CHAPTER 234

BEACH PROFILE SURVEYS ALONG THE U.S. PACIFIC COAST 1945 – 1947

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ABSTRACT: The Wave Project at the University of California at Berkeley was established in 1944 to develop a relationship between nearshore waves and the underlying topography for supporting amphibious military landings. The project was continued for scientific purposes until 1952 under the more general name of "Wave Observation and Beach Surveys," including the Amphibious Oceanography Project. These early field observations are a central part of the genesis of coastal engineering in the United States. Beach profiles were surveyed by stadia and by amphibious vehicle along the coasts of Washington, Oregon, and California, and the results were documented in University of California, Fluid Mechanics Laboratory, reports in the HE-116 series. The profile survey measurements, now 50 years old, are still the only such data available for many beaches along the U.S. Pacific Coast. The data set thus comprises a valuable baseline for documenting change in the coast, and it is a resource on the morphology and grain size for high-energy beaches that are extremely difficult to survey. The profile survey plots in the limited-circulation reports have been digitized and are available for general access in the present study. This paper reviews the early measurement program and the available data set.

INTRODUCTION

The Wave Project of the University of California at Berkeley, sponsored by the Navy Department, was established in 1944 to develop a relationship between nearshore waves and the underlying topography for aiding in WWII beach landings. The project was continued for scientific purposes until 1952 under the more general name of "Wave Observation and Beach Surveys (WOBS)," including the Amphibious Oceanography Project. These early field observations are the genesis of coastal engineering in the United States, and a typical objective was "... to relate wave characteristics to beach changes and to collect sufficient data on surf, beach, and meteorological conditions to make a comparison with the results of

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existing forecasting procedures and general wave theory" (Stump and Bascom 1947). Beach profiles were surveyed by stadia and by amphibious vehicle (Dukw – pronounced "duck") along the coasts of Washington, Oregon, and California, supplemented by measurement of numerous types of coastal processes. The Wave Project and WOBS are believed to have made the first systematic and comprehensive field measurements of the beach profile, sediment, waves, and water level. The results were documented in the HE-116 series of Laboratory Memorandums of the Fluid Mechanics Laboratory, Department of Civil Engineering, U. of California, Berkeley. In the early years, this pioneering program was planned, financed, and directed by Dean Morrough P. O'Brien (U. of California, Berkeley) and by John Isaacs (U. of California, San Diego). Isaacs (1947) made all the surveys in 1945, when he invented the system, and Willard Bascom made virtually all the rest, many at the risk of life. The profile survey measurements have been described authoritatively by Bascom (1964, 1980). The principals responsible for the work were M. P. O'Brien, J. D. Isaacs, W. N. Bascom, D. McAdam, D. Patrick, and R. L. Wiegel.

Surprisingly, the profile survey measurements, now 50 years old, are still the only data available for many beaches along North Pacific coast. In fact, Dean O'Brien had insisted that the northern beaches be surveyed in the winter when there was violent surf (see Bascom 1987 for further discussion), and it remains a challenge to repeat such measurements. The data set thus comprises a valuable baseline for documenting change in the beach that has occurred since that time, and it also serves as a rare resource on the morphology of high-energy beaches that are extremely difficult to survey. The data exist in limited circulation HE-116 reports as distance-elevation plots and have been little accessed, one exception being an article by Komar (1978), who discussed data from HE-116-229 (Isaacs 1947) and HE-116-247 (Bascom and McAdam 1947) for the Washington and Oregon coasts.

The objective of the present work was to capture and preserve the profile data taken on the U.S. West Coast over the period 1945-1952. However, only data for the period 1945-1947 could be recovered in the present effort. For our study, the available profile survey data were digitized manually from the original drawings and the information transferred to magnetic media. This paper presents an overview of the data set, including the institutions and personalities behind the WOBS projects. The paper was prepared as a contribution for the celebratory theme "Coastal Engineering Heritage" (Kraus 1996) of the Twenty-fifth International Coastal Engineering Conference. Further information about the history of coastal engineering in the United States can be found in Wiegel and Saville, Jr. (1996).

