UNIVERSITY OF WASHINGTON DEPARTMENT OF OCEANOGRAPHY
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COOS BAY, OREGON
A LITERATURE SURVEY

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Executive Officer

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This report was prepared under the supervision of Dr. Clifford A. Barnes. The report was arranged and written under the direction of Dr. Richard G. Bader. The primary effort for the completion of each section is as follows:

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Section 2.	Climatology	R. Bader
Section 3.	Hydrology	P. McLellan
Section 4.	Regional Geology	R. Bader
Section 5.	Geophysics	R. Bader & P. McLellan
Section 6.	Recent Sedimentation	R. Bader
Section 7.	Hydrography	R. Bader
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The survey of the literature, location of unpublished material and coordination of the report was accomplished by Mr. Peter M. McLellan.

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FOREWORD

The Literature Survey of Coos Bay, Oregon, has been completed by the Department of Oceanography of the University of Washington as authorized by the U. S. Navy Hydrographic Office Contract No. N62306s-303. The Department of Oceanography has provided a listing and analysis of published and unpublished literature.

The form of the paper is essentially that of an abstract of the current knowledge on each subject studied. These abstracts are not purported to be finished articles and should only be considered unpublished records subject to revision. Time allowed for preparation precluded refinement, Following each subject is an annotated bibliography of relevant publications and unpublished reports and data, whether used in the abstract or not.

Thirty five copies of this report, including the annotated bibliography, were submitted to the U. S. Navy Hydrographic Office. A limited number of additional copies have been made. Only two reports, complete with all enclosures (drawings and original data), were assembled. One complete report was submitted to the U. S. Navy Hydrographic Office, the other is on file at the University of Washington.

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SECTION I

GEOGRAPHY

GEOGRAPHY

PHYSICAL GEOGRAPHY

LOCATION

Coos Bay, the estuary of the Coos River on the Oregon Coast, lies 184 nautical miles south of the Columbia River Lightship and 379 miles north of the San Francisco Lightship.

DESCRIPTION OF THE AREA

The entrance to the bay is approximately one-half mile wide with steep sea cliffs on the south side and a low sand spit on the north. It trends southeasterly, and is obstructed by a bar composed of fine gray sand, extending about one-half mile seaward from the ends of the jetties. The crest of the bar describes a rough arc of about 1,500 feet radius, with its center about 1,000 feet outside the jetties.

The arm of the bay north of the entrance ranges from one-half to one and one-half miles wide, while South Slough with an extremely irregular shoreline, is six miles long (see Enclosure 1-1).

From the bar at the mouth to its upper end, the bay is 15 miles long and averages approximately 1,200 feet wide at low tide. The bay channel is tidal over its entire navigable length. Channel depths below mean lower low water, secured by maintenance dredging, vary from 30 to 22 feet over the entrance bar to Guano Rock about 1 mile inside, and from 26 to 21 feet from Guano Rock to Smith's mill (U. S. Army Corps of Engineers 1946).

Shoreline Features

North of Coos Bay the plains are low and consist almost exclusively of wave-formed, wind-formed, and marsh, deposits locally including stream alluvium, that partly or completely fill areas embayed as the result of a comparatively recent submergence. These areas are close to sea level, are largely occupied by sand dunes, marshes, and lagoons, and are characterized in particular by a smooth, even shoreline that is generally somewhat concave toward the sea. A plain of this type that extends from Coos Bay north 50 miles nearly to Heceta Head is from a quarter of a mile to $2\frac{1}{2}$ miles wide. At the back are several lakes occupying ponded valleys.

South of Coos Bay the coastal plains consist chiefly of moderately elevated marine terraces but include some low areas of filled embayment and related alluvial deposits. The largest plain extends from Port Orford north to the vicinity of Cape Arago. It is 2 to 4 miles wide and 37 miles long, and on it are Bandon and several smaller settlements (Pardee 1934).

THE SURROUNDING AREA

Mountains are not far from the shore along the Oregon coast. In some places mountains rise directly from the shore, and elsewhere they stand at the back of a narrow coastal plain. The slopes are generally steep, and summits a few miles back from the shore reach heights of 2,000 to 4,000 feet; the higher ones are toward the south.

Vegetation

Vegetation is encroaching the beach, but generally it extends almost if not quite to the beach. Inland the undergrowth is thick, and travel is very difficult away from roads, trails, or clearings (Pardee 1934).

A large portion of the area has been logged off at least once, and is now covered with second and third growth timber and a dense undergrowth of berry vines, ferns, and brush, along with fallen timber. About 900,000 acres of commercial timber remain in Coos County with a volume of about 20 billion board feet. Douglas fir is by far the most important, although substantial amounts of Port Orford cedar, western hemlock, Sitka spruce, and western red cedar are logged every year (Allen and Baldwin 1944).

CULTURAL GEOGRAPHY

INDUSTRY BORDERING COOS BAY

The most important industry is lumbering, with production of recent years exceeding half a million board feet annually, from over 30 sawmills in Coos County. Farming, largely dairying, is next in importance. Other industries of decreasing importance in recent years include the gathering of greens and herbs, shipbuilding, tourist trade, the raising of cranberries, etc. (Allen and Baldwin 1944). The shipping over the entrance bar from 1880 to 1920 is shown on Enclosure 1-2.

HARBOR MODIFICATION PROJECTS

The entrance to the bay has been improved by two parallel, rubble-mound, high-tide jetties 2,100 feet apart (see Enclosure 1-3). The north jetty is 9,600 feet long and the south jetty is 3,900 feet long. An underlay of rock outcroppings are found inside the bay for a distance of about two miles, some of which have been removed. Guano Rock is a rock reef about 4,000 feet inside the sea ends of the jetties. The highest point of Guano Rock is 1,300 feet south of the north jetty and the surface of the reef is 24 feet. At Pigeon Point Reef the channel follows the west side of the reef, and rock pinnacles have been removed to secure a least depth of 24 feet for a width of 300 feet. A 1,000 by 600 foot turning basin is provided at Coalbank Slough near Smith's Mill. At Smith's Mill the channel enters Isthmus Slough and the Slough to Millington is 22 feet deep and 150 feet wide (U. S. Army Corps of Engineers 1946).

Coos and Millicoma Rivers

The U. S. Army Corps of Engineers project provides for a channel five feet deep and fifty feet wide from the mouth of Coos River to Allegany on Millicoma River, and to Dellwood, on South Fork; three feet deep and fifty feet wide to mile 14.7 of South Fork; stabilization works on Coos River at the mouth. All depths refer to plane of mean lower low water (U. S. Army Corps of Engineers 1954).

Bridges

Three bridges cross the channel in the Coos Bay area. Specifications are shown in Corps of Engineers reports (U. S. Army Corps of Engineers 1946).

A steel swing-span highway bridge, erected by the State of Oregon in 1934 at Charleston, is the only bridge crossing South Slough (U. S. Army Corps of Engineers 1948).

BIBLIOGRAPHY

Allen, John Eliot and Ewart M. Baldwin
1944. Geology and Coal Resources of the Coos Bay Quadrangle, Oregon. Oregon State Department of Geology and Mineral Industries, Bulletin no. 27, 157 pages, 31 plates, 3 maps in pocket. (Describes in detail the stratigraphy, paleontology and structure in the Coos Bay area. Latter part of bulletin is concerned primarily with the coal deposits of Eocene age present.)

Appleton, John B.
1939. The Pacific Northwest: A Selected Bibliography, 1930-1939. Northwest Regional Council, Portland, Oregon, 456 pages. (Covers completed research in the Natural Resources and Socio-Economic fields, an annotated list of progress and completed research, together with critical comments thereon. Includes references on Coos Bay.)

Arpke, Frederick and Carol Colver
1943. The Economic Base for Power Markets in Coos County, Oregon. Bonneville Power Administration, Power Management Division, Market Development Section, Economic Unit, 49 pages (mimeographed).
(Area survey.)

Bascom, Willard and Donald McAdam
1947. Beach and Surf Conditions on the Beaches of the Oregon and Washington Coasts Between October 9, 1946 and November 18, 1946. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-247, 54 pages, photos, profiles (typewritten).
(Includes profiles, surf conditions, tire impressions, sand samples, and water table profiles. Data for Humboldt Bay, Coos Bay, and Grays Harbor areas. Large number of photos obtained in survey which were not included in the report.)

Federal Security Agency
1951. Summary Report on Water Pollution, Pacific Northwest Drainage Basins. Public Health Service, Division of Water Pollution Control, Pacific Northwest Drainage Basins Office, 79 pages. (Coos Bay area covered by chapters on Oregon Coast Sub-Basin. Summary of water pollution data and various tables of information included.)

Isaacs, John D.
1947. Beach and Surf Conditions on Beaches of the Oregon and Washington Coast Between August 27 and September 27, 1945. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-229, 125 pages, tables, photos, maps, diagrams (typewritten).
(Covers beaches off Grays Harbor and Coos Bay. Photos of beach and surf conditions and tire impressions. Beach profiles, sieve analyses of sand samples shown in tables and diagrams.)

Kehrli, Herman
1936. A Survey of Factors Bearing on the Consolidation of Cities in the Coos Bay Area. Oregon State Planning Board, Portland, Oregon, 48 pages.
(Contains aerial photos, population trends, and management problems of Coos Bay Harbor.)

Lomax, Alfred L.
1932. The Facilities, Commerce and Resources of Oregon's Coast Ports. University of Oregon, Business Administration Series, vol. 2, no. 7, Studies in Business, no. 14, 53 pages.
(Facilities and condition of Coos Bay Harbor.)

Newcombe, C. F. (editor)
1923. Menzies' Journal of Vancouver's Voyage, April to October 1792. Edited with Botanical and Ethnological Notes by C. F. Newcombe and a Biographical Note by J. Forsyth, Archives of British Columbia, Memoir no. V, W. H. Cullen, Printer, Victoria, B. C., 171 pages.
(Notes by a naturalist accompanying Vancouver on his voyage describing the Pacific Coast and harbors. No specific details on survey areas given.)

Oregon State System of Higher Education
1940. Physical and Economic Geography of Oregon. 319 pages.

Pacific Motor Boat
1939. Pacific Motor Boat Handbook. Pacific Motor Boat, vol. 31, no. 8, 202 pages.
(Lists harbor entrance and location data.)

Pardee, J. T.
1934. Beach Placers of the Oregon Coast. U. S. Geological Survey, Circular 8, 41 pages (mimeographed).
(Description of the beaches, terraces, and history of the Oregon coast in the vicinity of Coos Bay and south to the Rogue River. Describes the gold and platinum deposits of the black sands. NS. and EW. sections of South Slough at Coos Bay shown among shore profiles.)

U. S. Army Corps of Engineers

n. d. Coos Bay Bar, Oregon, Shipments over the Bar in Thousands of Tons, 1880-1923. Portland District, Portland, Oregon, Map File no. CB-1-107.1. (Unpublished.)

1908. Coos Bay and Bar Entrance, Oregon. House Document no. 958, 60th Congress, 1st Session, 12 pages.

1917. Coos Bay Harbor, Oregon. House Document no. 325, 65th Congress, 1st Session, 18 pages, 5 maps.

1922. Coos Bay Harbor and Isthmus Slough, Oregon. House Document no. 150, 67th Congress, 2d Session, 38 pages, 2 maps.

1927. Coos Bay, Oregon. House Document no. 110, 70th Congress, 1st Session, 37 pages, 1 map.

1946. Coos Bay, Oregon. Senate Document no. 253, 79th Congress, 2d Session, 33 pages, 1 map.

1948. Coos Bay at Charleston, South Slough, Oregon. House Document no. 646, 80th Congress, 2d Session, 20 pages, 1 map.

1949. Job History, Dredging and Rock Removal, Coos Bay, Oregon. On file Portland District, Portland, Oregon, 14 photos. (Unpublished.)
(Includes air photos of Coos Bay obtained during contract No. W35-026-eng-3808 for removal of rock and overburden in Coos Bay Channel from Guano Rock to Empire.)

1954. Project and Index Maps. Portland District, Portland, Oregon. (Processed.)
(For use by the Corps of Engineers. Reproduced to accompany the Annual Report of the Chief of Engineers presenting projects and their locations on reference maps. Both active and inactive River and Harbor and Flood Control projects are shown. Includes the Coos Bay area.)

U. S. Department of Commerce Coast and Geodetic Survey

1951. United States Coast Pilot, Pacific Coast, California, Oregon, and Washington, Seventh (1951) Edition. Serial no. 750, U. S. Government Printing Office, Washington, 578 pages.
(Comprehensive descriptions of harbor facilities and approaches.)

U. S. Department of the Interior Bonneville Power Administration
1942. Economic Atlas of the Pacific Northwest with Descriptive Text. Edited and Published by the Northwest Regional Council, Portland, Oregon, in cooperation with the Pacific Northwest Regional Planning Commission.
(Includes a discussion of climate, annual precipitation, warm season, forest types, soil areas, erosion, and population. Coos Bay area included.)

SECTION 2

CLIMATOLOGY

CLIMATOLOGY

INTRODUCTION

The climate of the Coos Bay region is typical for the Pacific Coast of the northwestern United States. It is characterized by wet comparatively mild winters and dryer cool summers. Maritime influences dominate the year round climate due to the prevailing westerly winds and the proximity to the Pacific Ocean. The usual vegetation of the northwest coastal area is well developed due to the long rain period and the slow rate of precipitation. The region is generally free from extremes of temperature and also from highly destructive storms. Visibility is often curtailed by coastal fog.

PRECIPITATION

The precipitation, though rather frequent and relatively continuous during the winter months, generally consists of a light rain. Approximately 50% of the days of the year have 0.01 inch or less of rain per day. The average annual precipitation at North Bend, Oregon, from records of 1902 to 1952 is 63.09 inches (U. S. Department of Commerce Weather Bureau n. d.). The months of November through March are the wettest, with an average of about 9.25 inches per month; January is usually the month of greatest rainfall. The spring months of April through June and fall months of September through October average about 3.19 inches per month. The dry period is in July and August with only 0.40 inch per month.

The U. S. Department of Agriculture Weather Bureau (1936) records for the city of Coos Bay show an average annual precipitation of 64.52 inches from 1911 to 1936. November through March average 9.30 inches per month; April through June, September and October, have 3.24 inches per month. About 0.42 inch per month fall in July and August.

According to the U. S. Army Corps of Engineers (1954) the normal annual precipitation on the Catching Inlet and Ross Slough area is about 70 inches a year. January is the wettest month; July and August are the driest with 75% of the rainfall occurring from November through March.

The following tabulation from the U. S. Department of Commerce Weather Bureau (1952) concerns the maximum 24-hour precipitation for the city of Coos Bay over a period of 28 years:

Jan 1903 -- 4.39"	May 1906 -- 2.04"	Sep 1914 -- 2.35"
Feb 1926 -- 5.16	Jun 1906 -- 2.24	Oct 1947 -- 4.19
Mar 1916 -- 4.02	Jul 1947 -- 1.12	Nov 1946 -- 4.92
Apr 1907 -- 3.07	Aug 1949 -- 2.04	Dec 1940 -- 3.66

The average precipitation, including snowfall is tabulated by the month for the cities of Coos Bay and North Bend, Oregon, in Table 2-1. Enclosure 2-1 is an isohyetal map of normal annual precipitation in western Oregon.

It seldom snows and when it does fall it is usually very light. The yearly average for snowfall in the city of Coos Bay is 1.9 inches, for North Bend it is 1.5 inches. The greatest monthly snowfall ever recorded for North Bend is 14.4 inches in January 1916.

TEMPERATURE

The yearly temperatures are mild; extremely low or high temperatures rarely occur. On the average the temperature falls to 32° F. or less about 15 days in the year and reaches 90° F. or more less than 1 day per year. January is the coldest month and August the warmest.

The recorded data from 1902 to 1952 at North Bend, show an average monthly temperature range of 44.6° in January to 59.8° in August. The yearly average for this 50 year period is 52.1°. The average maximum temperature ranges from 51.8° in January to 68.6° in August, the average minimum from 37.4° in January to 51.0° in July and August.

The city of Coos Bay shows a very similar temperature record. The monthly average is 44.1° in January and 59.9° in August; the yearly average is 51.8°. The average maximum temperature is 51.6° in January and 69.0° in August while the average minimums are 36.6° for January and 50.5° in August.

Table 2-2 summarizes the temperatures at North Bend and Coos Bay as obtained from the records of the U. S. Department of Agriculture Weather Bureau (1936). Temperatures recorded by John Queen in 1930-32 while collecting water samples and other oceanographic data are in Table 2-3.

VISIBILITY AND FOG

According to the records of the U. S. Department of Commerce Coast and Geodetic Survey (1951) and the U. S. Treasury Department Coast Guard (n. d. a) the summer and autumn have the maximum occurrence of fog and low visibilities. From 1951 to 1954 the months of July through November averaged 163 hours of fog per month. The fog occurrence for the rest of the year was 33 hours per month.

TABLE 2-1. Precipitation at Coos Bay and North Bend, Oregon. [In inches]

COOS BAY[1]				NORTH BEND[2]			
	Average Snowfall	Average Precip.	Average of days w/0.01" precip. or more		Average Snowfall	Average Precip.	Average of days w/0.01" precip. or more
No. Years Record	25	29	29	No. Years Record	43	--	50
Jan	1.3	10.97	20	Jan	1.0	10.41	20
Feb	0.4	8.97	17	Feb	0.3	8.64	18
Mar	0.1	7.51	18	Mar	0.2	7.54	19
Apr	Trace	4.86	15	Apr	0.1	4.44	15
May	0.0	3.22	12	May	0	2.99	12
Jun	0.0	1.71	9	Jun	0	1.74	9
Jul	0.0	0.45	4	Jul	0	0.45	4
Aug	0.0	0.39	4	Aug	0	0.36	4
Sep	0.0	2.40	8	Sep	Trace	2.00	8
Oct	0.0	4.19	12	Oct	Trace	4.77	13
Nov	0.0	10.02	18	Nov	Trace	9.51	17
Dec	0.1	9.83	20	Dec	0.1	10.16	21
Annual	1.9	64.52	157	Annual	1.5	63.09	160

1 U. S. Department of Agriculture Weather Bureau (1936)
2 U. S. Department of Commerce Weather Bureau (n. d.)

TABLE 2-2. Temperatures at Coos Bay and North Bend, Oregon. [In degrees F.]

COOS BAY[1]	Average	Average Maximum	Average Minimum	Highest	Lowest	NORTH BEND[2]	Average	Average Maximum	Average Minimum	Highest	Lowest
No. Years Record	29	29	29	29	29	No. Years Record	50	50	50	50	51
Jan	44.1	51.6	36.6	68	16	Jan	44.6	51.8	37.4	74	16
Feb	45.9	54.3	37.5	79	21	Feb	46.6	54.1	39.0	79	21
Mar	47.3	56.3	38.3	88	23	Mar	47.6	55.9	39.3	88	23
Apr	49.7	58.5	40.0	85	21	Apr	49.7	58.2	41.2	88	20
May	52.6	61.8	43.5	87	29	May	53.2	61.5	44.9	94	29
Jun	56.4	65.4	47.5	100	34	Jun	56.7	65.0	48.4	100	34
Jul	59.3	68.2	50.4	98	39	Jul	59.3	67.5	51.0	98	39
Aug	59.9	69.0	50.5	90	38	Aug	59.8	68.6	51.0	90	38
Sep	58.0	68.4	47.4	98	30	Sep	58.1	67.6	48.5	98	30
Oct	54.3	64.9	43.8	99	26	Oct	54.7	64.1	45.3	99	26
Nov	49.3	58.0	40.4	78	22	Nov	49.6	57.7	41.4	78	22
Dec	44.7	52.5	36.9	69	17	Dec	45.5	52.9	38.0	69	17
Annual	51.8	60.7	42.7	100	16	Annual	52.1	60.4	43.8	100	16

[1] U. S. Department of Agriculture Weather Bureau (1936)
[2] U. S. Department of Commerce Weather Bureau (n. d.)

TABLE 2-3. Temperature and Weather at Various Locations in Coos Bay, Oregon.

Date	Area[1]	Temp °C	Weather[2]	Date	Area[1]	Temp °C	Weather[2]
11 Jan 1930	A	8-10	R-Cd	23 Aug 1930	C	19-23	Cl
12	B	11-14	R-Cd	24	A	12-17	Cl
25	C	7-10	Cd-E		B	16-22	Cl
	A	11-14	CD-Cl				
	B	9-13	Cd	5 Sep	C	15-22	Cl
26	C	9-13	Cd-R	6	A	11-20	Cl
					B	16-22	Cl
9 Feb	A	8-10	R-Cd	20	A	10-14	Cl
	B	12-9	Cd		B	11-16	Cl
23	C	8-14	R-Cd	21	C	13-18	Cl
8 Mar	A	6-14	R-Cd	11 Oct	A	12-13	Cl
	B	9-13	Cd		B	12-13	Cl
9	C	11-13	R-Cl	12	C	10-13	Cl
29	A	7-16	F-Cd	25	A	11-13	Cl
	B	10-17	Cl		B	10-13	Cl
30	C	12-15	Cl	26	C	8-11	Cl
12 Apr	A	8-14	R	8 Nov	A	14-12	Cl-R
	B	10-14	R		B	15-17-12	R-Cl
13	C	11-17	R-Cd	15	C	11	R
26	A	11-13	R-Cd	20	A	14-11	Cl
	B	13-18	R-Cd		B	19-6	Cl
10 May	C	15-23	Cl	6 Dec	A	6-11	Cl
11	A	11-16	Cl		B	7-13	Cl
	B	12-20	Cl	13	C	6-11	Cl
				21	C	6-14	Cl
1 Jun	A	14-18	R				
	B	16-13	R-Cd	16 Jan 1931	A	8-13	Cl-R
7	C	12-17	Cd-R		B	8-14	Cl-Cd
8	A	12-20	Cl	25	C	10-13	R-Cd
	B	14-22	Cl				

[1] A = Cape Arago to Government Dock, Empire.
B = City Dock, North Bend to Millington.
C = Coos River Mouth to Daniels Creek Dock.

[2] R = Rain, Cl = Clear, F = Fog, M = Mist, Cd = Cloudy (0.4 or 0.5 cover to overcast).

[3] 1.65" of rain.

[4] Rain for 2 weeks previous.

TABLE 2-3. Temperature and Weather at Various Locations in Coos Bay, Oregon (continued).

Date	Area[1]	Temp °C	Weather[2]	Date	Area[1]	Temp °C	Weather[2]
1 Feb 1931	A	9-14	Cd	1 Jul 1931	C	21	Cd-Cl
	B	8-14	Cd-Cl	15	A	14-21	Cd-Cl
15	A	7-11	R[3]		B	17-19	Cl
	B	7-13	R	17	C	23-28	Cl
				28	A	13-20	Cl
1 Mar	A	14-19	Cl[4]		B	18-19	Cl
	B	15-18	Cl	30	C	17-24	Hazy
7	A	2-18	Cl				
	B	4-20	Cl	13 Aug	A	11-20	Cl
21	C	10-16	R		B	19-22	Cl-Cd
22	A	8-15	Cl	14	C	18-19	Hazy
	B	11-19	Cd-Cl	26	A	10-17	Cl
					B	17-21	Cl
1 Apr	C	12-15	R	27	C	18-23	Cl
4	A	10-13	R				
	B	11-13	R-Cd	12 Sep	A	12-19	Cl
18	A	8-14	Cd-Cl		B	18-21	Cl
	B	13-12	Cd-Cl	13	C	18-23	Cl
19	C	15-21	Cl	26	A	10-13	Cl
					B	13-16	Cl
2 May	A	14-16	Cd-Cl	27	C	12-15	Cl
	B	16-20	Cd-Cl				
3	C	21-24	Cl	10 Oct	A	10-12	Cd-R
16	A	11-18	R-Cl		B	10-15	Cd-Cl
	B	12-18	Cd-Cl	11	C	13	Cd
17	C	18-19	Cl	24	A	10-11	R
30	A	10-21	Cl		B	11-12	R
	B	18-22	Cl	25	C	12-13	R
31	C	21-24	Cl				
				7 Nov	A	12	R
17 Jun	A	17-22	Cd-Cl		B	13-12	R
	B	20-22	Cl	28	A	10-12	Cd-M
19	C	19-23	Cl		B	8-11	Cd-M
29	A	13-21	Cl				
	B	14-20	Cl				

[1]A = Cape Arago to Government Dock, Empire.
B = City Dock, North Bend to Millington.
C = Coos River Mouth to Daniels Creek Dock.

[2]R = Rain, Cl = Clear, F = Fog, M = Mist, Cd = Cloudy, (0.4 or 0.5 cover to overcast).

[3]1.65" of rain.

[4]Rain for 2 weeks previous.

TABLE 2-3. Temperature and Weather at Various Locations in Coos Bay, Oregon (continued).

Date	Area[1]	Temp °C	Weather[2]
5 Dec 1931	A	6-7	R
	B	7-12	R
9 Jan 1932	A	7-9	Cd-R
	B	10-12	Cd-R
23	A	7-10	R
	B	9-11	R
6 Feb	A	3-9	F-Cl
	B	7-13	F-Cl
20	A	7-11	R
	B	7-13	R
19 Mar	B	7-12	R
9 Apr	B	13-14	Cl
23	B	13-11	R
7 May	B	15-21	Cl
21	B	13-15	Cd
4 Jun 1932	B	18-22	Cl
18	B	15-20	Cl
2 Jul	B	14-18	F-Cl
27 Aug	B	10-20	Cl
3 Sep	B	19-26	Cl
24	B	15-16	Cl
1 Oct	B	11-15	Cd
29	B	10-12	R
12 Nov	B	9-12	R
26	B	9-12	Cd-R
10 Dec	B	7-11	R
26	B	6-10	R

[1] A = Cape Arago to Government Dock, Empire.
B = City Dock, North Bend to Millington.
C = Coos River mouth to Daniels Creek Dock.
[2] R = Rain, Cl = Clear, F = Fog, M = Mist, Cd = Cloudy (0.4 or 0.5 cover to overcast).
[3] 1.65" of rain.
[4] Rain for 2 weeks previous.

Table compiled from Queen and Burt (1955). Limited hourly temperature data also available.

Tables 2-4 and 2-5 tabulate the readily available fog and visibility observations for the region. Table 2-6 includes the 1954-55 visibility data from the Coos Bay Lifeboat Station, Charleston, Oregon. Information available from the log maintained by the U. S. Coast Guard Light Stations include wind direction and force, barometer readings, dry temperature, the form and amount of clouds, visibility and the direction and height of the sea. Except for the current year all these data are sent to the Coast Guard Archives in Washington, D. C., along with the logs of the Lifeboat Stations.

WIND AND WEATHER

The prevailing wind direction from November through February is from the southwest. During the months of March through October, a northwest wind prevails. The strongest prevailing winds also come from the northwest.

Table 2-6 consists of wind, weather, sea, and visibility data from the Coos Bay Lifeboat Station at Charleston, Oregon. An approximate average for the 6 watches on the first, seventh, fourteenth, twenty-first, and twenty-eighth day of each month during 1954-55 was compiled for this tabulation.

The Portland District of the Corps of Engineers has compiled the wind direction and velocity data from the Cape Arago Light Station log for the 10 year period from 1915 to 1925 and also 1933 (see Table 2-7). Enclosure 2-2 presents wind roses for the period 1915 to 1933.

