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# BEACH PROFILES OBTAINED WITH AN AMPHIBIOUS DUKW ON THE OREGON AND WASHINGTON COASTS

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## Introduction

During 1945 and 1946, a series of U.S. Navy-sponsored studies were conducted on Washington, Oregon, and California beaches. The overall purpose was to develop scientific means for determining beach morphology and characteristics of nearshore waves and currents that would make it difficult for landing craft to approach enemy-held beaches. The project was directed by M.P. O'Brien, Dean of Engineering, University of California, Berkeley, and included other illustrious names such as Willard Bascom, John Isaacs, J.W. Johnson, and Robert Weigel.

Results of the investigations are contained in a series of reports on file in the Water Resources Center Archives, University of California, Berkeley. Titles of some of the more scientifically interesting reports concerning Oregon-Washington beaches are included in the list of references following this paper. The atlases by Johnson and Bascom (1950) and Bascom (1950) contain many ground and aerial photographs that form a valuable source for considerations of long-term coastal changes. Other data, such as the depths of tire impressions left by the DUKW (pronounced "duck") on beaches, are specific to aiding amphibious landings and are of lesser scientific concern.

Of particular interest are beach profiles collected at 15 Washington and Oregon locations during the investigations. These profiles were obtained by using a DUKW (Figure 1), a six-wheeled amphibious vehicle that is 32 ft long and 8 ft wide, whose capabilities made it possible for beach-profile determinations to be made through the entire surf zone to beyond the breakers. Because of high surf conditions prevailing off the coasts of Oregon and Washington, subsequent attempts at obtaining beach profiles have been limited to the inner surf zone. Therefore, the University of California beach profiles are the only profiles available that show the entire offshore bar and trough system. These bars and troughs and their changes are important to an understanding of beach processes and erosion on the Oregon-

Washington coasts. A knowledge of the morphology of this zone is also required for the construction of sewage and industrial waste outfalls (pipes that must extend through the nearshore without being excavated by wave erosion).

Most of the beach profiles obtained by the University of California investigations in Oregon and Washington are included in the reports by Isaacs (1947) and Bascom and McAdam (1947). The purposes of this paper are to summarize and discuss the profiles obtained and to increase the availibility of typical and interesting examples.

## Profiling Techniques

The general methods of obtaining the beach profiles are discussed by Isaacs (1947) and Bascom and McAdam (1947). Bascom (1964, p. 173-183) also discusses these techniques and, in addition, describes the excitement of taking a DUKW through the surf.

The general procedure was to obtain the profile above the low-tide water line with a stadia rod and transit. During the following high tide, lead-and-line soundings were taken from the DUKW, starting about 4,000 ft from shore and extending through the breaker zone. The old lead-and-line method was used because echo sounders would not work amid the bubbles and turbulence of the surf zone.

The location of each sounding was determined by turning the interior angle from a point on the base line as the DUKW approached shore on a range (Figure 2). At frequent intervals, the leadsman in the DUKW called "Mark" into a radio transmitter and heaved the lead-weighted sounding line into water off the bow. As the DUKW passed the lead, the leadsman held the line vertical and read the depth of water beneath the wave trough. Upon hearing "Mark" via the radio, the transit man, who was following the progress of the DUKW with a telescope, read the angle. His assistant recorded the angle and the water depth, which had also been called out over the radio by the leadsman. In this way, the depths at a series of points along the range line were determined, establishing the overall beach profile.

In most cases, sand samples were obtained along the profile lengths, from the offshore sections as well as from postions of the profile which were exposed above the low-tide line. Offshore samples were collected by dragging a bucket along the bottom from the DUKW. Examples of grain-size distribution analyses of these sand samples can be found in Isaacs (1947) and Bascom and McAdam (1947).

High surf made DUKW operations difficult and hazardous. Bascom (1964, p. 178) relates that on one occasion a breaker heaved a DUKW onto its side on the beach face, wheels pointing out to sea. Fortunately, the next wave set it back on its wheels with-

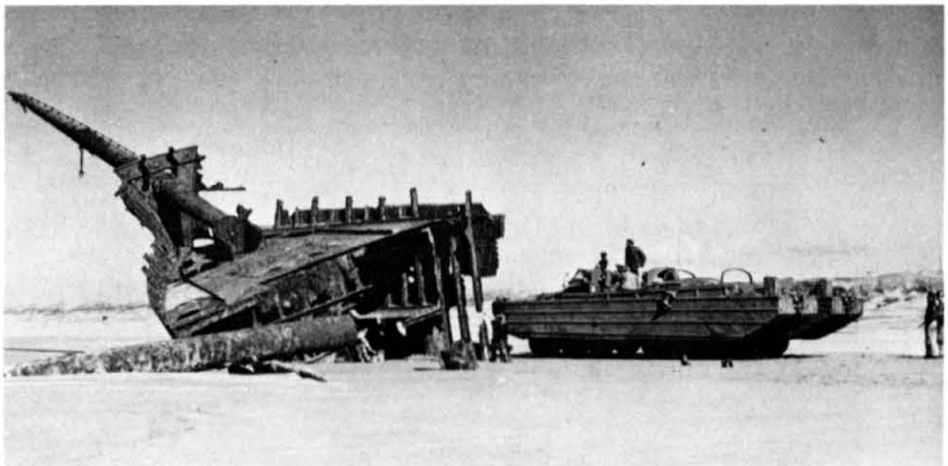

*Figure 1. A DUKW, used in beach surveys, next to the wreck of the Peter Iredale, Clatsop Beach, south of the mouth of the Columbia River (18 September 1945).*

