Chapter 1

EROSION OF SALT MARSHES ALONG THE EAST SHORE OF SAN FRANCISCO BAY

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Introduction

With the urbanization of the Bay Area, the salt marshes of San Francisco Bay have declined by an estimated 60,000 hectares (ha) (Knutson and Woodhouse, 1982). They play an important role in the ecosystem of the Bay by providing nutrients, oxygen and habitats for a variety of flora and fauna. The loss of salt marshes results in elimination of the animals that live in them. For example, two residents of the marsh, the clapper rail and salt marsh harvest mouse are now listed as endangered on the state and federal registers of endangered species.

For these reasons it is important to preserve what is left of this critical habitat. Historically, land development has been the major cause of destruction. Other factors, however, play a role in the loss of the marshes. Field observations by staff members of the State Department of Fish and Game and others indicate that salt marshes along the east shore of the South Bay have undergone substantial erosion in recent decades (Paul Kelly, pers. comm., 1985). Although observed, erosion of the salt marshes has not been documented. This study seeks to assess the extent and rates of marsh erosion between the San Mateo and Dumbarton bridges by comparing aerial photographs over a 32-year time span. It is hoped that by documenting erosion of the salt marshes, this report will contribute to solving the problem of decreasing marsh habitat.

Past Studies

No past studies exclusively concerned with the erosion of the salt marshes have been found. However, Atwater and others (1979) indicated that erosion was occurring in some bay marshes based on the locations of shorelines on historic maps.

Methodology

Aerial photographs were obtained from Pacific Aerial Survey. Photos taken at approximately five year intervals were used to determine the rate of erosion. The earliest photograph of the area found with a usable scale (approximately 1:12000 or greater) was 1953. Consequently, photos from 1953, 1959, 1969, 1975, 1981, 1985 were used in the study (see Appendix).

Three salt marshes between the San Mateo and Dumbarton bridges were selected (Figure 1) with assistance of Paul Kelly (pers. comm., 1986).

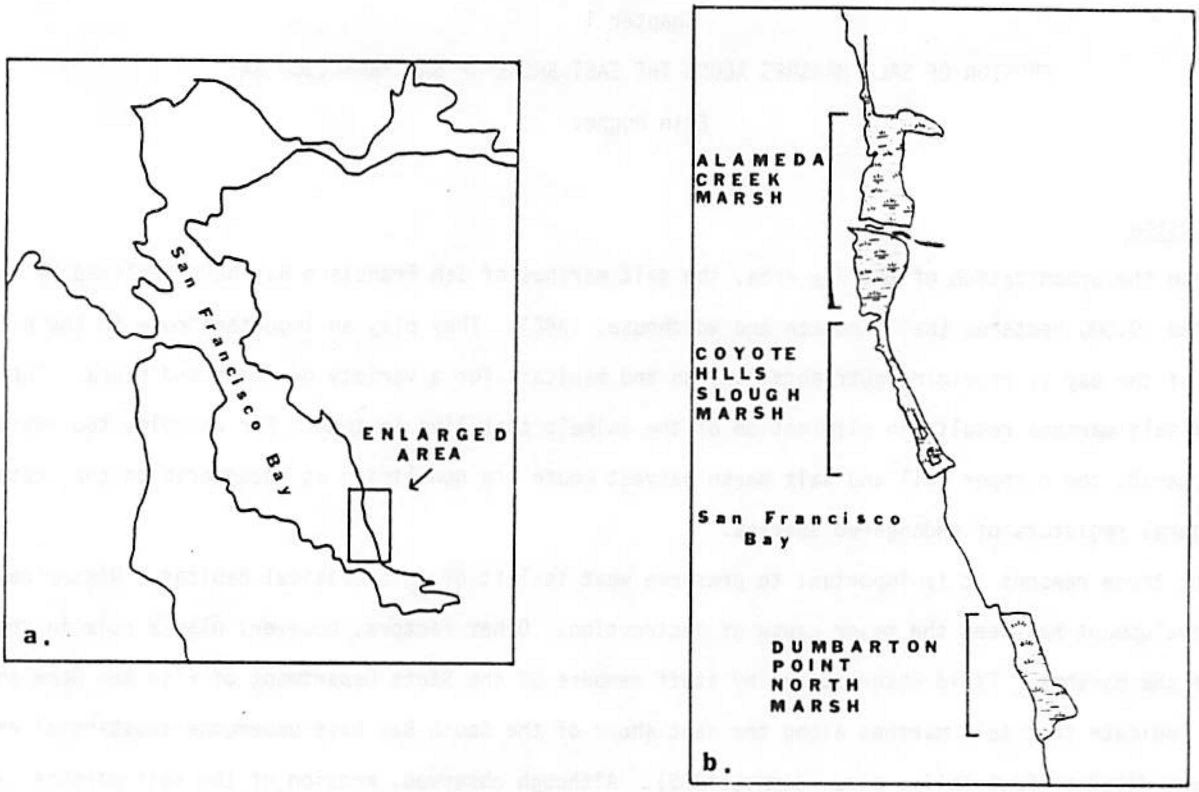


Figure 1. a. General location of study area.
b. Study sites.