About 1950 the U. S. Air Force studied the weather observations for Coos Bay and summarized precipitation, frost, temperature, fog, and wind information. A report of this study was submitted to:

Directorate of Installations
Western Air Defense Office
Hamilton Air Force Base
California.

In addition records of the daily precipitation, wind, and weather conditions are maintained by the:

761st Air Command and Warning
U. S. Air Force Base
North Bend, Oregon.

TABLE 2-4. Hours of Fog at Cape Arago Light Station.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1951-52	1	34	66	32	13	59	99	208	237	38	44	8	836
1952-53	60	28	44	77	0	5	248	240	231	387	151	5	1476
1953-54	20	50	9	15	59	49	153	205	143	39	43	52	837

Table compiled from the U. S. Treasury Department Coast Guard (n. d. a).

TABLE 2-5. Average Occurrence of Low Visibilities and Dense Fog, Coos Bay, Oregon.

Low Visibilities in Percent Hours	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
0-1/4 mi	1.6	1.0	1.9	1.8	2.4	2.0	2.9	6.1	6.3	7.8	5.3	2.9	3.5
0-1/2 mi	1.9	2.2	2.6	2.6	2.7	2.0	4.2	6.8	9.1	9.9	6.5	4.2	4.6
0-2 mi	3.0	4.7	5.7	4.8	4.6	6.1	8.4	12.8	16.7	15.4	8.9	8.5	8.4
Dense Fog in Percent Hours													
	1.3	1.0	1.8	1.8	2.4	2.0	2.9	6.1	6.3	7.9	5.3	2.9	3.5

Table compiled from U. S. Department of Commerce Coast and Geodetic Survey (1951). Records cover a 7-year period to 1951; elevation point 207 feet.

TABLE 2-6. Average Weather and Sea Conditions at Coos Bay Lifeboat Station, Charleston, Oregon.

Date	Wind	Weather[1]	Sea[2]	Visibility[3]
1 Apr 1954	SW 2	O	L	7
7	SW 2	BC, Z, B	L-M	7
14	NE-NW 3	B, C, BC	M	8
21	NE-NW 4	B, Z, BC	M	8
28	NW 3	C, BC, B	M	8
1 May	NW-Calm 3	B, BC	L	8
7	SW-Calm 2	B, F, C	M	5
14	Calm	F, O-F	M	5
21	NE-NW 3	O, Z, BC	M	8
28	N-Calm 1	BC, C	L-M	6
1 Jun	SE, NE 2	BC, Z, B	S-M	7
7	Calm-SW 1	F, O, Z	M	7
14	Calm-SW 2	O, F	L	5
21	NE 4	B, BC	L	8
28	NW-Calm 1	BC, F	L	7
1 Jul	Calm-NW 2	C, B	M	7
7	W-SW 2	O, Z	M	7
14	NE-NW 4	O, Z	M	7
21	Calm-NE-NW 5	Z, BC	M	7
28	N-NE 3	B, Z	M	7
1 Aug	NW 2	F, O, Z	L-M	5
7	N-NW 2	F	Obscured	0
14	Calm	O, Z, BC	L	6
21	Calm-NE-NW 3-4	O, BC	L-R	6
28	Calm	O, R	L	6
1 Sep	Calm	O	L	5
7	NE-NW 2	C, BC	M	6
14	Calm-SW 1	C, BC	M	5-6
21	Calm-NW 2	O, C	L-M	5
28	NW 3	B, BC	M	5
1 Oct	NW 2	B	M	5
7	SW 4	C, Z	R	4
14	SW-NW 2	BC	M	7
21	SW 3	O, R	R	4
28	Calm	BC, Z	M	5

TABLE 2-6. Average Weather and Sea Conditions at Coos Bay Lifeboat Station, Charleston, Oregon (continued).

Date	Wind	Weather[1]	Sea[2]	Visibility[3]
1 Nov 1954	Calm	O, F	M	5
7	SE 1	O, R, F	R	5
14	S-W 1	O, R	M	6
21	SW-NE 2	BC	R	5
28	SE-NW 2	BC	M	7
1 Dec	Calm	O, Z	M	5
7	SW 1	C	R	7
14	SW 2	O, F, O	M	6
21	SE 2	O, F	R	2
28	SE-SW 2	O	M	6
1 Jan 1955	NW 3	O	R	6
7	NE-W 1	BC	M	5
14	SW 4	O, Z	R	7
21	Calm	O, R	M	3
28	Calm	O, F	M	5
1 Feb	W 2	O, R	R	6
7	SW 1	O	M	8
14	NW 1	O, F	R	6
21	N 1	BC	M	7
28	S 5	O, R, F	R	4
1 Mar	SW 4	O, P, G	VR	6
7	Calm	B	R	7
14	NW 2	C	R	6
21	S 2	O	M	6
28	SW 2	O, R, Z	M	6

[1] Symbols to be used in recording the weather in tabulated form:

b-Blue sky, cloudless.
bc-Blue sky with detached clouds.
c-Sky mainly cloudy.
d-Drizzling, or light rain.
e-Wet air, without rain.
f-Fog, or foggy weather.
g-Gloomy, or dark, stormy-looking weather.
h-Hail.
i-Lightning.

TABLE 2-6. Average Weather and Sea Conditions at Coos Bay Lifeboat Station, Charleston, Oregon (continued).

[1]Symbols to be used in recording the weather in tabulated form (continued):

m=Misty weather.
o=Overcast.
p=Passing showers of rain.
q=Squally weather.
r=Rainy weather, or continuous rain.
s=Snow, snowy weather, or snow falling.
t=Thunder.
u=Ugly appearance, or threatening weather.
v=Variable weather.
w=Wet, or heavy dew.
z=Hazy weather.

[2]L = light, 0-4 feet; M = medium, 4-8 feet; R = rough, 8-12 feet; VR = very rough above 12 feet.

[3]Numerals to be used in recording visibility in tabulated form:

0=Prominent objects not visible at 50 yards.
1=Prominent objects not visible at 200 yards.
2=Prominent objects not visible at 500 yards.
3=Prominent objects not visible at 1/2 mile.
4=Prominent objects not visible at 1 mile.
5=Prominent objects not visible at 2 miles.
6=Prominent objects not visible at 4 miles.
7=Prominent objects not visible at 7 miles.
8=Prominent objects not visible at 20 miles.
9=Prominent objects not visible above 20 miles.

Table compiled from the log of the Lifeboat Station, U. S. Treasury Department (n. d. b).

TABLE 2-7. Wind at Entrance to Coos Bay, Oregon.

Wind Direction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total No. Days	Average No. Days Per Year	Percent of Time
N	10	10	6	7	3	5	9	8	8	5	5	10	86	9	2.4
NE	34	26	14	7	10	7	8	10	14	13	20	30	193	19	5.2
E	18	10	9	3	6	3	2	2	5	9	14	17	98	10	2.7
SE	94	56	55	39	25	17	7	11	26	66	112	116	624	62	17.0
S	40	39	37	20	19	15	11	10	21	23	37	28	300	30	8.2
SW	74	83	85	81	65	73	53	59	85	80	72	75	885	88	24.2
W	18	16	20	26	22	20	20	28	21	13	13	12	229	23	6.3
NW	25	44	84	116	161	158	199	18	120	98	29	21	1235	124	34.0

Wind Direction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total No. Days	Average No. Days Per Year	Percent of Time
N	-	1	-	-	-	-	-	-	-	-	-	-	1	-	0.3
NE	2	2	-	1	-	1	1	1	1	1	3	1	14	-	3.9
E	-	1	-	-	-	-	1	-	-	-	-	-	2	-	0.5
SE	16	11	21	4	9	3	-	3	9	8	11	19	114	-	31.5
S	-	1	-	-	-	-	-	-	-	-	-	-	1	-	0.3
SW	11	7	6	7	12	7	2	8	11	7	7	10	95	-	26.2
W	-	1	-	1	-	-	1	-	-	-	-	-	3	-	0.8
NW	2	4	4	17	9	19	26	18	9	14	9	11	132	-	36.5
													362		100.0

Compiled from U. S. Army Corps of Engineers Portland District (1926) for 1915-1925 data, U. S. Army Corps of Engineers (n. d.) for 1933 data.

Storms

The U. S. Army Corps of Engineers (1948) report the following wind conditions for South Slough, just inside the entrance to Coos Bay:

> During the summer, northwest winds prevail in this area and average about 17 miles per hour. Winter winds, averaging about 15 miles per hour, are generally from the south and, during storms, sometimes attain velocities up to 75 miles per hour, causing heavy seas to enter the bay. These severe winter storms hamper offshore navigation, particularly small craft, and compel the fishing fleet to seek shelter. The harbor at Charleston and the southerly section of the slough are partially protected from southerly storms by a low range of hills to the slough and west which terminates in Coos Head, a sandstone bluff 160 feet high on the slough side of the entrance to Coos Bay. There is no protection from waves created by outside winter storms. A long sand spit that extended easterly from high ground near Coos Head, formerly rendered a certain degree of protection to Charleston Harbor from wind and waves, but this has gradually been destroyed by winter storms.

Sky Conditions

The cloud cover compiled over a period of 41 years between 1911 and 1952 by the U. S. Department of Commerce Weather Bureau (n. d.) shows that on the average in North Bend, Oregon, there are 128 clear days, 67 partly cloudy days, and 170 cloudy days per year. The following is a monthly tabulation of the number of days of clear, partly cloudy, and cloudy sky conditions for the 1911-1952 period (see also Table 2-3).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Clear	21	6	7	8	9	10	15	16	13	10	7	6
Partly Cloudy	4	4	5	6	7	7	7	6	6	5	5	5
Cloudy	6	8	19	16	15	13	9	9	11	16	18	20

SPECIAL PHENOMENA

Wind conditions in conjunction with the general terrain apparently have an effect on the fog signal from the Cape Arago Light Station. On all but southerly winds the fog whistle is blocked out from the first sea buoy to a point approximately 4 miles inside the bay. The whistle is heard out to five miles at sea, however. This has been observed since about 1870 and a study has been made on this condition by Coast Guard personnel.

Radio reception in the Coos Bay region is apparently excellent; this is especially true in the vicinity of the Cape Arago Light Station.

BIBLIOGRAPHY

Baker, Frederick S.
1944. Mountain Climates of the Western United States. Ecological Monographs, vol. 14, no. 2, pp. 223-254.
(Climatic characteristics for coastal area, temperature, growing season, precipitation, and snowfall, shown graphically.)

Beals, Edward A.
1906. Climatology of the United States, Oregon. U. S. Department of Agriculture, Weather Bureau, Bulletin Q, W. B. no. 361, Government Printing Office, Washington, pp. 947-969.
(General and specific data given for Coos Bay area.)

Brown, Stuart G. and R. C. Newcomb
n. d. Ground Water on North End of North Spit at Coos Bay, Oregon. Manuscript on file in U. S. Geological Survey, Ground Water Branch, Portland, Oregon. (Unpublished.)
(Contains extent of dunes, rainfall, runoff and storage, evaporation and storage, ground water, and physical description of the sands.)

Carpenter, Archer B.
1934. Record November Fog Preceding Phenomenal Winter of 1933-34 in the Pacific Northwest. Monthly Weather Review, vol. 62, no. 11, pp. 404-407.
(A discussion of the fog and how it formed and some of the synoptic conditions that prevailed at that time. Includes Coos Bay area.)

Carpenter, Archer B.
1936. Behavior of a Warm Front on the Oregon-Washington Coast. Bulletin of the American Meteorological Society, vol. 17, no. 11, pp. 319-320. (Abstract.)
(An analysis of an air circulation pattern that includes the Coos Bay and Grays Harbor areas.)

Church, Phil E.
1942. Climates of the Pacific Northwest. The Pacific Northwest, Edited by Otis W. Freeman and Howard H. Martin, New York: John Wiley and Sons, Chapter 4, pp. 104-125.
(A complete discussion on the survey level.)

Counts, R. C., Jr.
1934. Storms Over the Northwest Pacific Ocean and Adjacent Land Areas in December 1933. Monthly Weather Review, vol. 62, no. 2, pp. 58-59.
(Causes of heavy precipitation for the period. Coos Bay area included.)

Donn, William L.
1951. Meteorology With Marine Applications. McGraw-Hill, New York, 2d edition, 465 pages.
(Presents several North Pacific weather maps showing circulation patterns as they affect the Pacific Coast area.)

Hansen, Henry P.
1941. Paleocology of Two Peat Deposits on the Oregon Coast. Oregon State Monographs, Studies in Botany, No. 3, Oregon State College, Corvallis, Oregon, 31 pages.
(History of area, geological, climatological, and biological. Woahink Lake and Sand Lake Bogs studied.)

Johnson, Arthur F.
1933. Hydrology Studies Applicable to Oregon. Thesis, Oregon State Agricultural College, Corvallis, Oregon, 106 pages plus plates and appendicies.
(Includes climatological data for Marshfield. Study is general, no specific data for hydrology in Coos Bay.)

Mann, C. W. and James E. Ferguson
1912. Soil Survey of the Marshfield Area, Oregon. U. S. Department of Agriculture, Field Operations of the Bureau of Soils, 1909, [printed 1912], pp. 1601-1634.
(Includes sections on climate, flora, physiography, and geology in the Coos Bay area. Soils map included.)

O'Brien, M. P.
n. d. [Oceanography of Coastal Harbors.] On file U. S. Army, Corps of Engineers, Beach Erosion Board, Washington, D. C. (Unpublished.)
(Sections on Grays Harbor, Coos Bay, and Humboldt Bay include description, tides, tidal current, waves, wind, sand samples and profiles, sand movements, and structures.)

Queen, John and Wayne V. Burt
1955. Hydrography of Coos Bay. School of Science, Oregon State College, Corvallis, Data Report No. 1, 16 pages (processed).
(Weather, cloud cover, air temperature, salinity, water temperature, current velocity, tide state and height, H_2S, and pH for 11 stations in and near Coos Bay.)

Stone, Robert G.
1936. Fog in the United States and Adjacent Regions. Geographical Review, vol. 26, no. 1, pp. 111-134.
(A study of periods of maximum occurrence, type, and causes of fog. Survey areas included but no station data specifically applicable.)

Stovall, James C. and Ruth Edwina Hopson
1940. Climate of Oregon. Physical and Economic Geography of Oregon, Oregon State System of Higher Education, chapter 4, pp. 83-91.

Stump, R. and R. T. Hermanson
1945. Comparison of Forecast and Observed Waves from Two Pacific Storms. University of California, College of Engineering, Berkeley, Report No. HE-116-124, 10 pages plus 12 tables, 9 weather maps and 2 photos (typewritten).
(Weather maps cover entire Pacific Coast. Two Observation stations at Humboldt Bay, the others in California only.)

Todd, D. K. and R. L. Wiegel
1951. Local Storms of the Pacific Coast and Their Effects on Wave and Beach Conditions. University of California, Institute of Engineering Research, Wave Investigation Technical Report HE-116-324, 15 pages (processed), 8 plates.
(The meteorological situations causing local storms in near-coastal areas are investigated because of the erosive action on beaches of high, short-period waves generated. Two local storms at Oceanside, California, are examined in detail.)

1952. Near-Coastal Storms and Associated Waves. Transactions of the American Geophysical Union, vol. 33, no. 2, pp. 217-225.
(Data from 3-year study of daily weather maps. Forecasting problems and limitations of resulting waves are discussed. Examples from Oceanside, California, presented.)

Toenges, Albert L., James J. Dowd, Louis A. Turnbull, J. M. Schopf, H. M. Cooper, R. F. Abernethy, H. F. Yancey, and M. R. Geer.
1948. Minable Reserves, Petrography, Chemical Characteristics, and Washability Tests of Coal Occurring in the Coos Bay Coal Field, Coos County, Oregon. U. S. Department of the Interior, Bureau of Mines, Technical Paper 707, 56 pages, illustrated.
(Includes descriptions of area, topography and geology, and climate.)

U. S. Army Corps of Engineers
n. d. Wind Roses Obtained from Various Drawings for Coos Bay. On file Portland District, Portland, Oregon. (Unpublished.)
(The years 1921, 1933, and the 10-year period ending 1925, were examined.)

1948. Coos Bay at Charleston, South Slough, Oregon. House Document no. 646, 80th Congress, 2d Session, 20 pages, 1 map.

U. S. Army Corps of Engineers
1954. Project Report on Catching Inlet Drainage District, Coos Bay, Oregon. Portland District, Portland, Oregon, 25 pages plus 2 plates (mimeographed). (Not for public release.) (Includes current investigation taking place, climate, normal annual precipitation, temperatures, stream flow, floods, tides, and plate showing diagrammatically average frequence of precipitation, storm patterns, and flood routings.)

U. S. Army Corps of Engineers, Portland District, Portland, Oregon [Coos Bay, Oregon--Maps (Unpublished)]
1926. Wind Charts for Coos Bay, Oregon. Map File No. CB-1-135. (Wind roses for 1916, 18, 20, 22, 24 and the years 1915-1925.)

1947. Isohyetal Map Normal Annual Precipitation Western Oregon. Map File No. WB-05-2/8. (Drawn for the Willamette River and Tributaries; covers entire western Oregon incorporating adjusted data.)

1954. Coos River, Catching Inlet Drainage District, Hydrologic Data. Map File No. CB-2-4/2.

U. S. Department of Agriculture
1936. Atlas of American Agriculture. Government Printing Office, Washington, D. C. (Physical basis including land relief, climate, soils, and natural vegetation of the United States. Section on climate is comprehensive.)

1941. Climate and Man, Yearbook of Agriculture. House Document No. 27, 77th Congress, 1st Session, Government Printing Office, Washington, D. C. (Summary offered for areas of report.)

U. S. Department of Agriculture Weather Bureau
1936. Climatic Summary of the United States, Section 3, Western Oregon. Government Printing Office, Washington, D. C., 48 pages. (Tables include Marshfield at Coos Bay.)

U. S. Department of Commerce Coast and Geodetic Survey
1951. United States Coast Pilot, Pacific Coast, California, Oregon, and Washington, Seventh (1951) Edition. Serial no. 750, U. S. Government Printing Office, Washington, 578 pages. (Includes meteorological data on harbors.)

U. S. Department of Commerce Weather Bureau

n. d. Climatic Summary for North Bend, Oregon (1902-1952 incl.). Prepared by the Weather Bureau Office, Portland, Oregon, 1 page (typewritten). (Unpublished.)
(This constitutes all summarization of data ever made by the Portland Office for the Coos Bay area other than that appearing in Climatic Summary of the U. S., Sec. 3, Western Oregon.)

Annual. Climatological Data--Oregon. Government Printing Office, nos. 1-12, Monthly; no. 13, Annual Summary; vol. 56 for the year 1950.
(Data for areas near Coos Bay.)

1952. Maximum 24-hour Precipitation in the United States. Weather Bureau Technical Paper no. 16, 284 pages, Government Printing Office, Washington, D. C.
(Survey areas included.)

U. S. Treasury Department Coast Guard

n. d.a. Hours of Fog Summary, 13th CG District. On file at the 13th Coast Guard District, Seattle, Washington. (Unpublished.)
(Hours of operation of fog signals per month for the years 1942-1945, 1947-1949, 1951-1954. Data from Cape Arago Lightstation.)

n. d.b. Log of the U. S. Coast Guard Cape Arago Life Station. On file at the 13th Coast Guard District, Seattle, Washington. (Unpublished.)
(Contains the following meteorological data recorded every 4 hours: dry bulb temperature, wind duration and force, weather description by symbols, cloud form and amount, sea conditions, visibility, within the period July 1951 to July 1954.)

Ward, Robert De C. and Charles F. Brooks

1936. The Climates of North America, Part I, Mexico, United States, Alaska. Handbuch der Klimatologie, Edited by W. Koppen and R. Geiger, Band II, Teil J, Verlag von Gebruder Borntraeger, Berlin, 325 pages.
(Text in English. Data for survey areas given.)

SECTION 3

HYDROLOGY

HYDROLOGY

DRAINAGE BASIN

The drainage area tributary to Coos Bay is 820 square miles. The Coos River, the principal tributary stream, drains an area of 420 square miles (see Enclosures 3-1, 3-2, and 3-3). This river is navigable, with a controlling depth of about five feet to its junction with Millicoma River, 5.5 miles above its mouth, and four feet to the head of navigation nine miles further upstream. Millicoma River has a navigable depth of about four feet for its lower 8.5 miles (U. S. Army Corps of Engineers 1946).

STREAM DISCHARGE

Discharges of streams into Coos Bay vary considerably with the seasons. During the summer months of very little rainfall, the total inflow probably does not exceed 100 second-feet. In winter and spring when heavy rains are frequent, discharge of these tributary streams may total more than 100,000 second-feet (see Enclosure 3-4). These floods carry a considerable amount of fine material into the bay (U. S. Army Corps of Engineers 1946).

SUCCESSION OF RIVERS

The following summary is based on material from Twenhofel (1943):

> It is believed that when the submergence of the coast of southwest Oregon began, the Coquille River flowed through the lowland extending from the town of Coquille through Isthmus Slough to Coos Bay and had its entrance into the sea in the vicinity of Coos Bay. The present valley of the Coquille River into the Bandon area did not then exist. The Sixes, Elk, Coos, Rogue, and other large streams had already established their valleys in bed rock in essentially their present positions. As the land sank, the mouths of the streams were progressively drowned and when the ocean level reached a level on land that is now 1,500 feet above sea level, each of the streams named was reduced to its headwaters. The land then emerged 800 feet. The streams extended themselves across the Pleistocene sands which had been deposited during the previous stage, and which then became exposed. They were free to wander more or less as they wished over these sands, as the structure of the rocks underlying the sands had no influence on the courses they selected. Each stream obviously took the shortest general course to the sea which, in the case of the Coquille, brought it into the Bandon area. The land emerged still more and during successive stationary periods, wave-

cut terraces were formed at 350, 150, 100, and finally at 50 feet. The Coquille continued to carve its valley in the older rocks which now border it on both sides between the town of Coquille and Bandon and thus it became fixed in its present channel. Tributaries to the Coos and Coquille Rivers reexcavated the old valley of the Coquille between the town of Coquille and Coos Bay.

SUBSURFACE AND GROUND-WATER CONDITIONS AT COOS BAY

The following summary is based on material provided by the Ground Water Branch of the U. S. Geological Survey (U. S. Department of the Interior Geological Survey 1954):

> The whole bay area is underlain by shales, shaly sandstones, and tuffs of Tertiary age. They have an over-all general inclination to the westward, though some local arches and downwarps are present and eastward dips do occur. The sedimentary formations with their areal and subsurface extent are well depicted in the publication known as Bulletin 27 [Allen and Baldwin 1944] of the Oregon State Department of Geology and Mineral Resources.
>
> There is essentially no fresh ground water entering the bay from the south and east. The Tertiary sediments are not productive of potable water.
>
> On top of the Tertiary beds a long strip of dune sand forms the terrain north of the bay (and west of North Slough). The sand terrain is arranged in long north-south strips with the dune ridges being separated by linear "lagoon" areas. Those topographic features are readily visible on the Empire and Reedsport quadrangle maps. The sand rests on a shale or clay base at sea level, plus or minus five feet. The sand contains a sizable lens of fresh ground water. It is perched upon the base of impervious material and does not have ready connection with the sea water. There is no published information on this perched lens of ground water but some data are on file from local shallow wells. An estimated 6,000,000 gallons of water per day is the average of the annual precipitation recharged to four square miles of the sand area just north of Coos Bay.

BIBLIOGRAPHY

Allen, John Eliot and Ewart M. Baldwin
1944. Geology and Coal Resources of the Coos Bay Quadrangle, Oregon. Oregon State Department of Geology and Mineral Industries, Bulletin no. 27, 157 pages, 31 plates, 3 maps in pocket. (Describes in detail the stratigraphy, paleontology and structure in the Coos Bay area. Latter part of bulletin is concerned primarily with the coal deposits of Eocene age present.)

Bascom, Willard and Donald McAdam
1947. Beach and Surf Conditions on the Beaches of the Oregon and Washington Coasts Between October 9, 1946 and November 18, 1946. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-247, 54 pages, photos, profiles (typewritten). (Includes profiles, surf conditions, tire impressions, sand samples, and water table profiles. Data for Humboldt Bay, Coos Bay, and Grays Harbor areas. Large number of photos obtained in survey which were not included in the report.)

Brands, M. D.
1947. Flood Runoff in the Willamette Valley, Oregon. U. S. Geological Survey, Water Supply Paper 968-A, pp. 1-59. (Marshfield included in maps.)

Brown, Stuart G. and R. C. Newcomb
n. d. Ground Water on North End of North Spit at Coos Bay, Oregon. Manuscript on file in U. S. Geological Survey, Ground Water Branch, Portland, Oregon. (Unpublished.) (Contains extent of dunes, rainfall, runoff and storage, evaporation and storage, ground water, and physical description of the sands.)

Isaacs, J. D. and W. N. Bascom
1949. Water-Table Elevations in Some Pacific Coast Beaches. Transactions of the American Geophysical Union, vol. 30, no. 2, pp. 293-294. (Pacific Coast beaches surveyed for water-table profiles: Grenville, Ocean City, Leadbetter, Oysterville, Clatsop Spit, Sand Lake, Seabright, Seacliff State Park, Del Monte Creek, and Carmel.)

Johnson, Arthur F.
1933. Hydrology Studies Applicable to Oregon. Thesis, Oregon State Agricultural College, Corvallis, Oregon, 106 pages plus plates and appendicies. (Includes climatological data for Marshfield. Study is general, no specific data for hydrology in Coos Bay.)

Langbein, Walter B. and others
1949. Annual Runoff in the United States. U. S. Geological Survey, Circular 52, 14 pages.
(Includes the survey areas in a comprehensive analysis of run-off, stream flow, and water yield. Effects of climate, geology, topography, drainage area, and vegetation are discussed.)

Lohr, E. W. and S. K. Love
1954. The Industrial Utility of Public Water Supplies in the United States, 1952--Part 2. States West of the Mississippi River. U. S. Geological Survey, Water-Supply Paper 1300.
(Chemical analyses of waters entering harbors.)

National Resources Planning Board
1941. Water Regimen Data Pacific Northwest Drainage Basins. Pacific Northwest Drainage Basins Committee, Subcommittee on Water Regimen, Federal Courthouse, Portland, Oregon (mimeographed).
(Lists and describes activities of U. S. Engineers, Geological Survey, Weather Bureau, etc., contains special reports, review of reports, tables, plates and bibliography; a type of literature survey.)

Twenhofel, W. H.
1943. Origin of the Black Sands of the Coast of Southwest Oregon. State of Oregon Department of Geology and Mineral Industries, Bulletin no. 24, 25 pages.
(Black sand deposits are found on present beaches and in deposits beneath elevated coastal plains. Prevailing southwesterly winds concentrate the sand just south of promontories or at the north side of embayments. Fluctuations in sea levels caused change in position of embayments and promontories with resultant changes in deposition of black sands.)

U. S. Army Corps of Engineers
1946. Coos Bay, Oregon. Senate Document no. 253, 79th Congress, 2d Session, 33 pages, 1 map.

1954. Project Report on Catching Inlet Drainage District, Coos Bay, Oregon. Portland District, Portland, Oregon, 25 pages plus 2 plates (mimeographed). (Not for public release.)
(Includes current investigation taking place, climate, normal annual precipitation, temperatures, stream flow, floods, tides, and plate showing diagrammatically average frequence of precipitation, storm patterns, and flood routings.

