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GEOLOGY AND COASTAL HAZARDS IN THE NORTHERN MONTEREY BAY, CALIFORNIA
Field Trip Guidebook
November 4, 2000

Open-File Report 00-438

U.S. Department of the Interior
U.S. Geological Survey

GEOLOGY AND COASTAL HAZARDS OF THE NORTHERN MONTEREY BAY, CALIFORNIA

FIELD TRIP GUIDEBOOK
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Field Trip in conjunction with:
"Preserving Coastal Environments"
California Shore and Beach Preservation Association Conference
Monterey, CA
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By

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Geology and Coastal Hazards of Northern Monterey Bay
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INTRODUCTION

This field trip will explore the relationships between geology and coastal hazards, and human influences in the northern Monterey Bay, which is a tectonically active high wave energy environment. Seacliffs, shore platforms, pocket beaches and a headland/embayment morphology characterize this rocky coastline. Many studies of the onshore and offshore geology and geophysics, the local wave climate, and the effects of large storm events and earthquakes on the coastline have been conducted in this region (see *Related Reading*). This field trip will summarize the many findings of these research investigations, as well as consider the relationship between the rates and styles of short- and long-term seacliff erosion and the variations in the local geology.

During the field trip we will investigate seacliff sites of different geological lithologies, geographic orientations, and varying protection from wave attack, and consider how these variables affect not only the rate or magnitude of seacliff retreat but also the styles of retreat. In general the two primary forcing factors in the retreat of seacliffs are marine and terrestrial processes. At the various field trip stops we will consider the relative importance of these processes in shaping the coastline at that particular location. Where beaches have developed, whether naturally or by emplacement of man-made structures, we will look at the occurrence of the beaches (why they exist where they do) and the response of the beaches to large storm events. Finally, this trip will focus on the various coastline protection structures that have been built, and their effectiveness in protecting development on the beaches or at the tops of the seacliffs.

The first stop of the trip will be at the Long Marine Lab facility where we will begin by looking at the most resistant geological unit, the Miocene Santa Cruz Mudstone, and some of the geological features associated with this part of the Bay. We will continue through the morning to make our way east and south into the inner Bay, as well as into the less resistant lithologies of the Pliocene Purisima Formation and finally the Pleistocene Aromas Sand. The route will follow the coast wherever possible so participants can get a full perspective of the northern Monterey Bay, even where stops have not been planned.

ACKNOWLEDGEMENTS

I wish to thank Gary Griggs for generously providing many of the accompanying photos used in this guidebook. This trip would not have been possible without the continual support

and numerous suggestions of Lesley Ewing. I would also like to thank Bruce Richmond, Ann Gibbs, Scott Calhoun and Amy Foxgrover for valuable input.

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CSBPA2000 Field Trip Itinerary
Geology and Erosion Hazards of Northern Monterey Bay
November 4, 2000

8:00am: Meet in lobby of Monterey Beach Hotel
8:05am: Bus leaves Monterey Beach Hotel

8:45am: Arrive **Stop 1**: Long Marine Lab Facility, Santa Cruz
Stop includes brief tour of facility by the director of the Institute of Marine Sciences, Dr. Gary Griggs, and a walk to the cliff edge to observe the geologic setting of the location.

9:15am: Leave Long Marine Lab; head east along West Cliff Drive, past the Santa Cruz Lighthouse, Wharf and Boardwalk. Cross over the San Lorenzo River on San Lorenzo Blvd. Take East Cliff Dr. to the San Lorenzo Point/Seabright Beach overlook.

9:30am: Arrive **Stop 2:** San Lorenzo Point/Seabright Beach Overlook
Walk out along San Lorenzo Point. This stop includes a discussion of the erosion hazards at Seabright Beach in terms of the history of the Santa Cruz Harbor Jetty, and an overview of the local geology.

10:00am Leave Seabright Beach Overlook; head east along East Cliff Dr., past Twin Lakes, Corcoran, and Moran Beaches to the Village of Capitola.

10:15am Arrive **Stop 3:** Esplanade at Capitola
Walk to end of Esplanade at pumping station. Discussion of Capitola Beach, the groins and their relation to the Santa Cruz Harbor, and the geology and erosion hazards of the seacliffs along Depot Hill.

