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THE SPRING 1976 EROSION OF SILETZ SPIT, OREGON

with an analysis of
the causative wave
and tide conditions

Paul D. Komar
Barbara Ann McKinney



OREGON STATE UNIVERSITY
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acknowledgment



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INTRODUCTION

Siletz Spit, located on the mid-Oregon coast immediately south of Lincoln City (Fig. 1), has been eroding since winter 1970-71. During two periods, December 1972 to January 1973 and January to March 1976, spit erosion was particularly severe due to high storm-wave conditions on the coast. During winter 1972-73, the erosion rate reached a maximum of 30 meters of spit property lost in a three-week period. One house under construction was destroyed, and a number of others were saved only by the immediate placement of riprap. That episode of erosion was investigated by Rea and Komar (1975) and by Komar and Rea (1975, 1976).

The purpose of this study is to document erosion during spring 1976, the second episode of severe erosion, and to contrast it with earlier winter erosion periods. As will be seen, a pronounced storm on Feb. 18, 1976 caused water to wash over the spit. Numerous beach drift logs were thrown atop the dunes. Such wash-overs have not been observed during other winter storms since 1970.

Actual storm systems in the north Pacific will be examined to determine conditions that produce the exceptionally high waves on the Oregon coast that result in erosion. Consideration of the importance of tide levels and storm surges will be included in the analysis.

THE PRE-1976 EROSION OF SILETZ SPIT

Erosion of Siletz Spit and other areas of the Oregon coast is confined almost entirely to the winter months, November through March. This is because erosion is associated with high energy wave conditions limited to these months. Fig. 2 shows wave breaker heights and periods, taken from the wave data compilation presented in Komar, et al. (1976). Significant wave breaker heights were determined four times daily at the Marine Science Center, Newport, Oregon, by a seismic recording system that detects microseisms produced by waves. The wave-measuring system is described in detail by Quinn, et al. (1974) and Komar, et al. (1976).

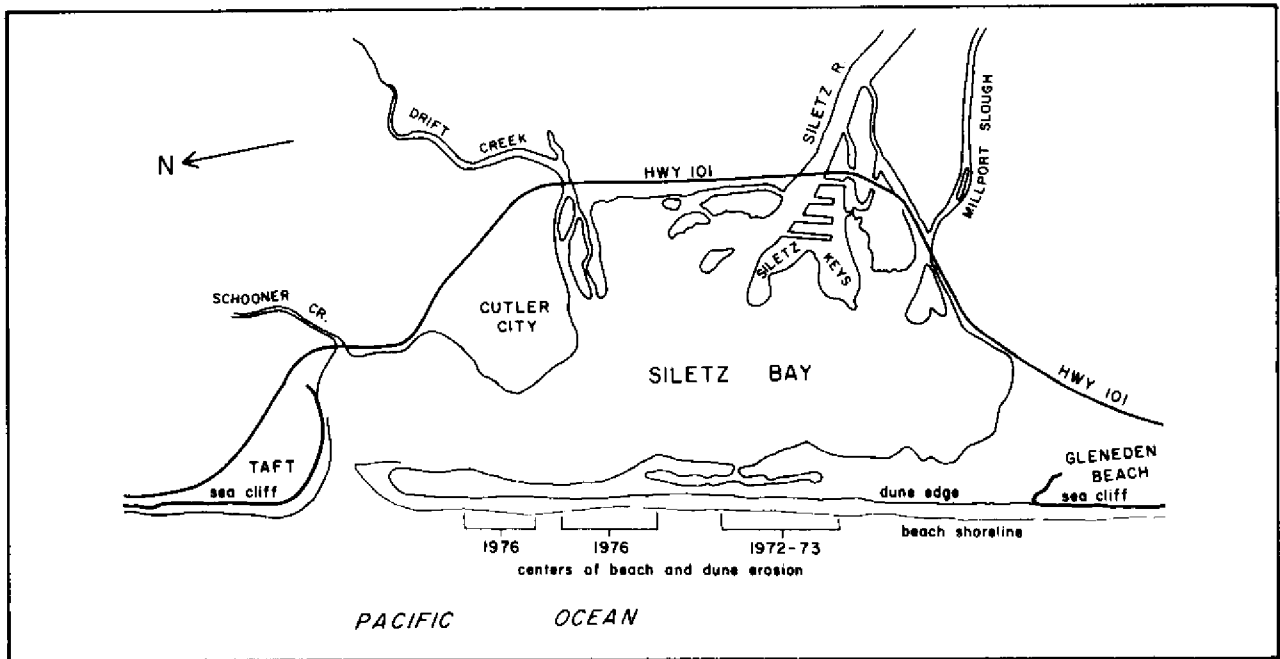


Fig. 1. Location map for the Siletz Spit and Bay area. Along the length of the spit are shown the areas affected by foredune erosion in the winters of 1972-73 and 1976.

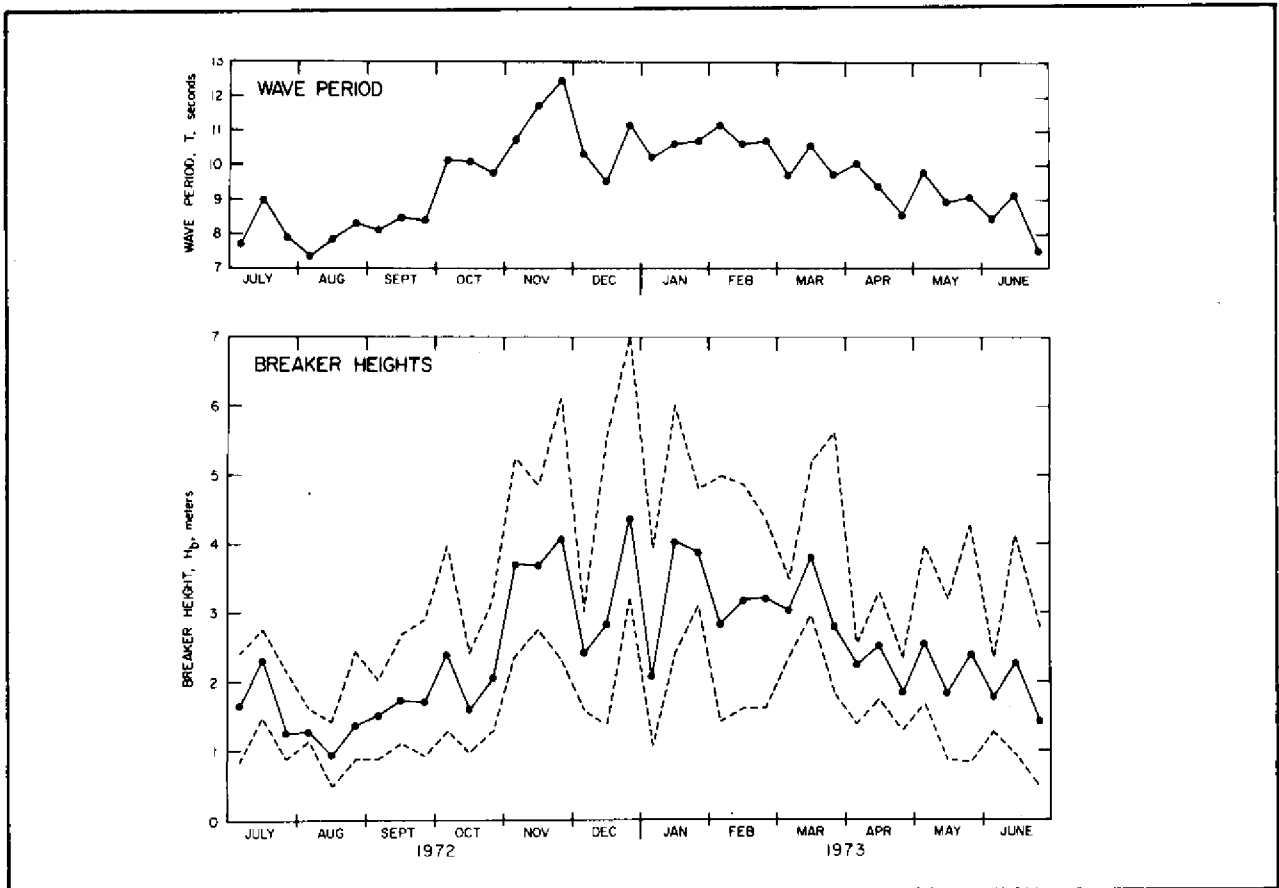


Fig. 2. Significant wave breaker heights and periods at Newport, Oregon, for July 1972 through June 1973, computed from wave measurements by the microseismometer system. (from Komar, et al. 1976)

The average significant breaker height H_b , plotted in Fig. 2, is a 10-day (one-third month) average. Maximum and minimum breaker heights measured during that one-third month are also plotted. The average H_b curve illustrates the overall increase in wave energy conditions from November through March. During these months, breaker heights average about 3 to 4 meters, in contrast to summer conditions when breaker heights average 1 to 2 meters. The maximum H_b curve of Fig. 2 reveals the largest storm conditions attained during any one-third month. Storms commonly produce breaker heights greater than 5 meters, and in the last third of December (actually on Dec. 24-25, 1972), breakers 7 meters high were measured. These are the highest wave conditions observed by the Newport seismic system since its installation in November 1971 (Komar, et al. 1976); these same waves caused the most severe damage due to erosion at Siletz Spit.