U. S. Army Corps of Engineers, Portland District, Portland, Oregon [Coos Bay, Oregon--Maps (Unpublished)]
1936. Coos River and Tributaries, Preliminary Examination. Map File No. CB-2-1.

U. S. Army Corps of Engineers, Portland District, Portland, Oregon [Coos Bay, Oregon--Maps (Unpublished)]

1937. Flood Control, Coos River Region, Preliminary Examination. Map File No. CB-2-2.

1939. Flood Control Survey, Coos River and Tributaries, Areas Affected by Tidal Overflow. Map File No. CB-2-3.

1954a. Coos River, Catching Inlet Drainage District, Proposed Levee Improvement, Map File No. CB-2-4/1.

1954b. Coos River, Catching Inlet Drainage District, Hydrologic Data. Map File No. CB-2-4/2.

U. S. Department of the Interior Geological Survey

Annual. Surface Water Supply of the United States. Part 14, Pacific Slope Basins in Oregon and Lower Columbia River Basin. Water Supply Papers, Government Printing Office. (Includes Coos River.)

1951. Index of Surface-Water Records, Part 14, Pacific Slope Basins in Oregon and Lower Columbia River Basin, to September 30, 1950. Geological Survey Circular 130, 21 pages.

1954. Personal Communication on Ground Water Conditions in the Coos Bay Area. Letter from R. C. Newcomb, District Geologist, Ground Water Branch, Portland, Oregon, to Peter M. McLellan, dated November 17, 1954. (Concerned with underlying sediments. Describes fresh water lenses in sand dunes along shore.)

SECTION 4

REGIONAL GEOLOGY

REGIONAL GEOLOGY

PHYSIOGRAPHY

The immediate coastal region around Coos Bay is generally lower than the shore areas to the north and south. The elevation is seldom over 100 feet near shore, however; foothills and low spurs of the coast range are never more than a few miles from the ocean. Elevations in excess of 2,000 feet are usually more than 25 miles inland. The coastal area 35 miles south of Coos Bay commonly has elevations of more than 2,000 feet within 6 or 7 miles of the shore. The low lying flats are occupied by lakes, sloughs, and dunes.

The main streams emptying into Coos Bay are the Coos and Millicoma Rivers. Both of these rivers have their sources in the coast range, less than 50 miles inland.

The Coos Bay area represents a typical, ria-type, estuarian coast line, formed by the partial submergence of a dissected plain (Smith 1933d). Formerly the oceans penetrated much farther inland than at the present. Subsequent regression of the sea has exposed areas formerly inundated. This relative change in sea level has produced an excellent series of terraces between Yokam Point and Cape Arago (Diller 1901). The lowest terrace stands about 60 feet above sea level; this is followed by a series of well-defined step-like terraces which extend inland up to elevations of 800 feet. These former beaches are more poorly defined at high elevations. Despite this re-emergence, the lower courses of some rivers are still partially submerged.

The coast south of the entrance to Coos Bay consists of rocky headlands and numerous offshore stacks of hard rock. The sea cliffs generally vary from 40 to 100 feet in height, with numerous serrations forming small coves which extend inland for distances up to a quarter mile. At low tide, sandstone outcrops are observed extending approximately parallel to the strike of the strata. In general, the coastline features are structurally controlled. Some of the more prominant points are: Yokam Point, Gregory Point, and Cape Arago.

The region is a typical retrograded shoreline (Pardee 1934). North of Coos Bay entrance the irregular shoreline is one of submergence with modification of an extensive north-south barrier beach. According to Pardee (1934), the barrier beach and associated spit is a typical example of a prograded shoreline. Further discussion of the beaches can be found in the section under RECENT SEDIMENTATION entitled Beaches.

The general physiographic features of the Coos Bay region and adjacent areas are described by Gulliver (1899), Diller (1896, 1899, and 1902), Mann (1912), Smith (1933a, 1933b, 1933c, 1933d, and 1942), Pardee (1934), Weaver (1944), Cooper (1954), Allen and Baldwin (1944), and Baldwin (1945).

STRATIGRAPHY

Pre-Tertiary Stratigraphy

In the southern portion of the Coos Bay quadrangle a series of Pre-Tertiary sedimentary, metamorphic, and igneous rocks are exposed. These Mesozoic rocks have been mapped and described by Diller (1901). In the immediate Coos Bay vicinity the exposed strata are all Tertiary and younger in age.

Tertiary Stratigraphy

The Tertiary rocks in the vicinity of Coos Bay have been described by Diller (1901, 1914), Diller and Pishel (1911), Dall and Harris (1892), Dall (1907, 1909), Arnold and Hannibal (1913), Howe (1922), Schenck (1927, 1928), Weaver (1937, 1945b), Allen and Baldwin (1944), and others. In general the coastal section, extending from Cape Arago eastward toward South Slough, consists of the Umpqua shales, lower Coaledo sandstone, shale and coal, Bastendorf shale, the Tunnel Point sandstone and the Empire sandstone. The predominant formations in Coos Bay proper are the Coaledo and the Bastendorf shale.

Quaternary Stratigraphy

The primary quaternary deposits resting unconformably on the Tertiary rocks are the upper Pleistocene terrace deposits composed of sand and gravel. Most of these terrace deposits are very small and localized. There are two regions where they are comparatively extensive. The largest of these is the coastal region north and south of the Coquille River. The other smaller area extends from South Slough through Empire and to the North Bend Municipal Airport. Recent alluvium fills the river valleys and consists of sand dunes and beach deposits along the coast. Descriptions of Quaternary sediments may be found in Diller (1902), Allen and Baldwin (1944), and Baldwin (1945).

GEOLOGIC HISTORY

The entire Oregon coastal area has been subjected to numerous oscillations of land and sea during geologic time. During some periods the coast line was displaced far to the west, in others, the ancient seas extended far inland to the Cascades and beyond.

Pre-Tertiary geologic history can be traced in detail for southwest Oregon; however, in the Coos Bay region there are no formations known to have been affected by any geologic process prior to the Tertiary. Probably there are Cretaceous and Jurassic sediments in the region. However they have not been located. According to Williams (1953) all of western Oregon and most of what is now the state of Oregon was submerged during the late Cretaceous. Only the Klamath Mountains stood up as islands.

During the early Eocene the whole of southwestern Oregon was a region of emergence and deformation. Apparently there was a basin of deposition north and east of Bandon, Oregon. This basin paralleled the axis of the coast range. The Umpqua formation was deposited during this period. The Eocene saw the beginning of volcanic activity, much of which occurred underneath the sea. These submarine basalts now form the basement rocks of the Oregon coast range. Some of the volcanics were incorporated in the Umpqua sediments. During the middle Eocene the coastline apparently ran along the present Cascade foothills near Portland, Salem, Eugene to Roseburg, and then westward to the present shoreline. Localized uplifts are in evidence during the middle Eocene in that the Tyee sediments east of Coos Bay have been truncated by erosion prior to the deposition of the Coaledo formation (Allen and Baldwin 1944).

According to Williams (1953) the warping of coastal areas during late Eocene caused the development of a long peninsula from Vancouver Island, Canada, through the present Olympic Mountains, Coos Bay, and south into California. The coal beds and coarse, cross-bedded sands of the lower Coaledo indicate continental origin. However the middle Coaledo was probably deposited in a shallow marine basin. Since the upper Coaledo is of continental origin, it appears that local fluctuation in land elevations continued into the late Eocene.

Subsidence is again indicated in the Bastendorf deposits since they were apparently deposited in quiet water, where no strong wave action prevailed (Schenck 1928).

The region was one of submergence and deposition during the early and middle Oligocene. The seas extended into the present Cascades. Land volcanism increased in activity as evidenced by the abundant tuffaceous products in the Tunnel Point sandstone. There are no upper Oligocene deposits known in the area. Either they were covered by the Empire formation in South Slough or this was a period of uplift.

In Miocene time the whole of western Oregon including the Cascade Mountains was uplifted. This was a period of deformation and erosion in Coos Bay and many other parts of the west coast. Volcanism was intense during this time.

Shield volcanoes were formed on the crest of the Cascade Mountains and the coastal plain continued to develop in the early Pliocene. Local downwarping allowed the formation of bays and the Empire formation in South Slough was deposited. The Oregon Coast Range was still non-existent. The upper Pliocene deposits are absent along the southern Oregon coast. This was probably a time of erosion which accompanied the development of the Oregon Coast Range.

The early and middle Pleistocene was a period of erosion and volcanism, the latter bringing about the high peaks of the Cascade Mountains. In the late Pleistocene regional uplift continued and numerous terraces were formed by marine erosion. Glaciation affected the region only indirectly.

GEOLOGIC STRUCTURE

According to Allen and Baldwin (1944):

> Three major periods of folding in the Tertiary have been recognized in the Coos Bay area. The first apparently took place in post-Tyee time, and affected the Umpqua and Tyee sediments; the second occurred during the Miocene and may have included more than one movement; and the third took place during the middle or late Pliocene or early Pleistocene. Minor post-Pleistocene faulting and warping also took place.
>
> A major structural basin which will be referred to as the Coaledo Basin occupies the center of the Coos Bay quadrangle, and is filled by Coaledo and later sediments. It is folded into minor arches and basins.

ECONOMIC GEOLOGY

The most important economic mineral deposit in the Coos Bay region is coal. Production exceeded 111,000 tons in 1904. Since 1923 about 7,000 to 15,000 tons a year have been produced. One area in the vicinity of South Slough is estimated to have 2,362,000 tons of coal (Allen and Baldwin 1944). Diller (1899, 1901, and 1914), Diller and Pishel (1911), Libby (1938), and Duncan (1953) also discuss the conditions, structure, and reserves of the Coos Bay coal fields.

In 1936 the Coast Oil Company put down a test well (Well No. 2) in sec. 10, T.28S., R.13W. of which the depth and results are unknown.

The black sands of the coast of southwest Oregon have been a source of platinum and gold. Diller (1901, 1914), Washburne (1904), Day and Richards (1906), Horner (1918), Pardee (1934), and Twenhofel (1943) discuss the origin, extent, and economic value of these deposits.

BIBLIOGRAPHY

Allen, John Eliot and Ewart M. Baldwin

1944. Geology and Coal Resources of the Coos Bay Quadrangle, Oregon. Oregon State Department of Geology and Mineral Industries, Bulletin no. 27, 15[illegible] pages, 31 plates, 3 maps in pocket. (Describes in detail the stratigraphy, paleontology and structure in the Coos Bay area. Latter part of bulletin is concerned primarily with the coal deposits of Eocene age present.)

Arnold, Ralph and Harold Hannibal

1913. The Marine Tertiary Stratigraphy of the North Pacific Coast of America. Proceedings of the American Philosophical Society, vol. 52, no. 212, pp. 559-605. (Describes formations in the Coos Bay area with maps and lithology.)

Baldwin, Ewart M.

1945. Some Revisions of the Late Cenozoic Stratigraphy of the Southern Oregon Coast. The Journal of Geology, vol. 53, no. 1, pp. 35-46. (Describes marine terraces in Coos Bay area.)

Bandy, Orville Lee

194[illegible]. Invertebrate Paleontology of Cape Blanco. Thesis, Oregon State College, Corvallis, Oregon, 138 pages. (Area is 30 miles south of Coos Bay.)

Brown, Stuart G. and R. C. Newcomb

n. d. Ground Water on North End of North Spit at Coos Bay, Oregon. Manuscript on file in U. S. Geological Survey, Ground Water Branch, Portland, Oregon. (Unpublished.) (Contains extent of dunes, rainfall, runoff and storage, evaporation and storage, ground water, and physical description of the sands.)

Buwalda, John P.

1927. Pleistocene and Recent Topographic Changes in the Pacific Coast States. National Research Council, Bulletin, vol. 61, pp. 39-43.

Clark, William Bullock

1891. Correlation Papers: The Eocene of the United States. U. S. Geological Survey, Bulletin 83, 173 pages. (Mentions briefly occurrence of Tejon strata at Coos Bay, Albany, and Astoria.)

Cooper, William S.
n. d. Coos Bay Sand Dunes. Boulder, Colorado, 8 pages (typewritten). (Unpublished.)
(Part of a paper on West Coast Sand Dunes to be published by the Geological Society of America. Presents a complete history and geology of the dune area. Includes discussion of the lakes entirely within its limits.)

1934. Types of Pacific Coast Dunes. Annals of the Association of American Geographers, vol. 24, no. 1, p. 46. (Abstract.)
(Describes sand dunes and types of dunes. Coos Bay dunes used as an Oregon type.)

1954. Sand-Dune Development and Sea-Level Changes on the Coast of Northern Oregon. Bulletin of the Geological Society of America, vol. 65, no. 12, part 2, p. 1373. (Abstract.)

Cushman, Joseph A., Roscoe E. and Katherine C. Stewart
1947. Five Papers on Foraminifera From the Tertiary of Western Oregon. State of Oregon, Department of Geology and Mineral Industries, Bulletin No. 36, 111 pages.
(Coos Bay area discussed.)

Dall, William H.
1907. Notes on Some Upper Cretaceous Volutidae, With Descriptions of New Species and a Revision of the Groups to Which they Belong. Smithsonian Institution of Washington, Miscellaneous Collections, vol. 50, pp. 1-23.
(Study began with Tertiary fauna of Coos Bay. Described as same species as those of upper Cretaceous. Discusses family Volutidae and compares with forms elsewhere in the world.)

1909. Contributions to the Tertiary Paleontology of the Pacific Coast: I. The Miocene of Astoria and Coos Bay, Oregon. U. S. Geological Survey, Professional Paper 59, 278 pages.
(Tertiary description of Astoria and Coos Bay, including invertebrate fauna. Thirteen appendices covering early reports by T. A. Conrad, J. D. Dana, B. F. Shumard, P. P. Carpenter, not usually available.)

Dall, William H. and Gilbert D. Harris
1892. Correlation Papers: The Neocene of North America. U. S. Geological Survey, Bulletin 84, 349 pages.
(On the coast from Port Orford to Cape Blanco, Coos Bay, Yaquina Bay, Tillamook Head.)

Day, David T. and R. H. Richards
1906. Useful Minerals in the Black Sands of the Pacific Slope. U. S. Geological Survey, Mineral Resources of the United States for 1905, pp. 1175-1258.
(Economic and analytical report.)

Detling, Mildred Riechers
1946. Forminifera of the Coos Bay Lower Tertiary, Coos County, Oregon. Journal of Paleontology, vol. 20, no. 4, pp. 348-361.

Diller, J. S.
1892a. Geology of the Taylorville Region of California. The American Geologist, vol. 10, p. 183. (Abstract.)

1892b. Geology of the Taylorville Region of California. Bulletin of the Geological Society of America, vol. 3, pp. 369-394.
(Eocene deposits of Roseburg, Coos Bay, and Riddle quadrangles contain fossil leaves and marine shells. Flora identified by Knowlton. Dr. Dall says fossils are Eocene. Strata also contain fossils characteristic of Oligocene on Atlantic Coast.)

Diller, J. S.
1896. A Geological Reconnaissance in Northwestern Oregon. U. S. Geological Survey, Seventeenth Annual Report, part 1, pp. 458-467, 475.
(Area included in general discussion.)

1899. The Coos Bay Coal Field, Oregon. U. S. Geological Survey, Ninteenth Annual Report, part 3, pp. 309-376, 13 plates, 23 figures, including maps.
(Describes topography, marine benches, alluvium, Empire (Miocene), Arago (Eocene) divided into Coaledo (younger) coal member and Pulaski (older). Coaledo contains brackish water fossils, Pulaski very few. Coal in basins. Two geologic maps, many cross and stratigraphic sections. Analysis of coal from 32 localities.)

1900. The Coos Bay Coal Field, Oregon. The Journal of Geology, vol. 8, pp. 100-101. (Abstract.)

1901. Coos Bay, Oregon. U. S. Geological Survey, Folio no. 73, 5 pages, 4 maps.
(Topography of the Pacific Coast and Coos Bay quadrangle. Sedimentry rocks--Myrtle (Cretaceous), Pulaski (Eocene), Coaledo formation (development and structure of coal seams), Empire (Neocene). Coos conglomerate and marine sands of Pleistocene age. Igneous rocks--serpentine and basalts. Gold has been found in Pleistocene sand deposits.)

Diller, J. S.
1902. Topographic Development of the Klamath Mountains. U. S. Geological Survey, Bulletin 196, pp. 1-69.
(Describes coastal plain and earlier valley of the Coos River in Coos Bay area.)

1908. Geology of the Taylorville Region, California. U. S. Geological Survey, Bulletin 353, 128 pages.
(Eocene deposits of Roseburg, Coos Bay, and Riddle quadrangles contain fossil leaves and marine shells. Flora identified by Knowlton. Dr. Dall says fossils are Eocene. Strata also contain fossils characteristic of Oligocene on Atlantic coast.)

1914. Mineral Resources of Southwestern Oregon. U. S. Geological Survey, Bulletin 546, 147 pages.
(Coos Bay area included.)

Diller, J. S. and Max A. Pishel
1911. Preliminary Report on the Coos Bay Coal Field, Oregon. U. S. Geological Survey, Bulletin 431, pp. 190-228.
(Includes 3 maps and 2 structure sections.)

Duncan, Donald C.
1953. Geology and Coal Deposits in Part of the Coos Bay Coal Field, Oregon. U. S. Geological Survey, Bulletin 982-B, pp. 53-73, 4 plates.
(General geology and description of major coal deposits in the Coos Bay area. Estimation of coal reserves based on drilling program.)

Grosvenor, Edward Rickman
1934. A Geological Report on a Section of Tertiary Sediments at Coos Bay, Oregon. Thesis, University of Washington, Seattle, Washington, 19 pages.

Gulliver, F. P.
1899. Shoreline Topography. Proceedings of the American Academy of Arts and Sciences, vol. 34, no. 8, pp. 151-258.
(Comprehensive dissertation. Coos Bay shown as an example of sea intention versus river intention.)

Hansen, Henry P.
1941. Paleocology of Two Peat Deposits on the Oregon Coast. Oregon State Monographs, Studies in Botany, No. 3, Oregon State College, Corvallis, Oregon, 31 pages.
(History of area, geological, climatological, and biological. Woahink Lake and Sand Lake Bogs studied.)

Harrison and Eaton (consultants)
1920. Report on Investigation of Oil and Gas Possibilities of Western Oregon. The Mineral Resources of Oregon, Oregon Bureau of Mines and Geology, vol. 3, no. 1, 40 pages.

Hertlein, Leo G. and Colin H. Crickmay
1925. A Summary of the Nomeclature and Stratigraphy of the Marine Tertiary of Oregon and Washington. Proceedings of the American Philosophical Society, vol. 64, pp. 224-282.
(Includes Coos Bay and Grays Harbor formations.)

Honor, R. R.
1918. Notes on the Black Sands Deposits of Southern Oregon and Northern California. Department of the Interior, Bureau of Mines, Technical Paper 196, 42 pages.
(Coos Bay to Crescent City. A comprehensive report, locations, analyses, and values.)

Howe, Henry V.
1922. Faunal and Stratigraphic Relationships of the Empire Formation, Coos Bay, Oregon. University of California Publications, Bulletin of the Department of Geological Sciences, vol. 14, no. 3, pp. 85-114.
(Distribution, description and fossil content of the Empire formation and overlying Coos conglomerate. Gives faunal proof of Pliocene age of both.)

James, Ellen L.
1950. A New Marine Fauna From Coos Bay, Oregon. Bulletin of the Geological Society of America, vol. 61, no. 12, pt. 2, p. 1539. (Abstract.)

Johnson, Douglas W.
1919. Shore Processes and Shoreline Development. John Wiley and Sons: New York, 584 pages.
(Not specifically applicable to survey areas but useful in analyzing shore processes envolved in harbor formation.)

Libbey, F. W.
1938. Progress Report on Coos Bay Coal Field. Oregon State Department of Geology and Mineral Industries, Bulletin no. 2, 14 pages (processed).
(A summary report stating conditions of the coal field.)

Mann, C. W. and James E. Ferguson
1912. Soil Survey of the Marshfield Area, Oregon. U. S. Department of Agriculture, Field Operations of the Bureau of Soils, 1909, (printed 1912), pp. 1601-1634.
(Includes sections on climate, flora, physiography, and geology in the Coos Bay area. Soils map included.)

McLaughlin, Willard T. and Robert L. Brown
1942. Controlling Coastal Sand Dunes in the Pacific Northwest. U. S. Department of Agriculture, Circular No. 660, 46 pages. (Coos Bay and Grays Harbor areas affected. Causes, extent and methods of control discussed.)

O'Brien, M. P.
n. d. [Oceanography of Coastal Harbors.] On file U. S. Army, Corps of Engineers, Beach Erossion Board, Washington, D. C. (Unpublished.) (Sections on Grays Harbor, Coos Bay, and Humboldt Bay include description, tides, tidal current, waves, wind, sand samples and profiles, sand movements, and structures.)

Pardee, J. T.
1934. Beach Placers of the Oregon Coast. U. S. Geological Survey, Circular 8, 41 pages (mimeographed). (Description of the beaches, terraces, and history of the Oregon coast in the vicinity of Coos Bay and south to the Rogue River. Describes the gold and platinum deposits of the black sands. NS. and EW. sections of South Slough at Coos Bay shown among shore profiles.)

Schenck, Hubert G.
1927. Marine Oligocene of Oregon. University of California Publications, Bulletin of the Department of Geological Sciences, vol. 16, no. 12, pp. 449-460. (General discussion of Oligocene in Oregon, relation of Oligocene to Eocene; includes stratigraphy of Coos Bay district.)

1928. Stratigraphic Relations of Western Oregon Oligocene Formations. University of California Publications, Bulletin of the Department of Geological Sciences, vol. 18, no. 1, pp. 1-50. (General discussion of Oligocene stratigraphy in western Oregon including Eugene district, Coos Bay, Yaquina, Alsea Bay districts.)

Schopf, James M.
1947. Botanical Aspects of Coal Petrology: Coal from the Coos Bay Field in Southwestern Oregon. American Journal of Botany, vol. 34, no. 6, pp. 335-345. (Differentiation in lithology and type characteristics from coal of Carboniferous age.)

Smith, Warren D.
1933a. Geology of the Oregon Coast Line. Pan-American Geologist, vol. 59, no. 1, pp. 33-44. (Describes, along with other areas along the coast, the general geology of the Coos Bay area.)

Smith, Warren D.
1933b. Physiography of the Oregon Coast. Pan-American Geologist, vol. 59, no. 2, pp. 97-114.
(Describes shoreline processes and evolution of the coast as well as individual inlets and bays.)

1933c. Special Physiographic Features of Oregon Coast. Pan-American Geologist, vol. 59, no. 3, pp. 190-206.
(Includes Coos Bay area in discussions.)

1933d Special Physiographic Features of Oregon Coast. Pan-American Geologist, vol. 59, no. 4, pp. 241-258.
(Coos Bay area described in detail.)

1942. Physical Framework of the Northwest Geology and Geomorphology of the Region West of the Cascade Mountains. The Pacific Northwest, Edited by Otis W. Freeman and Howard H. Martin, New York: John Wiley and Sons, Chapter 3, pp. 41-57.
(Describes the coastal area.)

Toenges, Albert L., James J. Dowd, Louis A. Turnbull, J. M. Schopf, H. M. Cooper, R. F. Abenethy, H. F. Yancey, and M. R. Geer
1948. Minable Reserves, Petrography, Chemical Characteristics, and Washability Tests of Coal Occurring in the Coos Bay Coal Field, Coos County, Oregon. U. S. Department of the Interior, Bureau of Mines, Technical Paper 707, 56 pages, illustr.
(Includes descriptions of area, topography and geology, and climate.)

Turner, F. E.
1938. Stratigraphy and Mollusca of the Eocene of Western Oregon. Geological Society of America, Special Papers, no. 10, pp. 26-40.
(Contains a description of the Cape Arago section exposed along the ocean front south of Coos Bay. Invertebrate faunal list plus fossil localities also included.)

Twenhofel, W. H.
1943. Origin of the Black Sands of the Coast of Southwest Oregon. State of Oregon Department of Geology and Mineral Industries, Bulletin no. 24, 25 pages.
(Black sand deposits are found on present beaches and in deposits beneath elevated coastal plains. Prevailing southwesterly winds concentrate the sand just south of promontories or at the north side of embayments. Fluctuations in sea levels caused change in position of embayments and promontories with resultant changes in deposition of black sands.)

Twenhofel, W. H.
1946. Minerological and Physical Composition of the Sands of the Oregon Coast from Coos Bay to the Mouth of the Columbia River. Oregon State Department of Geology and Mineral Industries, Bulletin no. 30, 64 pages (processed).
(Shore physiography, character and composition of the beaches, and mineral analysis.)

University of California
1946. Notes on Reconnaissance of Miscellaneous Pacific Beaches May 21-September 29, 1945. Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-223, 51 pages, maps, photos (typewritten).
(Captions accompanying the photos constitute the report. Photos show surf conditions, beaches, and sand dunes in the various areas studied.)

U. S. Army Corps of Engineers
1946. Coos Bay, Oregon. Senate Document No. 253, 79th Congress, 2d Session, 33 pages, 1 map.

Washburne, C. W.
1904. Beach Gold and Its Source. The Mineral Resources and Mineral Industry of Oregon for 1903, University of Oregon Bulletin, new series, vol. 1, no. 4, pp. 19-21.
(Coos Bay area not specifically included.)

1914. Reconnaissance of the Geology and Oil Prospects of Northwestern Oregon. U. S. Geological Survey, Bulletin 590, 111 pages.
(Coos Bay area discussed.)

Weaver, Charles E.
1937. Tertiary Stratigraphy of Western Washington and Northwestern Oregon. University of Washington Publications on Geology, vol. 4, Seattle, Washington, 266 pages, sketch maps, bibliog.
(Detailed report on area including maps, diagrams, and sections.)

1944. Correlation of the Marine Cenozoic Formations of Western North America. Bulletin of the Geological Society of America, vol. 55, no. 5, pp. 569-598.
(Coos Bay area described on page 589.)

1945a. Geology of Washington and Oregon and Its Relation to Occurrence of Oil and Gas. Bulletin of the American Association of Petroleum Geologists, vol. 29, no. 10, pp. 1377-1415.

Weaver, Charles E.
1945b. Stratigraphy and Paleontology of the Tertiary Formations at Coos Bay, Oregon. University of Washington Publications in Geology, vol. 6, no. 2, pp. 31-62.
(Detailed discussion of Tertiary strata exposed along ocean front in Coos Bay area.)

Williams, Howel
1953. The Ancient Volcanoes of Oregon. Oregon State System of Higher Education, Eugene, Oregon, 68 pages.
(Describes the origin of the area.)

SECTION 5

GEOPHYSICS

GEOPHYSICS

SEISMOLOGY

The coastal region of Oregon is relatively free of earthquakes; however, it lies immediately north of a region which has violent quakes. According to Byerly (1952) earthquakes are possible in this region and earthquake resistant construction should be considered in public buildings.

Seismic Activity

From 1769 to 1953 there were 12 recorded land shocks and 8 off-shore shocks in the Coos Bay region. The location of all Oregon earthquake shocks, both off-shore and on land, are shown in Byerly (1952). Most of these were of a minor nature. However the shock of October 12, 1877, was felt from Portland to Coos Bay (Marshfield) and in the Cascade Mountains. It was of sufficient violence to overthrow chimneys.