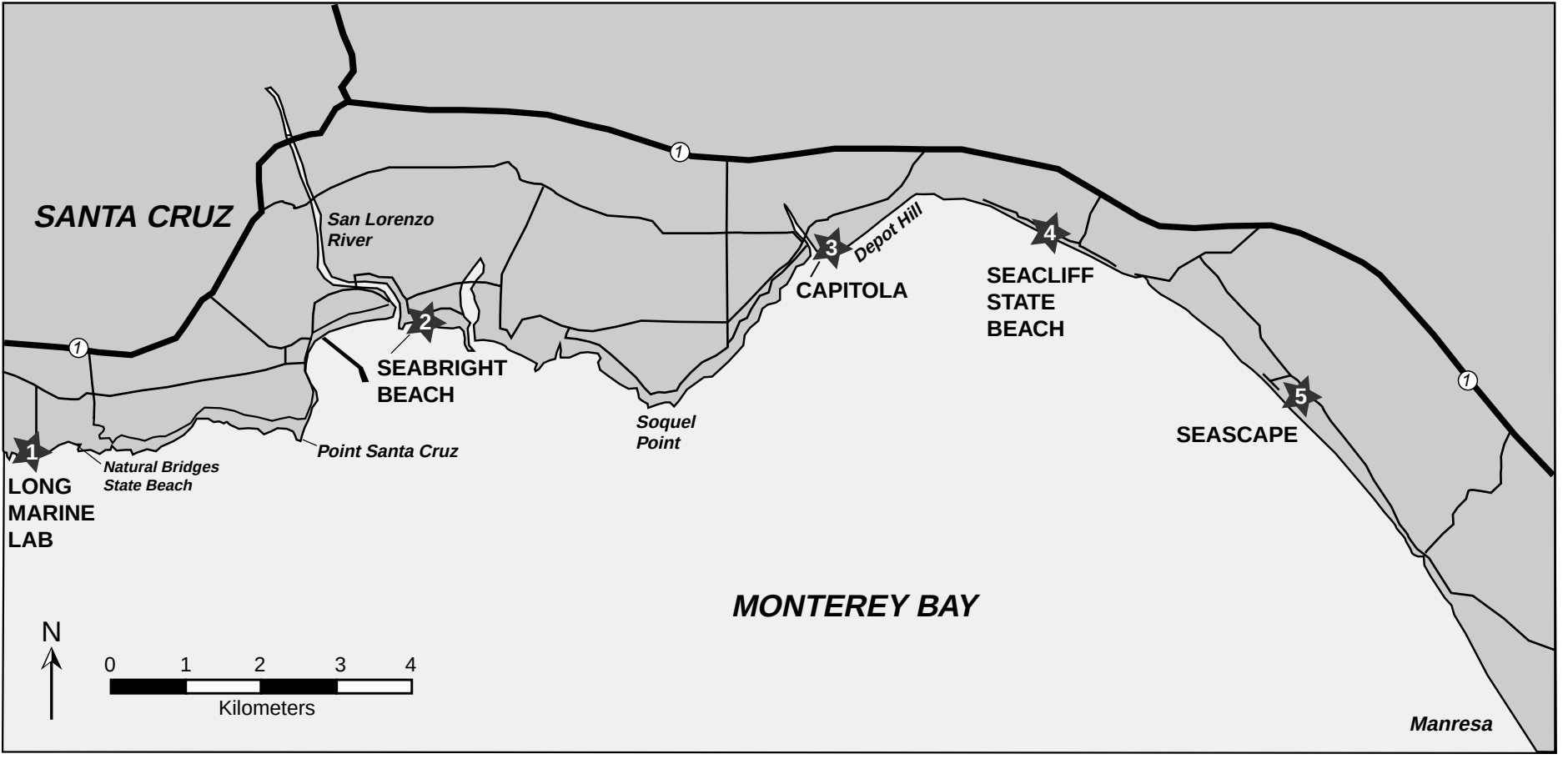
10:45am Leave Capitola; head east on Park Ave. Take Highway 1 south to State Park Dr. and State Park Dr. to Seacliff State Beach.

11:00am Arrive **Stop 4**: Seacliff State Beach
Walk along state park road to houses at Las Olas Dr. Discussion of beach and history of seawalls, geology and erosion hazards of the cliffs, and the problems associated with both cliff-top and base-of-cliff structures. History of the cement ship (the Palo Alto).

11:20am Leave Seacliff State Beach; head south on Highway 1 to San Andreas Rd. San Andreas south to Seascape Blvd. Seascape Blvd to Seascape Village.

11:35am Arrive **Stop 5:** "Beercan" Beach
Discussion of seawall at La Gaviota, geology and erosion history of Seascape area, summary/conclusion of field trip.

12:00pm Leave Seascape. Take Highway 1 south to Monterey Beach Hotel.
12:30pm Arrive at Monterey Beach Hotel



Map shows locations of field trip stops in relation to major geographic locations in the greater Santa Cruz area.

Institute of Marine Sciences
an Organized Research Unit
at UC Santa Cruz

Long Marine Lab

Over 130 UC Santa Cruz scientists, researchers, visiting scientists, graduate students and undergraduate students utilize the facilities at Long Marine Laboratory each year. Long Marine lab is known throughout the world for the innovative marine mammal research in areas such as diving physiology, physiological ecology, bioacoustics, and cognition. Active research at the lab is also underway in the areas of environmental toxicology, and in nearshore invertebrate marine biology.

General marine science research facilities located at Long Marine Laboratory include seawater laboratories for plankton and marine invertebrate research, radioisotope labs, environmental analytical labs for extraction and precise measurements of the trace levels of organic pollutants (DDT and derivatives, PCB's, PAH's, etc.) in water and tissue, a high volume seawater diluter for exposure experiments, a culture lab for marine invertebrate larvae and juveniles, controlled photoperiod labs, plankton culture lab, small-boat operation and research SCUBA diving facility, meteorological station, and a remote sensing surface current station (CODAR) operated in cooperation with NOAA.

Researchers and staff at Long Marine Lab have developed specially designed tanks and equipment that are used for diving physiology, bioacoustics, and cognition research of marine mammals. Facilities include a 17,000 sq. ft. enclosed yard with five large pools and five smaller pools. The largest tank is designed to be acoustically quiet, and has an underwater viewing lab with large windows for visual access. Opening into the marine mammal research yard in a nearby building are a marine mammal food preparation and storage lab, a veterinary/pathology lab, and general access research/procedure labs. Marine mammal support equipment includes high speed video cameras, hydrophones for underwater acoustic work and an acoustic analysis system, expanded frequency tape recorders, oxygen analyzer, blood gas analyzer, ultrasound sensor as well as specialized transport cages for moving pinnipeds and cetaceans to and from the field. The population of marine mammals present at the laboratory during the last several years has included two Atlantic Bottlenose dolphins, four California sea lions, an elephant seal and a harbor seal, as well as occasional or short-term residents (normally young elephant seals used for research projects) or stranded animals who ared taken care of at the lab for short periods of time before relocated to other facilities.