Winter erosion occurs when a series of storms, not necessarily large ones, remove sand from the exposed berm and deposit it offshore. The berm provides a buffer between the waves and the coastal dunes and sea cliffs. It may be extensive enough to prevent wave swash from reaching coastal property, even at highest tides. With the energy-dissipating berm removed, usually by mid-December, dunes and sea cliffs are more directly exposed to the high energy winter waves.

The potential for large-scale property erosion occurs when a rip current remains in one stable position along the beach, removing more sand from the berm to offshore and producing a local embayment on the beach. If the rip remains in the same position for a sufficient length of time, the embayment may reach up to the foredunes or sea cliff, causing erosion. High rates of erosion are associated with subsequent storms because waves are now able to pass through the embayment with little loss of energy and wash directly against the foredunes or cliffs. This was the case for the severe erosion of Siletz Spit in winter 1972-73, when the dunes in the central spit area retreated some 30 meters in three weeks (Rea 1975; Fig. 1) before riprap prevented additional erosion. In the process, one house under construction was lost and others had to be protected by riprap; in some cases their sides as well as ocean-facing fronts had to be protected.

Neap tide conditions prevailed during the December 1972 erosion period. Under neap tides the daily tidal range is the

smallest for that month. Therefore, water does not reach high levels on the dunes nor does it remain for long periods of time at levels where waves can strike dunes directly. Erosion in December 1972 would have been much more severe had spring tides (highest tide levels of the month) occurred simultaneously with the 7-meter high storm breakers. This factor of storm waves and tide level in spit erosion will be discussed later. It will be seen that the erosion in January 1973 and February 1976 was produced by smaller storm waves but under spring tide conditions.

THE 1976 EROSION

The Feb. 18, 1976 storm breakers at Siletz Spit registered a significant wave height greater than 6 meters on the Newport seismometer (see Fig. 16). It was of special importance that, unlike the December 1972 storm, the storm breakers occurred during spring high tide conditions when the tide water level exceeded by 3 meters the mean lower low tide level.

A mosaic of aerial photographs in Fig. 3 shows conditions on the spit on Feb. 5, 1976, a few days previous to the major storm. The most noticeable feature in these aerial photographs is the very pronounced embayment opposite the northernmost house on the spit. This embayment was produced by a rip current as described in connection with the earlier episodes of erosion. A second but lower amplitude embayment is located south of the most pronounced embayment; this embayment also became a center of dune erosion after the Feb. 18, 1976 storm. There is just a hint of an embayment opposite the southernmost beach houses shown in Fig. 3. This area was severely eroded during the December 1972 storm and on into January 1973. Evidence of erosion is apparent in the irregularity of the dune edge. The promontories fronting houses were held by riprap while empty lots eroded. South of the southernmost house is a series of four lots that were restored following the 1972-73 erosion that nearly reached the road. This area eroded again in spring 1976 and will be described later.

Another apparent feature in the aerial photographs of Fig. 3 is the older erosion scarp. It is most easily seen toward the north end of the spit and continues south past the immediate seaside front of the northernmost house. Rea (1975) and Rea and Komar (1975) determined from a series of aerial photographs that this erosion occurred about 1960, prior to house construction on the foredune area of the spit. As seen in

Fig. 4, this erosion scarp is apparent on the ground as a long, linear bluff. Many of the houses were constructed nearly even with this 1960 erosion scarp.

As in previous winters, the rip current embayments became centers for the 1976 erosion. Some foredune erosion had already occurred in the Feb. 5, 1976 aerials of Fig. 3, prior to the major storm of February 18. This early erosion is landward of the most pronounced embayment at the north. The embayment cut into the foredunes, and would have caused still more erosion except for the riprap present seaward of the northernmost house and the empty lots to its immediate south. Erosion was halted there, but went beyond the riprap line to the immediate north where no riprap was present. Erosion north of the riprap produced an erosion dune bluff about 1.5 meters high with a few drift logs protruding from the scarp (Fig. 5a). Wave swash also overtopped the riprap opposite the northernmost house, washing drift logs back into a line shoreward of the riprap line.

The presence of embayments along the beach, seen in Fig. 3, set the stage for the pronounced erosion that occurred during the Feb. 18, 1976 storm. As described in studies of erosion during previous winters (Rea 1975; Rea and Komar 1975; etc.), storm waves were able to travel shoreward through the deep water of embayments without breaking or losing energy until near the shoreline. This produced intense wave swash and therefore appreciable dune erosion. The nature of erosion associated with the Feb. 18, 1976 storm differed somewhat from that associated with the Dec. 24-25, 1972 storm. The difference can be attributed to tide heights at the time the storm occurred; the 1972 storm occurred during neap tides whereas the February 1976 storm took place during spring tides. The importance of tide levels in coastal erosion was already mentioned and is readily apparent. It has other effects, however, in addition to being a factor in the overall rate of dune retreat due to erosion. This can be seen in the area of the northernmost house on the spit, opposite the pronounced embayment of Fig. 3. Because of the high spring tide water level of Feb. 18, 1976, the swash of storm waves actually washed over the top of the spit rather than simply causing a further retreat of the dune escarpment. The effects can be seen in Fig. 5b, which shows the same area as 5a, but after the major storm. The wave swash went over the escarpment formed earlier in January and February, entirely flattening the area to an even slope; the escarpment disappeared. Immedi-

ately north of the northernmost house was a small beach access road used for bringing riprap onto the beach. The waves washed through this lowered area, flowed over the top of the spit and accumulated in a pond on the backside of the spit. Fig. 6 shows the water-gullied access road and the accumulation of driftwood in the pond area.

Erosion in the vicinity of the northernmost house is summarized in the field survey of Fig. 7. North of the riprap the storm of Feb. 18, 1976 eroded the foredunes back to the erosion escarpment produced in 1960. If riprap had not been present, the erosion seaward of the house would have been at least as severe and probably would have threatened the house. The storm wave swash overtopped the riprap, as seen in the photograph of Fig. 8 and indicated by the line labeled "1976 erosion scarp" in Fig. 7. The riprap suffered some damage; a number of large stones being washed down the beach and the finer, nonpermeable layer backing the boulders was partially eroded away. However, as already indicated, the riprap served its purpose in preventing a direct erosion threat to the house.

The area of the wash-over and back spit pond where water accumulated is also shown in the field survey of Fig. 7. Such wash-overs of the spit had not occurred during any other storm or erosion episode since our study began in 1970. There is no clear evidence from earlier aerial photographs, taken before house construction on the spit, of wash-overs during earlier storms. Of particular interest is that the storm of Dec. 25, 1972 produced no wash-overs even though the waves were higher than on Feb. 18, 1976. It is apparent that the spring tides during the February storm were of major importance in producing wash-over of the spit.

The storm of Feb. 18, 1976 also differed from other winter storms since 1970 in that large drift logs were thrown atop the dunes. This is most clearly seen in lots that were restored after the 1972-73 erosion; restored lots were log-free prior to the storm. Fig. 9a shows the restored lots as of July 10, 1975 before the storm; Fig 9b is a photograph of the lots after the Feb. 18, 1976 storm. Fairly large logs were thrown up on the lots, well beyond the maximum extent of wave swash. There are other examples on the Oregon coast of storm waves throwing large logs for appreciable distances. Logs have been thrown through first-story windows of the Inn at Spanish Head in Taft, north of the Siletz Spit (Fig. 1).

The February storm also caused some erosion



Fig. 3. Aerial photo mosaic of the northern half of Siletz Spit, taken on Feb. 5, 1976, showing erosion embayments on the ocean beach due to rip currents carrying sand offshore.

