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THE ANNUAL CYCLE OF PROFILE CHANGES OF TWO OREGON BEACHES

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Introduction

Two Oregon coast beaches with significant differences in grain size, and thus in beach profile morphology and response to wave conditions, were studied. Gleneden Beach, just south of Siletz spit and Lincoln City, has a median grain size of 0.35 mm (0.014 in) (medium sand) and a steep beach face slope; Devil's Punchbowl beach has a median grain size of 0.23 mm (0.009 in) (fine sand) and a low concave-up beach face slope. Between August 1976 and July 1977, fourteen sets of beach profiles were obtained both at Gleneden Beach and Devil's Punchbowl beach.

Beach profile and wave conditions

The beach profile configuration, in nature and laboratory wave tanks, is a function of the intensity of energy dissipation by waves breaking on the beach. Beach profile changes are caused by storms, longshore sand transport, tides, and coastal winds (Komar, 1976). Monitoring all of these variables at the same time in order to understand the variations in the beach profile is difficult.

The principal observed variation commonly found in beach profiles is annual, resulting from overall changes in the energy level of waves between summer and winter. Some of the first measurements of this annual shift were made on California beaches by Shepard (1950), and overall shift in profile type is illustrated in Figure 1. Shepard (1950) found that during the summer, when small waves prevail in California, beach profiles are characterized by wide berms and relatively smooth offshore profiles. Storms during the winter shift sand from the berms to offshore bars (Figure 1). Because profile types are generally seasonal, Shepard used the terms "summer profile" and "winter profile." As such shifts, however, are not always seasonal, the terms "swell profile" and "storm profile," after Komar (1976), are used in this paper. Figure 1 emphasizes the relationship of the profile types to swell waves and storm waves. Generally, however, Oregon beach profiles, like those of California beaches, are approximately seasonal.

The two types of beach profiles are most commonly related to steepness of waves, H_∞/L_∞, where H_∞ is the deep-water wave height and L_∞ the deep-water wave length. The deep-water wave length is related to the wave period, T, by

$$L_\infty = \frac{g}{2\pi} T^2$$

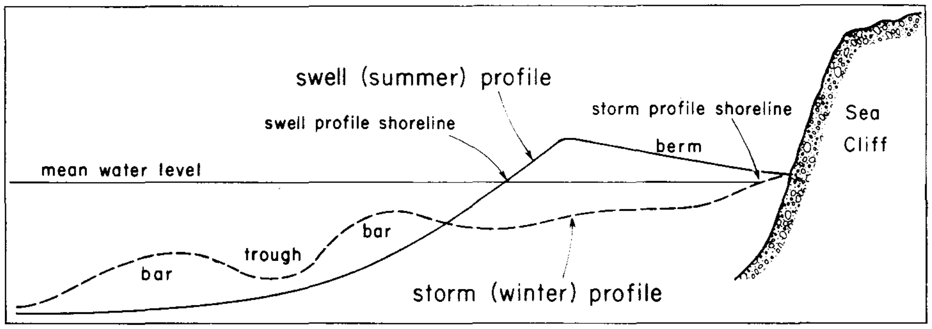

Figure 1. Swell (summer) profile with its wide berm v. storm (winter) profile with larger offshore bars. These differences result from changing wave conditions (from Komar, 1976).

where g is the acceleration of gravity. Thus wave steepness includes wave period as well as wave height. In wave tank experiments, Johnson (1949) found that the beach profile changed from a swell profile to a storm profile when wave steepness, H_∞/L_∞, reached a value of 0.025 to 0.03. Rector (1954) and Watts (1954) found the critical wave steepness to be 0.012, lower than values given by Johnson (1949). Using a wave tank which generated waves as large as those occurring on actual beaches, Saville (1957) found a critical wave steepness of 0.0064, much lower than that found in other studies.

Iwagaki and Noda (1963) and Nayak (1971) have shown that the value of the critical wave steepness for the change from a swell profile to a storm profile depends on the ratio, H_∞/D, where D is the mean grain size of beach sediment; their two studies, however, did not particularly agree. Dean (1973) presents a model for the shift in profile type based on a consideration of the trajectory of a suspended sand particle as it falls to the bottom, acted upon at the same time by horizontal water motions of waves. He finds that critical wave steepness depends on the ratio of the settling velocity of beach sediment to the period of waves.

All considerations of a critical wave steepness that causes the shift in profile type agree that the deep-water wave height, H_∞, and the wave period, T, are the major parameters important in the process, since they govern the value of the wave steepness. Previous studies clearly demonstrate that deep-water wave height, or breaker height, or wave energy (which depends on the wave height), is important in the shift in profile type. Komar (1976, p. 293) suggests, however, it is not clear that the wave period, T, is an important parameter. On North Carolina beaches, for example, Dolan (1966) found a significant correlation between both onshore-offshore shifts of sand and profile types with wave height or energy but almost no correlation with the wave period.

Purpose of study

The purposes of this study are (1) to examine annual changes in beach profiles on the Oregon coast and (2) to relate these changes to wave conditions. Of particular interest is winter erosion of the beach because when most of the beach berm has been removed, waves wash directly against the coastal sea cliffs or dunes (Komar and others, 1976), resulting in erosion of coastal properties such as has occurred on Siletz spit (Rea, 1975; Komar and Rea, 1976) and Bayocean spit (Terich and Komar, 1974; Komar and Terich, 1977). The ultimate purpose of the investigation is to allow the prediction of the amount of beach erosion or deposition (the onshore-offshore shifts of beach sand) from a knowledge of the wave conditions. Waves measured daily at the Marine Science Center in Newport on the mid-Oregon coast could thus be used to predict beach erosion along the coast.

