CHAPTER 85

SEASONAL BOTTOM CHANGES BOLINAS BAY, CALIFORNIA

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ABSTRACT

Five bottom surveys over a period of a year were made in the north portion of Bolinas Bay, California Comparisons between successive surveys permitted an evaluation of the areas and depths of scour and fill with the seasons and were correlated with littoral current measurements Data for a 22-year period also were available on the position of the mean high-tide line over a limited length of beach These data showed a cyclic variation of the position of the high-tide line with the season with the most variation from year to year occurring during the spring months

INTRODUCTION

In connection with a comprehensive study of the environment of a tidal lagoon, the inlet, and the adjacent ocean area at Bolinas, California (1)* numerous beach and bottom surveys were made at various times in the northern part of Bolinas Bay The portion of Bolinas Bay in which repeat surveys of the bottom were made is shown in Figure 1 These surveys covering a year were made in May, August, and December in 1968, and in April and May in 1969 Five beach ranges were established along Stinson Beach by the Corps of Engineers in 1961 and profiles were determined in March and August of that year (Fig 1) They were resurveyed in March and April of 1969 by the California State Lands Commission The State also established the location of the mean high tide line and several beach profiles along a 600 ft length of the beach on numerous occasions since 1948 (Fig 1) Twenty-seven surveys which were made during the years 1948-1970, inclusive, provide important information on seasonal profile changes on this semi-exposed beach Wave data, observed simultaneously with the bottom and beach surveys, were obtained from a bottom pressure-type wave gage as well as visual observations of wave height and period, littoral currents, and beach characteristics at Bolinas and Stinson Beach

WAVE CONDITIONS

The most important factors in the movement of sand in the nearshore area are wave action and tidal currents Information on these factors

*See References

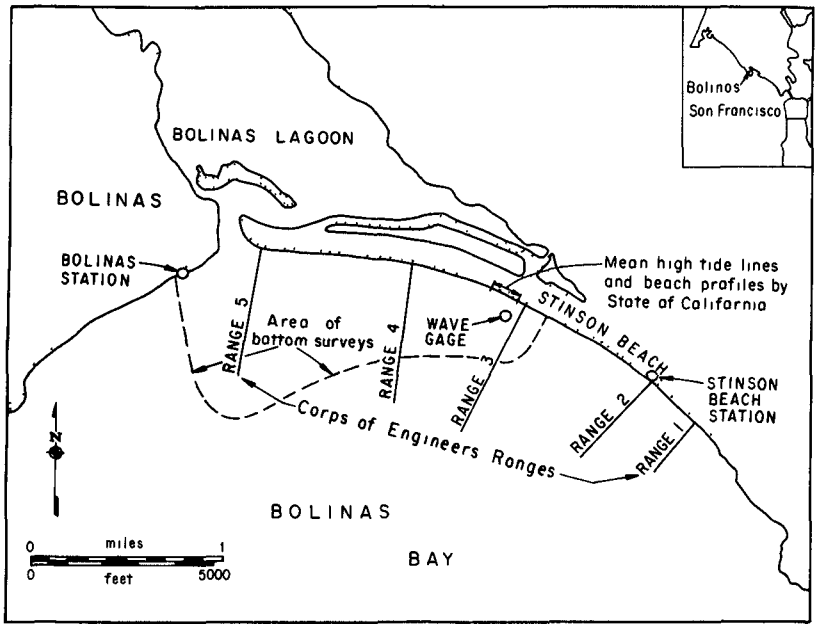

Figure 1 Location map, Bolinas Bay

in Bolinas Bay is provided by data obtained from a wave gage operated by the Bolinas Harbor District and visual surf observations made at the Stinson Beach State Park and at Bolinas for the Coastal Engineering Research Center (2) Figure 1 shows the locations of these stations The visual observations are of course not as accurate as the wave gage data on height and period, but there is considerable additional information such as wave direction, wave type, wind data, direction and strength of littoral current, beach-face characteristics, tide conditions, etc These data are of importance in the discussion below on the character and extent of sediment movement in the nearshore area of Bolinas Bay For ready accessibility, the available data from the Coastal Engineering Research Center on wave period and the direction and strength of the littoral current have been plotted in Figures 2 and 3 for the Stinson Beach and Bolinas stations, respectively It is evident from these two figures that there are extended periods of time when the littoral current prevailed in one direction For example, during the period of February to June, inclusive, in 1969 the littoral current at Stinson Beach was generally in a southeast direction with a reversal in direction occurring only on about 15 days