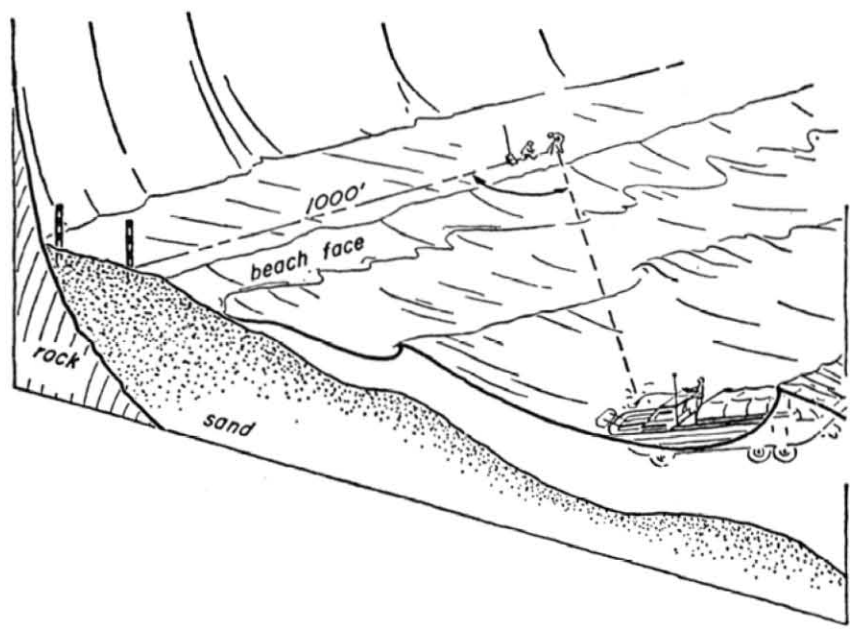


*Figure 2. Sketch showing survey techniques used in determination of beach profiles. The DUKW is run shoreward along range defined by two poles on beach, and its position is determined by triangulation from transit located 1,000 ft along beach (from Bascom, 1964).*

out damage. Altogether, three DUKW's were lost during the course of the study, two in the surf, and a third that rolled off a mountain cliff in Oregon and plunged 200 ft into the sea. Somehow, no one was ever seriously injured.

## Locations of Profiles

Beach profiles were obtained from nine locations on the Washington coast and from six on the Oregon coast. Locations are identified in Figure 3, and data from the sites are summarized in Tables 1 and 2.