Previous Oregon studies

Only two previous investigations of beach profile changes have been conducted on the Oregon coast. The first involved an extensive University of California, Berkeley, study of West Coast beaches for the Navy during and immediately following World War II. The findings of those studies are summarized by Komar (1977). The investigations summarized in this article can be viewed as a continuation of the studies of Oregon beach profiles undertaken by Fox and Davis (1974) from June 1973 to May 1974 when they examined the response of the beach to changing waves, winds, and tides, finding that during the winter, wave swash and nearshore currents remove large volumes of sand from the beach. They learned that the beach partially recovers during stormless periods, even during winter, because the sand removed from the berm and stored in offshore bars returns to the beach in the form of small intertidal bars that migrate onshore.

Beach Profile Locations

The two Oregon beaches from which profiles were obtained differ significantly in grain size. The coarser sand occurs along a stretch of beach at Gleneden Beach immediately south of Siletz spit and 9.2 km (5.7 mi) south of Lincoln City; the profiles were obtained at the northern edge of Gleneden Beach State Park and the private property to the immediate north of the park. More details of the location and arrangement of profiles are given by Aguilar-Tunon (1977).

Figure 2 shows a typical Gleneden Beach profile with the grain-size parameters along its length. The sand is generally approximately 0.36 mm (0.014 in) in median size (medium sand, according to Wentworth's (1922) classification). Gravel concentrations commonly appear on the beach face, especially within pronounced longshore troughs that develop during the spring.

Because of its relatively coarse sediment, the beach has a steep profile and beach face slope, demonstrating the relationship of increasing beach slope with increasing grain size (Bascom, 1951; Wiegel, 1964; and Komar, 1976, p. 303-308). Because coarse sand beaches change their profiles in response to varying wave conditions much faster than do beaches composed of finer sized grains, Gleneden Beach may also be expected to be in closer equilibrium with prevailing wave conditions.

The second beach examined in this study is located from 410 to 510 m (1,350 to 1,700 ft) south of Devil's Punchbowl at Otter Rock, 11.6 km (7.2 mi) north of Newport. Profiles were obtained far enough away from Devil's Punchbowl itself so that the rocky headland would not interfere with the waves at the profile locations and should therefore not significantly affect the beach response. Figure 3 shows a typical beach profile with the grain-size parameters along its length. The beach there is composed principally of fine-grained material (Wentworth, 1922), with a median diameter of approximately 0.23 mm (0.009 in),

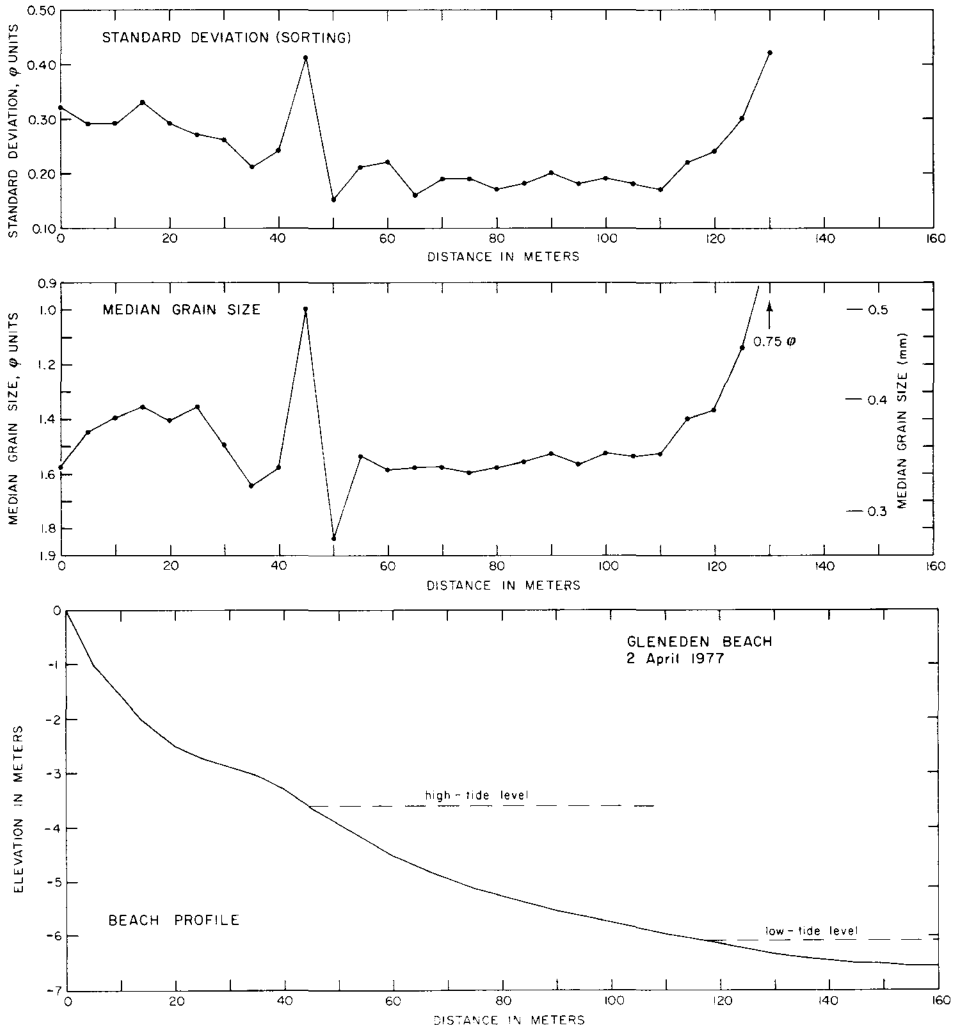

Figure 2. Median grain size and standard deviation (sorting) of grain-size distributions across typical beach profile at Gleneden Beach. Analyses were performed on sedimentation balance.

much finer than the sand at Gleneden Beach. The beach slope is also much lower.