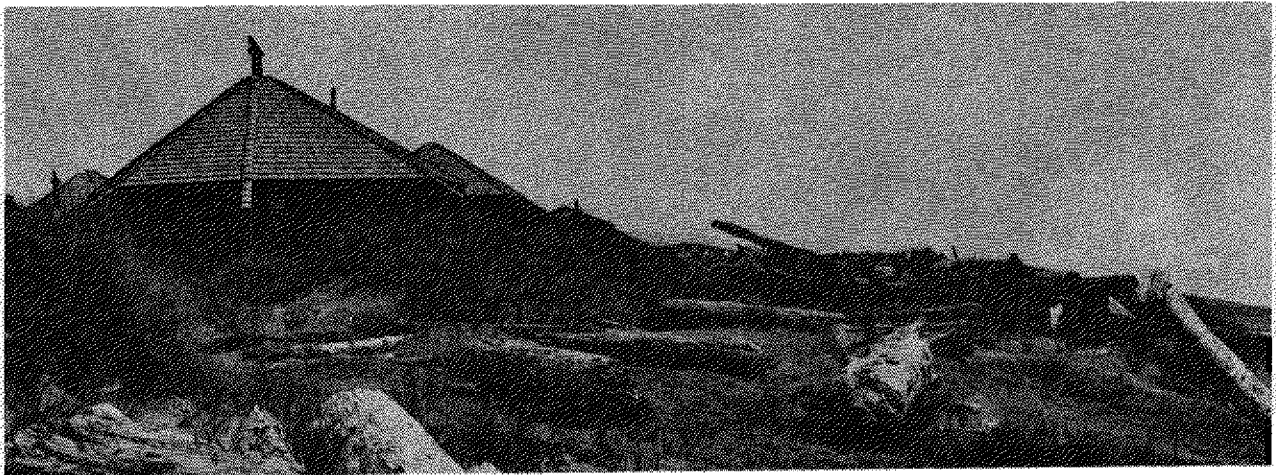


Fig. 4. Northernmost house on Siletz spit, viewed looking south with the ocean on the right. Immediately fronting the house is a dune bluff which marks the erosion scarp from an erosion episode about 1960. The gap in this bluff marks the beach access road used to bring riprap onto the beach and where waves washed over the spit during the storm of Feb. 18, 1976.



Fig. 5a. Erosional dune bluff on January 2, 1976, north of the northern most house on the spit.



Fig. 5b. Same area as in photo 5a (except viewed north) on March 20, 1976, after a major storm had washed over the dune bluff on the upper photo, flattening it into an even slope.



Fig. 6. Wash-over area north of the northern most house on Siletz Spit. Viewed toward Siletz Bay, in the foreground is the beach access road down which the wash-over water flowed, producing the gully. In the background is an accumulation of driftwood, which marks the pond area where the water accumulated.

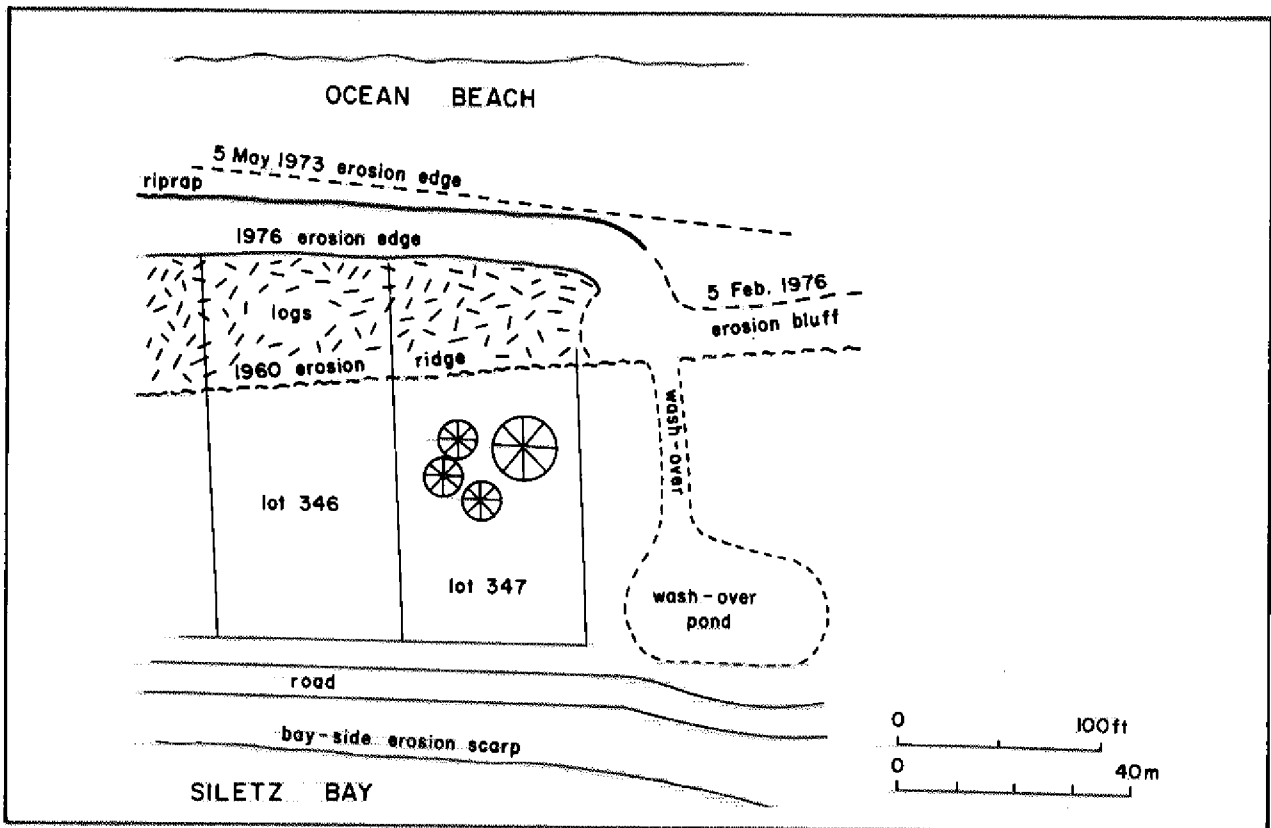


Fig. 7. Field survey of the area surrounding the northern most house on Siletz Spit. Shown are the erosion scarps at various stages and the location of the riprap protection.



Fig. 8. Erosion of the riprap seaward of the northern most house, photographed on March 20, 1976. It is seen that some of the finer-grained material backing the larger rocks has been eroded away. Waves washed over the riprap, pushing back the drift logs into a pile.

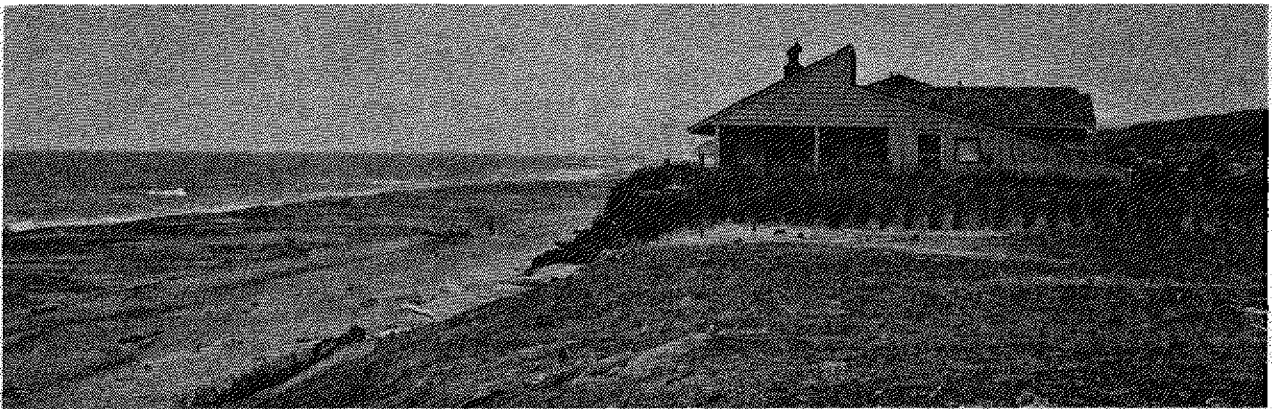


Fig. 9a. House in the mid spit area where severe erosion occurred during the winter of 1972-73 (compare with Figs. 3 and 4 of Komar and Rea 1976). The lots in the foreground have been restored by infilling of beach sands. Photo taken July 10, 1975.