The northern-most marsh, Alameda Creek Marsh, consists of two parts and lies just south of the San Mateo bridge. South of this marsh lies the second study study site, Coyote Hills Slough Marsh. The most southern marsh, Dumbarton Point North Marsh, lies north of the Dumbarton Bridge. As pointed out by Josselyn (1983), other names may be applied to these marshes.

To determine if erosion occurred during the time period 1953-1985, two measurements were made. First, a linear measurement of the shoreline position was taken along consistent transects throughout the years to determine if and by how much the shore was receding. Coyote Hills Slough Marsh showed no landmarks on the photographs to define base points, so no linear measurements could be made for this marsh.

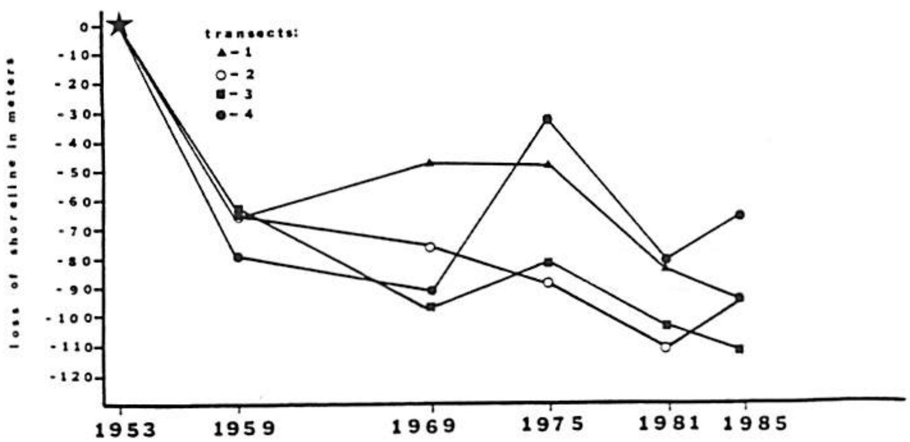
The second measurement was the change in area of the salt marshes. For this, the salt marshes were traced with a planimeter. Because Alameda Creek Marsh in 1953 was very different from the later periods, it was not possible to make a 1953 comparison.

Both linear and areal measurements were converted to scale by measuring distances between landmarks present on the photographs and the U.S.G.S. topographic map. Because the map scale was known, it was possible to calculate the exact scale of each photograph.

Measurements were taken with respect to a body of water under tidal action, so tide conditions must be considered. All the photographs were taken at similar tide levels (see Appendix), and although there may be small errors due to tide fluctuation, it is significantly less than the total differences of shoreline position over the 32-year study period.

Results

The changes of shoreline for Alameda Creek Marsh and Dumbarton Point North Marsh are shown in Figure 2. Four transects were made per marsh with each line on the graph representing one transect. These are expressed as change in shoreline position over time. The uniqueness of each line indicates that the rate of erosion differed at different sites along the shore.



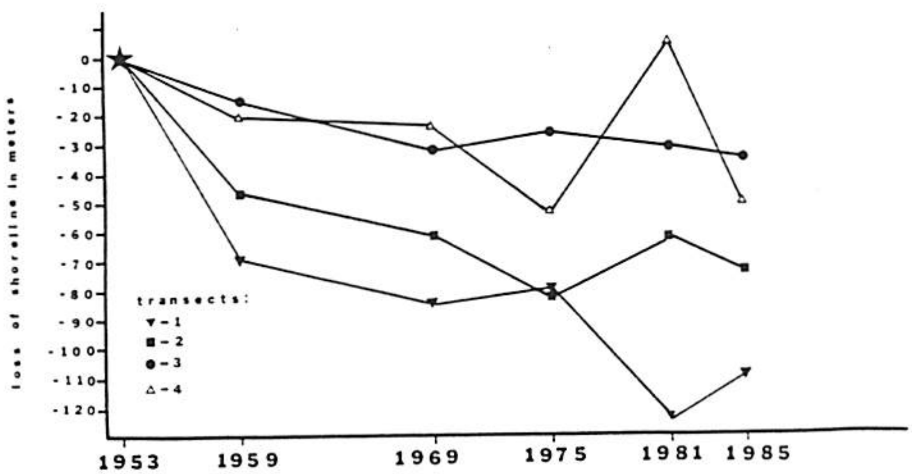


Figure 2. Linear Changes in Shoreline. Loss of Shoreline (m) vs Time for the Four Transects at (a) Alameda Creek Marsh, and (b) Dumbarton Point North Marsh.

