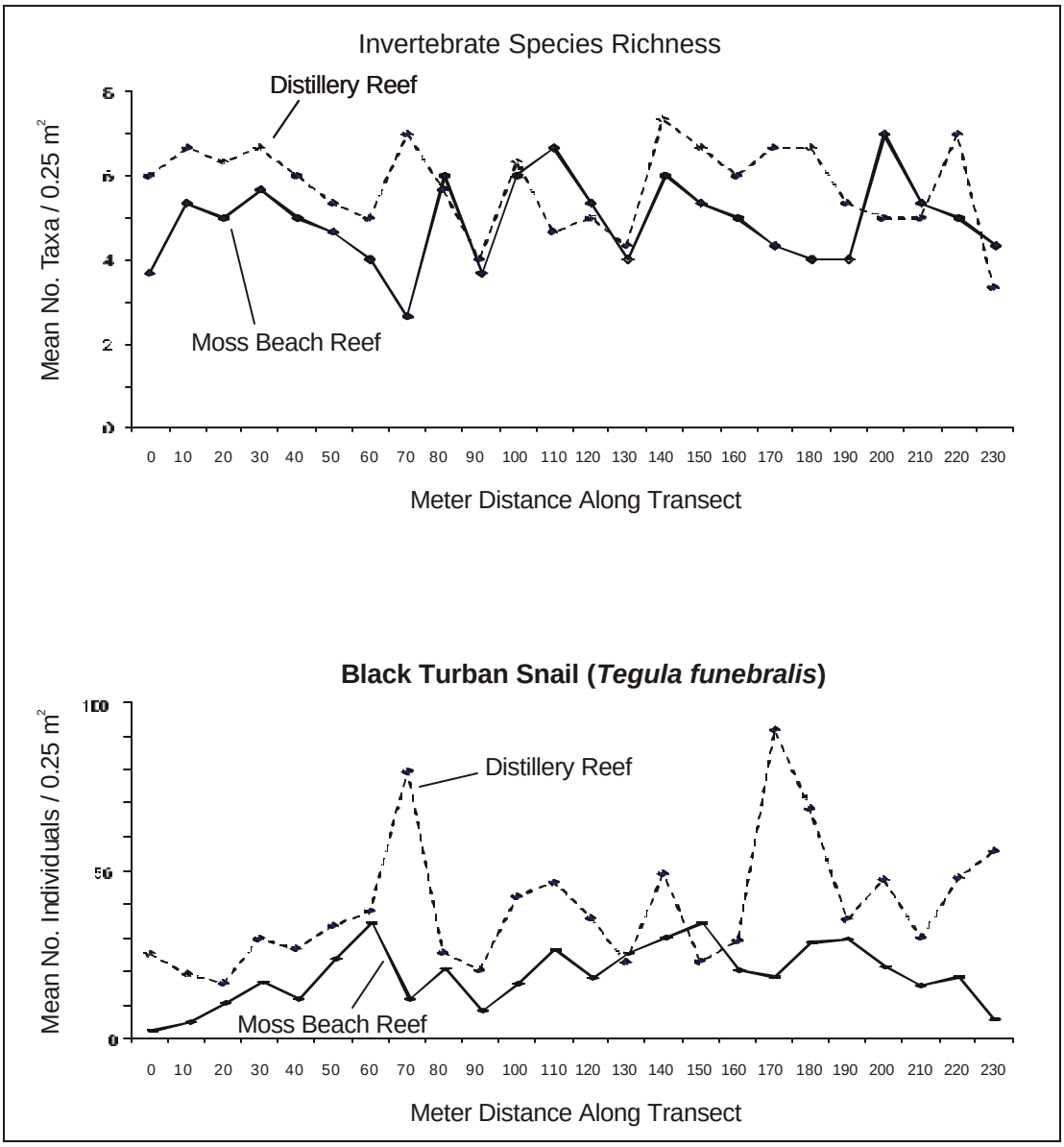



**Figure 3-8**. Invertebrate abundances along the 230 m transects on Moss Beach Reef and Distillery Reef.

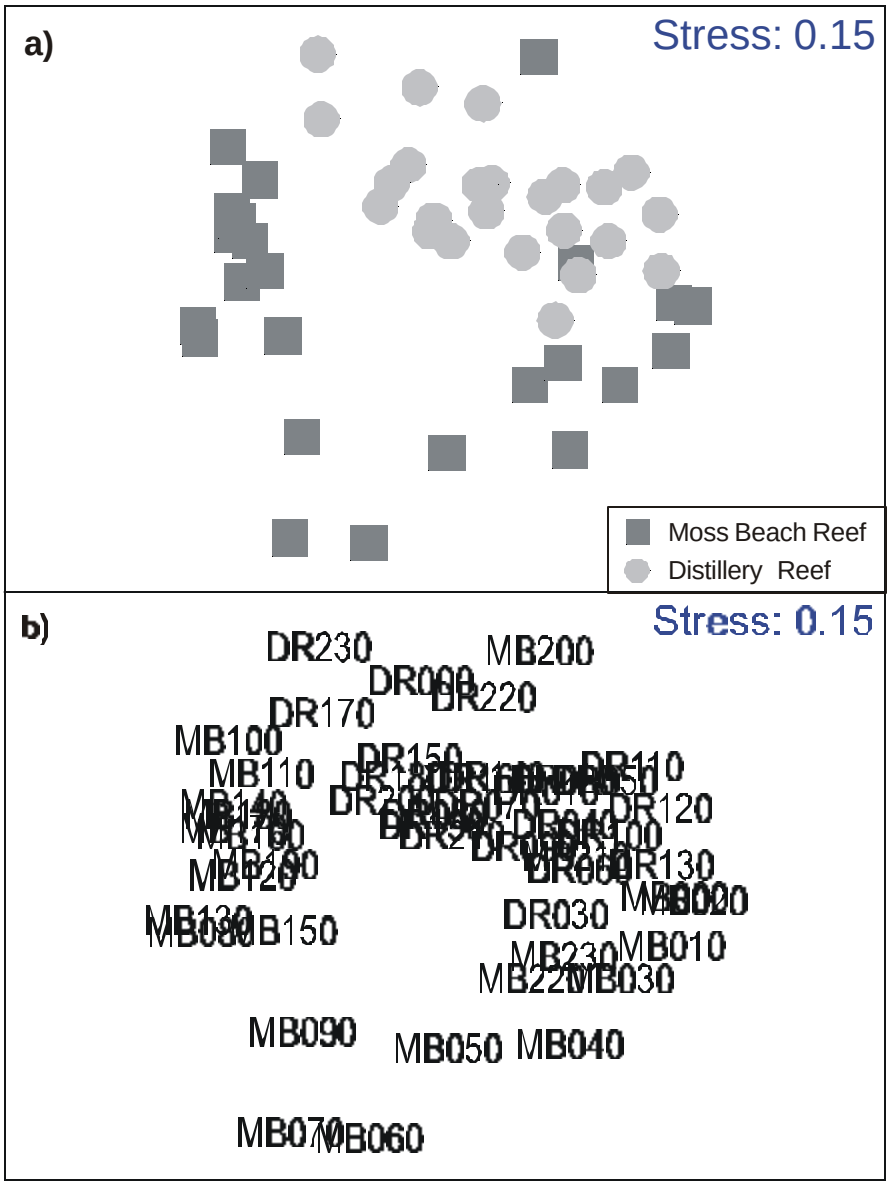



**Figure 3-9**. MDS analysis of average foliose algal abundances with: a) symbols representing transect locations on the Moss Beach Reef and Distillery Reef transects with b) values indicating the meter position of the symbols along each transect (MB=Moss Beach Reef; DR=Distillery Reef). The origin and terminus of each transect was upcoast and downcoast, respectively.

**Table 3-2**. Results of SIMPER showing algal taxa responsible for similarity among transect segments at: a) Moss Beach; and b) Distillery Reef. The average similarities among transect segments at the two sites are 24.76 and 42.47, respectively.

| a) Species | Average % Cover | % Contribution | Cumulative % |
|---|---|---|---|
| *Mazzaella oregona* | 8.49 | 28.30 | 28.30 |
| *Endocladia muricata* | 13.53 | 26.88 | 55.19 |
| juv. articulated coralline | 3.82 | 13.17 | 68.35 |
| *Neorhodomela larix* | 7.26 | 8.49 | 76.85 |
| *Pterosiphonia dendroidea* | 3.68 | 6.67 | 83.52 |
| *Gelidium coulteri* | 1.47 | 5.33 | 88.85 |
| *Cryptosiphonia woodii* | 1.74 | 3.69 | 92.54 |

| b) Species | Average % Cover | % Contribution | Cumulative % |
|---|---|---|---|
| *Endocladia muricata* | 17.18 | 49.07 | 49.07 |
| *Cryptosiphonia woodii* | 12.64 | 20.66 | 69.72 |
| *Mazzaella oregona* | 6.52 | 11.79 | 81.51 |
| *Mastocarpus papillatus* | 6.83 | 5.90 | 87.41 |
| *Gelidium pusillum* | 4.50 | 4.77 | 92.18 |

**Table 3-3**. Results of SIMPER showing algal taxa responsible for dissimilarity between transects at Moss Beach and Distillery Reef. Average number of foliose algal taxa and total foliose cover (not included in SIMPER analysis) are also presented.

| Species | Average % Cove Moss Beach | Average % Cove Distillery Reef | % Contribution | Cumulative % |
|---|---|---|---|---|
| *Endocladia muricata* | 13.53 | 17.18 | 22.63 | 22.63 |
| *Cryptosiphonia woodii* | 1.74 | 12.64 | 15.09 | 37.72 |
| *Mazzaella heterocarpa* | 8.49 | 6.52 | 13.06 | 50.77 |
| *Mastocarpus papillatus* | 1.97 | 6.83 | 8.25 | 59.02 |
| *Neorhodomela larix* | 7.26 | 0.00 | 7.68 | 66.70 |
| *Fucus gardneri* | 1.64 | 5.17 | 6.62 | 73.32 |
| *Gelidium pusillum* | 1.43 | 4.50 | 5.99 | 79.31 |
| juv. articulated coralline | 3.82 | 0.32 | 5.18 | 84.49 |
| *Pterosiphonia dendroidea* | 3.68 | 0.03 | 4.68 | 89.17 |
| *Cladophora* spp. | 0.21 | 3.86 | 4.45 | 93.62 |
| average foliose algal taxa | 7.4 | 7.1 | | |
| average foliose cover | 47.7 | 59.6 | | |

differences between areas were largely explained by higher abundances of the red algal taxa *Endocladia muricata, Cryptosiphonia woodii*, and *Mastocarpus papillatus* at Distillery Reef, and higher abundances of *Mazzaella oregona* and *Neorhodomela larix* at Moss Beach (**Table 3-3**).

Separate MDS analyses of transect segments at each site did not show clear patterns of change along the transects (**Figure 3-10a** and **b**). The RELATE analyses were significant for both areas (Moss Beach $p<0.01$ and Distillery Reef $p<0.01$), indicating some linear trends among the transect segments, but it was clear from the patterns of the MDS that the significance was related to spatial autocorrelation among closely spaced transect segments and not overall trends along the entire transects. For example, the Moss Beach results showed that segments at the transect origin (segment 000) and terminus (segment 230) were more similar than segments just 30 or 40 m away (**Figure 3-10a**).

### Invertebrate Analysis

Similar to the results for the algae, the MDS results showed greater variation among transect segments at Moss Beach when compared to Distillery Reef (**Figure 3-11a** and **b**). A significant difference was detected between areas (ANOSIM R-Value=0.19, $p<0.01$), which was likely due to the similarity among transect segments at the Distillery Reef site, relative to the Moss Beach segments.

SIMPER analysis showed that the invertebrate communities at both sites were dominated by a small number of taxa with only four invertebrates accounting for 90 percent of the similarity among transect segments at both sites (**Table 3-4a** and **b**). At both sites, black turban snails (*Tegula funebralis*) and rough limpets (*Lottia scabra*) accounted for the largest percentage of the similarity among transect segments. The low invertebrate diversity and large variation along the transects were reflected in the results that showed that over 60% of the similarity among transect segments in each area was explained by turban snails that have high spatial variability in their abundances (**Figure 3-12a** and **b**). The higher variability in turban snails at Distillery Reef probably accounted for the slightly lower contribution to the average similarity among transect segments compared to Moss Beach (**Table 3-4a** and **b**). The differences between areas were largely explained by higher abundances of littorine and black turban snails at Distillery Reef (**Table 3-5**). The abundances of most other invertebrates were very similar between areas.

Separate MDS analyses of transect segments at each site did not show clear patterns of change along the transects (**Figure 3-12a** and **b**). The RELATE analyses were significant for both areas (Moss Beach $p<0.01$ and Distillery Reef $p=0.02$), indicating some linear trends among the transect segments, but it was again clear that the significance was related to spatial autocorrelation among closely spaced transect segments and not overall trends along the entire transects. For example, the Moss Beach results showed that segments 000, 010, and 020 at the beginning of the transect and segments 210 and 230 at the end of the transect were more similar to one another than other segments just 30 or 40 m away (**Figure 3-12a**). Similarly, at Distillery Reef segment 000 was more similar biologically to segments 210 and 220 than it is to segment 010 (**Figure 3-12b**).

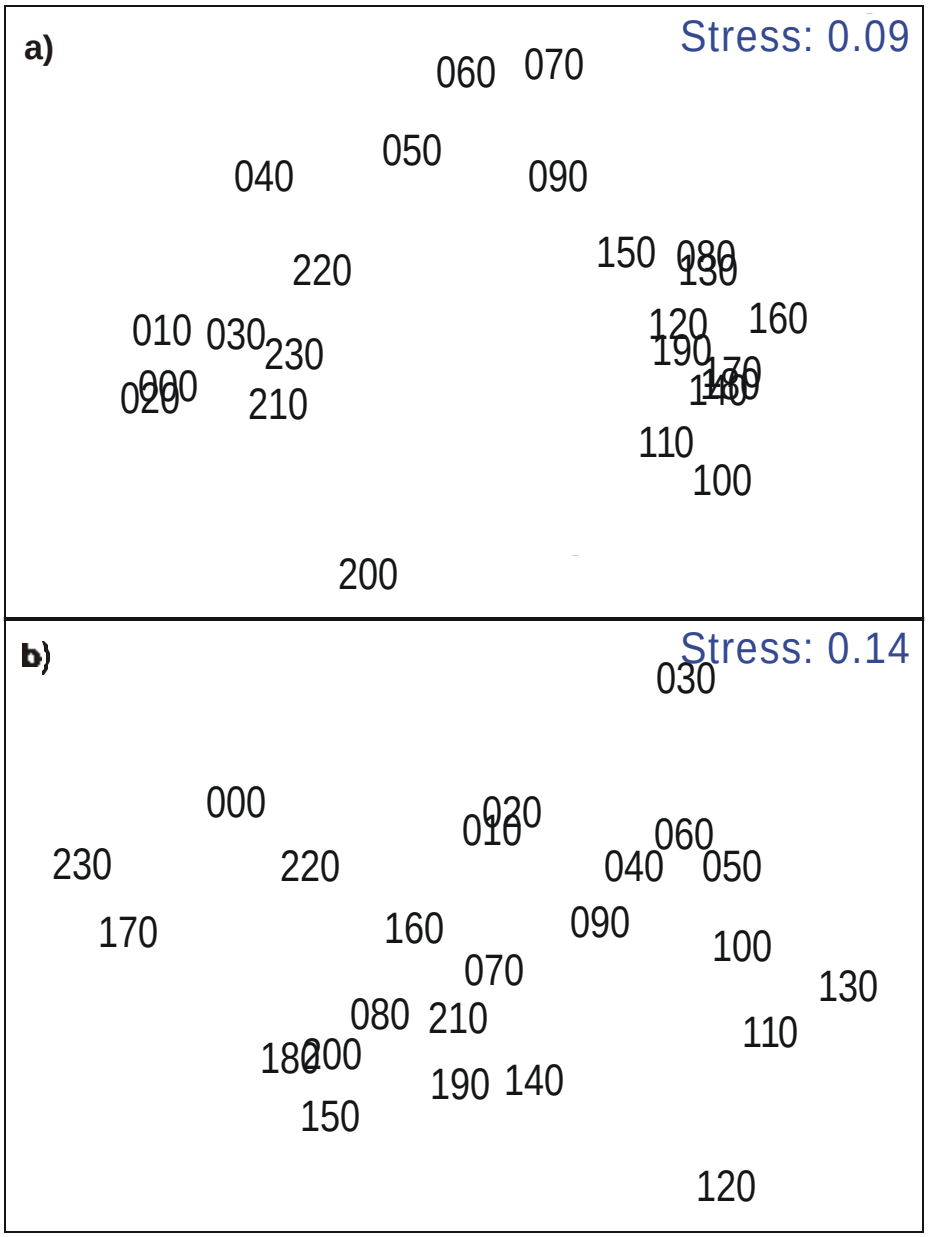



**Figure 3-10**. MDS analysis of average foliose algal abundances from: a) Moss Beach Reef; and b) Distillery Reef transects. Values indicate position in meters along each transect. The origin and terminus of each transect was upcoast and downcoast, respectively.

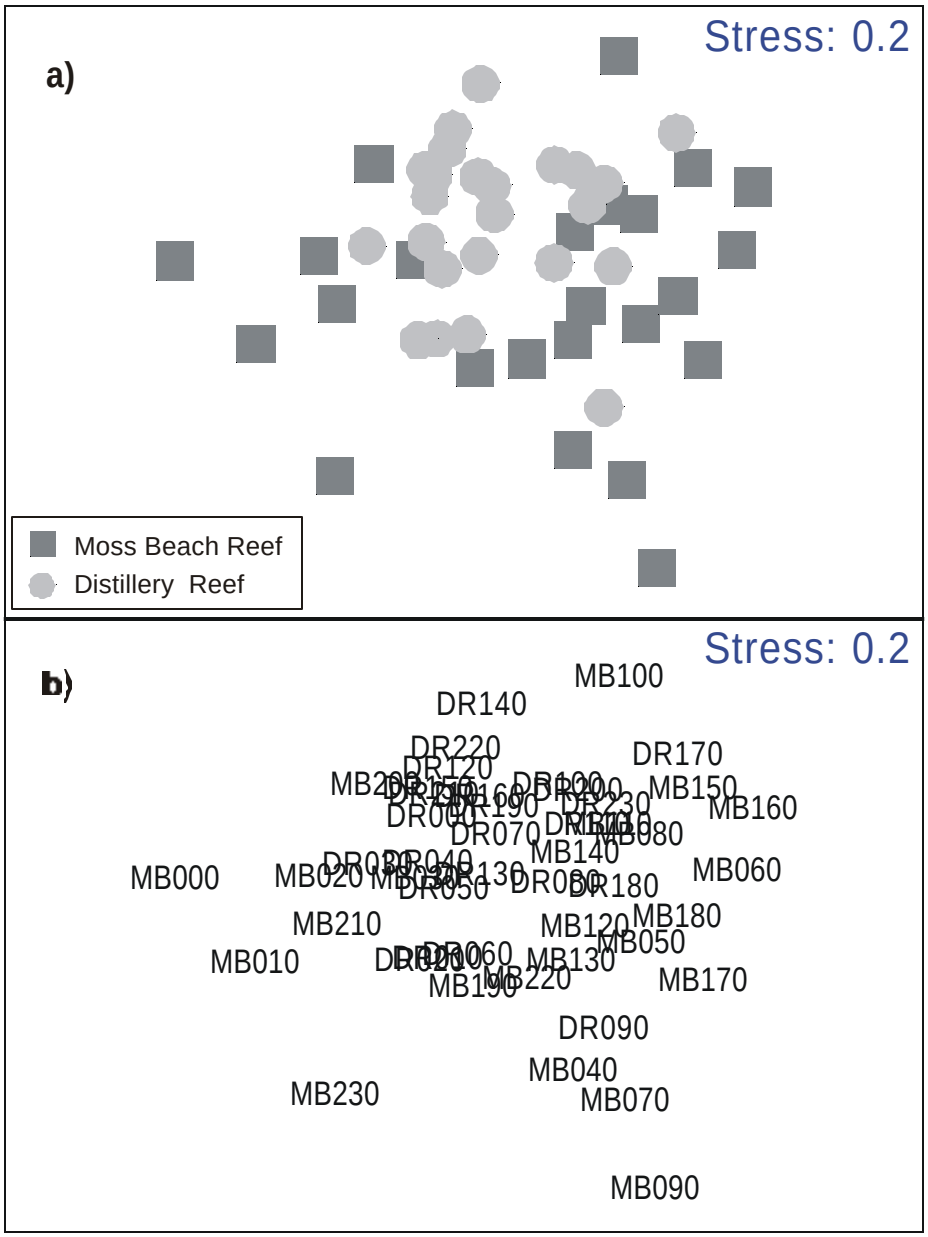



**Figure 3-11**. MDS analysis of average invertebrate abundances with: a) symbols representing transect locations on the Moss Beach Reef and Distillery Reef transects with b) values indicating the meter position of the symbols along each transect (MB=Moss Beach Reef; DR=Distillery Reef). The origin and terminus of each transect was upcoast and downcoast, respectively.

**Table 3-4**. Results of SIMPER showing invertebrate taxa responsible for similarity among transect segments at: a) Moss Beach; and b) Distillery Reef. The average similarities among transect segments are 56.78 and 42.47, respectively.

| a) Species | Average Abundance | % Contribution | Cumulative % |
|---|---|---|---|
| *Tegula funebralis* | 25.33 | 54.15 | 54.15 |
| *Pagurus* spp. | 15.00 | 33.25 | 87.40 |
| *Anthopleura elegantissima* | 1.54 | 9.95 | 97.36 |
| **b) Species** | **Average Abundance** | **% Contribution** | **Cumulative %** |
| *Tegula funebralis* | 129.60 | 52.42 | 52.42 |
| *Pagurus* spp. | 16.60 | 24.67 | 77.10 |
| *Anthopleura elegantissima* | 6.13 | 14.89 | 91.98 |

**Table 3-5**. Results of SIMPER showing invertebrate taxa responsible for dissimilarity between transects at Moss Beach and Distillery Reef.

| Species | Average Abundan Moss Beach | Average Abundance Distillery Reef | % Contributio | Cumulative % |
|---|---|---|---|---|
| *Tegula funebralis* | 25.33 | 129.60 | 21.87 | 21.87 |
| *Pagurus* spp. | 15.00 | 16.60 | 14.91 | 36.78 |
| *Anthopleura elegantissima* | 1.54 | 6.13 | 13.93 | 50.70 |
| *Lottia asmi* | 0.53 | 2.00 | 9.37 | 60.08 |
| *Lottia scabra* | 0.20 | 1.40 | 7.84 | 67.91 |
| Lottiidae | 0.47 | 0.67 | 5.95 | 73.86 |
| *Lottia pelta* | 0.47 | 0.27 | 3.66 | 77.52 |
| Grapsidae | 0.00 | 0.27 | 2.71 | 80.23 |
| *Heptacarpus* spp. | 0.40 | 0.07 | 2.50 | 82.73 |
| *Nucella* spp. | 0.33 | 0.00 | 2.22 | 84.96 |
| *Ocenebra circumtexta* | 0.20 | 0.07 | 2.02 | 86.98 |
| *Lottia limatula* | 0.00 | 0.20 | 1.94 | 88.92 |
| *Mytilus californianus* | 0.07 | 0.14 | 1.68 | 90.60 |

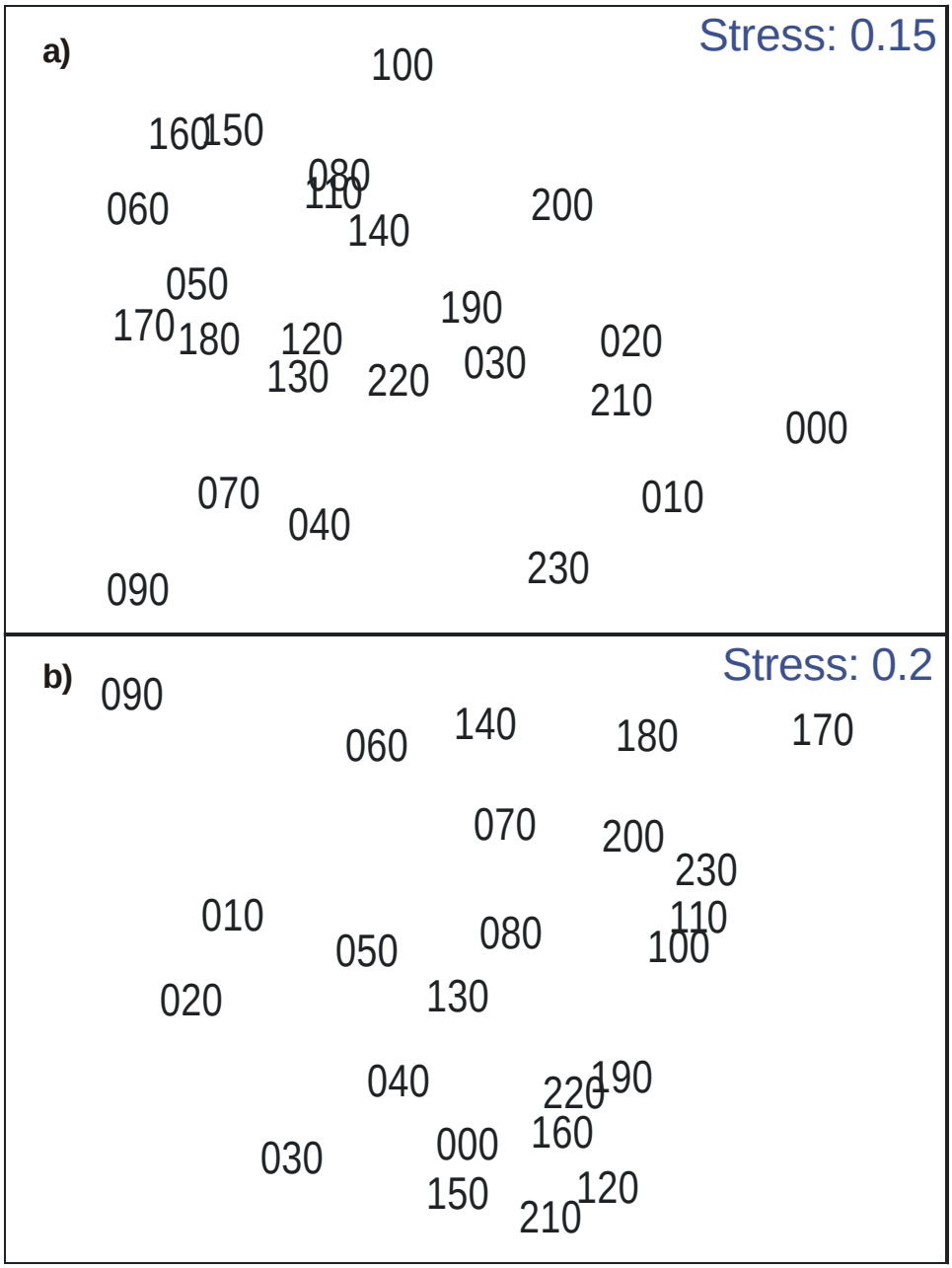



**Figure 3-12**. MDS analysis of average invertebrate abundances from: a) Moss Beach Reef; and b) Distillery Reef transects. Values indicate position in meters along each transect. The origin and terminus of each transect was upcoast and downcoast, respectively.

## Discussion

Although a significant difference was detected in upright algal communities between Moss Beach and Distillery Reef, the difference was not consistent with effects from greater levels of visitor use at Moss Beach. Even though similar flat rock bench platforms were sampled in both areas, it is very difficult to control for small-scale variation and differences in exposure to waves between areas. These factors probably accounted for the difference between the two transects. The effects of small-scale habitat differences is shown in the pattern of variation in the algal community at Moss Beach, which shows a high degree of similarity between the two ends of the transect (**Figure 3-10a**). This is also shown in the relative differences in cover of foliose algae along the Moss Beach transect (**Figure 3-6**). Some of the highest abundances of algae that are characteristic of normal undisturbed rocky intertidal communities occurred at the transect segments closest to the main access path, which would not be the case if visitor use was affecting algal cover. The relative differences in cover of foliose algae among transect segments at Distillery Reef were less than the differences among segments at Moss Beach (**Figure 3-6**). The slightly higher overall abundance of foliose algae at Distillery Reef (**Figure 3-5**) was probably a result of reduced habitat variation, relative to Moss Beach, since the transect does not traverse variable habitat areas, such as segment 190 and 200 at Moss Beach, where algal abundance was extremely low relative to other areas (**Figure 3-6**). While this resulted in lower overall algal cover, it may also explain the slightly higher average number of foliose algal taxa found along the transect, since habitat variation may result in increased species diversity.

Although a significant difference was detected in invertebrate communities between Moss Beach and Distillery Reef, the difference was not consistent with effects from greater levels of visitor use at Moss Beach. Similar to the algal community, the MDS results showed that there was considerably greater variation in the invertebrate community along the Moss Beach transect when compared to the Distillery Reef transect (**Figure 3-11a** and **b**). Also similar to the results for the algae, the difference is probably due to small-scale variation and differences in exposure to waves between areas. Habitat variation at Moss Beach probably accounts for sections of the transect with very low abundances of invertebrates, such as black turban snails (**Figure 3-8**). Although low abundances occur near the main access to Moss Beach at transect segment 000, the abundances are also low at the end of the transect at segment 230. Although there was also considerable variation in abundance at Distillery Reef, black turban snails were abundant along the entire transect, indicating more uniform habitat compared to Moss Beach. Both reef areas show low overall invertebrate diversity, relative to other intertidal areas, such as Point Pinos which has much greater variation in habitat (see below, *Section 5.4 – Resource Assessment*).

One of the problems in the study design was the absence of a strong gradient of visitor use along the transect at Moss Beach. The visitor census showed that visitors were generally dispersed across the 230 m length of our transect (see *Section 2.0 – Visitor Description*). Therefore, the distance we sampled did not have a strong gradient of visitor effects that would be necessary to detect a gradient of change in the highly variable intertidal communities we sampled. The transect could not be extended because it would have crossed surge channels and higher relief

areas that were different from the first 230 m transect of flat bench on Moss Beach Reef, in which case biological differences detected at the end of the transect might be due to habitat differences and not to visitor use. Therefore, the Distillery Reef transect was sampled for comparison. The differences between the two transects could not be attributed to different levels of visitor use, although black turban snails, which are sometimes the focus of collecting, were more abundant along the Distillery Reef transect. The difference in turban snail abundance between the two areas is discussed in *Section 3.2 – Tidepool Study*.

The results from our gradient study could have also been influenced by San Vicente Creek. The mouth of San Vicente Creek is at the main access, and fresh water runoff and potential pollutants in the creek could spread over the same area of intertidal that receives some of the highest visitor traffic. The results showed that the highest algal cover occurred nearest the main access (mouth of San Vicente Creek). Therefore, while San Vicente Creek may cause some differences in the marine biota, the spatial extent of effects and duration of effects are likely relatively small (State Water Resources Control Board 1979). In addition, the creek may enhance algal growth from nutrient input.

## 3.2 Tidepool Study

### Purpose

The purpose of this study was to determine whether any differences could be detected between tidepools in two areas that could be attributed to different levels of visitor use. The study also provided baseline data on an intertidal habitat that is known to be the focus of visitor activity in the Fitzgerald State Marine Park. This habitat was not sampled in previous studies and these results could be used as a baseline for future monitoring efforts.

### Background

Many people use the word 'tidepool' as a general term to refer to rocky shore intertidal zones. However, tidepools are actually a 'sub-habitat' of the rocky shore intertidal zone. Tidepools contain water after the tide recedes (**Figure 3-13**). Many invertebrates, algae and fishes can be found living in tidepools because, unlike the rest of the intertidal zone, their habitat remains even during low tides. Visitors are often attracted to tidepools because they are easily accessible, contain many

**Figure 3-13**. Tidepool on Moss Beach Reef.

species, and offer opportunities to view organisms that commonly occur lower on the shore.

Species composition in tidepools, however, is generally highly variable due to tidal height (position on the shore), size, depth, wave exposure, history of disturbance, flushing characteristics, and micro-habitat differences (e.g., substrate rugosity, internal ledges, undercuts). The Fitzgerald State Marine Park intertidal zone has a multitude of tidepools with a tremendous range of biological and physical variation. Nearly all of the tidepools occur on bench rock, because the rock-lined depressions hold water. They are less common in boulder-cobble fields that drain at low tide. The majority of the tidepools in the Park are generally small (less than 0.5 m deep and less than 2 $m^2$ in surface area). Many of the tidepools are rock fissures (crevices) in the bench rock, some are more bowl-shaped in configuration, while others are simply shallow, wet depressions in the bench rock.

## Methods

### Sampling

Fifteen tidepools were sampled for species composition and abundance on both Moss Beach Reef (high-use area) and also on Distillery Reef (low-use area) during spring 2004 (**Figure 2-1**). The tidepools were selected based on the following criteria:

- Clearly defined configuration of relatively steep sloping walls (puddles and wet depressions were not sampled).
- Surface area of approximately 0.25 $m^2$ –2.0 $m^2$ and depths not exceeding 25 cm (small enough to sample).
- Easily accessible to visitors (located in the upper intertidal at approximately the +3–4 ft MLLW tide level).

The surface area of each tidepool was estimated and the maximum depth recorded. The average area of the tidepools at Moss Beach Reef was 1.1 $m^2$, while the average area at Distillery Reef was 0.4 $m^2$. All fishes and motile invertebrates observed in each tidepool were counted and the percent cover of each algal species was estimated using the total surface area of the tidepool as the sample area. Sessile invertebrate species (e.g., anemones, mussels) were quantified as percent cover, using the total surface area of the tidepool as the sample area.

### Analysis

Since the size of the tidepools differed, the numbers of invertebrates and fishes in each tidepool were calculated as densities (number per 0.25 $m^2$). The percent cover values for the algae and sessile invertebrates did not need to be adjusted for the differences in the surface area of the tidepools between and within each area because percent cover is dimensionless.

The algal and invertebrate data were analyzed separately using MDS. Bray-Curtis measures of dissimilarity based on abundances from each tidepool were used in the MDS analyses. Data from

all of the tidepools sampled from the two areas were analyzed to contrast community patterns and to determine if statistically significant differences between areas could be detected. The ANOSIM procedure in PRIMER was used to determine if a significant difference between areas could be detected, while the species that contributed to the differences were analyzed using the SIMPER procedure in PRIMER.

The algal data analyzed with MDS, which included only foliose, non-crustose taxa, were square root transformed to reduce the weighting of algae with large abundances in the analysis. Invertebrate data were log transformed to reduce the scale differences between count and percent cover measures of taxa abundances.

## Results

### Overview

Algal cover (mainly total upright algal cover) was much higher in the Moss Beach Reef tidepools than in the Distillery Reef tidepools (**Figure 3-14**). The higher percentage cover of *Prionitis* spp. and *Neorhodomela larix* (both branched red algal species) and *Calliarthron/Bossiella* spp. and *Corallina vancouveriensis* (articulated coralline algae) in the Moss Beach Reef tidepools accounted for most of the observed differences.

In contrast, invertebrate abundances were higher in the Distillery Reef tidepools than in the Moss Beach Reef tidepools (**Figure 3-15**). Black turban snails (*Tegula funebralis*) accounted for the largest difference; they were over 10-fold more abundant in the Distillery Reef tidepools than in the Moss Beach Reef tidepools.

Because we found differences in the abundances of black turban snails between Moss Beach Reef and Distillery Reef in our gradient study (above), we increased the number of tidepools surveyed to determine if the results for black turban snails were an artifact of limited sampling. We sampled an additional 25–35 tidepools on Moss Beach Reef and also on Distillery Reef. In addition, we sampled 35 tidepools on Frenchman's Reef, another low-use area. We completed the additional sampling in summer (August 31 and September 1, 2004). The data collected in the spring were not combined with the data collected in summer since seasonal variation could have affected a comparison that included both sampling periods. The results from the summer surveys also showed that Moss Beach Reef tidepools contained fewer black turban snails than tidepools in areas with lower numbers of visitors (Distillery Reef and Frenchman's Reef) (**Figure 3-16**).

### Algae Analysis

The MDS results showed considerable variation among the tidepools at Moss Beach and Distillery Reef (**Figure 3-17**). Although both areas had approximately equal variation among tidepools, there was also a clear difference between areas that was statistically significant (ANOSIM R-Value=0.63 $p<0.01$).