RESOURCES CONSULTED

For this study, the originals of ten HE-116 reports were borrowed from the Water Resources Center Library, Department of Civil Engineering, University of California, Berkeley. Of these, five reports contained beach profile survey data. Table A1 of the appendix lists by report the beaches, years, and ranges for which profile data are available from these reports. The data set developed in the present study contains 216 profile surveys from nine beaches in Washington, six in Oregon, and 16 in California.

Many of the reports contain black and white photographs, most taken from the ground, but with some from the air by military planes. HE-116-223 (Fluid Mechanics Laboratory 1946) includes pictures and captions with the location and date for"...various beaches which were not at the time subjects of intensive study." In order to preserve the photographic record of west-coast beaches in the late 1940s and early 1950s, for the present project more than 100 photographs compiled from the different reports were scanned to create digital files.

After making three sets of copies of the reports, including the oversize plots of the profile plots, the originals were returned to the Water Resources Center Library. A complete set was sent to the Coastal Engineering Archive at the University of Florida, Gainesville, Florida; the University Library at Oregon State University, Corvallis, Oregon; and the Technical Library at the U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Many of the profile surveys extended from the upper beach to a depth of approximately 10 m, although surveys to wading depth were also made. Bascom (1980) gives a vivid first-hand account of the surveys made by amphibious vehicle (Dukw, Fig. 1). Horizontal position was measured by triangulation, and measurement points were marked through radio communication when a lead-line was heaved overboard. The sum of the water depth measured beneath the trough of a wave and one-third of the estimated wave height were reported by radio to a recorder on shore as an estimate of total water depth. The depths were converted to mean lower low water tidal datum by reference to either a tide gauge or predictions. Komar (1978) has summarized the measurement procedures and cites primary documents and reports not discussed here.

Other measurements or observations routinely made by the field parties included visual "surf observations" of the wave height and period, breaking wave type, and the nearshore current – both the longshore and rip currents. Measurements were sometimes made of the water table. Sediment samples were taken, but the authors were not able to locate the substantial information that should have been compiled. Other interested parties should continue in that search. An interesting aspect was documentation of the depth of tire impressions in the beach sediment made by the field-reconnaissance vehicles. Both military applications and relation of compaction to beach change were of interest, as was operation of the Dukws in future data collection.

In remainder of this paper, we focus on the beach profile survey data.

DIGITIZATION PROCEDURE

The original reports were unbound to mount the individual plots of the beach profiles on a digitization table. At first, it was planned to trace the profile lines by cross hair sighting on a high-resolution electronic digitization tablet. However, most of the pages eontaining the plots had become warped, making standard digitization mapping on to electronic axes inaccurate.

As an alternative to rubber sheeting through software, which would have introduced or distributed errors, distance-elevation pairs on the plotted profiles were located manually by placing a straight edge parallel to the grid lines on the plots and reading corresponding intersection values on the two axes. The locations of actual survey points on the plots were almost always unambiguously evident by discontinuities in the lines joining the points. Because of the presence of the grid lines on the plots, errors that might have been introduced by warping of the paper are believed to be minimal.

After manual digitization of the profile survey data, the distance-elevation pairs were entered into the computer and plotted to the same scale as the original drawings. Plots of the digitized data drawn on transparent paper were laid on top of the original drawings and visually compared for discrepancies, which were corrected. The resultant quality-controlled data set is believed to be an accurate representation of the original measurements. These data are available as ASCII files. The data are in the original American customary units (feet), but in this paper results are presented in metric units for the international audience.

12845
0+00 at Halfmoon Bay Municipal Beach
April 29, 1947 - 0930
Halfmoon Bay, California

12846
0+00 at Halfmoon Bay Municipal Beach
April 29, 1947 - 0835
Halfmoon Bay, California

Fig. 1. Survey preparations (from Wiegel 1947).

EXAMPLE RESULTS

In this section we give examples from Washington, Oregon, and California, from the data set compiled. Locations of many of the sites encompassed by the total data set are shown in Fig. 2. Appendix A gives the locations of all the beaches for which survey data were compiled.