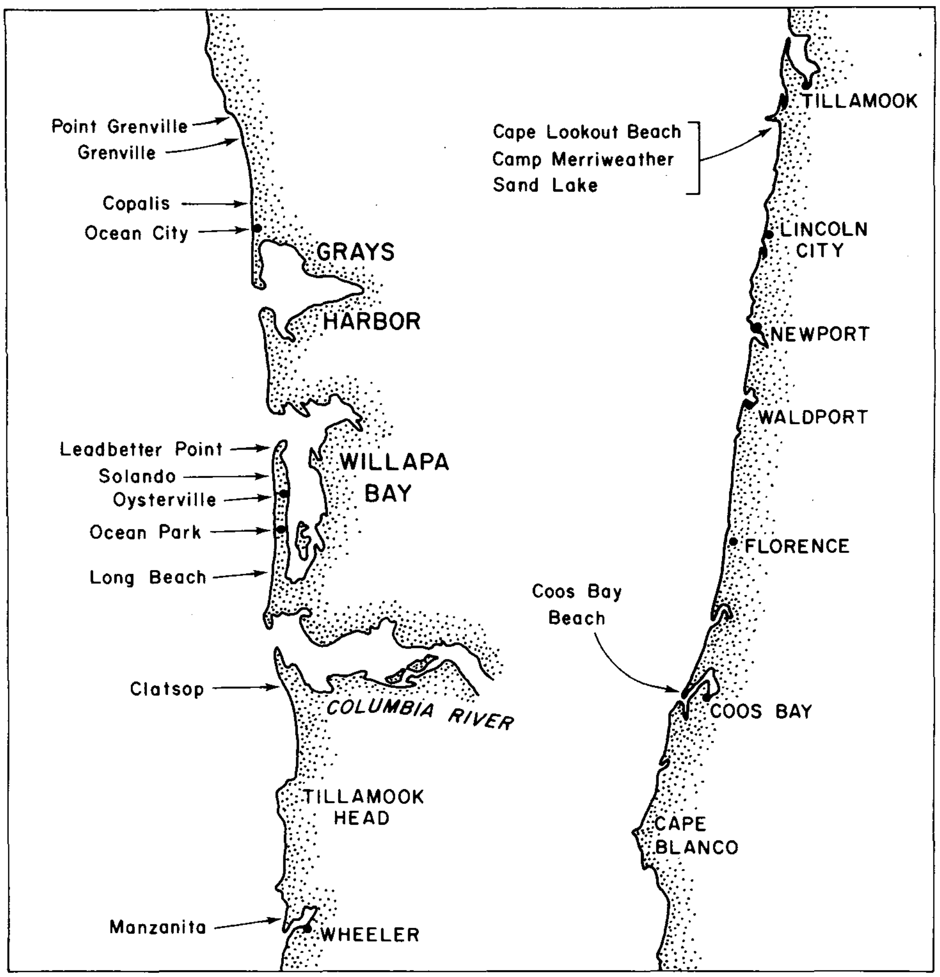


*Figure 3. Locations of DUKW surveys along Oregon-Washington coast. Cape Lookout station extended from south base of the cape, Merriweather station was about one mile from the cape, and Sand Lake station was about one mile north of the entrance to Sand Lake. Dates of surveys are given in Tables 1 and 2.*

Table 1. Beach profiles (Isaacs, 1947)

| | | |
|---|---|---|
| WASHINGTON | | |
| Copalis | 8/25/45 | (3 ranges) |
| Point Grenville | 8/28/45 | (3 ranges) |
| | 8/31/45 | (1 range ) |
| Ocean City Beach | 8/31/45 | (1 range ) |
| Leadbetter | 9/07/45 | (2 ranges) |
| Solando Wreck | 9/10/45 | (4 ranges) |
| Oysterville | 9/14/45 | (3 ranges) |
| Long Beach Portal | 9/13/45 | (1 range ) |
| Ocean Park Beach | 9/14/45 | (4 ranges) |
| OREGON | | |
| Sand Lake | 9/27/45 | (3 ranges) |
| Cape Lookout | 9/27/45 | (2 ranges) |
| Camp Merriweather | 9/27/45 | (1 range ) |

Table 2. Beach profiles (Bascom and McAdam, 1947)

| | | |
|---|---|---|
| WASHINGTON | | |
| Point Grenville | 10/08/46 | (1 range ) |
| South Grenville | 10/08/46 | (1 range ) |
| Copalis | 10/09/46 | (3 ranges) |
| Ocean City | 10/11/46 | (1 range ) |
| Leadbetter | 10/16/46 | (4 ranges) |
| | 11/08/46 | (1 range ) |
| Solando Wreck | 10/16/46 | (4 ranges) |
| | 11/08/46 | (1 range ) |
| Oysterville | 10/14/46 | (2 ranges) |
| | 10/17/46 | (3 ranges) |
| | 11/18/46 | (1 range ) |
| OREGON | | |
| Clatsop Beach | 11/04/46 | (1 range ) |
| | 11/07/46 | (2 ranges) |
| Manzanita | 10/18/46 | (3 ranges) |
| | 11/06/46 | (3 ranges) |
| Cape Lookout | 10/28/46 | (2 ranges) |
| Camp Merriweather | 11/12/46 | (1 range ) |
| Sand Lake | 10/26/46 | (1 range ) |
| | 11/05/46 | (1 range ) |
| | 11/12/46 | (2 ranges) |
| Coos Bay Beach | 11/15/46 | (3 ranges) |

Profiles which are presented by Isaacs (1947) were obtained in September 1945 and come mainly from the Washington coast (Table 1). Profiles described by Bascom and McAdam (1947) (Table 2) were obtained one year later (October and November 1946) from both Washington and Oregon.

Some profile ranges were surveyed by both field parties, providing some indication of changes that had occurred in profiles after one year. At some locations, profiles that were obtained on the same ranges after only a few days' interval gave some indication of expected short-term changes in beach profiles. Examples will be discussed in the next section. Two or three ranges were surveyed at some locations, the profiles usually being separated by 1,000 ft; this arrangement permitted the determination of longshore variations in the nature of beach profiles, especially of the extent of development of bars and troughs.

The Washington and Oregon beach profiles were determined from September through November, a time of transition during which wave heights are increasing along the coast as the low waves of summer months are giving way to the high waves of winter months (Komar and others, 1976). Lowest waves generally occur during June through August, highest waves during December through February. Details of the wave conditions during the 1945 and 1946 investigations are not known, although some visual estimates of breaker heights and periods are included in the reports. Beach profiles obtained by the study are therefore limited seasonally; no profiles were obtained during December to February, when the maximum amount of beach sand is shifted offshore into bars (Komar and others, 1967; Aguilar-Tunon and Komar, in prep.), or during midsummer, when sand has shifted back onto the exposed beach face.