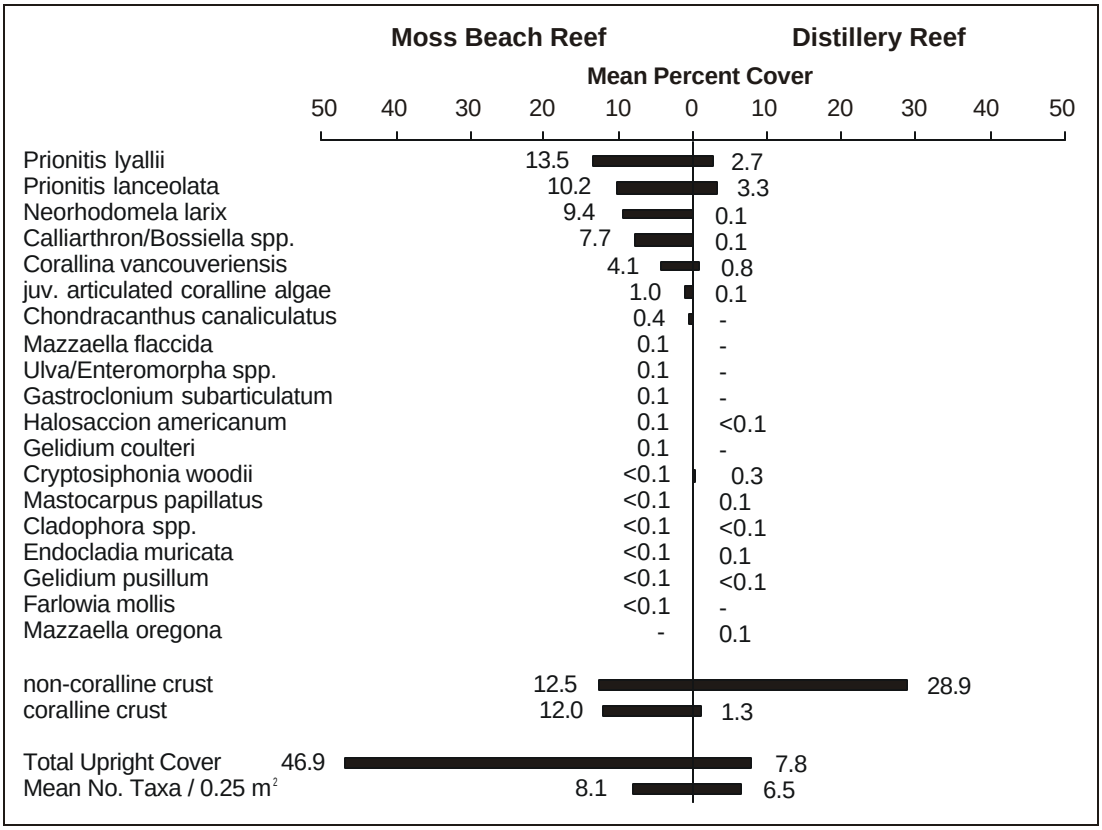



**Figure 3-14**. Algal abundances in tidepools sampled on Moss Beach Reef and Distillery Reef.

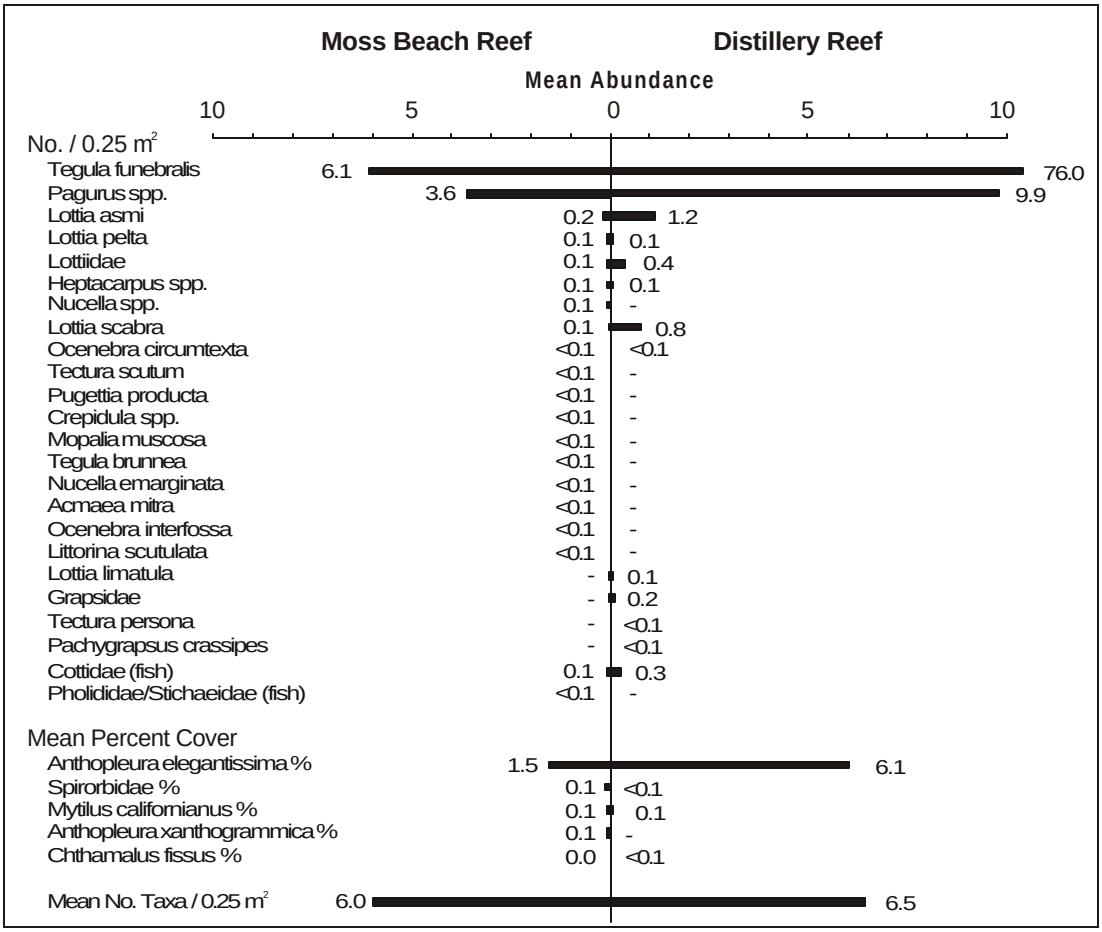



**Figure 3-15**. Invertebrate and fish abundances in tidepools sampled on Moss Beach Reef an Distillery Reef.

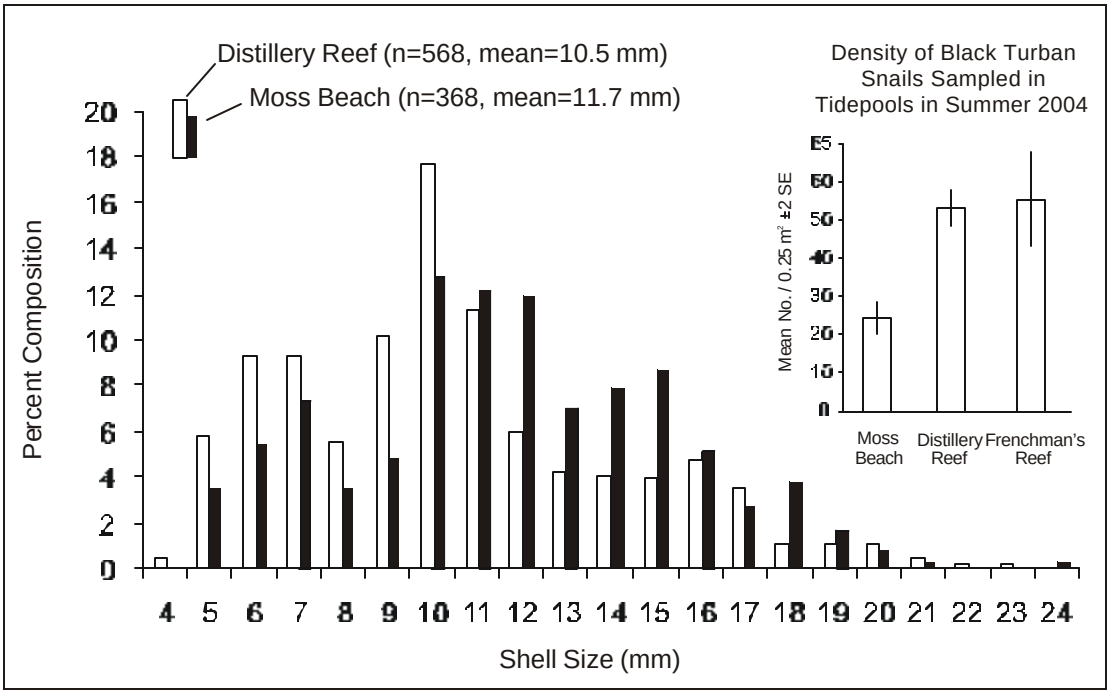



**Figure 3-16**. Shell size distribution of black turban snails sampled from tidepools on Moss Beach Reef and Distillery Reef and densities in tidepools sampled in summer 2004.

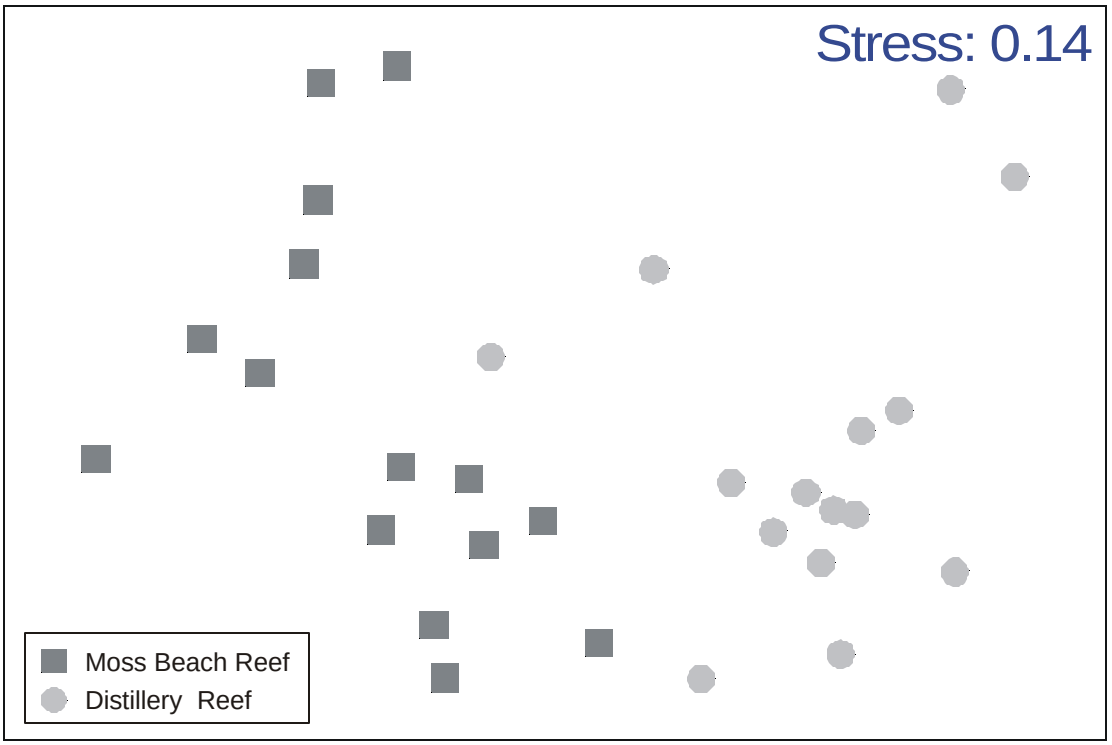



**Figure 3-17**. MDS analysis of upright algal abundances in tidepools on Moss Beach Reef and Distillery Reef.

SIMPER analysis showed that the algal communities at both sites were not particularly diverse; only five algae at Moss Beach and three at Distillery Reef accounted for greater than 90 % of the similarity among tidepools (**Table 3-6a** and **b**). Algal cover was much less in the Distillery Reef tidepools, relative to Moss Beach tidepools (**Table 3-7**). In addition, the tidepools at Distillery Reef had low abundances of articulated coralline algae, such as *Corallina vancouveriensis* and *Calliarthron*/*Bossiella*, which are often abundant in tidepools. These and other algae, primarily *Prionitis lanceolata* and *lyallii*, were responsible for the differences between areas.

### Invertebrate Analysis

The MDS results showed considerable variation in the invertebrate communities among the tidepools at Moss Beach (**Figure 3-18**). A significant difference was detected between areas (ANOSIM R-Value=0.63 $p<0.01$), which was likely due to the high similarity among tidepools at the Distillery Reef site, relative to the Moss Beach tidepools.

SIMPER analysis showed that the same three invertebrates accounted for greater than 90 % of the similarity among tidepools at both sites (**Table 3-8a** and **b**). Invertebrate abundance, especially for the black turban snail *Tegula funebralis*, was less in the Moss Beach tidepools, relative to the Distillery Reef tidepools (**Table 3-9**). At both locations, the three most abundant taxa, littorine snails *Littorina scutulata*, black turban snails *Tegula funebralis*, and rough limpets *Lottia scabra*, accounted for almost 50 % of the difference between areas. The abundances of the other invertebrates were very low, relative to these three.

## Discussion

The differences in algal cover between the Moss Beach Reef and Distillery Reef tidepools could have been influenced by differences between areas in the abundance of turban snails, which forage on the algae. It is possible that the greater algal cover in the Moss Beach Reef tidepools was the result of fewer turban snails, while the lower algal cover in the Distillery Reef tidepools may have been due to the greater abundance of turban snails. This would represent a secondary effect (grazing effect), and one not necessarily related to visitor use.

Results from both the spring and summer (May and August 2004) tidepools surveys showed that densities of black turban snails were twice as high in the low-use areas than in the high-use area. Densities of black turban snails along the transects in the gradient study were also greater at Distillery Reef than at Moss Beach Reef (see above, *Section 3.1 – Gradient Study*).

Although black turban snails may be commonly collected and handled (see *Section 2.0 – Visitor Description*), we noted during our sampling that the Distillery Reef population appeared to be comprised of smaller individuals than the snails at Moss Beach Reef, suggesting differences in recruitment intensity. We measured black turban shells from both areas to test the recruitment theory.

**Table 3-6**. Results of SIMPER showing algal taxa responsible for similarity among tidepools at: a) Moss Beach Reef; and b) Distillery Reef. The average similarities among tidepools at the two sites are 34.3 and 39.3, respectively.

| a) Species | Average % Cover | % Contribution | Cumulative % |
|---|---|---|---|
| *Prionitis lanceolata* | 10.20 | 28.30 | 28.30 |
| *Neorhodomela larix* | 9.40 | 21.24 | 49.53 |
| *Prionitis lyallii* | 13.47 | 16.42 | 65.95 |
| *Corallina vancouveriensis* | 4.07 | 14.33 | 80.28 |
| *Calliarthron/Bossiella* spp. | 7.73 | 13.84 | 94.13 |
| **b) Species** | **Average % Cover** | **% Contribution** | **Cumulative %** |
| *Prionitis lyalli* | 2.73 | 82.12 | 82.12 |
| *juv. articulated coralline algae* | 0.07 | 6.29 | 88.41 |
| *Mastocarpus papillatus* | 0.07 | 4.17 | 92.58 |

**Table 3-7**. Results of SIMPER showing algal taxa responsible for dissimilarity between tidepools at Moss Beach Reef and Distillery Reef.

| Species | Average % Cov Moss Beach | Average % Cover Distillery Reef | % Contribution | Cumulative % |
|---|---|---|---|---|
| *Prionitis lanceolata* | 10.20 | 3.33 | 21.21 | 21.21 |
| *Prionitis lyallii* | 13.47 | 2.73 | 18.34 | 39.56 |
| *Neorhodomela larix* | 9.40 | 0.13 | 16.99 | 56.55 |
| *Corallina vancouveriensis* | 4.07 | 0.80 | 13.92 | 70.46 |
| *Calliarthron/Bossiella* spp. | 7.73 | 0.07 | 12.31 | 82.77 |
| juv. articulated coralline algae | 1.00 | 0.07 | 4.73 | 87.50 |
| *Cryptosiphonia woodii* | 0.07 | 0.34 | 1.79 | 89.29 |
| *Mazzaella flaccida* | 0.13 | 0.00 | 1.55 | 90.84 |


**Figure 3-18**. MDS analysis of invertebrate abundances in tidepools sampled on Moss Beach Reef and Distillery Reef.

**Table 3-8**. Results of SIMPER showing invertebrate taxa responsible for similarity among tidpools at: a) Moss Beach Reef; and b) Distillery Reef. The average similarities among tidepools are 56.78 and 42.47, respectively.

| a) Species | Average Abundance | % Contribution | Cumulative % |
|---|---|---|---|
| *Tegula funebralis* | 18.88 | 68.25 | 68.25 |
| *Lottia scabra* | 2.07 | 13.43 | 81.68 |
| *Lottia asmi* | 0.81 | 4.99 | 86.67 |
| *Anthopleura elegantissima* | 0.45 | 3.35 | 90.02 |
| **b) Species** | **Average Abundance** | **% Contribution** | **Cumulative %** |
| *Tegula funebralis* | 39.13 | 61.86 | 61.86 |
| *Lottia scabra* | 2.32 | 13.62 | 75.48 |
| *Littorina scutulata* | 3.24 | 9.33 | 84.81 |
| *Lottia asmi* | 1.04 | 6.89 | 91.70 |

**Table 3-9**. Results of SIMPER showing invertebrate taxa responsible for dissimilarity between tidepools at Moss Beach Reef and Distillery Reef.

| Species | Average Abundance Moss Beach | Average Abundance Distillery Reef | % Contributior | Cumulative % |
|---|---|---|---|---|
| *Littorina scutulata* | 1.76 | 3.24 | 17.45 | 17.45 |
| *Tegula funebralis* | 18.88 | 39.13 | 14.28 | 31.73 |
| *Lottia scabra* | 2.07 | 2.32 | 11.93 | 43.66 |
| *Lottia asmi* | 0.81 | 1.04 | 8.82 | 52.48 |
| *Anthopleura elegantissima* | 0.45 | 0.32 | 5.61 | 58.09 |
| *Lottiidae* | 0.35 | 0.33 | 5.20 | 63.29 |
| *Ocenebra circumtexta* | 0.13 | 0.43 | 5.08 | 68.38 |
| *Pholadidae* | 0.29 | 0.22 | 4.47 | 72.85 |
| *Pagurus spp.* | 0.22 | 0.19 | 4.13 | 76.98 |
| *Acanthinucella spirata* | 0.75 | 0.03 | 4.01 | 80.99 |
| *Chthamalus fissus* | 0.15 | 0.19 | 3.13 | 84.11 |
| *Nucella emarginata* | 0.15 | 0.07 | 2.37 | 86.48 |
| *Mopalia muscosa* | 0.04 | 0.13 | 1.93 | 88.41 |
| Grapsidae | 0.01 | 0.13 | 1.84 | 90.25 |

Five tidepools were selected on Moss Beach Reef and also on Distillery Reef using the same habitat criteria described above. The tidepools were spread over a distance of approximately 150 m along the shore of each reef. All black turban snails were removed from the tidepools, measured (to the nearest millimeter) for greatest shell dimension across the basal whorl using a dial caliper (**Figure 3-19**) and then returned to their habitats.

**Figure 3-19**. Dial caliper used to measure black turban snail shell sizes.

The Distillery Reef population of black turban snails had a greater proportion of small individuals compared to the Moss Beach Reef population (**Figure 3-16**), which may indicate differences in recruitment between the areas. In other words, the lower densities at Moss Beach Reef may not be a result of losses due to collection. Although the species is often collected, it is unlikely that visitors would remove the smallest individuals.

# 3.3 Historical Park Study of Roped and Unroped Test Plots

## Purpose

The purpose of this study was to assess visitor impacts by comparing areas that limited visitor access (roped areas) with areas that were open to visitors (unroped areas) in the high-use area near the main access point for Moss Beach Reef.

## Background

Park Ranger Robert Breen began a manipulative experiment in 1994 to determine effects of visitor use on Moss Beach Reef. The experiment was conducted by establishing two sets of paired 100 $m^2$ plots adjacent to one another. One of the plots was roped off to restrict visitor access, while access to the adjacent plot was not restricted (**Figure 1-12**). The objective was to compare the biological communities in the adjacent plots to determine if differences could be detected over time, and if the differences could be attributed to reduced access in the roped plots.

## Methods

A total of seven 10 m x 10 m (100 $m^2$) plots (Plots A, B, C, D, E-0, F, and G-0) were established in Spring 1994 (**Figure 3-1**); three plots were roped off to prevent visitor use (Plots A, D, and F) and four plots were accessible to visitors (Plots B, C, E-0, and G-0). All plots were permanently marked by rock bolts placed at their corners. Within Plots D, E-0, F, and G-0, five 1 $m^2$ quadrat positions were randomly selected, and their locations marked with bolts to allow for subsequent sampling. Every daytime low tide, Park rangers cordoned off the roped plots by stringing a highly visible yellow rope around the corner bolts. Occasionally signs saying "Do Not Enter, Experiment in Progress" were placed next to the roped plots. The plots were not always roped off immediately after they were exposed during receding tide. Instead, the ropes tended to be deployed as visitor use increased. Therefore, the plots were protected from peak levels of visitor use, but not all visitor use.

Roped Plot A and associated unroped Plots B and C were located in mussel beds, and are discussed separately in **Section 3.5** (below). Roped Plot D and adjacent unroped Plot E-0 were located on bench rock habitat between the mussel beds and the main access to the intertidal zone, and roped Plot F and adjoining unroped Plot G-0 were located immediately west of the main access (**Figure 3-1**).

The frequency of occurrence of algal species and bare rock space was recorded for these plots. The 1 $m^2$ sampling quadrats were divided by strings into 100-10 cm x 10 cm subunits. The occurrence of each algal species in each subunit was recorded (e.g., a species that occurred in 20

subunits had a percent frequency of occurrence value of 20 %.). All invertebrates, except barnacles, were counted. The number of barnacles were either counted or estimated for each of the 100 subunits and recorded on the data sheet according to 'count categories' (0, 1–9 individuals, 10–99 individuals, 100–999 individuals).

Surveys were completed from 1994–2003 by Park rangers and trained volunteers. Invertebrates were surveyed one month and algae were surveyed the following month. Not all quadrats within each test plot were sampled every survey, and the number of surveys per year decreased with time, due to reduced availability of staff resources and volunteers.

The study was an extraordinarily large sampling effort that generated hundreds of field data sheets. The data were never entered onto a computer database. To manage the amount of data entry work for this analysis, we entered and analyzed the April 1994 and June 1998 surveys. These surveys had all the quadrats in all of the plots sampled and also represented the longest time interval between surveys that could be used for comparison.

To compare the changes between the two time periods we calculated the absolute difference between the two periods for the roped and unroped plots and then subtracted the percentage change at the unroped plots from the percentage change at the roped plots. Other analyses were not conducted because of the difficulty in interpreting the percentage frequency data from the plots.

## Results

### Algae

**Beginning of study:** Algal abundances averaged for the two roped plots (D and F) compared to the average of the two unroped plots (E-0 and G-0) are shown in **Figure 3-20**. Both types of plots show varying levels of abundance, but not much difference in species composition. *Mazzaella oregona*, a foliose red alga, followed by *Mastocarpus papillatus* (foliose red alga), and *Gelidium* spp. (turf alga) were among the most abundant non-crustose algae. On the other hand, the less abundant algae (less than about 2 % frequency of occurrence) were not always present in both types of plots. The mean number of taxa/species per $m^2$ was approximately equal between both types of plots. At the beginning of the study (May 1994), the amount of bare rock was greater in the unroped plots than in the roped plots.

**Changes in roped plots relative to unroped plots:** We compared changes in species composition and abundance between the roped and unroped plots for the period of May 1994 and June 1998. A four-year time period should be long enough for the species assemblages in the roped plots to respond to the reduced levels of visitor impacts had these impacts been significant at the start of the study. The majority of algal species increased in relative abundance in the roped plots compared to the unroped plots between 1994 and 1998 (**Figure 3-21**). However, the total upright algal cover (all upright species combined) declined, due mainly to a large decrease

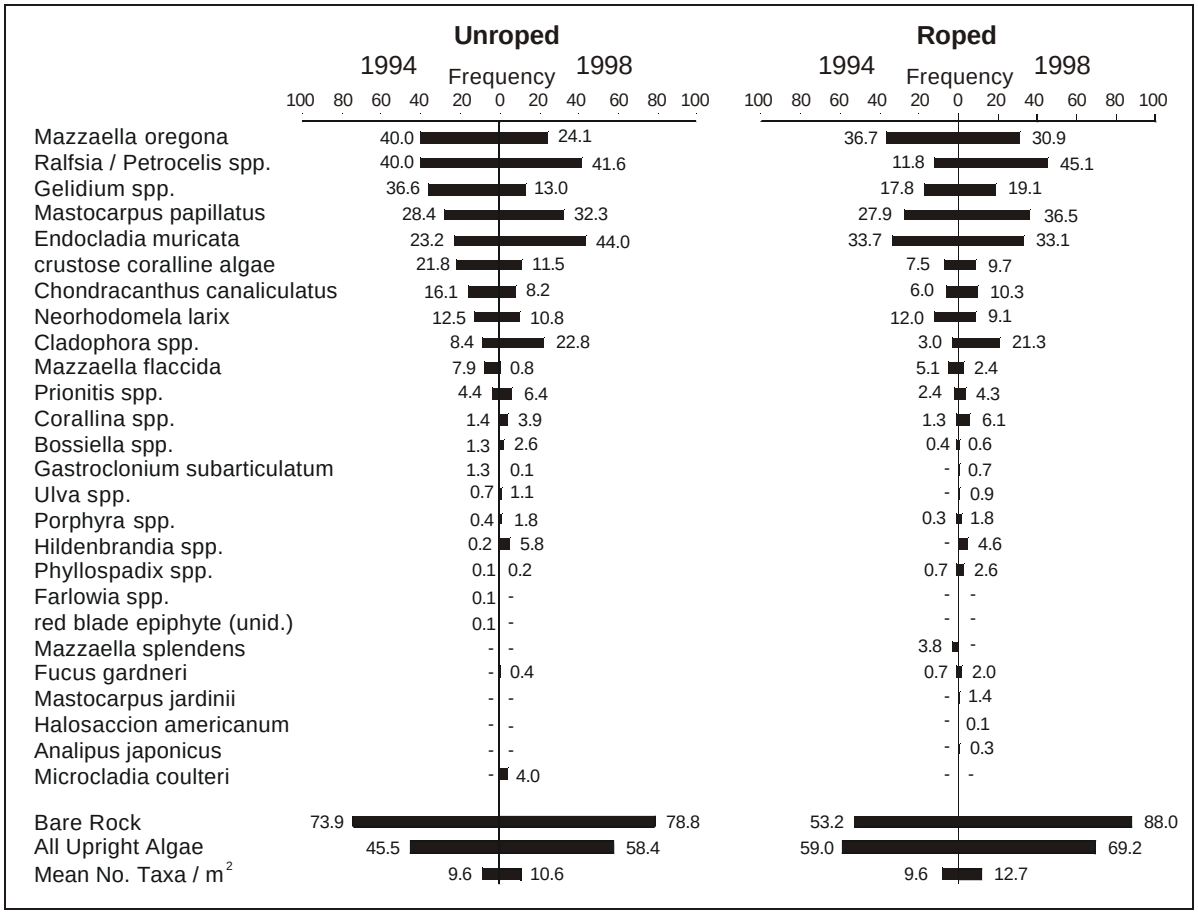



**Figure 3-20**. Average abundance of algae in roped Plots D and F compared to unroped Plots E and C for May 1994 and June 1998.

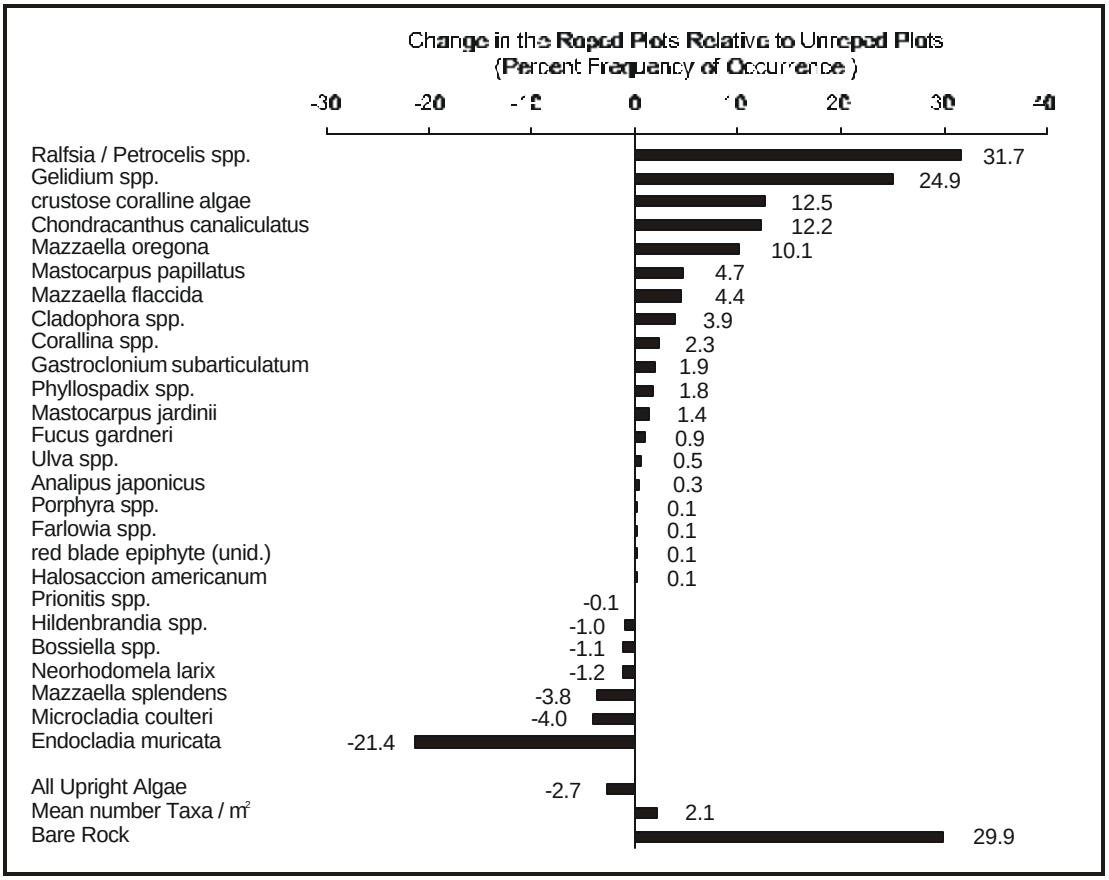



**Figure 3-21**. Change in algal cover in Park roped plots D and F relative to Park unroped plots E and G between 1994 and 1998.

in *Endocladia muricata* (nail brush seaweed) and because many of the increases occurred in crustose algal species such as *Ralfsia / Petrocelis* spp. and the crustose coralline group.

### Invertebrates

**Beginning of study:** Invertebrate abundances in the two roped plots (D and F) and the two unroped plots (E-0- and G-0) are shown in **Figure 3-22**. In May 1994, the invertebrate assemblage in both the roped and unroped plots was numerically dominated by *Tegula funebralis* (black turban snail), *Anthopleura elegantissima* (aggregating anemone), *Pagurus* spp. (hermit crab), and limpet species of the genus *Lottia* and *Tectura*.

**Changes in roped plots relative to unroped plots:** We examined the changes in invertebrate abundance using the same comparison method described above for the algae. Approximately the same number of species increased and decreased in the roped plots and unroped plots over the period analyzed (**Figure 3-23**). The most abundant species at the beginning of the study (aggregating anemones, hermit crabs, limpets) increased in the roped plots relative to the unroped plots. In contrast, black turban snails, which were the most abundant species in the roped plots in May 1994, decreased in abundance, relative to the unroped plots.

## Discussion

The design of this field experiment was intended to provide data for comparing biological communities that had received varying levels of visitor impact because of the reduced access to the roped plots. The expectation would be increased abundances of algae and invertebrates in the roped plots because of fewer visitor effects. However, the comparison of the two surveys from 1994 and 1998 did not show large differences in species composition and abundance. Although some algae increased in the roped plots relative to the unroped areas other algae decreased. While shifts occurred among the various algal species, total algal cover of the upright forms did not change markedly, and in fact declined slightly in the roped plots, relative to the unroped plots. In addition there were no common morphological characteristics among the algae that increased or decreased that would indicate that only the algae that were more susceptible to trampling effects changed in abundance. Results for the invertebrates were similar to those for algae with increases in some species and decreases in others and no pattern that would indicate any response to the reduced visitor access to the roped plots.

Algal abundance can be limited by grazing effects from increased limpet populations and by reduction in open space from colonization by invertebrates such as aggregating anemones. Although the results from the comparisons are variable, limpets and anemones increased in abundance in the roped plots, relative to the unroped plots. However, the increases in foliose algae in the roped plots do not indicate any effects from grazing or limited space for colonization.

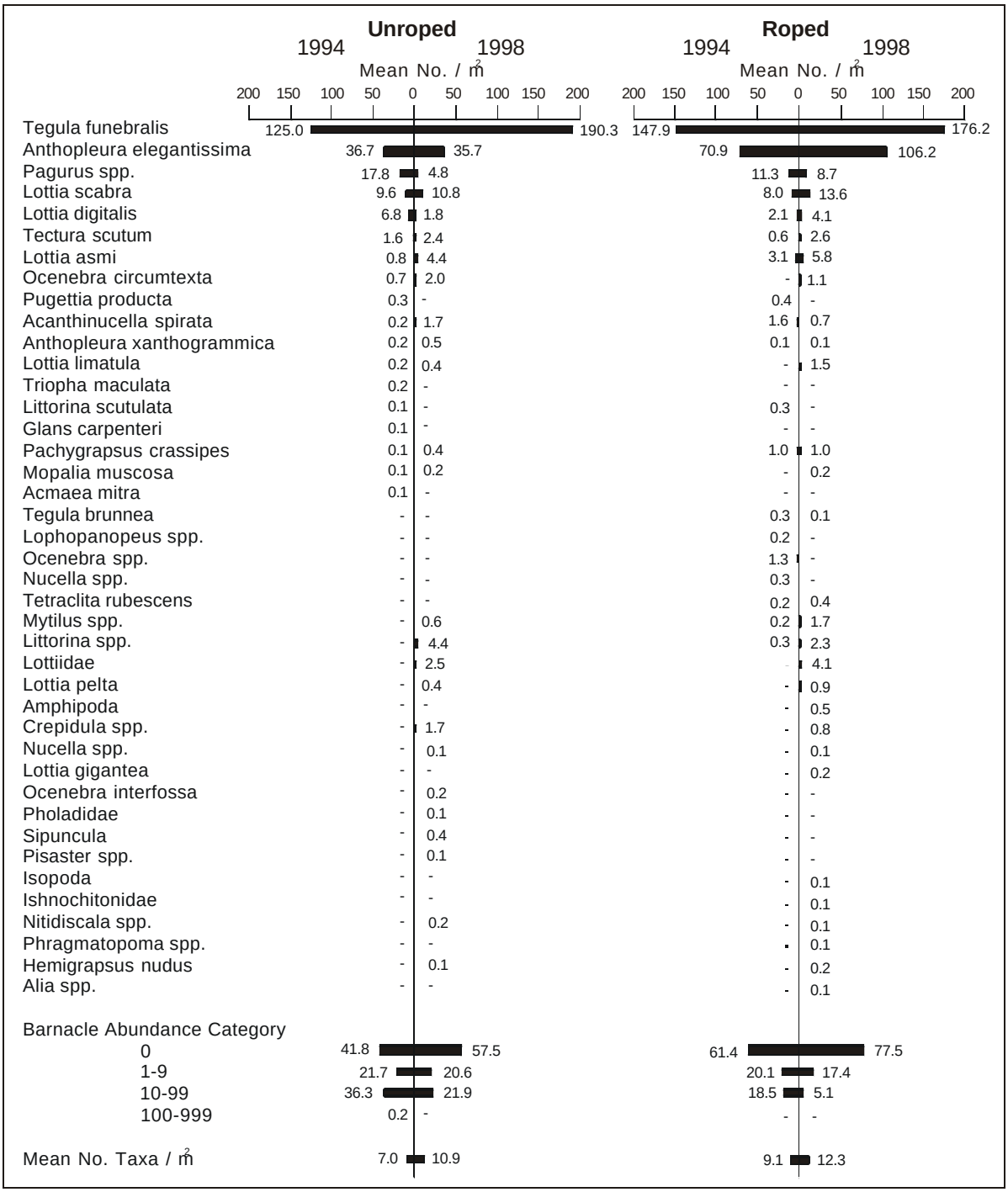



**Figure 3-22**. Average abundance of invertebrates in roped Plots D and F compared to unroped Plots and G for May 1994 and June 1998.

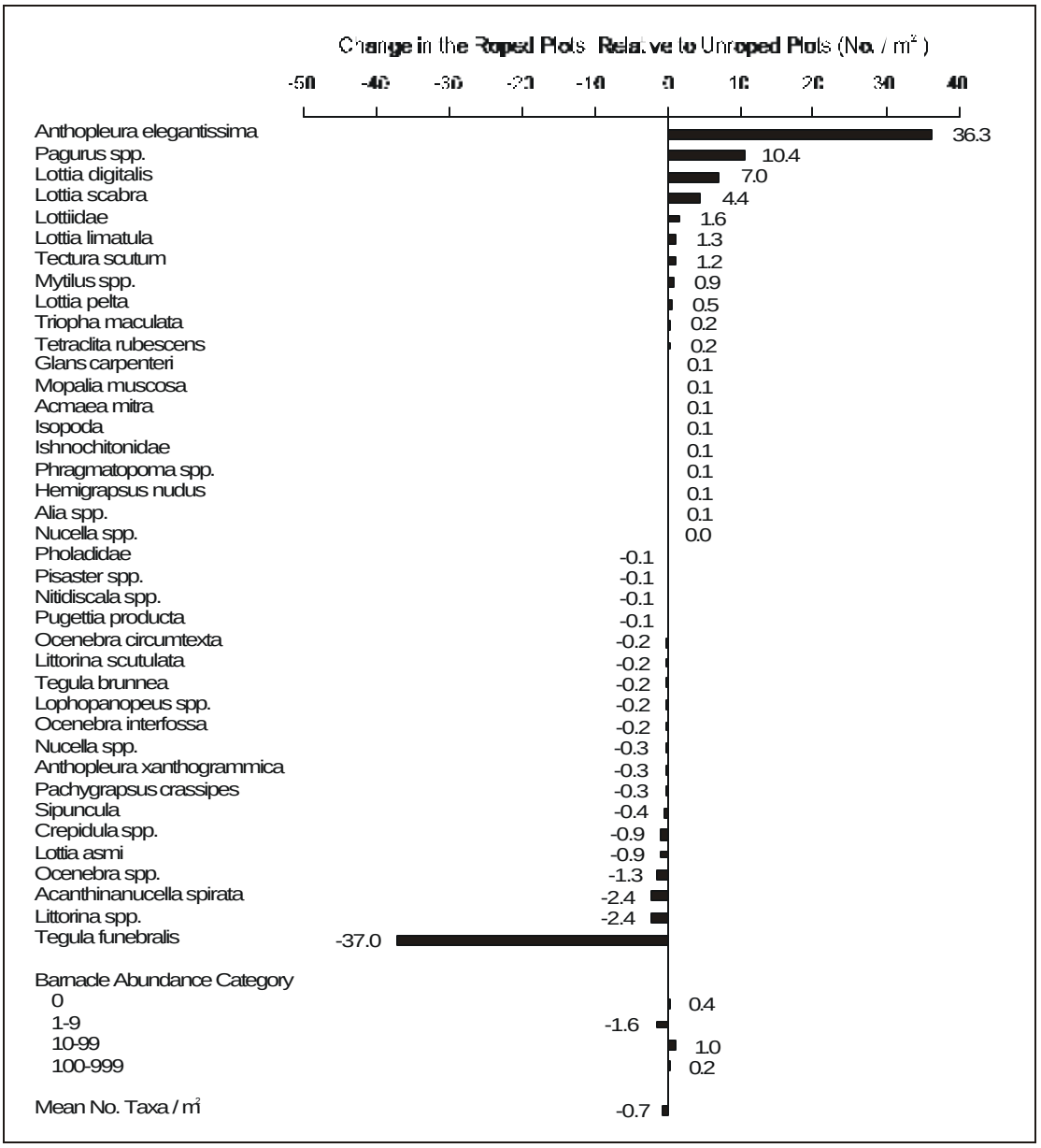



**Figure 3-23**. Change in invertebrate abundance in Park roped plots D and F relative to Park unroped plots E and G between 1994 and 1998.