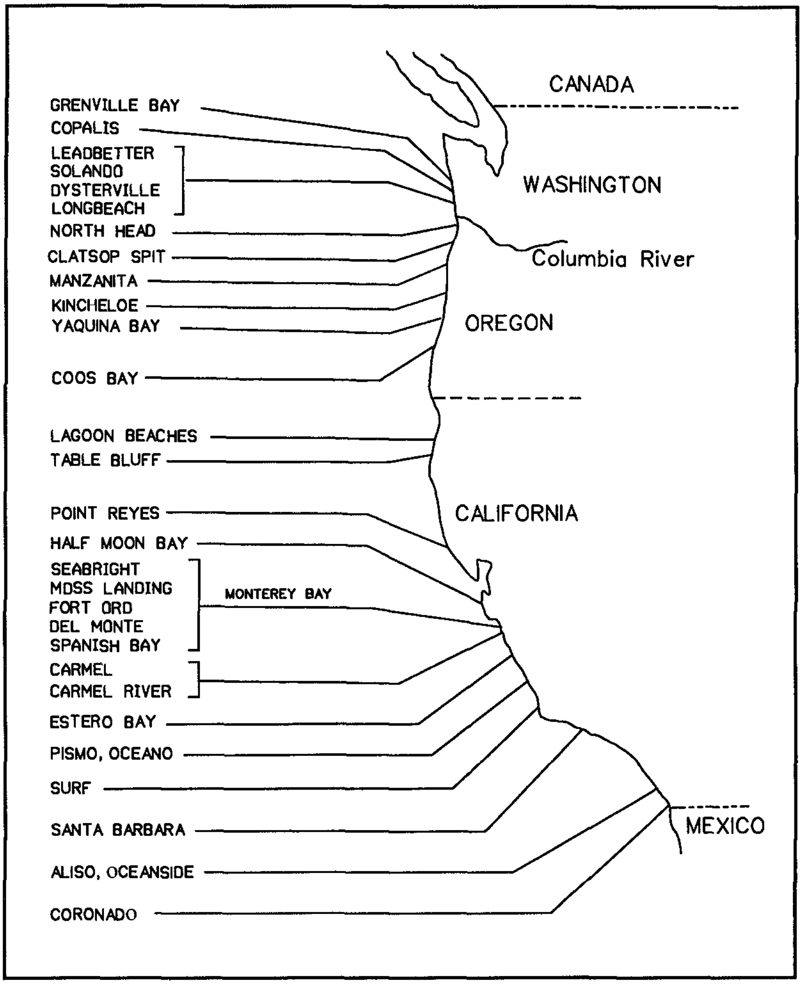

Fig. 2. Location of Pacific Coast beaches investigated (after Bascom 1951a).

Comparison to Echo Sounder

Depth soundings were typically made by lead line as described above, because echo sounders blanked out in the surf zone where air bubbles are present. Patrick and Bascom (1950) discuss technical details of the lead-line method and echo sounder measurement methods as applied in the Wave Project and subsequent studies. Many of the considerations are still valid today for making beach-profile surveys. As an example, we quote "After the ground control is established, the remaining field work is accomplished in two parts: water soundings during high tide and beach land profiles during low tide. The method gives *an overlap* (emphasis added here) of the data obtained and provides a check on the accuracy of the work." Lack of appreciation for the necessity of overlap of land and water surveys is found in some works today, which introduces ambiguity in collection of expensive data.

Patrick and Bascom (1950) compare the two methods "...made at Carmel (California, in 1947) and the results for one range line...," which is reproduced in Fig. 3 here. Although the lead-line method did not pick up detail of the bars on the profile, the comparison indicates remarkable skill in the lead-line survey that was consistent to almost 10-m depth, giving confidence in the reliability of the overall data set. The maximum difference in readings between the two methods is on the order of 1 m beyond the 6-m contour (MLLW).