Long Marine Lab provides an exceptional opportunity to develop marine programs and facilities that cannot be developed on campus because of space or funding constraints or because of the need for large volumes of running seawater and large outdoor tanks and pool needs. The close proximity of the lab, which is only a ten minute drive from campus, permits ease of integration of activities there with the campus' instructional and research activities.

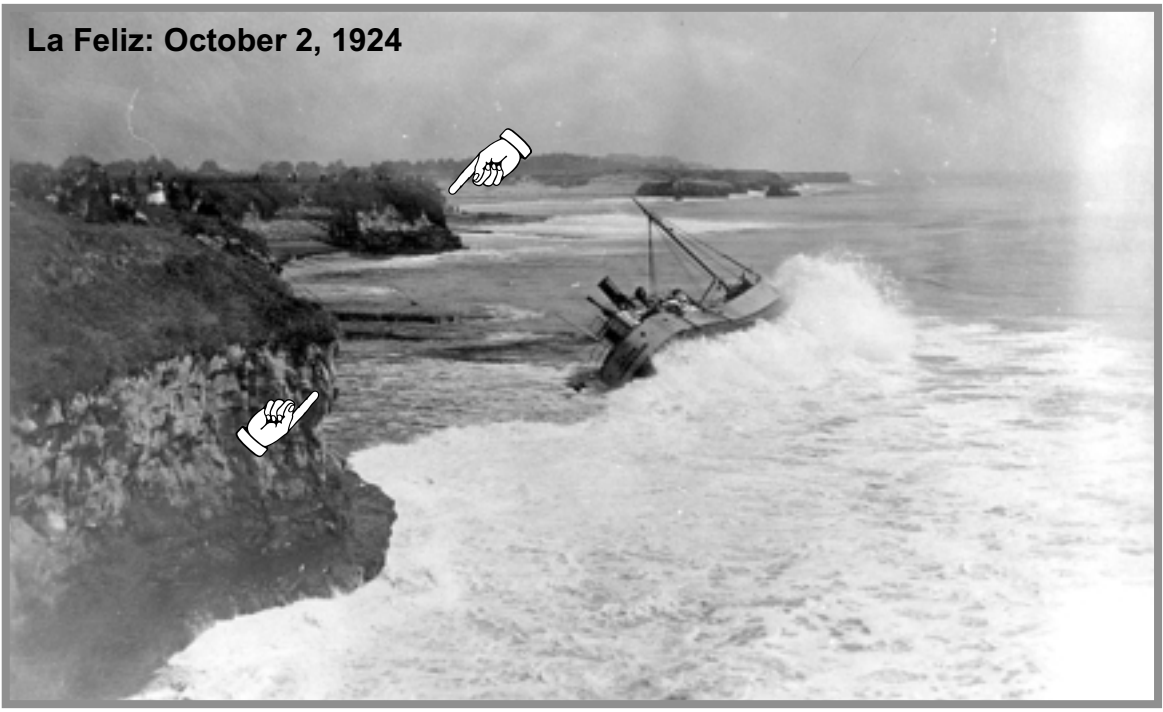
At present, LML is primarily a marine biology (both marine vertebrate/mammal and invertebrate biology) and environmental toxicology support facility. In the future it is envisioned as supporting a broader disciplinary cross section of marine sciences research activities. With the exception of some funds from the State Department of Fish and Game which assisted in the construction of the Trace Organics Facility at the lab, all of the present LML facilities were constructed with non-state funds, primarily private donations.

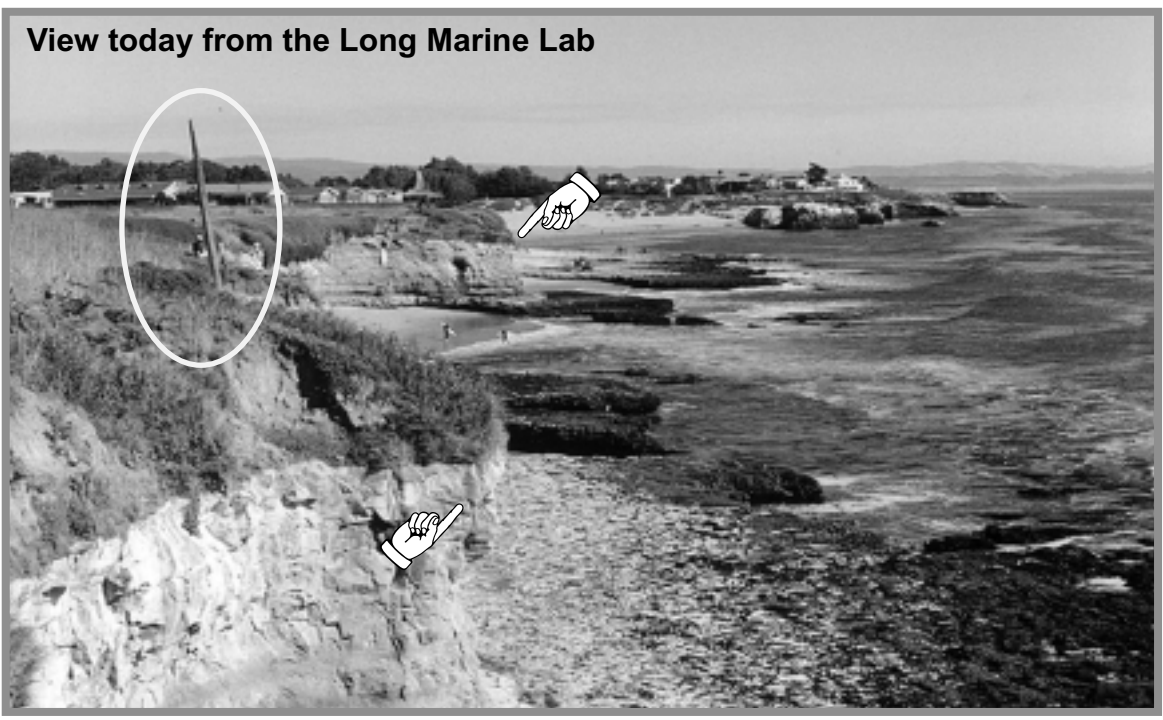
Long Marine Lab is located on the open coast immediately north of Monterey Bay. The seawater quality is excellent with no nearby sources of contamination. The water temperature ranges between 11 and 17 degrees centigrade. During upwelling events, nutrient-rich water is brought to the surface. The El Niño current periodically brings warmer seawater from the south. The flowing seawater temperature in the tanks and wet labs is within one degree of the seawater at the lab's ocean intake.