The variable results among species may be partially due to how and when the plots were roped each day. The time when the plots were roped off did not always coincide with the time when the plots were exposed by the receding tide. As a result the roped plots were left unroped and were exposed for periods of time to visitor use. Although the Park rangers roped off areas prior to peak use there were many occasions when visitors could walk through and explore the roped plots. It is unknown how the reduced visitor access would affect the comparison between plots.

## 3.4 Comparison of the Park Test Plots Including Other Unroped Areas Sampled in 2004

### Purpose

Similar to the previous analysis, the purpose of this study was to assess visitor impacts by comparing areas that limited visitor access (roped areas) with areas that were open to visitors (unroped areas) in the high-use area near the main access on Moss Beach Reef. This study used the same plots established by the Park rangers, but included data from additional plots that were sampled to obtain better estimates of the variation in the biological communities on Moss Beach Reef.

### Background

Although the manipulative field experiment (roped and unroped plots) provided a means to evaluate visitor impacts, we felt that it was important to determine how representative the experimental plots were to other areas of the reef. Some of the biological variation within and between the Park test plots was suspected to have resulted from the sampling design. The Park used 1 $m^2$ quadrats, which had been randomly selected and then sampled in subsequent surveys without regard to habitat variation within the plots. Although all of the test plots were on bench rock, there were micro-habitat variations within and among the quadrats within each plot. Consequently, some quadrats were located on flat bench rock, while others were located on portions of tidepools and ridges. Habitat variation will contribute to the biological variation among the quadrats within each plot, making it more difficult to detect differences between plots. Therefore, we sampled the Park test plots and established and sampled our own unroped plots, using a more structured sampling approach to reduce variation caused by micro-habitat variation.

### Methods

We divided each of the test plots (D, E-0, F, and G-0) (**Figure 3-1**) into a grid. X, Y coordinates were randomly chosen so that ten 0.25 $m^2$ quadrats could be placed in each plot on uniform habitat of bench rock (i.e., tidepools, ridges, and drop-offs were not sampled). A total of six additional unroped test plots (E-1, E-2, E-3, G-1, G-2, G-3) (**Figure 3-1**) of the same dimension

as the Park test plots (10 m x 10 m) were established; three near plots D and E-0, and three near Plots F and G-0. Random quadrat locations for these plots were also chosen in the same manner described above. In all quadrats, the cover of each algal species was visually estimated, including the cover of each sessile invertebrate species (e.g., mussels, anemones, barnacles) and bare rock. The individuals of all motile invertebrate species were counted.

We analyzed the data graphically and also using multivariate statistical techniques that examine the entire algal or invertebrate assemblages. The results of the analyses would provide strong evidence of visitor use effects if the difference between the roped and unroped plots exceeded the range of variation among the unroped and newly established plots. The most powerful test of this would be to use all of the data from the two sets of plots established on the Moss Beach Reef rock bench. Unfortunately, to conduct this test using all of the plots we had to determine if the two sets of Park plots could be treated as replicates or should be analyzed separately. Therefore, we conducted an analysis to determine if differences could be detected between the two unroped and two roped plots. If a difference was detected between either pair of plots it would indicate that the two sets of plots should be analyzed separately.

Differences between the communities in the roped and unroped plots were analyzed using the ANOSIM procedure in the PRIMER multivariate ecological statistical package (PRIMER-E Ltd. 2001). The ANOSIM procedure compares the observed differences between sites with the differences among the replicates within sites. The ten quadrats sampled within each plot were used as the replicates in the analysis. The Bray-Curtis measure of dissimilarity was used as the measure of difference among samples. The patterns of variation in the communities were analyzed using non-metric multi-dimensional scaling (MDS), a multivariate method for ecological analysis available in the PRIMER software package. When statistical differences were detected between groups, the SIMPER procedure in PRIMER was used to determine the species that contributed to the differences and the patterns in the MDS. Algal and invertebrate data were analyzed separately in all of the analyses.

The invertebrate data were log transformed to reduce the scale differences between count and percentage coverage measures of taxa abundances prior to analysis. The algal data were not tranformed.

## Results

Despite attempts to control habitat variation as best as possible, we found considerable variation in species abundances among all plots (**Figures 3-24 to 3-27**). In general, some species were greater in the roped plots than in the unroped plots, and there was considerable variation among the unroped plots. The first set of roped and unroped plots (D, E-0, E-1, E2, and E-3) did have lower total algal cover than the second set of plots.

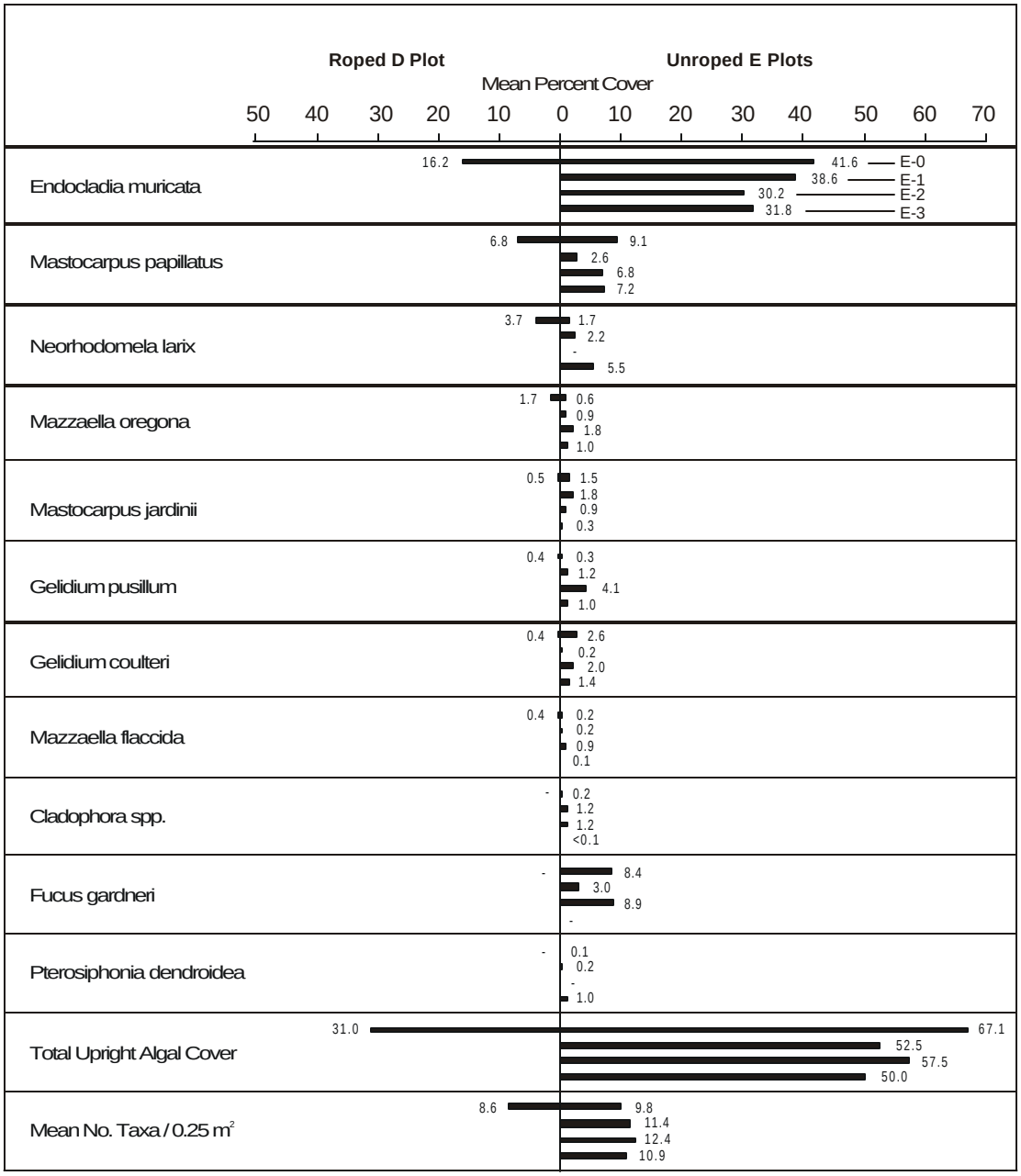



**Figure 3-24**. Abundance of algae in Roped D Plot and associated Unroped E Plots. Unroped Plot E-0 is the Park unroped E Plot. Unroped Plots E-1, E-2, and E-3 are additional unroped plots. The algae portrayed are those in which the mean abundance was equal to or greater than one percent cover in any given plot.

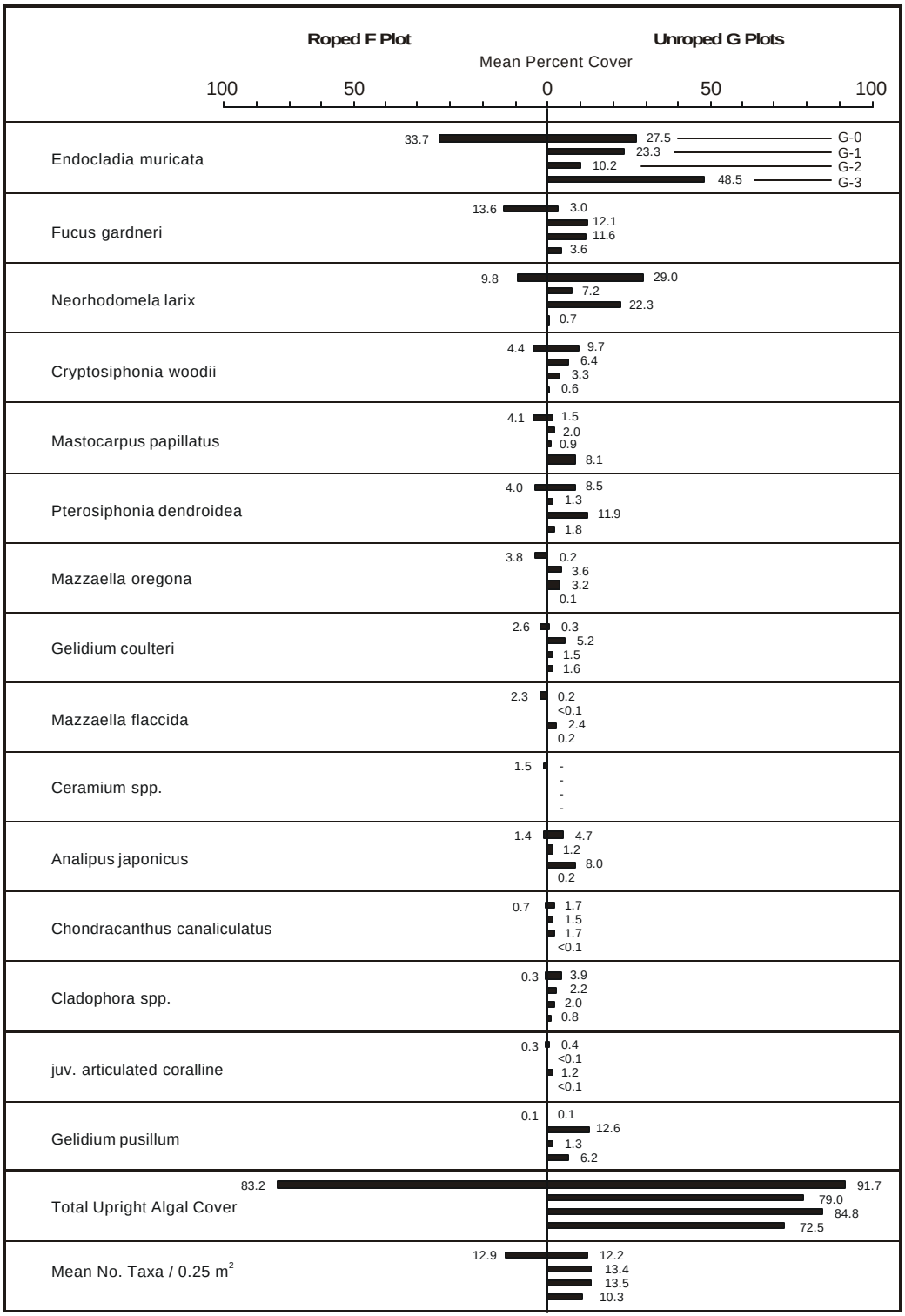



**Figure 3-25**. Abundance of algae in Roped F Plot and associated Unroped G Plots. Unroped Plot G-0 is the Park unroped G Plot. Unroped Plots G-1, G-2, and G-3 are additional unroped plots. The algae portrayed are those in which the mean abundance wa equal to or greater than one percent cover in any given plot.

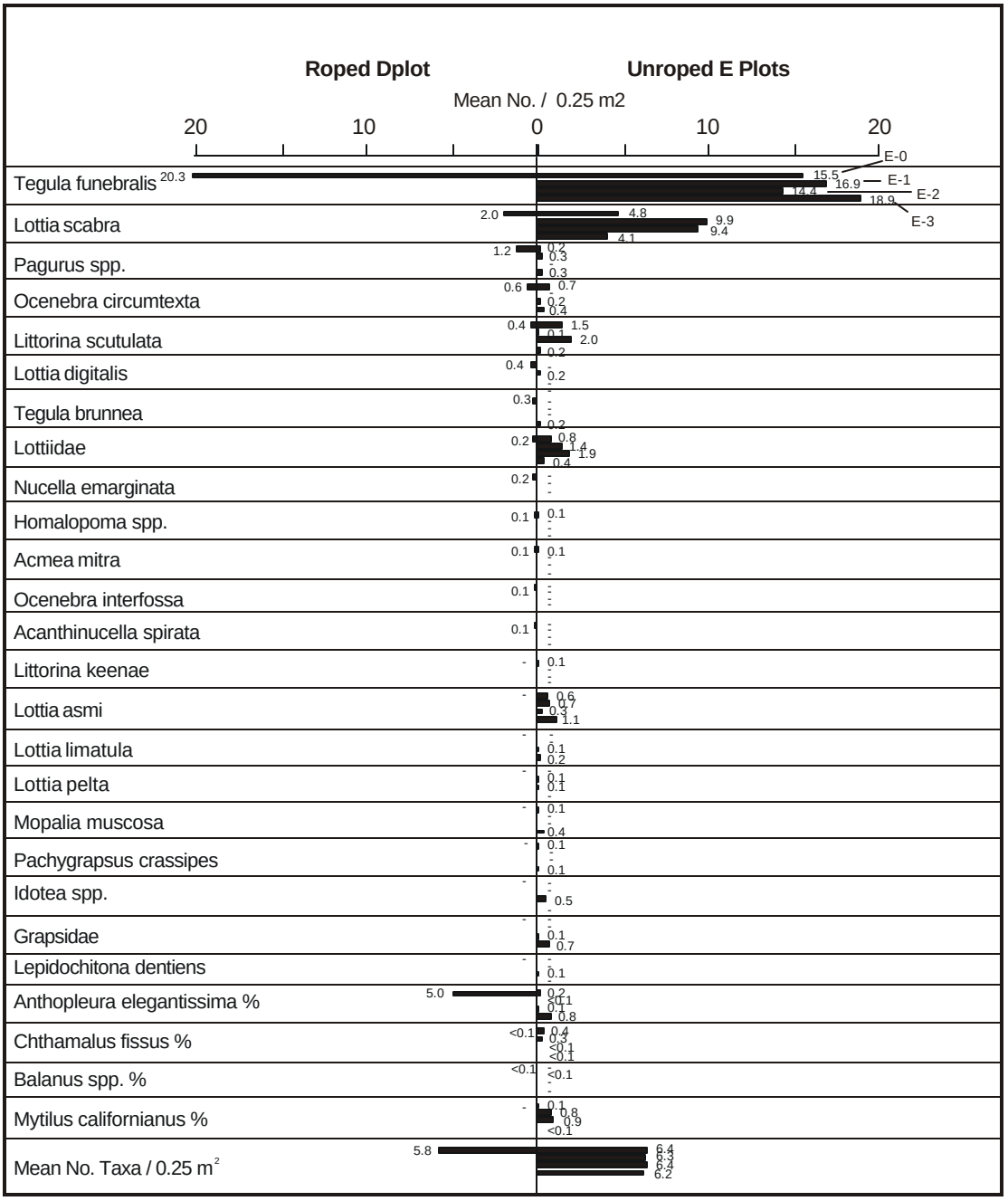



**Figure 3-26**. Abundance of invertebrates in Roped D Plot and associated Unroped E Plots. Unroped Plot E-0 is the Park unroped E Plot. Unroped Plots E-1, E-2, and E-3 are additional unroped plots.

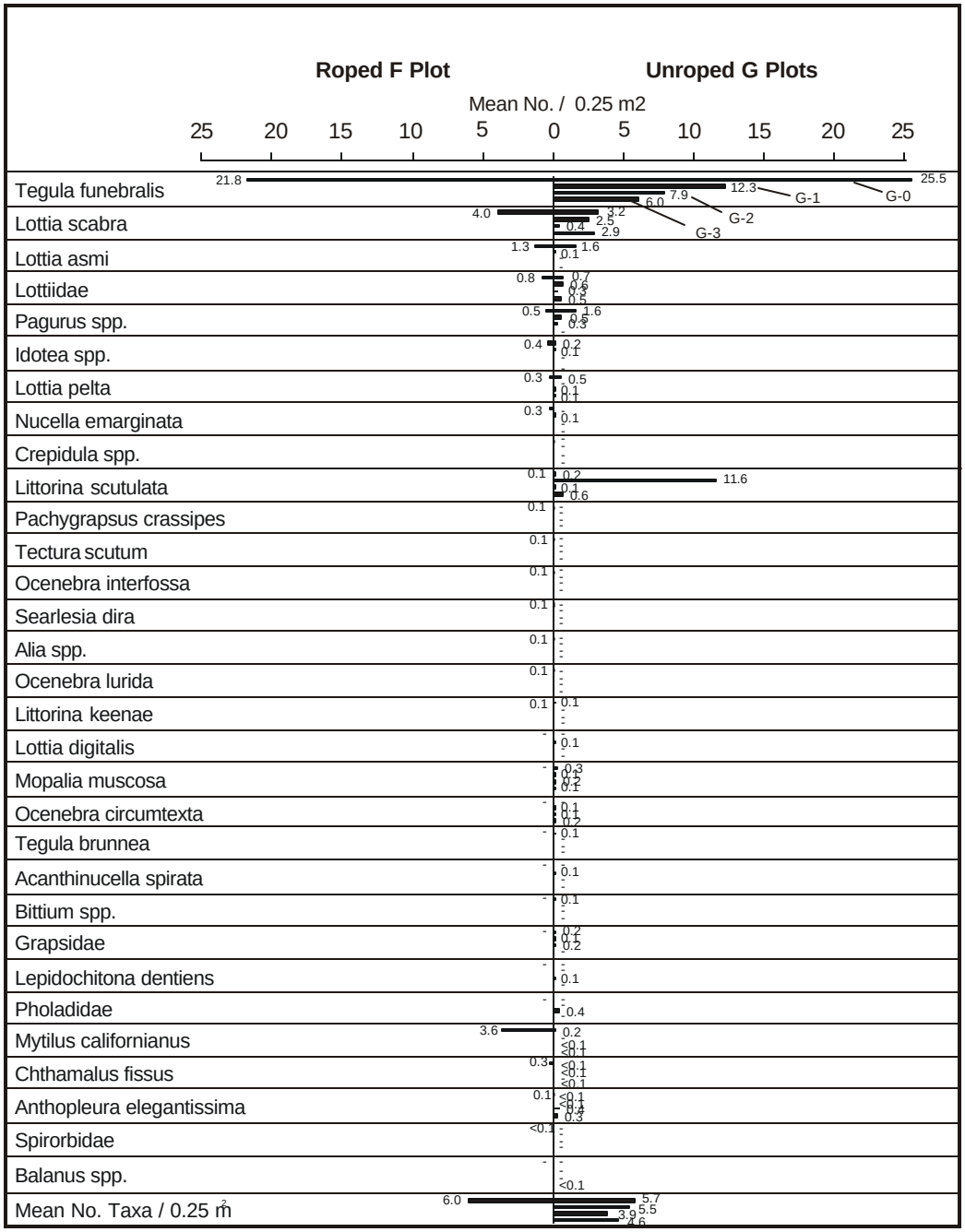



**Figure 3-27**. Abundance of invertebrates in Roped F Plot and associated Unroped G Plots. Unroped Plot G-0 is the Park unroped G Plot. Unroped Plots G-1, G-2, and G-3 are additional unroped plots.

## Algal Community Analysis

The foliose algal communities in the two roped and two unroped plots were significantly different from each other (**Table 3-10**). As a result the two sets of plots were analyzed separately. Otherwise differences between roped and unroped plots that may be due to the reduced visitor effects in the roped plots may not be detected because of the differences between the pairs of roped and unroped plots.

The MDS analysis of the first set of roped and unroped plots (Plots D, E-0, E-1, E-2, and E-3), showed that some of the quadrats from the roped plots were distinctly different from most of the quadrats in the unroped plots (**Figure 3-28**). The ANOSIM analysis detected a statistically significant difference between the groups of roped and unroped quadrats (R-Value = 0.267, p=0.01). SIMPER analysis showed that the algal cover was greater in the unroped quadrats, mainly due to higher abundances of nailbrush seaweed (*Endocladia muricata*) (**Table 3-11**). The difference between quadrat types was largely explained by higher abundances of nailbrush seaweed and rockweed (*Fucus gardneri*) in the unroped plots, and higher abundances of *Mastocarpus papillatus* and *Neorhodomela larix* in the roped quadrats. Although there was considerable variation among the quadrats in the unroped plots, many of the quadrats showed a high degree of similarity. SIMPER analysis showed that the average similarity among the 40 quadrats from the unroped plots (46%) was much greater than the average similarity among the ten roped plots (27%). This indicated that the spatial variation in algal communities in the roped plot was greater than the variation among the quadrats from all four unroped plots.

The MDS analysis of the second set of plots (Plots F, G-0, G-1, G-2, and G-3) showed that the variation among the quadrats in the roped plot were within the range of variation shown within the unroped plots (**Figure 3-29**). As a result, the ANOSIM analysis did not detect a significant difference between the second set of roped and unroped plots (R-Value = 0.087, p=0.16). The variation among many of the quadrats in this second set of plots was much less than the variation in the first set of plots. Although there was no statistically significant difference between groups, the SIMPER analysis was done to compare the average similarity among quadrats within the roped and unroped plots. Similar to the results from the other set of plots the average similarity among the 40 quadrats from the unroped plots (36%) was greater than the average similarity among the ten roped plots (29%).

## Invertebrate Community Analysis

Similar to the results for the foliose algae, the invertebrate communities in the two roped and two unroped plots were significantly different from each other (**Table 3-12**). As a result, the two sets of plots were analyzed separately. Otherwise, differences between roped and unroped plots that may be due to the reduced visitor effects in the roped plots may not be detected because of the differences between the pairs of roped and unroped plots.

The MDS analysis of the first set of roped and unroped plots (Plots D, E-0, E-1, E-2, and E-3), including the three additional plots sampled for this study, showed that although there was a large degree of variation among the quadrats in both types of plots, some of the quadrats from

**Table 3-10**. Results of ANOSIM analyses of foliose algal abundances from Park 100 $m^2$ plots comparing the two roped plots against each and the two unroped plots with each other. Both analyses used the ten quadrats within each plot as replicates. The ANOSIM R-Value is the test statistic representing the difference between the average of the rank similarities between all pairs of samples between plots and the average of the rank similarities between all pairs of samples within plots. R-values with p-value less than 0.05 (5.0 %) were significant

| Plot Type | ANOSIM R-Value | p-value |
|---|---|---|
| Unroped | 0.296 | <0.01 |
| Roped | 0.184 | 0.01 |

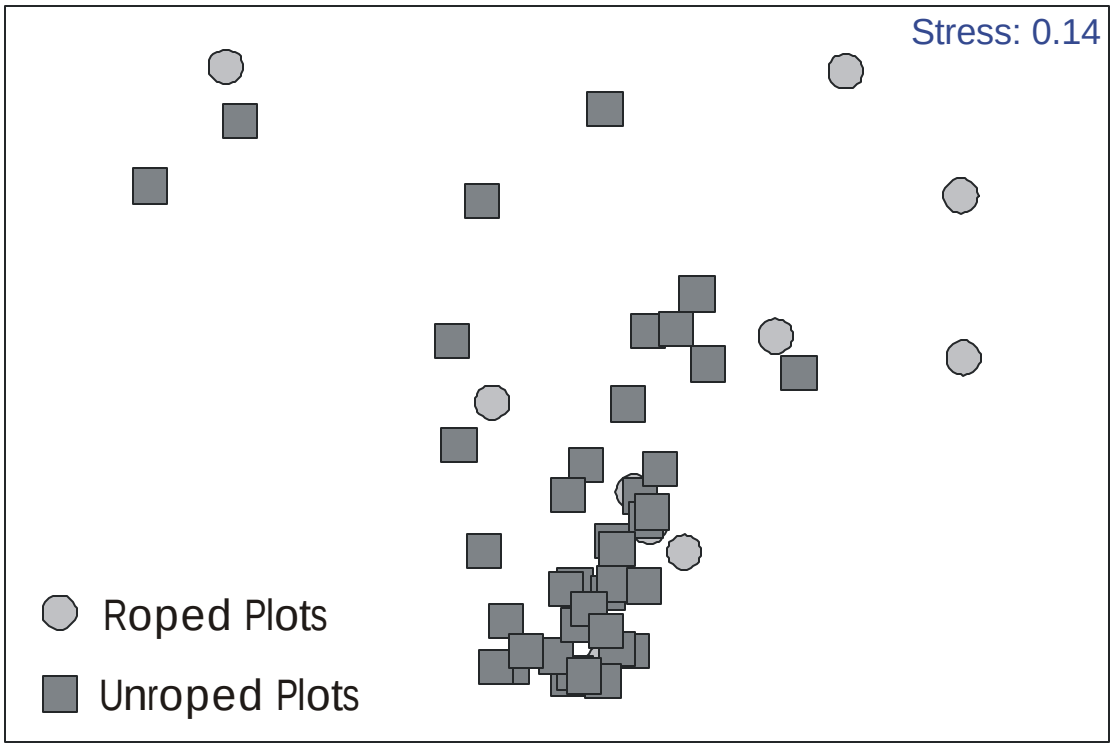



**Figure 3-28**. MDS analysis of foliose algal abundances for quadrats in first set of 100 $m^2$ plot (Plots D, E-0, E-1, E-2, E-3) with scores for quadrats in roped and unroped plots.

**Table 3-11**. Results of SIMPER analysis showing algal taxa responsible for dissimilarity between quadrats in the first 100 $m^2$ roped plot and set of four 100 $m^2$ unroped plots, including three plots sampled for this study (Plots D, E-0, E-1, E-2, E-3). Only the algae that together contributed up to 90 % of the difference between roped and unroped plots are shown.

| Species | Average % Cover Roped Plots | Average % Cover Unroped Plots | % Contribution | Cumulative % |
|---|---|---|---|---|
| *Endocladia muricata* | 16.20 | 35.55 | 50.39 | 50.39 |
| *Mastocarpus papillatus* | 6.80 | 6.43 | 12.30 | 62.70 |
| *Neorhodomela larix* | 3.70 | 2.35 | 10.95 | 73.64 |
| *Fucus gardneri* | 0.00 | 5.08 | 7.88 | 81.52 |
| *Mazzaella oregona* | 1.70 | 1.08 | 3.37 | 84.89 |
| *Gelidium pusillum* | 0.40 | 1.65 | 3.27 | 88.16 |
| *Gelidium coulteri* | 0.40 | 1.55 | 3.05 | 91.21 |

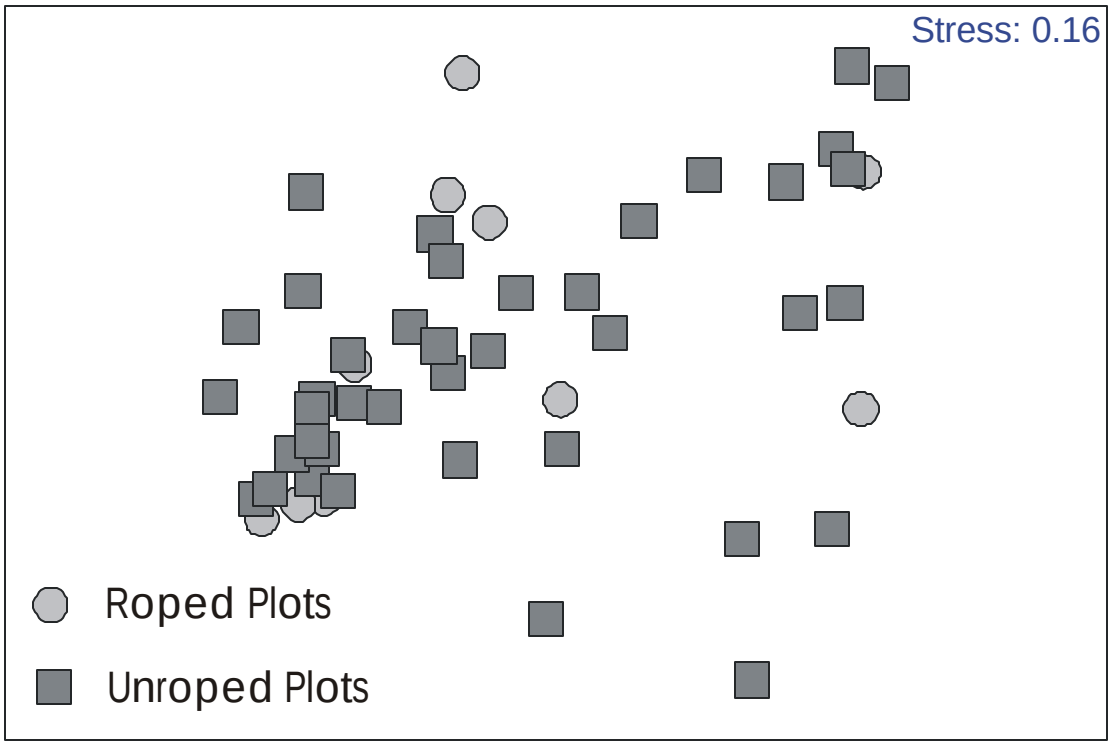



**Figure 3-29**. MDS analysis of foliose algal abundances for quadrats in second set of 100 $m^2$ plots (Plots F, G-0, G-1, G-2, and G-3) with scores for quadrats in roped and unroped plots.

**Table 3-12**. Results of ANOSIM analyses of invertebrate abundances from Park 100 $m^2$ plots comparing the two roped plots against, each and the two unroped plots against each other. Both analyses used the ten quadrats within each plot as replicates. The ANOSIM R-Value is the test statistic representing the difference between the average of the rank similarities between all pairs of samples between plots and the average of the rank similarities between all pairs of samples within plots. R-values with p-values less than 0.05 (5.0 %) were significant.

| Plot Type | ANOSIM R-Value | p-value |
|---|---|---|
| Unroped | 0.248 | <0.01 |
| Roped | 0.342 | <0.01 |

the roped plots were distinctly different from most of the quadrats in the unroped plots (**Figure 3-30**). The ANOSIM analysis detected a statistically significant difference between the groups of roped and unroped quadrats (R-Value = 0.505, p=<0.01). The SIMPER analysis showed that the largest percentage contribution to the difference between plot types was due to higher abundances of anemones *Anthopleura elegantissima* and black turban snails *Tegula funebralis* in the roped plot (**Table 3-13**). The average similarities among the quadrats in the roped (57%) and unroped (62%) were very close in value, which is reflected in the range of variation among the quadrats shown in **Figure 3-30**.

The MDS analysis of the second set of plots (Plots F, G-0, G-1, G-2, and G-3) showed that the variation among the quadrats in the roped plot was within the range of variation shown among the unroped quadrats (**Figure 3-31**). As a result of the similarity in the variation among the two groups of quadrats, no significant difference was detected in the ANOSIM analysis between the set of roped and unroped plots (R-Value = 0.1, p=0.13). Although there was no statistically significant difference detected between groups, the SIMPER analysis was done to compare the average similarity among quadrats within the roped and unroped plots. Similar to the results from the other set of plots, the average similarity among the 40 quadrats from the unroped plots (49%) was close in value to the average similarity among the ten roped plots (52%), which is also reflected in the range of variation among the quadrats shown in **Figure 3-31**.

## Discussion

The results do not provide strong evidence that differences between the one set of roped and unroped plots are consistent with effects of increased visitor use in the unroped areas. The most common impact from visitors to the intertidal is trampling which directly affects algal communities. Although a statistically significant difference was detected between roped and unroped quadrats for one of the set of plots, the results also show that the unroped plots had greater abundances of algae including rockweed and nailbrush seaweed, which are known to be


**Figure 3-30**. MDS analysis of invertebrate abundances for quadrats in the first set of 100 $m^2$ roped and unroped plots.

**Table 3-13**. Results of SIMPER analysis showing the invertebrate taxa responsible for dissimilarity between quadrats in first set of one 100 $m^2$ roped plot and four 100 $m^2$ unroped plots, including three plots sampled for this study. Only the invertebrates contributing up to 90 % of the difference between roped and unroped plots are shown.

| Species | Average % Cover Roped Plots | Average % Cove Unroped Plots | % Contribution | Cumulative % |
|---|---|---|---|---|
| *Anthopleura elegantissima* | 5.00 | 0.28 | 17.95 | 17.95 |
| *Lottia scabra* | 2.00 | 7.05 | 15.57 | 33.52 |
| *Tegula funebralis* | 20.30 | 16.43 | 12.65 | 46.16 |
| *Pagurus* spp. | 1.20 | 0.20 | 8.69 | 54.85 |
| Lottiidae | 0.20 | 1.13 | 7.45 | 62.30 |
| *Littorina scutulata* | 0.40 | 0.95 | 5.83 | 68.13 |
| *Ocenebra circumtexta* | 0.60 | 0.33 | 5.75 | 73.87 |
| *Lottia asmi* | 0.00 | 0.68 | 4.26 | 78.13 |
| *Mytilus californianus* | 0.00 | 0.45 | 3.08 | 81.22 |
| *Lottia digitalis* | 0.40 | 0.05 | 2.96 | 84.18 |
| *Tegula brunnea* | 0.30 | 0.05 | 2.90 | 87.09 |
| *Nucella emarginata* | 0.20 | 0.00 | 1.75 | 88.84 |
| Grapsidae | 0.00 | 0.20 | 1.59 | 90.43 |

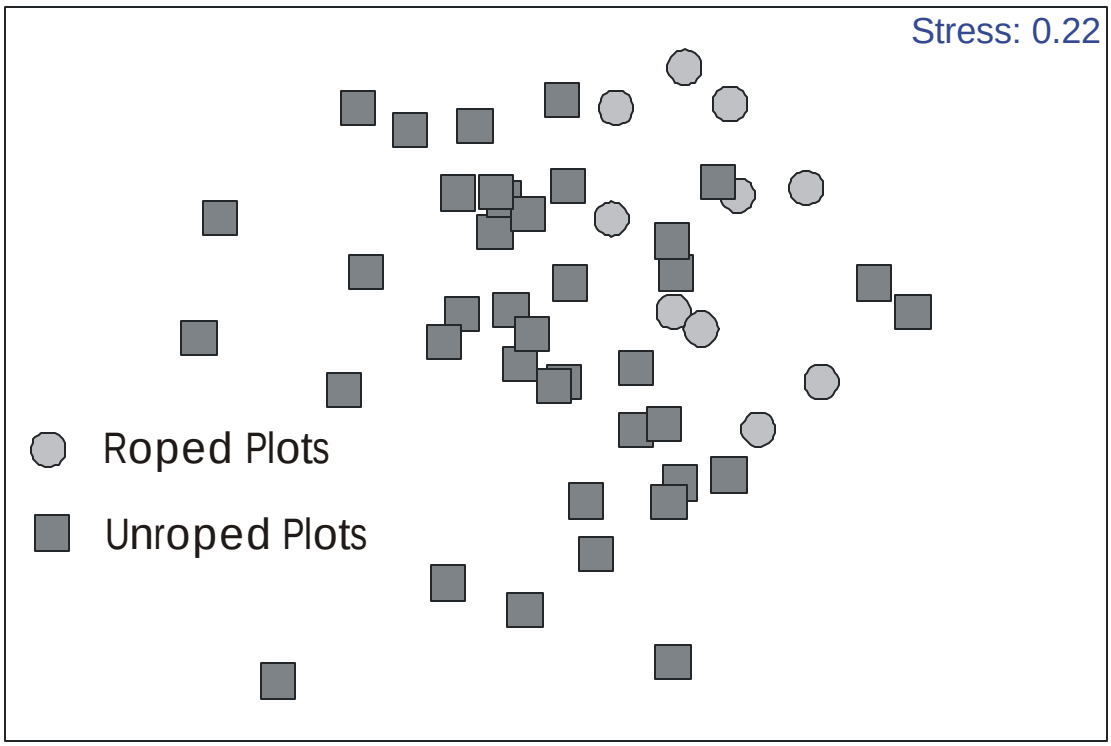



**Figure 3-31**. MDS analysis of invertebrate abundances for quadrats in the second set of 100 $m^2$ roped and unroped plots.

susceptible to trampling effects (Murray and Gibson 1979). In addition, the variation among the quadrats in both roped plots was much greater than the variation among the unroped plots. Even though there was a total of 40 quadrats sampled from the unroped plots in each set of plots, the similarity among those 40 quadrats was greater than the similarity among the ten quadrats in each of the unroped plots. If the differences were due to reduced levels of visitor use we would expect less variation among the quadrats in the roped plots relative to the unroped plots because trampling and other visitor impacts would be expected to increase spatial variation. Increased variation is recognized as a characteristic of disturbed communities (Warwick and Clarke 1993). Based on these results we concluded that the differences between the roped and unroped plots were not due to reduced levels of visitor use in the roped areas.