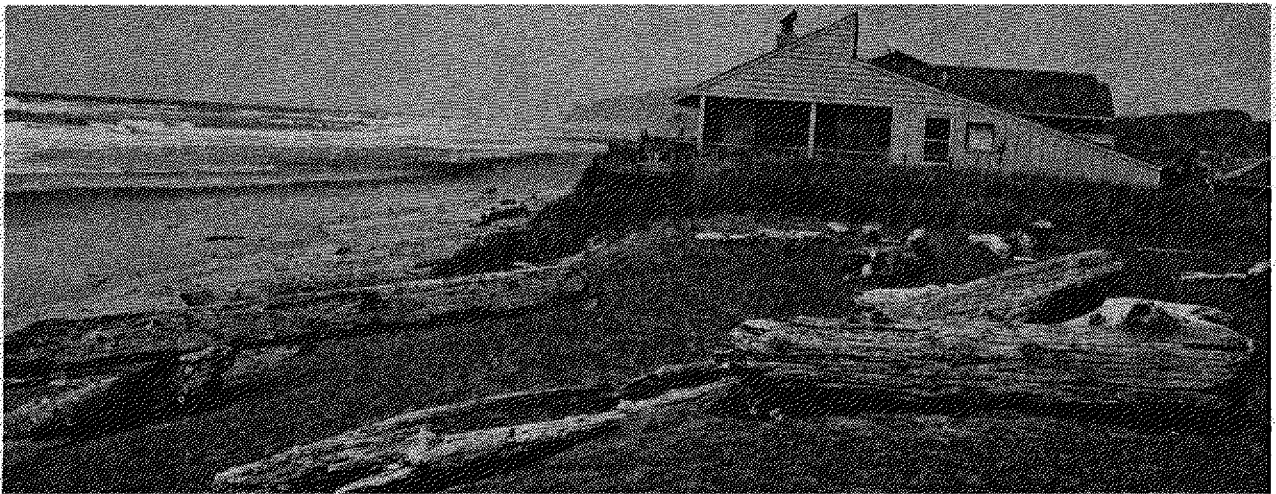


Fig. 9b. Same area as in photo 9a but after the Feb. 18, 1976 storm which threw logs atop the lot and caused some erosion of the property.

in the area that suffered from erosion in 1972-73. As seen in Fig. 10, the seaward edges of the restored lots were eroded back, exposing the riprap placed to protect them. Like the riprap opposite the northernmost house, this riprap also was degraded somewhat; Fig. 10 shows a broad area where the backup nonpermeable material was eroded. The riprap fronting houses in the background of Fig. 10, placed at the height of the erosion in December 1972 to protect the houses, was further eroded. As discussed and shown in Komar and Rea (1975), due to hurried emplacement, this riprap is inferior; even in mild winters of moderate storms it has been washed away. The storm of Feb. 18, 1976 removed still more of this riprap so that the decks of two houses presently extend over the bluff. Much of the riprap is entirely gone, exposing the underlying dune sands.

The greatest erosion in spring 1976 occurred in the second embayment (Fig. 3). It is apparent from these aerial photographs that as of February 5, erosion of the dunes had not occurred landward of the second embayment. Erosion became severe during the February 18 major storm. The foredunes retreated under attack of the wave swash, forming a high dune erosion bluff (Fig. 11). Four houses in the area were threatened, but riprap placement soon after erosion began prevented any immediate danger and somewhat limited the amount of erosion losses. Surveys along lot lines indicate that on the average the seaward edge of the vegetated portion of the dunes retreated by about 10 meters; if lower, unvegetated dunes are included in the erosion estimate, then about 24 meters of dune retreat occurred. As in earlier erosion episodes, numerous drift logs were exposed in the retreating, eroding dune bluff. Many of the logs were sawed by logging operations. In this area of the spit the 1960 erosion scarp is clearly seen in Fig. 3; the erosion which occurred in 1976 did not extend as far as the 1960 scarp. Thus the drift logs, including sawed logs, were emplaced in the foredunes during dune reformation following the 1960 erosion. This process of dune reformation following erosion is described by Rea (1975). That study found sawed logs shoreward of the 1960 erosion, indicating still greater episodes of erosion occurred prior to 1960 but after logging operations began on the Oregon coast, probably about the turn of the century. As indicated, the 1976 erosion did not extend beyond the 1960 scarp, so additional information on earlier erosion episodes could not be obtained.

No wash-overs occurred in this central spit area during spring 1976 and there is

no certain evidence more logs were thrown atop the dunes as farther south. There are already numerous logs covering the dunes so it is impossible to determine if additional logs were thrown there. The eroded dune bluff is fairly high, higher than to the south, so it is less likely that logs could be thrown over the bluff. The erosion opposite this middle embayment during 1976, was, therefore, more like the erosion processes of 1972-73 when no wash-overs or log throwing on the dunes occurred.

By mid-April 1976 the northern embayment had filled and berm sand nearly covered the riprap opposite the northernmost house. Erosion of the middle embayment continued, but at a much slower rate than before. By August the erosion had stopped entirely and a wide summer berm had developed, separating the waves from the dune bluff. Over the summer 1976 the only activity pertinent to the erosion problem was the placement of additional riprap in areas where erosion occurred in the middle embayment.

ANALYSIS OF EROSIONAL STORM SYSTEMS

The severity and nature of erosion on Siletz Spit is governed in large part by the energy and height of breaking waves and by tide levels attained during the storm. Figs. 12 through 16 present data on these important factors for the critical winter months, starting with December 1971 when some erosion occurred on Siletz Spit. Wave breaker heights given in these diagrams were computed from wave measurements obtained with the microseismometer system at the Marine Science Center, Newport. The observed high tide data were also measured at the Marine Science Center and are therefore measurements in Yaquina Bay. Siletz Spit is only 11km north of Newport, so it can be expected that wave and tide conditions were essentially the same. Figs. 12 through 16 plot the highest high tide of each day and show the fortnightly shift from spring tides, when the high tide reaches its maximum, and the neap tides, when the tidal range is at a minimum.

During winter 1971-72 (Fig. 12) breaker heights exceeded 6 meters twice (December 10 and January 10), but both periods occurred during neap tide conditions. Only minor erosion of dunes occurred on the spit that winter (Rea 1975).

Considerable erosion occurred during winter 1972-73, especially during and following the storm of Dec. 24-25, 1972 when breaker heights exceeded 7 meters (Fig. 13). Although this storm occurred at neap tide, the waves were the largest measured by the



Fig. 10. Same area of the spit as in Fig. 9, showing where waves have washed over the riprap line causing some erosion of the riprap as well as the property.

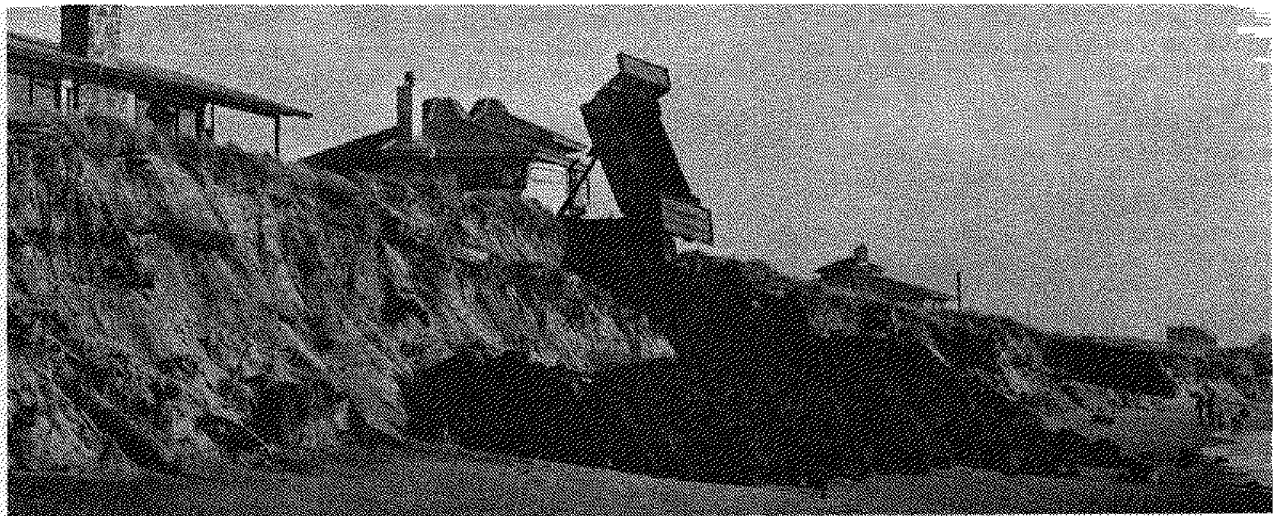


Fig. 11. Severe erosion in the mid spit area, shoreward of the middle rip current embayment seen in Fig. 3. Photos taken on March 10, 1976, but most of the erosion occurred during the Feb. 18, 1976 storm.

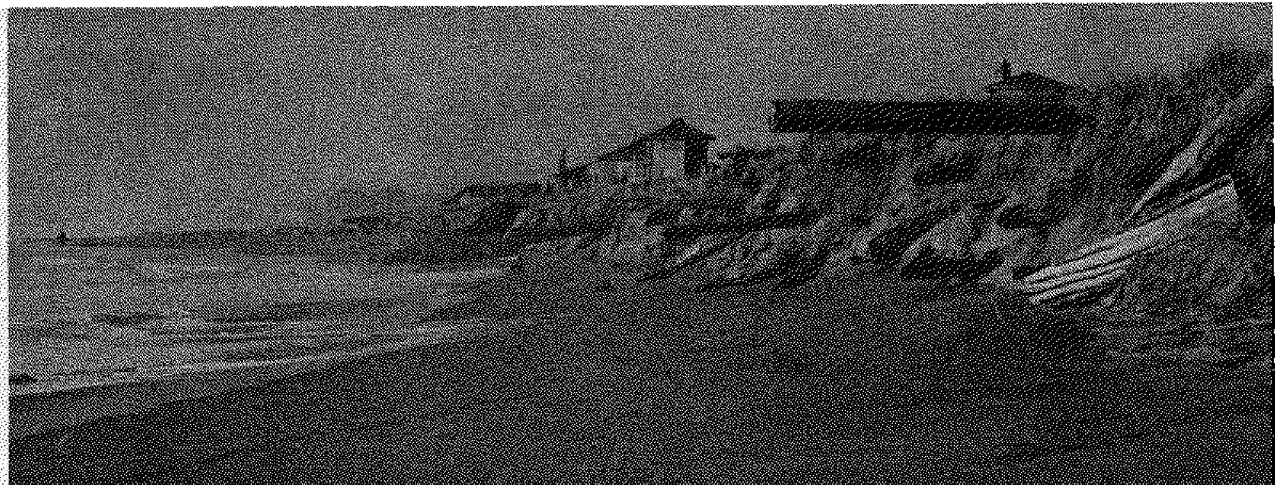


Fig. 11. View looking north.