Through an agreement with the U.S. Geological Survey, the institute operates the 43-foot research vessel David Johnston, which is berthed at the Santa Cruz Small Craft Harbor. The institute also maintains many smaller trailerable boats, inflatable boats, and kayaks.

The major components of the lab facilities are 12,000 square feet of permanent research buildings, 8,500 square feet of temporary office buildings, 2,000 square feet of facility support space in temporary buildings, and a seawater system capable of delivering 650 gallons per minute of high-quality filtered seawater. Basic support facilities include a computer room and administrative and academic offices.

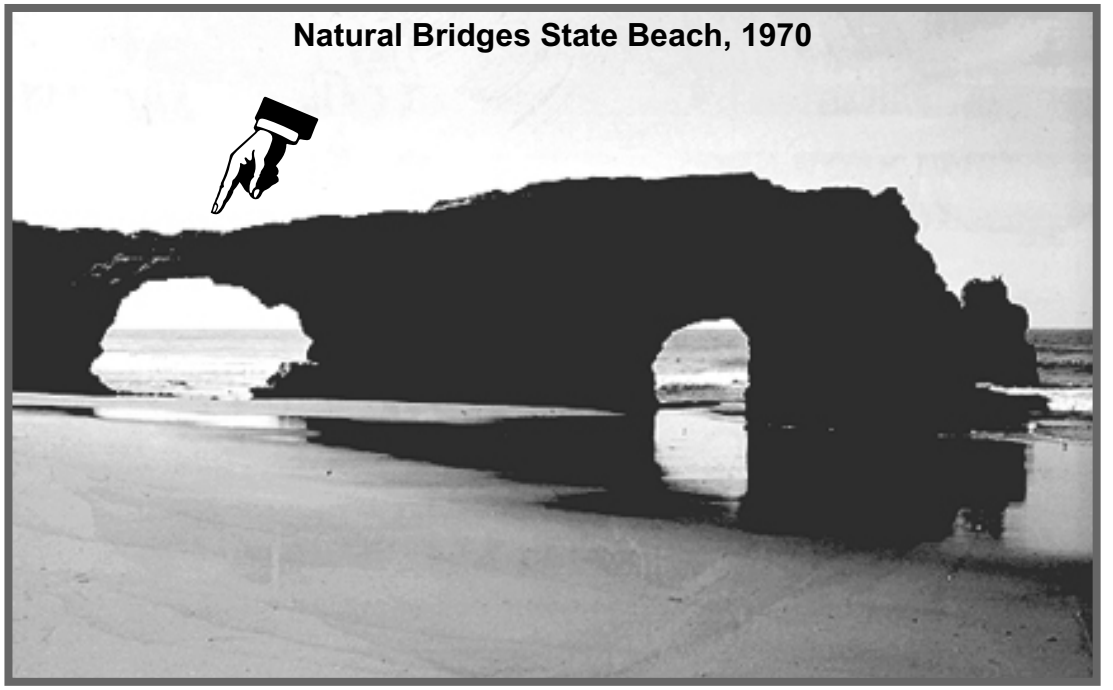
Stop 1: Evidence for Low Erosion Rates in the Santa Cruz Mudstone