There are other differences in the beaches, as well. The overall mineralogy of the beach at Devil's Punchbowl changes during the year. In summer, when the berm is widest, the beach is light in color because it consists mainly of clear to cream-colored quartz and feldspar. During winter, sand is shifted offshore from the upper beach, exposing a concentration of heavy minerals, mainly hornblende, epidote, and garnet, leaving the beach almost black, with a distinct green tinge due to the epidote. Gleneden Beach does not show similar concentrations of heavy minerals and resulting changes in color, consisting instead of quartz-feldspar sand throughout the entire year.

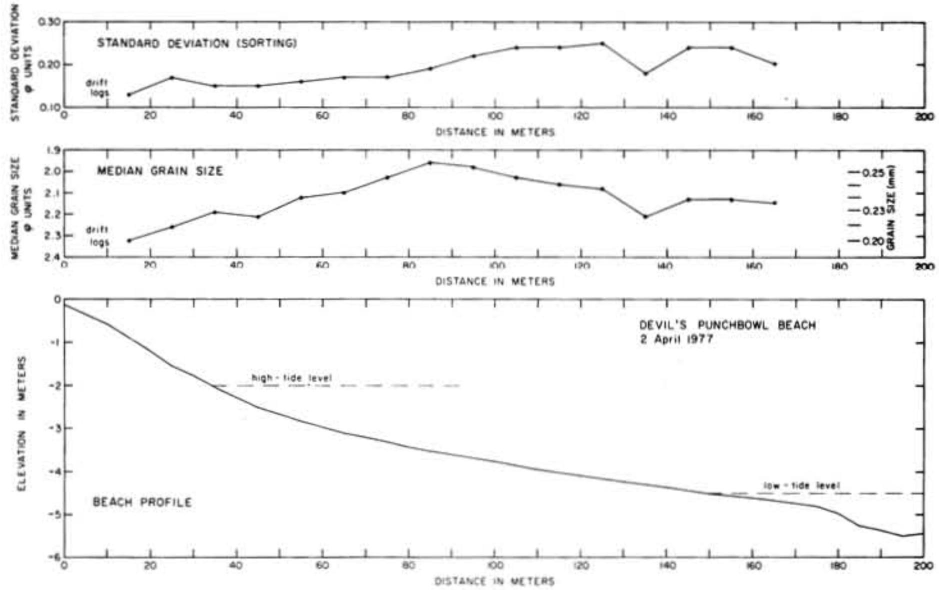

Figure 3. Median grain size and standard deviation (sorting) of grain size distributions across typical beach profile at Devil's Punchbowl beach. Sand on this beach is much more uniform and finer grained than that at Gleneden Beach (Figure 2).

Beach Profiling Techniques

The profiling techniques used in this investigation are the same as those described by Emery (1961), Hoyt (1971), Fox and Davis (1974), and, in greater detail, Aguilar-Tunon (1977). The approach is the line-and-stakes method, which utilizes the horizon to determine the horizontal to which vertical changes in the profile are referred. Emery (1961), Davis (1976), and Aguilar-Tunon (1977) discuss the accuracy of the approach.

The 14 sets of surveys conducted at both Devil's Punchbowl beach and at Gleneden Beach were generally carried out during spring tides, when the most beach is exposed. For this reason, the successive profile sets are separated in time by either two weeks or one month. Aguilar-Tunon (1977) lists profile dates. Four wooden stakes and one iron stake were located at the top of the beach along the base of the sea cliff at Gleneden Beach; the distance between the stakes was 60 m (200 ft) (Aguilar-Tunon, 1977, Figure 9). The stakes served as base marks for the survey lines; the tops of the stakes provided a base level to which the repeated profiles could be compared. Similarly, three wooden stakes located at the base of the cliff along Devil's Punchbowl beach were reference points for the three survey lines there (Aguilar-Tunon, 1977, Figure 10). Distance between these stakes was 50 m (165 ft).

The purpose of having multiple survey lines, five at Gleneden Beach and three at Devil's Punchbowl, was to allow longshore variations in beach erosion and deposition patterns to be assessed and averaged. The chief cause of these variations was expected to be rip currents, which hollow out more of the beach, producing embayments. If a single survey line were used and it happened to be at the location of a rip current, the resulting erosion would not correspond well to the wave conditions. Rip current embayments or other beach irregularities actually presented few problems until April to June 1977, toward the end of the study. This was a matter of chance, especially at Gleneden Beach, where rip current embayments could be seen both to the north and south of the survey area throughout the winter. Similarly, no longshore irregularities appeared on Devil's Punchbowl beach throughout the winter. Rip current embayments and irregular longshore throughs developed at both beaches in late April through June, as sand began to shift onshore, returning to the exposed beach berm. These irregularities will be discussed later.

Multiple survey lines served another purpose in that stakes were sometimes lost and had to be replaced. Fortunately, one stake at each location survived for the entire study period. Most determinations of beach erosion and deposition were obtained from those two survey lines, with confirmation checks from other survey lines to insure that longshore variations were not appreciable.

Wave Measurements

Sea wave conditions were recorded daily for 10-minute intervals every 6 hours at the Marine Science Center in Newport. The microseism system for wave measurements and the wave analysis procedures are described by Enfield (1973), Quinn and others (1974), Zopf and others (1976), and Komar and others (1976). The system empirically yields measurements of the significant wave height and period at a water depth of 12 m (40 ft) off Newport; as discussed by Komar and others (1976), these measurements can be considered as deep-water waves with little introduction of error. Corresponding breaker heights of waves were calculated from offshore wave data provided by the Newport seismic system, utilizing the equation developed by Komar and Gaughan (1973).