## Examples of Beach Profiles

Figure 4 shows two beach profiles obtained at Solando, Washington, which are typical of the many profiles obtained in the University of California study. Three bars separated by two troughs can be identified in each profile. In the three-week interval between the first profile on 16 October 1946 and the second on 8 November 1946, offshore bars and troughs had developed more relief but had not changed positions significantly. The seawardmost bar is 2,300 to 2,500 ft offshore, depending on the date, and is in 8 to 10 ft of water depth below the mean lower low water (MLLW) tide level. These offshore distances and depths are typical for the outer bar on most Oregon and Washington beaches. The shoreward trough of the 8 November 1946 profile extends to a depth of -17 ft MLLW, so there is a depth difference of some 9 ft from the top of the outer bar. The middle bar is at a water depth of -4 to -5 ft MLLW and so will not become exposed even during the lowest low tides.

A significant inner bar above MLLW appears on the 16 October 1946 profile but has essentially disappeared by 8 November. Such an inner bar with a shoreward trough becomes exposed at normal low tides and is an example of a bar familiar to beach observers. Inner bars are known to develop rapidly, migrate in the on-offshore direction under changing wave conditions, and disappear (Fox and Davis, 1974; Aguilar-Tunon and Komar, in prep.). They appear most commonly in the spring months of decreasing wave conditions, when they are formed by the onshore movement of sand from offshore bars to the exposed beach berm (Hayes and Boothroyd, 1969; Hayes, 1972; Davis and others, 1972). Exposed inner bars are rare from October through February because beach-berm erosion prevails during that period. The appearance of an inner bar on the 16 October 1946 profile (Figure 4) may indicate that a period of storms with accompanying high waves occurred, followed by a quieter time of low waves during which some sand shifted back onshore. Winter occurrences of inner bars were noted on Oregon beaches by Fox and Davis (1974) under such conditions. Between 16 October and 8 November 1946, a storm probably occurred, eroding away the inner bar and shifting sand offshore (Figure 4).

Figure 5 shows a profile obtained from the ocean beach one mile north of the inlet to Sand Lake, Oregon (Figure 3). Three bars are present, and possibly a small fourth bar is centered at 500 ft on the exposed portion of the beach. The small seaward-most bar is not completely transected by the profile but does appear in other profiles from that location. Of special interest is the very pronounced middle bar and trough system. The major bar extends up to the mean lower low water level (MLLW) and so could become exposed at lowest tides. The seaward trough extends to a depth of -18 ft MLLW, and the shoreward trough to -10 ft MLLW. Therefore, there are appreciable water-depth changes across the beach profile.

The majority of the beach profiles are much simpler, with only one or two offshore bars. Figure 6 is a profile from the ocean beach seaward of the spit at Coos Bay, Oregon. Only one relatively small bar is seen, about 1,300 ft offshore at a depth of -10 ft MLLW.

Two beach profiles (Figure 7), taken a week apart at Sand Lake, Oregon, give some indication of short-term changes. There are appreciable shifts in the positions of bars and troughs between the two profiles. Both bars and troughs have migrated in the shoreward direction by some 100 ft during that one-week interval. In the process, the bars and troughs have reached shallower depths. One or two feet of sand has accumulated on the exposed beach above MLLW. The overall shoreward migrations of bars and troughs and deposition above MLLW suggests that a period of reduced wave activity occurred during the time between profile determinations. Such migrations of the inner bar have been demonstrated on Oregon beaches, especially by Fox and Davis (1974). Figure 7 indicates that appreciable migrations and water-depth changes may also occur in the outer and middle bars. These changes could not always be detected by Fox and Davis because their surveys were limited to the inner surf zone.

The University of California investigators generally obtained beach profiles along two or three ranges about 1,000 ft apart at each location to give an indication of longshore vari-

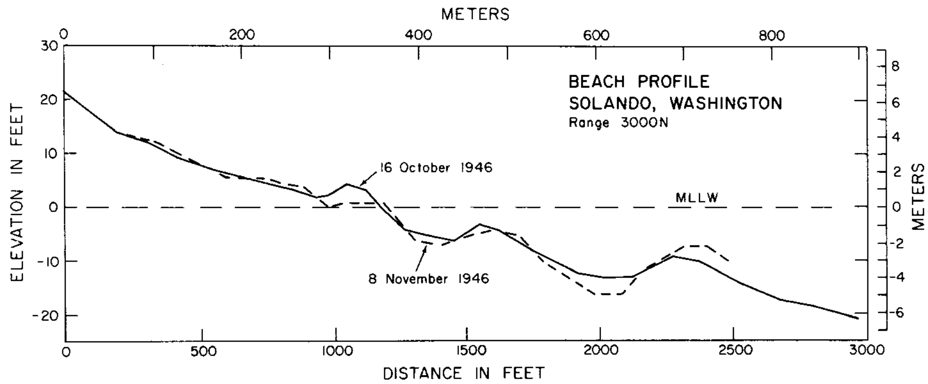


*Figure 4. Two profiles from Solando, Washington, showing a system of three offshore bars (after Bascom and McAdam, 1947).*