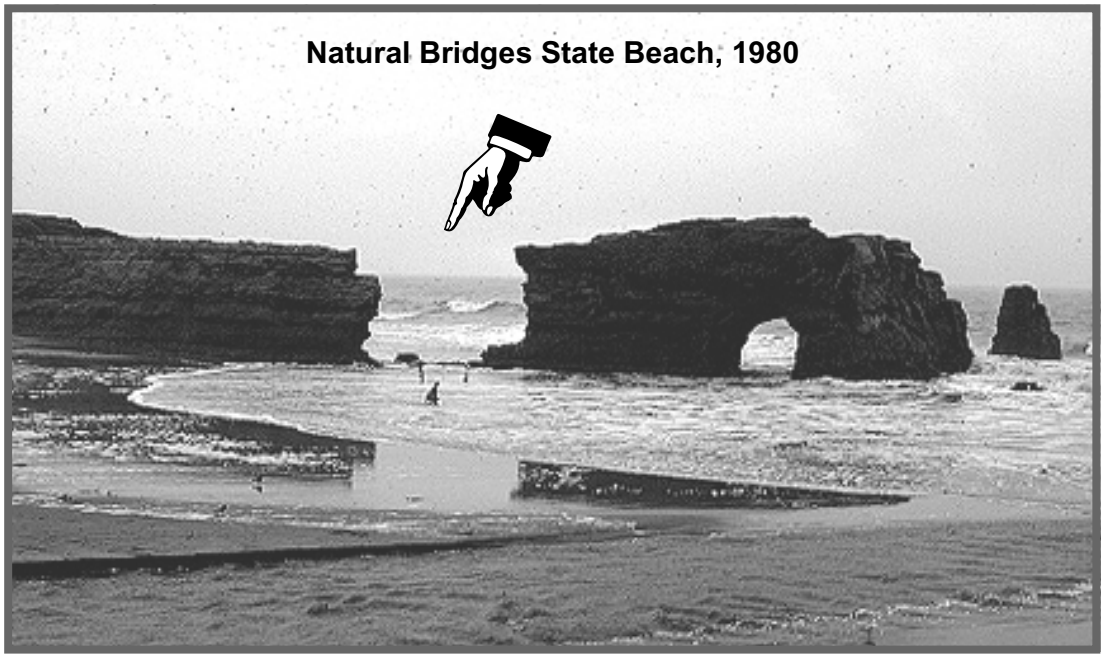




These photos show the wreck of the La Feliz (top) on October 2, 1924, and the mast of the La Feliz (bottom) which still stands today against the cliffs of the Santa Cruz Mudstone near the Long Marine Lab facility. Photos are both looking east towards Natural Bridges State Beach. The cliffs here are protected by a resistant shore platform which is quite visible in the lower photo. The arrows show the seaward extents of several small headlands which have not changed in the 76 years that span these photos.

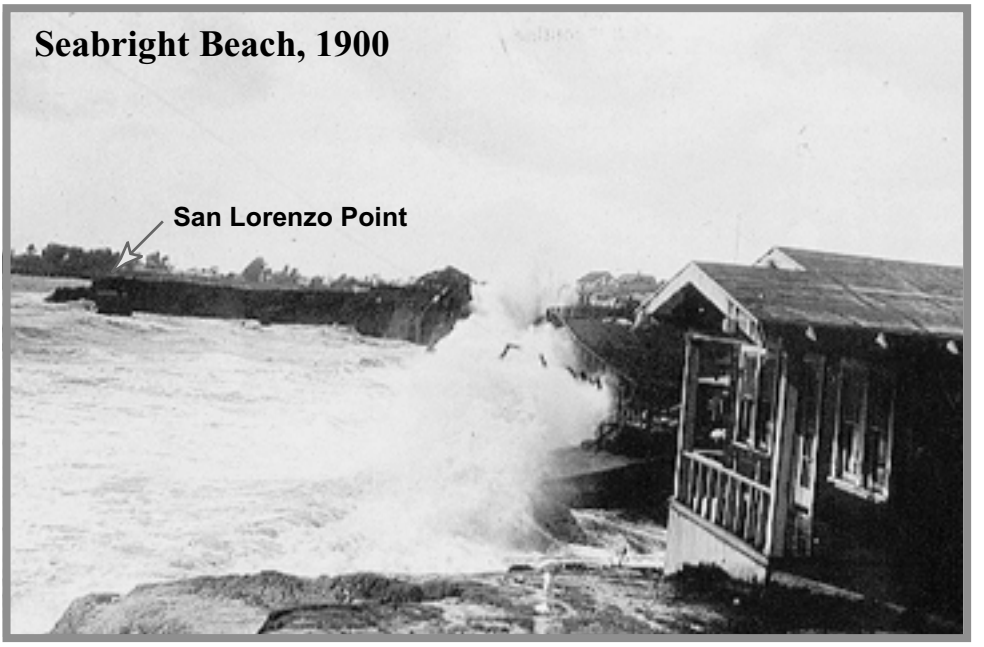
Stop 1: Coastal Features within the Santa Cruz Mudstone

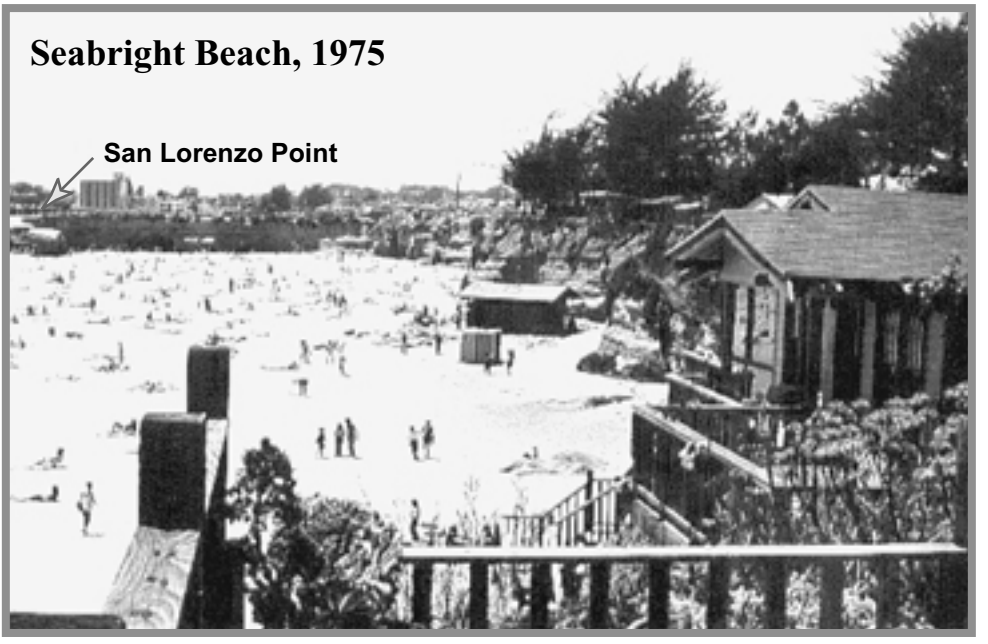




The cliffs and arches of Natural Bridges State Beach, just east of the Long Marine Lab, are formed within the Santa Cruz Mudstone. Although this geologic unit is more resistant than other lithologies in the northern Monterey Bay, zones of weakness within the mudstone lead to the formation and ultimate collapse of features such as the one shown above at Natural Bridges State Beach.