The results also do not provide strong evidence that the differences between invertebrate assemblages in the two sets of roped and unroped plots are due to increased visitor use in the unroped areas. The invertebrates responsible for differences between roped and unroped plots were not consistent between the two sets of plots. In addition, the difference detected in the second set of plots was likely a result of including the data from the three additional plots sampled for this study, because no difference was detected between the quadrats in the original

Park plots. This may be partially due to the design of the original Park study where the roped and unroped plots were located adjacent to one another. Therefore, it isn't surprising that the variation among the quadrats for these two plots would be similar relative to the additional plots sampled in this study that were located nearby. Even though the total numbers of unroped quadrats was greater than the roped quadrats, the variation was similar for the two groups. If the differences were due to levels of visitor use, we would expect less variation among the quadrats in the roped plots relative to the unroped plots, because visitor impacts would be expected to increase spatial variation. Increased variation is recognized as a characteristic of disturbed communities (Warwick and Clarke 1993). Based on these results we concluded that the differences between the roped and unroped plots were not entirely due to reduced levels of visitor use in the roped areas.

These results demonstrate the problems in designing studies to detect the effects of visitor use or any other human-induced disturbance in biological communities, which are extremely variable in abundances through time and among areas. Any impacts at Moss Beach that may be occurring due to visitor impacts would require the commitment to a long-term field study or field manipulative experiment. Although the Park field experiment was a good effort, it had several design problems that limited its value. First of all, the County sampling within each plot resulted in highly variable data, due to the random placement of the quadrats without regard to intertidal topography; a placement approach that potentially increased variation due to habitat differences. The method for quantifying the biota did not adequately represent the actual abundances in each quadrat making it more difficult to make comparisons over time and among plots.

Second, the roped and unroped plots were placed adjacent to one another. This creates several problems. There is a large area of the unroped plot that is adjacent to the roped plot that may experience spillover effects from any changes in the roped plot. The roped plot also likely attracts visitors to the unroped areas around the plot potentially generating greater visitor traffic than other areas of the reef.

Finally, the number of plots was not adequate to account for the large variation in the abundances of intertidal organisms. We tried to address this issue by sampling additional plots, but even with increased sampling it would be difficult to statistically detect visitor impacts, even with a longer-term study. This is largely due to the highly variable environment at Moss Beach, which experiences very high levels of natural disturbance, due to large waves, especially during winter storms.

# 3.5 Mussel Bed Studies–Roped and Unroped Test Plots and Baseline Mapping

## Purpose

The purpose of these studies was to determine if visitor impacts on mussel beds (*Mytilus californianus*) could be detected by examining an area that limited visitor access (roped area) and areas open to visitors (unroped areas) and to conduct mussel bed mapping to provide baseline data for use in following mussel bed dynamics.

**Figure 3-32**. Mussels (above photo) and *Postelsia* (below photo) that occasionally occurs in the same areas of mussels.

## Background

Mussel beds are relatively common in the Fitzgerald State Marine Park (**Figure 3-32**). They occur on rocks that are exposed to the full force of waves, mainly along the seawards edges of the bench platforms. Mussels are edible and ranked among the most common organism collected from the Park (see *Section 2.5 - Surveillance, Collecting Violations, and Advisories*). Mussel beds can be easily impacted if individuals are removed, because of potentially long recovery periods (Kinnetics 1989).

## Roped and Unroped Plot Study

### Methods

There are three large distinct mussel beds on Moss Beach Reef. One test plot was established by the Park rangers in each of the mussel beds (Plots A, B, and C) (**Figure 3-1**). Plots were sampled seven times from April 1994–January 1997 during the Park study described in **Section 3.3**. Mussel bed Plot A was roped during low tide periods and Plots B and C were left open.

The locations of the 10 m x 10 m (100 $m^2$) mussel bed plots were permanently marked using fixed bolts. However, the mussel bed plots were sampled differently than Plots D through G (**Section 3.3**). A 10-m length tape was laid along the inshore boundary of each plot. A 6-m tape

was attached to the 10 m tape and laid towards the ocean (perpendicular to shore) at meters 1.5, 3.0, 4.5, 6.0, and 7.5.

Individual 0.25 $m^2$ quadrats were sampled along the 6-m tape at meters 0, 2, 4, and 6. When facing the ocean, each 0.25 $m^2$ quadrat was positioned so that the meter interval occurred in the inshore-upcoast corner of the quadrat. The 0.25 $m^2$ quadrat was divided into a grid of 25-100 $cm^2$ subunits (10 cm x 10 cm). The number of mussels were either counted or estimated for each of the 100 subunits and recorded according to 'count category' (0, 1–9 individuals, 10–99 individuals, 100–999 individuals) for each subunit.

Because recovery of disturbed mussel beds can take years (Kinnetics 1989), we felt that the time period from April 1994 through January 1997 might not have been long enough to allow roped Plot A to recover from visitor effects that may have occurred before the plot was established. Therefore, we sampled the mussel plots again in summer 2004 using the same sampling methods used previously to provide a 10-year time span for assessing change.

## Results

In order to compare changes over time, we converted the frequencies of mussel abundance categories (0, 1–9, 10–99, etc.) to a percent cover value for each quadrat. Each of the 25 grid subunits in the 0.25 $m^2$ quadrat represented four percent cover. We found in our August 2004 sampling that the coverage of mussels in abundance category '1-9' was generally equivalent to half cover (two percent cover) in the grid subunit, and that the coverage of mussels in abundance category '10–99', regardless of number of individuals, was always equivalent to the full size of the grid subunit (four percent cover). Therefore, we summed all of the data from the 25 grid subunits according to the equivalent mussel coverage values and averaged them across the 20 quadrats sampled per plot per survey.

The results do not show any substantial changes over time in the coverage of mussels between the roped and unroped plots (**Figure 3-33**). However, a slight increase in the coverage of mussels occurred in unroped Plot C over this time span.

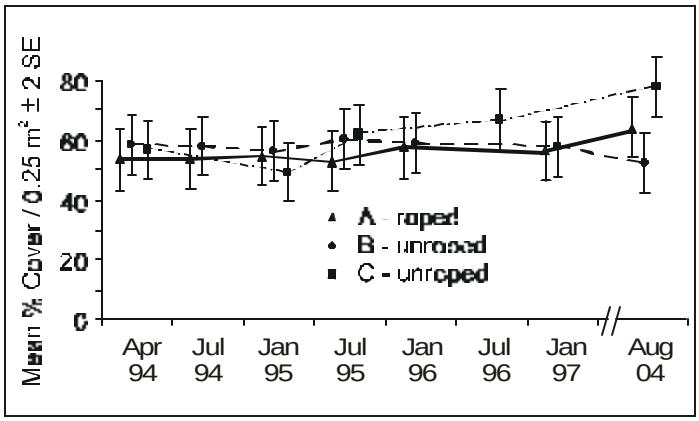



**Figure 3-33**. Abundance of mussels in the roped and unroped plots.

## Discussion

Results of this study indicated the abundance of mussels beds in the three test plots had not changed markedly over the past 10 years, and there was no evidence that the roped area was different from the unroped areas. The small changes over time are surprising

since Moss Beach experiences large natural disturbances from waves, especially during winter storms. Waves can tear out large patches of mussel beds, and this is an important process in providing new bare space for recruitment of new mussels and eventual expansion of the beds. The small changes may also result from the generally low abundances of sea stars at Moss Beach, which are a major predator on sea stars (Paine 1969, 1974). In fact, the small increase in mussel cover in unroped Plot C relative to the other plots may be due to the sea star abundance which declined in Plot C relative to the other test plots (see below, *Section 3.6 – Sea Star Study*).

## Mussel Bed Mapping

### Methods

We also assisted Ms. Aura DeMare (a graduate student at San Francisco State University) during a mussel bed mapping survey designed to provide baseline GIS data. We mapped 31 individual mussel beds on the flat rock bench platforms throughout the Park from Reef Point south to Pillar Point (**Figure 3-34**). Areas north of Reef Point (**Figure 3-1**) were not surveyed, due to steep rocks that prevent access to the intertidal zone. We also did not survey mussel beds on Nye's Rocks, due to the presence of harbor seals.

The location of each mussel bed was recorded using a hand-held Trimble GeoExplorer geographic positioning system (GPS) recorder. The cross width dimensions of each mussel bed were measured and recorded separately. The dimensions were approximate because the shapes of the mussel beds were typically not symmetrical. We visually estimated the spatial area of small mussel beds. The height (vertical thickness) of each mussel bed was also recorded by measuring the distance from the substrate to the tip of the mussel shell at five locations within the bed (four corners and middle). The corner measurements were inside the boundary of the mussel bed (by approximately 0.25 m) so that any 'edge effect' of the mussel bed would not be measured. An

edge effect might be present if smaller mussels tended to occur along the perimeter of the bed. The canvassing of the reefs also allowed us to map the location and patch sizes of sea palms (*Postelsia palmaeformis*).

### Results and Discussion

The patch sizes (area cover) of the 31 mapped mussel beds (**Figure 3-34**) varied throughout the study area, ranging between 1 $m^2$ and 135 $m^2$ (**Table 3-14**). The mussel bed canopy heights were not substantially different between beds, except on the outermost seaward fringes of Frenchman's Reef (beds 19, 20, 21, and 22) where the sizes of the mussels on the outermost seaward fringes of Frenchman's Reef (beds 19, 20, 21, and 22) were larger; shell lengths (canopy heights) ranged between 124 mm and 157 mm (**Table 3-14**).

The larger-sized individuals in mussel beds 19, 20, 21, and 22 on Frenchman's Reef could have been a result of more favorable wave exposure conditions or a lack of visitor access because these beds essentially occur on an island separated from the main reef by a deep surge channel.

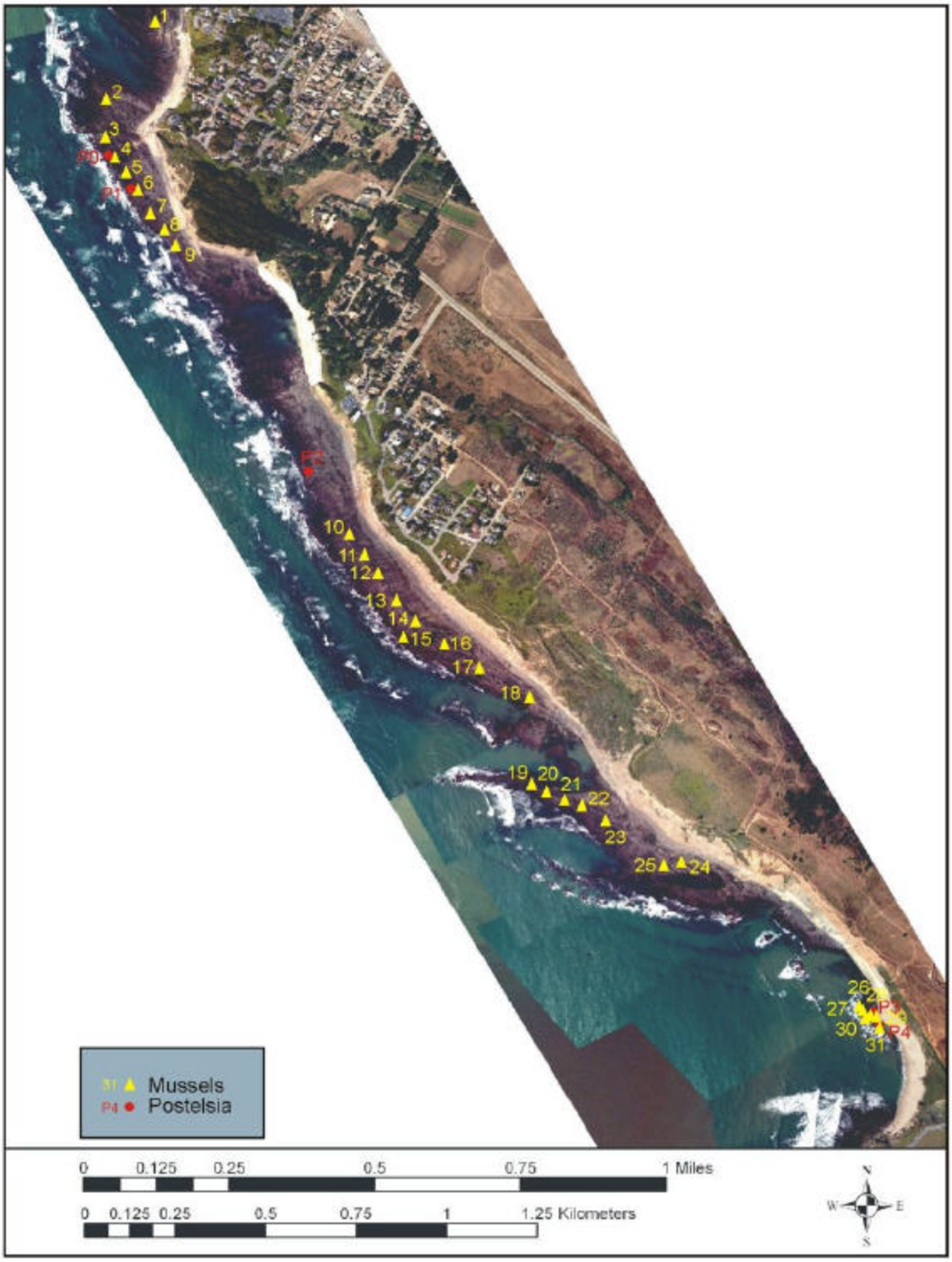



**Figure 3-34**. Locations of mussel beds and stands of *Postelsia*.

**Table 3-14**. Location and attributes of mussel and *Postelsia* patches.

| | Long. (NAD83) | Lat. (NAD83) | Area ($m^2$) | Mean Shell Height (mm) | Std. Dev. |
|---|---|---|---|---|---|
| Mussel Patch | | | | | |
| 1 | 122.51722 | 37.52677 | 3 | 35 | 14 |
| 2 | 122.51875 | 37.52479 | 43 | 97 | 36 |
| 3 | 122.51881 | 37.52378 | 10 | nd | nd |
| 4 | 122.51867 | 37.52320 | 12 | 52 | 31 |
| 5 | 122.51836 | 37.52280 | 97 | 77 | 18 |
| 6 | 122.51797 | 37.52245 | 93 | 75 | 16 |
| 7 | 122.51741 | 37.52199 | 135 | 70 | 17 |
| 8 | 122.51720 | 37.52174 | 32 | 64 | 16 |
| 9 | 122.51680 | 37.52149 | 6 | 66 | 29 |
| 10 | 122.51262 | 37.51380 | 45 | 74 | 13 |
| 11 | 122.51223 | 37.51331 | 32 | 108 | 22 |
| 12 | 122.51199 | 37.51301 | 43 | 57 | 24 |
| 13 | 122.51133 | 37.51219 | 28 | 75 | 9 |
| 14 | 122.51090 | 37.51194 | 19 | 21 | 4 |
| 15 | 122.51141 | 37.51149 | 1 | nd | nd |
| 16 | 122.51022 | 37.51146 | 2 | 26 | 10 |
| 17 | 122.50945 | 37.51069 | 2 | 36 | 10 |
| 18 | 122.50811 | 37.50982 | 32 | 46 | 37 |
| 19 | 122.50813 | 37.50771 | 27 | 157 | 42 |
| 20 | 122.50795 | 37.50764 | 5 | 184 | 30 |
| 21 | 122.50765 | 37.50754 | 90 | 195 | 34 |
| 22 | 122.50734 | 37.50747 | 12 | 124 | 56 |
| 23 | 122.50643 | 37.50695 | 18 | 52 | 25 |
| 24 | 122.50455 | 37.50584 | 4 | 47 | 13 |
| 25 | 122.50478 | 37.50582 | 7 | 105 | 38 |
| 26 | 122.50002 | 37.50192 | 10 | nd | nd |
| 27 | 122.49994 | 37.50182 | 3 | nd | nd |
| 28 | 122.49975 | 37.50164 | 4 | nd | nd |
| 29 | 122.49964 | 37.50163 | 1 | nd | nd |
| 30 | 122.49984 | 37.50156 | 3 | nd | nd |
| 31 | 122.49934 | 37.50136 | 1 | nd | nd |
| Postelsia Patch | | | | | |
| P0 | 122.51867 | 37.52320 | 12 | | |
| P1 | 122.51845 | 37.52283 | 11 | | |
| P2 | 122.51378 | 37.51543 | nd | | |
| P3 | 122.49983 | 37.50181 | 6 | | |
| P4 | 122.49944 | 37.50156 | 16 | | |

The larger sizes were not due to reduced sea star predation; we counted 144 sea stars (*Pisaster ochraceus*) associated with these four mussel beds, and this reef had the largest concentration of sea stars observed. We also mapped four stands of *Postelsia* in the study region (**Figure 3-34**).

## 3.6 Sea Star Study

### Purpose

The purpose of this study was to determine if visitor impacts on sea stars (*Pisaster ochraceus*) found in mussel beds could be detected by examining an area that limited visitor access (roped area) and areas open to visitors (unroped areas).

### Background

Sea stars are often a focus of visitors to the intertidal because they are one of the largest invertebrates in the intertidal zone and they are relatively conspicuous. Sea stars are usually collected out of curiosity and for souvenirs. Sea stars are adapted to cling tightly onto rocks, and are often found associated with mussel beds. Mussels are a common prey item for sea stars, and sea stars are regarded as a 'keystone species' that can control mussel abundance (Paine 1969, 1974).

### Methods

The number of sea stars (*Pisaster ochraceus*) in mussel bed test plots A, B, and C (**Figure 3-1**) was counted during the Park study in 1998–1999 and again by Tenera in summer 2004. Counts of sea stars were also recorded during the 2004 mapping of 31 mussel beds on the flat rock bench platforms from Reef Point south to Pillar Point (**Section 3.5**).

### Results

Counts of sea stars varied over time both within and between plots (**Figure 3-35**). The counts in summer 2004 were generally lower than the abundances

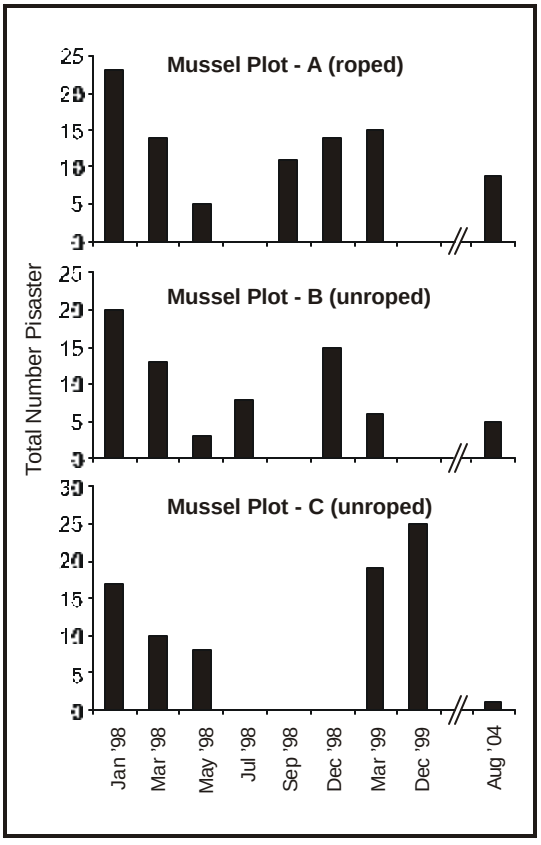



**Figure 3-35**. Abundance of sea stars (*Pisaster* spp.) in the mussel bed test plots. Note that all surveys but the last were completed in 1998-99.

recorded in 1998-99. The largest change relative to previous counts was in Plot C (unroped), where the lowest abundance occurred in 2004. It was also the lowest abundance for all the plots over the entire study.

In general, our wide area reconnaissance survey from Moss Beach Reef down to Pillar Point found sea stars (*Pisaster ochraceus*) to be relatively common. We counted 144 *Pisaster ochraceus* associated with four mussel beds **(**19, 20, 21, and 22**)** on Frenchman's Reef, a large difference from the single *Pisaster ochraceus* counted on Frenchman's Reef one year earlier by Talarico (2003). It is possible, however, that Talarico's 1.5 hr shore-walk survey did not cover the same area that we sampled.

## Discussion

We found the abundance of sea stars (*Pisaster* spp.) to be variable both within and among the mussel bed plots over time. The nature of the variation did not provide any evidence of differences correlating with visitor use. The decline in abundance in Plot C was probably not due to visitor use because of this plot's accessibility problems relative to the other plots.

Sea stars are an ecologically important species because they can alter the abundance of prey items, such as mussels. They are also relatively conspicuous, and are often associated with the intertidal zone. In previous studies, scientists and lay people alike offered opinions regarding the intertidal habitat (Tenera 2003). A common remark was, "Many organisms are not as abundant as they use to be". We also found similar responses from our questionnaire survey completed for this study. A common ancillary observation included a suspected decline in sea stars since the early 1970s. While this may be true, linking this type of change to a visitor effect would be entirely speculative. For example, in sea stars, a 'wasting disease' associated with warmer water El Niño conditions caused sharp declines in bat star abundance in southern California (Tegner and Dayton 1991, Engle 1997). Declines were also observed in central California in San Luis Obispo County during the 1983 El Niño where bat stars (*Asterina miniata*) have not recovered to former levels of abundance (**Figure 3-36**). It is not known if similar disease problems affected the sea star populations in the Fitzgerald State Marine Park.

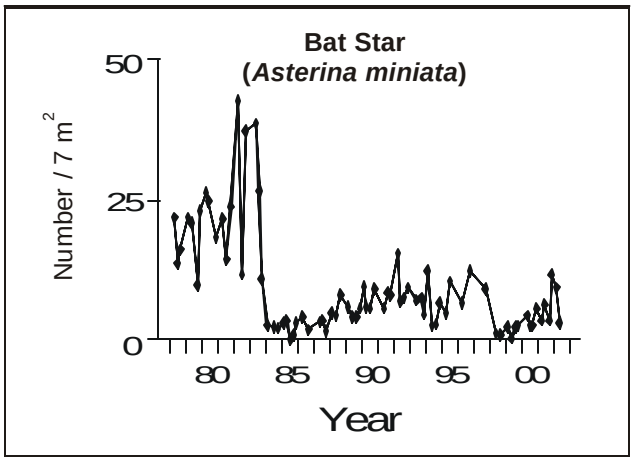



**Figure 3-36**. Abundance of bat stars at a shallow subtidal control station near the Diablo Canyon Power Plant in San Luis Obispo County. (Data courtesy of Pacific Gas and Electric Company.)

# 3.7 Owl Limpet Population Study

## Purpose

The purpose of this study was to determine if any effects of owl limpet collecting or poaching (*Lottia gigantea*) could be detected in the Fitzgerald State Marine Park.

**Figure 3-37**. Owl limpet (*Lottia gigantea*).

## Background

Owl limpets (**Figure 3-37**) are a large, long-lived limpet species, and are occasionally collected for human consumption. They range from Washington to Baja California (Morris et al. 1980). Owl limpets live out in the open, have clumped distributions, and tend to be most common on rocks that are smooth and exposed to the full force of waves (Ambrose et al. 1995, Lindberg et al. 1998).

Although it is illegal to remove owl limpets (and all other invertebrates) within the Fitzgerald State Marine Park, poaching has been recorded in the past. Poaching can potentially cause large reductions in the abundance in this long-lived species. Park enforcement records documented that large numbers of limpets have been collected from the Park on at least one occasion (see *Section 2.5 - Surveillance, Collecting Violations, and Advisories*).

No baseline data for this species existed that would allow us to look at changes in abundance over time. However, poaching can often affect the size distribution of owl limpets in an area since collectors typically remove the largest individuals (Hockey and Bosman 1986, Underwood and Kennelly 1990, Pombo and Esofet 1996, Griffiths and Branch 1997, Lindberg et al. 1998, Kido and Murray 2003). This difference in size distribution can then be detected by comparison with other areas where poaching is known to have not occurred.

Little was known previously on the distribution and abundance of owl limpets in the Fitzgerald State Marine Park, until the study completed by Ms. Nancy Levine (U.C. Berkeley) in Spring–Summer 2004. The following is a summary of her research findings based on her report submitted to the biological sciences department at U.C. Berkeley (Levine 2004). We compare her data with results that we obtained in a similar study we completed at Point Pinos, Monterey County (Tenera 2003).

## Methods

Rocky areas exposed to the full force of waves in the Fitzgerald State Marine Park from Reef Point south to Pillar Point (distance of approximately 2.5 mi, 4 km) were searched for owl limpets during low tides. (It is important to note that the majority of Pillar Point is immediately outside the Fitzgerald State Marine Park). The size of each area ($m^2$) encompassing an aggregation of owl limpets was estimated according to the approximate cross-width dimensions of the survey area. Sampling times were recorded. All owl limpets within the defined area were measured (greatest shell dimension) to the nearest millimeter using a dial caliper. Each owl limpet was measured in place and marked with a crayon to avoid duplicate measurements. The shell measurements were analyzed for significant differences between areas using analysis of variance (ANOVA).

## Results

Owl limpets were found aggregated in various abundances at 12 sites from Reef Point to Pillar Point. Over 140 owl limpets were measured. A single factor ANOVA did not detect a significant difference in mean shell lengths between areas considered to be high use (Moss Beach Reef and Pillar Point) and low use (Frenchman's Reef and Seal Cove Beach). The relatively small number of animals sampled, combined with the limited number of areas which they occurred, could account for the lack of a significant difference in the ANOVA. Owl limpet densities in the areas studied on Moss Beach Reef averaged almost one owl limpet per square meter. Densities were appreciably lower at Pillar Point (approximately 0.2 owl limpets per square meter). The mean shell length of the owl limpet population measured at the Moss Beach Reef sites was significantly greater than the population measured at Pillar Point ($p<0.05$) (**Figure 3-38**).

## Discussion

The study completed by N. Levine, as part of the present study and for her undergraduate studies at U.C. Berkeley, provided baseline information on the owl limpet population (*Lottia gigantea*) in the Fitzgerald State Marine Park. Owl limpets are at high risk to collecting because they are sought for consumption by humans. Her study provided some evidence that owl limpets may have been subjected to collecting at Pillar Point outside the Park where collecting owl limpets is legal (35 individuals/per person/day, 2004 CDF&G regulations).

Owl limpets were in highest abundance and were larger in size on Moss Beach Reef. While this area is considered an area of very high visitor use, it is also under close surveillance by Park rangers. Consequently, collecting may be less common on Moss Beach Reef. The mean shell size at Moss Beach Reef was larger (47 mm), compared with the mean length (35 mm) at Pillar Point, which is open to collecting. The mean size at Pillar Point is within the range of mean shell lengths (26–35 mm) reported from exploited populations in southern California and Mexico (Murray et al. 1999, Kido and Murray 2003). Owl limpets can grow up to a maximum size of

over 90 mm and those near this size are likely 10-15 years old (Morris et al. 1980, Kido and Murray 2003). Large individuals in the Pillar Point population were relatively scarce and were in the 41–50 mm size category. This suggests that they were only a few years old.

The 41–50 mm size class is larger than the size of reproductive maturity (25 mm) (Pombo and Esofet 1996). Therefore, there is some capacity for localized reproduction, although it may be limited. Furthermore, the larger individuals in the population tend to be females, because owl limpets are protandrous hermaphrodites (sex change) (Wright and Lindberg 1982, Ricketts, et al. 1985). Consequently, significant harvesting of large owl limpets could affect the population by altering reproduction capabilities (Ambrose et al. 1995, Kido and Murray 2003). Accordingly, reproduction and recruitment in the Pillar Point population may be limited from both a limited number of individuals that are reproductively mature and a reduced number of females. In contrast, the Moss Beach Reef population, having some individuals between 61–70 mm, strengthens the probability that the population consists of older individuals with a more well-mixed population of males and females.

A comparison of owl limpet populations at Fitzgerald State Marine Park to Point Pinos (located on the Monterey Peninsula) provides additional support that the Pillar Point owl limpet population has been subjected to collecting (**Figure 3-38**). Areas of Point Pinos that may have also been subjected to collecting still contain both an abundant adult population and juvenile population. The Pillar Point population is different from the others in lacking large individuals. Also, the Pillar Point and Moss Beach Reef populations are different than the Point Pinos population in lacking small individuals.

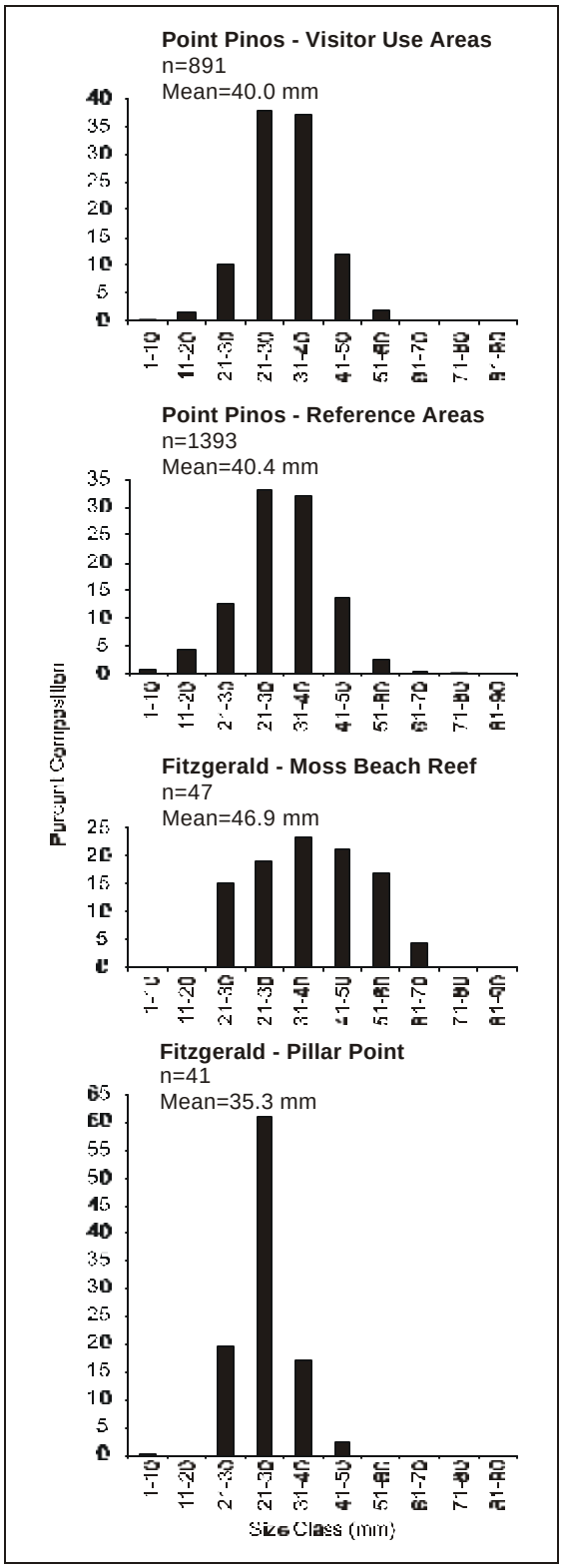



**Figure 3-38**. Comparison of shell size distributions of owl limpets sampled in the Fitzgerald State Marine Park and Point Pinos, Monterey Peninsula. (Point Pinos data from Tenera 2003).

The presence of the smaller owl limpets in the Point Pinos population is an indicator of recent recruitment (**Figure 3-38**). In contrast, there were few small limpets in the Fitzgerald State Marine Park populations. While this could be due to less frequent recruitment, it is also important to note that small owl limpets are often difficult to distinguish from other limpets and are also difficult to find. For example, owl limpets that recruit within the byssal threads of tightly compacted mussels could remain undetected. It is also likely that habitat differences contributed to the differences between the Point Pinos and Fitzgerald State Marine Park populations. At Point Pinos we counted and measured nearly 2,000 owl limpets using search efforts similar to those used at the Fitzgerald State Marine Park. Only about 140 owl limpets were sampled in N. Levine's study. At such low numbers the owl limpet population at the Park may be extraordinarily sensitive to any reductions in abundance.

## 3.8 Invertebrate Composition Associated With Turnable Substrate Habitat

### Purpose

The purpose of this study was to describe the fauna that occurs underneath turnable rocks in the intertidal zone, and to determine if effects of visitor use could be detected.

### Background

Diverse assemblages of intertidal invertebrates occur not only on the exposed surfaces of rocks but also underneath boulders and cobbles (Davis and Wilce 1987, McGuinness 1987, Addessi 1994). Many of the invertebrates inhabit both surface and under-substrate habitats, but some species that need constant shade and moisture are almost exclusively found underneath rocks (McGuinness 1987, Chapman and Underwood 1996). For example, porcelain crabs (*Petrolisthes* spp.) are more commonly found underneath turnable substrates. At the same time, many motile species may be active on the tops of rocks at high tide but then retreat to the undersides of rocks for protective cover during low tide. Some fishes, notably members of the prickleback, gunnel, and clingfish families, specifically use the under-rock intertidal habitat for protection from predation and desiccation at low tide (Gibson and Yoshiyama 1999).

The refuge underneath turnable substrate also enables portions of populations to persist in areas of visitor use, providing that extensive rock turning and collecting doesn't occur (Addessi 1994, Chapman and Underwood 1996). These populations can help replenish populations impacted through a variety of disturbances (Kingsford et al. 1991, Pombo and Escofet 1996). When a rock is overturned sessile organisms on the undersides can become exposed to prolonged light and desiccation that can lead to mortality (Chapman and Underwood 1996). Wave action can overturn boulders greater than 1 m and can cause substantial damage during storm events

(McGuinness 1987). These disturbances result in a mosaic of algal and invertebrate composition both above and underneath moveable boulders and cobbles (Davis and Wilce 1987).

HLA (1993) made a qualitative observation that under-rock fauna were absent or were found in very low numbers on Moss Beach Reef, compared to what would be expected at similar rocky shore habitats. We therefore completed a quantitative study to compare the under-rock invertebrate assemblages at Moss Beach Reef with the less visited Distillery Reef.

## Methods

Cobble/boulder fields occur in channels close to access points on Moss Beach Reef, as well as in other areas of the Fitzgerald State Marine Park. While the Park consists mainly of flat rock bench platforms, surge channels lined with cobbles bisect the platforms at various angles. This study was conducted in the upper intertidal zone on Moss Beach Reef (**Figure 3-1**) and on the less-visited Distillery Reef (**Figure 3-2**).

A 50 m transect was deployed parallel to shore. A 10 $m^2$ length transect was then attached to the 50 m transect and deployed in an offshore direction in areas of small boulders and large cobbles. Three 0.25 $m^2$ quadrats were randomly placed in boulder/cobble habitats having at least 70% turnable substrate. The 'turnable' substrate had to be moveable by hand and included small boulders and large cobbles in the range of approximately 15–50 cm (6–20 in.) greatest dimension.

Invertebrates occurring on the top surfaces and sides of rocks were categorized as 'above-substrate' while those on the undersides of the turnable substrates and on the surfaces of underlying rocks were categorized as 'under-substrate' fauna. Motile species were counted individually and sessile/colonial species were estimated as percent cover in each quadrat.

## Results

Black turban snails, littorine snails, and hermit crabs were the most abundant species counted in all areas sampled (top surfaces, underneath, and at both locations) (**Figure 3-39**). Other species collected underneath the turnable rocks at both locations were porcelain (*Petrolisthes* spp.) and shore crabs (*Pachygrapsus crassipes*). The number of taxa/0.25 $m^2$ was approximately equal between the surface and under-substrate habitats and approximately equal between the Moss Beach Reef and Distillery Reef study areas.