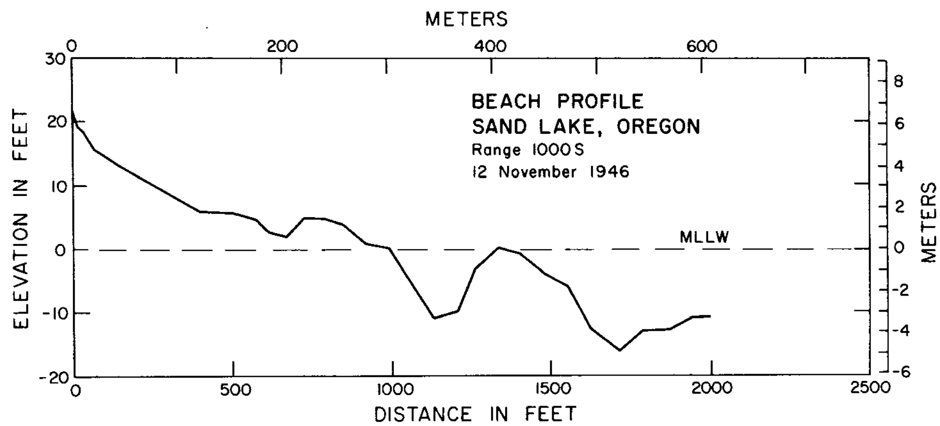


*Figure 5. Profile from ocean beach one mile north of entrance to Sand Lake, indicating a very pronounced system of offshore bars and troughs (after Bascom and McAdam, 1947).*

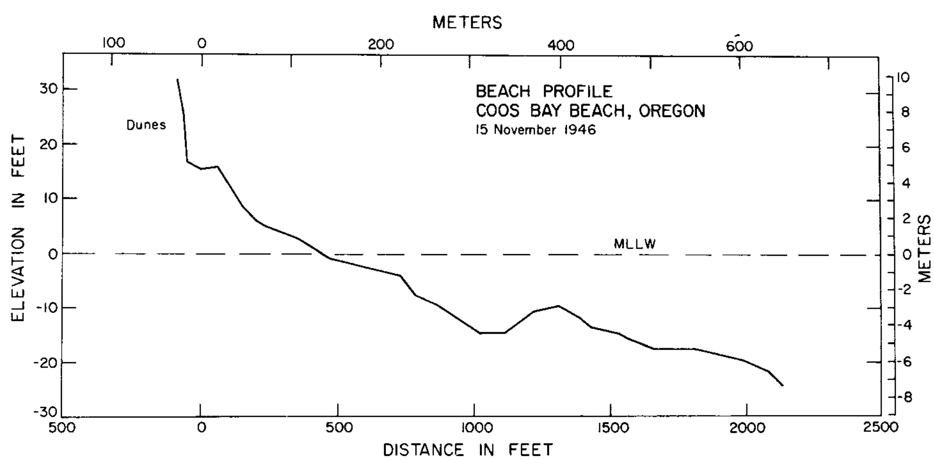


*Figure 6. Typical beach profile of Oregon-Washington coast, with only one major offshore bar and perhaps a smaller bar just below MLLW (after Bascom and McAdam, 1947).*

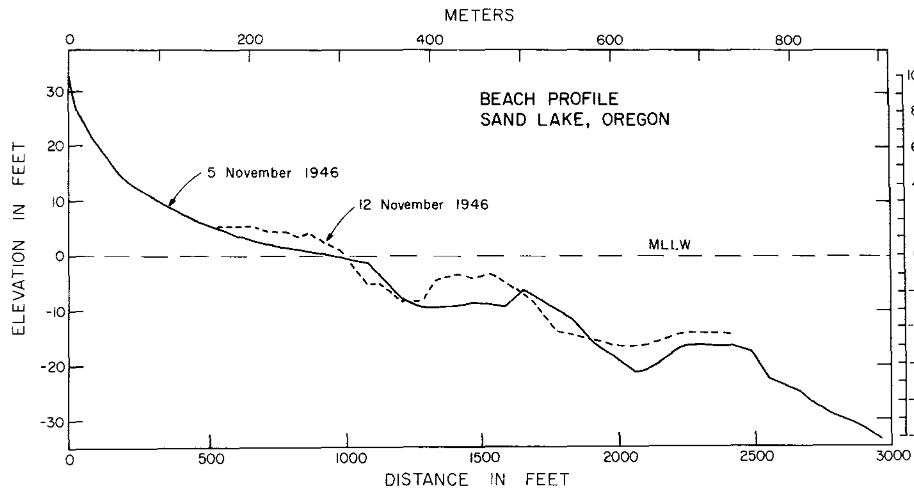


*Figure 7. Two Sand Lake ocean-beach profiles. The second profile, taken one week after the first, shows onshore migration of bars and troughs (after Bascom and McAdam, 1947).*