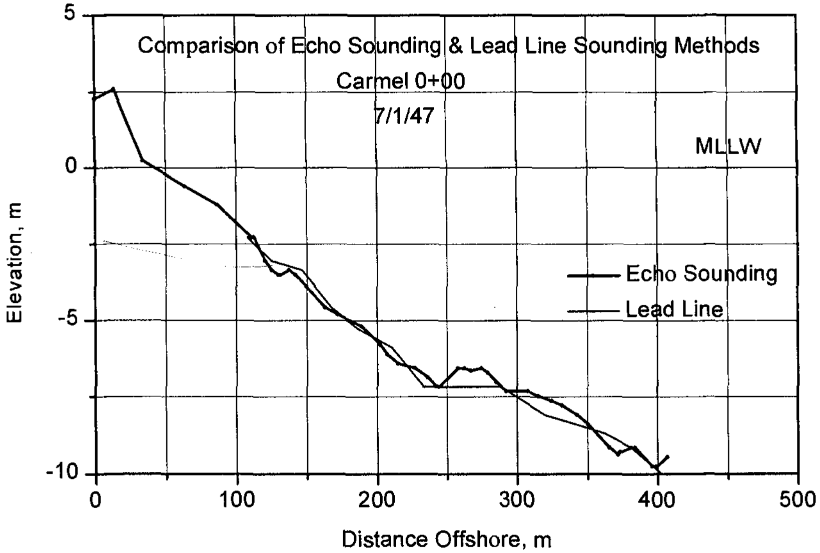

Fig. 3. Comparison of sounding methods (adapted from Patrick and Bascom 1950).

Point Grenville, Washington

This beach is located north of the mouth of the Columbia River and north of Grays Harbor, Washington. The two profiles plotted in Fig. 4 were surveyed approximately 1 year apart, with the 1945 survey made by a party led by Isaacs (1947) and the 1946 survey made by a party led by Bascom and McAdam (1947). Quoting from Isaacs: "(Between August 27 and September 27, 1945) ...the field party of the University of California Wave Investigation Project made surveys of the beach and surf characteristics at a number of beaches of the Pacific Northwest. These beaches are noted for their gentle slopes and fine grained materials." Further in the report, it is stated for the Point Grenville, South Station: "About 2 miles (3.2 km) south of the Cape (Cape Grenville) a section of the beach existed where the beach face was comparatively steep. No berm existed and it was apparent that high water reached the low clay banks in this region. The profile there showed a slope of beach face of about 1:20. The breaker zone was quite irregular but the bottom offshore was smooth and of gentle slope." This description fits Fig. 4 well. Wave breaker heights tabulated by Bascom and McAdam (1947) at the approximate time of the 1946 survey were approximately 1.5, 2, and 3 m for the inner, middle, and outer bars, respectively.

Grain-size information is not given for Point Grenville in the two aforementioned reports. However, Bascom (1951a) indicates that a representative median grain size might be on the order of 0.17 mm. As an example of a possible use of the profile data, we fit an equilibrium profile following a "distance to the 2/3 power law" (Dean 1991) to the 1945 profile survey. The grain size of 0.14 mm was inferred from the shape parameter (Moore 1982) of the equilibrium profile, which is seen to describe the survey measurements well from MLLW shoreline to the survey limit (7-m depth). This small exercise confirms the concept that profile shape is governed primarily by sediment grain size on an open-coast beach (see Bascom (1951a) for a conclusions about a wave-sheltered beach).