At Alameda Creek Marsh an overall decrease in shoreline from 1953 to 1985 occurred. However, during some of the periods marsh growth instead of erosion occurred. For example, Transect 1 increased in length by 15 meters (m) between 1969 and 1975. Similarly, Transect 2 increased between 1981 and 1985, Transect 3 between 1969 and 1975, and Transect 4 between 1969 and 1975 and between 1981 and 1985.

As with Alameda Creek Marsh, Dumbarton Point North Marsh also showed overall erosion during the period studied along with intermittent periods of growth. However, overall the growth rate was always less than the erosion rate.

The difference in distance of each transect between 1953 and 1985 is the net difference in shoreline. This value is used to calculate the rate of erosion, as shown in Table 1. At Alameda Creek Marsh, the shoreline at Transect 1 and 2 eroded at a rate of 3 m/yr, Transect 3 at 3.5 m/yr, and Transect 4 at 2.1 m/yr. At Dumbarton Point North Marsh, erosion rates covered a greater range; the shoreline at Transect 1 eroded at a rate of 3.4 m/yr, Transect 2 at 2.3 m/yr, Transect 3 at 0.16 m/yr, and Transect 4 at 1.6 m/yr.

Transect	Alameda Creek	Dumbarton Point North
1	3.0	3.4
2	3.0	2.3
3	3.5	.16
4	2.1	1.6

Table 1. Rates of Erosion Along Selected Transects at Alameda Creek Marsh and Dumbarton Point North Marsh, in Meters Per Year.

Figure 3 shows the relative differences in the position of the shorelines of Coyote Hills Slough Marsh and Dumbarton Point North Marsh: erosion is apparent at both marshes. The Dumbarton Point North Marsh has eroded unevenly over the period of time. In 1953 the shore was straight and in 1985 it became jagged, indicating that the shoreline did not erode uniformly along its length.

The difference in area for each salt marsh is shown in Figures 4 and 5. The northern part of Alameda Creek Marsh shows a net growth in area. Both the north and south halves of the marsh showed a decrease in area until 1969, and between 1975 and 1981. There is an increase in area from 1969 to 1975. The northern marsh exhibited a large increase in area from 1981 to 1985, resulting in a larger marsh in 1985 than the one of 1953. The southern marsh continued to decrease in size between 1981 and 1985.

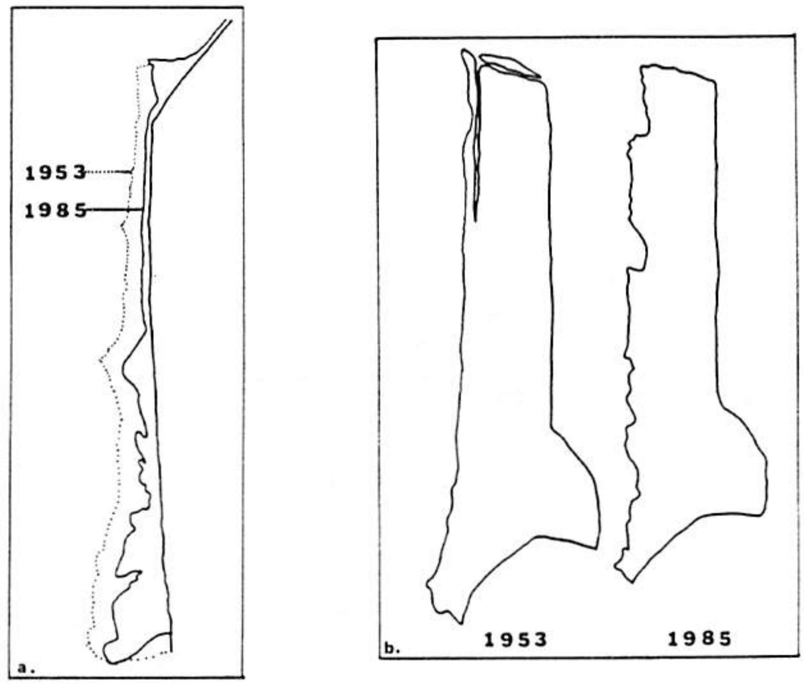


Figure 3. Example of Erosion Between 1953 and 1985 at (a) Coyote Hills Slough Marsh, and (b) Dumbarton Point North Marsh.