ations in the nature of beach profiles at a given time. Figure 8 shows a series of three profiles from the beach along the Clatsop Plains, Oregon (Figure 3). Although profiles from ranges 0 and 1000S were obtained on 7 November 1946 and the profile on range 1000N was obtained three days earlier, the small time difference should not be too significant. It is quite apparent that profiles change appreciably in the longshore direction. The profile on range 1000S is unusually flat, with a sudden increase in depth at 2,500 ft offshore. In marked contrast, the profiles at ranges 0 and 1000N have pronounced bars and troughs. Such longshore variations in beach profiles have been demonstrated for the inner bar of Oregon beaches by Fox and Davis (1974) as well as at coastal locations elsewhere in the world by studies such as those of Hom-ma and Sonu (1963). These variations are usually associated with a system of nearshore currents consisting of longshore currents flowing parallel to shore within the surf zone and feeding rip currents, which are narrow currents that flow seaward from the surf zone to beyond the breakers (Komar, 1976, p. 168-182, p. 263-266, p. 274-280).

Longshore currents are confined mainly to longshore troughs that are shoreward of significant offshore bars such as those that appear in ranges 0 and 1000N of Figure 8. Seaward flow of a rip current will breach the offshore bar, producing a beach profile that is characterized by an even offshore slope with little, if any, bar-and-trough system. A seaward-flowing rip current probably formed the unusual profile at the 1000S range of Figure 8, but because its inner half is so shallow, the profile is not entirely typical of one found in a rip-current position. Instead,

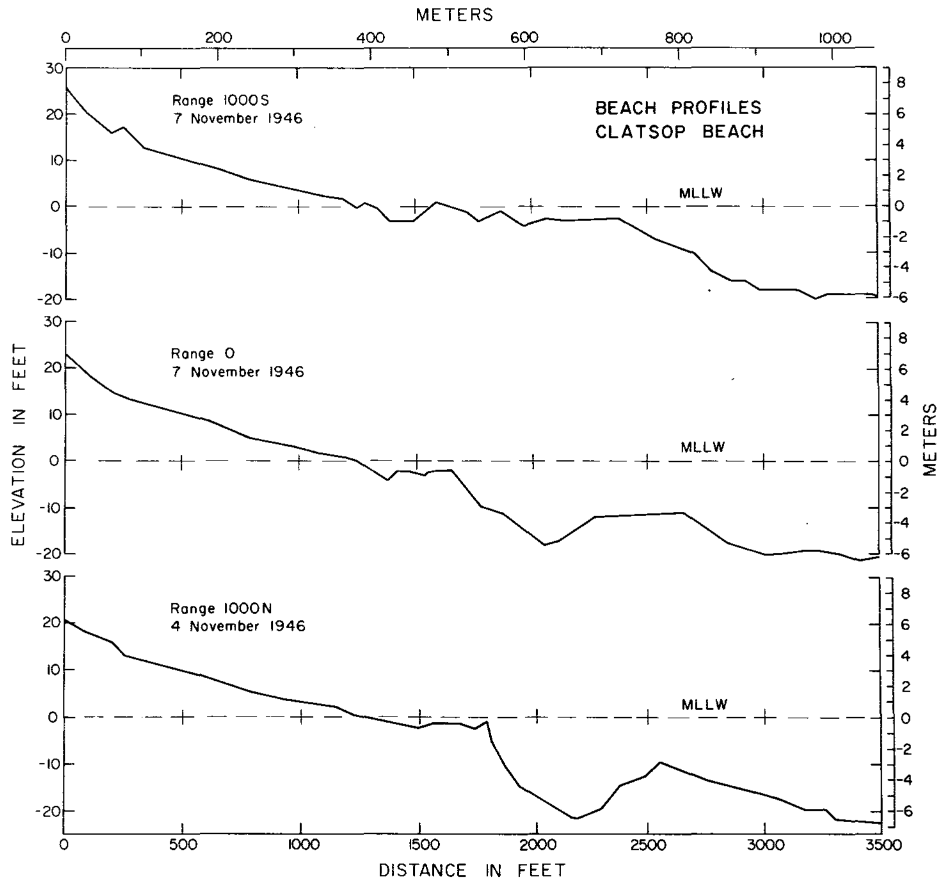


*Figure 8. Three Clatsop Beach profiles, separated by 1,000 ft in the longshore direction, showing pronounced changes in development of the offshore bar and trough. Variations were probably produced by a system of longshore currents feeding a rip current (after Bascom and McAdam, 1947).*

it is possible that the shoal (shallow portion) is part of a zone of deposition that has formed shoreward of the rip-current position and may even be part of a cusp formed on the shoreline. Another possibility is that the shoal is part of a transverse bar that has built across the surf zone, extending in the seaward direction (Komar, 1976, Figures 10-19). Such bars, which can develop under a rip-current system modified by waves breaking at appreciable angles to the shoreline trend, have been investigated especially by Sonu (1969, 1973).