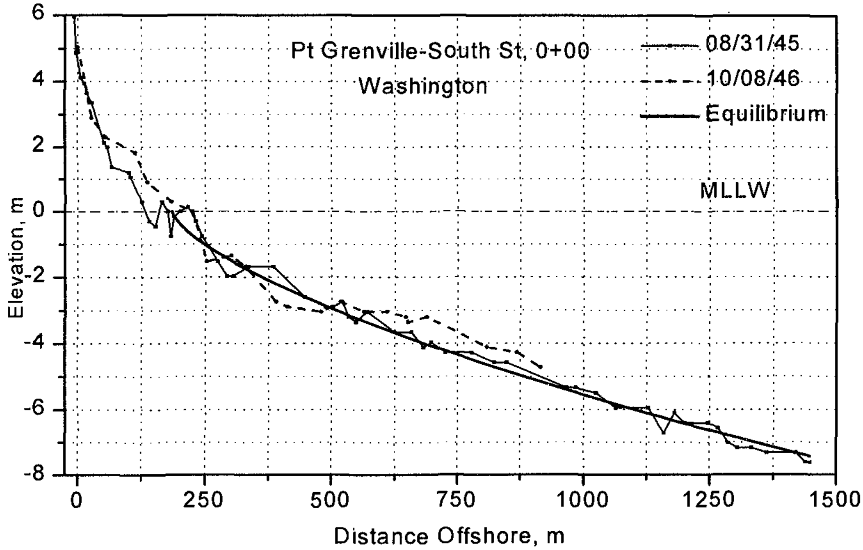

Fig. 4. Profile surveys approximately 1 year apart, Pt. Grenville, South Station, Washington.

Clatsop Spit Beach, Oregon

This beach is located south of the Columbia River, Oregon. The two profile surveys shown in Fig. 5 were taken only 3 days apart and within approximately 300 m of each other. A substantial bar-and-trough topography existed on the profiles. Komar (1978) speculated on mechanisms that might be responsible for the substantial trough. Clatsop Spit is presently experiencing moderate erosion, and data such as shown below will be useful for understanding the coastal processes acting at the site.

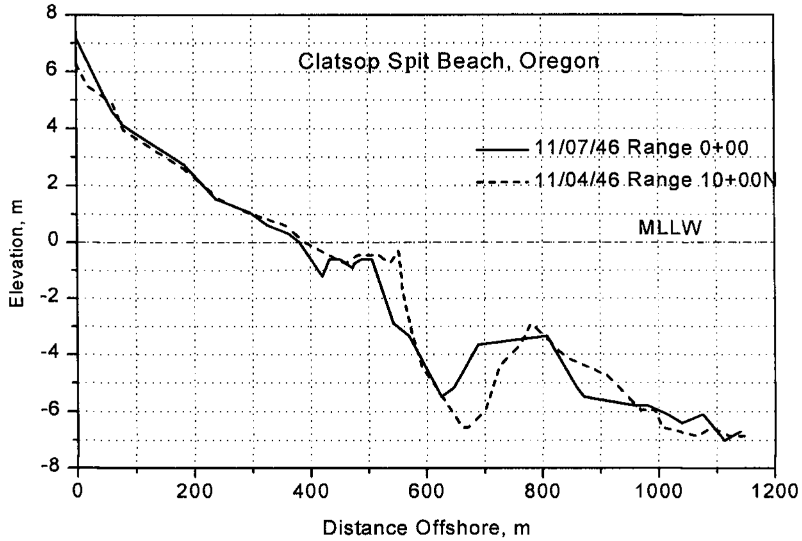

Fig. 5. Profile surveys on two range lines, Clatsop Spit Beach, Oregon.

Carmel Beach, California

The beach at Carmel, California, was studied intensively while the surveying parties "...would rest in the spring to recover from winter encounters with the northern surf" (Bascom 1980). Fig. 73 in Bascom (1980) illustrates seasonal shifts in the berm at Carmel, which were measured to be more than 60 m. Figs. 6 and 7, taken from data given by McAdam and Bascom (1947), reproduce some of the profiles in Bascom (1980) and display the remarkable seasonal changes at Carmel Beach. Bascom (1951a) indicates that a representative grain size for Carmel Beach is about 0.35 mm. This beach was one of those analyzed by Bascom (1951a) in a seminal paper on the relation between beach slope, grain size, and exposure to waves. In Fig. 6, it is interesting to note that little profile change occurs below approximately 4-m depth (MLLW) as compared to the elevation changes above that depth.