The following is a tabulation of some of the dates of quakes felt at Coos Bay taken from Holden (1898), McAdie (1907), Townley and Allen (1939), and Bulletin of the Seismological Society of America (n. d.).

Land Shocks	Offshore Shocks
22 Nov 1873	26 Nov 1856 (?)
12 Oct 1877	11 Nov 1906
18 Apr 1906	31 Jan 1922
28 Oct 1909	28 May 1938
31 Jan 1922	24 Aug 1949
22 Jan 1923	16 Dec 1950
	13 Oct 1951

Seismograph Stations

There are only two active seismographic stations in Oregon. The teleseismic station at Oregon State College, Corvallis, Oregon, is within a 100-mile radius of Coos Bay. The State Office Building in Portland, Oregon has a Strong-Motion Seismograph. This is 160 miles from the harbor.

VOLCANOLOGY

The geologic history of the Oregon Coastal region shows the effect of volcanic activity; presumably this had its beginning during the Tertiary. During the early and middle Eocene, submarine volcanism occurred on the then submerged coastal area. The late Eocene saw the waning of volcanic activity which was renewed farther inland during the early and middle Oligocene. The ancestral Cascade volcanoes and those in the coastal region near Eugene were extremely active into the late Miocene. In Pliocene times the shield volcanoes of the Cascade Mountains were developed. During the Pleistocene the composite cones of Mounts Shasta, Pitt, Mazama, South Sister, Jefferson, Hood, St. Helens, Adams, and Rainier formed on the Cascades.

The most noted event in Oregon's volcanic history is probably the eruption of Mount Mazama which occurred about 6,500 years ago. The last minor eruptions, from Wizard Island, Crater Lake, took place approximately 1,000 years ago.

Rigg and Richardson (1938) investigated some bog deposits in Clear Lake and failed to find any volcanic ash. This lake is in the sand dune region south of the mouth of the Siuslaw River. This indicates that the bog is younger than the last volcanic eruption or that the prevailing wind prevented any ash from being air-borne to the west.

BIBLIOGRAPHY

GEOPHYSICS

VOLCANOLOGY

Diller, J. S.
1899. Latest Volcanic Eruptions of the Pacific Coast. Science, new series, vol. 9, pp. 639-640.
(Discussion of evidence of a recent eruption of Mount St. Helens and other Pacific Coast volcanoes.)

Hague, Arnold and Joseph P. Iddings
1883. Notes on the Volcanoes of Northern California, Oregon, and Washington Territory. American Journal of Science, 3d series, vol. 26, no. 152, pp. 222-235.
(Relationship of volcanoes including those adjacent to the coastal area.)

Hanson, Henry P.
1947. Postglacial Forest Succession, Climate, and Chronology in the Pacific Northwest. Transactions of the American Philosophical Society, vol. 37, Part 1, pp. 1-130.
(Occurrence of volcanic ash layers in peat bogs may possibly be used for chronology. Data presented includes Coos Bay area.)

Holden, Edward S.
1898. A Catalogue of Recorded Earthquakes on the Pacific Coast, 1769 to 1897. Smithsonian Miscellaneous Collections, no. 1087, 253 pages.
(Includes reports of volcanic eruptions and seismic sea waves.)

Plummer, Frederick G.
1896. Reported Volcanic Eruptions. Publications of the Astronomical Society of the Pacific, vol. 8, no. 50, pp. 176-178.
(Alaska, Washington, Oregon, and California from the year 1690 to 1895. Definitely stated that many eruptions would be contradicted if examination had been possible.)

Rigg, George B. and Carl T. Richardson
1938. Profiles of Some Spagum Bogs of the Pacific Coast of North American. Ecology, vol. 19, no. 3, pp. 408-434.
(No volcanic ash layers identified in Coos Bay area while ash is found near Grays Harbor.)

Williams, Howel

1933. Mount Thielsen A Dissected Cascade Volcano. University of California Publications Bulletin of the Department of Geological Sciences, vol. 23, no. 6, pp. 195-214. (Includes Mt. Bailey.)

1942. The Geology of Crater Lake National Park, Oregon, With a Reconnaissance of the Cascade Range Southward to Mount Shasta. Carnegie Institution of Washington, Publication no. 540, 162 pages.

1953. The Ancient Volcanoes of Oregon. Oregon State System of Higher Education, Eugene, Oregon, 68 pages. (Describes the origin of the area.)

SEISMOLOGY

Bascom, Willard

1946. Effect of Seismic Sea Wave on California Coast. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum HE-116-204, 23 pages (typewritten). (Includes data and photos. Covers mostly central and southern California but arrival time shown for points from Neah Bay on South.)

Bradford, Donald C.

1932. Microseisms, Their Characteristics, Occurrences, and Possible Origin. Thesis, University of Washington, Seattle, Washington, 107 pages. (Contains tables of the rates of transmission of earthquake waves through some of the formations in the Coos Bay area.)

Bulletin of the Seismological Society of America

n. d. Seismological Notes. (Monthly issues from 1930 to 1954 examined for earthquake records.)

Byerly, Perry

1940. Seismicity of the Northern Pacific Coast of the United States. Bulletin of the Geological Society of America, vol. 51, no. 2, pp. 255-260. (A map is presented showing the epicenters of strong earthquakes on the west coast of the United States.)

1952. Pacific Coast Earthquakes. Oregon State System of Higher Education, 38 pages. (Emphasizes earthquakes in Oregon.)

Clark, Jane Townley
1944. Index to Descriptive Catalogue of Earthquakes of the Pacific Coast of the United States, 1769-1928. Bulletin of the Seismological Society of America, vol. 34, no. 1, pp. 35-62. (Index to the Catalog by Townley and Allen.)

Gutenberg, B.
1952. Microseisms With Periods of 5-8 Seconds in the Pacific Coastal Area, November 25 to December 6, 1951. Bulletin of the Geological Society of America, vol. 63, no. 12, part 2, p. 1353. (Abstract.) (Original records of microseisms are studied.)

Heck, N. H.
1947. Earthquake History of the United States: Part I. Continental United States (exclusive of California and western Nevada) and Alaska. U.S. Department of Commerce Coast and Geodetic Survey, Serial No. 609, Revised (1947) Edition, Washington, D.C., 83 pages. (Pages 63 to 69 list earthquakes in Washington and Oregon with descriptions of each.)

Holden, Edward S.
1887. List of Recorded Earthquakes in California, Lower California, Oregon, and Washington Territory. California State Printing Office, Sacramento.

1898. A Catalogue of Recorded Earthquakes on the Pacific Coast, 1769 to 1897. Smithsonian Miscellaneous Collections, no. 1087, 253 pages.

McAdie, Alexander G.
1907. Catalogue of Earthquakes on the Pacific Coast, 1897 to 1906. Smithsonian Miscellaneous Collections, no. 1721, part of vol. XLIX, 64 pages.

Miller, Alfred L.
1953. Earthquake Lessons From the Pacific Northwest. The Trend in Engineering at the University of Washington, vol. 5, no. 1, pp. 13-17, 32, Engineering Experiment Station, University of Washington.
(A discussion of the 1949 earthquake from an engineering viewpoint. U. S. Coast and Geodetic Survey isoseismal map reproduced.)

Newman, Frank
1953. Earthquake Investigation in the United States. U. S. Department of Commerce Coast and Geodetic Survey, Special Publication no. 282, Revised (1953) Edition, 40 pages.
(Lists all active teleseismic stations in U. S., describes U. S. C. and G. S. program.)

O'Brien, M. P.
1946. Preliminary Report on Seismic Sea Waves from Aleutian Earthquake of April 1, 1946. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Technical Report No. HE-116-207, 10 pages (mimeographed).
(Discussion of effects on Pacific Coast, listing arrival time for harbors along the coast).

Roop, R. C.
1946a. A Study Relating Data from the Seismic Sea Wave of April 1, 1946, to the Theory of its Propagation. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-212, 9 pages (typewritten).
(Coos Bay and other locations along Pacific Coast listed for time of arrival and other analysis of earthquake data).

1946b. A Study Relating Data from the Seismic Sea Wave of April 1, 1946 to the Theory of its Propagation. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-215, 71 pages, maps, graphs (typewritten).
(Data and wave front diagrams present for the Pacific Coast).

Smith, Warren Du Pre
1919. Earthquakes in Oregon. The Bulletin of the Seismological Society of American, vol, 9, no. 3, pp. 58-71.
(Includes fault map and lists known earthquakes. Reassures existence of the occurrence of earthquakes in Oregon).

Townley, Sidney D.
1919. Earthquakes on the Pacific Coast of North America. Bulletin of the Seismological Society of America, vol. 9, no. 3, pp. 72-85.
(Concerned primarily with examples from California. The absence of mention of earthquakes in Oregon and Washington is to be noted).

Townley, Sidney D. and Maxwell W. Allen
1939. Descriptive Catalogue of Earthquakes of the Pacific Coast of the United States 1769 to 1928. Bulletin of the Seismological Society of America, vol. 29, no. 1, pp. 1-279.
(Catalogue showing the time, location, duration, and description of each recorded earthquake. Oregon covered on pages 253 to 258.

U. S. Department of Commerce Coast and Geodetic Survey
1954. Strong-Motion Stations--Instrumental Data. Seismological Field Survey, 7 pages (mimeographed). (Unpublished).
(Lists location and operational data of all stations operated).

Wood, Harry O.
1942. A Chronologic Conspectus of Seismologic Stations. Bulletin of the Seismological Society of America, vol. 32, no. 2, pp. 97-159.
(Data for all seismological stations presented in tabular form with location maps.)

GEOMAGNETISM

Deel, Samuel A.
1946. Magnetic Declination in the United States, 1945. U. S. Coast and Geodetic Survey, Serial 664, Washington, D. C., 67 pages. (Intended for use in making compass surveys. Contains the distribution of the magnetic declination in the United States and its annual rate of change for the beginning of 1945. Report areas included.)

1948. United States Magnetic Tables and Magnetic Charts for 1945. U. S. Coast and Geodetic Survey, Serial 667, Washington, D. C., 137 pages.
(Contains observed values and 1945 values of declination, dip, and horizontal intensity for all repeat stations and similar data for other observations from 1937 to 1947; secular-change tables and magnetic charts. Report areas included.)

Howe, H. Herbert, and David G. Knapp
1938. United States Magnetic Tables and Magnetic Charts for 1935. U. S. Coast and Geodetic Survey, Serial 602, Washington D. C., 163 pages.
(Contains observed values and 1935 values of the magnetic declination, dip, and horizontal intensity for all stations occupied about 1937; secular-change tables and magnetic charts. Data for report areas.)

GEODESY

Bowie, William
1917. Investigations of Gravity and Isostasy. U. S. Department of Commerce, Coast and Geodetic Survey, Special Publication 40, 196 pages, Government Printing Office, Washington, D. C. (Contains gravity measurements made near the areas of survey, California, Oregon, and Washington.)

1924. Isostatic Investigations and Data for Gravity Stations in the United States Established since 1915. U. S. Coast and Geodetic

Survey, Serial No. 246, Special Publication No. 99, Government Printing Office, Washington, D. C., 91 pages.
(Survey areas are included.)

1926. Isostatic Condition of the United States as indicated by Groups of Gravity Stations. U. S. Coast and Geodetic Survey, Serial No. 366, Government Printing Office, Washington, D. C., 11 pages.
(Discusses the data presented in Special Publication 99 in the light of a regrouping of the gravity stations. Report areas are included.)

Duerksen, J. A.
1949. Pendulum Gravity Data in the United States. U. S. Coast and Geodetic Survey, Special Publication No. 244, Government Printing Office, Washington, D. C., 218 pages.
(Two tables of pendulum gravity data are given. One contains the adopted pendulum gravity data together with the gravity anomalies. The other contains the observed gravity data whenever more than one pendulum gravity determination has been made. Survey areas are included.)

Hayford, John F. and William Bowie
1912. The Effect of Topography and Isostatic Compensation Upon the Intensity of Gravity. U. S. Department of Commerce, Coast and Geodetic Survey, Special Publication 10, 132 pages, Government Printing Office, Washington, D. C.
(Contains gravity measurements made near the areas of survey, northern California, Oregon, and Washington.)

U. S. Department of Commerce Coast and Geodetic Survey
n.d.a. Index to Hydrographic Surveys, West Coast, United States. Washington, D. C.
(Loose leaf pages showing location and boundaries of surveys. Surveys from 1850 to 1937 for Coos Bay area shown.)

n.d.a. Index to Topographic Surveys, West Coast, United States. Washington D. C.
(Loose leaf pages showing location and boundaries of surveys. Surveys from 1850 to 1937 for Coos Bay area shown.)

1947. Triangulation Diagram, Showing Triangulation Stations, Adjusted on North American 1927 Datum, March 1947, Chart 5984, Coos Bay.

1954a. Index Map, Control Leveling, State of Oregon.

U. S. Department of Commerce Coast and Geodetic Survey
1954b. Triangulation Diagram, State of Oregon.

U. S. Navy Hydrographic Office
1951. Radio Navigational Aids. H. O. Pub. No. 205, Government Printing Office, Washington, 422 pages.
(Direction finder stations, radio beacons, time signal navigational warnings, distress signals, medical advice and quarantine, long range navigational aids, and radio regulations for territorial waters.)

U. S. Treasury Department Coast Guard
1952. Complete List of Lights and Other Marine Aids, Pacific Coast of the United States. Volumes I-V, CG-162, Government Printing Office, Washington, 288 pages.
(This listing is intended to furnish more complete information concerning aids to navigation than can be conveniently shown on charts.)

Wagner, Henry R.
1937. The Cartography of the Northwest Coast of America to the Year 1800. University of California Press, Berkeley, Vol. I, pp. 1-270, Vol.II, pp. 271-543.
(A comprehensive presentation of the early charts and history of early mapping and exploration. Place names still in use and obsolete place names.)

SECTION 6

RECENT SEDIMENTATION

RECENT SEDIMENTATION

BEACHES

Beach Characteristics

The barrier beach, north of Coos Bay entrance is in excess of a quarter of a mile wide at many locations. The landward side consists of numerous sand dunes, some of which attain heights of 300 feet. Generally two large storm ridges separate the beach area from the sand dunes. The embayed regions behind the barrier beach, North Slough, and Haynes Inlet, are being supplied with sands from the drifting dunes. The destruction of the vegetation which formerly stabilized some of the dunes has caused a renewal of their activity. This sand movement constantly changes the topography of the barrier. The sand is steadily moving inland, covering older stabilized areas and encroaching on the railroad tracks on the west side of North Slough (Smith 1933).

Additional information on physiographic features of the sand dunes may be obtained in Mann and Ferguson (1912), Pardee (1934), Cooper (1934), and McLaughlin and Brown (1942). Mr. William S. Cooper of Boulder, Colorado, is now preparing a manuscript on the dunes of the Oregon coast. The Coos Bay region is discussed in detail. This will probably be published in the Bulletin of the Geological Society of America.

The Fluid Mechanics Laboratory, University of California, Berkeley, California, set up 3 ranges on the north spit in 1946. The area studied was about 3 miles north of the north jetty (see Enclosure 6-1). The beach profiles indicate a sand bar, the center of which is about 850 feet offshore from the MLLW line. The bar is 10 feet high with about 10 feet of water above it. An aerial photo indicates that there may be another offshore bar present in some seasons. The average slope of the entire beach profile is about 1/75; that for the beach face is 1/20 (Bascom and McAdam 1947). These profiles are shown in Enclosure 6-2. The relationship between sand size and beach face slope is discussed by Bascom (1951). It is shown that the beach face slope is controlled by two factors: (1) size of sand particles, and (2) intensity of wave action.

General beach conditions in Oregon are discussed by Isaacs (1947). This report, as well as that by Bascom and McAdam (1947), lists all of the aerial photos taken by the Fluid Mechanics Laboratory, Berkeley, California.

Dr. M. P. O'Brien, Department of Engineering, University of California, has information on file concerning the beach region of Coos Bay. This information is not entirely in available reports.

Beach Sands

Twenhofel (1946) discusses the factors which control the deposition of sediments on the Oregon beaches and also the composition of the beach and dune sands in the Coos Bay region. The headlands supply a great amount of sediments, the indentations contribute very little. The coarser sediments are supplied by the harder rocks while the silts, clays, and sands come from the weaker rocks of the Tertiary and Pleistocene. The silts and clays are rapidly removed from the beaches by winds carrying them inland or water movements transporting them out to sea. Sixteen samples taken at high, low, and mid tide levels along the beach from the Coast Guard Trail to a point 11 miles to the north, consist mostly of quartz and feldspar. These two minerals constitute from 56% to 88% of the sand; most of the remaining material consists of rock fragments. The sands are generally well sorted; 47% to 99% of the grains ranged between 1/2mm to 1/8mm in diameter. In only two instances did this size range account for less than 85% of the sample. See Tables 6-1, 6-2, and 6-3. The sample locations are given on Enclosure 6-1.

When the beach sands are dry, primarily during May to September, the wind is an important factor in transportation. During the summer season the winds of the coastal region prevail from the northwest at an average velocity of about 15 miles per hour (McLaughlin and Brown 1942). The movement of the sand by the wind will thus be predominantly in a southeastern direction. This selective transport will remove the finer and lower specific gravity particles, leaving the larger, heavier ones on the beaches. The sand dunes are thus essentially composed of quartz, feldspar, and calcite (Twenhofel 1946).

Brown and Newcomb (n. d.) of the U. S. Geological Survey, Portland, Oregon, are preparing a report on ground water on the north spit. The results of this report come from the data of 19 test holes which vary from 20 to 30 feet deep. The sands are well sorted and are about 0.4 mm in diameter. This corresponds with the channel sands of Coos Bay, Empire, and Jarvis Lower Ranges. The mechanical analysis of the samples is being done by the U. S. Geological Survey, Hydrological Laboratories, Denver, Colorado. Under the sand is a clay deposit.

SHORELINE CHANGES

Prior to the construction of the jetties at the entrance to Coos Bay an expansive area of "breakers" existed immediately west of Guano Rock. A natural channel, 10 feet deep and 200 feet wide existed across the entrance bar. It is reasonable to assume that the location of this channel varied somewhat through the years. A marked change occurred with the construction of the north jetty. By comparing the surveys from

1892 to the present it appears that the north spit has been built southward and westward (see Enclosure 6-3). The beaches immediately south of the entrance channel have also been extended to the west after the construction of the south jetty. Between 1892 and 1905 the high water line moved to the west about 2,700 feet. The southern tip of the spit advanced about 1,500 feet to the south, filling in behind the jetty. The low water line moved approximately 2,000 feet southward. Between 1905 and 1935 the spit had a westward growth of some 1,300 feet, the low water line showed a seaward advance of about 250 feet.

Before the south jetty was constructed the low water line south of the entrance, from Coos Head to Tunnel Point, extended from headland to headland with little or no beach at the headlands. In 1925, after the construction of the south jetty, the low water line had advanced seaward by some 200 feet. By 1934 the low water line had moved 1,500 feet west of the foot of the former shore cliffs. The high water line advanced seaward by some 500 feet. In 1950 the high water line lay approximately 1,000 feet west of the foot of the shore cliffs.

The radical change in the size and configuration of the spit and the south shore line recorded by the surveys of the U. S. Army Corps of Engineers may be attributed to the effect of the jetties on the carrying capacity of the littoral currents. Between the years 1892 and 1905 the spit had its most radical change. The rate of seaward advance of the spit was about 250 feet per year. After this initial period of deposition, the rate of advance slowed to an average of 43 feet per year between 1905 and 1935. After the initial deposition of sands by the littoral currents, the winds probably accounted for the westward and southward growth of the spit above the high water line.

BOTTOM SEDIMENTS

Bay Sediments

No direct studies have been found in this survey concerning the supply of river sediments to Coos Bay. However, some deductions are possible. The drowning of the river mouths would prevent most of the sediments derived from the headwaters of the Coos and Millicoma rivers from reaching the sea. Most of the sediment load would be deposited in Coos Bay itself. Twenhofel (1946) believes that all the coarse sediments of the large streams are, and have been, deposited in the bays of these streams. In the opinion of the U. S. Army Corps of Engineers (1932) sediments between Smith Mill and Coos Bay are primarily derived from the rivers by gravity settlement and flocculation in salt water.

The Coos River flows almost entirely over Tertiary sedimentary rocks and the present channel of the stream consists of almost all quartz and feldspar. This, according to Twenhofel (1946), makes it unlikely for significant contributions to have been made by the Coos River to the black minerals of the coastal sands. Since the Millicoma River flows over the same type of rock (Pardee 1934), the same can be said of it.

The bay, after its initial formation by recent submergence, and the development of the large north spit, has been filling by the accretion of wind blown sands (Smith 1933), the transportation of shore and spit sands by tidal currents (U. S. Army Corps of Engineers 1932), and by river sedimentation. Prior to harbor improvement there were numerous sediment shoals crossing the existing channel (U. S. Army Corps of Engineers 1946). For a bottom profile of the channel showing the shoals and the dredging improvements, see Enclosure 6-4.

The following tabulation of the 1949 to 1954 dredging records have been supplied by the U. S. Army Corps of Engineers (n.d.b.). These figures concerning the number of cubic yards dredged from the inner channel do not necessarily represent annual depositions of sediments, since only the channel is considered and identical regions were not dredged each year. It does however, give some idea of the volume of sediments deposited over a period of years, since dredging is a continual operation.

Year	Coos Bay Range	Empire Range	L. Jarvis Range	U. Jarvis Range	Above
1949	15,600	26,412	18,616	9,804	--
1950	4,300	--	--	--	--
1951	--	--	--	--	5,513,718
1952	171,182	255,273	85.090	169,005	--
1953	495,100	741,200	497,619	247,704	929,789
1954	225,604	338,686	225,798	112,897	708,644
Total	1,260,805	1,795,310	853,110	539,410	7,169,151

Flood deposits usually occurring during spring rains bring in large amounts of sediment. Summer depths are about 23 feet in the upper bay above the railroad bridge (U. S. Army Corps of Engineers 1946).

In conjunction with a current survey in 1932 the Portland District of the U. S. Army Corps of Engineers analyzed 109 sediment samples from the jetties to the city of Coos Bay. These samples ranged from muds, sand, sand and shell, to rock and sand. Table 6-4 presents the details of these analyses. The relationship of the velocity of bottom currents and distribution of particle size was also considered (see Enclosure 8-2). From November 1952 to August 1954 the Army Engineers analyzed 10 sediment samples. These were taken in the channel and at the entrance bar;

TABLE 6-1. Mechanical Analysis of Beach Sands from Coos Bay.

Sample No.[1]	1/2-1 mm.	1/4-1/2 mm.	1/8-1/4 mm.	1/16-1/8 mm.
1	0.80%	77.35%	21.50%	0.35%
2	5.50	84.50	10.00	--
3	0.85	84.70	14.40	--
4	--	12.20	87.00	0.80
5	4.55	85.95	9.10	0.40
6	6.15	84.30	9.20	0.35
7	--	23.00	76.90	0.10
8	--	14.90	82.25	2.85
9	--	47.00	53.00	--
10	3.00	71.30	25.45	0.25
11	--	59.10	40.90	--
12	53.00	44.50	2.50	--
13	24.15	74.05	1.80	--
14	14.10	84.70	1.20	--
15	6.00	89.50	4.50	--
16	11.50	86.75	1.75	--

[1] Locations: (1) End of Coos Bay Coast Guard Trail to beach on Coos Bay Spit, high-tide level. (2) Same as No. 1, mid-tide level. (3) Same as No. 1, low-tide level. (4) Two miles north of Coos Bay Coast Guard Trail, high tide level. (5) Same as No. 4, mid-tide level. (6) Same as No. 4, low-tide level. (7) Two to three miles north of Coos Coast Guard Trail, high-tide level. (8) Same as No. 7, low-tide level. (9 - 16) three through ten miles north of Coast Guard Trail, one sample taken every mile at the high-tide level.

Table modified from Twenhofel (1946).

TABLE 6-2. General Analysis of Beach Sands from Coos Bay.

Sample No.[1]	Quartz-Feldspar	Green Minerals	Garnet	Zircon	Magnetite	Ilmenite-Chromite	Rock
1	88.30	trace	trace	rare	0.05	0.30	11.35
2	67.25	-	-	-	-	-	32.75
3	73.20	-	-	-	-	-	26.80
4	87.85	1.80	0.80	-	0.30	0.30	9.25
5	68.60	trace	trace	-	-	-	31.40
6	78.85	trace	trace	-	-	-	21.15
8	56.10	-	-	rare	-	-	43.90
9	64.40	-	-	none	-	-	35.60
10	64.20	1.05	-	rare	0.15	0.15	34.60
11	88.20	-	-	-	-	-	11.80
12	69.05	-	-	-	-	-	30.95
13	76.40	-	-	-	-	-	23.60
14	65.80	trace	-	-	trace	trace	34.20
15	77.05	-	-	-	-	-	22.95
16	65.95	-	-	-	-	-	34.05

[1] Locations: (1) End of Coos Bay Coast Guard Trail to beach on Coos Bay Spit, high-tide level. (2) Same as No. 1, mid-tide level. (3) Same as No. 1, low-tide level. (4) Two miles north of Coos Bay Coast Guard Trail, high tide level. (5) Same as No. 4, mid-tide level. (6) Same as No. 4, low-tide level. (7) Two to three miles north of Coos Coast Guard Trail, high-tide level. (8) Same as No. 7, low-tide level. (9 - 16) Three through ten miles north of Coast Guard Trail, one sample taken every mile at the high-tide level.

Data obtained from Twenhofel (Twenhofel 1946).

TABLE 6-3. Descriptive Analysis of Sand at Location No. 4.[1]

1/4 to 1/2mm - 12.2%

Angular to round clear quartz	7.80%
Rounded yellow quartz	2.10
Rounded rock	2.30

1/8 to 1/4mm - 87.0%

Angular to subangular clear quartz	67.60%
Subangular to round yellow quartz	10.10
Rounded rock	6.95
Round green mineral	1.55
Round pink garnet	0.08

1/16 to 1/8mm - 0.80%

Angular quartz	0.25%
Round Olivine	0.25
Round black mineral	0.30

Totals

Clear quartz and feldspar	75.65%
Yellow quartz	12.20
Rock	9.25
Green mineral	1.80
Garnet	0.80
Black mineral	0.30

1 Sample from 2 miles north of Coos Bay Coast Guard Trail, high-tide level.

Table modified from Twenhofel (1946).

TABLE 6-4. Analysis of Sediment Samples.