## Discussion

A study in San Diego found that rock turning was the reason for decreased abundances of under-substrate fauna, based on changes in abundance along a gradient from areas of high to low visitor use (Addessi 1994). However, the results of the present study suggest that, in the Fitzgerald State

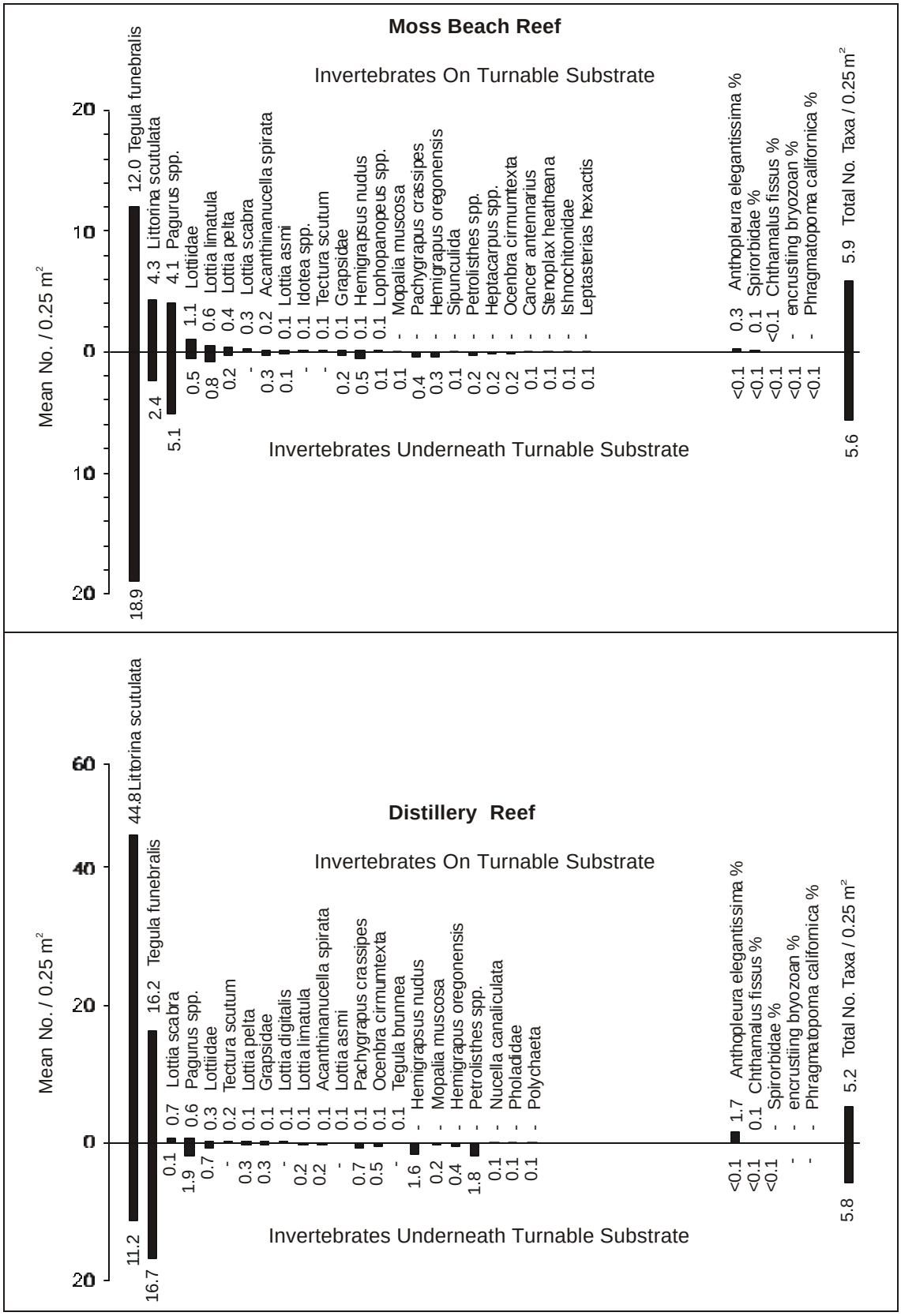



**Figure 3-39**. Invertebrates on and underneath turnable substrates in the Fitzgerald State Marine Park.

Marine Park, no large differences exist in the composition and abundance of under-substrate fauna between areas of high and low visitor use. Furthermore, we found no large differences in 'above substrate' faunal composition and abundance compared to 'under-substrate' faunal composition and abundance both within and between study areas.

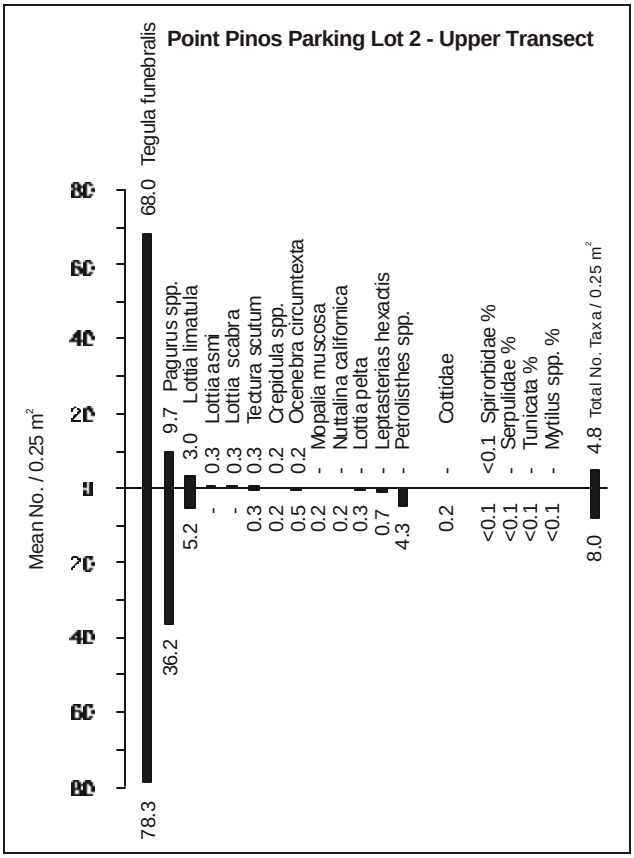



**Figure 3-40**. Invertebrates on and underneath turnable substrates in a high use area at Point Pinos, Monterey Peninsula. (source: Tenera 2003)

A similar study at Point Pinos, Monterey Peninsula (Tenera 2003) provided data to compare species associated with turnable substrates in another high use area. The methods used and the elevations sampled at Point Pinos were the same as those used in the present study. The Point Pinos area had greater abundances of under-substrate fauna compared to the Fitzgerald State Marine Park (**Figure 3-40**). For example, turban snails, porcelain crabs, and limpets were more abundant at Point Pinos. These differences may reflect regional variation because the nature of the boulder/cobbles fields was different between study areas. The boulder/cobble field studied at Point Pinos was expansive in area and was interspersed among tall rock outcrops. The outcrops helped to break up and dissipate wave energy. In contrast, the boulder/cobble fields sampled in the Fitzgerald State Marine Park were largely in confined channels that are likely exposed to greater wave energy. Therefore, the greater abundance of under-substrate fauna at Point Pinos may be partially due to the differences in habitat and wave exposure.

In more extreme cases, excessive wave energy can result in entire areas of boulder/cobbles being largely devoid of biota, due to the constant shifting and movement of boulders and cobbles. This is particularly evident in heavy wave exposed sections of shore along the Big Sur Coast (Tenera, unpublished observations). Consequently, the boulder/cobble fields in the Fitzgerald State Marine Park appear to be 'intermediate' in exposure and susceptibility to 'natural' rock turning from wave action. Rock turning in the Fitzgerald State Marine Park is not as great as on heavily wave impacted shores (e.g., Big Sur), but greater than on semi-protected shores (e.g., Point Pinos).

The areas of small boulders and larger size cobbles sampled at the Fitzgerald State Marine Park were mainly in surge channels where wave action results in some level of continual disturbance. In the Park study there were overturned cobbles in nearly every quadrat, as evidenced by bleached empty barnacle tests, bleached encrusting coralline algae, and empty calcareous worm tubes, all still attached to the exposed rock surfaces. These surfaces were likely once oriented downward. While visitors may have overturned these rocks, the cobbles and boulders in these habitats were most likely overturned from wave action since similar frequencies of overturned boulders and cobbles were observed in low-use areas. We suspect that this 'natural' cobble turning from wave action explains the lack of large differences in under substrate faunal composition between areas of high and low visitor use in the Fitzgerald State Marine Park. Because we found no large differences in under substrate fauna between high- and low-use areas in the Fitzgerald State Marine Park, we suspect the low abundance of the under substrate fauna described by HLA (1993) was perhaps regional, related to natural causes, rather than an effect of visitor use.

## 3.9 Finfish Fishery Resources Study

### Purpose

This study had two objectives: 1) to evaluate the population status of recreational finfish species in Fitzgerald State Marine Park by updating and analyzing catch records from 1973-2003; and 2) to compare the availability and use of shoreline habitat for juvenile eels between the heavily used Moss Beach segment of the Park and control areas within the Park that receive comparatively little use. Differences in the juvenile habitat availability among areas may partially explain recruitment success in the Park and the eventual replenishment of adult eels that are removed through fishing activities.

### Background

Recreational shore fishing in the Park can be generally subdivided into two categories: 1) eel fishing, which targets prickleback eels by using 'poke pole' fishing techniques; and 2) surf fishing, which targets surfperches, cabezon, lingcod, and other finfishes by using conventional rod and reel techniques. The Park is relatively unique among shoreline areas in supporting a monkeyface eel and rock prickleback recreational fishery because of good access to surge channels and a jagged outer platform edge that are favored eel habitats. Monkeyface eels and rock pricklebacks (referred to as "eels" because of their elongate body shape, but are not true eels) are one of the most popular target species in the recreational fishery at the Park. Monkeyface eels can reach lengths of >76 cm (30 in.). Fishers seek adult eels using 'poke-poles', which are long rods with a short wire at the end onto which a lure or hook with bait is tied. The long poles enable the lures to be waved about or 'poked' into surge channels and crevices (**Figure 1-4**).

Juvenile eels commonly recruit into areas of small boulders and cobbles in the intertidal zone where they seek protection under these substrates. As the juveniles increase in size they move offshore into channels and other nearby subtidal rocky habitats where they find protection in crevices. Individual adults typically do not venture far from their home range locations.

Fishing statistics from 1976 through 1991 for eels and surf fishes were reported by HLA (1993). The findings indicated a decline in fishes caught per unit of time spent fishing. The results were indicative of a decline in population abundances of these two sought after species. The present study appends new data to the earlier statistics and also investigates the occurrence and quality of intertidal habitat for juvenile eels and other shore fishes.

## Methods

### Recreational Fishery Use

Park rangers have collected data on catch statistics for eels and surf fishes since 1973. The number of people fishing from the shore and the type of fishing activity were recorded during periods of good low tides each month of the year. When opportunities arose, Park rangers also interviewed the fishers for time spent fishing and type and number of fishes caught (creel census data). Most interviews were conducted in the main parking lot at Moss Beach when the fishers were returning to their cars. This information, which is necessary to calculate catch per unit of effort (CPUE), was not consistently recorded until 1978, therefore only numbers of anglers and fishes are available for previous years.

We appended unpublished data to the previously reported results (HLA 1993) up through 2002 to provide an update of the eel fishery and surf fishery in the Park. Data from 2003 were incomplete and not included in the report.

### Recruitment Habitat Study

Monkeyface eels, rock pricklebacks and several other species of eel-like fishes commonly recruit into areas of boulders and cobbles in the intertidal zone (**Figure 3-41**). The Fitzgerald State Marine Park has extensive boulder and cobble fields at low, protected elevations that provide good recruitment habitat for these species. Broad depressions (lagoon-like) that are lined with boulders and cobbles form large tidepools adjacent to algal-covered flats on Moss Beach Reef and Frenchman's Reef and provide good intertidal fish habitat.

**Figure 3-41**. Monkeyface eel juvenile.

We sampled areas of Moss Beach Reef and Frenchman's Reef at approximately the +1.0-2.0 ft. MLLW level that were characterized by extensive cobble and boulder fields to assess whether these areas were populated with young monkeyface eels, rock pricklebacks, and other intertidal fishes. A 50 m length transect was deployed parallel to shore in each area (**Figures 3-1** and **3-3**). A 10 m length transect was attached perpendicular to the shore transect at 10 meter intervals, beginning at meter zero, and deployed in an offshore direction. Fishes were counted in three randomly located 1.0 $m^2$ quadrats along each 10 m transect. Additional quadrats were sampled by extending the transect line if time allowed. Approximately 30 quadrats were sampled in each area. In each quadrat, individual boulders and cobbles were carefully lifted by hand to expose any fishes that occurred underneath. The fishes were captured with dip nets, identified, measured for total length, and then returned.

## Results

### Recreational Fishery Use

Total number of eel fishers per year using the Moss Beach Reef shoreline area declined steadily from 1973-1994 with a high of over 800 fishers observed per year in 1974, and has remained relatively steady at less than 100 fishers observed per year from 1995-2003 (**Figure 3-42**). An apparent decline in fishery use in 1978 resulted from incomplete data collection, and it is likely that use was not substantially different from either the preceding or following year. The average number of hours per angler engaged in fishing in the Park varied considerably among years from over 3.0 in 1985 and 2001 to a low of less than 1.0 hrs in 1998. The typical level of effort over the study period was approximately 2 hrs of fishing per visit, and was likely a function of the limited availability of suitable fishing areas during low tide periods.

The total recorded catches of both monkeyface eels and rock pricklebacks declined throughout the study with the highest numbers being taken from 1973 through 1977 (**Figure 3-43**).

Monkeyface eels were generally caught in greater abundance than rock pricklebacks, especially from 1982 onward when very few rock pricklebacks were caught each year. The actual annual catches of eels in the Park were greater than those reported, by at least a factor of two or three, because there were many more people generally observed fishing than were interviewed. Furthermore, the true number of fishers engaged in poke pole fishing was also underestimated because censuses did not occur during every low tide period during the year.

Catch per unit of effort (CPUE), shown as the number of eels caught per hour of fishing, was generally steady from 1979 through 1989 at slightly less that 1 eel per hour, and then variable from year to year thereafter with an average of about 0.5 eels caught per hour of fishing. In general, the trend of declining numbers of fishes caught was not reflected in a greatly reduced CPUE over the same period because there were fewer anglers fishing in the Park.

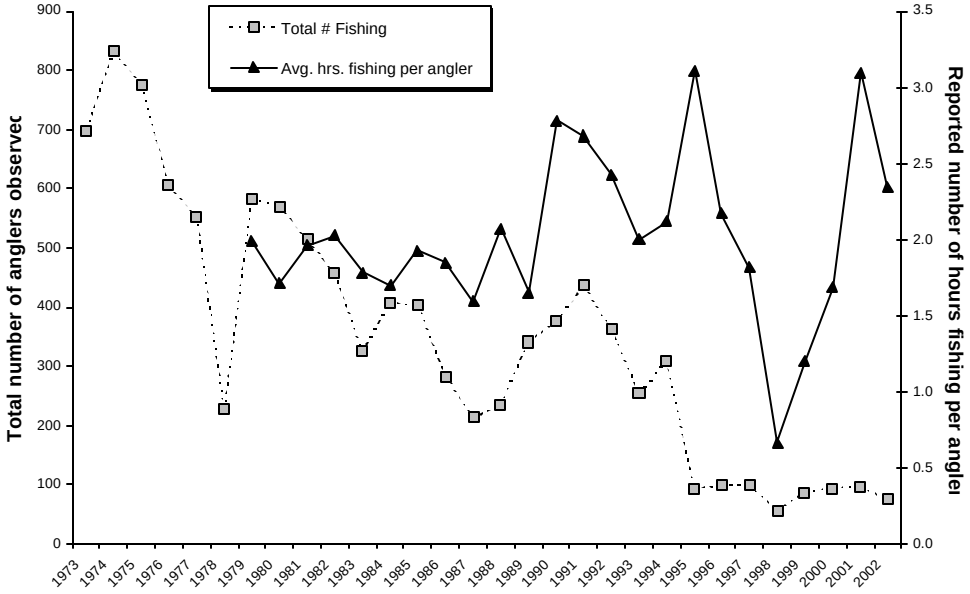



**Figure 3-42**. Angler use of the Moss Beach site for eel (poke pole) fishing, 1973-2002. Data for 1978 are incomplete. Angler interviews began in 1979.

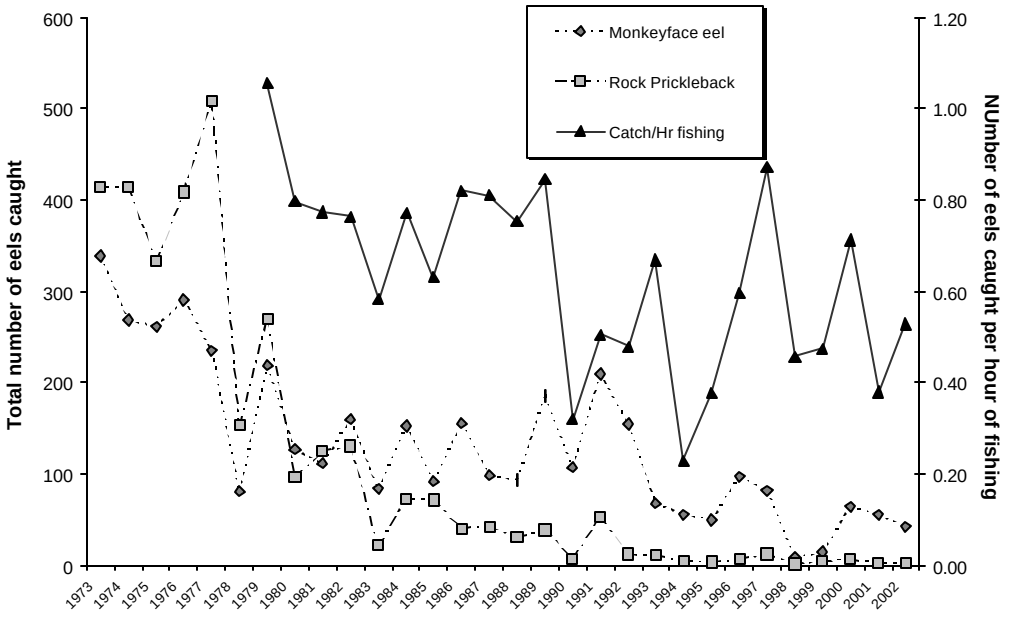



**Figure 3-43**. Total catches of monkeyface eel and rock prickleback, and catch per unit of effort at the Moss Beach site, 1973-2003. Data for 1978 are incomplete and represent partial years. Angler interviews began in 1979.

The total number of surf fishers declined steadily from 1983 to 2002, although the reported number of hours fishing per angler remained relatively constant at approximately 2 hrs per visit (**Figure 3-44**). Surfperches (family Embiotocidae) were the most abundant group of fishes caught from shore using conventional rod and reel fishing techniques, with the greatest relative catches occurring in 1992 and the least in 2002 (**Figure 3-45**). The corresponding catch per unit effort for cabezon, lingcod, and surfperches showed that fishing success for surfperches increased from 1983 to 1992 and then declined sharply, whereas cabezon remained at low and relatively stable catch levels of over the duration of the study (**Figure 3-46**). Lingcod were the least abundant of the three surf fishing species-groups tallied. Other groups of fishes that were caught occasionally, but not recorded in the database included greenlings and rockfishes.

### Intertidal Fish Abundances

Intertidal fishes were surveyed at Moss Beach Reef and Frenchman's Reef on June 7-8, 2004. A total of 65 quadrats was sampled yielding 161 fish from 10 taxa (**Table 3-15**). Some of the fishes were too small to be positively identified in the field or could not be collected in dip nets for positive identification. These were classified into combination categories or only identified to the family level. Total fish densities were higher at Moss Beach Reef with greater numbers of black pricklebacks, clingfishes, and sculpins. Gunnels and high cockscomb were more abundant at Frenchman's Reef. Juvenile monkeyface eels were uncommon in both areas with a total of five individuals positively identified from both areas. The mean size of the monkeyface eels at Moss Beach was 161.8 mm (6.4 in.), while the single individual from Frenchman's Reef was 69.0 mm (2.7 in.). Juvenile black pricklebacks were similar in average size between areas (~ 81-86 mm, 3.2-3.4 in.). No rock prickleback juveniles were positively identified in the field but may have been included in the Pholididae/Stichaeidae category.

## Discussion

A substantial decline in the number of anglers in the Fitzgerald State Marine Park since the early 1990s reflects a more gradual decline in overall catch per unit effort, an indication that fishing success for target species, such as eels and surfperches has declined. Because the number of observation days or the level of observation effort per day were not included in the database, the data could not be standardized for direct comparison among years. However, the number of observation days and counting methods were approximately similar among years, and any inconsistencies would not affect the overall conclusion that the absolute numbers of fishers has substantially declined from levels noted in the early years of the study.

The high variation in catch per unit effort among years would indicate that the resources have not been seriously depleted. For example, peak CPUE for eel fishers in 1997 and 2000 were equivalent to or greater than those in the 1980s when there were approximately five times more anglers using the shoreline. One factor not accounted for in the database, however, was the size of the fishes caught. Because there is no minimum size limit on monkeyface eels or rock

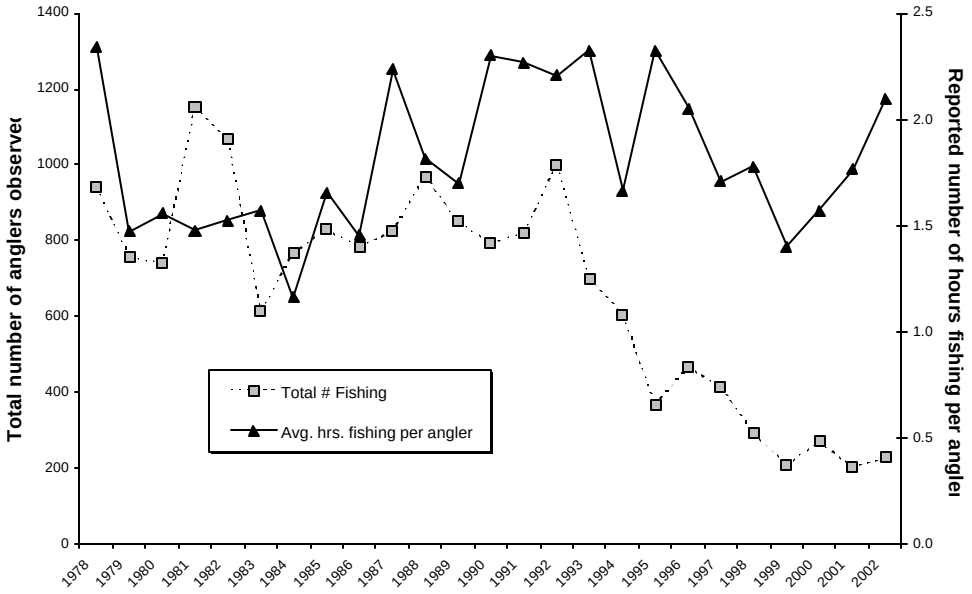



**Figure 3-44**. Angler use of the Moss Beach site for surf fishing, 1978-2002.

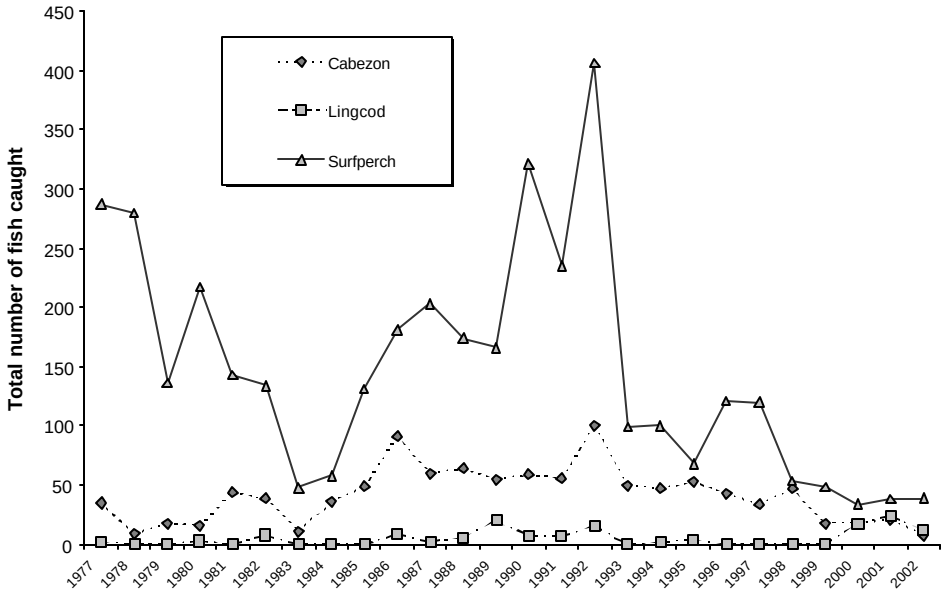



**Figure 3-45**. Total catches of cabezon, and lingcod, and surfperches at the Moss Beach site, 1977-2002.

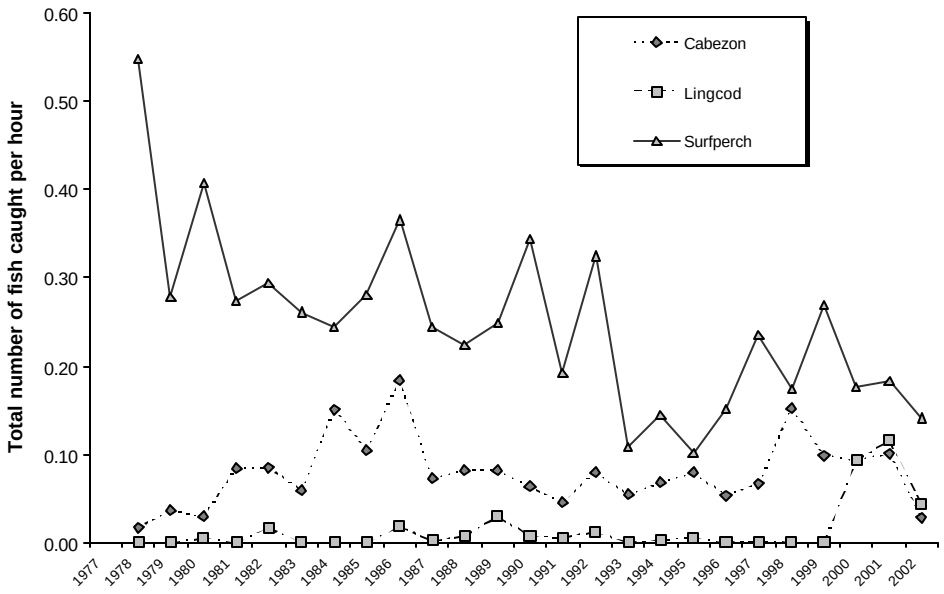



**Figure 3-46**. Surf fishing catch per unit of effort for cabezon, lingcod and surfperches at the Moss Beach site, 1978-2002.

**Table 3-15**. Summary of intertidal fish abundance and mean sizes between Moss Beach (MB) and Frenchman's Reef (FR) low intertidal study sites.

| | | | Count per transect | | Abundance per $m^2$ | | Mean Size (mm) | |
|---|---|---|---|---|---|---|---|---|
| Scientific name | Common name | **Total** | MB | FR | MB | FR | MB | FR |
| *Anoplarchus purpurescens* | High cockscomb | **49** | 21 | 28 | 0.64 | 0.88 | 52.4 | 61.0 |
| Cottidae | Sculpins | **25** | 21 | 4 | 0.64 | 0.13 | 27.0 | 20.3 |
| *Xiphister atropurpureus* | Black prickleback | **24** | 21 | 3 | 0.64 | 0.09 | 80.9 | 86.0 |
| Pholididae / Stichaeidae | Gunnels / Prickleback eels | **19** | 6 | 13 | 0.18 | 0.41 | 77.5 | 51.0 |
| Gobisox spp. | Clingfishes | **19** | 19 | 0 | 0.58 | 0.00 | 46.3 | - |
| Pholididae | Gunnels | **9** | 1 | 8 | 0.03 | 0.25 | 26.0 | 33.6 |
| *Xererpes fucorum* | Rockweed gunnel | **7** | 6 | 1 | 0.18 | 0.03 | 63.2 | 34.0 |
| *Cebidichthys violaceus* | Monkeyface eel | **5** | 4 | 1 | 0.12 | 0.03 | 161.8 | 69.0 |
| *Anoplarchus/Cebididichthys* | High cockscomb / Monkeyface eel | **2** | 2 | 0 | 0.06 | 0.00 | 22.0 | - |
| *Apodichthys flavidus* | Penpoint gunnel | **2** | 0 | 2 | 0.00 | 0.06 | - | 130.5 |
| | Totals | **161** | **101** | **60** | **3.06** | **1.88** | | |

pricklebacks, it is very likely that the reduced fishing effort reflects a decline in the mean size of these fishes, and therefore the quality of the fishes caught. Fishing effort per angler is likely to remain at approximately 2 hrs per visit because the optimum fishing times during daylight hours are determined by periods of slack low tide which last approximately 2-3 hrs.

The Park may be supporting a small sustainable fishery for monkeyface eels and rock pricklebacks because suitable habitats for both juvenile recruitment and adult residence are relatively close to one another. The fishing is popular because there are paths to the shore and the flat rock bench platforms make for relatively easy access to fishing areas. Yet the rugged nature of the coastline and the fact that populations of adult eels extend into the shallow subtidal depths are two factors that may help to prevent overfishing of the populations. Also, rough surf limits the number of days that fishing areas are accessible, particularly in winter months. Although monkeyface eels, and probably rock pricklebacks, generally do not move more than a few meters from their shelters (Ralston and Horn 1986), the limited movements would enable larger fish to slowly colonize habitats vacated by other eels caught in the fishery.

The number of anglers targeting surf fishes at the Park declined steadily since the early 1990s although catch per unit effort for surfperches, in particular, did not decline as rapidly. In fact, the data show that cabezon and lingcod catches per angler actually increased slightly over time, declining only recently in 2002. This decline could have been a result of actual coast-wide catch reductions in these species (Leet et al. 2001) from increased regulation since passage of the Marine Life Management Act in 1998. Also, new minimum size limits of 14 in. for cabezon and 30 in. for lingcod, coupled with reduced bag limits, would tend to decrease legal catches of these species from shore at the Park.

The fishery database for the Park reveals that angler use has declined, but that enough quality fish have remained over time to attract a sustainable level of fishing effort at the Park when conditions are suitable. Some unanswered questions remain, however, that could be addressed with a more systematic approach to collecting creel census data at the Park:

1. Is the average size of target species, including eels, surfperches, cabezon and other species declining over time? This could be addressed by measuring the catches, or even estimating fish sizes, when the ranger or volunteer conducts the creel census. Overfishing typically results in decreased mean sizes in the population. Of course, species such as cabezon that have a regulated minimum size would be less likely to yield useful data if many of the fish are caught at or slightly above the legal size.

2. What is the annual fishing pressure at the Park in terms of absolute numbers of anglers per unit time, and how does this change by season? Because there were no data on number of hours observers spent counting shore fishers, or the number of days that counts took place relative to the number of 'fishable' days, it is difficult to accurately compare angler use data between years. A standardized measure of use would allow

comparison not only over time at the Park but possibly among other shore fishing locations in the region.

The information would be helpful for developing any management plans for potentially regulating fishing activities at the Park beyond those presently enacted through the CDF&G code of regulations.

Our study of intertidal fish abundance was designed to compare the occurrence of juvenile pricklebacks between an area that is generally heavily used by visitors (Moss Beach Reef) and an area with low visitor use (Frenchman's Reef, approximately 1.5 miles south). Although it is rarely possible in a field study to select control and experimental sites with identical substrate and exposure characteristics, the two survey areas were at similar tidal heights and generally had similar sized cobble substrate. Juvenile intertidal fishes are strongly dependent on the size of substrate for recruitment and subsequent distribution as they mature (Setran and Behrens 1993). The reason that juvenile rock pricklebacks were not recorded in the present study may have been related to the lack of certain sized cobble along the sampled transects.

Surprisingly, intertidal fishes were nearly twice as abundant at the heavily used area compared to the lightly used area. Black pricklebacks were much more abundant at Moss Beach Reef, even though juvenile monkeyface eels were uncommon in both areas. Pricklebacks typically spawn in late winter and spring (Moser et al 1996), and the small mean sizes of fishes in both areas indicated that some recruitment had occurred at both locations. An unexpected result was the numerical dominance of black pricklebacks compared to monkeyface eels at Moss Beach Reef, yet the area offered good habitat for both species. The overall densities of fishes at the Park (1.9-3.0 per $m^2$) were similar to densities of fishes (2.8 per $m^2$) found in a long-term intertidal fish study at Diablo Canyon in San Luis Obispo County (Tenera 1997) although relative species composition differed, as would be expected between widely separated locations.

It can be concluded that visitor impact on juvenile intertidal fishes is low at the Fitzgerald State Marine Park. The areas that were surveyed are uncovered at only a very low tide (below 0.0 ft MLLW) so the amount of time that visitors would be able to directly impact the fish habitat by moving cobbles or rolling rocks was limited. Most visitors tend to walk on the horizontal rock benches, not the cobble fields, and visitor education tends to limit the amount of rock rolling that could potentially harm fishes living beneath the substrates. Also, recruitment of juvenile eels is not necessarily dependent upon local population spawning success because the pelagic larval stages drift and disperse in the plankton for several weeks. This potentially allows larvae originating from other coastal areas north and south of the Park to colonize the intertidal zone.

# 3.10 GIS Coastal Habitat Mapping of the San Mateo County Shoreline

## Purpose

A Geographic Information System (GIS) project was completed to map and quantify the shoreline habitat features of the Fitzgerald State Marine Park and adjacent segments of the San Mateo County outer coast. Rocky shoreline habitat can support a high diversity of intertidal biological assemblages and quantifying its extent in the Park will enable comparisons among other coastal segments.

## Background

In the 1980s, a team of scientists, under contract to the U.S. Minerals Management Service (MMS), classified and mapped substrate and biological characteristics of the intertidal zone along the entire California coast. A total of 164 USGS 7.5 minute topographic quad maps that covered the entire California coastline were used for the base map. All information was hand drawn on the maps with associated attributes coded and referenced in tables. The data included substrate type (e.g., cliff, platform, beach, offshore rocks), vertical relief (micro- and macro-), wave exposure, across-shore width, and along-shore length of each substrate classification per segment of shore. Tenera Environmental recently digitized all of the maps, tables, and substrate codes, including those for San Mateo County.

## Methods

The digitized images of the MMS coastal quad maps for the San Mateo County Coast were imported into ArcGIS and georeferenced to the recently released California Digital Raster Graphics (DRG) topographic maps, 7.5 Minute Series, in the Teale (Albers NAD83 meters) projection. Then the various substrate and exposure classifications were converted into ESRI ArcView/ArcGIS themes. Ms. Aura DeMare (San Franciso State University) completed the work. We then analyzed the substrate classification information for the San Mateo County coast and queried the results to determine what major substrate features were unique to the Park, in relation to the remainder of the County.

An example of the analysis of substrate characteristics for a segment within the Park is shown in **Figure 3-47**. The information for Segment Q (highlighted) in the Park is presented in the embedded table. The length of Segment Q is 1.6 km. Primary and secondary physical shore characteristics for Segment Q (Psz_char, Psz_char2) are associated with MMS coded substrate classifications for morphology (e.g., Ca = cliff-active/erosional; Pf = platform-horizontal) and texture. Other code combinations are also listed in the imbedded table for Section Q.

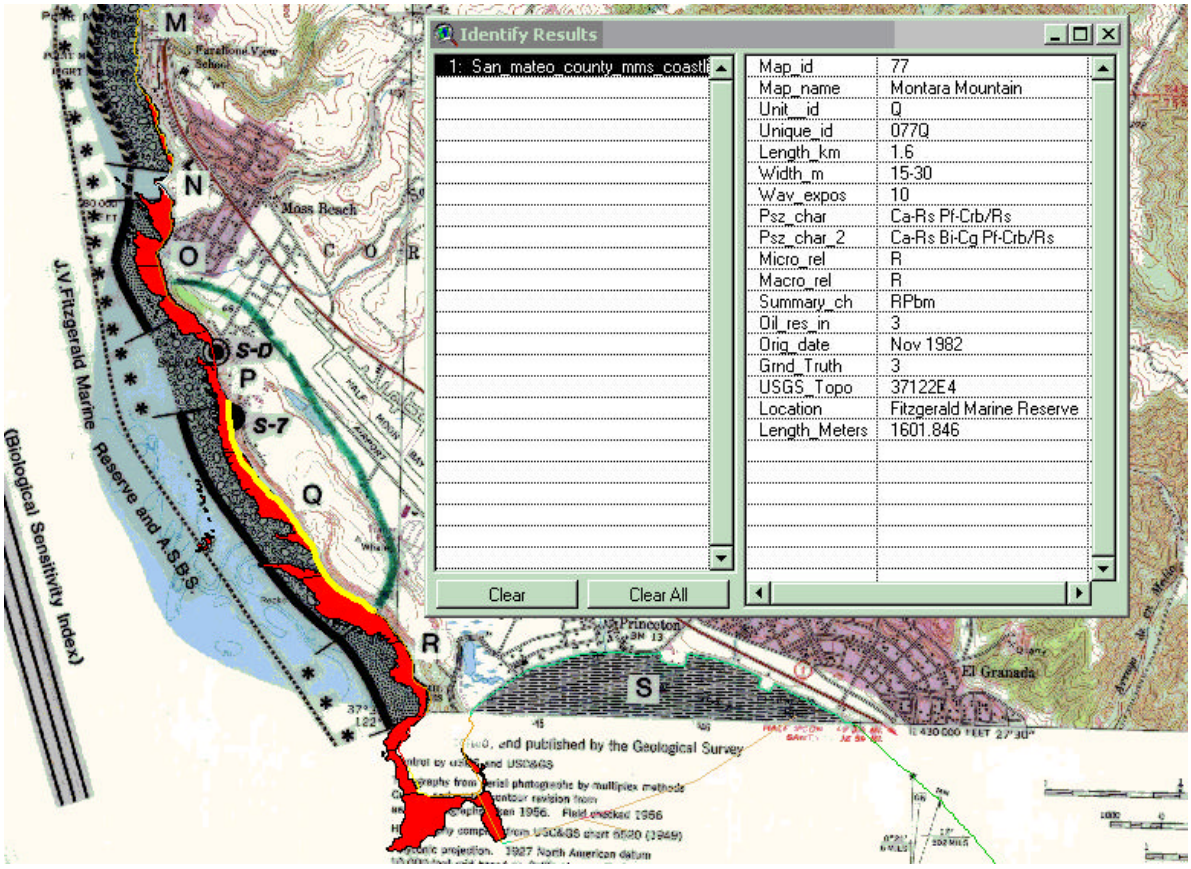



**Figure 3-47**. Example of coastal GIS mapping and analysis of substrate classifications in th Fitzgerald State Marine Park

## Results

Broad intertidal platform benches characterize the Fitzgerald State Marine Park. A shoreline classification used in the MMS survey included 'platform' with one sub-classification being 'horizontal platform'. We therefore queried the GIS for the occurrences of 'platforms' and 'horizontal platforms' separately for all of the San Mateo County coast. The GIS query also provided information on shoreline dimensions of each classification.

The results of this GIS analysis show that the Park, on a per unit shoreline distance, consists of a disproportionately greater amount of platform intertidal habitat, especially horizontal platform habitat, compared to the remainder of the County's coastline. The following summarizes the findings:

- The Fitzgerald State Marine Park comprises approximately 5 % of the outer coastline of San Mateo County (5.19 km of 99.84 km).

- In the Park, approximately 74 % of the shore is classified as one of several horizontal substrate subcategories (3.82 km of 5.19 km); 46 % is horizontal rock platform (2.36 km of 5.19 km).

- 27 % of horizontal rock platform habitat, county-wide, occurs in the Fitzgerald State Marine Park (2.36 km of 8.83 km).