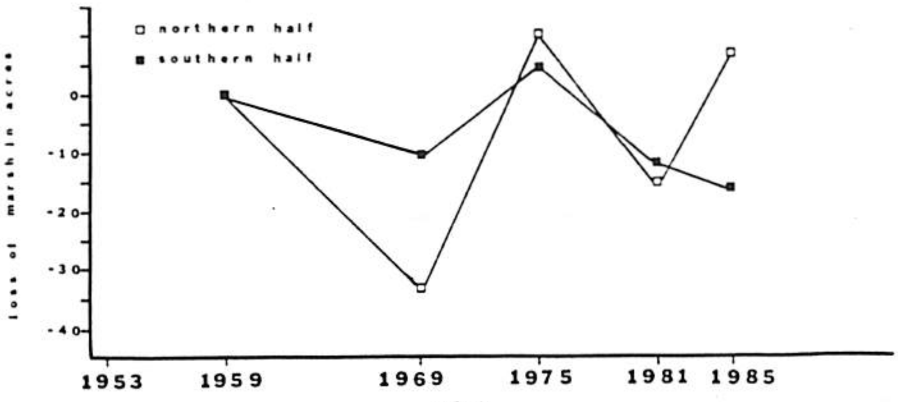


Figure 4. Loss of Marsh Area Over Time for the Two Parts of Alameda Creek Marsh.

Coyote Hills Slough Marsh experienced steady loss of area during the period studied, with no growth occurring. Dumbarton Point North Marsh decreased in area at a steady rate until 1969 but showed growth between 1969 and 1975. During the next ten years erosion occurred and the marsh decreased in size, as illustrated in Figure 5.

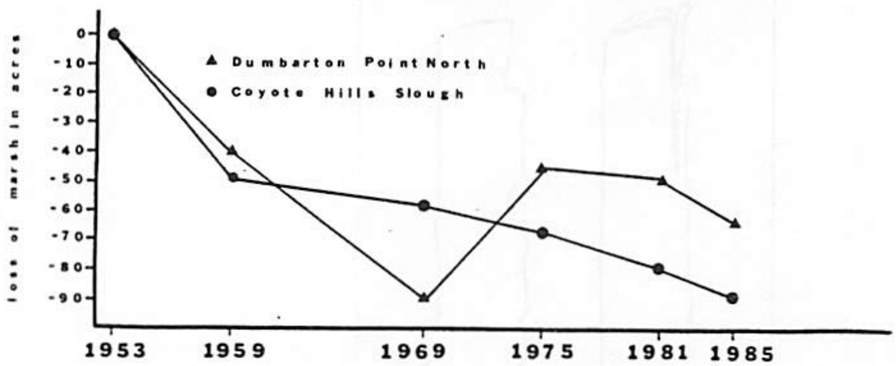


Figure 5. Loss of Marsh Area Over Time at Coyote Hills Slough Marsh and Dumbarton Point North Marsh.

The total net difference in area over the time period from 1953 to 1985 is used to calculate the rate of erosion in area shown in Table 2. Coyote Hills Slough Marsh had the greatest rate of erosion with a loss of 2.6 acres per year. Dumbarton Point North showed a rate of 2 acres per year and the southern half of Alameda Creek Marsh showed the smallest rate of erosion with 0.63 acres per year. The northern half of the marsh showed no erosion but instead showed a growth rate of 0.26 acres per year.

Marsh	Total Loss		Erosion Rates (per year)	
	Acres	Hectares	Acres	Hectares
Alameda Creek				
top	+6.7	+2.7	+.26	+.11
bottom	-16.4	-6.6	-.63	-.25
Coyotes Hills Slough	-83.1	-33.7	-2.6	-1.1
Dumbarton Point North	-62.9	-25.6	-2.0	-.80

Table 2. Total Loss and Rates of Erosion of the Marshes, in Acres and Hectares.

Discussion

The results of linear and areal measurements show that erosion occurred between 1953 and 1985 at the three marshes examined. However, a sample size of only four transects per marsh may not have been large enough to normalize the data. If more transects were made for Alameda Creek Marsh, then perhaps it would be apparent that growth was occurring instead of erosion.

Alameda Creek Marsh - The areal measurements indicate the northern half of Alameda Creek Marsh has actually grown since 1953, yet the transects show the shoreline has eroded. This contradiction implies that erosion occurred at some places while sediment was deposited in other parts. Alameda Creek, which transects the marsh, could be depositing sediment on the marsh as it flows into the Bay. In addition, its geographical location, just south of the San Mateo Bridge, may protect the marsh from eroding as much as the other marshes. The southern half of the marsh showed trends consistent with the other marshes studied.