Cross Section No.	Boat No.	Sample No.	Weight (per cu. ft.)	Settling rate (ft. per min.)	% on No. 4 sieve	% thru No. 4 and on No. 10	% retained above No. 10	% thru No. 10 and on No. 20	% retained above No. 20	% thru No. 20 and on No. 30	% retained above No. 30	% thru No. 30 and on No. 50	% retained above No. 50	% thru No. 50 and on No. 100	% retained above No. 100	% thru No. 100	Composition of Sample	Average size[1] of material (in mm)
1	2	1	63.7	0.23	2	6	8	8	16	3	9	8	27	17	44	57	Mud	0.0030[2]
1	1	2	50.6	0.39	0	0	0	5	5	4	9	4	13	10	23	77	Mud	.0050[2]
4	1	3	51.3	0.35	0	0	0	0	0	½	½	½	1	5	6	94	Mud	.0019[2]
4	2	4	50.6	0.49	0	0	0	0	0	0	0	3	3	31	34	62	Mud	.0056[2]
7	2	5	55.0	0.60	1	3	4	4	8	4	12	5	17	42	59	40	Mud	.0064
7	1	6	47.5	0.42	0	0	0	0	0	4	4	19	23	16	39	62	Mud	.0038[2]
11	1	7	65.0	0.29	0	0	0	2	2	0	2	3	5	17	22	80	Mud	.0044[2]
11	2	8	46.7	0.28	0	0	0	0	0	0	0	4	4	30	34	65	Mud	.0052[2]
15	1	9	56.2	0.33	25	6	31	7	38	3	41	6	47	28	75	25	Shell and Sand	.0100
15	2	10	83.1	0.93	0	0	0	1	1	1	2	10	12	80	92	8	Shell and Sand	.0068
19	1	11	86.2	1.54	0	0	0	1	1	1	2	8	10	82	92	9	Shell and Sand	.0068
19	2	12	91.9	4.41	0	1	1	2	3	1	4	40	44	53	97	2	Shell and Sand	.0110
23	1	13	55.9	7.93	46	10	56	5	61	1	62	8	70	28	98	2	Shell and Sand	.1300
23	2	14	90.0	9.32	1	3	4	6	10	2	12	49	61	39	100	1	Shell and Sand	.0132
23	3	15	90.0	4.65	0	0	0	1	1	0	1	7	8	88	96	3	Shell and Sand	.0092
26	1	16	94.4	7.50	0	1	1	0	1	2	3	39	42	58	100	½	Shell and Sand	.0108
26	2	17	88.1	8.18	8	15	23	11	34	3	37	20	57	44	101	1	Shell and Sand	.0134
28	4	18	80.6	8.44	9	20	29	15	44	4	48	5	53	43	96	3	Shell and Sand	.0132
28	3	19	93.1	9.63	3	6	9	3	12	1	13	47	60	38	98	1	Shell and Sand	.0128
28	2	20	90.0	6.28	0	0	0	0	0	1	1	30	31	67	98	1	Shell and Sand	.0102

TABLE 6-4. Analysis of Sediment Samples (continued).

Cross Section No.	Boat No.	Sample No.	Weight (per cu. ft.)	Settling rate (ft. per min.)	% on No. 4 seive	% thru No. 4 and on No. 10	% retained above No. 10	% thru No. 10 and No. 20	% retained above No. 20	% thru No. 20 and on No. 30	% retained above No. 30	% thru No. 30 and on No. 50	% retained above No. 50	% thru No. 50 and on No. 100	% retained above No. 100	% thru No. 100	Composition of Sample	Average size[1] of material (in mm)
28	1	21	82.5	4.91	0	1	1	1	2	1	3	8	11	80	91	10	Sand	.0084
29	1	22	91.3	5.30	0	0	0	0	0	4	4	17	21	75	96	3	Sand	.0087
29	2	23	93.7	6.00	0	1	1	0	1	1	2	26	28	72	100	0	Shell and Sand	.0088
29	3	24	83.8	10.00	12	20	32	15	47	4	51	3	54	43	97	2	Shell and Sand	.0260
29	4	25	93.1	6.92	15	14	29	10	39	2	41	2	43	54	97	2	Shell and Sand	.0098
31	1	26	60.6	5.51	0	1	1	0	1	0	1	7	8	90	98	3	Shell and Sand	.0077
31	2	27	93.1	6.75	0	0	0	0	0	0	0	11	11	88	99	1	Shell and Sand	.0082
31	3	28	96.3	7.72	0	1	1	1	2	0	2	35	37	62	99	1	Shell and Sand	.0102
31	4	29	96.3	6.00	0	0	0	0	0	0	0	10	10	90	100	0	Shell and Sand	.0080
33	1	30	93.7	6.92	0	0	0	0	0	0	0	48	48	50	98	1	Shell and Sand	.0112
33	2	31	96.3	7.72	0	1	1	0	1	0	1	26	27	73	100	0	Shell and Sand	.0095
33	3	32	96.9	7.35	0	1	1	1	2	1	3	33	36	65	101	0	Shell and Sand	.0102
33	4	33	95.6	8.70	0	1	1	0	1	0	1	15	16	84	100	0	Shell and Sand	.0090
35	1	34	98.1	9.00	0	1	1	0	1	1	2	70	72	28	100	0	Shell and Sand	.0138
35	2	35	98.1	7.11	0	1	1	0	1	1	2	24	26	74	100	0	Shell and Sand	.0094
35	3	36	96.9	7.50	0	0	0	0	0	1	1	44	45	56	101	0	Sand	.0112
35	4	37	96.3	7.11	0	0	0	0	0	0	0	36	36	63	99	1	Sand	.0109
37	1	38	96.3	8.44	0	1	1	0	1	2	3	46	49	50	99	0	Shell and Sand	.0117
37	2	39	98.1	9.32	1	1	2	1	3	1	4	57	61	38	99	½	Shell and Sand	.0130
37	3	40	93.7	7.93	0	0	0	0	0	1	1	44	45	55	100	0	Sand	.0111

TABLE 6-4. Analysis of Sediment Samples (continued).

Cross Section No.	Boat No.	Sample No.	Weight (per cu. ft.)	Settling rate (ft. per min.)	% on No. 4 sieve	% thru No. 4 and on No. 10	% retained above No. 10	% thru No. 10 and on No. 20	% retained above No. 20	% thru No. 20 and on No. 30	% retained above No. 30	% thru No. 30 and on No. 50	% retained above No. 50	% thru No. 50 and on No. 100	% retained above No. 100	% thru No. 100	Composition of Sample	Average size[1] of material (in mm)
37	4	41	93.7	7.35	1	0	1	0	1	$\frac{1}{2}$	$1\frac{1}{2}$	22	$23\frac{1}{2}$	76	$99\frac{1}{2}$	$\frac{1}{2}$	Sand	.0100
39	4	42	96.3	9.00	2	1	3	0	3	1	4	48	52	48	100	0	Shell and Sand	.0118
39	3	43	93.7	7.93	0	1	1	0	1	$\frac{1}{2}$	$1\frac{1}{2}$	44	$45\frac{1}{2}$	56	$101\frac{1}{2}$	0	Shell and Sand	.0110
39	2	44	93.1	10.00	0	0	0	0	0	1	1	59	60	39	99	0	Shell and Sand	.0127
39	1	45	95.3	10.39	1	1	2	1	3	1	4	55	59	40	99	0	Shell and Sand	.0126
41	4	46	91.9	7.93	0	0	0	0	0	1	1	30	31	70	101	0	Sand	.0091
41	3	47	94.4	9.32	0	1	1	0	1	4	5	49	54	47	101	0	Shell and Sand	.0120
41	2	48	95.6	9.00	0	1	1	0	1	1	2	48	50	51	101	0	Shell and Sand	.0113
41	1	49	95.6	9.32	0	1	1	1	2	1	3	44	47	53	100	0	Shell and Sand	.0112
43	3	50	93.1	9.32	0	0	0	0	0	1	1	61	62	38	100	0	Sand	.0129
43	4	51	91.9	8.70	0	0	0	0	0	0	0	40	40	59	99	0	Sand	.0110
43	2	52	90.0	8.70	0	0	0	0	0	1	1	40	41	59	100	0	Sand	.0111
43	1	53	94.4	8.18	0	0	0	$\frac{1}{2}$	$\frac{1}{2}$	0	$\frac{1}{2}$	43	$43\frac{1}{2}$	56	$99\frac{1}{2}$	$\frac{1}{2}$	Sand	.0112
45	4	54	96.9	8.70	0	0	0	0	0	1	1	57	58	42	100	0	Sand	.0128
45	3	55	94.4	8.44	0	0	0	0	0	1	1	60	61	39	100	0	Sand	.0129
45	2	56	93.1	8.44	0	0	0	0	0	1	1	52	53	47	100	0	Sand	.0119
45	1	57	95.6	7.93	0	0	0	0	0	0	0	26	26	74	100	0	Sand	.0102
47	4	58	96.3	8.70	0	0	0	0	0	1	1	34	35	66	101	0	Sand	.0100
47	3	59	96.3	9.63	0	0	0	0	0	3	3	75	78	23	101	0	Sand	.0152
47	2	60	93.7	9.00	0	0	0	0	0	1	1	47	48	52	100	0	Sand	.0116

TABLE 6-4. Analysis of Sediment Samples (continued).

Cross Section No.	Boat No.	Sample No.	Weight (per cu. ft.)	Settling rate (ft. per min.)	% on No. 4 Sieve	% thru No. 4 and on No. 10	% retained above No. 10	% thru No. 10 and on No. 20	% retained above No. 20	% thru No. 20 and on No. 30	% retained above No. 30	% thru No. 30 and on No. 50	% retained above No. 50	% thru No. 50 and on No. 100	% retained above No. 100	% thru No. 100	Composition of Sample	Average size[1] of material (in mm)
47	1	61	95.6	8.70	0	0	0	1	1	½	1½	52	53½	46	99½	½	Sand	.0120
49	4	62	93.7	9.32	4	1	5	0	5	3	8	66	74	26	100	0	Rock and Sand	.0150
49	3	63	95.6	9.63	0	1	1	0	1	2	3	69	72	28	100	0	Shell and Sand	.0136
49	1	64	91.9	11.25	26	4	30	8	38	4	42	40	82	20	102	0	Shell and Sand	.0194
49	2	65	91.3	12.86	29	5	34	8	42	4	46	36	82	16	98	0	Shell and Sand	.0210
51	4	66	94.4	10.00	0	0	0	0	0	1	1	53	54	45	99	0	Sand	.0121
51	3	67	94.4	10.79	0	0	0	0	0	8	8	80	88	11	99	0	Sand	.0182
51	2	68	94.4		16	3	19	6	25	6	31	53	84	15	99	0	Shell and Sand	.0168
51	1	69	89.4		41	6	47	6	53	5	58	43	92	9	101	0	Shell and Sand	.0500
52	4	70	96.3	10.00	0	0	0	1	1	4	5	67	72	28	100	0	Sand	.0148
52	3	71	95.6	10.39	0	0	0	1	1	3	4	80	84	16	100	0	Sand	.0165
52	2	72	98.7		50	4	54	2	56	5	61	31	92	8	100	0	Shell and Sand	.187
52	1	73	93.7	13.58	55	7	62	5	67	3	70	20	90	9	99	0	Rock, Shell and Sand	
54	4	74	96.3	9.00	0	0	0	1	1	1	2	42	44	56	100	0	Sand	.0108
54	3	75	96.3	9.32	0	0	0	1	1	1	2	64	66	35	101	0	Sand	.0138
54	2	76	94.4	15.00	1	9	10	9	19	12	31	66	97	2	99	0	Shell and Sand	.0200
54	1	77	95.6	12.26	60	3	63	3	66	3	69	18	87	13	100	0	Shell and Sand	.
56	4	78	91.3	8.44	0	0	0	1	1	1	2	13	15	86	101	0	Sand	.0082
56	3	79	95.6	9.32	0	0	0	0	0	1	1	54	55	45	100	0	Sand	.0120
56	2	80	93.7	15.00	0	4	4	7	11	13	24	75	99	1	100	0	Shell and Sand	.0199

TABLE 6-4. Analysis of Sediment Samples (continued).

Cross Section No.	Boat No.	Sample No.	Weight (per cu. ft.)	Settling rate (ft. per min.)	% on No. 4 sieve	% thru No. 4 and on No. 10	% retained above No. 10	% thru No. 10 and on No. 20	% retained above No. 20	% thru No. 20 and on No. 30	% retained above No. 30	% thru No. 30 and on No. 50	% retained above No. 50	% thru No. 50 and on No. 100	% retained above No. 100	% thru No. 100	Composition of Sample	Average size[1] of material (in mm)
56	1	81	90.0	10.79	32	5	37	5	42	4	46	29	75	24	99	2	Shell and Sand	.0200
57	4	82	94.4	7.93	0	0	0	1	1	1	2	24	26	73	99	0	Sand	.0094
57	3	83	91.3	8.44	0	0	0	0	0	1	1	34	35	65	100	0	Sand	.0104
57	2	84	91.3	14.20	0	1	1	4	5	5	10	87	97	3	100	0	Shell and Sand	.0158
57	1	85	96.3	11.25	24	2	26	3	29	3	32	48	80	20	100	0	Shell and Sand	.0178
59	4	89	95.6	9.00	0	0	0	1	1	1	2	30	32	68	100	0	Sand	.0099
59	3	90	93.1	7.93	0	0	0	0	0	1	1	20	21	79	100	0	Sand	.0087
59	2	91	96.9	9.00	0	0	0	0	0	1	1	51	52	48	100	0	Sand	.0117
59	1	92	80.6		82	1	83	1	84	1	85	8	93	7	100	0	Shell and Rock	
61	3	86	96.3	9.32	0	0	0	1	1	2	3	44	47	52	99	0	Sand	.0120
61	2	87	94.4	10.79	0	0	0	3	3	7	10	50	60	41	101	0	Shell and Sand	.0130
61	1	88	90.0		46	4	50	6	56	4	60	22	82	20	102	0	Shell and Sand	.0787
63	4	93	93.7	7.72	0	0	0	1	1	2	3	34	37	63	100	0	Sand	.0102
63	3	94	95.6	10.00	0	0	0	0	0	1	1	37	38	62	100	0	Sand	.0100
63	2	95	93.7	10.79	0	0	0	3	3	2	5	66	71	29	100	0	Shell and Sand	.0132
63	1	96	91.9	15.00	0	2	2	2	4	8	12	85	97	3	100	0	Shell and Sand	.0191
65	4	97	94.4	10.00	0	0	0	1	1	6	7	59	66	34	100	0	Sand	.0130
65	3	98	93.7	9.00	0	0	0	0	0	1	1	36	37	63	100	0	Sand	.0103
65	2	99	93.7	9.63	0	0	0	1	1	1	2	71	73	27	100	0	Shell and Sand	.0136
65	1	100	94.4	11.75	0	1	1	2	3	3	6	68	74	26	100	0	Shell and Sand	.0140

TABLE 6-4. Analysis of Sediment Samples (continued).

Cross Section No.	Boat No.	Sample No.	Weight (per cu. ft.)	Settling rate (ft. per min.)	% on No. 4 sieve	% thru No. 4 and on No. 10	% retained above No. 10	% thru No. 10 and on No. 20	% retained above No. 20	% thru No. 20 and on No. 30	% retained above No. 30	% thru No. 30 and on No. 50	% retained above No. 50	% thru No. 50 and on No. 100	% retained above No. 100	% thru No. 100	Composition of Sample	Average size[1] of material (in mm)
66	1	101	93.1	14.20	0	2	2	2	4	7	11	84	95	5	100	0	Shell and Sand	.0168
66	2	102	95.6	10.00	0	0	0	1	1	1	2	56	58	42	100	0	Shell and Sand	.0124
66	3	103	94.4	10.79	0	0	0	1	1	1	2	44	46	54	100	0	Shell and Sand	.0112
66	4	104	95.6	10.79	0	0	0	1	1	4	5	67	72	28	100	0	Shell and Sand	.0140
67	4	113	94.4	10.00	0	0	0	1	1	12	13	65	78	22	100	0	Sand	.0168
67	3	114	91.3	9.00	0	0	0	0	0	1	1	36	37	63	100	0	Sand	.0105
67	2	115	91.9	9.32	0	0	0	0	0	1	1	49	50	50	100	0	Sand	.0117
67	1	116	93.7	10.79	0	0	0	0	0	4	4	84	88	12	100	0	Sand	.0178
69	3	110	93.1	10.39	0	0	0	0	0	2	2	81	83	17	100	0	Sand	.0117
69	2	111	93.7	10.39	0	0	0	0	0	2	2	46	48	52	100	0	Sand	.0150
69	1	112	85.0	22.50	0	30	36	17	53	24	77	20	97	3	100	0	Rock and Sand	.0390
72	3	105	95.6	11.25	0	1	1	2	3	25	28	54	82	18	100	0	Sand	.0198
72	2	106	95.6	9.63	0	0	0	1	1	3	4	60	64	36	100	0	Sand	.0140
72	1	107	96.3	10.79	0	0	0	0	0	4	4	58	62	38	100	0	Sand	.0131
76	2	108	91.9	10.39	0	0	0	0	0	1	1	70	71	29	100	0	Sand	.0142
76	3	109	93.7	12.86	0	0	0	0	0	9	9	80	89	11	100	0	Sand	.0189

1 Average size is the size screen on which 50% of the material will be retained.
2 Sieve analysis extrapolated.

Data have been obtained from the Corps of Engineers (U. S. Army Corps of Engineers 1932e).

all are classified as sands. The graduation curve, specific gravity, and wet and dry weights, for these sediments are shown in Enclosure 6-5. All sample locations are on Enclosure 6-1.

Borings of the sediments at the bay entrance to Pigeon Point undertaken by the U. S. Army Corps of Engineers in 1916, 1919, 1926, and 1927, indicate that the sediment thickness in this region ranges from about 10 to 40 feet. These sediments are sands which rest on a soft sandstone bedrock. By considering the geologic investigation of Allen and Baldwin (1944), it is logical to conclude that the underlying bedrock is the Pliocene Empire formation. The bedrock of the jettied portion of the entrance may be the Oligocene Tunnel Point sandstone. The location and depth of the borings at which rock was encountered is shown in Enclosures 6-6 through 6-11.

Off Shore Sediments

No direct studies of the ocean sediments in the vicinity of Coos Bay have been found in this survey, but according to Pardee (1934), the surface of the bottom is covered with sand, pebbles, or shells, for distance from 3 to 15 miles offshore. Rock bottom has been reported. Apparently the outer limit of sand deposition is at about a depth of 300 feet; beyond this depth muds prevail. See also U. S. Coast and Geodetic Survey Chart No. 5984.

ALONGSHORE TRANSPORT

The movement of sand along the coast is dependent upon the waves and currents which bring in and remove the available sediments according to the competency of the water movement.

The waves approach the Oregon Coast from the southwest from late September to May and from the northwest during the remainder of the year (see Climatology, Section 2). The winter season (December through March) is the time of greatest wave action, thus the strongest shore currents are active and will move the fine and coarse sediments northward along the beach. In the summer season the finer sediments will be moved southward by the water.

The spit at Coos Bay has been built southward from the north shore of the Bay. In this instance, as well as others, such as at Winchester and Alsea Bays, the wind appears to have been the principal factor in the development of the spit (Twenhofel 1946). The north spit is also a broad dune area which supports this contention.

The transportation of sands along the shore causes a continuing problem at the entrance to Coos Bay. Prior to 1879 the channel depth across the bar was about 10 feet. Under natural circumstances the entrance depth may fluctuate according to the changing ratio of deposition to erosion. The U. S. Army Corps of Engineers (1946) report a shoaling on the bar and in the entrance channel during winter storms which limits the average allowable winter drafts to about 21½ feet.

Dredging of the bar is a continuous operation. In order to keep the channel open to depths of approximately 30 feet a total of 4,245,104 cubic yards of sediment have been removed from the bar between 1949-1954. The following is a yearly tabulation of the number of cubic yards removed from the bar since 1949 (U. S. Army Corps of Engineers n.d.b).

1949	287,860	1952	1,695,569
1950	821,012	1953	271,056
1951	694,067	1954	475,540

The transportation of sediments along the coast by the littoral currents set up by wave action has changed the configuration of the spit and adjacent shorelines. Enclosure 6-3 illustrates the recorded changes since 1892. The variations in the 24 and 30 foot depth curves from 1885 to 1924 are shown in Enclosures 6-12 and 6-13. These changes are the result of sediment transport, jetty construction, and in some part, dredging operations.

BIBLIOGRAPHY

Allen, John Eliot and Ewart M. Baldwin
1944. Geology and Coal Resources of the Coos Bay Quadrangle, Oregon. Oregon State Department of Geology and Mineral Industries, Bulletin no. 27, 157 pages, 31 plates, 3 maps in pocket. (Describes in detail the stratigraphy, paleontology and structure in the Coos Bay area. Latter part of bulletin is concerned primarily with the coal deposits of Eocene age present.)

Bascom, Willard N.
1951. The Relationship Between Sand Size and Beach-Face Slope. Transactions of the American Geophysical Union, vol. 32, no. 6, pp. 866-874.
(A series of diagrams is presented which illustrates the variability of sand size and beach-face slope and the relationship between the two as observed on 20 Pacific Coast beaches.)

Bascom, Willard and Donald McAdam
1947. Beach and Surf Conditions on the Beaches of the Oregon and Washington Coasts Between October 9, 1946 and November 18, 1946. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-247, 54 pages, photos, profiles (typewritten). (Includes profiles, surf conditions, tire impressions, sand samples, and water table profiles. Data for Humboldt Bay, Coos Bay, and Grays Harbor areas. Large number of photos obtained in survey which were not included in the report.)

Brown, Stuart G. and R. C. Newcomb
n. d. Ground Water on North End of North Spit at Coos Bay, Oregon. Manuscript on file in U. S. Geological Survey, Ground Water Branch, Portland, Oregon. (Unpublished.)
(Contains extent of dunes, rainfall, runoff and storage, evaporation and storage, ground water, and physical description of the sands.)

Byrd, Nathan L.
1950. Vegetation Zones of Coastal Dunes Near Waldport Oregon. Thesis, Oregon State College, Corvallis, Oregon, 44 pages. (Study of dune vegetation in an area north of Coos Bay. Environmental factors studied.)

Cooper, William S.
n. d. Coos Bay Sand Dunes. Boulder, Colorado, 8 pages (typewritten). (Unpublished.)
(Part of a paper on West Coast Sand Dunes to be published by the Geological Society of America. Presents a complete history and geology of the dune area. Includes discussion of the lakes entirely within its limits.

1934. Types of Pacific Coast Dunes. Annals of the Association of American Geographers, vol. 24, no. 1, p. 46. (Abstract.)
(Describes sand dunes and types of dunes. Coos Bay dunes used as an Oregon type.

1954. Sand-Dune Development and Sea-Level Changes on the Coast of Northern Oregon. Bulletin of the Geological Society of America, vol. 65, no. 12, part 2, p. 1373. (Abstract.)

Isaacs, John D.
1947. Beach and Surf Conditions on Beaches of the Oregon and Washington Coast between August 27 and September 27, 1945. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-229, 125 pages, tables, photos, maps, diagrams (typewritten).
(Covers beaches off Grays Harbor and Coos Bay. Photos of beach and surf conditions and tire impressions. Beach profiles, sieve analysis of sand samples shown in tables and diagrams.)

Mann, C. W. and James E. Ferguson
1912. Soil Survey of the Marshfield Area, Oregon. U. S. Department of Agriculture, Field Operations of the Bureau of Soils, 1909, (printed 1912), pp. 1601-1634.
(Includes sections on climate, flora, physiography, and geology in the Coos Bay area. Soils map included.)

McLaughlin, Willard T. and Robert L. Brown
1942. Controlling Coastal Sand Dunes in the Pacific Northwest. U. S. Department of Agriculture, Circular No. 660, 46 pages.
(Coos Bay and Grays Harbor areas affected. Causes, extent and methods of control discussed.)

Pardee, J. T.
1934. Beach Placers of the Oregon Coast. U. S. Geological Survey, Circular 8, 41 pages (mimeographed).
(Description of the beaches, terraces, and history of the Oregon coast in the vicinity of Coos Bay and south to the Rogue River. Describes the gold and platinum deposits of the black sands. NS. and EW. sections of South Slough at Coos Bay shown among shore profiles.)

Smith, Warren D.
1933. Special Physiographic Features of Oregon Coast. Pan-American Geologist, vol. 59, no. 4, pp. 241-258.
(Coos Bay area described in detail.)

Twenhofel, W. H.
1943. Origin of the Black Sands of the Coast of Southwest Oregon. State of Oregon Department of Geology and Mineral Industries, Bulletin no. 24, 25 pages.
(Black sand deposits are found on present beaches and in deposits beneath elevated coastal plains. Prevailing southwesterly winds concentrate the sand just south of promontories or at the north side of embayments. Fluctuations in sea levels caused change in position of embayments and promontories with resultant changes in deposition of black sands.)

1946. Mineralogical and Physical Composition of the Sands of the Oregon Coast from Coos Bay to the Mouth of the Columbia River. Oregon State Department of Geology and Mineral Industries, Bulletin no. 30, 64 pages (processed).
(Shore physiography, character and composition of the beaches, and mineral analysis.)

University of California
1946. Notes on Reconnaissance of Miscellaneous Pacific Beaches May 21-September 29, 1945. Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-223, 51 pages, maps, photos (typewritten).
(Captions accompanying the photos constitute the report. Photos show surf conditions, beaches, and sand dunes in the various areas studied.)

U. S. Army Corps of Engineers
n. d.a Analysis of Bottom Sand from Bar and Channel Areas for Coos Bay. Gradation curves obtained from North Pacific Division Testing Laboratory, Portland District, Portland, Oregon. (Unpublished.)
(Ten curves for survey obtained between 1952 and 1954.)

n. d.b Cubic Yards of Dredged Material Removed from Coos Bay. Data on file in Portland District, Portland, Oregon. (Unpublished.)
(1949 through 1954 summarized for this survey.)

1932. Report on Coos Bay Tidal Current Survey, Appendix A to Survey Report Submitted to Congress September 12, 1932. Portland District, Portland, Oregon, 27 pages (processed).
(Survey completed in 1931.)

U. S. Army Corps of Engineers
1946. Coos Bay, Oregon. Senate Document no. 253, 79th Congress, 2d Session, 33 pages, 1 map.

U. S. Army Corps of Engineers, Portland District, Portland, Oregon
[Coos Bay, Oregon--Maps (Unpublished)]
1916a. Borings near Entrance. Map File No. CB-1-62.

1916b. Borings near Entrance. Map File No. CB-1-63.

1919. Borings at Pigeon Point Reef, Sept.-Oct. Map File No. CB-1-83.

1921. Borings at Guano Rock Reef, Surveyed August. Map File No. CB-1-92.

1926. Entrance Surveys of March and October with Cross Sections Showing Amount of Material Excavated, and a Profile Along Channel Range. Map File No. CB-1-138.

1927. Pigeon Point Reef Borings, Compiled from Surveys of 1916-19-26-27. Map File No. CB-1-147.

1928. Progress Profile, South Jetty and North Jetty. Map File No. CB-1-163.

1930. Entrance, Cross Sections Between Jetties. Map File No. CB-1-182.

1931. Profile Along Channel Line, March-October. Map File No. CB-1-209/1.

1932a. Tidal and Silt Scour Relations. Map File No. CB-1-209/2.

1932b. Comparative Channel Cross Sections. Map File No. CB-1-209/3.

1932c. Paths of Maximum Bottom Velocities in Estuary Channel. Map File No. CB-1-209/4.

1932d. Discharge Measurements, Velocity Data, Prism-Volumes, Area/Prism-Velocity-Material Size Relations. Map File No. CB-1-209/5.

1932e. Bottom Material Analysis and Rate of Settlement. Map File No. CB-1-209/12.

SECTION 7

HYDROGRAPHY

HYDROGRAPHY

BATHYMETRY

Coos Bay is an extremely shallow waterway, being mostly less than 20 feet in depth. In order to accomodate ocean shipping, the channel must be kept open by dredging. The original surveys of 1899 and 1907 indicate that the channel region showed depths of 10 feet or less below MLLW at Pigeon Point and between North Bend and the city of Coos Bay. Depths of about 14 feet below MLLW existed at the entrance and Pony Slough Shoal near the Jarvis Upper Range. The maximum channel depth was approximately 50 feet below MLLW near the Charlestown Coast Guard Station. The channel dredging record up to 1932 is illustrated on Enclosure 6-4.