## Discussion

The GIS work (above) was completed as a subset of map preparations for a larger GIS coastal mapping project that will include all of California. This GIS product, which is to be completed in early 2005, will be an important management tool that will provide habitat information for coastline areas statewide that are under consideration as Marine Protected Areas (MPAs) (see *Section 6 - 0 County Park Management and the Marine Life Protection Act Process*). The GIS analysis showed that the Fitzgerald State Marine Park has a large percentage of horizontal bench platform habitat in San Mateo County, which highlights the unique habitat character for this length of coast.

# 4.0 OTHER HUMAN INFLUENCES

The marine biological resources at the Fitzgerald State Marine Park are exposed to potential effects from human influences in addition to visitors using in the intertidal zone. Other sources include freshwater runoff and possible contaminants conveyed to the Park via San Vicente Creek. Sewage discharges and oil spills are other potential threats, and jet ski activities and low-flying aircraft can disturb marine wildlife. Excluding a water quality assessment for San Vicente Creek, no special studies were completed in this project to determine how these other types of human influences might affect the Park resources. Potential effects from sewage discharges, oil spills, jet ski activities, and low-flying aircraft are currently under investigation and regulation by resource agencies other than San Mateo County, and are described below.

## 4.1 San Vicente Creek

### Purpose

Existing information on water quality was available to determine sources of bacteria contamination reaching the Fitzgerald State Marine Park via San Vicente Creek. The information was collected as a joint project between the San Mateo County Environmental Health Services Division and the Surfriders Foundation. The Surfriders Foundation is a nationwide, non-profit organization devoted to preserving beaches and oceans. The study and findings from the joint project were communicated to Tenera in discussions with Steven Hartsell, REHS (San Mateo County Environmental Health Services Division, Program Supervisor). A description of the project and findings is presented below.

### Background

San Vicente Creek drains into the Fitzgerald State Marine Park near the Park's main public access to the shore (Figure 4-1). The watershed of San Vicente Creek is approximately four square miles (1,036 ha). Land in the watershed is largely privately owned, and is used for floriculture, pasture, and stable operations. Commercial and residential developments surround the Park's main entrance.

Another creek, 'Sunshine Creek', is located immediately north of the main access. It is not a perennial creek, but it is a smaller drainage that has surface flows during rain periods. Sunshine Creek is an unnamed creek of the U.S. Geologic Survey, and was given its name by San Mateo County Parks and Recreation Division. Sunshine Creek does not pose the same water quality issues as San Vicente Creek, due to its smaller size and drainage area that is mainly residential areas that are on a municipal sewer system. San Vicente Creek was the focus of the present study, because it has larger freshwater inflows and an existing baseline of water quality data.

Beach closure warning signs to avoid water contact are posted when the concentration of certain 'indicator' fecal bacteria (*Escherichia coli*) in the water are found to exceed levels established by the State of California (concentrations of 400 CFU/100 ml at any one time or 200 CFU/100 ml as a five-week average). The presence of these bacteria in large numbers indicates fecal contamination, and the specific levels used for posting were adopted by the State based on several studies, the key one completed in Santa Monica Bay, California. In Santa Monica Bay, it was demonstrated that people who swam in waters near storm drains with high concentrations of these bacteria were twice as likely to experience symptoms of illness (nausea, diarrhea, vomiting, fever) within ten days, than those who swam elsewhere (S. Hartsell, pers. com.).

The San Mateo County Environmental Health Services Division (San Mateo EH) collects and analyzes weekly water samples taken from the surf zone at the Fitzgerald State Marine Park at a location approximately 50 ft (15 m) from the San Vicente Creek mouth, which is located near the Park's main public access to the shore (Figure 1-4). Sampling at the mouth of San Vicente Creek in the Fitzgerald State Marine Park was added to the surf zone monitoring program in 1998.

In 1999, Ms. Ellen Gartside, member of the Board of the San Mateo County Surfriders Foundation Chapter, discussed with San Mateo EH the need to add a water quality study in the San Vicente Creek watershed to identify sources of contamination that may contribute to the high bacteria levels that were being detected at the creek mouth and nearby in the surf zone. The upland watershed includes ranches and farms that could be potential sources of fecal contamination. Ms. Gartside was concerned mainly with public water contact with the creek, as visitors entering through the Park's main access must cross San Vicente Creek to reach the Park's shoreline (**Figure 1-4**). Also, the mouth of the creek meanders across a sandy beach near the main access where children often play.

## Methods

In 2000, a San Vicente Creek watershed sampling program was added to the surf zone and creek mouth sampling program, and is still continuing. The additional program consists of water samples collected simultaneously at various upstream and downstream locations in the watershed along with the continued monitoring of the creek mouth and surf zone. Surfrider volunteers collect the samples in San Vicente Creek. San Mateo EH analyzes the samples. The program requires cooperative work efforts with the various landowners surrounding the creek, San Mateo EH, the Surfriders Foundation, the San Mateo County Farm Bureau, and the San Mateo County Resource Conservation District.

## Results

### San Vicente Creek Monitoring

The San Mateo EH has prepared staff summaries and department memoranda on the study, its progress, and findings. The department memoranda have included bacteria levels detected at the

various upstream creek locations, potential contamination sources, and measures implemented to reduce contamination. Results from the initial stages of the sampling program, including site observations, revealed several sources in the watershed that were likely large contributors to bacteria contamination in the creek. The sources included the following:

- Outhouse (probably long out of service)
- Storm water drainage passing through horse stables and paddocks and into the creek.
- A washing machine discharging directly into the creek
- A septic tank not properly covered
- A septic tank pipe discharging directly into the creek

Subsequent corrective measures completed in 2000-2001 by the several land owners adjoining the upstream and downstream reaches of the creek included:

- Moving stables and paddocks away from the creek
- Maintaining cleaner stable and paddock areas
- Installing manure bins for containment until disposal offsite
- Developing a manure composting project with the San Mateo County Resource Conservation District
- Grading of land to divert storm water runoff from draining through stables and paddocks
- Abandoning the use of the septic tank that was not working properly

In general, continued monitoring following the corrective actions showed lower bacteria concentrations along upstream reaches of the creek and downstream to the west side of Highway 1. However, bacteria concentrations have remained high at the creek mouth (**Figure 4-1**). At the creek mouth, the largest peak in bacteria concentrations, to date, occurred in early 2000, prior to the watershed improvements, and although similar peaks have not occurred since then, events with elevated concentrations have continued to occur, but slightly less frequent (**Figure 4-1**). Continued high concentrations at the creek mouth may be from residual sources, tributaries not sampled, or other sources. It is also suspected that storm drains that receive runoff from residential and public areas west of Highway 1, which discharge into the lower reaches of the creek, are contributing factors. At all sampling locations, bacteria concentrations are typically highest immediately after rains, but diminish thereafter.

### Surf Zone Monitoring

Bacteria concentrations in the surf zone have also continued to fluctuate, but at levels appreciably lower than the creek (**Figure 4-1**). Coliform bacteria have limited life spans in seawater. Consequently, bacteria concentrations in seawater would generally tend to always be lower than creek concentrations.

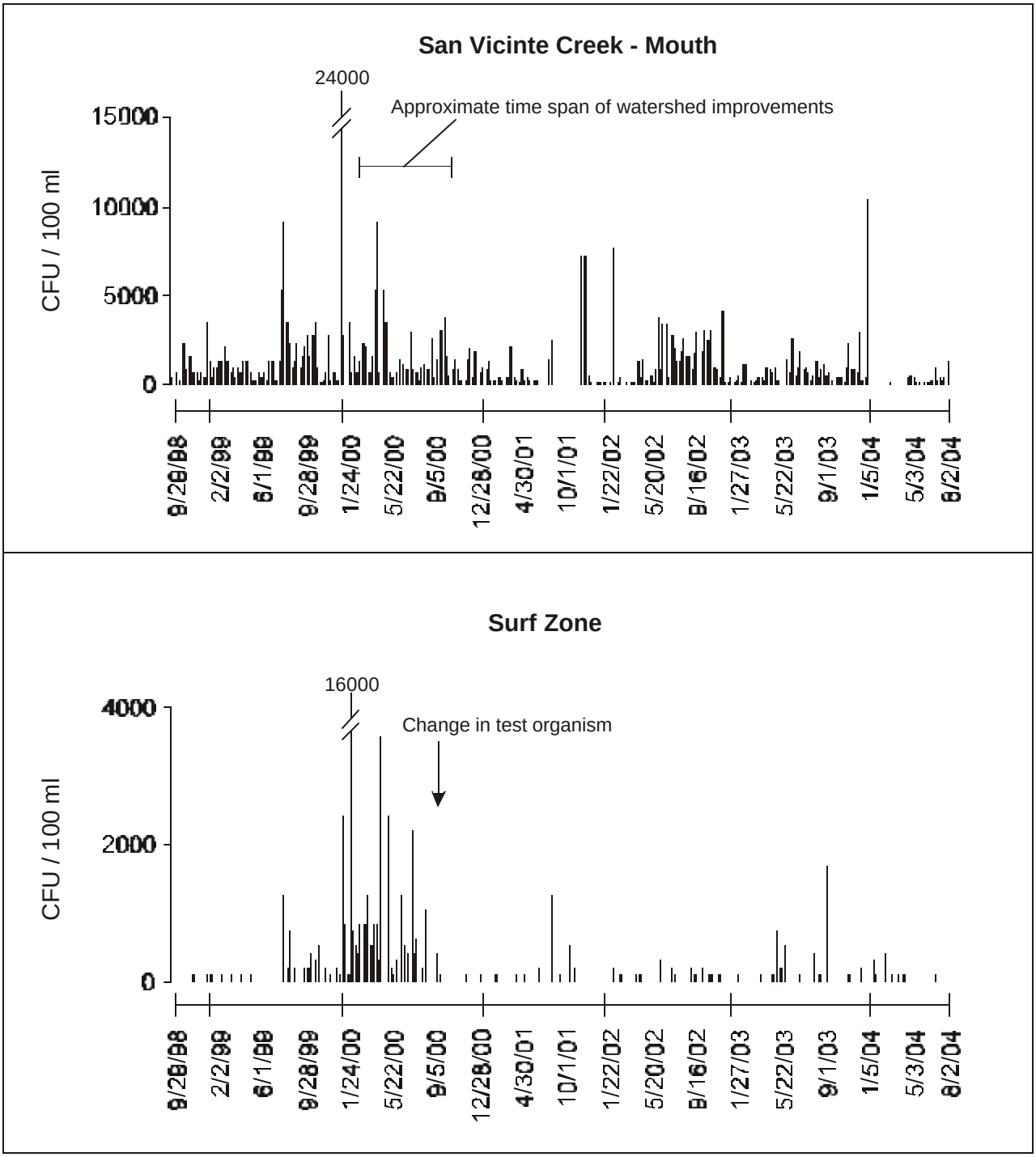



**Figure 4-1.** Weekly bacteria concentrations of *Escherichia coli* (CFU / 100 ml) in water samples taken at the mouth of San Vicente Creek and from the adjoining surf zone from Sep. 29, 1998 to Aug. 2, 2004.

There is no clear evidence whether changes in watershed management practices have had any effect on lowering ocean bacteria counts. One reason is that a change was made in the indicator organism from fecal coliform to *Escherichia coli* during the study period, which prohibits direct before-after comparisons. Contamination from other causes likely obscures comparisons and contributes to variation, as well. For example, a perennial seal haulout area is located near the water quality sampling site. Fecal matter from marine mammals and other wildlife undoubtedly affects surf zone bacteria counts and variation over time. Also, spatial variation in bacteria concentrations from currents and tides and variation in storm water runoff from land also contribute to variation in the test samples.

## Discussion

San Mateo EH has adequate reason to conclude that the measures implemented by landowners to reduce bacteria contamination into San Vicente Creek have been completed to the best extent practical. Landowners have also been prompt and cooperative in implementing corrective measures.

Although a number of watershed improvements have been made, other sources of contamination may remain that have not been fully resolved (e.g., input from storm drains, possible leaks from sewer pipes). Also, other technologies are now available to help search and isolate important source factors of bacterial contamination. DNA fingerprinting of fecal matter is now possible, and has been applied to marine and estuarine ecosystems to help identify sources of bacteria contamination. DNA libraries exist to determine whether the source of contamination is from dogs, cats, marine mammals, birds, cattle, or humans. For example, DNA testing found that bird (seagull) fecal matter was the main cause of high bacteria counts near oyster beds in Morro Bay, not cattle or septic tanks in the surrounding landscape, as what was first suspected. Application of this new technology for San Vicente Creek could also be explored to help explain and identify the sources of contamination.

Excessive nutrient input into the Fitzgerald State Marine Park, in the form of nitrates and ammonia from San Vicente Creek, is also a concern, as excessive nutrient input can result in nuisance algal blooms and shifts in community composition. Sources include equestrian facilities, fertilizers applied to farmlands, septic leach fields, underground broken sewer pipes, and runoff from residential areas. However, we did not find evidence of a nutrient effect on marine invertebrate and algal composition in the areas we studied near the creek mouth (see *Section 3.0 – Biological Description*).

In addition, pesticides and herbicides in San Vicente Creek have been documented in analyses for DDT and PCB (Brady/LSA 2002). Other sources of pollution include non-point runoff contamination from automobiles, roads, residences, and commercial properties (e.g., oil and grease). Without very specialized monitoring studies and experiments, the effects of excessive nutrient input and other contamination cannot be separated.

Only one study was found in the literature describing the influence of San Vicente Creek on the marine biota in the Fitzgerald State Marine Park. A reconnaissance survey in the Park that includes the 'State Water Quality Protection Area' (see below, *Section 6.2 – State Marine Resource Mangaement*) was completed to evaluate the status of protection in the Park (California State Water Resources Control Board 1979). The Board's report stated: "San Vicente Creek runoff does not appear to have significant long-term effects on the intertidal biota near the creek mouth." However, during the reconnaissance survey of the intertidal, high turbidity water was present, over which a surface film (detritus material) was present in tidepools near the creek mouth. In addition, many algal species appeared to be under physiological stress, evidenced by bubbles (gas production) on the fronds, bleaching, and discoloration, compared to the same algal species in areas further away not under the influence of creek runoff. The above conditions were noted when San Vicente Creek runoff was high. Accordingly, the effects to the algae likely stemmed from lowered salinity and/or the presence of a chemical or biological pollutant conveyed to the ocean via San Vicente Creek.

During our spring-summer 2004 survey, we did not find substantial indications that freshwater runoff from San Vicente Creek was affecting the intertidal biota near the creek mouth (see *Section 5.5 - Separating Potential Effects of San Vicente Creek from Visitor Use*). There were no algal species that appeared discolored or had any other indications of being in a stressed condition. The only algal species that were relatively unique in occurrence near the creek mouth that would be indicative of freshwater runoff belonged to the green sea lettuce complex (*Ulva/Enteromorpha* spp.). However, creek runoff was relatively low during our study and higher creek runoff volumes might result in conditions similar to those observed in the State Water Resources Control Board study. Based on the conditions of the intertidal communities near the mouth of the creek, it appears that the intertidal biota may recover from any impacts that may occur with higher flows in the rainy season.

In developing plans to control contamination, the San Mateo EH could further explore and develop the partnership with the California Critical Coastal Areas (CCCA) Program to form a comprehensive plan to identify and reduce contamination in San Vicente Creek. San Vicente Creek is currently listed on the CCCA strategic plan as a creek needing water quality improvements, based on the Program's criteria of 'impaired waters that flow into Marine Managed Areas'.

The CCCA Program is a non-regulatory state program that unites government agencies, stakeholders, landowners, and interest groups to better coordinate resources, efforts, and funding to improve coastal areas in need of protection. One of the most successful CCCA Program accomplishments is the designation of Morro Bay as a U.S. Environmental Protection Agency National Estuary. This led to the development of an integrated watershed management program and funding to implement measures to reduce contamination, excessive nutrient input, and sedimentation into the bay.

San Mateo EH is required to post beach closure signs when bacteria levels in the surf zone exceed state health standards, and they have also chosen to post a closure sign for San Vicente Creek (**Figure 4-2**). While the surf zone is largely safe for water contact, San Vicente Creek bacteria levels remain a potential threat to public health, as visitors must cross through the creek to access the Park, and the area is easily accessible for children. Although there are intermittent occasions when bacteria levels at the mouth of San Vicente Creek are below state health standards, EH maintains a sign year-round at the creek mouth notifying people to not contact the creek water (**Figure 4-2**). Accordingly, contamination in the creek remains a concern and potential threat to public health at the main public access to the Fitzgerald State Marine Park.


**Figure 4-2**. Sign on main access warning not to contact San Vicente Creek water.

In conclusion, the need to maintain monitoring and seek ways to further improve water quality in San Vicente Creek remains. The County of San Mateo may wish to submit applications to the CCCA Program for their support and guidance in developing programs to help reduce contamination in the creek. There should be considerable support for a program, since San Vicente Creek flows into a Park that is classified as a Marine Managed Area by the State of California. Creek contamination of all types may also be important issues to resolve if the County elects to seek further protection of the Park's marine resources through the Marine Life Protection Act (MLPA) process, as creek contamination should be resolved in context with other measures to protect marine resources.

## 4.2 Sewage

Prior to the 1980s, the Montara Water and Sanitary District operated a sewer treatment facility in the town of Montara located approximately 0.5 mi (0.8 km) north of the Park. The offshore outfall was permanently abandoned in 1983, and the treatment plant (now a pumping station) is used to convey the sewage south to the city of Half Moon Bay, which is located approximately 3 mi (4.8 km) south of the Fitzgerald State Marine Park. At Half Moon Bay, the Mid-Coastside Sewer Authority treats the sewage (secondary treatment) and discharges the effluent through a pipe offshore at a depth of approximately 35 ft (11m) and 2,000 ft (610 m) from the mean high tide line.

The Fitzgerald State Marine Park occurs within a State Water Quality Protection Area (see *Section 6.2 - State Marine Resource Management*). Previously called an Area of Special

Biological Significance, point source wastewater discharges into the area are prohibited, but there are no prohibitions on non-point discharges (e.g., storm water drain overflows, parking lot runoff).

The wastewater and stormwater conveyance system to the Montara Water and Sanitary District treatment facility has not operated without some problems. A lift station at the terminus of California Street near the Park's main parking lot has had backup problems. This occurred approximately five years ago. The problem stemmed from improper functioning of line-level controls used to regulate flows. The lift station was upgraded shortly after discovering the problem (Tony Pullin, Mid-Coastside Sewer Authority, pers. com.).

It remains unknown what effects might have occurred to the marine biota in the Fitzgerald State Marine Park as a result of the spillovers from the lift station failures. However, sewage spills are acute disturbances and while species might have been affected, the duration of the impact was likely short.

Vacation cruise ships have become more frequent in the Monterey Bay National Marine Sanctuary (MBNMS), and present a new potential threat of sewage discharges in the MBNMS and near the Fitzgerald State Marine Park. However, California Assembly Bill AB121, recently enacted, bans discharges of gray water and sewage into California waters from cruise ships. The prohibition zone extends 12 mi (19 km) offshore. This law will go into effect January 1, 2005. The regulation was brought about after a luxury liner several miles off shore of Monterey, California in 2002 discharged about 36,000 gallons (136,275 liters) of sewage and other wastewater into the MBNMS.

## 4.3 Oil Spills

Oil spills will always be a potential threat to shorelines. However, a main purpose for creating the Monterey Bay National Marine Sanctuary (MBNMS), within which the Park occurs, was to develop a permanent prohibition on offshore oil development in the area. The establishment of the MBNMS effectively blocked offshore oil development, including the development of onshore oil support facilities, undersea pipelines, and includes more stringent controls on nearshore oil vessel traffic.

The U.S. Coast Guard (USCG) and California Department of Fish and Game's Office of Spill Prevention and Response are the lead agencies for oil spill response in the state. The MBNMS participates in providing information to help assess damage to resources from spills, including habitat damage from vessel groundings and methods to remove debris. For smaller events, the MBNMS can assume a lead role in ensuring that fuel, oil, debris, and where possible, the vessel itself, are adequately removed to minimize damage. MBNMS has recently initiated an interagency subcommittee effort to improve prevention and coordinated interagency response and funding efforts related to small vessel sinkings and groundings.

Oil spills response times and cleanup methods can vary, however, depending on the size, location, and nature of the spill, equipment availability, and logistics, but technologies and response times are improving. While spills from large tankers will always be a possible threat, there is likely a greater threat of oil (fuel) spills from local fishing boat groundings than from tankers, including cruise ships.

The Pillar Point harbor near the south end of the Park is a base of operation for a commercial fishing industry, including recreational boat fishing. Therefore, boat traffic is frequent in the area. Commercial fishing, including from boats, is prohibited in the Fitzgerald State Marine Park. While recreational fishing from boats can occur, the periodic moratoriums that CDF&G now places on rockfish fishing has reduced the number of opportunities for recreational fishing. Consequently, the potential for small boat groundings and oil spills are now likely lower than in the past.

## 4.4 Motorized Personal Water Craft (MPWC) for Tow-In Surfing

MPWCs (jet skis) are becoming more popular as tow vehicles for surfers to catch and surf large waves. A large conflict centers on potential disturbance to marine wildlife from the noise and exhaust. Potential impacts include behavior modification of sea otters, sea birds, fish, pinnipeds (seals, sea lions), and area abandonment and avoidance by pinnipeds, porpoises, and whales.

There are numerous conflicting perspectives on the significance of the potential impacts of MPWCs within environmental groups and within the surfing community. Some people contend that MPWCs are no more of a threat than fishing boats frequenting an area. However, jet skis are highly maneuverable and fast, which can make it easy to harass and chase marine wildlife. Others contend that seals are not harassed because MPWCs are used only when waves are big, and when pinnipeds are not in the area. Furthermore, there are few days when the surf is large enough to use MPWCs for tow assistance, and therefore there is minimal impact. Within the surfing community there is also debate on the use of MPWCs. While some contend that it represents a technological advancement that has created a new sport, others object to MPWCs operating in the same areas as traditional paddle surfers.

The National Marine Sanctuary is updating management plans (Joint Management Plan) for the Cordell Bank, Gulf of the Farallones and Monterey Bay National Marine Sanctuaries. These plans include a review of sanctuary resource protection and regulatory goals. The Joint Management Plan (Draft) is currently in review. Among the various action plans are policies to regulate tow-in surfing. The Joint Management Plan, as described now for tow-in surfing, will allow tow-in surfing at Mavericks. However, tow-in surfing activities would be regulated through a permit process to control numbers and frequency of use (Huff McGonigal, MBNMS environmental policy specialists, pers.com.).

## 4.5 Low-Altitude Aircraft Flyovers

The Half Moon Bay Airport is located within 0.5 miles (0.8 km) of the Fitzgerald State Marine Park. It was built in 1943 as part of the coastal protection air network during World War II. Some time later a few commercial airline companies for public transportation used the airport. Currently, mainly small private and commuter aircraft use the airport. Larger aircraft (greater than 12,500 lbs) are prohibited from using the airport without prior approval from the airport manager.

Low-altitude flyovers that are associated with the airport can be common over the Park. As conveyed to us in personal testimonies by people who frequently visit the Park, and consistent with what we observed on several occasions during our surveys, low flying aircraft over the Park can occur quite frequently, particularly on calm, sunny days. It was not uncommon to see aircraft flying over the water immediately off the Park at low altitudes that were close to the height of the cliff bluffs (well below 500 ft).

The potential disturbance to local wildlife from low-flying aircraft is addressed in the National Marine Sanctuary Program's Draft Joint Management Plan Review. Recommended policies in the MBNMS include a prohibition on flying under 1,000 ft (305 m) in four 'overflight restriction zones', except as necessary for law enforcement purposes. However, the Fitzgerald State Marine Park is not within any of the four overflight restriction zones. All four zones occur south of the Park; Big Sur Coast, Pescadero Point-Santa Cruz, Elkhorn Slough, and offshore of Moss Landing harbor.

Airports obviously require allowances and options for low flight traffic patterns. Current airport operation policies at the Half Moon Bay Airport include specified landing and take-off patterns to maintain safety and also to minimize mainly noise impacts to the surrounding neighborhoods and towns. Current flight policies include:

- Reduce power as soon as safe and practical. This is intended to minimize noise to the best extent practical, but can jeopardize aircraft safety.
- Avoid flying over homes in extremely noise sensitive areas. If able, fly after 10:00 am on weekend and holiday mornings. This is to minimize noise impacts to people during the early morning when most people are still at home.
- Do not implement turns until reaching 500 ft Mean Sea Level (MSL). This is to ensure safe exit from the airport. The policy does not prohibit planes from reducing altitude after they have left the airport, and are over the ocean immediately off of the Park.
- Avoid flying over St. Catherine Hospital, located immediately north of the airport. This is to minimize noise impacts to hospital patients and business operations.
- Maintain a flying altitude of 1,000 ft MSL until necessary to descend for landing. The primary purpose of this condition is for incoming air traffic safety, but it also tends to keep air traffic away from the Park.

- Avoid flying over homes whenever possible. This is to reduce noise impacts to local residences.
- Aircraft over 12,500 lbs are prohibited without prior approval from the airport manager. This is to ensure that runway conditions are suitable for heavy aircraft.
- Helicopter operations need to contact airport office for procedures. Helicopters do not require the same spatial airflight zones as fixed wing aircraft.

## 4.6 Desalination Plant

The Montara Water and Sanitary District and Coastside County Water District are currently investigating whether the two districts share common interests to jointly apply for State of California Department of Water Resources Proposition 50 grant money for a feasibility study to construct a desalination plant. This plant would be located approximately 0.25 mi (0.4 km) north of the Park boundaries, and within a State of California Water Quality Protection Area (formerly ASBS).

A number of potential marine environmental issues would be related to the project: water withdrawals and the discharge of elevated saline water (brine) into the ocean. Open ocean water withdrawals may require the proposed facility to comply with the new Clean Water Act 316(b) rules, which would address the project's impingement and entrainment effects on local fish and invertebrate populations (source: www.epa.gov/waterscience/316b/). The source of seawater from beach wells would not necessarily be regulated under 316(b) rules. Beach wells have the potential to cause other effects, including altering the nature of groundwater aquifers and seawater intrusion. A Coastal Development Permit would have to be acquired from the San Mateo County Planning Department and the California Coastal Commission. The project's discharge would necessitate a National Pollutant Discharge Elimination System (NPDES) permit issued by the State Regional Water Quality Control Board, whether the discharge was routed through an existing discharge or a new discharge. Other state resource agencies would be involved in the permitting process (e.g., State Water Resources Control Board, Monterey Bay National Marine Sanctuary, Gulf of the Farallones National Marine Sanctuary). Potential impacts to the marine resources in the Fitzgerald Marine State Park would largely depend on the size of the desalination plant.

# 5.0 Integrated Discussion of Visitor Use and Biological Impacts

## 5.1 Background of Human Use Impacts

Rocky intertidal shorelines, similar to those at the Fitzgerald State Marine Park, support diverse assemblages of marine plants and animals that are known to be susceptible to impacts from trampling, handling, displacing, and collecting organisms by people who visit these areas (Chan 1970, Beauchamp and Gowing 1982, Povey and Keough 1991, Brosnan and Crumrine 1994, Murray and Gibson 1979, Murray 1998, Murray et al. 1999, Engle and Davis 2000). The nature and intensity of human impacts due to visitors, however, depends on the type of biological community present (e.g., species composition), physical nature of the habitats (e.g., bench platforms, boulder/cobble fields, rock outcroppings, wave exposure, etc.), access to these areas, and levels of visitation (Addessi 1994, Clowes and Coleman 2000, Clowes 2002; Tenera 2003).

Chronic disturbances from visitor use can result in intertidal areas having reduced biodiversity relative to unimpacted areas (Povey and Keough 1991, Brosnan and Crumrine 1994). On the other hand, intertidal biological communities are resilient to many types of natural and human-induced impacts, and can recover from intermittent disturbances (Sousa 1979, Tenera 2003). For example, the large reproductive output of many of the species in the intertidal help provide for recovery through settlement of spores and larvae, and subsequent growth of new individuals (Hockey and Bosman 1986, Catterall and Poiner 1987, Lasiak 1991, Keough and Quinn 1998).

Studies have shown that in disturbed areas the species, including recovery rates, can vary in abundance depending on the types of assemblages affected (Foster et al. 1988, 2003; Kinnetics 1989). Highly motile species, such as turban snails that are dislodged from rocks, can recover almost immediately, since they can move back into their former habitats (Chapman and Underwood 1996). On the other hand, slower moving species, such as sea stars, may not be able to occupy their former habitat as quickly after being dislodged or displaced. Mussels that are attached to the rocks may take up to 10 years or more to recover (Kinnetics 1989, Richards 1994).

Organisms that are associated with the impacted populations can also be indirectly affected (Ghazaanshaki et al. 1983, Moreno et al. 1984, Duran and Castilla 1989, Povey and Keough 1991, Brown and Taylor 1999, Schiel and Taylor 1999). For example, trampling that reduces algal cover may in turn reduce the abundance of invertebrates that utilize algal cover for protective habitat (Brown and Taylor 1999). Conversely, algal cover may increase when invertebrate grazers are collected (Moreno et al. 1984), and prey species (e.g., turban snails) may increase when predator species (e.g., sea stars) are collected and removed from the community.

## 5.2 Study Approach

Results from the field studies for this project were used to determine the effects of both extractive (fishing and collecting) and non-extractive (tidepooling for educational or other purposes) visitor activities on the intertidal resources in the Fitzgerald State Marine Park. The studies were completed in spring-summer 2004. The findings are integrated with the Fitzgerald Marine Reserve Master Plan (see below, *Section 6.0 - County Park Management and the Marine Life Protection Act Process*). The Master Plan serves as the planning document for the San Mateo County Parks and Recreation Division for future resource management of the Park.

There has not been a comprehensive description of the overall condition of the Park's marine biota or assessment of the magnitude and ecological significance of potential impacts in the last 10 years. A study by HLA (1993) completed over 10 years ago found evidence of trampling effects on certain algae, a lower abundance of under rock fauna presumably resulting from rock turning, and evidence of a decreased prickleback (eel) fishery based on catch statistics. We completed literature reviews and performed additional studies on these topics to provide an update on potential changes in the nature, magnitude, and extent of effects of human use on the Park's marine resources.

Our assessment of impacts relied mainly on statistical comparisons of the composition and abundance of assemblages of intertidal species in areas that differed in the intensity of visitor use. In addition to using control/reference and impact areas in 'side-by-side' comparisons, we also analyzed existing data collected from an experimental study in which two types of areas were studied; one was roped off and visitors were not allowed access and the other was open to visitor access. The findings provided additional data on the potential impacts of human use.

## 5.3 Limitations of the Study

Our study of visitor impacts was conducted only within a four-month period, and therefore could not account for seasonal or inter-annual changes. Species undergo both short- and long-term natural changes that are related to numerous factors. This natural background variation must be distinguished from variation caused by visitor impacts to determine if changes in species abundances can be associated with visitor activities. This makes it difficult to detect human impacts on biological communities with high levels of spatial and temporal variation, such as the intertidal communities in the Park (Gunnill 1985; Paine 1986; Stewart-Oaten et al. 1986; Underwood 1992, 1993, 1994; Green 1993; Schroeter et al. 1993; Wiens and Parker 1995).

In rocky intertidal habitats and other natural environments where species abundances change considerably over time and among areas, robust assessment methods designed to evaluate potential impacts require much longer study periods. For example, a longer-term study could have used a before-after-control-impact (BACI) design, where sampling occurs in both control and impact areas for a period of time before and during or after the impact (Stewart-Oaten et al.

1986). Another alternative would have been to sample impact and reference/control areas concurrently over a long period of time to determine whether trends in species composition and abundance in control and impact areas depart, converge, or parallel one another (Coats et al. 1999). However, both of these approaches require commitment to a long-term study.

## Assessment Criteria

While high natural variation in species abundances in the intertidal make it difficult to detect differences among areas, it can also result in statistically significant differences between areas with high and low visitor use, which are not related to human impacts. Therefore, a necessary part of our evaluation was to determine if statistically significant differences identified in the analysis were actually due to visitor use. The evidence for impacts of visitor use was categorized as 'strong' if the difference between areas with high and low visitor use was due to a large number of species rather than differences in just one or two species. For example, strong evidence for visitor impacts would exist if we detected lower abundances of frequently collected invertebrates (e.g., sea stars, sea urchins, shore crabs, turban snails, hermit crabs) in visitor use areas, relative to reference areas.

We did not use historical descriptions as a baseline for assessing impacts. All shorelines in California have been affected by human use, beginning with subsistence living and shell collecting dating back to about 10,000 B.P. Spanish settlers arrived in California several hundred years ago, and exploited resources through hunting sea otters and harvesting abalone for trade with coastal Native Americans. The City of Moss Beach began to grow rapidly in the early 1900s, and it has long been recognized that people were exploiting the marine resources of the intertidal reefs in the area even during that time. In addition, we could not determine if the areas with highest visitor use were more diverse in the past than our reference areas. In any case, resource managers and planners today are more concerned with minimizing impacts given current levels of use and the nature of visitor activities.

# 5.4 Resource Assessment

## Non-Extractive Activities

The greatest uses of the Park are all related to non-extractive activities. Visitor use at Moss Beach Reef in the Park has been recorded for the past 35 years (1969–2003). These records show that ≥ 100,000 people visit Moss Beach Reef each year. Over 99 % of the visitors use the Park for educational activities, picnicking, walking, photography, and other non-extractive activities. Less than 1 % of the visitors use the Park for fishing. Moss Beach Reef is a small section within the Park of approximately 500 m (547 yd) coastline distance. Accordingly, Moss Beach Reef is among the most, if not the most, visited shoreline in California for the purpose of non-extractive resource enjoyment.

Despite the high levels of use, our results did not provide substantive evidence that Moss Beach Reef is in serious jeopardy of significant, permanent ecological degradation from non-extractive forms of visitor use or that impacts could not be reversed if visitor use ceased. Our study showed that the biological communities at Moss Beach Reef were relatively diverse and similar to other areas of the Park where lower levels of visitor use were measured. We sampled bench rock habitats and tidepools in high and low use areas, and did not find large differences between areas using our low use areas as a baseline of natural conditions.

Although we recognize the limitations of the study design to detect human impacts, we also cannot dismiss the potential that the management efforts for resource protection at the Park have had beneficial effects in reducing visitor impacts to levels where they are not detectable. Park rangers, who have been present every day for the past 30 years, including docents accompanying field trips, may have reduced the impacts of visitors. In addition, the bus reservation system started in 1994 has helped control the number of visitors to the Park and could also have contributed towards minimizing impacts. While it is impossible to determine the reasons why we were unable to detect visitor impacts, it seems reasonable to conclude that these management schemes have had some beneficial effects on the marine resources of the Park.

A few intertidal algal and invertebrate species had large differences in abundance between areas of high and low visitor use, but when investigated further these differences could not be related to varying levels of visitor use. For example, black turban snails, which are commonly collected from the intertidal, were significantly lower in abundance in tidepools located within the visitor use area, relative to tidepools in reference areas. We compared the shell size distributions between the two areas and found a much larger number of smaller individuals in the reference areas. If the difference between areas was due to varying levels of visitor collecting, the reference area would be expected to have a greater number of larger sized snails than the area with higher visitor use. The observed differences in the size frequency distribution between high use and reference areas indicates that these differences were likely due to variation in recruitment, and not to direct impacts of collecting.

We also examined potential impacts to under-rock fauna, since visitor impacts on these biota were highlighted in the HLA report (1993). HLA's qualitative observations were similar to the results from a quantitative study of under-rock fauna completed between 1971 and 1991 in a high visitor use area in San Diego, California, which determined under-rock fauna were reduced by rock turning (Addessi 1994). However, we were unable to find any evidence of differences between under-rock faunal composition and abundance between areas of high and low visitor use.

Our study of jurvenile intertidal fish abundance in turnable substrate areas revealed that intertidal fishes were nearly twice as abundant at the heavily used area (Moss Beach Reef) compared to the lightly used area (Frenchman's Reef). We also note that the overall densities of intertidal fishes at the Fitzgerald State Marine Park (1.9-3.0 per $m^2$) were similar to densities of fishes (2.8 per $m^2$) found in a long-term intertidal fish study at Diablo Canyon in San Luis Obispo County

(Tenera 1997) where access is strictly limited. We therefore conclude that visitor impact on juvenile intertidal fishes (e.g., monkeyface eels and rock pricklebacks) is low at the Park, and that the Park provides suitable habitat for recruitment for these species. Also, most visitors tend to walk on the horizontal rock benches, not the cobble fields where these species recruit, and visitor education tends to limit the amount of rock turning that could potentially harm fishes living beneath the rocks. In addition, recruitment of juvenile eels is not necessarily dependent upon local population spawning success because the pelagic larval stages are planktonic for several weeks. This allows larvae originating from other coastal areas north and south of the Park to colonize the Park's intertidal zone.

## Extractive Activities

### Finfish Fishing

While fishers currently represent a small percentage of those who use the Park, they were once in greater numbers. The decline in the number of anglers from 1973 through 2002 is also reflective of a more gradual decline in overall catch per unit effort, an indication that fishing success for target species, such as eels and surfperches, has declined. In contrast, data show that cabezon and lingcod catches per angler increased slightly over time, declining only recently in 2002. This decline could be a result of actual coast-wide reductions in take of these species (Leet et al. 2001). The new minimum size limit of 14 in. for cabezon and 30 in. for lingcod, coupled with reduced bag limits, is intended to decrease catches of these species.

The overall impact of fishers at the Park is probably minimal in comparison with the magnitude of other visitor activities, even though fishing is an extractive activity. Fishers comprise less than 1% of the total visitor trips per year. Records suggest that current levels of fishing at the Park are sustainable, but the data also indicate that the quality (size) of target species, especially prickleback eels, has probably declined over time. This would be a typical result of concentrated fishing for a target species with limited mobility. The presence of juvenile eels in the adjacent intertidal zone indicates that it is a suitable habitat for continued recruitment to the local population. Other potential impacts at the Park caused by fishers may include the illegal collection of bait, such as mussels, and also trampling effects similar to those caused by non-extractive users.