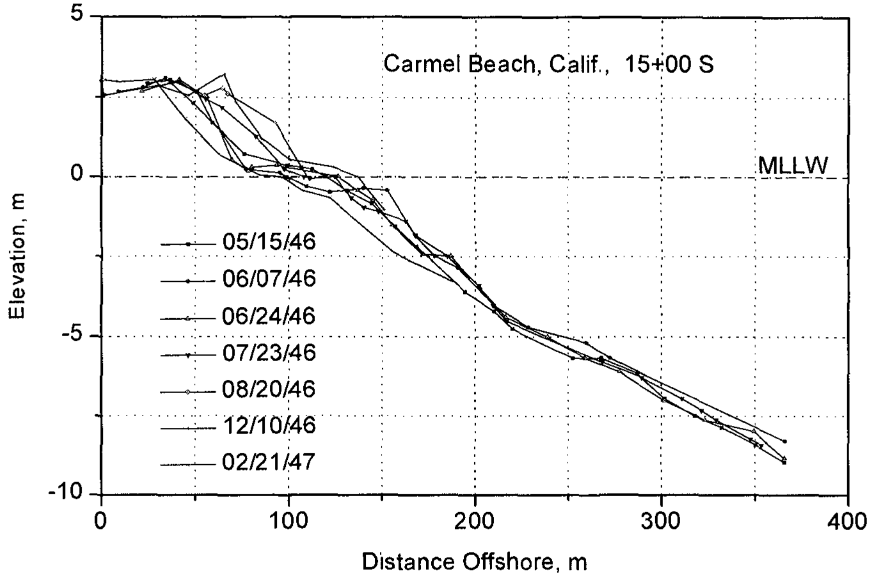

Fig. 6. Seasonal change in the berm and foreshore, Carmel Beach, California.

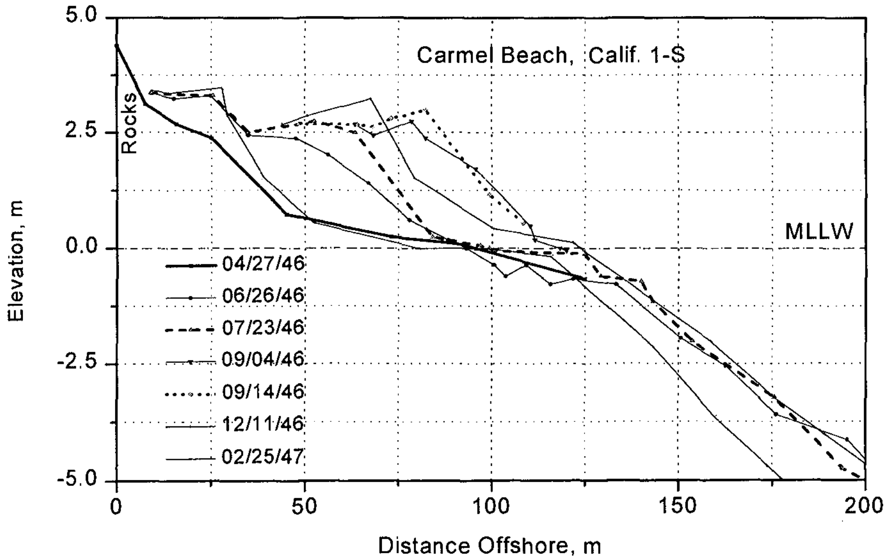

Fig. 7. Close-up view: seasonal change in the berm at Carmel Beach, California.

Miramar Beach, California

Discussion of the survey range lines along Halfmoon Bay, California, including Miramar Beach (Fig. 8) is given by Wiegel (1947). In the present study, it was originally intended to recover the locations of such range lines and reestablish survey monumentation. However, lack of funding prevented us from undertaking this task. Fig. 8 is provided to inform others that the HW-116 reports do contain information with which to reoccupy many of the survey ranges. Although recovery of the vertical datum may be impossible because of loss of benchmarks, location of many of the range lines along the beach will be straightforward because of the excellent photographic documentation.