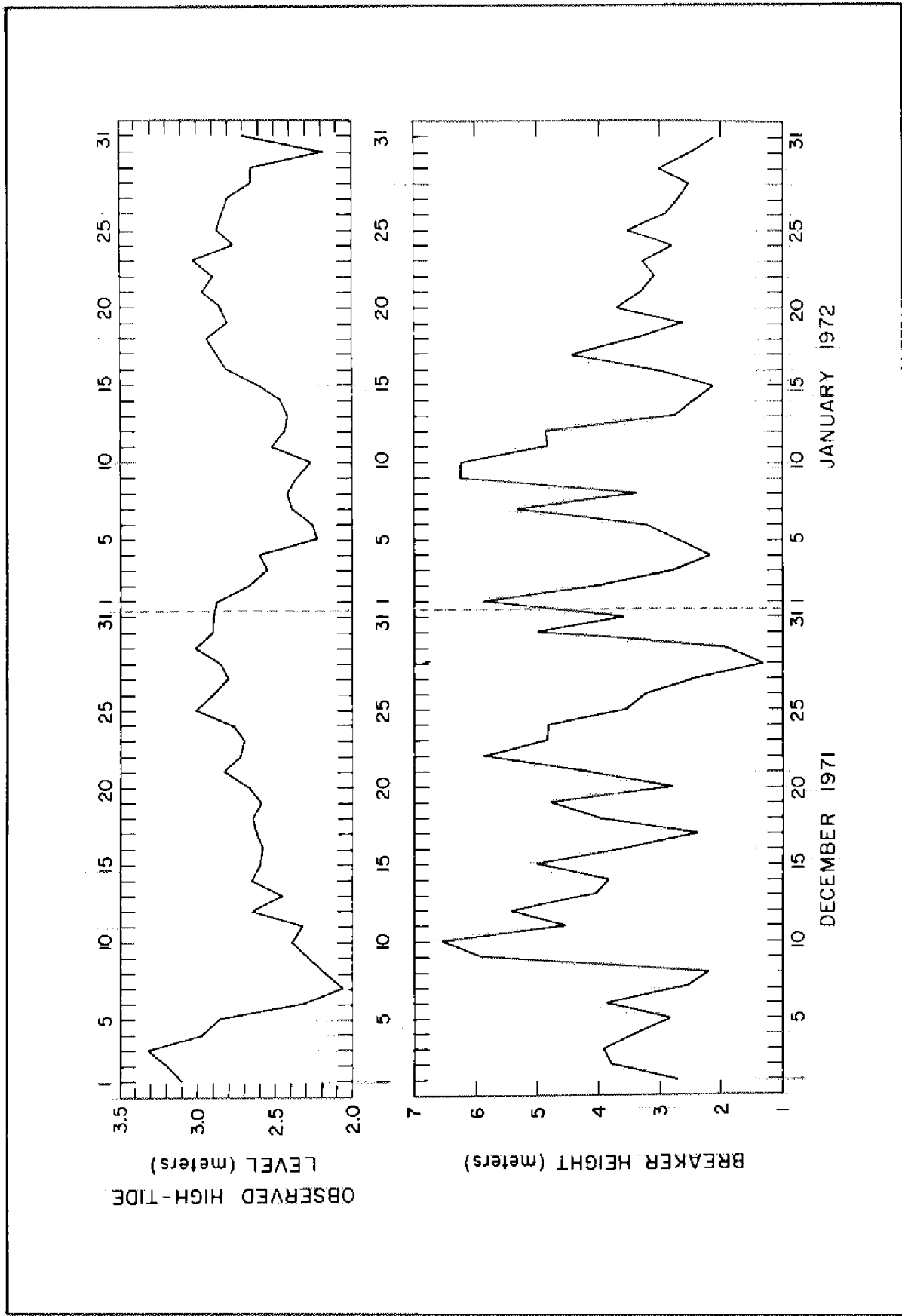


Fig. 12. Observed high tide levels and breaker heights measured at Newport, Oregon, during December 1971 and January 1972.

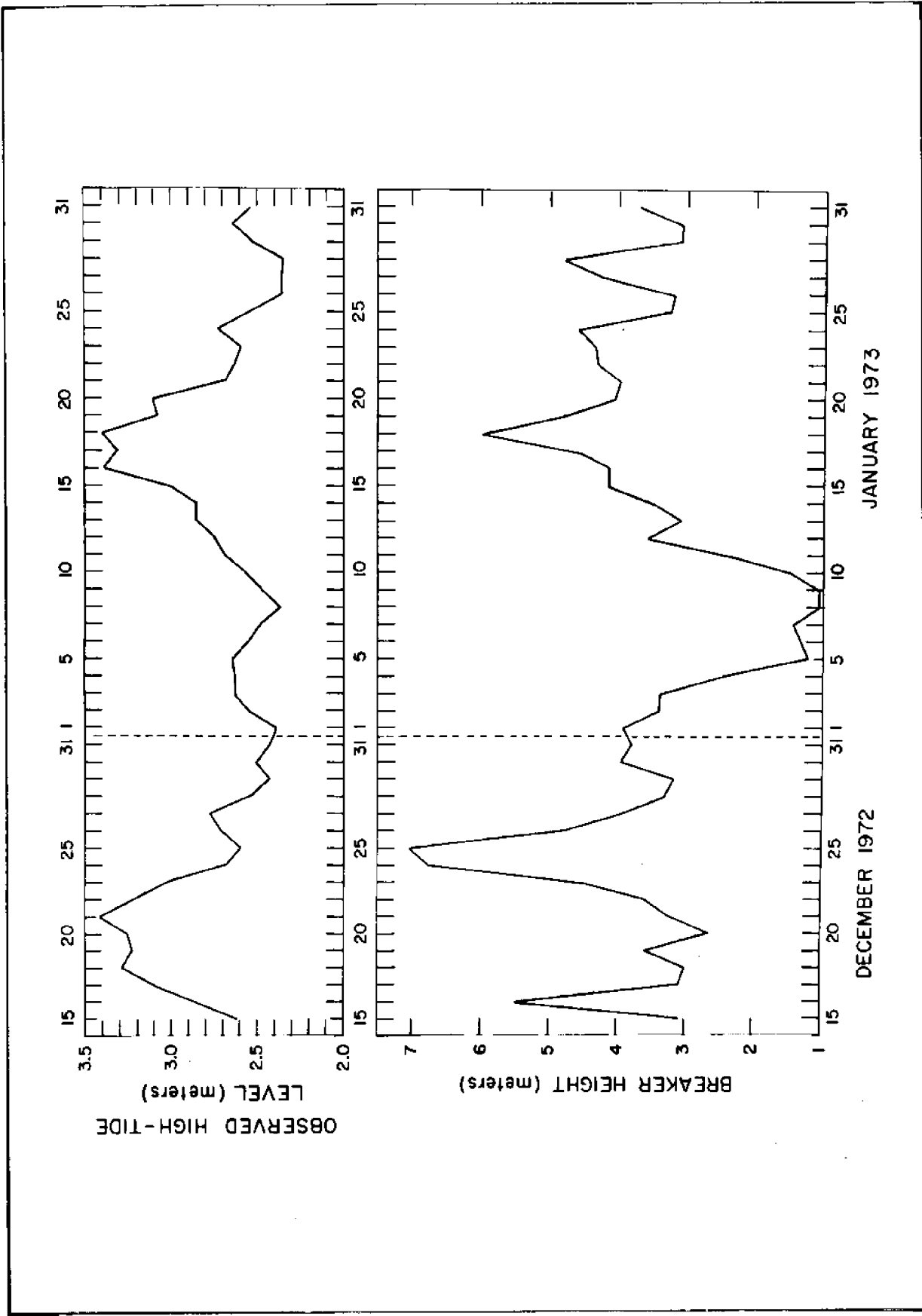


Fig. 13. Observed high tide levels and breaker heights measured at Newport, Oregon, during December 1972 and January 1973.

seismic system since its installation in 1971. The waves were large enough to reach the foredunes with sufficient energy to cause severe erosion. As already discussed, wave erosion was aided by the development of pronounced rip current embayments that cut into the beach berm. Following this major storm there was an unusual period of 10 to 15 days during which wave activity dropped to very low levels (Fig. 13), more like wave levels that prevail during the quiet summer months. In spite of this, erosion continued, but at a much slower rate. The pronounced rip current embayment allowed continued erosion by permitting wave swash against the dunes, even though the swash was weak under the small waves. On Jan. 18, 1973 a second storm occurred (Fig. 13); wave breakers were only about 6 meters high, but they occurred during spring tide conditions. Although the waves were lower than in the December 1972 storm, the higher tide level allowed the waves to lose less of their energy passing through the nearshore and allowed them to swash against a longer stretch of foredunes on the spit. Erosion accelerated over the rates maintained during the lesser wave conditions, but did not reach the extent experienced during the December 25 storm. It was this 1972-73 episode of erosion that was documented in the study of Rea (1975), Komar and Rea (1975, 1976), and which was summarized earlier in this report.