BOTTOM SURVEYS

To obtain a measure of the seasonal bottom changes in the offshore area each survey made between May 17, 1968 and May 16, 1969, inclusive,

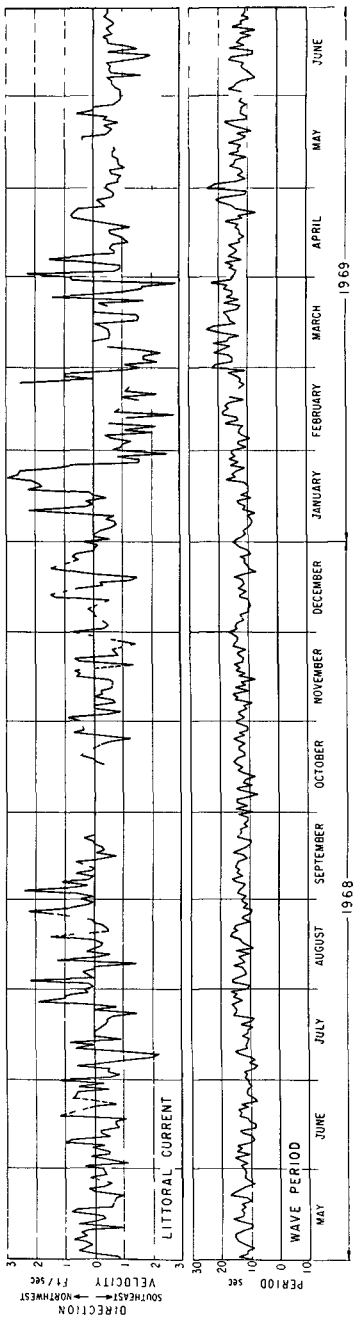

Figure 2 Wave period and littoral currents, Stinson Beach State Park, California, 1968-69

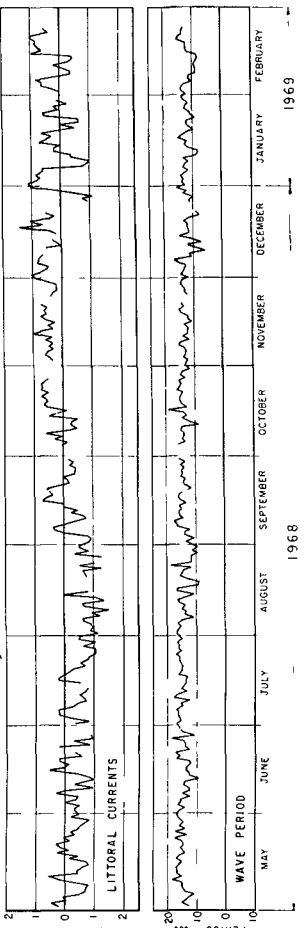

Figure 3 Wave period and littotal currents, Bolinas, California, 1968-69

was compared with the next following survey and the depth of scour or fill was noted on an overlay These overlays were then contoured to give areas and depth of scour and fill occurring between the two dates These comparison maps are shown in Figures 4-7, inclusive Thus, Figure 4 is the result of comparing a survey made toward the end of the winter season (May 17, 1968) and a survey well into the summer season (August 21, 1968) The differences in depths between surveys are all minus, that is, depths in August were all deeper than in May As will be shown below in connection with beach changes this indicates that sand is moved generally from the offshore area to create a fill on the beach face during the summer This onshore movement is also illustrated by the fact that the 30 ft depth contour is closer inshore in August than in May

Figure 5 shows a comparison between the summer survey of August 21, 1968 and the survey of December 19, 1968 which is at the beginning of the winter season An area of scour occurred near the entrance of Bolinas Lagoon, but a general fill occurred over the remainder of the area surveyed, with the largest fill occurring near the surf zone--probably such material was removed from the beach face and deposited immediately offshore by early winter storms As a result of this general fill the position of the 30 ft depth contour in December was further offshore than in August

Figure 6 shows a comparison between the winter survey of December 19, 1968 with a survey taken on April 15, 1969 which was toward the end of the winter season This map shows a general scour of one to two feet in April compared with December A deep area of scour occurred immediately offshore of the lagoon entrance Areas of fill occurred on the west and northeast sides of the area mapped As a result of the general scour the position of the 30 ft contour in April is slightly further inshore than in December