CONCLUDING DISCUSSION

This study has attempted to capture and preserve, in digital form, beach profile survey data obtained on the Pacific Coast of the United States during the inception of the discipline of coastal engineering, the mid-1940s through mid-1950s. Ten original reports from that era were consulted, of which five contained plots of the survey data, which were digitized and quality checked. Approximately 100 photographs were also scanned to create digital copies. The basic product is a data base consisting of 216 profile surveys for 31 beaches in Washington, Oregon, and California, taken during the years 1945-1947.

The data set is expected to be valuable for coastal engineers, planners, and researchers because of its uniqueness – profile surveys extending to 10-m depth on high-energy beaches of various grain sizes. The data set allows study of fundamental aspects of beach morphology, including summer-winter profile change, time scales of profile change, bar size and movement, and beach slope versus grain size. Early analysis of the data (Bascom 1951a, 1951b) has yielded now-classic results on beach behavior. Many more insights and uses of the data can be expected.

The quest should not end for additional data from the WOBS project. Bascom (1951a) reports that approximately 500 beach profile surveys were made on some 40 beaches, so that the present study has located less than half of the available surveys. In addition, in this unfunded project we were not able to find much of the data for the approximately 600 sediment samples taken (see Bascom 1951a, 1951b for some data). Our goal of recovering all the beach profile survey ranges was not achieved, and we hope that this paper will serve as a stimulus for researchers to locate and preserve the remaining data, and for Federal, state, and local agencies in Washington, Oregon, and California, responsible for the coast to locate and reestablish the range lines.

ACKNOWLEDGEMENTS

This study would not have been possible without the cooperation of the Water Resources Center Library, Department of Civil Engineering, University of California, Berkeley, which permitted long-term loan of the HE-116 original reports. Digitization of the profile survey data was carried out at the Conrad Blucher Institute for Surveying and Science, Texas A&M University-Corpus Christi, while the first author served as Director of the Institute. The digitization and quality-control checks were performed by Ms. Karen Bridges and Ms. Margie Langely, both undergraduate students. The day-to-day work was supervised by Ms. Deidre Williams, graduate student in charge of the Blucher Institute Geographic Information Systems Laboratory. Permission was granted to N. C. Kraus by Headquarters, U.S. Army Corps of Engineers, to publish this information.

Fig. 8. Range lines at Miramar Beach, California (circa April 1947).

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APPENDIX A: DATA FOUND IN THIS STUDY

Table A1 lists profile data by source and state that was available for digitization in this study.

Table A1. Source and locations of available data			
Report No.	**Surveyed Beaches**	**Range**	**Date**
Washington			
HE-116-229	Grays Harbor to Columbia		
HE-116-229	Copalis to Cape Grenville		
HE-116-229	Longbeach to Leadbetter		
HE-116-229 HE-116-247	Point Grenville	0+00; 5+00S 10+00S	8/27/45, 10/8/46 8/28/45 8/31/45
HE-116-229 HE-116-247	Point Grenville, South St.	0+00	8/31/45, 10/8/46
HE-116-229 HE-116-247	Copalis Beach	0+00, 10+00N, 10+00S	8/28/45, 10/9/46
HE-116-229 HE-116-247	Ocean City	0+00	8/31/45, 10/11/46
HE-116-229 HE-116-247	Leadbetter Point	10+00S 20+00S 0+00 30+00S	8/31/45, 10/16/46 9/7/45, 10/16/46 9/8/45, 10/16/46 9/10/45, 10/16/46
HE-116-229 HE-116-247	Solando Wreck	0+00; 10+00N, 20+00N, 30+00N	10/16/46; 9/10/45, 10/16/46
HE-116-229 HE-116-247	Oysterville Beach	10+00S 0+00; 10+00N	9/14/45, 10/14/46, 10/17/46; 9/14/45, 10/17 - 11/18/46; 9/14/45, 10/14/46, 10/17/46
HE-116-229	Ocean Park	10+00N; 0+00; 10+00S	9/12/45; 9/14/45; 9/14/45
HE-116-229	Long Beach Portal	0+00	8/31/45
Oregon			
HE-116-229 HE-116-247	Clatsop Spit Beach	0+00; 10+00N; 10+00S	9/24/45, 11/7/46; 9/24/45, 11/4/46; 9/24/45, 11/7/46
HE-116-247	Manzanita	0+00, 8+00N, 8+00S	10/18/46, 11/6/46
HE-116-229 HE-116-247	Cape Lookout Station (Lookout Beach)	0+00, 10+00S	9/27/45, 10/28/46
HE-116-229 HE-116-247	Cape Merriweather Station	0+00	9/27/45, 10/26/46, 11/12/46
HE-116-229 HE-116-247	Sand Lake Station	0+00; 10+00S; 10+00N	9/27/45, 10/26/46, 11/5/46, 11/12/46; 9/27/45, 11/12/46; 10/26/46
HE-116-247	Coos Bay (Empire Beach)	0+00, 10+00S&N	11/15/46