During the winters of 1973-74 (Fig. 14) and 1974-75 (Fig. 15), breaker heights never exceeded 6 meters. Such waves were not sufficiently large to cause severe erosion of the spit though some of the higher waves (5.5 meters) occurred during spring tide. Very little spit erosion took place during these winters.

As documented earlier in this report, considerable erosion again occurred on Siletz Spit from January to March 1976. Some erosion took place in January due to the exceptionally large rip current embayment that developed at the north end of the spit (Fig. 3). Most of the erosion was associated with the storm of Feb. 18, 1976 when breaker heights were about 6.5 meters (Fig. 16). The well-developed rip current embayments set the stage for erosion, but of particular importance to the erosion were the storm waves which occurred under spring tide conditions as shown by the curve of observed high-tide levels in Fig. 16. Therefore, although the waves were not as high as during Dec. 24-25, 1972, the water level was much higher due to the tides. The quantity of erosion measured in terms of the amount of dune bluff retreat was not

quite as large although it extended over a wider stretch of spit length. Of special interest is that tide conditions during the late 1976 storm allowed water to wash over the spit and logs to be thrown atop the dunes, neither of which happened during the December 1972 storm even though the waves were larger.

Weather charts, each representing an average for a six-hour period, were analyzed for the three storms that produced severe erosion on Siletz Spit; Dec. 24-25, 1972, Jan. 18, 1973 and Feb. 18, 1976. The purpose was to characterize types of storm fetches and wind velocities that generate erosive waves on the Oregon coast. Fetches were generally located in the north Pacific just south of the Aleutian Islands. Storm systems were followed for several days prior to severe wave conditions on the Oregon coast, as the waves can be generated by distant fetches and take some travel time before arriving at Siletz.

Fig. 17 shows an intense low-pressure system in the north Pacific on Dec. 23, 1972, the system that produced the large storm waves on the Oregon coast on December 24-25. Winds blow nearly parallel to the isobars in a counterclockwise direction around the low (L), so it is seen in Fig. 17 that there is a large fetch area directly west of Oregon, extending over most the width of the Pacific. Winds reach 30 knots over much of this fetch area. This storm system produced the highest waves measured at Newport since the installation of the seismic recording system. Therefore the storm system of Fig. 17 must be truly exceptional as to fetch area, wind speed and storm duration--the important factors in wave generation. An examination of weather charts during periods of normal winter waves demonstrates this to be the case.

The storm system that led to the large waves of Feb. 18, 1976 is shown in Fig. 18. Major differences from the December 1972 storm system of Fig. 17 are evident. In February 1976 the low-pressure system was farther south, off the coast of British Columbia, Canada. Isobars south of the low-pressure center were directed at the Oregon coast, but provided a much smaller fetch area than the December 1972 storm of Fig. 17. On the other hand, wind speeds were much higher, reaching 50 to 60 knots, as recorded by ships in the area. Thus the storm system of February 1976 was much different in character than the 1972 storm that caused erosion on Siletz Spit. Larger waves could have been produced by the storm system of Fig. 18 except that the system moved inland at a high rate, moving too fast

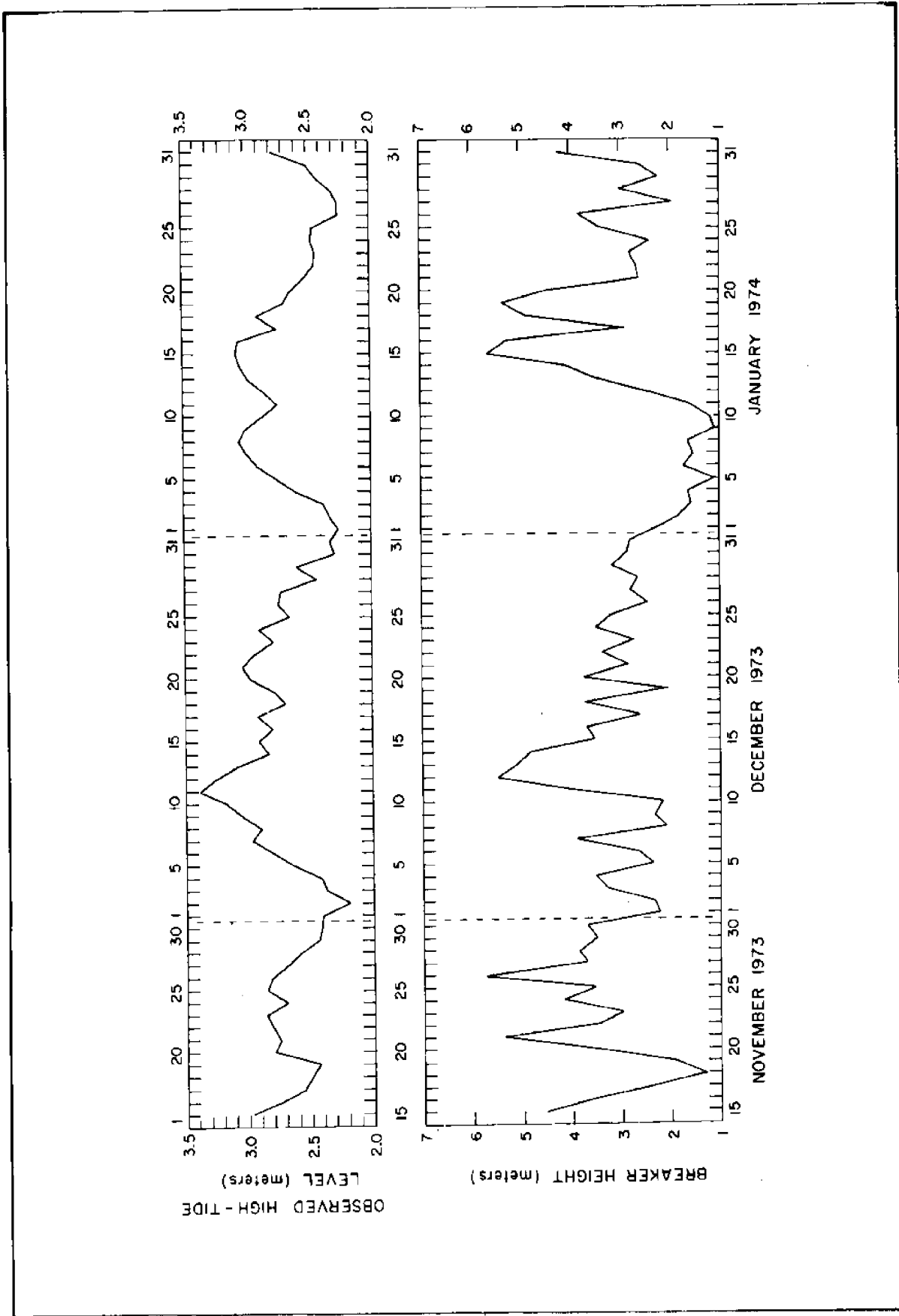


Fig. 14. Observed high tide levels and breaker heights measured at Newport, Oregon, during November 1973 through January 1974.