Figure 7 shows a comparison between two surveys taken a month apart (April 15 and May 16, 1969) in the transition period from winter to summer conditions A slight filling occurs in the offshore area, a considerable fill at the lagoon entrance, and a scour area on the westerly part of the area surveyed Because of the limited coverage by the April survey, it is not possible to determine the source of the sand which filled much of the area represented by this map, however, it is possible that this sand has been shifted laterally from the west to the east as a result of the change in wave direction from the southwesterly direction in winter (April) to the more northwesterly direction at the beginning of summer (May)

That sand may be shifted laterally within Bolinas Bay is evident in Figure 8 which shows a comparison of the positions of several depth contours as they existed on May 17, 1968 and on May 16, 1969 Examination of this figure shows that the area opposite the entrance to Bolinas Lagoon has been filled generally by May 1969 compared with the May 1968, that is, over most of the area the May 1969 contours are seaward of the positions of the contours in 1968 On the other hand, at the easterly end of the map shown in Figure 8, a region of scour has occurred, that is, the 1969 contours are generally shoreward of the 1968 positions

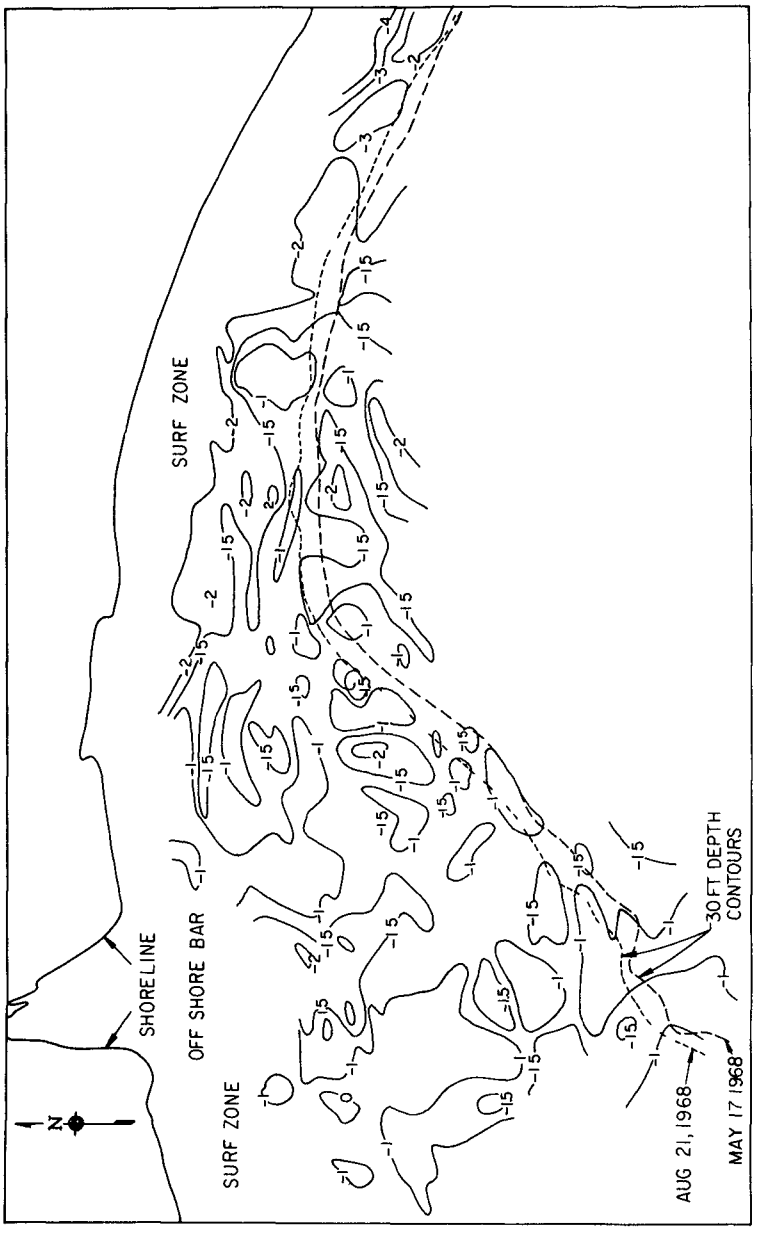

Figure 4 Areas of scour and fill between May 17, 1968 and August 21, 1968

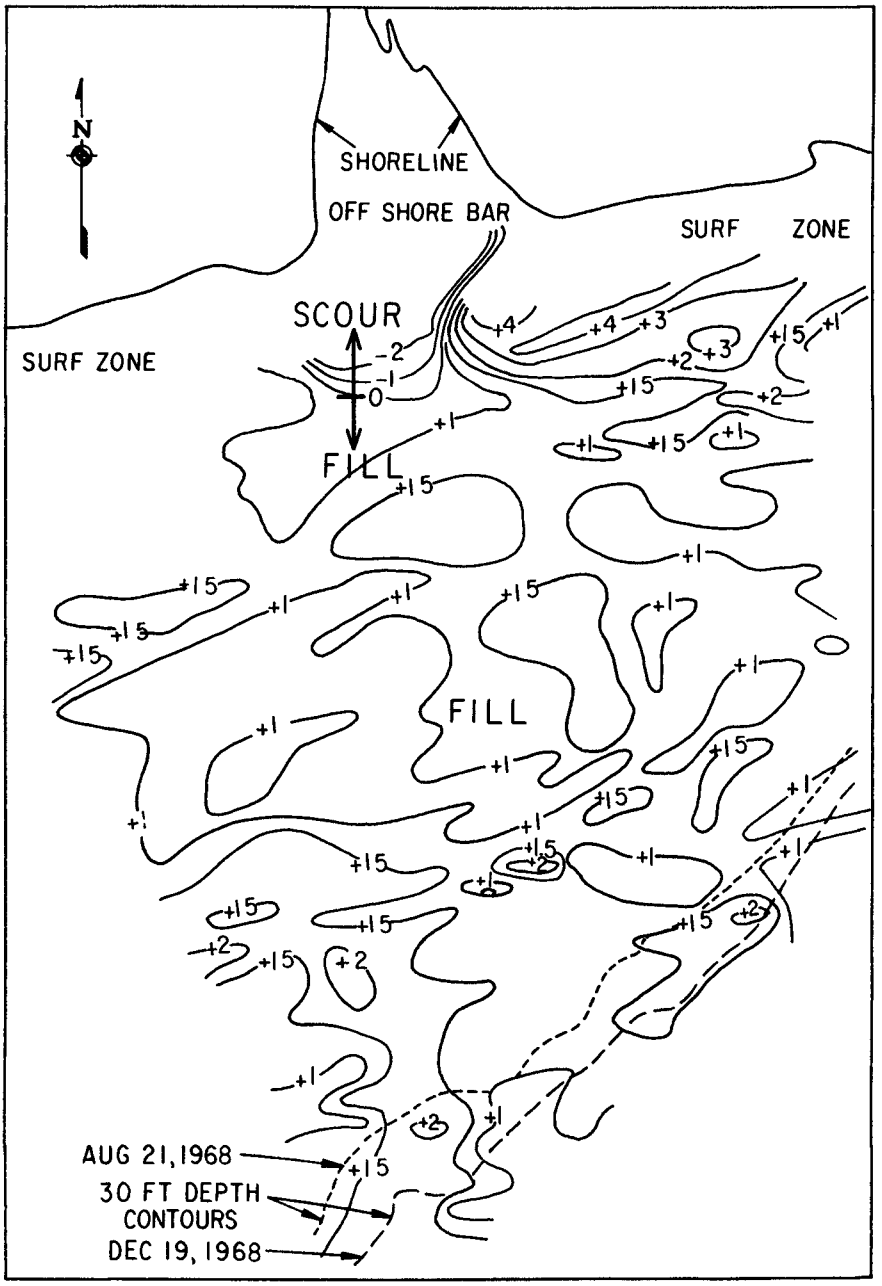

Figure 5 Areas of scour and fill between August 21, 1968 and December 19, 1968

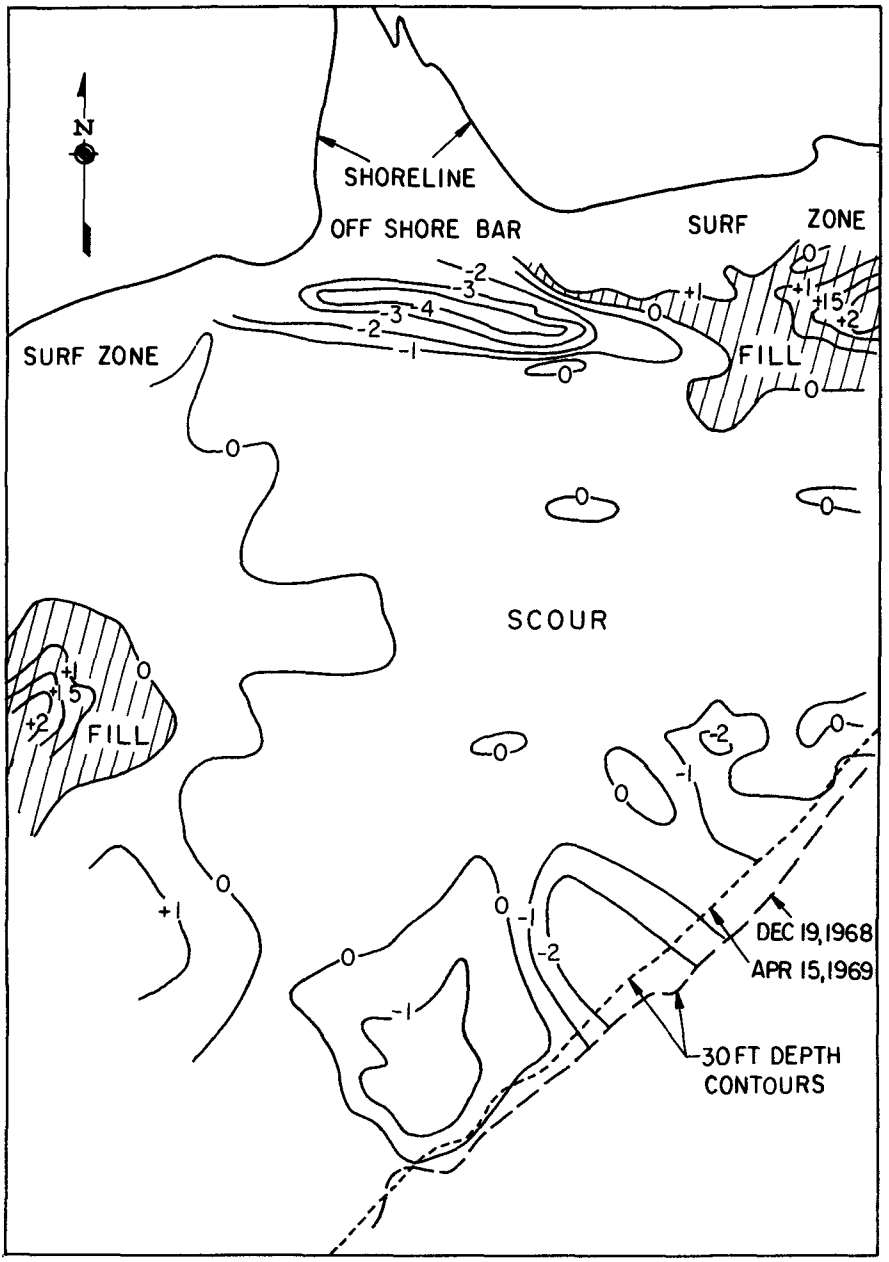

Figure 6 Areas of scour and fill between December 19, 1968 and April 15, 1969

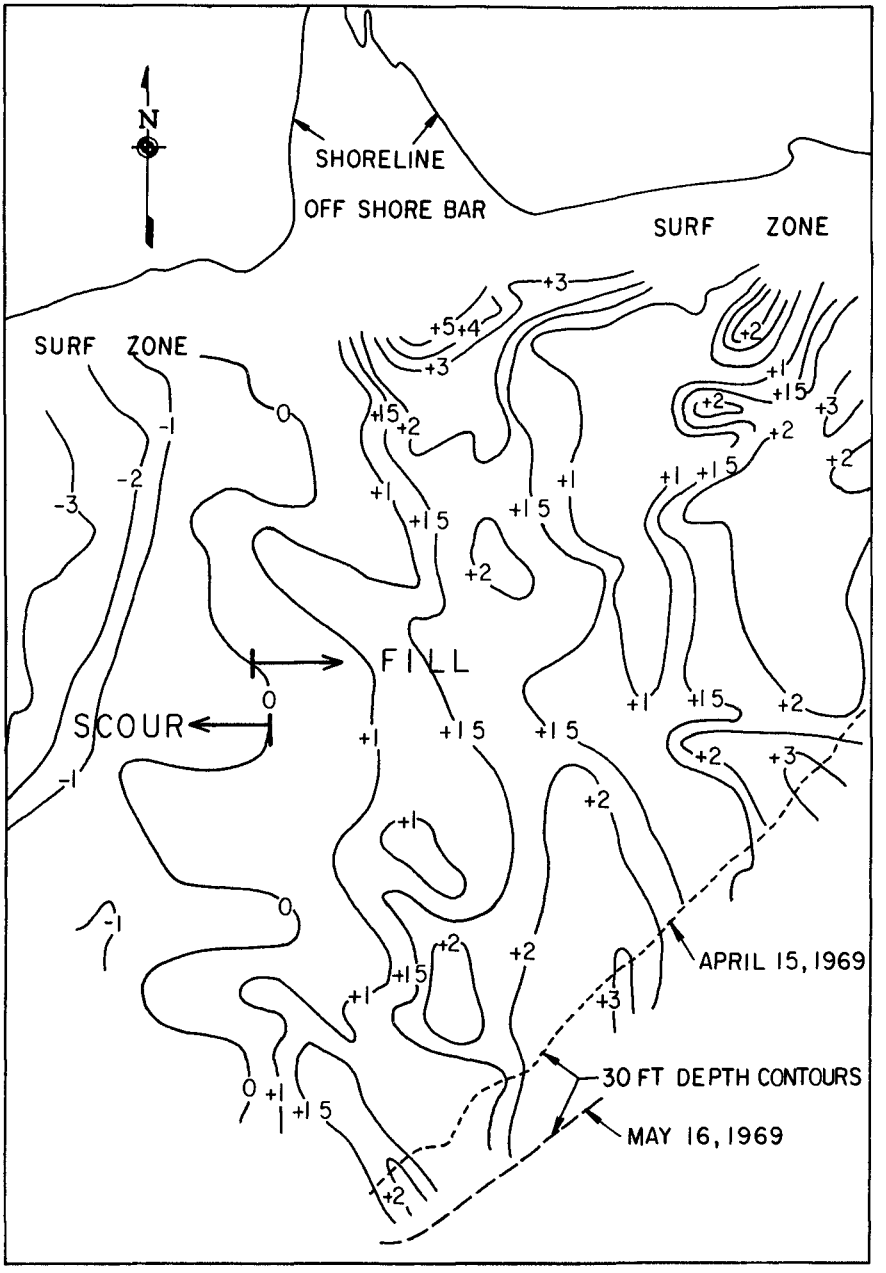

Figure 7 Areas of scour and fill between April 15, 1969 and May 16, 1969

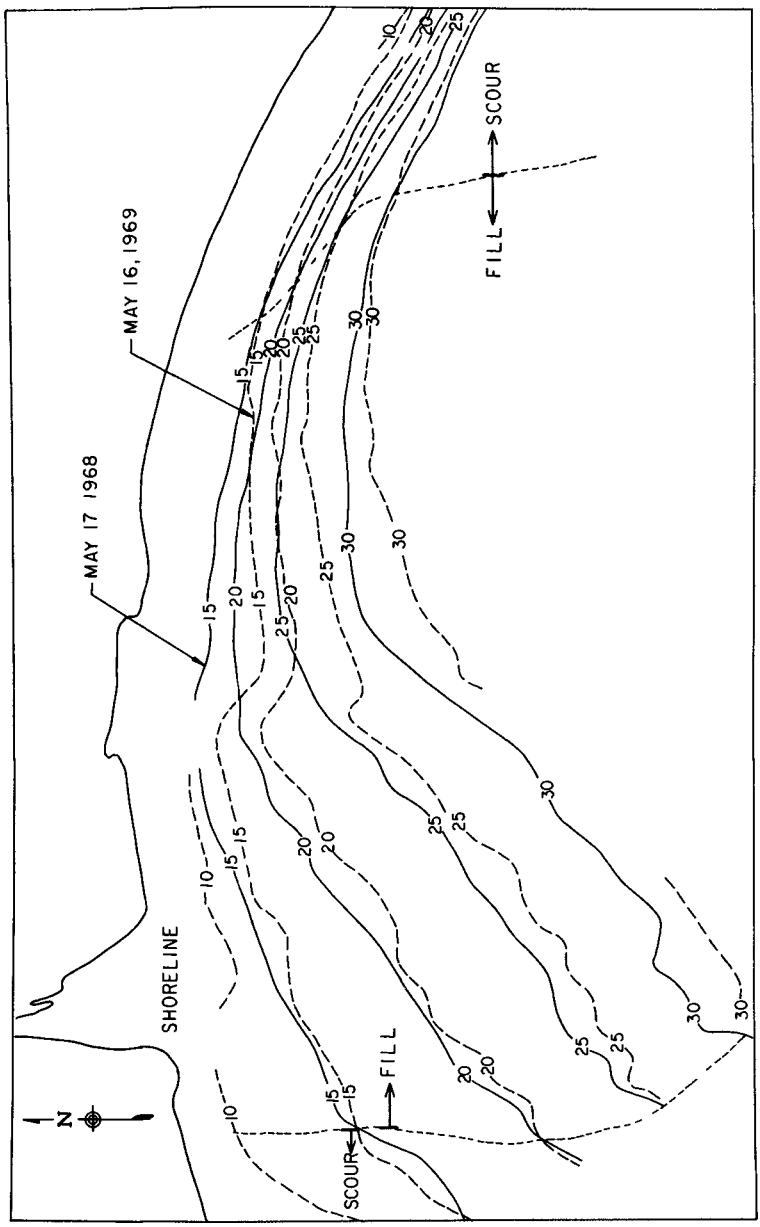

Figure 8 Comparison of bottom contour maps of May 17, 1968 and May 16, 1969

This indicates that, between the 1968 and 1969 surveys, sand appears to have been shifted northward from Stinson Beach into the north end of Bolinas Bay Wave conditions and tidal currents in the coming year could possibly be of a character that the material would be shifted back in an east and southerly direction It should be recognized in the comparison maps discussed above (Figs 4-8) that the actual depths of scour and fill are subject to some sounding error, but the areas of scour and fill show no randomness and are consistent with seasonal changes as generally observed elsewhere