Original Condition of Bay

The original condition of Coos Bay is briefly described by the U. S. Army Corps of Engineers (1946):

> Prior to improvement at Coos Bay, a channel existed across the bar 10 feet deep and 200 feet wide, which followed the north spit in a tortuous course into the inner bay. From the entrance to North Bend, a controlling depth of about 11 feet with a minimum width of 200 feet prevailed. Above North Bend the channel narrowed gradually to the town of Coos Bay (Marshfield), where it was only about 50 feet wide and 6 feet deep. Numerous shoals over its entire length restricted use of the bay to small coastal vessels.
>
> The original project, authorized by the River and Harbor Act approved March 3, 1879, provided for the construction of a half-tide jetty from a point inside the entrance about 750 feet below Fossil Point (mile 2.2), on the south side of the bay, on a line toward the east end of Coos Head, the structure to be of wood and stone or stone, as should be found best. The object of the jetty was to prevent accretion to the south end of the sand spit on the north side of the entrance and to open and maintain a deeper and more direct channel across the bar.

Channel Characteristics

The characteristics of the channel have been markedly changed from the original condition due to the continuing dredging program. Flood deposits, normal river deposits, wind blown sands, and alongshore transportation are continuously affecting the channel. The U. S. Army Corps of Engineers (1946) describe the channel in the following manner:

> Shoaling on the bar and in the entrance channel during winter storms limits the average allowable winter drafts to about $21\frac{1}{2}$ feet as set by the surveyor for the San Francisco Board of Marine Underwriters. Flood deposits in the upper bay above the railroad bridge, during spring rains, limit summer drafts to about 23 feet.
>
> Guano Rock is a rocky reef about 4,000 feet inside the outer entrance. The highest point of Guano Rock is 1,300 feet south of the north jetty, and the surface of the reef descends toward that jetty. The controlling depth to rock where the channel crosses the reef is 24 feet. Access to the inner bay is somewhat difficult because of a sharp turn of 92° and radius of only 2,000 feet, in the channel at approximately mile 1.5, just inside the rock reef above-mentioned.

The controlling depths of Coos Bay and the Coos and Millicoma Rivers are also discussed by the U. S. Army Corps of Engineers (1954):

> Controlling depths are 26 feet on the bar and 23 feet from the entrance to Coos Bay (Survey of April 1954). Project depth of 30 feet in this area will be restored by maintenance dredging in Fiscal Year 1955. Controlling depth in Isthmus Slough to Millington is 20 feet.
>
> [The controlling depths are] about 4 feet from the mouth of the Coos River and 2 to 3 feet in the South Fork and Millicoma to the head of Navigation.

Depth and Profiles

The U. S. Army Corps of Engineers have periodically surveyed the bay in conjunction with their numerous projects of improvement and maintenance. Soundings for the entire bay and specific portions thereof are available from 1892 to 1950. In conjunction with a current study by the Army Engineers in 1932, profile and cross sectional studies were made. These compare the original bottom configuration of 1899 and 1907 with the surveyed conditions of 1931. Borings carried on by the Corps of Engineers show that rock underlies the veneer of channel sediments at the Pigeon Point Reef area and at the entrance to the bay. The results of these borings have been discussed in Section 6, Recent Sedimentation. All included charts, profiles and cross sections, etc., pertinent to the bathymetry of the bay are listed in Table 7-1. Additional charts concerned with specific projects and area soundings can be obtained from the U. S. Army Corps of Engineers at Portland, Oregon.

SHIPWRECKS

Records of shipwrecks are available from 1870. These are now on file as Records of Assistance maintained by the U. S. Coast Guard Life Boat Service and Record of Shipwrecks formerly maintained by the U. S. Coast Guard Light House Service.

TABLE 7-1. Listing of Enclosures on Bathymetric Information.

Enclosure No.	U. S. Army Corps of Engineers No.	Date	Subject
7-1	CB-1-26	1899	Entrance soundings.
7-2	CB-1-35	1905	Entrance soundings.
7-3	CB-1-85	1920	Entrance soundings.
7-4	CB-1-87	1920	Entrance soundings.
7-5	CB-1-109	1924	Entrance soundings.
7-6	CB-1-119	1924	Entrance soundings.
7-7	CB-1-126	1925	Entrance soundings.
7-8	CB-1-157	1928	Pony Slough Shoal soundings.
7-9	CB-1-369	1947	Entrance, Charleston and South Slough soundings.
7-10	CB-1-384/2	1949	North Bend Channel soundings.
7-11	CB-1-388	1950	Charleston and South Slough soundings.
7-12	CB-1-391	1950	Charleston and South Slough soundings.
7-13	CB-1-138	1926	Entrance Survey, cross sections showing material excavated and profile along channel.
7-14	CB-1-156	1928	Profile Pony Slough Shoal.
7-15	CB-1-182	1930	Cross Section between Jetties from 1925 to 1930.
7-16	CB-1-209/1	1931	Centerline of cross sections and channel profile.
7-17	CB-1-209/3	1932	Comparative channel cross-sections.
8-2	CB-1-209/4	1932	Location of cross-sections on Enclosure 7-17.
6-4	CB-1-209/2	1932	Channel profile and dredging record (on tidal and silt scour relations).
6-6	CB-1-62	1916	Borings near entrance.
6-7	CB-1-63	1916	Borings near entrance.
6-8	CB-1-83	1919	Boring at Pigeon Point Reef.
6-9	CB-1-92	1921	Borings at Guano Rock Reef.
6-10	CB-1-139	1926	Borings at Pigeon Point Reef.
6-11	CB-1-147	1927	Borings at Pigeon Point Reef (1916-1927).
6-12	CB-1-116	1925	24 foot curve at entrance (1855-1924).
6-13	CB-1-117	1925	30 foot curve at entrance (1855-1924).

BIBLIOGRAPHY

Anonymous
1923. Wrecks in North Pacific, Bering Sea, and Arctic Since 1853. The Marine Digest, vol. 1, no. 33 and no. 34. (Survey areas included.)

Jones, E. Lester
1918. The Neglected Waters of the Pacific Coast, Washington, Oregon, and California. U. S. Coast and Geodetic Survey, Special Publication no. 48, Serial no. 81, 21 pages. (Gives relationships between the Pacific, Atlantic, and Southern Coasts shorelines, weather, and physiography. Summary of the major wrecks.)

LeConte, Joseph
1891. Tertiary and Post-Tertiary Changes of the Atlantic and Pacific Coasts; With a Note on the Mutual Relations of Land-Elevation and Ice Accumulation During the Quaternary Period. Bulletin of the Geological Society of America, vol. 2, pp. 323-330. (Physical geography, orogenic history, and changes in rivers briefly discussed.)

Mason, W. A.
1952. Strandings and Wrecks of Vessels on the Coasts of California, Oregon, and Washington [Map]. San Pedro Blueprint Company, San Pedro, California. (Certain wrecks and strandings are plotted with respect to general area of incidence. Not accurate as to location. Revised frequently.)

O'Brien, M. P.
n. d. [Oceanography of Coastal Harbors.] On file U. S. Army, Corps of Engineers, Beach Erosion Board, Washington, D. C. (Unpublished.) (Sections on Grays Harbor, Coos Bay, and Humboldt Bay include description, tides, tidal current, waves, wind, sand samples and profiles, sand movements and structures.)

U. S. Army Corps of Engineers
1946. Coos Bay, Oregon. Senate Document no. 253, 79th Congress, 2d Session, 33 pages, 1 map.

1949. Job History, Dredging and Rock Removal, Coos Bay, Oregon. On file Portland District, Portland, Oregon, 14 photos. (Unpublished.) (Includes air photos of Coos Bay obtained during contract No. W35-026-eng-3808 for removal of rock and overburden in Coos Bay Channel from Guano Rock to Empire.)

U. S. Army Corps of Engineers
1954. Project and Index Maps. Portland District, Portland, Oregon. (Processed.)
(For use by the Corps of Engineers. Reproduced to accompany the Annual Report of the Chief of Engineers presenting projects and their locations on reference maps.)

U. S. Army Corps of Engineers, Portland District, Portland, Oregon [Coos Bay, Oregon--Maps (Unpublished)]
1889. Map showing Tidal Areas. Map File No. CB-1-10.

1899. Entrance, Surveyed August. Map File No. CB-1-26.

1901. Sketch of Entrance Channel Showing Soundings and Direction of Tidal Current, March. Map File No. CB-1-31.

1905. Entrance, Surveyed June. Map File No. CB-1-35.

1920a. Entrance, Surveyed June. Map File No. CB-1-85.

1920b. Entrance, Surveyed August to September. Map File No. CB-1-87.

1924. Entrance, Surveyed June and July. Map File No. CB-1-109.

1925a. Entrance, 24-Foot Curve, Compiled from Surveys of 1885 to 1924. Map File No. CB-1-116.

1925b. Entrance, 30-Foot Curve, Compiled from Surveys of 1885 to 1924. Map File No. CB-1-117.

1925c. Entrance, Studies of Jetty Extensions, Soundings Taken June and November. Map File No. CB-1-119.

1925d. Soundings of 1924-25. Map File No. CB-1-126.

1926a. Pigeon Point Reef, Surveyed August to October. Map File No. CB-1-139.

1926b. Entrance Surveys of March and October with Cross Sections Showing Amount of Material Excavated, and a Profile along Channel Range. Map File No. CB-1-138.

1928a. Pony Slough Shoal, Profile, Center Line of Channel Range. Map File No. CB-1-156.

1928b. Pony Slough Shoal, March. Map File No. CB-1-157.

1932. Discharge Measurements, Velocity Data, Prism-Volumes, Area/Prism-Velocity-Material Size Relations. Map File No. CB-1-209/5.

U. S. Army Corps of Engineers, Portland District, Portland, Oregon [Coos Bay, Oregon--Maps (Unpublished)]

1938. Entrance, Lines Run by Dredge "Pacific" and Lines of Ebb Tide Floats, June. Map File No. CB-1-277.

1947. Channel at Charleston, South Slough, Survey. Map File No. CB-1-369.

1949. Entrance To Smith Mill, Location of Oyster Beds, June. Map File No. CB-1-384/2.

1950a. South Slough Channel at Charleston, February. Map File No. CB-1-388.

1950b. Channel at Charleston, South Slough, Breakwater. Map File No. CB-1-391.

U. S. Treasury Department Bureau of Customs

Annual. Merchant Vessels of the United States. Government Printing Office, Washington.
(Presents a complete listing of all vessels registered. "Vessels Lost" is of interest for ship wreck data. First volume published in 1906.)

SECTION 8

PHYSICAL OCEANOGRAPHY

PHYSICAL OCEANOGRAPHY

TIDES

The tide in Coos Bay is of the mixed type with inequalities in both the high and low waters which are somewhat larger in the low. The mean and diurnal ranges, respectively, decrease from 5.2 and 7.0 feet inside the entrance to 4.9 and 6.7 feet at Empire, and then increase to 5.6 and 7.3 feet at the town of Coos Bay. The time of tide becomes progressively later on passing inward from the entrance; at Empire and Coos Bay it is 40 minutes and 1 hour and 25 minutes later, respectively, than at the entrance. At Empire, high tide occurs on the average at the upper and lower transits of the moon.

Tide Stations

The tidal predictions for Coos Bay are based on the published times and heights of high and low waters for each day of the year at Humboldt Bay (U. S. Department of Commerce Coast and Geodetic Survey 1954). Tidal harmonic constants are published for Humboldt Bay (U. S. Department of Commerce Coast and Geodetic Survey 1942; International Hydrographic Bureau 1933) and for the city of Coos Bay (Marshfield) (U. S. Department of Commerce Coast and Geodetic Survey 1942).

Additional tidal data for the following stations:

1. Coos Bay Entrance
2. Empire
3. City of Coos Bay

consists of: the time of tide, height of high water (1955), and ratio of ranges compared to the tide at Humboldt Bay (U. S. Department of Commerce Coast and Geodetic Survey 1954); the high water interval (prior to 1955), the mean range of tide and the diurnal range of tide (U. S. Department of Commerce Coast and Geodetic Survey 1954); and the elevations referred to mean lower low water of the following planes: highest tide (estimated), mean higher high water, mean high water, half tide level, mean low water, mean lower low water, and lowest tide (estimated) (U. S. Department of Commerce Coast and Geodetic Survey 1946).

Monthly Tidal Variations

The tide at Coos Bay follows the monthly lunar cycles in response to the moon's changing phase, distance, and declination as follows:

Lunar Cycle	Measure of Tidal Effects	Ratio	Lag of Maximum Effect in Hours
Phase	Spring to neap range	1.6	35.5
Parallax	Perigean to apogean range	1.5	29.4
Declination	Tropic to mean diurnal inequality	1.4	11.8

This dependence on all three factors indicates a complicated monthly variation in tidal range. However, these variations are not large compared to the daily differences in range.

In addition, the time of tide relative to the moon's transit undergoes monthly change. A maximum deviation from the mean of about two hours can be expected.

Tidal Datum Planes

Mean lower low water, based on two years of automatic gage records, is the datum for the charts of Coos Bay (U. S. Department of Commerce Coast and Geodetic Survey 1946).

Sea level will undergo variations over periods of a day, month, year, and longer. The long-term trends of sea level can be expected to follow those for Seattle and San Francisco (Marmer 1949, 1952). The yearly variation will be somewhat similar to those at Astoria and Crescent City, but will also depend on more local seasonal changes in runoff and oceanographic conditions (Marmer 1951). Shorter period fluctuations are generally unpredictable.

Semidiurnal Wave in Coos Bay

The behavior of the tide in its passage into Coos Bay has been studied by the U S. Army Corps of Engineers (1932). They give the heights of the following planes as functions of the distance from the entrance: highest tide, mean higher high water, mean lower high water, mean tide level, mean higher low water, mean lower low water, and lowest tide.

The instantaneous profiles of the water level at times of MHHW slack and MLLW slack and the tide lag from the entrance have also been determined as functions of the distance from the entrance (see Enclosure 6-3).

Comparison of Measured and Predicted Tides

The predicted and measured heights of high and low waters have been compared for the city of Coos Bay, Empire, and Charleston (U. S. Army

Corps of Engineers 1932). In addition the predicted and measured heights throughout a diurnal cycle have been compared. A maximum deviation of about 1 foot was noted in the high and low water heights. The plotted data are available in Enclosures 6-3 and 8-1.

TIDAL CURRENTS

In Coos Bay entrance, the average and tropic tidal current velocities are 2.0 and 2.7 knots, respectively. During long runouts an ebb current of 5 knots has been found at Guano Rock, and up to 7 knots at the bell buoy, same buoy being run under at times in winter months. Flood current usually has a maximum velocity of $3\frac{1}{2}$ knots (U. S. Department of Commerce Coast and Geodetic Survey 1951).

The time of slack water at the entrance to Coos Bay varies with the height of the tide. The ebb runs from 1 to $1\frac{1}{2}$ hours after low water, and the flood from 1/2 to 3/4 hours after high water. The time of change of current at North Bend is about 45 minutes later than at the entrance (U. S. Department of Commerce Coast and Geodetic Survey 1951)

Current Predictions

Current tables list the time difference and velocity ratios for Coos Bay entrance which makes it possible to derive its maximum flood and ebb current velocities and its time of maximum ebb, flood, and slack waters from the reference station predictions (U. S. Department of Commerce Coast and Geodetic Survey 1953a).

Tidal Prisms and Discharge

Relations between discharge tidal range, upstream tidal prisms and sectional areas have been obtained by the U. S. Army Corps of Engineers Portland District (1932h). They have constructed the following graphs:

1. MLLW, MTL and HW channel widths; MLLW and MTL sectional areas; and the mean ebb tidal prism upstream as functions of the distance upstream from the end of the jetties.

2. Average area/prism ratio, area/prism ratio for ebb MHHW-MLLW, area/prism design ratio, maximum bottom velocity at mean ebb range (MHHW-MLLW), average ebb velocity, maximum bottom velocity at mean flood range (MLLW-MLHW), average flood velocity as functions of the distance upstream from the end of the jetties.

3. Mean velocity in the vertical for each boat position and total section discharge as functions of tide stage for each of three sections near the mouth of the Bay.

4. Tidal prism volume as a function of phase range for the above three sections.

5. Maximum discharge as a function of phase range for the above three sections.

6. Velocities on flood and ebb as functions of phase range for eight sections.

7. Bottom ebb velocity as a function of area/prism ratio.

The location of the boat positions and cross sections is shown on Enclosure 8-2. The relationship between the above factors may be found in Enclosures 6-3 and 8-3.

Surface Currents

Surface currents have been measured at approximate biweekly intervals at 5 stations in Coos Bay from 11 January 1930 to 20 February 1932 and at 4 stations in the lower 5 miles of the Coos River from 12 January 1930 to 25 October 1931 (Queen and Burt 1955). These measurements were taken from a dock near a time of half tide at each station. They therefore represent currents at the approximate times of maximum current but somewhat to the side of the channel out of the strongest tidal stream. The ebb currents were generally stronger than the flood. The velocities depend on the tidal range and the river runoff and varied from 0.2 to 2.7 knots for ebb and 0.2 to 1.1 knots for flood.

Additional current measurements were made at hourly intervals for one complete tidal cycle at Empire and the city of Coos Bay and for a partial tidal cycle in the Coos River.

The U. S. Army Corps of Engineers Portland District (1892, 1901, 1925a, 1925b, 1938a, 1938b) have made flood and ebb drift measurements at the entrance under various stages of jetty construction. The maximum midchannel velocities shown between the jetties are somewhat in excess of $3\frac{1}{2}$ knots. The ebb current apparently fans directly out from the entrance, while the flood has a pronounced southerly set towards the jetty mouth (see Enclosures 8-4 through 8-10).

Current observations were made across the channel at the site of the proposed Willamette Pacific Railway Bridge in 1912 by the U. S. Army Corps of Engineers. The maximum velocity on the center line of the dredged cut, observed by current meter at the flood tide was 2.25

knots with tide at 6 feet, range of tide 2.7 to 8.1 feet. The maximum velocity on the centerline of the dredged cut, observed by current meter on the ebb tide was 2.54 knots with the tide at 4 feet, range of tide 8.1 to 1.6 feet. A strong southerly wind was blowing at the time of these observations. On the following day, when drift observations were made, the wind was calm (see Enclosure 8-11).

Bottom Currents

Bottom current observations, mostly at 2 feet above the bottom, have been taken over a tidal cycle at several stations in each of 32 sections throughout Coos Bay (U. S. Army Corps of Engineers 1932). This information is presented in figures as follows:

1. Bottom current measurements and tide height as functions of time for each station.

2. The paths of maximum bottom velocities in the estuary channel.

3. Bottom current distribution across 17 sections for the four tides of a mean tidal cycle.

These figures may be found in Enclosures 8-12 through 8-15.

Vertical Distribution of Currents

Tidal current velocities over one or two days have been measured at 6 foot intervals of depth for each station in 3 sections near the Bay entrance (U. S. Army Corps of Engineers 1932). The vertical current distribution is plotted as a function of time for each station. These figures may be found in Enclosures 8-1 and 8-16.

The upper layer velocities shown from the above data are mostly larger than those at depth and may be more than three times as great on occasion. There is little difference in the phase of the currents in the same vertical plane.

Offshore Tidal Currents

Tidal current measurements have been made from five light vessels along the Pacific Coast of the United States in depths ranging from 20 to 30 fathoms (Marmer 1926). At some locations the measured currents are strongly influenced by adjacent entrances to large inland bodies of water while at others there is no such effect. In all cases the currents were rotary. At times of high water the set was generally in the northeast quadrant. The direction of maximum current followed the general trend of the local shoreline although the effect of on-shore tidal flow was evident in some cases. The maximum tropic velocities ranged from about 0.1 to 1.1 knots. It is estimated that at a depth of 20 to 30 fathoms off the Coos Bay entrance, the tropic velocity would be about 0.4 to 0.5 knot.

WAVES

Wind waves occuring in Coos Bay may be either generated by the local wind or the result of waves and swell entering from the Pacific Ocean. Since the Bay has limited fetches and is well protected from the ocean, its waves, in general, can be expected to be moderate in size.

Off the adjacent coast in winter, seas greater than 8 feet and swells greater than 12 feet occur from the westerly directions about 20 and 30 percent of the time, respectively (U. S. Navy Hydrographic Office 1944).

Local Wind Waves

Wave conditions in the Bay can be derived from wind observations in the surrounding area. The following wind information is available for this purpose:

1. Wind charts for the years 1916, 1918, 1920, 1922, 1924, and 1933. These contain the mean velocity and duration of prevailing winds at the entrance to Coos Bay (U. S. Army Corps of Engineers Portland District 1926).

2. Wind chart for the ten-year period 1915-1925 similar to the above (U. S. Army Corps of Engineers Portland District 1926).

3. Wind chart giving the mean velocity and duration of prevailing winds at Coos Bay for the year ending May 31, 1921 (U. S. Army Corps of Engineers n. d.).

4. Wind chart giving the maximum velocity and duration of prevailing winds at Coos Bay for the year ending May 31, 1921 (U. S. Army Corps of Engineers n. d.).

5. Table giving direction of wind by months at the entrance to Coos Bay from July 1915 to July 1925 (U. S. Army Corps of Engineers n. d.).

6. Table giving direction of wind by months at the entrance to Coos Bay for the year 1933 (U. S. Army Corps of Engineers n. d.).

7. A velocity-duration curve for directions north, east and southeast for North Head, Washington is shown on Enclosure 8-17.

8. Monthly wind roses and the frequency and duration of high surface winds in Puget Sound Region of Washington (Harris and Rattray 1954).

This wind information is summarized in Section 2, Climatology (see Enclosure 2-1 and Tables 2-6 and 2-7).

Offshore Waves, Swell, and Surf

Data on the distribution of waves in the open ocean off the Oregon coast are available as follows:

1. Percentages of high and low seas and swell in winter and summer (Bigelow and Edmondson 1947).

2. The relative annual frequency of waves of different heights in the North Pacific (Bigelow and Edmondson 1947).

3. Percentages of high, medium and low seas and swell from each direction for each month of the year (U. S. Navy Hydrographic Office 1944).

4. Percentages of waves in the approximate height ranges 0-3 feet, 3-8 feet, 8-20 feet and over 20 feet for each month of the year (Maritime Safety Agency 1951; U. S. Navy Hydrographic Office 1943).

Waves

Some photographs taken of surf along the Oregon coast and a few heights and periods of the associated breakers are given in the following reports: University of California (1946), Isaacs (1947), and Bascom and McAdam (1947).

Wave heights and periods from April 1947 to June 1948 have been obtained at Heceta Head about 50 miles north of Coos Bay (Chinn 1947; Serville 1947; Wiegel 1949a, 1949b).

Sea observations are recorded at the U. S. Coast Guard Light and Lifeboat Stations at approximate 4-hour intervals.

Tsunamis

Sea waves occur along the Pacific Coast of the United States from seismic activity around the periphery of the North Pacific Ocean. Data are available on the tsunami of April 1, 1946 which resulted from an earthquake on the north face of the Aleutian Trench, south of Unimak Island, at $53\frac{1}{2}^{o}$ N., between 163^{o} and 164^{o} W. (Bascom 1946; O'Brien 1946; Roop 1946a, 1946b; Bulletin of the Seismological Society of America 1946; Transactions of the American Geophysical Union 1946). The times of arrival along the United States coast were within $2\frac{1}{2}$ hours of each other and can be explained by shallow water wave theory. The heights recorded ranged from 1 to 17 feet. There was no consistent variation of height along the coast; evidently the local bathymetry of the shelf if critical in this regard. In the tsunami of April 1, 1946, the largest heights were reached in those bays which had a southerly exposure.

Data on the tsunami of November 4, 1942 compared to the one in 1946, indicates a roughly similar distribution and magnitude in heights recorded at tide stations. These heights however are generally less than the maximum observed in the surrounding area (U. S. Department of Commerce Coast and Geodetic Survey 1953).

Listings of other tsunamis are available in U. S. Department of Commerce Coast and Geodetic Survey (1953b), Heck (1947), and Holden (1898) (see also section on Seismology).

WATER CHARACTERISTICS

Coos Bay is an estuary of the positive type where precipitation and runoff exceed evaporation. The Coos River enters the head of the Bay and supplies most of the fresh water. This river has not been gaged so the exact annual runoff pattern is unknown. However, since the drainage area is small (820 sq. miles), has little snowfall, and extends only a short distance into the coastal range, it can be assumed that the runoff follows the local precipitation pattern (see Section 2, Climatology). A narrow dredged entrance, flanked by jetties, permits access to the ocean water at essentially all depths in the bay.

Only meager information exists on the water characteristics of Coos Bay. John Queen observed temperature, salinity, pH, dissolved oxygen, and occasionally hydrogen sulfide, at approximately biweekly intervals from January 1930 through March 1932 (Queen and Burt 1955) at the stations shown in Enclosure 8-18. The Coast and Geodetic Survey measured the temperature and density at a tide gage station near the entrance (47° 20.9' N., 124° 19.3' W.) in 1933 and 1934 (U. S. Department of Commerce Coast and Geodetic Survey n. d., 1952a, 1952b). See Enclosure 8-19.

The Scripps Institution of Oceanography measured salinity, temperature, and minor constituents from 50 to 75 miles offshore at various times since 1930 (University of California Scripps Institution of Oceanography 1949-51; Sverdrup 1943). The University of Washington ran a section to within 13 miles of the beach about 27 miles north of the entrance of Coos Bay in August 1939 (Thompson n. d.). See Table 8-1.

Salinity Distribution

The salinity of the ocean water directly off the entrance of Coos Bay has not been measured but can be estimated from Scripps Institution of Oceanography and University of Washington data to range from 32°/oo to 34°/oo. Reported values below 33°/oo reflect coastal dilution. Salinities appreciably exceeding 34°/oo are open to question. The annual salinity pattern for offshore water in this general area in 1949 showed a maximum in October of about 32.7°/oo. The section run by the University of Washington in August 1939, which extended farther inshore, showed some increase in salinity towards the beach with a value of 33.5°/oo at the surface. The coastal salinity will be affected by precipitation and runoff which drops to a minimum in August and by upwelling which appears to reach a maximum at about the same period.

Inside Coos Bay, the salinity varies from the oceanic range given above to that of fresh water in the river discharge. The phase of the tide and the runoff largely determine the salinity at any particular place and time. Such changes as occur in the oceanic salinity will be only a secondary factor in affecting the salinity within the bay. The surface salinity along channel (from Queen and Burt 1955) is shown in Enclosure 8-20 for March and September. These months are near the annual salinity extremes. The increase in surface salinity with increase in tide height is readily apparent in Enclosure 8-20. During periods of low river runoff, the most abrupt changes in salinity occurred at Empire (Station lV) and at the Coos River mouth (Station VIII). During periods of high river runoff, the salinity decreased rapidly and uniformly from the entrance upstream for 12 miles. From this point on to Station XI, the water was essentially fresh. Except near the river mouth the water column was quite well mixed from the surface to the bottom. Surface salinities at high water measured periodically at three stations in the Bay (Enclosure 8-21) show annual minima from January to March and maxima in August or September.

TABLE 8-1. Oceanographic Data 27 Miles North of Coos Bay.

Stat 1 — Date 5 August 1939 — Time 1500 — Lat 43°48' — Long 124°28' — Depth 67 fm.