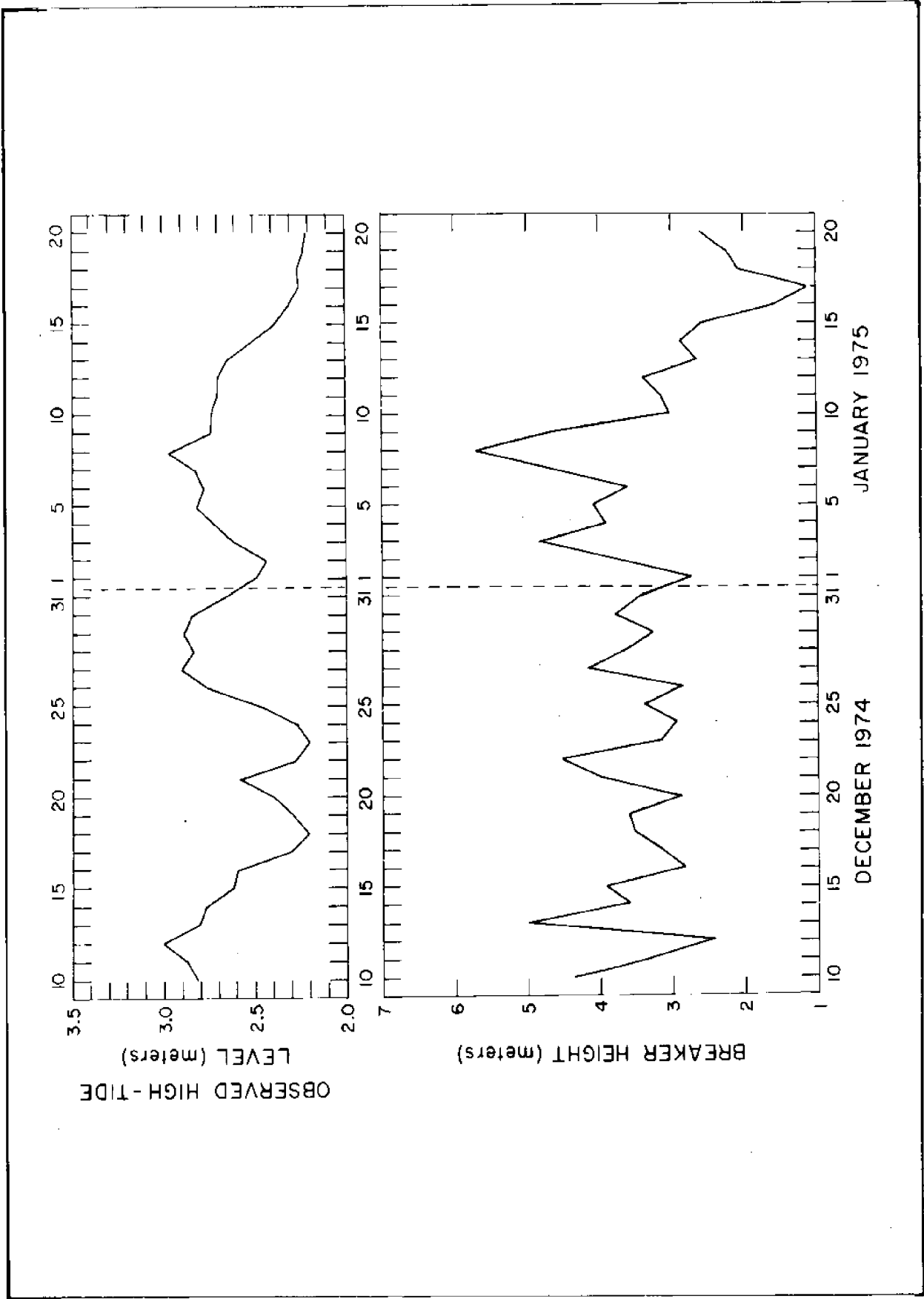


Fig. 15. Observed high tide levels and breaker heights measured at Newport, Oregon, during December 1974 and January 1975.

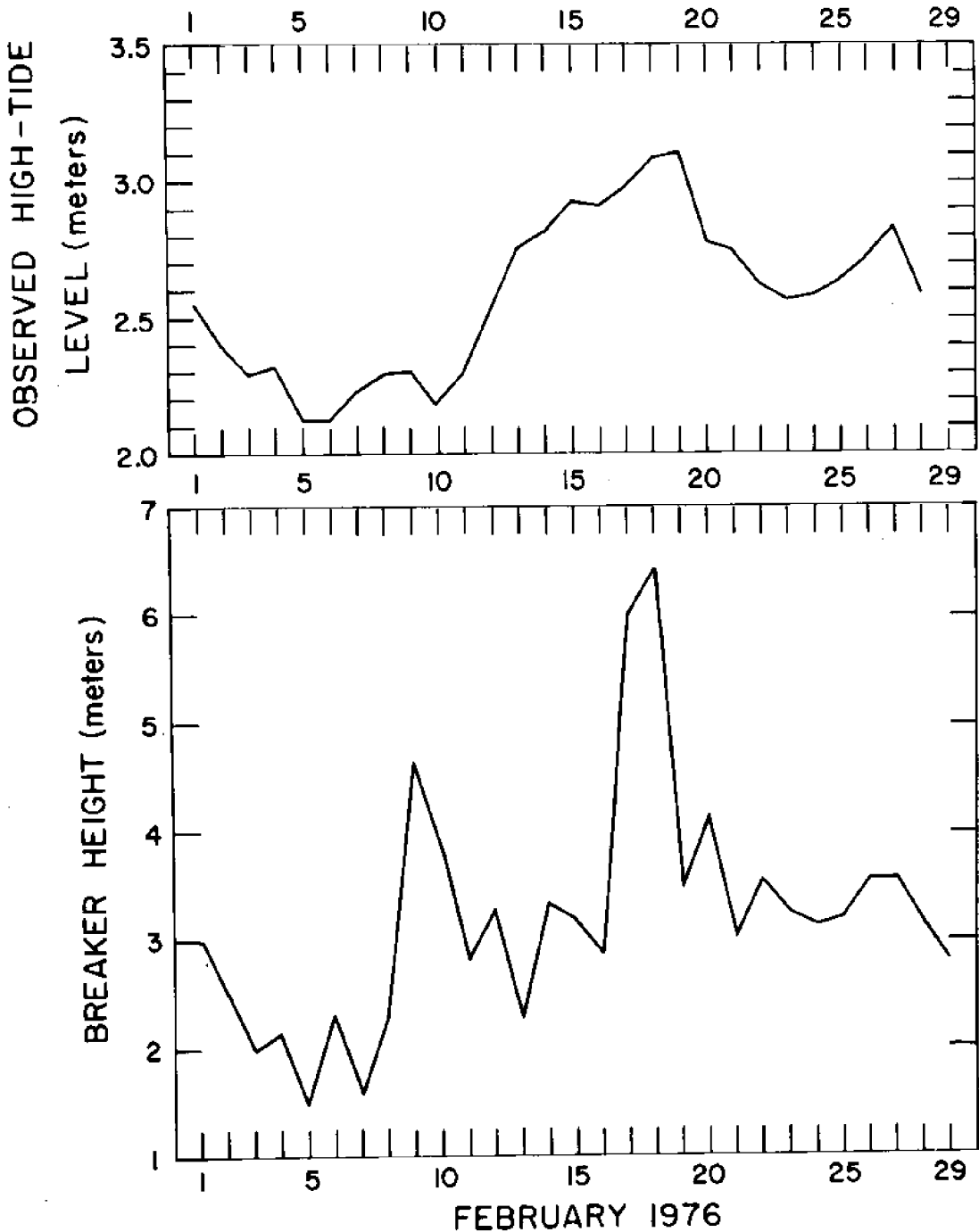


Fig. 16. Observed high tide levels and breaker heights, measured at Newport, Oregon, during February 1976. Erosion occurred on Siletz Spit due to the storm on February 18 at high spring tides.