Resulting Beach Profiles

Gleneden Beach

Figures 4 and 5 show the 14 profiles obtained at Gleneden Beach along the profile range for which the stake was not lost, and all profile elevations and horizontal distances are relative to the top of that stake. Profile 1 (27 August 1976), Figure 4, shows a berm 70 m (230 ft) wide, sloping in a landward direction, meeting the seaward-sloping beach face in a pronounced berm crest. Such a profile, with a low in the mid-berm and a sharp berm crest, is a typical swell (summer) profile for this location. The landward-sloping berm is produced by waves washing over the berm crest, depositing sand, and then ponding in the low of the mid-berm. Bascom (1954) shows similar profiles at Carmel, California.

Profile 2 (7 October 1976), Figure 4, shows that the berm has been partially eroded. Profile 3 and subsequent profiles in Figure 4 show no berm, the beach instead consisting of an offshore-sloping beach face, a typical concave-upward storm (winter) profile. Thus, between Profiles 1 and 3, a shift similar to that shown in Figure 1 has occurred. The summer type of profile has been transformed into the winter type. Sand has presumably moved offshore into bars which could not be reached by these profiles but which can be seen in profiles obtained with an amphibious DUKW (Komar, 1977).

Figure 5 includes Gleneden Beach profiles that demonstrate the growth of the exposed beach berm as wave conditions change and the profile shifts

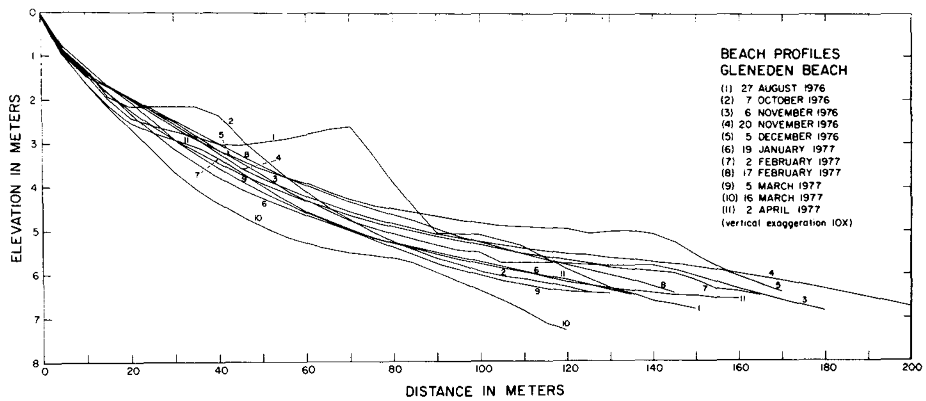

Figure 4. The first 11 beach profiles obtained along Profile Range 4 at Gleneden Beach on indicated dates, showing progressive beach erosion.

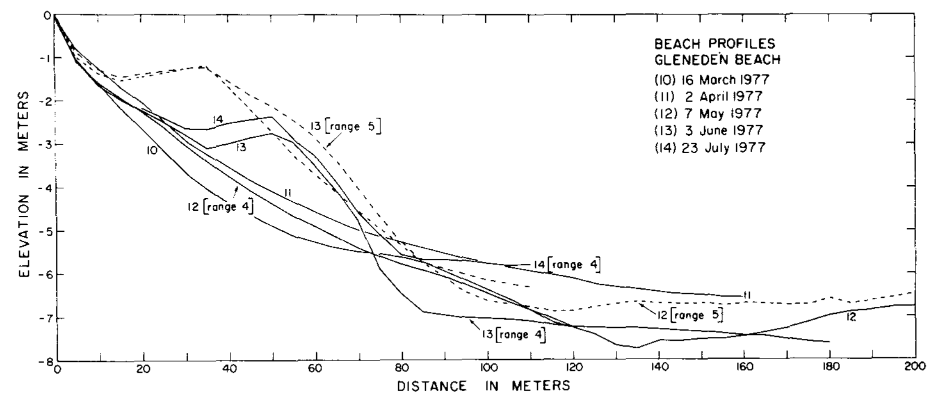

Figure 5. Profiles 10 through 14 at Gleneden Beach, showing recovery of beach berm under lowered wave conditions of spring and early summer. Dashed lines show Range 5; solid lines indicate Range 4; longshore separation of the two ranges is 50 m (165 ft). Note considerable longshore variability in berm recovery shown by these two ranges.

back to the swell-type profile that prevails during the summer. Profiles 10 and 11 are repeated from Figure 4, showing the maximum amount of erosion (Profile 10) and the beginning of recovery (Profile 11). Beginning with Profile 12 (7 May 1977), longshore variations in the profiles are appreciable, especially in the degree of berm recovery and in irregularities of the offshore portions. From this time through July, rip currents were very apparent, with longshore troughs cut by longshore currents feeding the rip currents. This was the main cause of the longshore variations in the beach profiles. It also governed local recovery of the berm.

Two beach profiles are given in Figure 5 for surveys 12 and 13 to depict this longshore change; all profiles shown in Figure 4 are located on Range 4, the location of the one stake not lost during the study.

Range 5 is 60 m (200 ft) to the south. Figure 5 shows the berm recovered much sooner at Range 5 than at Range 4 because a rip current was centered off Range 4 during this period. It was not until 23 July 1977 (Profile 14) that the berm at Ranges 4 and 5 appeared about equal in extent (elevations of Ranges 4 and 5 in Figure 5 are not comparable, since they are related to different stakes having different levels). Even during July, the beach profiles seaward of the steep beach face differed considerably due to the presence of nearshore circulation of longshore currents and rip currents.

Devil's Punchbowl

Representative profiles of the total 14 sets obtained at Devil's Punchbowl beach are shown in Figure 6; all the profiles can be found in Aguilar-Tunon (1977). At this beach, which is composed of fine sand, changes are much less pronounced than at the coarser grained Gleneden Beach. Devil's Punchbowl has little, if any, true berm, even in Profile 1 (27 August 1976). At the back of the beach a portion 10 m (30 ft) wide covered with drift logs could be called a beach berm. Otherwise, the exposed beach profile, even in midsummer, consists of a concave-upward beach face. Total vertical changes in the beach level from August 1976 to June 1977 were only on the order of 1 m (3 ft).