California			
HE-116-205	Table Bluff		10/27/45 - 2/10/ 46 3/24/46 - 3/30/46
HE-116-224	Seabright Beach	0+00; 4+47N; 1+50N	6/5/46, 7/30/46, 2/4/47; 6/12/46, 7/30/46, 2/4/47; 6/21/46
HE-116-224	Seacliff Beach	0+00; 5+00N; 2+85N	6/5/46, 7/30/46, 2/4/47; 6/13/46, 7/30/46, 2/4/47; 6/21/46
HE-116-224	Moss Landing Beach, North	0+00, 5+00N	6/6/46, 6/12/46, 8/14/46, 3/6/47
HE-116-224	Moss Landing Beach, South	0+00, 5+00N, 5+00S	8/14/46, 8/15/46, 3/6/47
HE-116-256	Halfmoon Bay Municipal Beach	0+00, 10+00N	4/29/47
HE-116-256	Coast Guard Beach	0+00	4/28/47& 4/29/47
HE-116-256	Princeton Beach	0+00, 10+00S	4/28/47& 4/29/47
HE-116-256	Miramar Beach	0+00, 6+00S, 6+00N; 0+00; 6+00S; 6+00N	4/28/47& 4/29/47; 7/17&18/45, 4/28 & 29/47; 7/17&18/45, 4/28 & 29/47; 7/17&18/45, 4/28 & 29/47
HE-116-224	Fort Ord (Soldier's Club)	0+00, 5+00S, 5+00N	6/13/46
HE-116-224	Fort Ord (Concrete Block)	0+00, 5+00S, 10+00S	6/13/46
HE-116-224	Fort Ord (Landing Barge)	0+00, 5+00S	6/13/46, 8/2/46, 2/24/47
HE-116-224	Spanish Bay	2+75N	5/24/46, 7/24/46
HE-116-224	Spanish Bay, South St.	2+75N	5/24/46, 7/24/46
HE-116-224	Carmel	1-S; 15+00S; 5+00S, 10+00S; 0+00 5+00N 10+00N 15+00N	4/27/46, 6/26/46, 7/23/46, 9/4/46, 9/14/46, 12/11/46, 2/25/47; 5/15/46, 6/7/46, 6/24/46, 7/23/46, 8/20/46, 12/10/46, 2/21/47; 5/15/46, 6/7/46, 6/24/46, 7/23/46, 8/20/46, 12/11/46, 2/21/47 4/24/46, 5/22/46, 6/24/46, 7/23/46, 8/21/46, 12/11/46, 2/21/47 5/15/46, 6/7/46, 6/24/46, 7/23/46, 8/21/46, 2/21/47 4/24/46, 5/15/46, 6/7/46, 7/23/46, 8/20/46, 2/21/47 5/15/46, 6/7/46, 6/26/46, 7/23/46, 8/20/46, 2/21/47
HE-116-224	Carmel River Bight	2+50N 0+00 2+50S 5+00S	6/11/46, 7/23/46, 2/25/47 6/11/46, 7/23/46, 2/25/47 6/11/46, 7/23/46, 2/25/47 6/11/46, 7/23/46, 2/25/47
HE-116-22	Point Sur	3+50S 0+00 5+00N	6/18/46, 7/31/46 6/18/46, 7/31/46 6/18/46, 7/31/46