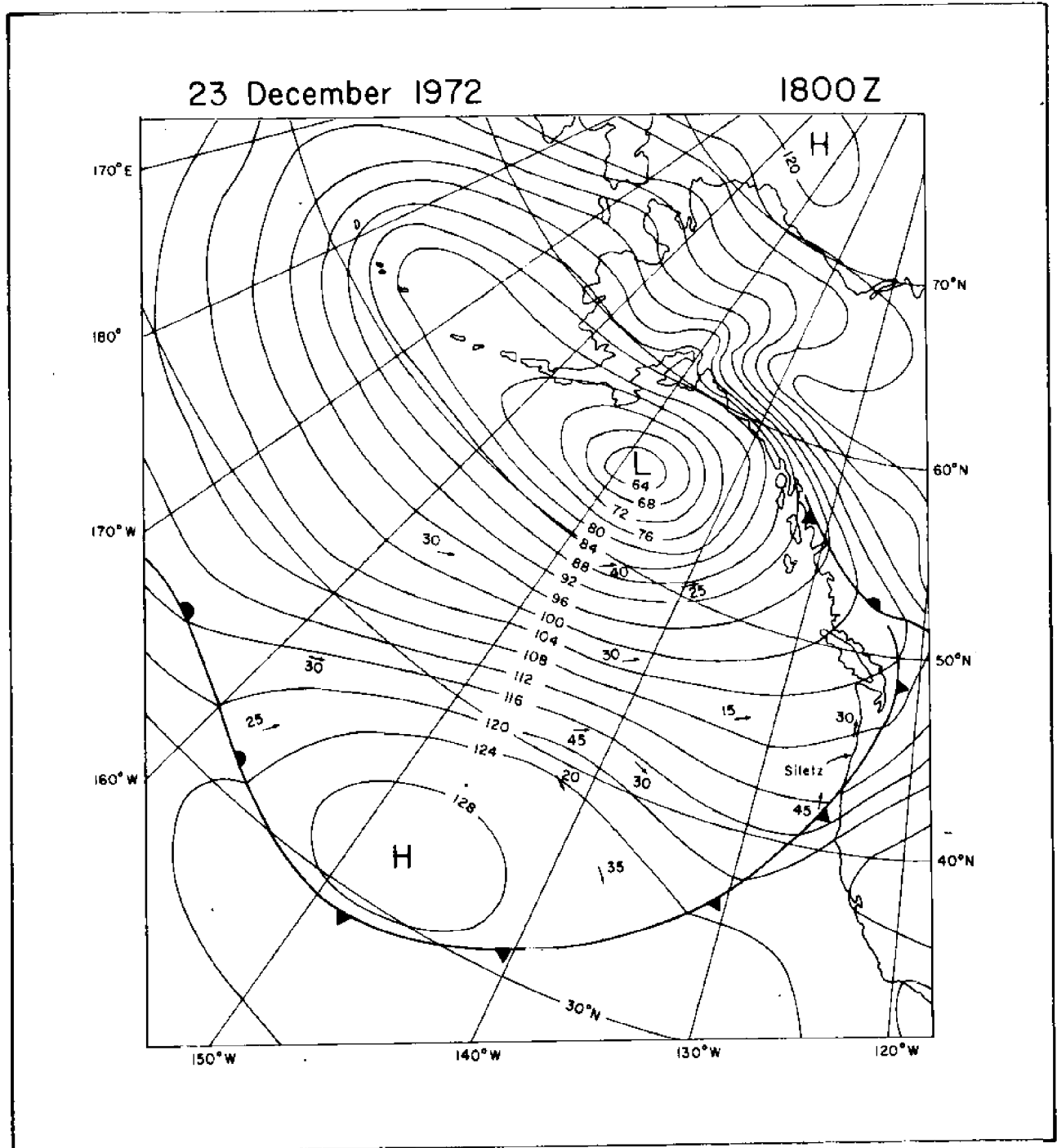


Fig. 17. Storm system on December 23, 1972 which contributed to high wave conditions on the Oregon coast on December 24-25, the largest waves that have been measured since our measurements began in November 1971. The vectors with numbers give wind velocities in knots as measured by ship observations. Pressure given in millibars.

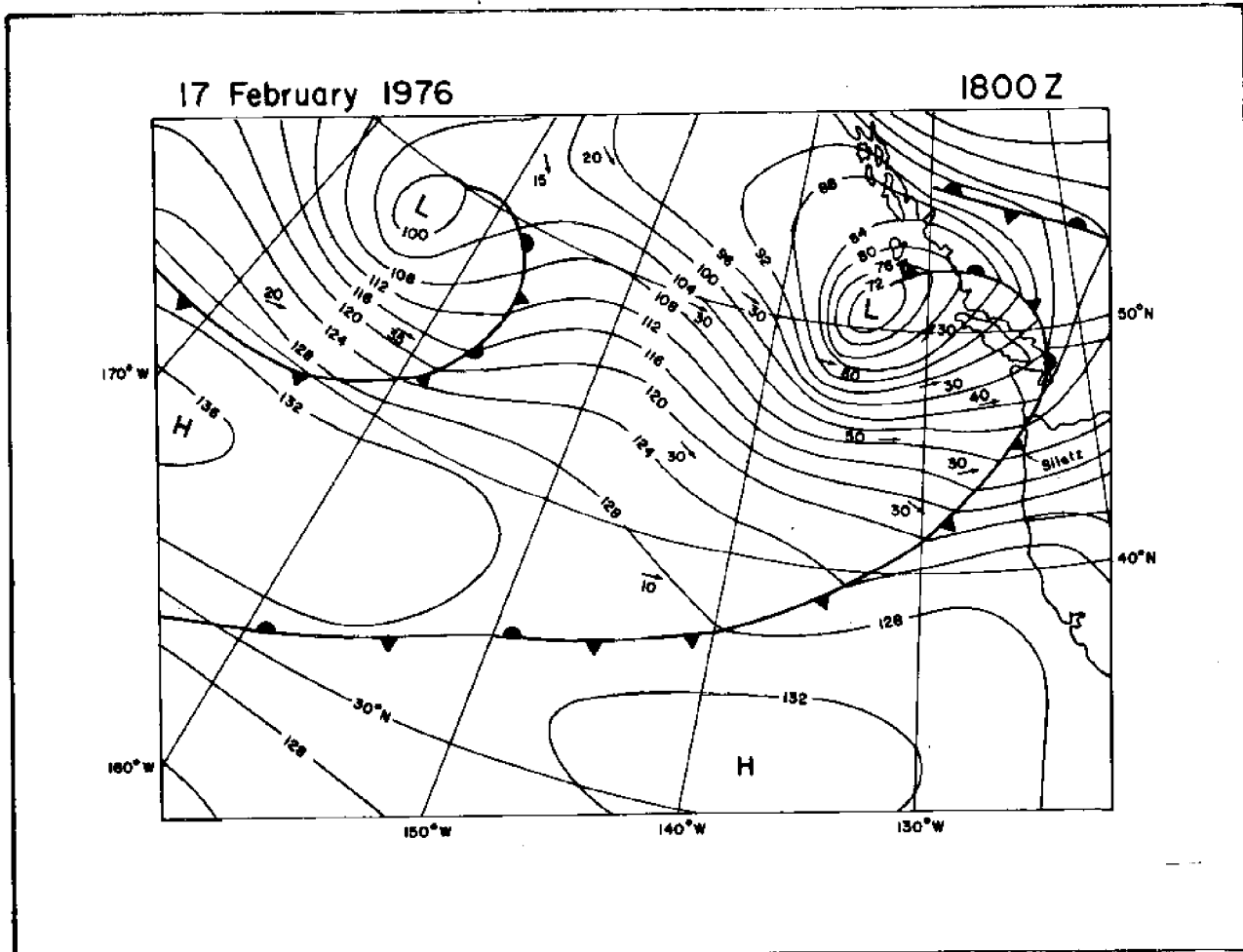


Fig. 18. Storm system of February 17, 1976 that contributed to high wave activity causing severe erosion on the Oregon coast. The fetch to the west of Siletz for this storm is much smaller than the storm of Fig. 17, but the wind velocities are up to 60 knots (indicated by vectors in the figure at locations where there were ship observations).

for the full development of storm waves.

The thesis of McKinney (1976) utilizes weather charts for wave prediction, then compares them with the waves actually measured at Newport. The wave prediction methods of Enfield (1974) were employed, which are a computerized version of the wave spectrum approach of Pierson, Neumann and James (1955). Predicted and observed wave heights and periods agreed quite favorably, indicating correct identification of the storm systems that produced the high erosive waves on the Oregon coast.

The thesis of McKinney (1976) also analyzed tide data from Yaquina Bay at Newport to determine if storm surges played any role in aiding erosion at Siletz Spit. The storm surge component in Yaquina Bay was determined by subtracting the predicted high tide level from the actual high tide level observed. This analysis showed that storm surges did not occur at the times of storm waves that caused spit erosion. Thus water levels were due entirely to the stage of the tide. This is not surprising because the large waves were produced by distant fetches, not by local coastal winds. This was further shown by an analysis of the winds measured at Newport during times of maximum erosion on Siletz; there was no correlation.

SUMMARY

The two most severe episodes of erosion of Siletz Spit were associated with major storms in the north Pacific. However, the two storms differed in several ways. The December 1972 storm (Fig. 17) had a fetch area covering a major portion of the Pacific but with only moderate wind speeds (about 30 knots). In contrast, the February 1976 storm (Fig. 18) was closer to the Oregon coast with a small fetch but high wind speeds (50-60 knots). The December 1972 storm produced breakers on the Oregon coast in excess of 7 meters, the highest recorded by the seismic system at Newport since it was made operational in 1971. The February 1976 storm produced breakers 6.5 meters high.

Although both storms caused major erosion of Siletz Spit, the character of the erosion differed. These differences can be attributed mainly to tide conditions during the storms; neap tides prevailed during the Dec. 24-25, 1972 storm whereas spring tides existed during the Feb. 18, 1976 storm. Due to the higher water levels during the 1976 storm, one wash-over of the spit took place and beach drift logs were thrown atop the dunes. Neither took place during the

December 1972 storm even though the waves were larger. Both storms caused extensive dune retreat, necessitating the placement of riprap to protect homes built on the dunes.

Storm surges, which would have produced an additional water level rise above the tidal level, played no role in the erosion of Siletz Spit. This was because the erosive waves were produced by distant storm fetches, not by local onshore coastal winds which are necessary to generate a storm surge.

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