Coyote Hills Slough Marsh - This long thin marsh exhibited high rates of erosion. The photographs show what might be a levee or dike that was destroyed on the east shore of the marsh by erosion. The marsh has no protection from the waves and at the present rate of erosion it will be gone in approximately 20 years.

Dumbarton Point North Marsh - Dumbarton Point North Marsh showed erosion was taking place in both the linear transect measurements and the areal measurements. The marsh lost an average of 2 acres per year with as much as 3.4 meters per year at one point along the shore and as little as 0.16 meters per year at another.

Causes of Erosion

There are several possible causes of erosion at these salt marshes. First, as originally observed by Gilbert (1917), there has been a rise of mean sea level. This will play a role in the erosion. Second, Josselyn (1983) suggested that erosion along the East Bay shore may be partially due to waves generated by the northwesterly winds. The replacement of the San Mateo Bridge may play a role in the wind-induced erosion of these salt marshes (Paul Kelly, pers. comm., 1986); apparently the old bridge helped protect the shoreline by acting as a wind-break that minimized the intensity of the waves hitting the shore. The new bridge is elevated and may allow more wind near the surface of the Bay, creating larger waves. These factors, along with a possible increase in marine traffic in the Bay, creating even more waves, may increase the destruction of the shore.

Another possible factor contributing to the erosion of the marshes is the burrowing isopod *Sphaeroma quoyanum* (Carlton, 1979). This crustacean has affected levees, dikes and salt marshes along the Bay by burrowing into the soil, weakening the clay banks, and enhancing the ability of the waves to erode the shore. The United States Army Corps of Engineers was fighting the isopod around the Bay because of its potential damage to dikes (Hannon, 1976). Floyd and Newcombe (1976), while studying the growth of marsh plants on dredged material, noticed that in the absence of plants the populations of the isopods were unusually high. In these unvegetated areas there were densities of 3000 isopods per square meter, but only a few *Sphaeroma* were found in vegetated areas. They suggested that " . . . grading an intertidal area and stabilizing it with plants prevented the occurrence of this isopod and the resulting erosion . . ."

Since the present study has looked only at aerial photographs, the condition of the salt marshes is unknown. If for some reason the density of vegetation is declining in the salt marshes, it is possible that the isopod is colonizing these areas and contributing to the erosion.

In another study, Knutson and Woodhouse (1983) confirmed that major storms can decrease the stem density of the marsh vegetation, which in turn leads to erosion. Further studies and field work would be necessary to confirm such a hypothesis.

Conclusion

The ongoing loss of salt marshes will also mean the loss of the organisms that live in that environment, including the endangered clapper rail and salt marsh harvest mouse. Since landfill activity has caused much destruction of the salt marshes around San Francisco Bay, it is important to save what is left of the salt marsh ecosystems. This study shows that there is a continuing major problem with erosion of the salt marshes along the East Bay shoreline; the problem may be occurring elsewhere as well.

In order to stop the erosion of the marshes, the cause must be determined. A combination of field work and research to learn more about factors affecting the stability of the salt marshes needs to be undertaken. This research should include examination of man's activities in the Bay, to see if increases in boating or other uses of the Bay have played a role in the erosion of salt marshes.

Once the causes are identified, the appropriate solutions may be developed to prevent future degradation. There may be a need to construct barriers to wave attack, or to limit boat traffic near the shore. Replanting the marshes after severe storms may quicken the recovery rate and reduce erosion.

If the erosion solutions are not feasible, then we will have to assess the value of the plants and animals that will be lost with the salt marshes. Since habitat is specific to certain organisms, the salt marshes should be protected from eventual disappearance from the San Francisco Bay. If erosion is not controllable, then perhaps former salt marshes that have been developed may be restored to their previous state. With expeditious and proper attention, something can be done before the extinction of any of the inhabitants of the salt marsh.

Appendix

Aerial Photographs

year	date month/ year	agency code	flight path numbers	estimated time of photo	estimated tide in meters
1953	10/2	AV119	13	-	-
			18	-	
1959	7/3	AV337	02	11:46	+2.1
			03	11:36	
1969	5/19	AV209	02	13:30	+2.1
			03	13:19	
1975	5/29	AV1193	02	10:53	+2.2
			03	11:05	
1981	6/22	AV2040	02	11:51	+2.3
			03	11:57	
1985	5/15	AV2640	02	8:50	+2.3
			03	8:24	

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