The beach profiles shown in Figure 8 are rather extreme examples of longshore variations, changing from a profile with an unusually large trough-bar system (range 1000N) to a troughless-barless profile (range 1000S) with a shoreward shoal. More commonly there will be less dramatic longshore changes in profiles, with profiles in rip-current positions becoming flat without offshore bars.

## Summary

The beach profiles that were obtained with an amphibious DUKW during University of California investigations show one, two, or three offshore bars at various localities on Oregon and Washington beaches. The seawardmost bar is generally some 2,300-2,500 ft offshore with its shallowest depth reaching -8 to -10 ft MLLW. The middle bar is larger (when present) and may extend to water depths sufficiently shallow to become exposed at lowest tides. At times, a small inner bar may exist on the exposed beach face, even during the winter months, which are generally characterized by beach-face erosion and an offshore shift of sand.

All bars can migrate in the on-offshore direction under changing wave conditions and alter their depths in the process. Horizontal migration distances of some 100 ft are demonstrated by repeated profiles, separated by short time periods, on the same range.

There may be appreciable longshore variations in the nature of the beach profiles. The data include examples where one profile has a pronounced bar-and-trough system, and at the same time, some 1,000 to 2,000 feet in the longshore direction, the beach profile is flat. Such longshore changes in the profiles can be best explained as having been caused by a system of longshore currents feeding offshore-flowing rip currents.

The beach profiles obtained by the University of California study are particularly valuable in that they extend across the entire nearshore zone and include information on the outer bars and troughs. Beach profiles obtained with the conventional stadia rod and transit are confined to the inner surf zone, seldom reaching the middle bar and never the outer bar. Considering the intensity of the surf on Oregon and Washington beaches and the difficulties of measurement in this zone, it is doubtful whether additional profiles that span the entire nearshore to beyond the breakers will be obtained in the near future.

## Acknowledgments

This work is a result of research sponsored by the Oregon State University Sea Grant Program, supported by the National Oceanographic and Atmospheric Administration, under grant number 04-6-158-44004.

I would like to thank Professor Joe Johnson, University of California, and the librarians of the Water Resources Center Archives for their active help in seeking out the materials upon which this paper is based.

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## MINED LAND RECLAMATION OFFICE RELOCATES

In response to a directive from the Governing Board of the State Department of Geology and Mineral Industries, the Albany Mined Land Reclamation staff has moved into new quarters in the Carriage House Plaza, 1129 South Santiam Road, Albany, Oregon 97321. The new offices will house not only the Mined Land Reclamation staff but also the Department's Mineral Resource Survey staff. The purpose of this move is to make the Department even more available and responsive to the needs of the State's mineral industries, public agencies, and general public.

Herbert G. Schlicker, Engineering Geologist, Department of Geology and Mineral Industries, previously stationed on the Oregon State University campus, will also be moving shortly to the new Albany office, making it then the Department's third full-fledged field office in operation. A real advantage to this consolidation will be the immediate availability of top geological expertise to the Mined Land Reclamation staff. The Mined Land Reclamation program involves all aspects of natural resource management, but because of the very nature of the mining industry, geological concerns and problems are among the most prominent ones requiring expert handling. This move will enable the staff to respond to these concerns even more quickly and positively than has been possible in the past.

The Mined Land Reclamation program is having a real, positive impact around the State in spite of the small staff and funding problems that have hampered the program since it was created by the legislature in 1972. Changes by the 1977 legislature in the Mined Land Reclamation Law have improved funding of the program, but at the present time, the staff remains at its previous level of two professional and two clerical employees.

Currently 242 surface mining reclamation plans are in effect around the State. About six new plans are approved each month, for an average net gain of about three plans per month. In addition, the number of "grandfather" or reactivated sites shows a net increase of about three a month.

Inquiries by the score for information and numerous requests for assistance, either in the preparation and development of mining plans or in dealing with on-going mining problems, continue to come to the Mined Land Reclamation staff. Although these requests add to the workload, they are a real measure of the effectiveness and credibility of the Mined Land Reclamation program.

The staff of the Mined Land Reclamation program intends to continue to be available to the general public, industry, and State and local agencies and authorities as all work together to build a growing reclamation and conservation ethic within the mining industry while simultaneously being responsive to the growing needs of the State for mineral resource development.

## 83RD ANNUAL MINING CONVENTION OPENING SPEAKERS ANNOUNCED

"Mining at the Crossroads," the theme of the Northwest Mining Association's 83rd Annual Convention to be held December 2-3 at the Davenport Hotel in Spokane, Washington, reflects the uncertainty the mining industry feels today. The Opening General Session will feature speakers from the federal government who will talk about the way members of the Senate and House of Representatives view resource exploration and development of public lands and how they see prospective changes in our mining laws. Speakers for the Opening General Session are Michael Harvey, chief counsel for the Senate Committee on Energy and Natural Resources; William Shafer, staff member of the House Committee on Interior and Insular Affairs; and Vincent McKelvey, director of the U.S. Geological Survey.