No ordered sequence of erosion occurs as the winter months of high waves begin followed by deposition as low waves return (Figure 6). While the coarser grained Gleneden Beach is undergoing erosion, Devil's Punchbowl beach might be undergoing deposition, and vice versa. The correspondence to the changing wave conditions was also rather poor; for example, erosion did not always occur when wave heights increased. The nonsystematic changes of Devil's Punchbowl beach cannot be attributed to errors in the profiling techniques because the changes are sufficiently large to be resolved by the approach, and, in most cases, all three profiles show the same changes. Perhaps the presence of Devil's Punchbowl headland some 400 to 500 m (1,300 to 1,650 ft) to the north has an indirect effect, even though it does not alter wave conditions at the profiling site. For example, the effects of the change in direction of waves from southwest to northwest and the resulting change in direction of the littoral drift, which would be blocked by Devil's Punchbowl, may have been felt as far south as the profiling location. This effect cannot be understood without further field studies.

A common feature of the beach at Devil's Punchbowl is a pronounced

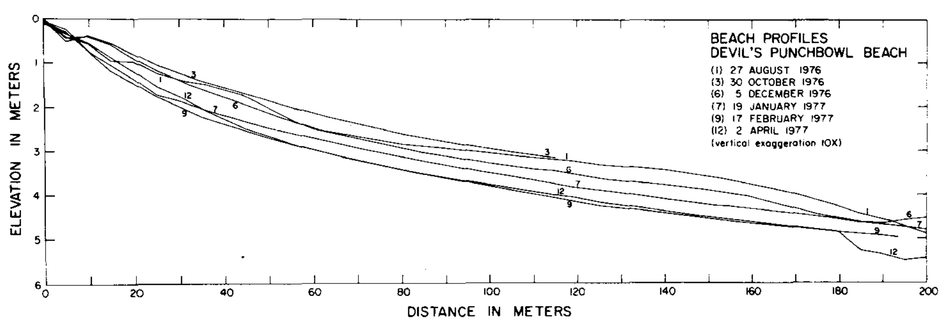

Figure 6. Selected beach profiles from Devil's Punchbowl beach, showing winter erosion of exposed beach.

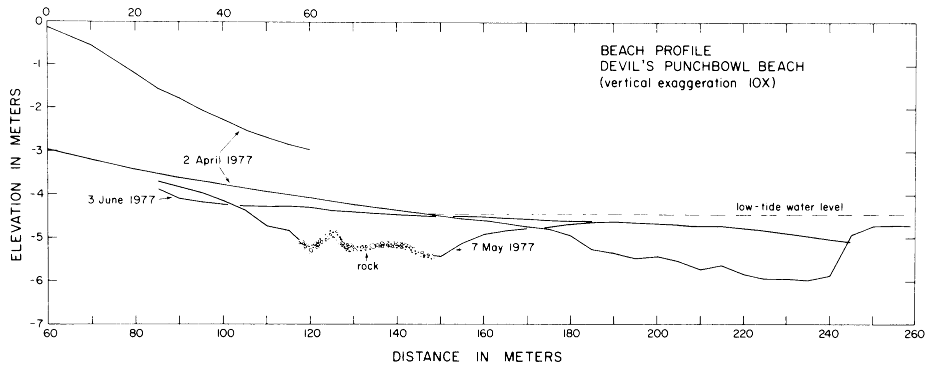

Figure 7. Development of an onshore-migrating bar as sand returned to beach berm during spring and early summer. A pronounced longshore trough developed between bar and exposed beach face, finally cutting completely through beach sand down to bed rock.

longshore trough and offshore bar. From August 1976 to March 1977, the trough was deep and the bar well offshore, and the profiles could not generally reach the bar. In spite of pronounced troughs, longshore currents were not strong. Rip currents were also weak; during the winter months they did not significantly hollow out embayments into the beach to produce longshore variations in the exposed beach. The 2 April 1977 profile (Figure 7) shows the offshore bar beginning to migrate shoreward while the confined longshore trough cuts deeper into the beach. On 2 April 1977, the bar top-to-trough-bottom relief was 1.3 m (4.3 ft); at low tide, the water depth in the trough was 1.5 m (4.9 ft). By 7 May 1977, the date of the next series of profiles, the bar had migrated shoreward by some 80 m (260 ft) (Figure 7). The more confined shoreward trough dug completely through the beach sand and flowed, in part, over exposed rock. During this stage, longshore currents were much stronger than during the winter, even though the waves were smaller. As individual waves dumped into the trough, water flowed over the bar into and along the trough until it reached a rip current. At the same time, the trough and rip current system produced significant longshore changes in the beach profiles. Figure 7 shows that by 3 June 1977, the date of the last profile, the trough had been completely refilled with sand and the onshore-migrating bar had welded itself onto the beach face. Such shoreward-migrating bars are better documented by Fox and Davis (1974) on Oregon beaches and in studies by Davis and others (1972), Hayes and Boothroyd (1969), and others on different coasts.

Beach Erosion and Deposition

Beach profiles obtained in this study have been used to compute the volumes of beach erosion or accumulation. Volumes of material moved by erosion or deposition during the time interval between two successive beach profiles are obtained by subtracting one profile from the other, assigning positive values (+) to areas where the second profile in time is higher than the first (deposition) and negative (-) to areas where the second profile is lower than the first (erosion). The procedure for approximating areas uses the trapezoid rule given in most calculus texts and yields a cross-sectional area between two successive profiles.

The resulting area can be thought of as the volume of erosion or accretion per unit length of beach in the longshore direction. This volume is, of course, also a function of the profile lengths. If the profiles had been somewhat longer, the volumes of calculated erosion or deposition would in most cases be greater. To help eliminate profile length effects on calculated volume, computed volumes were normalized by dividing by profile lengths. The result was the volume of erosion or deposition per unit profile length (cubic meters/meter) per meter of longshore beach distance.