DEPTH (m)	TEMP (°C)	SAL (°/oo)	O_2 (mg-at/l)	PO_4 (μg-at/l)
0	10.40	33.51	0.582	0.9
10	10.40	33.53	0.579	0.7
20	9.17	33.57	0.420	1.46
30	9.00	33.64	0.387	1.76
50	8.44	33.73	0.321	2.18
75	7.67	33.89	0.243	2.24
100	7.24	33.96	0.215	2.04

Stat 2 — Date 5 August 1939 — Time 1350 — Lat 43°48' — Long 124°35' — Depth 144 fm.

DEPTH (m)	TEMP (°C)	SAL (°/oo)	O_2 (mg-at/l)	PO_4 (μg-at/l)
0	12.35	32.88	0.566	0.6
10	12.25	32.90	0.571	0.5
20	11.12	33.03	0.522	0.7
30	9.14	32.99	0.464	0.85
50	8.69	33.48	0.379	1.62
75	8.70	33.77	0.368	1.88
100	8.31	33.86	0.324	1.88
200	7.02	34.02	0.207	2.02

Stat 3 — Date 5 August 1939 — Time 1145 — Lat 43°48' — Long 124°50' — Depth 375 fm.

DEPTH (m)	TEMP (°C)	SAL (°/oo)	O_2 (mg-at/l)	PO_4 (μg-at/l)
0	11.76	32.94	0.576	0.6
10	11.05	33.22	0.555	0.7
20	10.05	33.26	0.514	0.9
30	9.81	33.58	0.488	1.34
50	9.55	33.64	0.475	1.38
75	9.00	33.69	0.407	1.40
100	8.24	33.84	0.319	1.58
200	7.03	34.02	0.205	1.76
300	6.47	34.05	0.150	2.24
400	6.05	34.09	0.110	2.28
500	5.55	34.13	0.076	2.40
600	4.05	34.25	0.043	2.64

Stat 4 — Date 5 August 1939 — Time — Lat 43°48' — Long 125°05' — Depth 776 fm.

DEPTH (m)	TEMP (°C)	SAL (°/oo)	O_2 (mg-at/l)	PO_4 (μg-at/l)
0	10.87	33.37	0.565	0.90
10	10.77	33.51	0.548	1.05
20	10.39	33.55	0.539	1.10
30	9.59	33.58	0.497	1.30
50	9.34	33.66	0.473	1.34
75	8.70	33.77	0.386	2.04
100	8.05	33.84	0.310	2.04
200	6.69	33.96	0.198	2.08
300	5.96	34.04	0.120	2.12
400	5.54	34.09	0.083	2.36
500	5.25	34.13	0.071	2.42
600	4.38	34.22	0.030	3.40
700	4.64	34.25	0.035	2.84
800	4.42	34.29	0.024	3.20
900	4.04	34.34	0.025	3.10
1000	3.76	34.42	0.027	3.10
1200	3.14	34.49	0.040	2.95

Table compiled from original data on file at the University of Washington (Thompson n. d.).

Temperature Distribution

The surface temperature of the ocean off the entrance of Coos Bay is estimated to range from 8° to 16° C. during the year. The annual maximum found by Scripps Institution of Oceanography for offshore water in this general area in 1949 was 15.7° C. in September and October. The surface temperature at a station 13 miles off the beach, run by the University of Washington in August 1939, was 10.4° C., about 2° C. lower than at the next station 18 miles offshore. Upwelling, which appears to reach a maximum about August, gives lower surface temperatures than would be expected from seasonal warming.

Inside Coos Bay, the temperature during 1930-1932 varied from 5° to 24° C. (Queen and Burt 1955) with the fresher water exhibiting the greatest range. The temperature is less affected by phase of tide than is the salinity. The surface temperature along channel (Enclosure 8-22) increased from the mouth to the head of the Bay during the warming months, March to August, but decreased from September to February. The difference along the channel varied from less than 2° C. in the winter to more than 15° C. in the summer. Surface temperatures at high water measured periodically at three stations in the Bay (Enclosure 8-23) show the annual minima in January and maxima in July.

Other Chemical Properties

No reliable information is available on the oxygen distribution in Coos Bay. The data obtained by Queen indicates that the minimum oxygen content to be not less than 2 ml/liter.

Hydrogen sulfide was found to exist in the landward end of Coos Bay in concentrations up to 1.2 ppm during the autumn months, indicating a partial stagnation of the salt water. Usually the concentration was less than 0.4 ppm.

Queen measured the pH of the water on a few occasions and found the range to be from 6.6 to 8.0.

BIBLIOGRAPHY

Bascom, Willard

1946. Effect of Seismic Sea Wave on California Coast. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-204, 23 pages (typewritten).
(Includes data and photos. Covers mostly central and southern California but arrival time shown for points from Neah Bay on south.)

1947. Surging in Depoe Bay, Oregon. University of California, Department of Engineering, Fluid Mechanics Laboratory, Field Report no. 2, 2 pages (processed), map, photos, diagrams.
(An examination of an unusual surging condition. Bay located about 100 miles north of Coos Bay and 90 miles south of the Columbia River.)

Bascom, Willard and Donald McAdam

1947. Beach and Surf Conditions on the Beaches of the Oregon and Washington Coasts Between October 9, 1946 and November 18, 1946. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-247, 54 pages, photos, profiles (typewritten).
(Includes profiles, surf conditions, tire impressions, sand samples, and water table profiles. Data for Humboldt Bay, Coos Bay, and Grays Harbor areas. Large number of photos obtained in survey which were not included in the report.)

Bigelow, Henry B. and W. T. Edmondson

1947. Wind Waves at Sea, Breakers and Surf. U. S. Navy Hydrographic Office, H. O. Pub. No. 602, 177 pages.
(Not specifically applicable to each harbor area--a general reference.)

Bulletin of the Seismological Society of America

1946. Seismological Notes, North Pacific Ocean, off Alaska Peninsula, April 1, 1946. Vol. 36, no. 2, p. 125.
(Describes "tidal" wave which hit the coasts of California and Oregon.)

Chinn, Allen J.

1947. Records of Waves on the Pacific Coast of California and Oregon. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Appendix to Technical Report No. HE-116-263, 27 pages, tables, diagrams (mimeographed).
(Summary of refraction coefficients and refraction diagrams.)

Harris, Russell G. and Maurice Rattray, Jr.
1954. The Surface Winds over Puget Sound and the Strait of Juan de Fuca and Their Oceanographic Effects. University of Washington, Department of Oceanography, Technical Report no. 37, 101 pages (mimeographed), including 41 figures.
(All available wind report summaries accumulated in form of monthly wind roses for each reporting station. Determination made of frequency and maximum duration of surface winds. Oceanographic effects discussed and approximate calculations are made of maximum wave heights. Stress on water surface and resultant currents discussed).

Heck, N. H.
1947. List of Seismic Sea Waves. Bulletin of the Seismological Society of America, vol. 37, no. 4, pp. 269-286.
(Includes records of waves that have struck the Pacific Coast).

Holden, Edward S.
1898. A Catalogue of Recorded Earthquakes on the Pacific Coast, 1769 to 1897. Smithsonian Miscellaneous Collections, no. 1087, 253 pages.
(Includes reports of volcanic eruptions and seismic sea waves).

Holway, Ruliff S.
1905. Cold Water Belt Along the West Coast of the United States. University of California Publications Bulletin of the Department of Geological Sciences, vol. 4, no. 13, pp. 263-286.
(Temperature observations of the Tuscarora and Albatross. Includes general temperature conditions, maximum, minimum, and range; hypothesis accounting for cold water belt and summary).

International Hydrographic Bureau
1933. Tides--List of Harmonic Constants. Special Publication no. 26, Monaco.

Isaacs, John D.
1947. Beach and Surf Conditions on Beaches of the Oregon and Washington Coast Between August 27 and September 27, 1945. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-229, 125 pages, tables, photos, maps, diagrams (typewritten).
(Covers beaches off Grays Harbor and Coos Bay. Photos of beach and surf conditions and tire impressions. Beach profiles, sieve analyses of sand samples shown in tables and diagrams).

Isaacs, John D. and Saadia Schoor
1947. Records of Waves on the Pacific Coast of California and Oregon. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Technical Report No. HE-116-263, 5 pages (mimeographed).
(Coastal characteristics determined from instruments located at Point Sur, California and Heceta Head, Oregon. Primarily a request for records, no data presented.)

Isaacs, John D. and Thorndike Saville, Jr.
1948. A comparison Between Recorded and Forcast Waves on the Pacific Coast. University of California, Department of Engineering, Fluid Mechanics Laboratory, Technical Report No. HE-116-285, 8 pages (processed), weather chart, graph.
(Wave recorders operated at Heceta Head and Pt. Sur.)

Isaacs, J. D. and W. N. Bascom
1949. Water-Table Elevations in Some Pacific Coast Beaches. Transactions of the American Geophysical Union, vol. 30, no. 2, pp. 293-294.
(Pacific Coast beaches surveyed for water-table profiles: Grenville, Ocean City, Leadbetter, Oysterville, Clatsop Spit, Sand Lake, Seabright, Seacliff State Park, Del Monte Creek, and Carmel.)

Johnson, J. W.
1949. Wave Investigations, Final Report, A List of Reports and Publications Completed on Contract Nobs 2490. University of California, Department of Engineering, Fluid Mechanics Laboratory, Technical Report No. HE-116-300, 33 pages (processed).

Johnson, J. W. and R. L. Wiegel
1953. Summary of Research on Waves, Surf, and Beaches. University of California, Institute of Engineering Research, Waves Research Laboratory, Technical Report, Series 3, Issue 350, Part 1, 29 pages (processed).
(Bibliography of Pacific Coast.)

Maritime Safety Agency
1951. Wave Chart in North Pacific Ocean, Jan. to Dec. Tokyo, Japan, No. 6035-1 thru -12.
(Monthly charts with small area symbols covering ocean area showing waves.)

Marmer, H. A.
1926. Coastal Currents Along the Pacific Coast of the United States. U. S. Department of Commerce, Coast and Geodetic Survey, Special Publication no. 121, 80 pages.
(Data obtained from Blunts Reef Light Vessel, located off Cape Mendocino, 22 miles south of Humboldt Bay).

1949. Sea Level Changes Along the Coasts of the United States in Recent Years. Transactions of the American Geophysical Union, vol. 30, no. 2, pp. 201-204.
(Values for San Francisco and Seattle given).

1951. Tidal Datum Planes. U. S. Department of Commerce, Coast and Geodetic Survey, Special Publication no. 135 [Revised 1951 Edition], 142 pages.

1952. Changes in Sea Level Determined from Tide Observations. Proceedings of Second Conference on Coastal Engineering, Houston, Texas, November 1951, Edited by J. W. Johnson, The Engineering Foundation Council on Wave Research, pp. 62-67.
(Values for San Francisco, Astoria, and Seattle given which bracket the survey areas).

O'Brien, M. P.
n. d. [Oceanography of Coastal Harbors.] On file U. S. Army, Corps of Engineers, Beach Erosion Board, Washington, D. C. (Unpublished).
(Sections on Grays Harbor, Coos Bay, and Humboldt Bay include description, tides, tidal current, waves, wind, sand samples and profiles, sand movements, and structure).

1946. Preliminary Report on Seismic Sea Waves from Aleutian Earthquake of April 1, 1946. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Technical Report No. HE-116-207, 10 pages (mimeographed).
(Discussion of effects on Pacific Coast, listing arrival time for harbors along the coast).

1951. Wave Measurements at the Columbia River Light Vessel, 1933-1936. Transactions of the American Geophysical Union, vol. 32, no. 6, pp. 875-877.
(Record is representative of conditions at sea off the North Pacific Coast).

Oregon State Highway Department
1955. Personal communication on a tidal current survey made in the North Slough area of Coos Bay in 1954. Letter from C.W. Enfield, Chief Counsel, Salem, Oregon, to Peter McLellan, dated May 31, 1955.
(Results have not been prepared in the form of a report but consist of notes, charts, and data. Material is not available at present but will be published in the future).

Queen, John and Wayne V. Burt
1955. Hydrography of Coos Bay. School of Science, Oregon State College, Corvallis, Data Report No. 1, 16 pages (processed).
(Weather, cloud cover, air temperature, salinity, water temperature, current velocity, tide stage and height, H_2S, and pH for 11 stations in and near Coos Bay).

Roop, R. C.
1946a. A Study Relating Data from the Seismic Sea Wave of April 1, 1946, to the Theory of its Propagation. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-212, 9 pages (typewritten).
(Coos Bay and other locations along Pacific Coast listed for time of arrival and other analysis of earthquake data).

1946b. A Study Relating Data from the Seismic Sea Wave of April 1, 1946 to the Theory of its Propagation. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-215, 71 pages, maps, graphs (typewritten).
(Data and wave front diagrams present for the Pacific Coast).

Saville, Thorndike, Jr.
1947. Comparison of Recorded and Forecast Waves on California and Oregon Coast from June to September. University of California, Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Technical Report No. HE-116-268, 3 pages plus 18 diagrams (mimeographed).
(Data for instrument locations at Point Sur, California and Heceta Head, Oregon shown diagramatically).

Stump, R. and R. T. Hermanson
1945. Comparison of Forecast and Observed Waves from Two Pacific Storms. University of California, College of Engineering, Berkeley, Report No. HE-116-124, 10 pages plus 12 tables, 9 weather maps and 2 photos (typewritten).
(Weather maps cover entire Pacific Coast. Two Observation stations at Humboldt Bay, the others in California only).

Sverdrup, H. W.
1943. Oceanic Observations of Scripps Institution in 1939. Records of Observations, Scripps Institution of Oceanography, vol. 1, no. 2, pp. 65-160.
(Contains physical and chemical data off the Oregon and California coasts).

Thompson, Thomas G.
n. d. Physical and Chemical Data Obtained from the M. V. CATALYST off the Coast of Washington, Oregon, and California. On file at the University of Washington, Department of Oceanography, Seattle.
(Unpublished).
(Data obtained in the period 1939 to 1941).

Tibby, Richard B.
1941. The Water Masses off the West Coast of North America. The Sears Foundation; Journal of Marine Research, vol. 4, no. 2, pp. 112-121.
(Summarizes existing data and reports results of observations from Lower California to the Columbia River. Primarily method rather than data).

Todd, D. K. and R. L. Wiegel
1951. Local Storms of the Pacific Coast and Their Effects on Wave and Beach Conditions. University of California, Institute of Engineering Research, Wave Investigation Technical Report HE-116-324, 15 pages (processed), 8 plates.
(The meterorological situations causing local storms in near-coastal areas are investigated because of the erosive action on beaches of high, short-period waves generated. Two local storms at Oceanside, California, are examined in detail).

1952. Near-Coastal Storms and Associated Waves. Transactions of the American Geophysical Union, vol. 33, no.2, pp. 217-225.
(Data from 3-year study of daily weather maps. Forecasting problems and limitations of resulting waves are discussed. Examples from Oceanside, California, presented).

Transactions of the American Geophysical Union
1946. Seismic Sea Wave of April 1, 1946. Vol. 27, no. 3, p. 453.
(Includes data for Pacific Coast where effects were recorded on tide gages).

University of California
1946. Notes on Reconnaissance of Miscellaneous Pacific Beaches May 21-September 29, 1945. Department of Engineering, Fluid Mechanics Laboratory, Berkeley, Laboratory Memorandum No. HE-116-223, 51 pages, maps, photos (typewritten).
(Captions accompanying the photos constitute the report. Photos show surf conditions, beaches, and sand dunes in the various areas studied).

University of California Scripps Institution of Oceanography
1949-51. Physical and Chemical Data. Marine Life Research Program, Division 111, Physical Oceanography, Division of Chemical Oceanography, 13 volumes.
(Each volume reports data from a separate cruise off the coast of Washington, Oregon, and California).

U. S. Army Corps of Engineers
n. d. [Wind Roses Obtained from Various Drawings for Coos Bay.] On file Portland District, Portland, Oregon. (Unpublished). (The years 1921, 1933, and the 10-year period ending 1925, were examined).

1932. Report on Coos Bay Tidal Current Survey, Appendix A to Survey Report Submitted to Congress September 12, 1932. Portland District, Portland, Oregon, 27 pages (processed). (Survey completed in 1931).

1946. Coos Bay, Oregon Senate Document no. 253, 79th Congress, 2d Session, 33 pages, 1 map.

1948. Interim Report on Model Study of Umpqua River Entrance, Oregon. Mississippi River Commission, Waterways Experiment Station, Vicksburg, Mississippi, 13 pages plus 4 tables, 25 photos and 14 plates (typewritten).
(Umpqua River less than 30 miles north of Coos Bay. Shows current velocities and strength of ebb and flood tides. Height, length, sequence, and direction of waves reproduced during model tests also included).

1950. Surging in Depoe Bay, Oregon. The Bulletin of the Beach Erosion Board, vol. 4, no. 4, pp. 32-39.
(An examination of an unusual surging condition).

1954. Project Report on Catching Inlet Drainage District, Coos Bay, Oregon. Portland District, Portland, Oregon, 25 pages plus 2 plates (mimeographed). (Not for public release).
(Includes current investigation taking place, climate, normal annual precipitation, temperatures, stream flow, floods, tides, and plate showing diagrammatically average frequence of precipitation, storm patterns, and flood routings).

U. S. Army Corps of Engineers, Portland District, Portland, Oregon [Coos Bay, Oregon--Maps (Unpublished)]
1889. Map Showing Tidal Areas. Map File No. CB-1-10.

1892. Entrance Current Observations, March. Map File No. CB-1-18.

1901. Sketch of Entrance Channel Showing Soundings and Direction of Tidal Current, March. Map File No. CB-1-31.

U. S. Army Corps of Engineers, Portland District, Portland, Oregon
[Coos Bay, Oregon--Maps (Unpublished)]

1912. Current Observations at Site of Proposed Willamette Pacific Ry. Bridge. Map File No. CB-1-44.

1925a. Entrance Current Observations, Ebb Tide, June. Map File No. CB-1-121/1.

1925b. Entrance Current Observations, Flood Tide, June. Map File No. CB-1-121/2.

1926. Wind Charts for Coos Bay, Ore. Map File No. CB-1-135. (Wind roses for 1916, 18, 20, 22, 24, and the years 1915-1925).

1932a. Paths of Maximum Bottom Velocities in Estuary Channel. Map File No. CB-1-209/4.

1932b. High and Low Waters Vertical Velocity Profiles, Sec. 72, 76. Map File No. CB-1-209/10.

1932c. Bottom Velocity Readings Section No. 57 to 72. Map File No. CB-1-209/6.

1932d. Vertical Velocity Profiles, Sections 66, 72. Map File No. CB-1-209/11.

1932e. Bottom Velocity Readings Sections No. 43 to No. 56. Map File No. CB-1-209/7.

1932f. Bottom Velocity Readings Section No. 28 to No. 41. Map File No. CB-1-209/8.

1932g. Bottom Velocity Readings Section No. 1 to No. 26. Map File No. CB-1-209/9.

1932h. Tidal and Silt Scour Relations. Map File No. CB-1-209/2.

1938a. Entrance Current Observations, Flood Tide, June. Map File No. CB-1-276/1.

1938b. Entrance Current Observations, Ebb Tide, June. Map File No. CB-1-276/2.

1938c. Entrance, Lines Run by Dredge "Pacific" and Lines of Ebb Tide Floats, Jun. Map File No. CB-1-277.

1954. Coos River, Catching Inlet Drainage District, Hydrologic Data. Map File No. CB-2-4/2.

U. S. Department of Commerce Coast and Geodetic Survey

n. d. Monthly Sea Water Temperature and Density Records for Coos Bay Entrance, for April 1933 through March 1934 (except November 1933 for which there is no record). On file, Washington, D. C. (Unpublished).

1942. Tidal Harmonic Constants--Pacific and Indian Oceans. Publication TH-2, Washington, 133 pages. (Covers the survey areas).

1946. Index Map, Tidal Bench Marks, Oregon.

1949. Surface Water Temperatures at Coast and Geodetic Survey Tide Stations, Pacific Ocean. Publication TW-2, [Revised 1948 Edition], 47 pages. (Data for Coos Bay included).

1950. Density of Sea Water at Coast and Geodetic Survey Tide Stations, Pacific Ocean. Special Publication no. 281, [Revised 1950 Edition], 37 pages. (Coos Bay listed).

1951. United States Coast Pilot, Pacific Coast, California, Oregon, and Washington, Seventh (1951) Edition, Serial no. 750, U. S. Government Printing Office, Washington, 578 pages. (Comprehensive descriptions of harbor facilities and approaches).

1952a. Density of Sea Water at Coast and Geodetic Survey Tide Stations, Pacific Ocean. Publication DW-2, [Revised 1950 Edition], 37 pages. (Coos Bay listed).

1952b. Surface Water Temperatures at Tide Stations, Pacific Coast, North and South America and Pacific Ocean Islands. Special Publication no. 280, 59 pages. (Contains data for Coos Bay).

1953a. Current Tables, Pacific Coast, North America and Asia for the Year 1954, Serial no. 769. (Current differences for Coos Bay referred to San Francisco Entrance).

1953b. The Tsunami of November 4, 1952 as Recorded at Tide Stations. Special Publication no. 300, 62 pages. (Records at Seattle, Neah Bay, Astoria, Crescent City and San Francisco).

1954. Tide Tables, West Coast, North and South America (Including the Hawaiian Islands), for the Year 1955. Serial no. 774. (Tidal differences for Coos Bay referred to Humboldt Bay).

U. S. Navy Hydrographic Office
1943. Waves in the North Pacific Ocean [charts]. H. O. Misc. No. 11, 117-1 thru-12.
(Monthly charts with small area symbols covering ocean area showing classes of waves. Based on Japanese charts).

1944. Sea and Swell Charts, Northeastern Pacific Ocean. H. O. Misc. No. 10, 712-D-1 thru-12.
(Monthly charts with small area symbols covering ocean area showing conditions).

Wiegel, R. L
1949a. An Analysis of Data From Wave Recorders on the Pacific Coast of the United States. Transactions of the American Geophysical Union, vol. 30, no. 5, pp. 700-704.
(Wave measuring instruments located at Quillayute, Heceta Head, Pt. Cabrillo, Pt. Sur, and Pt. Arguello. Data from Pt. Sur and Heceta Head have been compared for the period from 1947 to 1948).

1949b. An Analysis of Data From Wave Recorders on the Pacific Coast of the United States. University of California, Department of Engineering, Fluid Mechanics Laboratory, Technical Report HE-116-298, 5 pages (processed), plus maps, diagrams, and photos.
(The wave heights and periods from wave recorders installed off Pt. Sur, California, and Heceta Head, Oregon, have been compared for the period from April 1947 to June 1948. Wave measuring instruments are also located at Pt. Cabrillo, California, and Quillayute, Washington.

1954. Final Report, Wave Instrumentation. University of California, Institute of Engineering Research, Wave Research Laboratory, Technical Report, Series 3, Issue 372, 19 pages (Processed), 1 plate.
(Bibliography of Pacific Coast).

SECTION 9

MARINE BIOLOGY

MARINE BIOLOGY

BORING AND FOULING ORGANISMS

No specific information has been found. The Clapp Laboratories, engaged in harbor studies concerning boring and fouling organisms, were unable to supply any information for Coos Bay.

ALGAE

A paper by Sanborn and Doty (1944), primarily concerned with algae gives a good description of Coos Bay, Oregon. The following is an excerpt from that paper:

> Coos Bay is centrally located on the western coast of Oregon at a point approximately midway between Puget Sound and the San Francisco-Monterey area of California. Here we find a meeting place of many of the algae from the north and the south, with frequently the southward extension of the range of some species previously reported from Puget Sound stations and Alaska; and again the northern range of species recorded from the Californian beds.
>
> The algae included in this paper have been collected from some stations within Coos Bay and others south along the open ocean to and including Cape Arago, approximately five miles below the mouth of the bay. These regions include stations in which are found varying types of habitat, as mud flats, sandy beaches, rocky reefs, vertical and horizontal rocky areas. The sandy beaches above and below Cape Arago tend to concentrate the elements essential to algal growth, resulting in a heavy growth of algae about the cape.
>
> Within Coos Bay the stations include: (1) the rocks at Coos Head and in the vicinity of the Coast Guard Station; (2) the piles and old dock and the sandy beaches near the Oregon Institute of Marine Biology on the west side of South Slough, a southward extension of Coos Bay; (3) the wharves and docks and mud flats near Charleston, also on the west side of South Slough about three-quarters of a mile beyond the Marine Station; (4) the Old Jetty; (5) Fossil Point and the beaches and mud flats on the east side of South Slough, just across the Slough from the Marine Station; (6) the docks and wharves at (a) North Bend, (b) Marshfield, and (c) Empire on Coos Bay.

Two jetties guard the mouth of Coos Bay. These jetties would appear at first sight tobe rich collecting grounds, but one is always disappointed after reaching the end. This lack of algal growth may be due to the extremely heavy wave action to which the rock surfaces are exposed and the resulting frequent shifting of the rock masses.

Just within the entrance to the bay, collections were made at the Coast Guard Station or at the base of Coos Head. These locations are subject to moderate wave action, and consist largely of boulders lying on rocky shelves beneath a cliff about forty heet in height. A great many species representing all groups of the algae are to be found here. This station and the jetties are peculiar in the fact that Fucus, a littoral form common elsewhere on the Pacific Coast, is rarely seen.

The rocks about the base of the Old Dock in front of the Institute of Marine Biology Station, those forming the Old Jetty, and those at Fossil Point directly across South Slough from the Biology Station support a flora similar to that of the more protected areas along the ocean front. The rocky beaches near the station and the piling in the lower portions os South Slough abound in species of Ulva and fine red, green, and brown algae. In the channels farther up South Slough little is found but filimentous red algae that are attached to shells; on the mud flats Entermorpha is found. A mile or so above Charleston, species representing Monostroma, Entermorpha, and Rhizoclonium are abundant.

The authors have not given much attention in this study to the brackish or fresh water forms; a few of these are listed as a matter of record.

The change from a strictly marine type algal flora to the brackish water type flora along the main channel is interrupted and obscured by the presence of pulp and sawmills at Empire. These mills dump large quantities of commercial refuse into the bay. For several miles along the bay below Empire there is a scarcity of marine life due to the action of these wastes. It is to be expected that the continued practice of dumping waste into the bay will in time cause serious damage to the present marine algal flora above and near these mills.

A very few red algae are to be found above Empire. On the wharves of North Bend and Marshfield are found some of the finer Rhodophyceae, and with these are some small forms such as Monostroma and Entermorpha of the Clorophyceae and Ilea of the Phaeophyceae.

Fucus, on the other hand, is quite abundant in some locations in the upper bay.

From Coos Head just within the bay to the Cape Arago region the ocean front is rugged with rocky promontories, small embayments, including Sunset Bay, and long sandy beaches. Outside the bay the collecting stations are: (1) Bassendorf Beach, (2) Mussel Reef, (3) the Lighthouse (a) Beach and (b) Reef, (4) Squaw Island (an island only at high tide), a jagged rocky formation that is accessible from the mainland at low tides, (5) Sunset Bay, (6) North Bay, (7) Middle Bay, and (8) South Bay. Those collecting stations outside Coos Bay are listed as going south from the mouth of Coos Bay. Some collections have been made at intermediate points also, these collections usually being included with the collections from the station to which the location was nearest.