Other data which provide information on the general movement of sediment in the entire Bolinas Bay are presented in the following chapter by Wilde and Yancey in which heavy minerals are utilized as tracers The reader is referred to that paper for details on procedures and conclusions Other supplementary data on sediment movement in Bolinas Bay resulted from sand tracing studies along the beach face as obtained by the U S Geological Survey in connection with investigations of sedimentation and hydrology in Bolinas Lagoon (3) This study involved the placement of fluorescent-dyed sand on the beach at both the town of Bolinas (Brighton Avenue) and the Stinson Beach State Park and then periodically detecting the direction of movement away from the source by use of an ultraviolet lamp Placement of sand at both localities was made on July 23-24, 1968 and then periodically sampled until late October 1968 when the dyed material either was completely scattered and buried or the dye strength had been greatly reduced

The results of these limited and qualitative tests showed that at Bolinas the movement of sand was always eastward toward the entrance of Bolinas Lagoon, but no material ever crossed the lagoon entrance to the Stinson spit Although the surf observations summarized by the Coastal Engineering Research Center showed a general westerly littoral current in this same locality during the period of the sand tracing studies (Fig 2), it is possible that the tidal currents into Bolinas Lagoon rather than wave generated littoral currents were instrumental in generally moving sand eastward along the beach at Bolinas

In the case of the Stinson Beach State Park studies it was found that the dyed sands were moved in both the southeasterly and northwesterly directions, with some material being detected about one and one-half miles northwesterly up the beach two months after initial placement of the dyed sand This might be expected upon examination of Figure 2 which shows that a northwesterly littoral current prevailed over most of the period, (August and September), following the start of the tracer tests

BEACH CHANGES

It has long been established that beaches exposed to wave action undergo changes to their profiles throughout the year because of the seasonal changes in wave characteristics (4,5, and 6) One of the most important factors in determining the character of a beach profile is the ratio of wave height to wave length--a factor commonly referred to as the "wave steepness " During extended periods of low wave steepness,

low berms usually are built on the foreshore with very steep profiles on the beach face, and bars and underwater berms immediately offshore tend to disappear or become discontinuous During periods of high wave steepness (storm or winter conditions) the beach face becomes less steep and the offshore underwater bars become more pronounced

In the case of the beaches along Bolinas Bay the seasonal changes in their characteristics are less well defined than in the offshore area This lack of beach data is primarily due to the difficulties and hazards of making accurate bottom surveys in the surf zone--especially during winter storms It is to be noted that the hydrographic surveys used in preparing Figures 4-7, inclusive, were not made closer to shore than about the 8 ft depth contour The data on seasonal beach changes are therefore confined to the beach profiles made by (a) the University of California (6) and (b) the Corps of Engineers in 1961 (7) and repeat surveys of these ranges by the California State Lands Commission in 1969 The location of the Corps' ranges is shown in Figure 1 Surveys by the State Lands Commission to determine the position of the mean high-tide lines over a limited length of the Stinson spit for the period 1948 to 1970 are of importance in evaluating beach changes in Bolinas Bay