The results of this analysis are presented in Figure 8, together with the measured wave steepness, H_∞/L_∞, and breaker height, H_b, obtained from the microseismometer system at Newport. The wave conditions show the usual general increase in breaker heights and wave steepness as the winter begins (Komar and others, 1976). Wave conditions fluctuate considerably because periods of large waves caused by North Pacific storm systems are separated by intervals of lower waves, when there are no storms. The largest waves measured during the study occurred on 9 March 1977, when breaker heights reached a significant wave height of 6.0 m (20 ft). Larger waves have been measured by the Newport wave recorder, installed in 1971. The largest breakers, 7.0 m (23 ft) high, occurred on 24-25 December 1972, causing considerable erosion on Siletz spit to the north of Geneden Beach (Komar and Rea, 1976). The storm on 9 March 1977 caused some erosion of property on Siletz spit, but not as much as that caused by the earlier erosion episodes of 1972-73 and of spring 1976.

The values of the wave steepness, H_∞/L_∞, in Figure 8 tend to be more erratic than the breaker height because the steepness includes both the measured wave height and period, each with inherent measurement errors. For this reason, Figure 8 includes a plot of the average, maximum, and minimum values of the wave steepness for the time intervals between profiles.

The resulting computations of beach erosion and deposition shown in Figure 8 further demonstrate that the volumes involved are much greater at the coarser grained Gleneden Beach than at the finer grained Devil's Punchbowl beach. Maximum erosion at Geneden Beach was 0.71m^3/m (7.6 cu ft/ft) of profile length; maximum erosion at Devil's Punchbowl beach was 0.25 m^3/m (2.7 cu ft/ft) of profile length. Simple progressive erosion of the exposed beach does not take place at either location as the winter months are entered because periods of net deposition occur between subsequent profiles, even in midwinter. It appears that the finer grained Devil's Punchbowl beach shows lesser volumes of change than the coarser grained Gleneden Beach, and erosional or depositional response may be entirely different.

Figure 9 shows the relationship between the amount of erosion or deposition between two successive profiles and the average breaker height that prevailed during the time. Also given are the total ranges of breaker heights observed during each period, the data bars extending from the maximum to the minimum observed breaker heights. As in Figure 8, computations are limited to months before April 1977, at which time longshore variations in the beaches became appreciable.

Figure 9 shows only a vague relationship between the amount of erosion/deposition and average breaker height. The slight trend that does exist indicates that with increasing breaker height comes an expected shift from deposition to erosion and an increase in the amount of erosion. More important to the erosion/deposition might be the maximum and minimum wave conditions that occur during the time period. The one