Other convention sessions and chairmen are:

Geology/Session 1 - New Exploration Techniques: Daniel B. Robertson, Consultant.

Geology/Session 2 - New Deposits: Gerald G. Booth, Cominco American, Inc.

Cost of Environmental Protection/Reclamation: Bruce A. Kennedy, Golder and Associates.

Innovative Techniques in Metallurgy: Rhoshan B. Bhappu, Mountain State Engineers.

Innovative Mining Techniques: Merle W. Emmert, Anaconda Co.

Nontechnical Session: Mrs. Dan Robertson.

Energy in the Northwest: Harold W. Harding, Washington Water Power Co.

Regional Development: Jerry J. Gray, Oregon Department of Geology and Mineral Industries.

Student Session: Joseph Mills, Washington State University.

Money Session: Robert W. Holder, Merrill, Lynch, Pierce, Fenner, and Smith.

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## GOVERNOR APPOINTS GEOLOGIST EXAMINER BOARD MEMBERS

Governor Bob Straub has appointed the following persons to the State Board of Geologist Examiners: Herbert Schlicker, State Department of Geology and Mineral Industries; Harold Enlows, Geology Department, Oregon State University; Lloyd W. Staples, Professor Emeritus of Geology, University of Oregon; Robert L. Gamer, Consulting Geologist, Salem; and Emily Schue, Public Member, Eugene.

The Geologists Registration Bill (HB 2288) became law in October and is administered by the State Department of Commerce, 428 Labor and Industries Building, Salem, Oregon 97310. Geologists planning to register should write immediately to the Department of Commerce.

## NEW CHIEF GEOLOGIST NAMED

Dallas L. Peck has been named Chief Geologist to head the Geologic Division of the U.S. Geological Survey, Department of the Interior. He succeeds Richard P. Sheldon, who occupied the post since 1972, and who will return to his research in economic geology.

As the Survey's new Chief Geologist, Peck will direct the operations of one of the major divisions of the USGS, representing the largest single group of geologic science professionals in the United States.

Peck is a native of Spokane, Washington. He received formal training in geology at California Institute of Technology, where he received his B.S. degrees with honors in 1951 and his M.S. in 1953. He earned his Ph.D. in geology at Harvard University in 1960, after concentrating on mining geology.

Peck joined the U.S. Geological Survey in 1951. He has become a nationally and internationally recognized authority on a wide variety of geological studies, particularly on geothermal energy and volcanology. His pioneering research on ponded lava flows in Hawaii resulted in a better understanding of the processes of solidification of lava and the physical properties of basalt.

During the earlier part of his USGS career, Peck was assigned to field geological studies in California, Colorado, and Oregon. His studies in Oregon, which led to the publication of a geologic map of western Oregon, unraveled the underlying structure and volcanic stratigraphy of the Cascade Range and yielded an improved understanding of the geologic history of the state.

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## EXPLORATION GEOCHEMISTS TO MEET IN APRIL

The Association of Exploration Geochemists is sponsoring the 7th International Geochemical Exploration Symposium, to be held in Golden, Colorado, April 16-20, 1978. In addition to technical sessions, a number of geochemically-oriented field trips are planned to various mining districts in the western United States. Spouse/guest activities are also planned.

Further information concerning the Symposium will be sent to those making requests (by AIRMAIL if overseas) to:

M.A. Chaffee, Secretary
Organizing Committee
7th International Geochemical Exploration Symposium
U.S. Geological Survey
5946 McIntyre Street
Golden, Colorado 80401 U.S.A.

## SYMPOSIUM TO STUDY DIRECT UTILIZATION OF GEOTHERMAL ENERGY

To demonstrate the scope, availibility, and economy of low-temperature geothermal resources, a Direct Utilization of Geothermal Energy Symposium, sponsored by the U.S. Energy Research and Development Administration (ERDA) and coordinated by the Geothermal Resources Council, will be held Tuesday, January 31 through Thursday, February 2, 1978, at the Bahia Motor Hotel, 998 West Mission Bay Drive, San Diego, California.

The symposium will focus on the results of 18 ERDA-sponsored Engineering and Economic Studies of Nonelectric Applications of Geothermal Heat and other selected recent work in the area of geoheat utilization. Papers from industry and universities, as well as federal, state, and local agencies, will be included. Emphasis will be placed on current and proposed practical applications of geothermal heat such as for commercial industrial enterprises and municipal district heating systems. The symposium will cover four major areas of direct uses of geothermal resources: space conditioning, agribusiness (agriculture and aquaculture), industrial processing, and integrated applications.

For more information, write:

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