### Poaching / Illegal Collecting

Poaching, for the purposes of this study, is defined as the illegal collecting of species for consumption. Poaching is probably the most harmful type of collecting because poachers often seek the largest specimens and collect from a single area until the local population is nearly depleted (Underwood and Kennelly 1990, Pombo and Escofet 1996, Griffiths and Branch 1997). Reproduction can also be adversely affected by the selective removal of the larger older animals (Ambrose et al. 1995, Kido and Murray 2003). A few instances of intensive poaching may result in impacts that are similar to, or exceed incidental collecting by the numerous visitors who are at the Park primarily for non-extractive purposes.

Accurately determining the frequency of poaching and the types of organisms being removed is not possible without constant surveillance. Park records from 1971 through 2003 show that the number of poachers (including general visitors casually collecting) has steadily decreased from over 450 collectors per year to approximately 24 collectors per year, with a substantial decline in number of organisms collected, as well. Mussels, limpets, and turban snails were the most commonly collected organisms.

While poaching activities appear to have decreased substantially, it is reasonable to assume that poaching (excluding casual collecting) occurs more commonly than 24 times per year, as poachers probably target areas that are not patrolled, conduct their activities after the Park rangers have left for the day, and hide organisms to avoid being caught. Consequently, many instances of poaching likely go undetected. However, it is reasonable to assume that recent levels of poaching have not reached the maximum number of over 450 poachers per year recorded in 1971.

### Incidental Collecting and Handling by Casual Visitors

Although less severe than poaching and fishing, souvenir collecting and handling can also affect intertidal populations. Unlike poaching and fishing, however, most people (general public and school groups) do not visit the Park with the intention of collecting organisms, shells, or rocks. However, visiting the shore for tidepool exploration has become increasingly popular for educational purposes, relaxation, and tourism, and consequently there is always the risk of visitors removing and displacing animals from their habitats.

During the visitor census surveys approximately 28 % of the people on the shoreline were engaged in some form of 'active' tidepooling behavior (touching or handling organisms). The actual percentage is probably higher than 28 % because it is likely that most people who visit the intertidal will eventually touch or handle organisms. This activity is not necessarily harmful, as long as the organism is quickly and properly returned to its appropriate habitat. We did not attempt to determine whether organisms that had been handled were properly returned.

Visitors do not collect and handle every type of organism. In general, visitors tend to collect or handle the more conspicuous and common species (e.g., turban snails, sea stars). Sea stars, however, can be particularly at risk to becoming depleted from an area from collecting, because they are conspicuous and generally not very abundant. Furthermore, collecting of one type of organism may cause indirect effects on others. For example removal of sea stars may increase the abundance of their prey items (e.g., turban snails, mussels). Turban snails also tend to be collected because of their high abundance in the intertidal zone. Although turban snails could be collected for consumption, it is more likely that they are collected for curiosity or as souvenirs.

Species life history characteristics must also be taken into account when assessing the magnitude of impacts resulting from collecting. These characteristics include the size and distribution of the target population, rate of recruitment, age to maturity, fecundity, longevity, mobility of the organism, and intensity of extraction. For example, turban snails are typically the most widely

distributed and most abundant invertebrate species in California intertidal zones (Tenera 1997, 2003). Consequently, turban snails may be among the least harmed by collecting a few or even hundreds of individuals. However, collecting would have greater effects on organisms that have smaller populations, are longer-lived, and are slower to reproduce, such as sea stars and abalone. As noted in the beginning of this section, indirect effects may occur, as any change in a dominant invertebrate species or an algal habitat-forming species may result in secondary effects on associated organisms (Dayton 1971, Moreno et al. 1984, Keough and Quinn 1998, Brown and Taylor 1999, Schiel and Taylor 1999). Consequently, high levels of collecting (poaching or casual collecting) could be detrimental to the entire community.

### Scientific Collecting

Another activity that involves removing organisms is scientific collecting. Scientific collecting is done for voucher collections, taxonomic research, maintaining museum specimens, and for laboratory studies. It is our opinion that any effects resulting from scientific collecting are minimal compared to other forms of collecting. Our studies could not distinguish the effects of scientific collecting from other forms of collecting. Scientific collections often require only limited numbers of animals and plants, and all collections are required to be reported to CDFG. Scientists also generally recognize the ecological consequences of collecting. Furthermore, the CDFG regulates scientific collecting and also the methods of collection.

## 5.5 Natural Resource Values to User Groups

### Resource Values to Non-Extractive Users

The natural resources of the Fitzgerald State Marine Park are the primary reason that over 100,000 people visit the Park each year. The Park is a popular shoreline destination because it is mainly a flat extensive rock bench platform that is easy to walk across to observe the many different types of intertidal assemblages in the Park. In contrast, intertidal zones in other areas are composed of large boulders and steeply sloped shores that make exploring the intertidal much more difficult and treacherous (Tenera 2003). Consequently, the Fitzgerald State Marine Park provides a unique opportunity for safely exploring the intertidal that is not available at most other locations in California.

Ninety-nine percent of the people who visit the Park are there for non-extractive activities that are related to the high natural resource values of the Park. For this reason, protecting the natural resources at the Fitzgerald State Marine Park should be the highest priority for the San Mateo County Parks and Recreation Division and Board of Supervisors. One of the primary focuses of visits to the Park is marine environmental education. This large user group could be affected as a result of resource degradation to the Park. If the natural resources at the Fitzgerald State Marine Park became degraded, or if the Park were closed, hundreds of thousands of visitors would be displaced to other coastal areas or may not visit the shoreline at all. Consequently, the Park

managers have recognized that the resources at the Park need to be protected while still providing for continued access and visitor enjoyment.

Currently, county Park managers are developing plans to enhance the educational opportunities at the Park while also protecting the Park's natural resources (Brady/LSA 2002). These include the building of a Marine Science Education Center and the development of additional educational programs at the Park. To ensure continued protection of the Park's natural resources, Park rangers will continue surveillance and enforcement. In addition, visitor use will be more strictly controlled by requiring visitors arriving by bus, or in groups greater than 10, to have a reservation with the County. The Friends of Fitzgerald, a marine science education outreach non-profit organization, will continue to provide assistance with resource education through docent-led trips. County Park managers will likely request State assistance in meeting County objectives in protecting the natural resources and educational benefits of the Park to the fullest extent possible by re-classifying the Park as a State Marine Reserve as part of the MLPA process (see *Section 6.0 - County Park Management and the Marine Life Protection Act Process*). This classification would prevent recreational fishing.

## Resource Values to Extractive Users

The main extractive use at the Park is recreational fishing, which is allowed and regulated by the CDF&G. This includes spear fishing. Commercial fishing is prohibited. The Park is unique because of its 'poke-pole' shoreline fishery for monkeyface eels and rock pricklebacks. The Park supports a shore fishery because of the easy access to the large reef areas that provide suitable habitats for both juveniles and adults. This environmental setting provides unique, easy, and safe shore fishing opportunities. However, shore fishers represent less than 1 % of the park visitors.

While catch statistics from 1973 through 2002 indicate that catch per unit effort has decreased overall, the open nature of the coastline, and the fact that populations of the targeted species extend into the near-offshore subtidal depths, are two factors that may help to prevent overfishing of the populations. Also, rough surf conditions limit the number of days that fishing areas are accessible, particularly in winter months. Furthermore, high variation in catch per unit effort among years indicates that the resources have not been seriously depleted. One factor not accounted for in the analyzed database, however, was the size of the fishes caught. There is no minimum size limit on monkeyface eels or rock eels. Therefore, it is very likely that the reduced fishing effort reflects a decline in the mean size and therefore the quality of the fishes caught.

Scientific collecting is allowed, and the Park was historically an important collecting area for scientific studies, voucher collections, and museum records. We do not have current records on how frequently the Park is still used for scientific collecting, but the Park still provides a diversity of habitats that are attractive to scientists seeking areas to collect. We did not observe any people collecting for scientific purposes during our studies. The school groups that we

observed were not collecting, but rather observing and taking notes from the class teaching materials.

The intertidal habitats in the Park contain owl limpets, black abalone, and mussels, which are of value for human consumption. Effects of collecting owl limpets and black abalone, in particular, could be especially severe because of their low abundances and typically slow growth. Poaching these species could result in permanent depletion of their populations at the Park. On the other hand, the Park may not be an area targeted for owl limpets and black abalone, due to their relatively low population sizes. In contrast, mussels remain susceptible to poaching in the Park.

## 5.6 Separating Potential Effects of San Vicente Creek from Visitor Use

One difficulty in distinguishing the potential effects of visitor use is the location of the main access to Moss Beach Reef at the mouth of San Vicente Creek. The creek could have a direct effect on the marine biota, which is unrelated to visitor use. In addition to the fresh water inflows influencing community composition near the creek mouth, San Vicente Creek is also known to have water quality issues with pollutants and high levels of bacteria (see *Section 3.0 – Other Human Influences*). However, we agree with the conclusions of the California State Water Resources Control Board (1979) that San Vicente Creek probably has a limited spatial effect on the marine biota on Moss Beach Reef.

At the terminus of the main access there is also an area of changing dimension (on the order of several hundred square meters) that has much lower abundances of algae and invertebrates relative to other areas of Moss Beach Reef (**Figure 5-1**). Although these bare areas are located near the main access, sand scour, more so than excessive foot traffic and freshwater inflow, probably causes the reduced algal and invertebrate abundances. During our study period, this area supported scattered patches of green algae (e.g., *Ulva/Enteromorpha* spp.), which are commonly associated with disturbance because these species can colonize areas more rapidly than other species when bare space for settlement is made available. This algal group is also commonly associated with freshwater inflows,

**Figure 5.1**. Bare rock area of the Moss Beach Reef platform. near the main access and the mouth of San Vicente Creek. Green patches are *Ulva/Enteromorpha* spp.

since these green algal species are more tolerant of lower salinity than other marine algae.

**Figure 5-2**. Evidence of chronic trampling on a footstep in the intertidal zone at Point Pinos, Monterey County. Note that trampling did not cause this rock to become completely bare, as crustose algae remain with some upright algae. Ruler is six inches. (photo source: Tenera 2003).

It is our opinion that the bare areas on the Moss Beach Reef platform adjoining the sandy beach are primarily caused by sand scour and not by visitor traffic. Sediment from the watershed drained by San Vicente Creek is transported into the intertidal areas of Moss Beach Reef. This sediment accumulates on the sand beach that backs the Moss Beach Reef platform, and the rocks nearby are maintained in a barren state from the souring of wave-borne sand. Visitor traffic generally does not result in areas becoming completely barren (Davis 2002). Some algal species (e.g., encrusting and other species) will still be present, especially if there are depressions in the rocks where they are not affected by trampling (**Figure 5-2**). Consequently, the complete absence of algae near sources of sand would be indicative of sand scour. The sand is also transported across the reef in surge channels, which we believe explains the reduced algal and invertebrate abundances in those areas, as well.

## 5.7 Biodiversity at the Fitzgerald State Marine Park Compared to Other Areas of High Use

We compared the species composition and abundance of marine biota in the upper and mid-intertidal zones between Moss Beach Reef and Point Pinos, located on the Monterey Peninsula. Both areas are subject to relatively high visitor use. We found that species composition and abundance of the marine biota in the upper and mid-intertidal zone on Moss Beach Reef was not as diverse as that found at Point Pinos (**Figure 5-3**). The differences in species abundances between areas can be largely explained by habitat differences. Unlike the flat rock benches found at Fitzgerald State Marine Park, Point Pinos has a greater amount of mixed substrates (e.g., rock outcrops, boulders, cobbles) and vertical relief in habitat structure. The mixed substrates and higher relief over small spatial scales provide greater habitat complexity, which has long been known to be correlated with greater biodiversity.

Other areas of the Park do contain complex habitats with levels of biodiversity that are more similar to Point Pinos, and may exceed the diversity of many other coastal areas. These are the seaward edges of the rock bench platforms of the Park where the outer edges of the platforms are

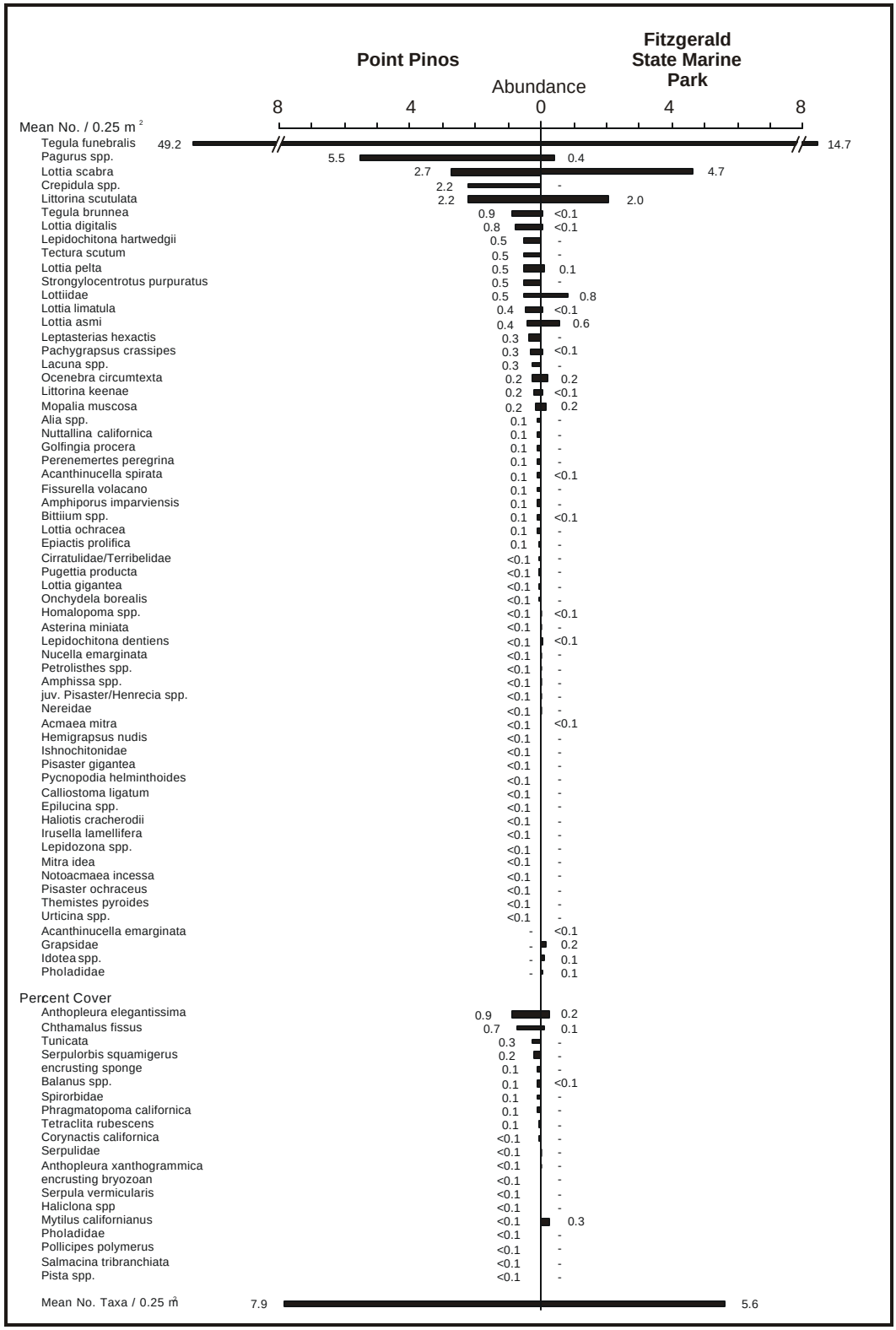



**Figure 5-3**. Intertidal invertebrate abundances at the Fitzgerald State Marine Park (Plots E0-E3, G0-G3) and Point Pinos, Monterey County. Point Pinos data from Tenera (2003).

incised with deep surge channels and jagged rocks. The seaward edge habitats extend along the entire length of the Park (approximately 3 mi, 5 km), and have the greatest habitat diversity and biodiversity (**Figure 5-4**).

**Figure 5-4**. Outer edge of reef platform characterized by greater habitat diversity with surge channels, ledges, cuts, and overhangs.

## 5.8 Assessment of the Ecological Significance of the Findings

Any human activity within a natural habitat will cause some degree of change to the environment. However, a fundamental part of the impact assessment process is to determine whether such changes are ecologically significant and affect the sustainability, persistence, and maintenance of the structure and function of the ecosystem (Menge 1976, Underwood and Kennelly 1990). Statistically significant changes in the abundances of certain species may not necessarily be ecologically significant. Conversely, the lack of statistical evidence for impacts does not necessarily imply that adverse ecological impacts are absent (Schroeter et al. 1993). In highly variable environments, it is also very difficult to statistically demonstrate gradual changes, which may eventually become large. Below we discuss the relevance of our study findings in context with ecological significance assessment criteria.

### Community Functioning

A change that is ecologically significant implies that the community has changed in diversity, food web structure, or productivity (Connell and Sousa 1983, Lubchenco et al. 1984). The results of our study, however, do not provide evidence that community parameters in the Park have been appreciably altered, have shifted, or are in imminent jeopardy from visitor use. The results show that there appears to be sufficient redundancy and complexity in the community whereby many species and assemblages perform and fulfill similar functions. This diversity of organisms creates food webs and interactions that can buffer changes and help reduce the effects of visitor impacts.

## Spatial Scale of Effects

The area mainly exposed to visitor impacts in the Fitzgerald State Marine Park (Moss Beach Reef) is relatively small in relation to the adjoining shoreline, which consists of similar habitats and species assemblages that are less visited. The number of species and habitats at risk to visitor use in the Park are generally near access points. Effects of visitor use would not necessarily affect the ability of the organisms in the Park to propagate and provide larvae and spores to help affected areas recover, and to provide larvae and spores beyond the boundaries of the Moss Beach Reef area and the Park.

Even though any visitor effects would likely be maximized in the relatively small area of Moss Beach Reef, there is still a need for conservation measures. Increases in visitor use with increased population growth could result in greater impacts over larger areas.

## Other Factors Affecting the Resource Assessment

Some amount of uncertainty will always exist when assessing impacts, even when the assessment utilizes an extensive long-term database. Short-term studies, such as this study (four months), will not provide a complete picture of the ecological conditions in an area. Many species are known to undergo sporadic recruitment cycles and, therefore, changes in their abundances and population structures might not be detected in short-term studies. The limitations of a short-term study are apparent in the results for owl limpets, in which the low numbers of smaller-sized individuals suggest a lack of recent recruitment. Subsequent sampling may have detected a recruitment event, which would indicate a greater mix of age classes in the population. Therefore, conclusions based on observations made over a few visits are not necessarily representative of what may occur during other years.

Natural seasonal variations in community composition and species abundances also affect biological assessments, and should be incorporated in resource studies whenever possible (Tenera 1997). Long-term monitoring in control areas without visitors near the Diablo Canyon Power Plant in San Luis Obispo County shows large natural variations in species abundances that probably occur in the same intertidal species present at the Park (**Figure 5-5**). This large amount of variation serves to highlight the difficulty in determining what baseline conditions should be used for interpreting changes in intertidal populations or communities resulting from human influence. Other factors, such as long-term changes in ocean temperatures, can cause changes in species composition and abundances over large geographic regions (Barry et al. 1995, Sagarin et al. 1999). Also, El Niños, La Niñas, and recurring storms can result in changes in biological parameters over both long- and short-time intervals and over different spatial scales (Dayton and Tegner 1984a, Gunnill 1985, Ebling et al. 1985, Tegner and Dayton 1991, Dayton 1992, Tenera 1997).

The recent return of sea otters into the area of the Fitzgerald State Marine Park (Mike Harris, CDF&G, pers. com., R. Breen, unpubl. data) will likely influence both subtidal and intertidal

marine communities over time as the otters prey on abalone, urchins, crabs, snails, and other macroinvertebrates. This will result in a shifting ecological baseline and potential changes in community composition. This is why long-term quantitative monitoring is so important for evaluating changes and identifying trends in coastal populations, and correlating these changes with changes in environmental conditions.

## Comparison of Human Induced Impacts with Natural Disturbances

Open coast rocky intertidal communities, such as those at the Fitzgerald State Marine Park, are comprised of species adapted to numerous natural disturbances, including wave stress, sand scour, scraping from drift logs, and rock displacement (Dayton 1971, Daly and Mathison 1977, Seapy and Littler 1982, Littler et al. 1983, Shanks and Wright 1986, McGuinness 1987, Chapman and Underwood 1996). Both natural and human-induced disturbances over time can result in a mosaic patchwork through the intertidal zone with areas in various stages of disturbance and recovery. Depending on the intensity of impacts, the effects from visitor use may be indistinguishable or within the range of changes resulting from natural disturbances, which can occur due to strong wave action or severe weather (Bally and Griffiths 1989, Newton et al. 1993).

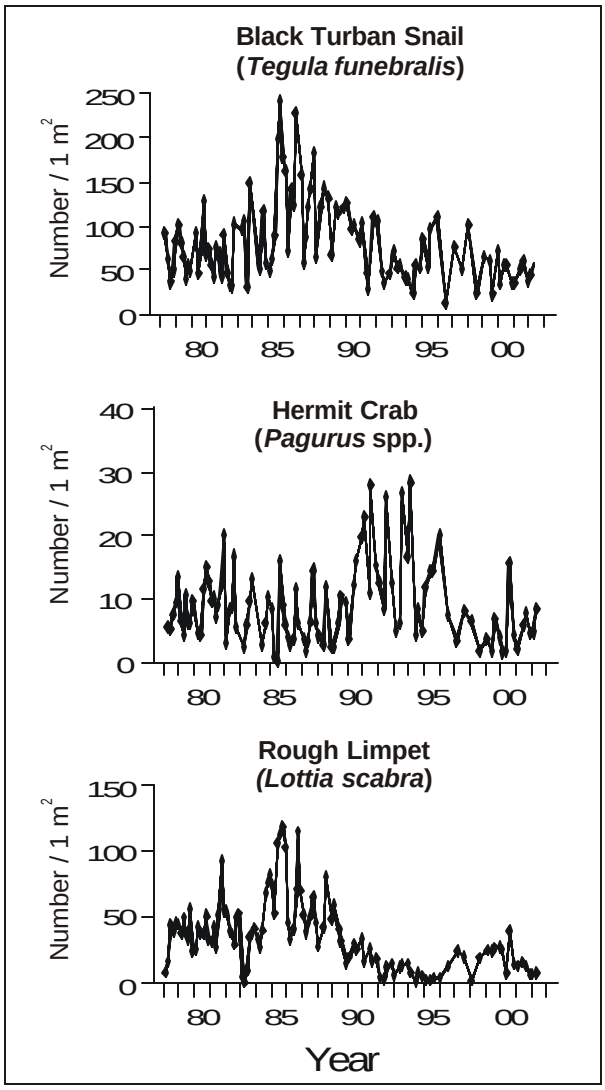



**Figure 5-5**. Long-term changes in common intertidal species in permanent 1 $m^2$ quadrats at a control transect (n=10 per transect) located near the Diablo Canyon Power Plant, San Luis Obispo County. (Data courtesy of Pacific Gas and Electric Company).

Many of the disturbances caused by visitor use in the Park, such as rock turning and scraping by trampling, resemble changes caused naturally by waves and storms. Loose rocks can be constantly moved about. Sand and gravel beaches back much of the rock bench platforms in the Park, and the loose sediments move back and forth across the platforms, due to wave surge. In extreme circumstances, sand can completely cover rocks, but then be cleared away by waves exposing large areas of bare bedrock (**Figure 5-6**). In less extreme circumstances, the loose

sediments only scour portions of rocks. This latter type of disturbance mosaic contributes to the high spatial variability in species composition and abundance in many areas of the Park's intertidal zone. While this can make it difficult to distinguish whether changes in species abundances have been caused by visitor use or are the result of natural factors, mosaic patterns of species populations in various stages of age, growth, and maturity, which reflect the ability to recover, are components of diverse communities (Paine 1969, 1974; Connell 1978; Sousa 1979).


**Figure 5-6**. Influence of sand scour and changes in sand cover creating and exposing bare rock on Moss Beach Reef. Arrows point to same rock outcrop for spatial reference.

## Temporal Scales and Recovery Potential

Under natural conditions, ecosystems are dynamic and are constantly changing both seasonally and annually (Dayton et al. 1998, Tenera 1997). Therefore, it is not realistic to assume that a system should remain static. The ability of a system to resist or recover from disturbance is a measure of the ecosystem's resilience to change (Orians 1975, Connell and Sousa 1983).

The marine communities at the Park are constantly in the process of recovery from natural and visitor-induced disturbances. The ability of the communities in the Park to recover from disturbance is a function of their high diversity, the large areas of the Park that are unaffected by visitor use or that receive varying levels of impact from natural disturbances, the high reproduction and growth potential of many species in the surrounding region, and strong currents and upwelling in the area that help distribute spores and larvae. However, the specific recovery times for each area will depend on the individual species involved, their life history characteristics, spore and larval dispersal capabilities, and the nature of the substrate types affected (Kinnetics 1989, Walder and Foster 2000).

Recolonization rates can vary among different types of intertidal habitats. Many intertidal species are capable of rapid recolonization, due to large numbers of larvae and spores, which can

be transported from undisturbed areas. This, combined with rapid growth for some species, facilitates rapid recovery. However, recovery rates can vary among communities with recovery occurring within 1–6 years in some communities, and taking up to 10 years or more in other communities, such as mussel beds (Kinnetics 1989). On the other hand, the apparent recovery in rocky intertidal communities in Alaska that consisted mainly of mussels, barnacles, and rockweeds, occurred within a few years in some areas following the Exxon Valdez oil spill (Coats et al. 1999).

The results of our studies indicate that the recovery potential of the rocky intertidal community in the Fitzgerald State Marine Park is, in general, relatively high, considering the area is exposed to such high visitor use. Furthermore, visitor impacts are largely reversible, since they do not typically result in a permanent alteration of the habitat that would reduce the potential for species to recover.

The combination of seasonal changes in species abundance, weather, and tidal regimes also contributes to the maintenance of relatively high biodiversity in the Park. Intertidal organisms are most susceptible to visitor impacts during the spring when visitor attendance is at its peak, mainly from school field trips. Spring is a popular time to explore tidepools, because the lowest low tides occur during daylight in the spring when the weather can also be relatively nice. The lowest tides during the summer, another peak period for visitor attendance, occur during early morning darkness or just after sunrise. Consequently, this limits visitor access to the lower intertidal zone during the daytime in summer and provides intertidal species some natural protection from visitor impacts. This is ecologically beneficial because central California species are often at their peak levels of abundance in summer (and fall), and this is also the time of year when most species are reproductive (Sparling 1977, Horn et al. 1983, Tenera 1997). Although there are very good low tides during the daylight in winter, larger waves and poorer weather conditions can reduce the number of visitors to the intertidal.

## Balancing Use and Protection

There is an inherent challenge in balancing allowable public uses while maintaining resource protection. The current level of human use at the Fitzgerald State Marine Park, along with potential for impacts, is likely to continue and will likely increase due to population growth. Although there are no guidelines on how to balance resource conservation with existing uses, some form of management oversight will always be necessary because excessive, non-monitored visitor use could potentially result in degradation of habitat and therefore harm existing public benefits. Resource management plans are currently being addressed in the Fitzgerald Marine Reserve Master Plan (Brady/LSA 2002). While the intertidal assemblages at the Park may be capable of absorbing some additional stresses without compromising existing ecological values, increased resource protection is required because of the potential for increased impacts due to population growth and interest in increasing the opportunities to use the Park as a center for marine environmental education.

# 6.0 County Park Management and the Marine Life Protection Act Process

## 6.1 County Park Management

### History

Since its inception, the San Mateo County Parks and Recreation Division has managed the Fitzgerald Marine Reserve (State Marine Park) for multiple purposes (education, research, and recreation). In 1969, County Parks began its own surveillance and monitoring program of visitor attendance and fishing at the Park. Despite existing regulations to protect natural resources, including onsite ranger presence for enforcement, County Park managers and rangers, including volunteer docents, have remained concerned that natural resources continue to be negatively impacted by the high numbers of visitors. County Parks has had no authority to control fishing in the Park, but has been aware of the potential of impacts from high levels of visitor use, and implemented measures to control visitor use (e.g., bus reservation system, docent led field trips).

The long-term goal of the San Mateo County Parks and Recreation Division and Board of Supervisors has been to elevate the level of resource protection at the Fitzgerald State Marine Park. Currently as a State Marine Park, recreational, but not commercial extraction, is allowed, along with all other uses; scientific collecting with a permit, research, monitoring, and public recreation (including recreational harvest, unless otherwise restricted). In 1983, San Mateo County passed a resolution urging the California Fish and Game Commission to approve a full 'no-take' status for the Park. However, six attempts by the County to achieve this goal failed, due to opposition by fishing interests (Brady/LSA 2002), including an insufficient amount of data to conclude that the resources in the Park were at risk to over-fishing (Paul Riley, CDF&G, pers. com.). If all extractive uses were restricted in the Park, it would be designated by the State resource agencies as a fully protected State Marine Reserve.

### County Goals and Objectives

The primary mission of the San Mateo County Parks and Recreation Division is to focus on preserving, protecting, and providing education on the resources contained within Fitzgerald State Marine Park, because education and non-extractive recreational activities represent greater than 99% of the activities at the Park. Continued visitor use is important in meeting the County's goal of allowing the Park to be used for educational opportunities. However, high levels of educational use, combined with other uses, contribute to concerns about degradation of the Park's natural resources.

The potential for impacts to continue and possibly worsen, due to the variety of visitor uses, created the need for studies to provide information to further inform the development of County management goals. In addition, County Park managers identified the need for a comprehensive 'Master Plan', since it was clear that increased management would be necessary to ensure a balance between levels of use and the protection of the area's natural marine resources. Accordingly, the Fitzgerald Marine Reserve Master Plan (Master Plan) was created (Brady/LSA 2002) to function as a management tool for resource protection and use at the Park.

The Master Plan also functions as a planning tool to improve Park operations and facilities including modifications to restrooms, picnic areas, parking, scenic lookouts, trails, and signs, etc. Also, the newly acquired Pillar Point Marsh, located inland from the south end of the Fitzgerald State Marine Park, provides additional opportunities for education. Since the marsh represents a very different natural resource ecosystem than the shoreline areas of the Park, a comprehensive management plan was needed to include resource protection for the marsh within the context of the Park as a whole.

County managers recognized that making available a greater number of programs that foster appreciation and education of the natural resources could help meet the goal of continued use and protection. Current plans include creating a Marine Science Education Center at the Park and arranging for a greater percentage of field trips to be led by trained docents. While the bus reservation system will remain in place to control visitor numbers, additional controls will be achieved by requiring the general public to make reservations for groups of 10 or more.

The Master Plan is currently in the California Environmental Quality Act (CEQA) environmental review process. Responses to comments on the Draft Environmental Impact Report (EIR) for the project have been prepared, and with the DEIR, comprise the Final EIR (Thomas Reid Associates 2004). The San Mateo County Board of Supervisors is the lead agency that will approve the final project. The Master Plan outlines the following actions to preserve and enhance natural resources:

- Opportunities for educational outreach and interpretation.
- Need for well-trained staff to implement programs.
- Identify baseline information needs.
- Improvements to visitor management.
- Visitor facilities upgrades.
- Identification of the need to minimize impacts to neighborhoods.
- Protection of cultural resources.
- Recreational opportunities.
- Funding opportunities.

# 6.2 State Marine Resource Management

## Background

The Marine Life Protection Act (MLPA) (Chapter 10.5 of the CDF&G Code, Sections 2850 through 2863), which became law on January 1, 1999, created a new approach to the management and conservation of California's marine resources. The MLPA mandates that the State of California (CDF&G) design and manage an improved system of marine protected areas (MPAs) through the adoption of a Marine Life Protection Program. Section 2851 recognizes that a clearly defined purpose and set of scientific guidelines were not used in the past to establish existing state MPAs, including the Fitzgerald Marine Reserve.

The Marine Life Protection Act (MLPA) process will include recommendations for a system of MPAs, including sets of MPAs forming networks, with the goal of improving marine life protection on a regional basis (Section 2853(c)(1)).

Goals for the MLPA (Section 2853b) include:

- Protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.
- Sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.
- Improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and to manage these uses in a manner consistent with protecting biodiversity.
- Protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic value.
- Ensure that California's MPAs have clearly defined objectives, effective management measures, and adequate enforcement, and are based on sound scientific guidelines.
- Ensure that the state's MPAs are designed and managed, to the extent possible, as a network.

It is recognized that the various MPAs included in this system will require different levels of management, protection, and allowable uses to account for current uses, impacts, management concerns, and needs. Hence, as the MLPA process proceeds, decisions will need to be made as to the status of Fitzgerald State Marine Park in the regional MPA system. However, it is clear that all of the County's goals and objectives are consistent with the MLPA's goals and objectives in promoting greater management oversight to sustain resources and educational benefits, including enforcement.

A component of the State's efforts to improve marine resource management has been the re-classification of all existing MPAs using a more uniform system, which in a consistent manner conveys resource conservation objectives and allowable and non-allowable uses. Six classifications now replace the previous 18 State MPA classifications. Different levels of regulations are recognized in the current MPA classification system, which became effective on January 1, 2002 (Marine Managed Areas Improvement Act; Chapter 385, Stats. 2000). As related to marine resource protection, three types of MPAs are now designated: State Marine Reserves, State Marine Parks, and State Marine Conservation Areas. State Marine Cultural Preservation Areas, State Marine Recreational Management Areas, and State Marine Water Quality Areas are the three other types of MPAs, but are not part of the MLPA initiative, since they do not focus on marine biological resources.

In addition, Public Resources Code (PRC) section 36750 provides that, as of January 1, 2003, all State Water Resources Control Board Areas of Special Biological Significance (ASBSs), including the Fitzgerald ASBS, are classified as State Water Quality Protection Areas. A State Water Quality Protection Area [(36700(f) PRC)] is designated to protect marine species, biological communities, or unique or significant resources from an undesirable alteration in natural water quality.

- **Restrictions**: prohibits or limits by special conditions point source waste and thermal discharges. Nonpoint source pollution is controlled to the extent practicable.
- **Allowable Uses**: no other uses are restricted.

## James V. Fitzgerald State Marine Park

Based on the existing levels of protection, the James V. Fitzgerald Marine Reserve is currently classified by the CDF&G as the James V. Fitzgerald State Marine Park, a designation allowing recreational but not commercial extraction. The regulatory process to officially change the names of existing MPAs is expected to be completed in December 2004.

In the new classification system, a 'state marine park' is a non-terrestrial marine or estuarine area that is designated so the managing agency may provide opportunities for spiritual, scientific, educational, and recreational opportunities, as well as one or more of the following:

- Protect or restore outstanding, representative or imperiled marine species, communities, habitats and ecosystems;
- Contribute to the understanding and management of marine resources and ecosystems by providing the opportunity for scientific research in outstanding, representative or imperiled marine habitats or ecosystems;
- Preserve cultural objects of historical, archaeological and scientific interest in marine areas;
- Preserve outstanding or unique geological features.

The following restrictions and allowable uses apply to State Marine Parks:

**Restrictions**: it is unlawful to injure, damage, take or possess any living or nonliving marine resources for commercial exploitation purposes. Any human use that would compromise protection of the species of interest, natural community or habitat, or geological, cultural or recreational features, may be restricted by the designating entity or managing agency.

**Allowable Uses**: all other uses are allowed, including scientific collection with a permit, research, monitoring and public recreation (including recreational harvest, unless otherwise restricted). Public use, enjoyment and education are encouraged, in a manner consistent with protecting resource values.

## 6.3 Consistency Between County Actions and the MLPA Process

### County Actions

The program actions that San Mateo County have implemented for the Fitzgerald State Marine Park are consistent with the MLPA goals and objectives, and have been designed to address improved levels of marine resource protection to sustain educational benefits and resources through both education outreach, monitoring, and enforcement. The Fitzgerald Marine Reserve Master Plan provides the comprehensive management framework needed to balance improved resource protection with access and uses in this highly visited area. The Management Plan is focused on the non-extractive users at the Park and the protection of natural resources for those users. The Park is used almost exclusively for its educational and non-extractive recreational values. It is among the highest, if not the highest, used area in California for these purposes. If the natural resources at the Fitzgerald State Marine Park become degraded, due to high levels of visitor use or increases in extractive uses, hundreds of thousands of individual users would be affected. For many, visitation could be displaced to other coastal areas, and many people may not visit the shore at all. Consequently, the focus has been to protect the resources at the Park while effectively managing visitor impacts.

Accordingly, a goal of the San Mateo County Board of Supervisors has been to elevate the level of protection at the Park by eliminating all take, which would effectively change the Park to a State Marine Reserve. If this occurs, the James V. Fitzgerald State Marine Park would be re-designated and re-named the 'James V. Fitzgerald State Marine Reserve'. The results of the present study can be used by the CDF&G to assist in determining the need for increased resource protection, and the appropriate status for the Park within the state MPA system.

## MLPA Processes and Status

An essential element of the MLPA process is the design of regional MPA systems that improve the protection of marine resources. To achieve this objective, some existing MPAs might be re-classified to become 'State Marine Reserves' (SMRs) where all extractive activities, including fishing, are prohibited. Alternatively, regulations for some existing MPAs might be revised to provide for greater extractive activities, depending on the role of that particular MPA in the newly constructed State system. The MLPA states that: "Marine Life Reserves (no-take areas) are essential elements of an MPA system because they protect habitats and ecosystems, conserve biological diversity, provide a sanctuary for fish and other sea life, enhance recreational and educational opportunities, provide a reference point against which changes in the marine environment can be measured, and may help rebuild depleted fisheries" (Section 2851(f)).

The following restrictions and allowable uses apply to State Marine Reserves:

> **Restrictions** [36710(a) PRC]: it is unlawful to injure, damage, take or possess any living, geological or cultural marine resource, except under a permit or specific authorization from the managing agency for research, restoration or monitoring purposes. While, to the extent feasible, the area shall be open to the public for managed enjoyment and study, the area shall be maintained to the extent practicable in an undisturbed and unpolluted state. Therefore, access and use (such as walking, swimming, boating and diving) may be restricted to protect marine resources.
>
> **Allowable uses** [36710(a) PRC]: research, restoration and monitoring may be permitted by the managing agency. Educational activities and other forms of non-consumptive human use may be permitted by the designating entity or managing agency in a manner consistent with the protection of all marine resources.