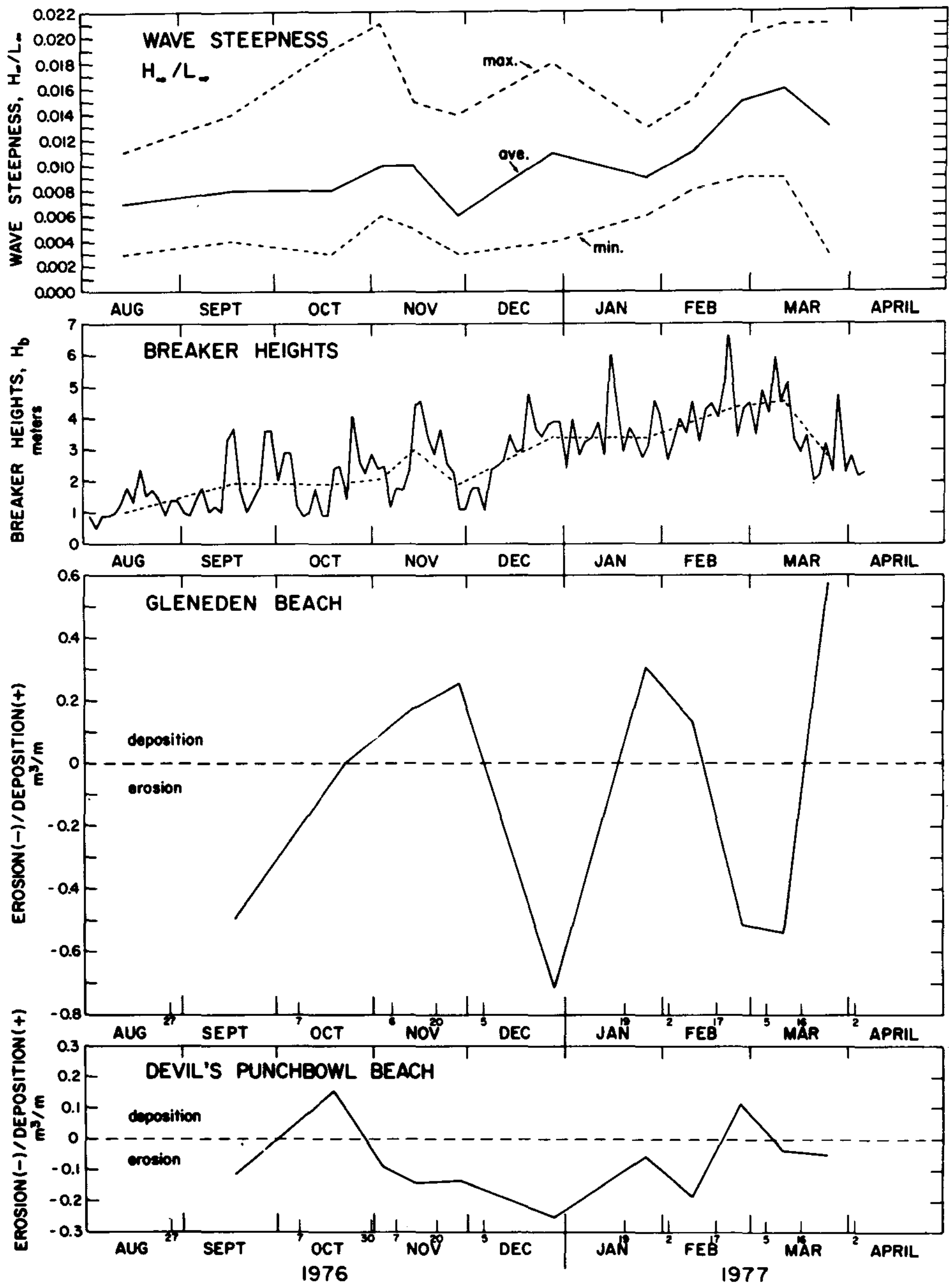

Figure 8. Beach erosion/deposition throughout study period before appreciable longshore variations v. wave steepness and breaker heights determined from wave data. Dates of surveys upon which erosion/deposition evaluations are based are shown. Wave steepness values are averages for intervals between surveys. Daily breaker heights and average values between surveys are indicated.

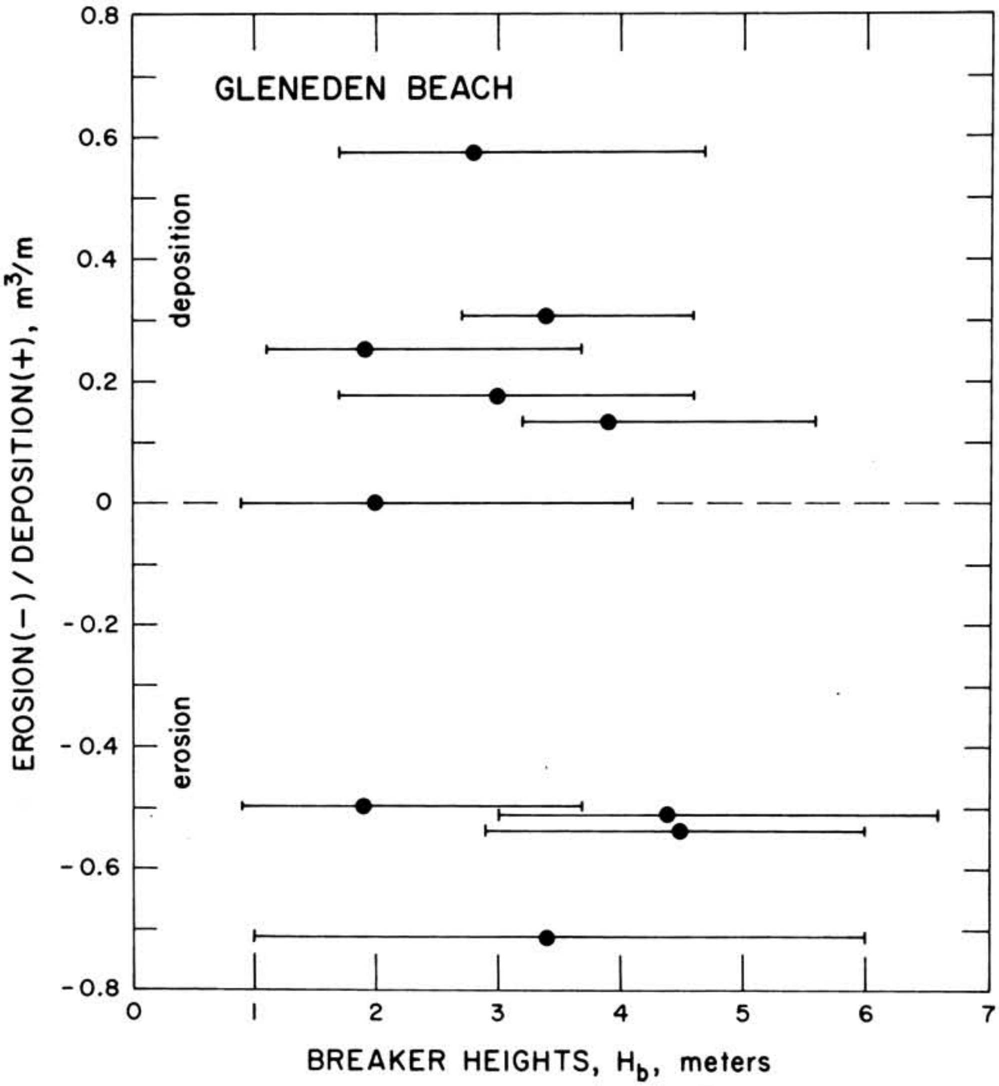

Figure 9. Volumes of erosion or deposition between successive beach profiles v. breaking wave heights prevailing during time intervals. Average breaker heights are plotted as well as total ranges of values measured.

large storm that took place during the period, represented by the maximum breaker height, might be responsible for the beach erosion, whereas the average or minimum breaker heights do little to change the volumes of sand on the exposed beach. This certainly appears to be the case; one single large storm with breakers higher than 6 m (20 ft) usually initiates erosion on Siletz spit (Rea, 1975; Komar and Rea, 1976). Deposition apparently occurs when there is no major storm during the period and the breaking waves average around 4 m (13 ft) or less. The minimum wave breaker heights that occur during the period do not appear to be significant, not differing between the periods of erosion and deposition (Figure 9), possibly because the minimum waves have such little energy and power that they are unable to appreciably change the volume of sand on the exposed beach. They may cause some beach deposition, but its importance is small compared with the volume changes associated with the average or maximum waves during that time period.