Stop 2: Seabright Beach and the effects of the Santa Cruz Yacht Harbor Jetty





The photos above, taken from approximately the same location (the house on the right is the same house), show the Seabright Beach area, looking west towards San Lorenzo Point. The cliffs here were once subjected to regular wave action (top), with little or no fronting beach. Since the emplacement of the Yacht harbor jetty in the early 1960's the beach has progressively widened to be one of the widest beaches in the northern Monterey Bay.

Stop 2: Seabright Beach and the effects of the Santa Cruz Yacht Harbor Jetty

These 3 photos, shown looking east towards the Yacht Harbor, show the remains of a seastack at Seabright Beach (shown by arrows). The beach has increased significantly in volume since the construction of the jetty, nearly burying the seastack. Barely exposed above the sand during the summer months (center photo), the rock is occasionally exposed as storm waves remove sand from the beach (bottom photo), such as during the 1997-98 El Nino winter.

Orthophotomosaic of Seabright Beach from 3/6/98 Coastal Aerial Mapping System (CAMS) data. Retreat magnitudes are shown for the decade between October 1989, immediately after the Loma Prieta earthquake, and March 1998.

Timeline of Coastal Protection, Capitola (1900-1984)

1900
Concrete seawall constructed

1926-27
Overtopping and flooding of esplanade

1933
Masonry seawall constructed east of concrete seawall

1939-40
Overtopping and flooding of esplanade

1941
Concrete flume built below pumping station

1950
Overtopping and flooding of esplanade

1960
Riprap emplaced along pilings in front of restaurants

1963
Harbor Jetty completed

1965
Capitola Beach below high tide level in front of wall

1970
Groin and sand fill completed

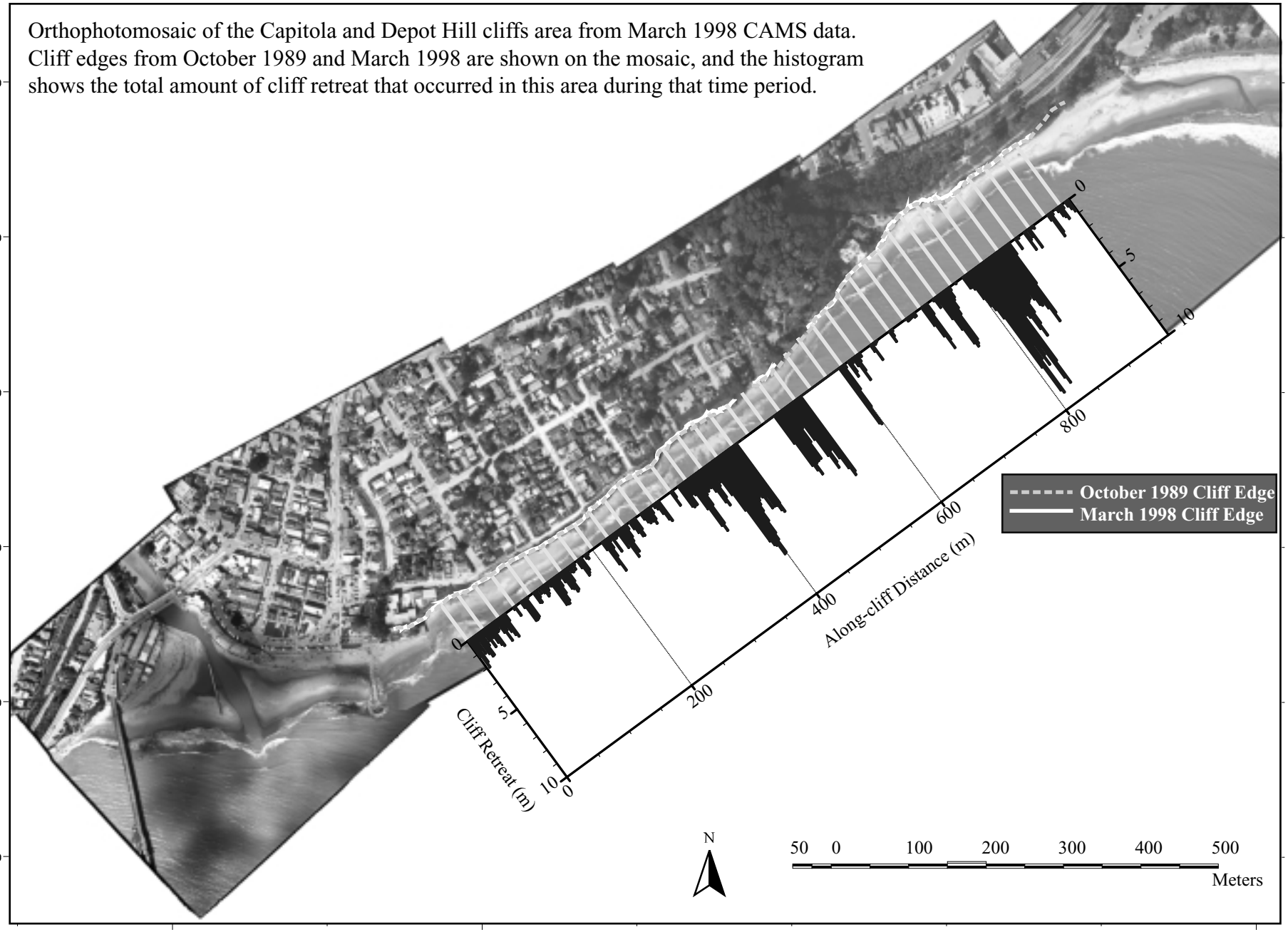
1978
Overtopping and flooding of esplanade