The MLPA process has been stalled due to State budget problems. Prior to this period of inactivity, the process involved regional working groups consisting of stakeholders representing the fishing community, regulatory agencies, non-consumptive users, environmentalists, and other special interest groups. The working groups were to develop a preferred set of MPAs for their region that met the scientific and other goals specified in the MLPA. A final state-wide set of preferred MPAs was then to be subject to environmental review according to the requirements of the California Environmental Quality Act (CEQA). The entire process was to be completed in 2002, but shortages in State funding postponed these actions.

At the time that this report was being prepared in late summer 2004, meetings were being held to re-initiate the MLPA process with a priority on central California, a region that may include Fitzgerald State Marine Park. The central California region is being considered for the initial phase of MLPA implementation because this region offers a sound foundation for progress in the current MLPA process, based upon the efforts of prior working groups, available scientific resources, and potential partnerships to complete the project. A new approach is currently being

developed for implementing the MLPA, but the process will still include evaluations of existing and potential MPA sites, and determining the goals and objectives of any proposed MPA that may be included in the State's revised MPA system.

## MPA Goals, Monitoring, and Evaluation

The success of an MPA in meeting its goals can only be determined with a program of monitoring and evaluation. Consistent with this management component, the Fitzgerald Marine State Park has a historical record of close management attention and monitoring of visitor use patterns and trends, including biological resource inventories and evaluations for the purpose of assessing habitat conditions exposed to visitor use. The strong efforts by the San Mateo County Board of Supervisors and County Parks and Recreation Division in meeting these monitoring and evaluation objectives are consistent with requirements that would likely be required for an MPA. Hence, the management goals for the Fitzgerald Marine State Park should be clearly articulated, and these should serve as the basis for establishing a refined monitoring and evaluation plan. Considerations in refining the management framework for future monitoring and evaluation are presented in the next section of the present report.

In addition to efforts by County managers to increase resource stewardship of the Park, the GIS shoreline classification analysis of the San Mateo coast (see *Section 3.11 - Coastal GIS Mapping*) provides a valuable tool for documenting the unique habitat features of the Park, relative to other coastal areas in San Mateo County and the State. This type of analysis will be very important in the review of the proposed MPAs for the State.

## Adaptive Management

In moving toward a more effective and improved system of MPAs, the MLPA process recognizes the need for 'adaptive management' [2852(a) FGC]. Adaptive management allows managers to continue to improve their stewardship of natural resources, by continually evaluating their monitoring, and management programs and goals. Adaptive management recognizes that existing programs are tools for learning, and can be used to redirect management goals and objectives. Even if programs fail to meet their goals, they provide useful information for future actions. Monitoring and re-evaluation is emphasized so that the relationships of different actions and marine community responses can be better understood.

A number of changes are currently in the planning stages for the Fitzgerald State Marine Park that will affect visitor use and behavior. A key element of change is the new Marine Science Education Center that is proposed to be built in the parking lot (Brady/LSA 2002). The Education Center will affect visitor numbers and behavior. Several benefits and associated ecological consequences could potentially occur with the development of this Center. Continued monitoring and program evaluation actions are warranted as part of the adaptive management strategy for the Fitzgerald State Marine Park. These are discussed in the following section.

# 7.0 Resource Values and Management Considerations

A number of changes that will affect visitor use are currently in the planning stages for the Fitzgerald State Marine Park. This section evaluates current management and monitoring plans designed for changes in Park operations and use. This type of evaluation needs to occur on a regular basis as part of an 'adaptive management' approach that is an important component of the MLPA process (see *Section 6.3 - Consistency Between County Actions and the MLPA Process*).

Visitor use at the Park will change as a result of the new Education Center that is proposed to be constructed in the parking lot (Brady/LSA 2002). The Education Center could result in increased numbers of visitors to the Park and intertidal zone. The following management considerations were developed with an expected change in use in mind and the same commitment to the Fitzgerald Marine Reserve Master Plan objectives in protecting the natural resources. The considerations are intended to serve as a guide for future management planning, and are discussed below for extractive and non-extractive uses.

## 7.1 Non-Extractive Uses

### Levels of Visitation and Monitoring

A 'carrying capacity' goal of 500 people per day not to exceed 300 people at any given time was recommended by HLA (1993) and incorporated in the Fitzgerald Marine Reserve Master Plan (Brady/LSA 2002). The carrying capacity goal was recommended only as a 'target' to lower visitation, and was not expected to eliminate the concerns for visitor impacts and the need for visitor use management. The number of visitors in the past has frequently exceeded this 'carrying capacity', and past levels of visitation have been strongly implicated in reducing biodiversity in the Park. Therefore, we take a precautionary approach, and suggest that the carrying capacity limits (or some similar target level) remain, but combined with monitoring of visitor attendance. New methods will be needed to regulate and monitor visitor attendance.

Plans to build a Marine Science Education Center are in process. The facility would be constructed in the present parking lot area at North Lake Street. The Center is to provide opportunities for marine biological education and improve awareness of the types of impacts that can occur through visitor use. The parking lot would be expanded from 39 to 56 parking spaces with the Center. The operation and use of the Marine Science Education Center will likely introduce new challenges for managing visitor levels while striving to stay within the Master Plan carrying capacity goal. The following are considerations to control, monitor, and evaluate levels of visitation during operation of the new Education Center.

- New methods will be needed to determine total attendance levels at the Park, in order to determine whether the 'carrying capacity' (500 people per day and 300 people at any given time) of the Park is exceeded. Attendance at the park is and has been estimated by counting the number of cars in the parking lot each day. However, the proposed Marine Science Education Center will change how people use the Park. With this facility, many people may park in the lot and only use the center. Therefore, another method is needed to distinguish counts of those visiting the intertidal zone from those only visiting the Education Center. For example, a turnstile or infrared counter at the head of the main access path would provide direct counts of people using the intertidal zone.
- The Education Center could likely result in an increase in both the number of school field trips and the number of other visitors. The addition of the Education Center may also alter seasonal patterns of visitor use. The year-round operation of the proposed Education Center could result in increased visitation to the intertidal zone in winter, which is presently the season with lowest use. School groups that visit the Education Center in winter could also likely visit the intertidal zone. Like spring, there are low tides in the day during the winter. Increased numbers of visitors in winter could result in impacts to these areas that would not have occurred otherwise. However, if the increase in school field trips in winter results in fewer numbers of field trips in spring there would be no net change in the annual total of school trips.
- In order to prevent visitor levels exceeding 500 people day, school field trips should be closely monitored. For example, it might be necessary to limit the numbers participating in actual field trips to 300 students per day (or lower), which would allow for an additional 200 non-school related visitors per day. Furthermore, the timing when school trips explore the intertidal zone will need to be closely regulated in order to not exceed the Master Plan carrying capacity level of 300 people at any given time.
- Presently, daily peak use at the Park occurs mainly during low tides and nice weather. The Education Center could increase use throughout the day and over more days, and also be less dependent on weather conditions. The associated increased vehicle traffic would impact the neighborhood differently. Plans should be put in place to reduce the impacts of increased traffic to the neighborhood.

## Access and Improvements

- We agree with the Fitzgerald Master Plan, which states that the main access path to the intertidal zone that leads to Moss Beach Reef remain as the main access, and that all other paths remain as secondary access points. Limiting large improvements to other access areas will avoid potential impacts to associated upland habitats, lessen impacts to other neighborhoods, and prevent the potential for increased traffic on roads that are presently not greatly affected by visitors. However, a number of changes and improvements are proposed for the main access area (above). How these changes affect visitor use should be monitored. Retaining a single main access will enable visitor flow to be controlled and monitored most easily. The resulting information should then be used to determine whether other access paths should be improved or created, based on how well visitor use can be regulated through the main access.

- The option to pursue improving other shoreline access areas will always remain. For example, the County currently has the option to pursue creating an additional access path leading to the south end of Seal Cove Beach. This path would originate from the Distillery Restaurant parking lot. The path would involve securing easements from two private property parcels, one with a home and the other with the Distillery Restaurant (San Mateo County Parks and Recreation Division 2002). The combination of both easements would provide the continuous pathway necessary to connect Seal Cove Beach with the public right-of-way. However, it is not imperative at this present time to open this pathway, leaving the option for the County to focus and improve visitor access and management at the main access. Once visitor management efforts are in place. The County may decide later to improve other access areas.
- The access over San Vicente Creek should be improved to provide safer footing and to ensure that contact with the creek water is avoided, due to periodic occurrences of high concentrations of bacteria. The County presently has plans to improve the creek crossing to avoid water contact.
- Access fees (e.g., parking fees) could be implemented to offset some of the costs for Park improvements and maintenance. Results of our questionnaire showed that the public was about equally divided in their opinions concerning implementation of an access fee; about half of the respondents approved and half disapproved. However, it is important to note that the majority of the respondents indicated that an access fee would not necessarily deter them from visiting the Park.

## Education Outreach

- We suggest the Education Center be available not only to school groups but also to the general public, since the general public accounts for the largest proportion of visitors, particularly during weekends.
- The County should contact and potentially collaborate with other marine education programs in central California, such as programs sponsored by the Monterey Bay Aquarium that have successfully provided marine science education to various user groups. Another group is the Seashore Wonders-Tidepool Treasures Program in San Luis Obispo, CA. This program has an Education Center of similar size as that currently planned according to the Fitzgerald Marine Reserve Master Plan (**Figure 7-1**). The managers, operators, and staff of the Seashore Wonders-Tidepool Treasures Program have extensive experience in the development of marine science education curricula, displays, and interpretive modules, including the design and layout of classrooms,

**Figure 7-1**. Tidepool touch tank of the Seashore Wonders-Tidepool Treasures Program (San Luis Obispo, CA).

aquaria, seawater systems, and audiovisual equipment. The program includes traveling live aquaria with exhibits and satellite facilities. The planners of the Fitzgerald Education Center would benefit from the demonstrated success of the Seashore Wonders-Tidepool Treasures Program.

- The Education Center could include a seawater 'touch tank' that contains live organisms (**Figure 7-1**). The 'touch tank' experience can result in students spending less time in the intertidal zone, and can lessen the potential for handling organisms in the field.
- The Education Center could also include a traveling live 'touch tank' to visit schools, as used by the Seashore Wonders-Tidepool Treasures Program. This may reduce the number of school trips to the State Marine Park.
- Operation and maintenance costs must be considered in any facility relying on flowing seawater and live organisms for aquaria and displays. Seawater and organisms would need to be replaced/exchanged on a periodic basis. The facility could use seawater that is trucked in or use artificial seawater. Grant money and donations could be explored to offset costs. An onsite seawater intake and discharge for a flow-through seawater system would be cost prohibitive.
- School trips into the intertidal zone could be scheduled according to 'tidal level'. For example, elementary school groups could be scheduled to spend much of their time in the Education Center and only explore the upper intertidal zone. Time periods with lower tides would be reserved for older students who would benefit from the opportunity to explore lower intertidal areas that are more diverse.
- A field education program could also be patterned after the California State Parks program at the Asilomar Conference Grounds located on the Monterey Peninsula. This is one of the most structured marine science field education programs in California for school groups ranging from kindergarten through 12$^{th}$ grade. Each visiting school group is divided into sub-groups of 5-6 people to limit the number of students in the intertidal. An education outreach interpreter and chaperone lead each sub-group. The sub-groups are rotated between sandy beach-based activities and tidepool-based activities approximately every 15 minutes until all groups have been able to explore the tidepools. Each sub-group is taken to a different, but nearby rocky area, to reduce overuse of the same areas on the same days. A drawback in this program is that large school groups do not have the time for this lengthy process. Therefore, they go to other coastal areas that have no restrictions on numbers of people.
- We suggest that the Education Center have alternative marine science education programs that include other ecosystems and locations. On some occasions, all available openings for group visits to the Park may be reserved. During these times, curricula for other habitats, such as pier pilings and sand dunes could be provided for alternative marine science education opportunities. Additional docents to lead the field trips and curricula would be needed for these options.
- All types of visitor activities and compatibility with the neighborhood should be analyzed and monitored. The Education Center could change how people use the area, their behavior in the intertidal zone, traffic, and parking.

## Collaboration with Other Resource Stewardship Programs, Monitoring, and Evaluation

- San Vicente Creek water quality remains a potential issue for the health and safety of downstream habitats and user groups. Park management may benefit from partnering with the California Critical Coastal Area Program (joint government agency program) in addressing water quality issues. They may help establish programs to maintain/improve watershed practices to minimize, to the best extent practical, potential downstream effects to habitats and uses.
- We recommend that the Park monitoring program be designed so that the same data can be used for site-specific needs and compared with data from other research groups. We recommend that Park management have a liaison to the Multi-Agency Rocky Intertidal Network (MARINe). MARINe consists of scientists from Federal, State, and local government agencies, universities, and private and volunteer organizations that monitor important shoreline resources. The network is supported by 23 organizations. Key rocky intertidal habitats and species that include mussels, sea stars, abalone, surfgrass, rockweeds, and barnacles are sampled routinely each year. The monitoring has been conducted since the early 1990s at numerous sites in southern and central California. The data provides both spatial and temporal baselines for future monitoring at the Park, and can be used to evaluate and compare Park data with historical data over a broad geographic area. The liaison representing the Fitzgerald State Marine Park should have a strong marine biology background and experience with sampling and analysis methods, in addition to knowledge of the Park's habitats, baseline conditions, and history.
- Field monitoring assistance could be provided by members of the 'Long term Monitoring Program & Experiential Training for Students' (LiMPETS) organization of the Monterey Bay National Marine Sanctuary (MBNMS) and the 'Sustainable Seas' high school education program (Gulf of the Farallones National Marine Sanctuary). Partnerships with these organizations would strengthen their purpose and goals, and at the same time help to minimize costs for long-term monitoring.
- Monitoring at the Fitzgerald State Marine Park should include routine surveys to assess the abundance and health of the Park's black abalone population. A decline in black abalone in California from withering syndrome is well documented in the literature (Haaker et al. 1992, Steinbeck et al. 1992, Richards and Davis 1993, VanBlaricom 1993, Lafferty and Curis 1993, Tissot 1995, Alstatt, et al. 1996, Raimondi et al. 2002). MARINe has ongoing surveys to follow the northerly spread of withering syndrome. Currently the northern range of the syndrome is in Cambria, located approximately 140 mi (225 km) south of the Park. The LiMPETS and Sustainable Seas organizations could assist in monitoring black abalone in the Park for baseline information, changes in abundance, and the presence of withering syndrome in this species.
- LiMPETS and Sustainable Seas could also complete studies focused on other target species. Monitoring target species avoids the need to have a diverse background in marine taxonomy and identification. Surveys could focus on mussel bed mapping and surveys of sea stars, black turban snails, sea anemones, rockweeds, and owl limpets,

because these organisms are readily identifiable in the field and are also among the organisms at risk to visitor impacts.

- We strongly recommend that an on-site computer system be provided for data entry and that a database management system be developed to maintain visitor attendance records and biological monitoring data. Interface computer programs should be developed so that visitor logs and biological monitoring results are accessible to Park personnel. Members of MARINe (above) could help provide input for this task.

## 7.2 Extractive Uses

### Enforcement

- The signs at all trailheads should be improved to include information on tidepool etiquette and restricted activities in the Park (e.g., poaching, collecting of specimens, and harassment of marine mammals). The signs should also state that laws will be strictly enforced. The signs should include appropriate phone numbers to report suspected or confirmed violations (DFG-CALTIP-888.334.2258 and the Park ranger kiosk-650.728.3584).
- The information on the signs should be provided in multiple languages, as done at Point Pinos on the Monterey Peninsula where visitor use is also high.
- Surveillance and enforcement by Park rangers should continue, and perhaps the levels of surveillance should be increased.

### Fishers

Our review of shore fishing catch records collected by County Park rangers revealed an overall decline in numbers of anglers since the 1970s. The number of fishes caught per time spent fishing has also declined overall, but occasionally good numbers of fish can still be caught. Shore fishing in the Park is unique for the same reasons as tidepool exploring; the area is diverse and the flat bench rock platforms provide easy access to fishing areas. A factor in fishing success that could not be fully addressed from the existing data was whether the sizes of the fish have declined as a result of ongoing fishing pressure.

- County Park rangers should continue obtaining catch records from fishers. The catch data should also include length measurements when possible. Fish length/frequency data provide a more direct means to assess the status of the population with regards to fishing pressure. For example, a change to smaller fishes caught would be indicative of populations being overfished.

## Regulatory Considerations

Because over 99 % of the use in the State Marine Park is centered on education, an additional goal of the Fitzgerald Marine Reserve Master Plan is to designate the area exclusively for this use. An increased level of resource protection would also exclude recreational fishing, which would effectively change the State Marine Park to a 'no-take' area (i.e., State Marine Reserve). This change in status could only occur through the CDF&G Marine Life Protection Act (MLPA) process, which was established to create an improved network of marine protected areas in the State (see *Section 6.0 – County Park Management and the Marine Life Protection Act Process*). The current MLPA process is focused on central California and may include the James V. Fitzgerald State Marine Park.

- An argument that supports prohibiting all forms of fishing in the Park is the prime County management goal to support non-extractive uses of the Park's natural resources. Information reviewing resource conditions at the Park (status and trends), existing and planned Park use, and County management plans to ensure resource protection, are described in the present report.
- An alternative option in the MLPA process is prohibiting fishing within certain areas of the Park. This would partition the existing Park into two management zones. One zone, designated a State Marine Park, would allow recreational but not commercial fishing. The second zone, designated a State Marine Reserve, would provide complete protection for all resources by functioning as a no-take MPA. Regardless, effective monitoring would be needed to determine if the resource protection goals of the Park were being met.
- Without a change in fishing regulations in the Park, the County may explore using signs to encourage fishers to use only certain areas of the Park for fishing.

# 8.0 Literature Cited

Abbott, I. A. and G. J. Hollenberg. 1976. Marine algae of California. Stanford University Press. Stanford, California.

Addessi, L. 1994. Human disturbance and long-term changes on a rocky intertidal community. Ecol. App. 4(4):786-797.

Altstatt, J. M., R. F. Ambrose, J. M. Engle, P. L. Haaker, K. D. Lafferty, and P. T. Raimondi. 1996. Recent declines of black abalone, *Haliotis cracherodii*, on the mainland coast of central California. Mar. Ecol. Prog. Ser. 142:185-192.

Ambrose, R. F., J. M. Engle, P. T. Raimondi, M. Wilson, and J. Altstatt. 1995. Rocky intertidal and subtidal resources: Santa Barbara County mainland. Final report. U.S. Department of the Interior, Minerals Management Service. Pacific OCS Region.

Bally, R. and C. L. Griffiths. 1989. Effects of human trampling on an exposed rocky shore. Int. J. Env. Studies. 34:155-125.

Barry, J. P, C. H. Baxter, R. D. Sagarin, and S. E. Gilman. 1995. Climate-related long-term faunal changes in a California rocky intertidal community. Science. 267:672-675.

Beauchamp, K. A. and M. M. Gowing. 1982. A quantitative assessment of human trampling effects on a rocky intertidal community. Mar. Env. Res. 7:279-293.

Brady/LSA. 2002. Fitzgerald Marine Reserve Master Plan (Final Draft). Prepared for San Mateo County, Division of Parks and Recreation. May 2002.

Breen, B. 1998. Visitor impacts at Fitzgerald Marine Reserve. Ecosystem Observations. Monterey Bay National Marine Sanctuary.

Brosnan, D. M. and L. L. Crumrine. 1994. Effects of human trampling on marine rocky shore communities. J. Exp. Mar. Biol. Ecol. 177:79-97.

Brown, P. J. and R. B. Taylor. 1999. Effects of trampling by humans on animals inhabiting coralline algal turf in the rocky intertidal. J. Exp. Mar. Biol. Ecol. 235:45-53.

California State Water Resources Control Board 1979. California marine waters areas of special biological significance reconnaissance survey report. James V. Fitzgerald Marine Reserve, San Mateo County. State Water Resources Control Board. Surveillance and Monitoring Section. Water Quality Monitoring Report No. 79-12.

Catterall, C. P. and I. R. Poiner. 1987. The potential of human gathering on shellfish populations with reference to some NE Australian intertidal flats. Oikos 50:114-122.

Chan, G. L. 1970. Analysis of the effects of public and educational school field trips on a marine environment, Duxbury Reef. Ph.D. dissertation, University of California, Berkeley. 139 p.

Chapman, M. G. and A. J. Underwood. 1996. Experiments on effects of sampling biota under intertidal and shallow subtidal boulders. J. Exp. Mar. Biol. Ecol. 207:103-126.

Clarke, K. R. and R. M. Warwick. 2001. Change in marine communities: an approach to statistical analysis and interpretation, 2nd edition. PRIMER-E ltd. Plymouth, United Kingdom.

Clowes, S. W. 2002. Temporal change in algal communities at Point Pinos rocky intertidal as potential indicators of human and natural disturbance. M. S. Thesis. Hopkins Marine Station. Stanford University. 46 pp.

Clowes, S. W. and B. S. Coleman. 2000. A quantitative analysis of human activity at Point Pinos rocky intertidal. Hopkins Marine Station. Stanford University. Biology 175H. June 2000.

Coats, D. A., E. Imamura, A. K. Fukuyama, J. R. Skalski, R. S. Kimura, and J. R. Steinbeck. 1999. Monitoring of biological recovery of Prince William Sound intertidal sites impacted by the Exxon Valdez oil spill. 1997 Biological monitoring survey. NOAA Technical Memorandum NOS OR&R 1. Seattle, Washington. February 1999.

Connell, J. H. 1978. Community interactions on marine rocky intertidal shores. Ann. Rev. Ecol. Syst. 3:169-192.

Connell J. H. and W. P. Sousa. 1983. On the evidence needed to judge ecological stability or persistence. Am. Nat. 121(6):789-824.

Daly, M. A. and A. C. Mathison. 1977. The effects of sand movement on intertidal seaweeds and selected invertebrates at Bound Rock, New Hampshire, USA. Mar. Biol. 43:45-55.

Davis, A. N. and R. T. Wilce. 1987. Algal diversity in relation to physical disturbance: a mosaic of successional stages in a subtidal cobble habitat. Mar. Ecol. Prog. Ser. 37:229-237.

Davis, C. 2002. The effect of trampling on the abundance and density of algal and invertebrate assemblages of the upper intertidal at Point Pinos. Student Paper, Marine Ecology. Moss Landing Marine Laboratories. December 2002.

Dayton, P. K. 1971. Competition, disturbance, and community organization: the provision and subsequent utilization of space on a rocky intertidal community. Ecol. Monogr. 42(4):351-389.

Dayton, P. K. 1992. Temporal and spatial patterns of disturbance and recovery in a kelp forest community. Ecol. Monogr. 62(3):421-445.

Dayton, P. K. and M. J. Tegner. 1984. Catastrophic storms, El Niño, and patch stability in a southern California kelp community. Science. 224:283-285.

Dayton, P. K., M. J. Tegner, P. B. Edwards, and K. L. Riser. 1998. Sliding baselines, ghosts, and reduced expectations in kelp forest communities. Ecol. App. 8(2):309-322.

Duran, L. R. and J. C. Castilla. 1989. Variation and persistence of the middle rocky intertidal community of central Chile, with and without human harvesting. Mar. Biol. 103:555-562.

Ebling, A. W., D. R. Laur, and R. J. Rowley. 1985. Severe storm disturbances and reversal of community structure in a southern California kelp forest. Mar. Biol. 84:287-294.

Engle, J. M. 1997. Nearshore El Niño effects: disturbance and renewal. Alolkoy 10(4):6.

Engle, J. M., and G. E. Davis. 2000. Ecological condition and public use of the Cabrillo National Monument intertidal zone 1990-1995. U.S. Geological Survey Report 00-98. Prepared for the Cabrillo Historical Association, Cabrillo National Monument, Point Loma, California. 175 p.

Foster, M. S. A. P. DeVogelaere, C. Harrold, J. S. Pearse, and A. B. Thum. 1988. Causes of spatial and temporal patterns in rocky intertidal communities of central and northern California. Mem. Calif. Acad. Sci. 9:1-45.

Foster, M. S., E. W. Nigg, L. M. Kiguchi, D. D. Hardin, and J. S. Pearse. 2003. Temporal variation and succession in an algal-dominated high intertidal assemblage. J. Exp. Mar. Bio. Ecol. 289:15-39.

Ghazaanshaki, J., T. D. Huchel, and J. S. Devinney. 1983. Alteration of southern California rock shore ecosystems by public recreational use. J. Env. Manag. 16:379-394.

Gibson, R. N. and R. M. Yoshiyama. 1999. Intertidal fish communities. pp.264-296 *in* Horn, M. H., K. Martin and M. A. Chotkowski (eds.), Intertidal Fishes: Life in Two Worlds. Academic Press. San Diego. 399 pp.

Green, R. H. 1993. Application of repeated measures designs in environmental impact and monitoring studies. Aust. J. Ecol. 18:81-98.

Griffiths, C. L. and G. M. Branch. 1997. The exploitation of coastal invertebrates and seaweeds in South Africa: historical trends, ecological impacts and implications for management. Trans. Roy. Soc. S. Afr. 52(1):121-148.

Gunnill, F. C. 1985. Population fluctuations of seven macroalgae in southern California during 1981-1983 including effects of severe storms and El Niño. J. Exp. Mar. Biol. Ecol. 85:149-164.

Haaker, P. L., D. O. Parker, H. Togstad, D. V. Richards, G. E. Davis, and C. S. Friedman. 1992. Mass mortality and withering syndrome in black abalone, *Haliotis cracherodii*, in California. *in* S.A. Shepherd, M.J. Tegner, and S.A. Guzman del Proo (eds.). Abalone of the world: biology, fisheries and culture. Blackwell Scientific Publications Ltd., Oxford. p. 214-224.

Harding Lawson and Associates. 1993. James V. Fitzgerald Marine Reserve baseline and carrying capacity study. Prepared for the County of San Mateo, Department of Environmental Services. Redwood City, California.

Hockey, R. A. R. and A. L. Bosman. 1986. Man as an intertidal predator in Transkei: disturbance, community convergence and management of a natural food resource. Oikos. 46:3-14.

Horn, H., S. N. Murray, and R. R. Seapy. 1983. Seasonal structure of a central California rocky intertidal community in relation to environmental variation. Bull. Southern Calif. Acad. Sci. 82(2):79-94.

Keough, M. J. and G. P. Quinn. 1998. Effects of periodic disturbances from trampling on rocky intertidal algal beds. Ecol. App. 8(1): 141-161.

Kido, J.S. and Murray S.N. 2003. Variation in owl limpet *Lottia gigantea* population structures, growth rates, and gonadal production on southern California rocky shores. Mar. Ecol. Prog. Ser. 257:111-124

Kingsford, M. J., A. J. Underwood, and S. J. Kennelly. 1991. Humans as predators on rocky reefs in New South Wales, Australia. Mar. Ecol. Prog. Ser. 72:1-14.

Kinnetics, Inc. 1989. Study of the rocky intertidal communities of central and northern California. Final report. Vol. I of III. OSC Study. MMS 91-0089.

Lafferty, K. D. and A. M. Kuris. 1993. Mass mortality of abalone *Haliotis cracherodii* on the California Channel Islands: tests of epidemiological hypotheses. Mar. Ecol. Prog. Ser. 96:239-248.

Lasiak, T. 1991. The susceptibility and/or resilience of rocky littoral mollusks to stock depletion by the indigenous coastal people of Transkei, Southern Africa. Biol. Conserv. 56:245-264.

Leet, W.S., C.M. Dewees, R. Klingbell, and E.J. Larson (eds.). 2001. California's Living Marine Resources: A Status Report. The Resources Agency, California Department of Fish and Game.

Levine, N.E. 2004. Size frequency data of *Lottia gigantea* at the James V. Fitzgerald Marine Reserve, Moss Beach, California. Student paper submitted to the biological sciences department, University of California, Berkeley.

Lindberg, D. R., J. A. Estes, and K. I. Warheit. 1998. Human influences on trophic cascades along rocky shores. Ecol. App. 8(3):880-890.

Littler, M. M., D. R. Martz, and D. S. Littler. 1983. Effects of recurrent sand deposition on rocky intertidal organisms: importance of substrate heterogeneity in a fluctuating environment. Mar. Ecol. Prog. Ser. 11:129-139.

Lubchenco, J., B. A. Menge, S. D. Garrity, P. J. Lubchenco, L. R. Ashkenas, S. D. Gaines, R. Emlet, J. Lucas, and S. Strauss. 1984. Structure, persistence, and role of consumers in a tropical rocky intertidal community (Taboguilla Island, Bay of Panama). J. Exp. Mar. Biol. Ecol. 78:23-73.

McGuinness, K. A. 1987. Disturbance and organisms on boulders. I. Patterns in the environment and community. Oecologia. 71:409-419.

Menge, B. A. 1976. Organization of the New England rocky intertidal community: role of predation, competition, and environmental heterogeneity. Ecol. Monogr. 46:355-393.

Moreno, C. A., J. P. Southerland, and H. F. Jara. 1984. Man as a predator in the intertidal zone of southern Chile. Oikos. 42:155-160.

Morris, R. H., D. P. Abbott, and E. C. Haderlie. 1980. Intertidal invertebrates of California. Stanford University Press. Stanford, California.

Moser, H. G., W. Watson, S. R. Charter, D. A. Ambrose and E. M. Sandknop. 1996. The Early Stages of Fishes in the California Current Region. California Cooperative Oceanic Fisheries Investigations, Atlas No. 33. Allen Press Inc., Lawrence, Kansas.

Murray, S. N. 1998. Effectiveness of marine life refuges on southern California shores. pp. 1453-1465 in: Taking a Look at California's Ocean Resources: An Agenda for the Future, ASCE, Reston, VA (USA), 1998, Vol. 2.

Murray, S. N. and T. A. Gibson. 1979. Vulnerability of the rockweed *Pelvetia compressa* to anthropogenic disturbance on southern California rocky shores. Phycologia. 36:75-76.

Murray, S. N., T. G. Denis, J. S. Kido, and J. R. Smith. 1999. Human visitation and the frequency and potential effects of collecting on rocky intertidal populations in southern California marine reserves. CalCOFI rep. 40:100-106.

Newton, L. C., E. V. H. Parkes, and R. C. Thompson. 1993. The effects of shell collecting on the abundance of gastropods on Tanzanian shores. Biol. Conserv. 63:241-245.

Orians, G. H. 1975. Diversity, stability and maturity in natural ecosystems. pp. 139-150 *in* Unifying concepts in ecology. W.H. Van Dobben and R.H. Lowe-McConnel (eds.). Dr. W. Junk B. V. Publishers. The Hague, Netherlands.

Paine, R. T. 1969. A note on trophic complexity and species diversity. American Naturalist. 100:91–93.

Paine R. T. 1974. Intertidal community structure. Experimental studies on the relationship between a dominant competitor and it principal predator. Oecologia. 15:93-120.

Paine R. T. 1986. Benthic community-water column coupling during the 1982-1983 El Niño. Are community changes at high latitudes attributable to cause or coincidence? Limnol. Oceonogr. 31(2):351-360.

Pombo, O. A. and A. Escofet. 1996. Effect of exploitation on the limpet *Lottia gigantea*: a field study in Baja California (Mexico) and California (U.S.A.). Pac. Sci. 50(4):493--403.

Povey, A. and M. J. Keough. 1991. Effects of trampling on plant and animal populations on rocky shores. Oikos. 61:355-368.

Raimondi, P. T., C. M. Wilson, R. F. Ambrose, J. M. Engle, and T. E. Minchinton. 2002. Continued declines of black abalone along the coast of California: are mass mortalities related to El Niño events? Mar. Ecol. Prog. Ser. 242:143-152.

Ralston, S.L. and M.H. Horn. 1986. High tide movements of the temperate zone herbivorous fish Cebidichthys violaceus (Girard) as determined by ultrasonic telemetry. J. Exp. Mar. Biol. Ecol. 98:35-50.

Richards, D. V. 1994. Effects of disturbance on population dynamics of selected taxa in the rocky intertidal zone of Channel Islands National Park, California. pp. 45-58 *in* W. L. Halverson and G. J. Maender (eds.), Fourth California Islands Symposium: Update on the Status of Resources. Santa Barbara Museum of Natural History, Santa Barbara, California.

Richards, D. V. and G. E. Davis. 1993. Early warnings of modern population collapse in black abalone *Haliotis cracherodii*, Leach. 1814 at the California Channel Islands. J. Shellfish Res. 12(2):189-194.

Ricketts, E. F., J. Calvin, J. W. Hedgepeth, and D. W. Phillips. 1985. Between Pacific tides. Fifth edition. revised by J. Hedgepeth. Stanford University Press. Stanford, California. 652 pp.

Sagarin, R. D, J. P. Barry, S. E. Gilman, and C. H. Baxter. 1999. Climate-related change in an intertidal community over short and long time scales. Ecol. Monogr. 69(4):465-490.

San Mateo County Parks and Recreation Division. 2002. Coastal Access Improvement Plan. October 2002.

Schiel, D. R. and D. I. Taylor. 1999. Effects of trampling on a rocky intertidal algal assemblage in southern New Zealand. J. Exp. Mar. Biol. Ecol. 235:213-235.

Schiel, D.R., J.R. Steinbeck, and M.S. Foster. 2004. Ten years of induced opcenn waming causes comprehensive changes in marine benthic communities. Ecol. 85(7):1833-1839)

Schroeter, S. C., J. D. Dixon, J. Kastendiek, and R. O. Smith. 1993. Detecting the ecological effects of environmental impacts: a case study of kelp forest invertebrates. Ecol. App. 3(2):331-350.

Seapy, R. R. and M. M. Littler. 1982. Population and species diversity fluctuations in a rocky intertidal community relative to severe aerial exposure and sediment burial. Mar. Biol. 71:87-96.

Setran, A.C. and D.W. Behrens. 1993. Transitional ecological requirements for early juveniles of two sympatric fishes, *Cebidichthys violaceus* and *Xiphister mucosus*. Env. Biol. Fish. 37:381-395.

Shanks, A. L. and W. G. Wright. 1986. Adding teeth to wave action: the destructive effects of wave-borne rocks on intertidal organisms. Oecologia. 69:420-428.

Smith, G. M. 1969. Marine algae of the Monterey Peninsula, California. Stanford University Press, Stanford, CA. 752 pp.

Smith, R. I. and J. T. Carlton. 1975. Light's manual: Intertidal invertebrates of the central California coast. R. I. Smith and J. T. Carlton (eds.). The Regents of the University of California. Third Edition.

Sousa, W. P. 1979. Disturbance in marine intertidal boulder fields: the non-equilibrium maintenance of species diversity. Ecology 60:1225-1239.

Sparling, R. 1977. An annotated list of the marine algae (Chlorophyta, Phaeophyta, Rhodophyta) of San Luis Obispo County, California with keys to genera and species. Blake Printery. San Luis Obispo, California. 88 pp.

Steinbeck, J. R., J. M. Groff, C. S. Friedman, T. McDowell, and R. P. Hedrick. 1992. Investigations into a mortality among populations of the central California black abalone. *in:* S.A. Shepherd, M.J. Tegner, and S.A. Guzman del Proo (eds.). Abalone of the world: biology, fisheries and culture. Blackwell Scientific Publications Ltd., Oxford. p. 203-213.

Stewart-Oaten, A., W. M. Murdoch, and K. R. Parker. 1986. Environmental impact assessment: "pseudoreplication" in time? Ecology 67:929-940.

Talarico, J. 2003. Abundance of *Pisaster ochraceus* at six rocky intertidal reefs from Pacifica to Pigeon Point, California. Student paper. Biological sciences department. San Francisco State University.

Tegner, M. J. and P. K. Dayton. 1991. Sea urchins, El Niños, and the long term stability of southern California kelp forest communities. Mar. Ecol. Prog. Ser. 77:49-63.

Tenera Environmental. 1997. Diablo Canyon Power Plant Thermal Effects Monitoring Program Analysis Report. Chapter 1 - Changes in the Marine Environment Resulting from the Diablo Canyon Power Plant Discharge. Prepared for Pacific Gas and Electric Co., San Francisco, CA.

Tenera Environmental. 2003. A Comparative intertidal study and user survey, Point Pinos, California. Submitted to the Monterey Bay Sanctuary Foundation. July 2003.

Tissot, B. N. 1995. Recruitment, growth, and survivorship of black abalone on Santa Cruz Island following mass mortality. Bull. Southern Cal. Acad. Sci. 94(3):32-47.

Underwood, A. J. 1992. Beyond BACI: the detection of environmental impacts on populations in the real, but variable, world. J. Exp. Mar. Biol. Ecol. 161:145-178.

Underwood, A. J. 1993. The mechanics of spatially replicated sampling programmes to detect environmental impacts in a variable world. Aust. J. Ecol. 18:99-116.

Underwood, A. J. 1994. On beyond BACI: Sampling designs that might reliably detect environmental disturbances. Ecol. App. 4:3-15.

Underwood, A. J. and S. J. Kennelly. 1990. Pilot studies for designs of surveys of human disturbance of intertidal habitats in New South Wales. Aust. J. Mar. Fresh. Res. 41:165-173.

VanBlaricom, G. R., J. L. Ruediger, C. S. Friedman, D. D. Woodward and R. P. Hedrick. 1993. Discovery of withering syndrome among black abalone *Haliotis cracherodii* Leach 1814, populations at San Nicholas Island, California. J. Shellfish Res. 12:185-188.

Walder, R. R. and M. S. Foster. 2000. Recovery of rocky intertidal assemblages following the wreck and salvage of the *F/V Trinity*. Final Report, Monterey Bay National Marine Sanctuary: Years 1 and 2. June 2000.

Warwick, R. M. and K. R. Clarke. 1993. Increased variability as a symptom of stress in marine communities. J. Exp. Mar. Biol. Ecol. 172:215-226.

Wiens, J. A. and K. R. Parker. 1995. Analyzing the effects of accidental environmental impacts: approaches and assumptions. Ecol. App. 5:1069-1083.

Wright, W. G. and D. R. Lindberg. 1982. Direct observation of sex change in the patellacean limpet *Lottia gigantea*. J. Mar. Biol. Assoc. U.K. 62:737-38.