A further complication is the time element. This is especially apparent in Figure 9, which shows that erosion was produced by waves averaging only 2 m (7 ft) in breaker height with the maximum waves of the time period reaching only 3.7 m (12 ft). This occurred at the initial transition between the swell profile that prevails during summer and the storm profile that occurs during winter. As wave conditions are initially changing, the beach profile in its full summer condition is most out of equilibrium with the increasing wave heights. For this reason, during the transition period, an increase in wave height to even 2.0 to 3.8 m (7 to 13 ft) produces a large volume of erosion. Once the beach profile has shifted more toward the winter storm profile, those same wave heights would cause little, if any, erosion and might at that time even cause some beach deposition. Thus wave heights that at one time of year cause erosion may cause accretion on the exposed beach at another time of year. Of importance is the condition of the beach profile at the time the waves occur, whether it is shifted well into the swell (summer) configuration or into the opposite extreme, the storm (winter) profile.

Results of similar analyses undertaken to relate the volume of erosion/deposition to prevailing deep-water wave steepness, H_∞/L_∞, can be found in Aguilar-Tunon (1977). In this analysis, wave steepness shows an even poorer relationship than does breaker height (Figure 9) to erosion/deposition. There is only a slight indication that increasing wave steepness is accompanied by increasing tendency toward erosion and an increase in the volume of erosion. This led to the conclusion that including the wave period in the analysis to yield wave steepness, rather than using the wave height or energy alone, does not appear to be warranted, which agrees with the findings of Dolan (1966).

Summary of Conclusions

Oregon beaches undergo the usual profile changes resulting from seasonal variations in the wave conditions. During the year of this study, the beaches under investigation transformed from swell (summer) profiles to storm (winter) profiles from September through November, the period of generally increasing wave heights. The transition was accompanied by general erosion of the exposed portions of the beach. The swell (summer) profiles returned the following spring, making the transition in April through June, during which months the wave heights again decreased. The return to the swell (summer) profiles was marked by the shoreward migration of bars, producing for a time deeply incised longshore troughs and an increased nearshore water circulation.

Seasonal changes in profile types and accompanying erosion or deposition are not entirely systematic. For example, deposition on the exposed portion of the beach occurred even in midwinter during periods of prolonged low wave activity.

Of the two beaches under investigation, the coarser grained Gleneden Beach showed larger volume changes of sand on the exposed beach due to erosion and deposition. Vertical changes in the level of the beach face were also greater. The coarser grained and finer grained beaches did not always respond to the changing wave conditions in the same way; one could be eroding while the other showed a net accretion. Of the two, the coarser grained beach changes appeared to be more systematic and to correspond more closely to varying wave conditions.

Attempts were made to relate erosion or deposition volumes to changing wave breaker heights and deep-water wave steepness, H_∞/L_∞. This analysis met with only limited success, partly due to the time factor because waves of a given height could cause erosion during one season and deposition during another season. The governing factor in the response was the degree to which the beach profile was out of equilibrium with the waves. In general, for the Oregon beaches studied, the principal beach erosion occurred during storm conditions when wave breaker heights exceeded 5 to 6 m (16 to 20 ft). Deposition occurred when there was no major storm and breaking waves averaged 4 m (13 ft) or less. Wave steepness, H_∞/L_∞, showed a poorer relationship to the erosion/deposition than did breaker heights, indicating that the wave period was not a significant factor in the onshore-offshore shift of sand and the resulting changes in the beach profile type.

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GEOLOGISTS REGISTRATION FEES ANNOUNCED

The State Department of Commerce Board of Geologist Examiners has announced fees for registering under the Geologist's Registration Act, Sec. 14, Chap. 612, Oregon Laws, 1977, passed by the 1977 session of the Oregon Legislature. The fee for examinations will be $50; initial or annual renewal licenses, $50; initial or annual renewal of certification in a specialty, $25; restoration of a past-due license or certificate, $10; replacement of lost certificate, $3.00.

Geologists 70 years old or older will pay a reduced fee of $10. All licenses must be renewed each year on or before November 1. Qualified practicing geologists may obtain licenses without examination by applying before September 30, 1978.

Address applications to the Department of Commerce, Board of Geologist Examiners, 428 Labor and Industries Building, Salem, Oregon 97310.

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BIBLIOGRAPHY OF OREGON CAVES PUBLISHED

The Oregon Speleological Survey has recently published "Bibliography of Oregon Speleology," an annotated and comprehensive bibliography of caves in Oregon. Data for the 101-page bulletin were painstakingly gathered by Charles V. Larson, who dedicated the work to Phil Brogan, longtime Bend newspaperman.

Although this book is technically a bibliography, the copious annotations have almost converted it into a basic text on Oregon speleology. In addition to the 1,155 entries, a list of caves is cross-referenced to pertinent literature. Also included are a map of caves that have been found in the state, a list of cave leads, and a table giving duplicate cave names.

The bibliography is available, at $6.00 postpaid, from the Oregon Speleological Society, 13402 N.E. Clark Road, Vancouver, Washington 98665.

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FORMER BOARD MEMBER DIES

Herbert Lyle (Van) Van Gordon, member of the Department's Governing Board from April 1973 through March 1976, died January 21, 1978, in Grants Pass. Van Gordon was born June 26, 1913, in Cove, Oregon. He spent his boyhood in Nevada and later took mining courses at the University of Nevada. During the war years, Van Gordon served on the War Manpower Commission, involved in magnesium research and process control. In 1944 he moved with his family to Grants Pass, where he was self-employed until 1950, when he began work for Pacific Power and Light Company.

Upon his appointment by then-Governor Tom McCall to the Governing Board, Van stated: "This is the finest and will be the most interesting and rewarding opportunity to serve that has come my way."

State Geologist Donald A. Hull, on receiving the news of Van Gordon's death, observed: "Lyle Van Gordon's interest in mining and the outdoors gave him unique insights into the activities of the Department. A personal knowledge of Oregon's mining areas contributed to his outstanding service as a member of the Department's Board of Governors."

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(Please include remittance with order; postage free. All sales are final - no returns. A complete list of Department publications, including out-of-print, mailed on request.)

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