1980
Overtopping and flooding of esplanade

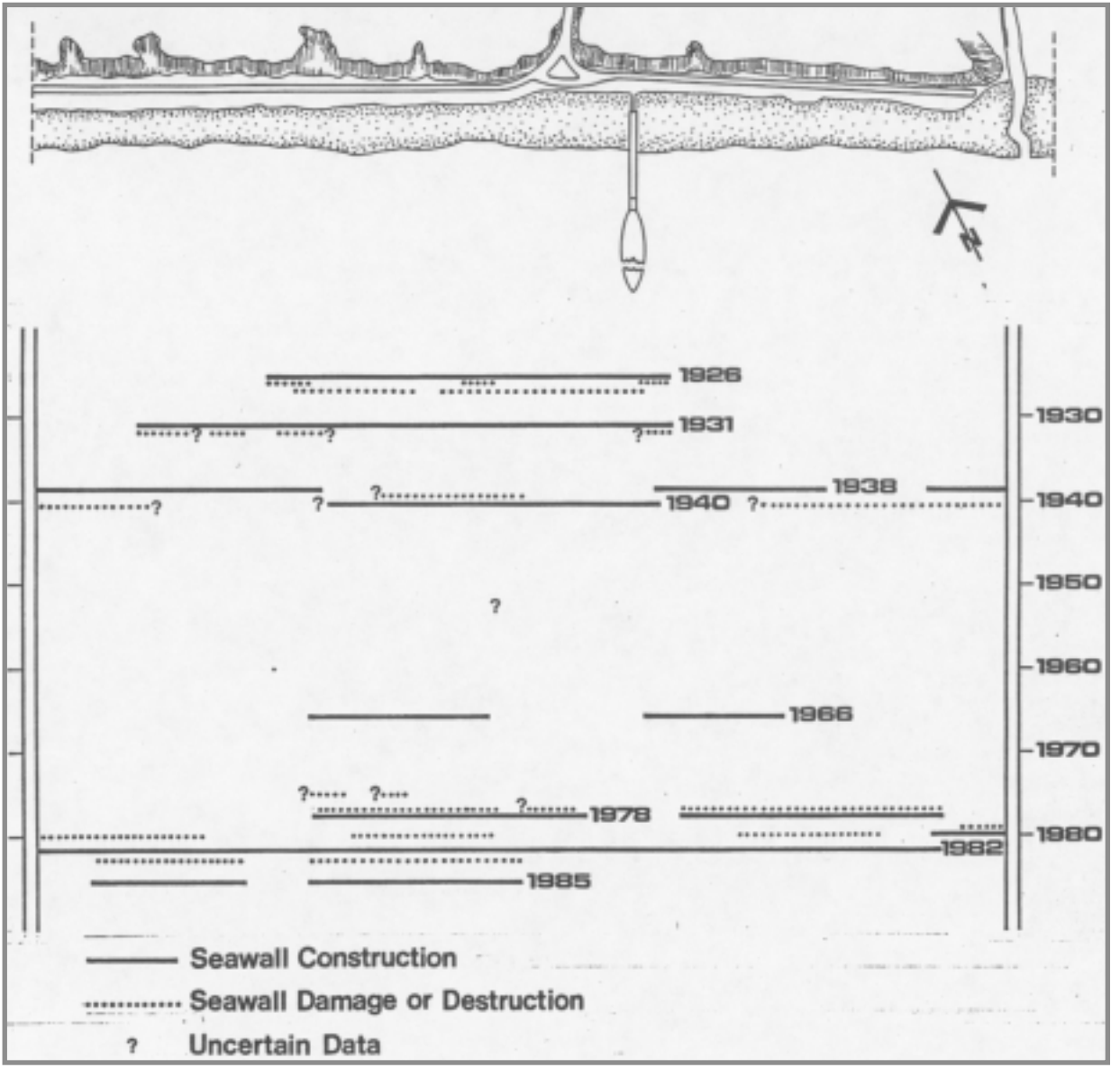
1983
Overtopping and flooding of esplanade