To provide an accurate measure of the seasonal fluctuations of the width of the beach at Stinson spit the data on the position of the mean high-tide line, as determined by the State Lands Commission and other sources on twenty-seven occasions from 1948 to 1970, are of considerable value To obtain information on the position of the mean high-tide line the distance from a base line to the high-tide line was measured and plotted as shown in Figure 9 for the appropriate day of the month There is an obvious cyclic pattern with the seasons as to the position of the high-tide line, but no precise relationship obviously exists because of the variation of intensity of wave attack that undoubtedly occurred from year to year An upper and lower envelope has been drawn on Figure 9 to enclose the plotted points Inspection of this plot shows that the position of the mean high-tide lines is more variable from year to year during the spring months than during late summer and fall The distance between envelopes during the spring may amount to as much as 50 ft, and the beach at the mean high-tide line is approximately 150 ft wider in summer than in winter The surveys of the five Corps of Engineers ranges showed an average difference in width of about 100 feet between winter and summer conditions at the mean high-tide level (7)

Of importance in connection with Figure 9 is the magnitude of the mean monthly wave height for the California coast as shown in Figure 10 This figure, plotted from data compiled by Galvin et al (1969), shows that the time of occurrence of the lowest mean monthly wave height occurs at about the same time (August) as does the time when the beach on Stinson spit (Fig 9) is the widest, that is, the beach is widest when the wave steepness is the lowest

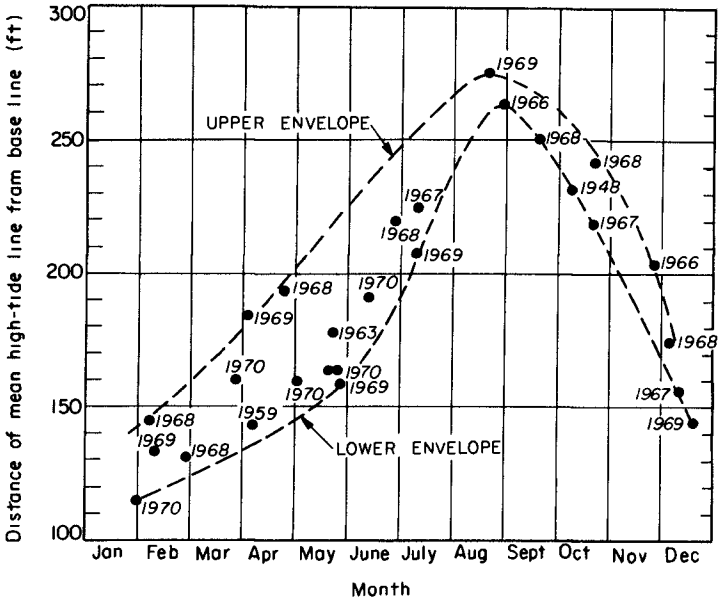

Figure 9 Seasonal variation of the position of the mean high-tide line, Stinson Beach spit 1948-1970 (Data compiled by California State Lands Commission)

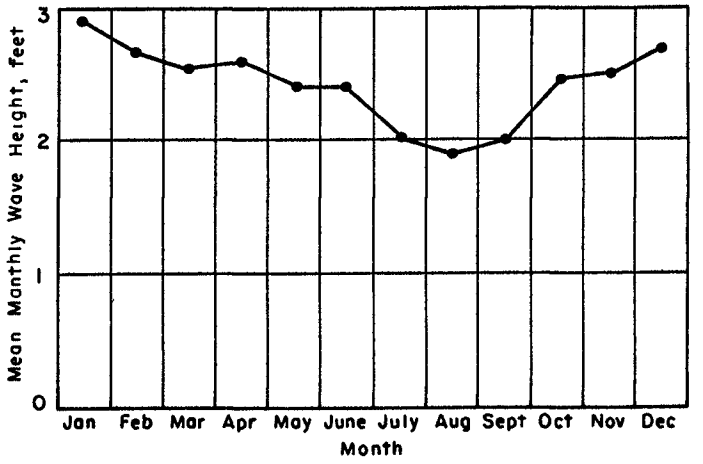

Figure 10 Mean monthly wave heights for the California coast From data for 31 station years compiled by C J Galvin, Jr , et al (1969)

SUMMARY

1 Five bottom surveys made in 1968-69 of the northern part of Bolinas Bay show an offshore-onshore movement in the depths between 8 ft and 35 ft below MSL as a result of varying wave conditions with the seasons A survey in May 1969, when compared with a survey one year earlier in May 1968, shows an accretion in the northern part of Bolinas Bay and a scouring of the shoreline southward along the Stinson spit

2 Repeat surveys at five ranges located along the Stinson spit show a seasonal change with the seasons, that is, the beach averages about 100 ft greater in width during the summer compared with the winter Repeat surveys of the location of the mean high-tide line at one location on Stinson spit over a period of several years (1948-1970) shows a cyclic position of the high-tide line with the season with the most variation from year to year occurring during the spring months

ACKNOWLEDGMENTS

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