Stop 3: Erosion Hazards along the Depot Hill Cliffs, Capitola

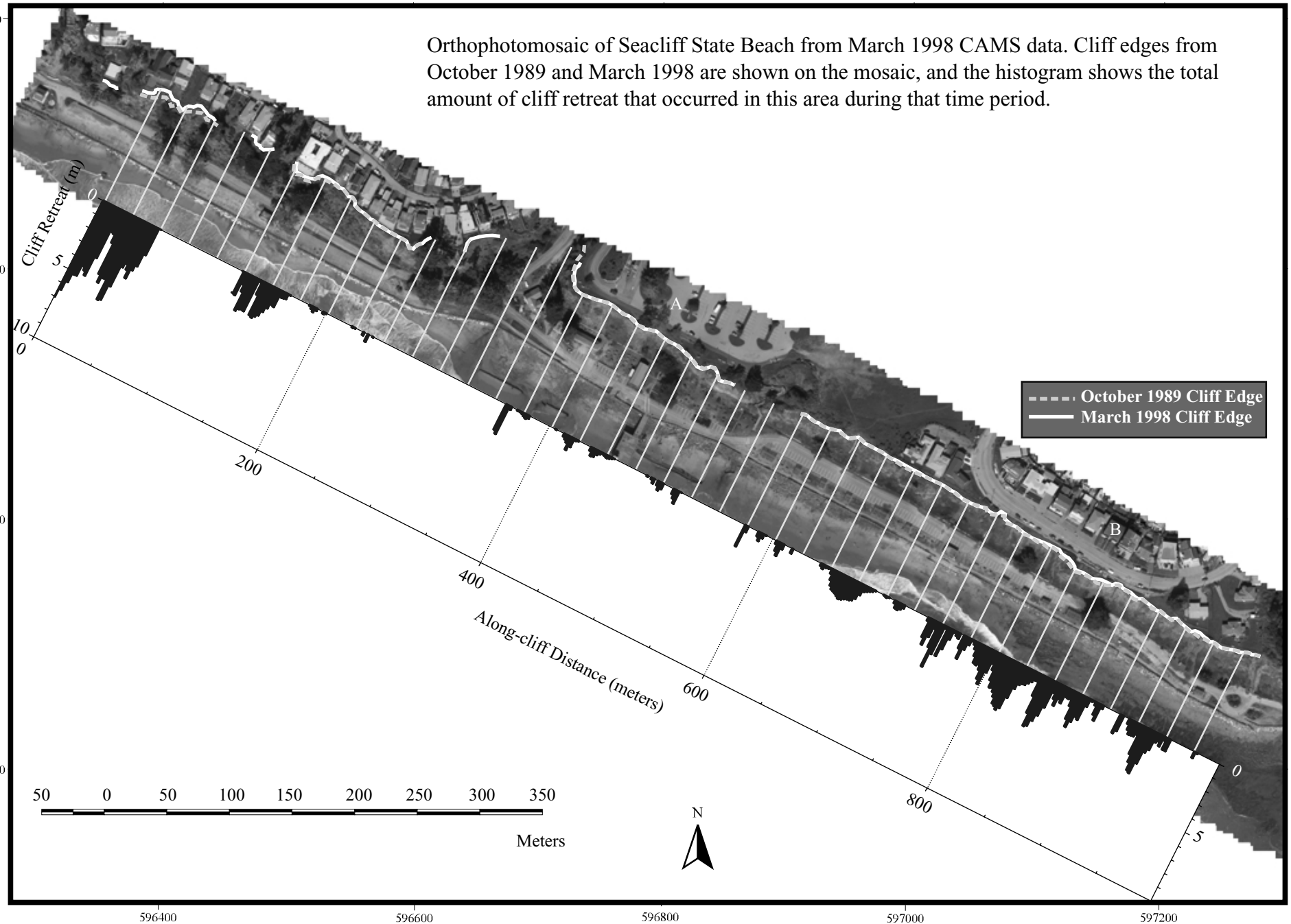
Photo at top shows a large blockfall, a common style of failure along the Depot Hill cliffs. A person (circled) gives an indication of scale. The lower photo shows the undercutting of the Crest Apartments from cliff failures associated with the Loma Prieta earthquake.


Orthophotomosaic of the Capitola and Depot Hill cliffs area from March 1998 CAMS data.
Cliff edges from October 1989 and March 1998 are shown on the mosaic, and the histogram shows the total amount of cliff retreat that occurred in this area during that time period.
4093000
4092800
4092600
4092400
4092200
4092000
593000
593200
593400
593600
593800
594000
594200
594400
594600
Cliff Retreat (m)
0
5
10
Along-cliff Distance (m)
0
200
400
600
800
October 1989 Cliff Edge
March 1998 Cliff Edge
N
50 0 100 200 300 400 500
Meters

History of Seawall Construction and Destruction at Seacliff State Beach



from: Griggs, G.B. and Kim Fulton-Bennett, 1987, Failure of Coastal Protection at Seacliff State Beach, Santa Cruz County, California, USA: Environemntal Management, v.11, n.2, pp175-182.


Orthophotomosaic of Seacliff State Beach from March 1998 CAMS data. Cliff edges from October 1989 and March 1998 are shown on the mosaic, and the histogram shows the total amount of cliff retreat that occurred in this area during that time period.
Cliff Retreat (m)
0
5
10
0
A
B
October 1989 Cliff Edge
March 1998 Cliff Edge
200
400
600
800
Along-cliff Distance (meters)
0
5
4092600
4092400
4092200
4092000
50 0 50 100 150 200 250 300 350
Meters
N
596400
596600
596800
597000
597200

Why there is a ship at the end of the pier? Was it built there -- or did it sink there?

In 1910 a Norwegian civil engineer named Fougner thought of using concrete to build ships. It wasn't until 1917, when wartime steel shortages required the use of cement for construction that Fougner's idea was used. Three concrete ships were built at the U.S. Naval Shipyard in Oakland, California. These ships were the Faith, the Peralta, and the Palo Alto. The Peralta and the Palo Alto were built for wartime use as tankers, however World War One ended before ship construction was finished -- so they were never used.

The Palo Alto remained docked in Oakland until 1929, when the Cal-Nevada Company bought the ship with the idea of making her into an amusement and fishing ship. Her maiden voyage was made under tow to Seacliff State Beach. Once positioned at the beach, the sea cocks were opened and the Palo Alto settled to the ocean bottom. By the summer of 1930 a pier had been built leading to the ship, the ship was remodeled. A dance floor on the main deck was added, also a cafe in the superstructure was built, as was a fifty-four foot heated swimming pool, and a series of carnival type concessions were placed on the afterdeck. The Cal-Nevada Company went broke after two seasons -- then the Palo Alto's was stripped, leaving the ship and the pier used only for fishing.

Stop 5: Seawall at Via Gaviota, Seascape

A group of homes built on the beach in 1969 were initially protected by riprap. Waves associated with large southwesterly storms in early 1983 overtopped the riprap and caused major damage (top photo). In June of 1983, a 1000-foot concrete seawall was emplaced to protect the houses from further damage (bottom photo).

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