The long stretch of Bassendorf Beach is composed entirely of sand and is therefore of little interest to the algalogist. Mussel Reef, composed of steeply pitching beds striking out to sea, is incised by deep channels extending far shoreward. The Lighthouse Beach is also a sandy stretch. Near the southern end, solid rock ridges protrude through the sand and afford adequate footholds for heavy growths of Prionitis and Laminaria Sinclairii. This southern part, after each period of rough weather, is often covered with a mass of algae that has been washed ashore, and is consequently a good locality for obtaining sub-littoral species.

Lighthouse Reef proper is separated from the mainland by a channel partly exposed at low tide and floored with boulders resting on a rocky surface. The outer portion of this reef is precipitous and the rock surfaces are exposed to heavy wave action.

Squaw Island is an island only at high tide. At low tide it is connected with the mainland by a rocky reef scoured by the tides that remove much of the algal growth. On the outer side of the island there is a boulder field exposed to heavy surf; this area and the jutting rocks beyond abound in algae, several species of which have not been found elsewhere along this portion of the coast.

Sunset Bay behind Squaw Island is shut off from the open ocean on one side by shelving rocks in which large crevices have developed; these crevices abound in algal species found in low shaded locations. The south shore-side of the bay is a sandy beach and the northern side is a mud flat at half tide. The southwestern side of the bay is floored by protected boulder fields and steep-walled or flat-rock surfaces. Bold rocky protuberances at the entrance to the bay break the full force of the swells and these support a restricted flora of Postelsia, Alaria, and Constantinea. Between Sunset Bay and South Bay, a distance of about three miles, are numerous small embayments cut in the rocky cliffs. These embayments are quite inaccessible except at low tide, and have not been visited regularly. Hence the collections from this area are incomplete.

North Bay on the north side of Cape Arago is a vast expanse of protected boulder fields interrupted by solid rock prominences and tidal pools. The boulder field and the rock-floored bottom are interrupted by several deep water channels. This collecting area because of its size has never been thoroughly explored for algae. Such rarities (for this region) as Fauchea, Laminaria cuneifolia, and Griffithsia, however, have been noted.

Middle Bay on the south side of Cape Arago is a boulder field separated from the open ocean by uptilted rocks cut by the surf into three small embayments; this station has yielded deep-growing algae. Much of the Middle Bay area, however, is strewn with huge boulders that together with the solid rock are exposed to the full force of waves, and as a result the vertical surfaces support little but corallines.

South Bay is separated from Middle Bay by jutting rocks and is floored by a boulder field on its west side, a sandy beach at its head, and wave cut terraces in solid rock, the latter cut by numerous small channels. South Bay is approximately five miles from the mouth of Coos Bay.

Vertical rocks exposed to heavy wave action occur at Squaw Island, Lighthouse Reef, Mussel Reef, Sunset Bay, and South Bay. At most of these places relatively large areas of horizontal rock surfaces also occur; some, as at Squaw Island, are exposed only at minus tides. Boulder fields such as are found at Squaw Island, Sunset Bay, Middle Bay, and South Bay are excellent collecting grounds, while on that of the Lighthouse Reef the algal growth is not abundant.

Channels with sandy bottoms having a depth of from 1 to 5 feet and the width of 2 to 4 feet, are found at Sunset Bay, North and Middle bays. The corallines are very abundant in the channels at Middle Bay.

The distribution of the algal species at the several collecting stations of the Coos Bay region is shown in a check list. The stations are indicated by name and number since they are shown on the map by number (Sandborn and Doty 1944).

Kelp Beds

Kelp beds of the Pacific Coast of the United States have been investigated by F. K. Cameron (1914). A map, No. 23, covers the Coos Bay region. The abundance of kelp is indicated by color code on charts which are reproductions of the U. S. Coast and Geodetic Survey charts. Map 23 indicates three beds of Nereocystis kelp in the Coos Bay region.

Bed No. 8 was five miles north of Coos Bay with dimensions 3,500 x 200 yards, bed No. 9 at Cape Arago Light was 800 x 220 yards, and bed No. 10 at Cape Arago was 1,700 x 200 to 400 yards. All beds were oriented with the long axis roughly parallel to the coastline.

BENTHOS AND NEKTON

Hartman and Reish (1950) have made a study of the marine annelids in Coos Bay. Most of their stations were intertidal. The paper contains keys and a checklist of polychaetous annelids of the area with a description and references for the station locations involved.

Exploratory shrimp fishing along the Oregon Coast (Pruter and Harry 1952) between the Columbia River and the Rogue River indicated some of the richest shrimp hauls taken off Coos Bay with catches averaging 153 pounds per drag which was roughly ten times as rich as other areas. Almost all the shrimp (Pandalus jordani) were taken in water between 60 and 80 fathoms. Because of gear limitations it was not possible to fish in water deeper than 100 fathoms.

Keen and Doty (1942) started an annotated checklist of the gastropods of the Cape Arago region which was not completed for the shell bearing gastropods but rather represents a progress report up to 1941.

Striped bass studies by Morgan and Gerlack (1950) in Coos Bay lists catches and statistics on hours spent per fish caught, etc., while Gharrett and Hodges (1950) list Coos Bay in salmon fishery studies of the coastal rivers of Oregon south of the Columbia River. For fishes of Oregon and Coos Bay a distribution record and bibliography is available by Schultz and DeLacy (1935-36). Catch statistics of Coos Bay are available in a paper edited by F. G. Cleaver (1951) which includes material on silver and chinook salmon and shad.

Papers of a more general nature, but having some reference to the Coos Bay area either directly or through similarity of the area considered, include the following articles.

Descriptions of marine crustaceans belonging to the Callianassidae which includes material collected from Coos Bay (Stevens 1928). A paper by M. P. Fish (1948) contains descriptions of varieties of fish in Pacific Ocean regions indicating the type of noise and the method of production of noise by the various species. J. A. Shotwell (1950) describes the vertical zonation of Acmaea for Sunset Bay, Oregon, five miles south of Coos Bay. He suggests that the vertical distribution is governed by the particular species of algae and that both the algae and the limpets are governed by the maximum time of uninterrupted exposure to air during a year.

McGowan and Pratt (1954) in studies on the reproductive system of a nudibranch list Coos Bay as the collection area.

Incidental papers include a compilation of food and shell fish laws of the State of Oregon by the Oregon State Fish Commission, and a paper covering fish and shellfish landings in the coastal district of Oregon with no special reference to Coos Bay, by Anderson and Peterson (1954).

Unpublished papers of possible interest, mostly theses from Oregon State College, are listed in the bibliography.

BIBLIOGRAPHY

Anderson, A. W. and C. E. Peterson
1954. Fishery Statistics of the United States, 1951. U. S. Department of the Interior, Fish and Wildlife Service, Statistical Digest 30, 341 pages (processed).
(Includes statistics on fish and shellfish landings on the coastal district of Oregon as well as a summary of equipment and personnel which were employed. No special reference to Coos Bay.)

Cameron, Frank K.
1914. Kelp Groves of the Pacific Coast and Islands of the United States and Lower California. U. S. Department of Agriculture Bureau of Soils, Office of the Secretary, Report no. 100, Government Printing Office, Washington, D. C.
(Map number 23 covers the Coos Bay area. Abundance of kelp is indicated by color code on the charts which are reproductions of the regular U. S. Coast and Geodetic Survey charts. Also includes statistics on abundance and chemical analysis of kelp.)

Cleaver, F. C. (editor)
1951. Fisheries Statistics of Oregon. Oregon Fish Commission, Portland, Contribution No. 16, 176 pages.
(Catch statistics for Coos Bay.)

Curtiss, Charles E.
1949. The Oregon Shore Anemones (Anthozoa). Thesis, Oregon State College, Corvallis, Oregon, 71 pages.
(Work done at Coos Bay.)

Dunlap, Delpha D.
1951. A Survey of the Helminth Parasites of Leptocottus armatus armatus Girard. Thesis, Oregon State College, Corvallis, Oregon, 25 pp.
(Work done at Coos Bay.)

Fish, Marie Poland
1948. Sonic Fishes of the Pacific. Woods Hole Oceanographic Institution, Woods Hole, Mass., Technical Report no. 2.
(Includes varieties found in the survey area.)

Gharrett, John T. and John I. Hodges
1950. Salmon Fisheries of the Coastal Rivers of Oregon South of the Columbia. Oregon Fish Commission, Portland, Contribution No. 13, 31 pages.
(Coos River included.)

Gregoire, Earl
1951. Helminth Parasites of Eopsetta Jordani (Lockington) Thesis, Oregon State College, Corvallis, Oregon, 30 pages.
(Work done at Coos Bay.)

Hartman, Olga and Donald J. Reish
1950. The Marine Annelids of Oregon. Oregon State Monographs, Studies in Zoology, No. 6, Oregon State College, Corvallis, Oregon, 64 pages.
(Coos Bay area included.)

Keen, A. Myra and Charlotte L. Doty
1942. An Annotated Check List of the Gastropods of Cape Arago, Oregon, Oregon State Monographs, Studies in Zoology, No. 3, Oregon State College, Corvallis, Oregon, 16 pages.
(Coos Bay area.)

McCauley, James E.
1954. Some Hemiurid Trematodes of Oregon Marine Fishes. Thesis, Oregon State College, Corvallis, Oregon, 73 pages.
(Taxonomic study of Coos Bay and Newport.)

McGowan, John A. and Ivan Pratt
1954. The Reproductive System and Early Embryology of the Nudibranch Archidoris montereyensis (Cooper). Bulletin of the Museum of Comparative Zoology at Harvard College, vol. 111, no. 7, pp. 261-276.
(Animals collected from Coos Bay.)

Morgan, Alfred R. and Arthur R. Gerlach
1950. Striped Bass Studies on Coos Bay, Oregon, in 1949 and 1950. Oregon Fish Commission, Portland, Contribution No. 14, 31 pages.

Oregon State Fish Commission
n. d. Oregon Commercial Fisheries Code, 1953-1954. Office of Commission, 307 State Office Building, 1400 S. W. 5th Avenue, Portland, Oregon, 160 pages.
(A compilation of the laws of the state of Oregon relating to the protection and propagation of food and shellfish.)

Pruter, Alonzo T. and George Y. Harry, Jr.
1952. Results of Preliminary Shrimp Explorations Off the Oregon Coast. Fish Commission Research Briefs, Fish Commission of Oregon, Portland, vol. 4, no. 1, pp. 12-24.
(Data for off Coos Bay.)

Reish, Donald J.
1949. The Intertidal Polychaetons Annelids of the Coos Bay, Oregon Region. Thesis, Oregon State College, Corvallis, Oregon, 89 pages.

Sandborn, Ethel I. and Maxwell S. Doty
1944. The Marine Algae of the Coos Bay--Cape Arago Region of Oregon. Oregon State Monographs, Studies in Botany, No. 8, Oregon State College, Corvallis, Oregon, 66 pages.
(Geographic location, physical features, and distribution of the marine algae. Coos Bay contains the northern limits of southern species and the southern limits of the northern species.)

Schultz, Leonard P. and Allan C. DeLacy
1935-36. Fishes of the American Northwest. Mid-Pacific Magazine, vol. 48, no. 4, vol. 49, no. 1-4.
(A catalogue of the fishes of Washington and Oregon with distributional records and a bibliography. Coos Bay area listed.)

Shearer, Gilbert M.
1942. A Study of Marine Isopods of the Coos Bay Region. Thesis, Oregon State College, Corvallis, Oregon, 64 pages.

Shotwell, J. Arnold
1950. The Vertical Zonation of Acmaea, the Limpet. Ecology, vol. 31, no. 4, pp. 647-649.
(Work done at Sunset Bay, Oregon, a small coastal Bay just south of Coos Bay.)

Sowell, Robert R.
1949. Taxonomy and Ecology of the Nudibranchiate Mollusca of the Coos Bay, Oregon Region. Thesis, Oregon State College, Corvallis, Oregon, 54 pages.

Stevens, Belle A.
1928. Callianassidae from the West Coast of North America. Publications Puget Sound Biological Station, vol. 6, pp. 315-369.
(Includes keys and descriptive material. Collections include material from Coos Bay.)

U. S. Army Corps of Engineers
1949. Coos Bay, Oregon, Entrance to Smith Mill, Location of Oyster Beds, June. Portland District, Portland, Oregon, Map File No. CB-1-384/2. (Unpublished.)

APPENDIX A

TIDAL CURRENT SURVEY

This appendix has been reproduced from the text of the following document:

U. S. Army Corps of Engineers
1932. Report on Coos Bay Tidal Current Survey. Appendix A to Survey Report Submitted to Congress September 12, 1932. Portland District, Portland, Oregon, 27 pages (processed).

REPORT ON COOS BAY TIDAL CURRENT SURVEY

APPENDIX A

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REPORT ON COOS BAY

TIDAL CURRENT SURVEY

APPENDIX A

1. Observations. A tidal current survey was carried out during the period October, 1931 - March, 1932, to secure date on current velocity in the bay channel and on the bar.

2. Velocity readings were made two to ten feet from the bottom, at from two to four observation points on a section normal to the channel. Readings were made half hourly at each station during a complete tidal cycle of 25 hours. The cross sections were located approximately 4,000 feet apart above mile 11, and 2,000 feet apart below that point. Complete discharge measurements covering one tidal cycle each were made near the entrance at sections 66 and 72, and covering one-half cycle at section 76.

3. The height of tide was achieved during velocity and discharge measurements only, at Empire dock, Mile 32, and also at Charleston (U.S.E.D. south jetty wharf), Mile 1.4, and at Marshfield, Mile 14.2, when readings were taken near these points. See Plate IV for gage locations and Plate X for observed high and low waters.

4. Assistance. The tidal measurements and surveys were made under the direction of F. C. Behubert, Senior Engineer, by field parties under R. F. Cole, Engineer at Coos Bay. The tidal hydraulic studies contained in this appendix were made by H. G. Gornes, Assistant Engineer.

5. Tides. The tide at Coos Bay is of the Pacific Coast mixed type characterized by two high and two low waters of unequal height each day. The shape of the tide graph and the normal sequence of the waters within the cycle are shown by the group of and major tides at Empire, plotted on Plate II. The normal sequence of waters is from higher high to lower low to lower high to higher low to higher high. The lag of slack water varied from -0.2 to +1.6 hours, the average being 0.6 hours after low water and 0.9 hours after high water.

6. The mean diurnal range at Coos Bay entrance is 6.7 feet, increasing to 6.9 at Marshfield, Mile 14.2. The entrance range between highest and lowest waters is 12.5 feet. Tidal reference planes are shown on Plate II. The time of tide at Empire is 45 minutes later than at the entrance, and 1 hour 50 minutes later at Marshfield, giving rise to the curved water surface shown on the instantaneous water surface profile. This lag indicates a tidal wave of the progressive type, although the large range at Marshfield, near the head of the bay, shows that the tidal

waterway is relatively free and open. Data on the height and range of tide in Coos Bay, derived from publications and manuscript information of the U. S. Coast and Geodotic Survey, are tabulated below.

TABLE I

Data on Tidal Reference Planes - Coos Bay

Station	Charleston, U.S. Coast Guard Station	Empire	Marshfield
Miles from entrance	1.4	5.2	14.2
Elevations above mean lower low water:			
Highest tide	9.5	9.5	9.5
Mean higher high water (MHHW)	6.7	6.7	6.9
Lower high water (LHW)	5.5	5.5	5.7
Half tide level (HTL)	3.6	3.6	3.7
Mean higher low water(MHLW)	2.2	2.2	2.2
Mean lower low water (MLLW)	0.0	0.0	0.0
Lowest tide	-3.0	-3.0	-3.0
Time of tide after entrance	0.00	+0.45	+1.50
Elevation of MTL, USGS, Bull.556, p.150	-	-0.08'	-0.28'
Period of record	5/18/28 to 10/25/28	June,1922 to May, 1923	4 day record 1922
Record compared with	Newport and San Francisco	San Francisco	Empire and San Francisco

7. As the tidal prism volumes are closely proportional to the phase ranges, it is seen that the typical tide cycle contains two unequal flood volumes and two unequal ebb volumes and that the inequality in the ebb volumes is greater than in the flood volumes. The large ebb contains the greatest volume of the four flows composing the cycle and the maximum velocity and greatest discharge occurs during this tide, which is therefore of primary importance in the consideration of channel improvements and the movement of silt. The normal sequence of waters is inverted for only a few days near the middle of each two week period of lunar declination, during which time the larger flood range and volume exceed the larger ebb in magnitude. Measurements made during this time should be interpreted with

with care. The variation in tidal range and sequence during the period of current observations, November, 1931 - March, 1932, is shown on Plate X.

8. Tidal Prism. The tidal prism in an estuary may be difined as the net volume contained between the water surfaces occurring above a given station, referred to as the "home section," at two consecutive slack waters.

The definition of a prism thus requires a statement of the home section, time at the first and second slack waters, and the phase range accompanying the slack waters. The range between slack waters has been termed the "prism range" and the range between the high and low water the "phase range." If there is no river inflow or consumptive use of the waters of an estuary, the volumetric difference between the successive water surface above the home section should be equal to the volume of water flowing past the home section during the time interval between the slack waters considered. To illustrate: On March 9, 1932, the ebb prism volume above section 76, Coos Entrance jetties, between slack after MHW at 14.5 o'clock and slack after LLW at 20.7 o'clock was measured by successive current gagings and found to be 53,000 acre-feet. The phase range was 5.1 feet. The computed volume read off a graph prepared from the tidal area and range, Plate V, Figure 2, was 50,000 acre-feet.

9. The tidal prism varies with each tide and the larger ebb prism (HH-LL) accompanying a mean tidal cycle has been selected as a measure for the comparison of channel areas. To compute the mean ebb prism, the water surface profiles at slack after MHHW and MLLW were constructed, assuming that slack water occurs 1.4 hours after high and low water and that the time of tide up the bay lagged as shown on Plate II. The mean tide area of Coos Bay was planimetered in sections and the prism volume built up by multiplying each area by the appropiate range between the water surface profiles. This computation is given below:

TABLE II

Computed Volume - Mean Ebb Prism at Coos Bay Entrance - Home Section.
Phase Range MHHW-MLLW, 6.7 feet.
Prism Range between Slack Waters, 5.5 feet.
Assumed Slack Water Lag, 1.4 hours after high low water.

Home Section	Mean Tide Area Acres	Tide Lag to section Hours	Prism Range at section Feet	Partial Prism Volume Acre-foot
Jetty entrance:	101	0.0	5.5	550
Sec. 76	220	0.1	5.6	1,230
" 72	1,073	0.7	6.4	6,870
South Slough:	554	0.5	5.8	3,220
Sec. 66	529	0.4	6.0	3,180
" 61	680	0.6	6.2	4,220
" 54	749	0.8	6.5	4,870
" 43	889	1.0	6.5	5,780
" 33	685	1.4	6.7	4,800
Harpers Slough:	1,914	1.1	6.7	12,830
Sec. 23	751	1.3	6.7	5,040
" 15	1,167	1.7	6.7	7,820
" 4	667	3.0	5.2	5,470
Coos River	530	2.6	5.8	3,080
Isthmus Slough	-	-	-	-
Total	10,509			66,760
Level volume	10,509	x 6.7 equals		71,000

10. The prism volume thus computed was found to be 94 per cent of the level volume computed by multiplying the mean tide area by the entrance range. To facilitate further computation this ratio was adopted and prism volumes above the inner home sections were computed as 94 per cent of the respective level volumes as show below:

TABLE III

Tidal Prism Volumes - Coos Bay

			Prism volume above section - acre-feet			
Home Section	Mean Tide Area Acres	Area above Home Section Acres	Mean ebb prism MHH-MLL Phase range 6.7'	Mean flood prism MLL-MLH Phase range 5.5'	Maximum ebb prism HH-LL Dec. 9, 1931 Phase range 9.8'	Maximum flood prism LL-LH Dec. 9, 1931 Phase range 7.3'
Jetty entrance	101	10,509	66,200	54,300	97,000	72,100
Sec. 76	220	10,408	65,600	53,900	96,000	71,500
" 72	1,073	10,188	64,200	52,600	93,900	69,900
Smith Slough	554	-	-	-	-	-
Sec. 66	529	8,561	54,000	44,200	78,800	58,700
" 61	680	8,032	50,600	41,600	74,000	55,100
" 54	749	7,352	46,300	38,000	67,800	50,500
" 43	889	6,603	41,600	34,200	61,000	45,400
" 33	685	5,714	36,000	29,500	52,500	39,200
Haynes Slough	1,914	-	-	-	-	-
Sec. 23	751	3,115	19,600	16,100	28,700	21,400
" 15	1,167	2,364	14,900	12,200	21,800	16,200
" 4	667	1,197	4,200	3,400	6,200	4,600
Coos River	530	530	3,300	2,700	4,900	3,600
Isthmus Slough	-	-	-	-	-	-

11. Prism volumes computed above for sections 66, 72, and 76, where discharge measurements had been made were plotted against phase range with the measured volumes, as shown on Plate V. The computed and measured prisms were found to check fairly well, the average discrepancy being 10 percent.

12. As the larger ebb prism produces the greatest velocity and silt carrying capacity of any of the four tides of a typical cycle, the net result of the mixed, Pacific Coast, type of tidal flow is to affect a gradual movement of suspendid and bed-rolled silt toward the sea. The mean ebb prism has been therefore selected as an index of the transporting power of the tidal current and is plotted as a profile on Plate II.

13. Stream flow. None of the tidal prisms or measured velocities considered at Coos Bsy have been corrected for river flow, as no stream gagings are available. The drainage area tributary to Coos Bay is approximately 820 square miles, of which 420 square miles forms the watershed of Coos River. The one per cent chance flood discharge to Coos Bay approximates 100,000 second-feet, a rate which would seriously disturb tidal and silting conditions during a large flood. The probable maximum discharge to Coos Bay during 1931-1932 was 25,000 second-feet, occurring December 31, 1931. The low water discharge falls during the summer to practically zero, the estimated 1931 low water flow, from the Coos Bay watershed, being 30 second-feet.

14. Cross section areas. The channel areas at half tide level were computed for each section by planimetering the areas below MLLW to MHHW and adding the portion below mean tide level. These areas and widths are shown as profiles on Plate II, which also shows the original and existing bottom profiles of Coos Bay, together with the successive dredging projects excuted to the present time. Plate III shows compartive water way cross sections. From the profiles it may be noted that sections 45-47 56-59 contain probably the only sections of the bay channel where the original tidal regimen, presumable stable, has not been materially altered. Successive bay cross sections, looking toward the sea are grouped on Plate III, showing the original channel, existing channel, and project section.

15. Bottom Material. The dredged material, except at Pigeon Point Reef and Guano Rock, where medium soft sandstone is found, is described as "sand and shells" from Pigeon Point to section 15 above North Bend. Above section 15, silt and fine sand, described as "mud" is found. Below Pigeon Point Reef, medium sand, unmixed with shells, is found, the absence of shells being possibley due to the attrition of bottom material near the entrance. The classification and probable origin of the harbor deposits are tabulated below and are shown on Plates IX and XII.

TABLE IV

Source and Classification of Coos Bay Deposits.

Section	1-15	19-41	41-76
Location	Smith Mill - Marshfield	North Bend Pony Slough Shoal	Lower Jarvis Range - Jetty Entrance
Material, size, inches:			
Maximum	0.0060	0.014	0.019
Average	0.0036	0.011	0.014
Minimum	0.0020	0.0082	0.012
Field description	Mud Shell and sand	Shell and sand Sand	Shell and sand Sand
Classification	Silt - Very fine sand Fine sand	Fine sand - Medium sand	Medium - Sand
Probable origin	River silt, deposited by gravity settlement and/or by flocculation in salt water	Beach sand from North Spit, spread flood and/or ebb on currents	

16. The fine and medium sand found up as far as North Bend is probably derived from North Spit, and carried into the upper bay by the flood tides, the river silt described as mud, being settled on the broad tide flats opposite North Bend and Marshfield both by silting and by flocculation in the reach where the suspended river silt first makes contact with the saline bay water during flood periods.

17. Bottom velocities. A considerable portion of the observations made consisted of the measurement of current velocities at points 2 to 10 feet from the bottom, half hourly, during a complete tidal cycle, readings being made simultaneously at from two to four points on each cross section. The observed velocities at each position were plotted against time, and minor discrepancies ironed out, after which the peak velocity during each tidal phase was plotted against the phase range. Floods were separated from ebb tides in this plotting. The peak or maximum bottom velocity was selected, rather than the average, for this work, because the former was more readily determined and also because the silt carrying capacity of the tidal stream increases very rapidly with velocity, so that the maximum

phase velocity appears a better index of the silt moving power of the tide than the average velocity. If the average velocity is desired, it may be closely approximated as 0.7 of the maximum velocity.

18. From study of these groups of plotted points, typical curves for the relation of flood and ebb velocities to phase range were developed, and curves of the typical shape were drawn through the plotted points for each measurement position, as shown on Plate V. From these latter curves the larger ebb and flood velocities for a mean tidal cycle (MHH - MLL- MLH) were read off and the highest value at each section drawn on Plate II, as profiles of maximum ebb and flood bottom velocities. Values for the mean tidal cycle were selected because this cycle is the derived mean of the infinitely varying actual tides and best expresses the long time average both of tidal ranges and velocities.

19. From analysis ofvelocity measurements at sections 66 and 72, boats 2, the ebb bottom velocity at those points was found to range from 65 to 95 per cent of the mean velocity in the vertical line, averaging 80 per cent, and the flood bottom velocity was found to range from 50 to 90 per cent of the mean, averaging 70 per cent.

20. The bottom velocity, while highly irregular, appears to lag the mean velocity for both ebb and flood, the ratio falling to a minimum value near the beginning of the tide, rising to a maximum during the latter half of the tidal phase and falling again at the end.

21. It should be noted that these "bottom" velocities are not those prevailing in contact with the bottom, but have been measured at heights ranging from 2 to 10 feet off the bottom, and at the best merely bear a fairly fixed relation to the actual bottom velocities which are considerably smaller. The mean tidal cycle bottom velocities encountered in the three sections into which the bay channel naturally divides are tabulated below, where it is seen that the bottom velocity for both ebb and flood diminishes toward the head of the bay, and that the strength of the ebb diminishes more rapidly than the flood.

TABLE V

Bottom Velocities - Mean Tidal Cycle.

Section	1-15	19-41	43-76
Description	Smith Mill Marshfield	North Bend Pony Slough Shoal	Lower Jarvis Range Jetty Entrance
Ebb Tide, MHW-MLL:			
Maximum	2.45	3.1	4.4
Mean	1.73	2.41	3.44
Minimum	1.3	1.8	3.0
Flood Tide, MLL-MLH:			
Maximum	2.1	2.9	5.4
Mean	1.57	2.19	2.57
Minimum	0.8	1.8	1.9

22. The maximum velocity at each measurement position for the four places of the mean tidal cycle have been plotted on Plate IV to show the distribution of bottom velocity across the measurement sections. The of maximum flood and ebb velocities indicate that the flood and ebb currents do not necessarily follow the same paths. At unsymmetrical bends the ebb and flood paths diverge, as at section 47, Lower Jarvis Range, where the ebb current hugs the west shore while the flood current passes up the center of the waterway, creating a long crossing bar between the current paths. At North Point, both flood and ebb currents follow the same course around the bend, but from Marshfield to Smith Mill it is noticeable that both flood and ebb currents are deflected to the opposite shore after passing around each bend, and that the currents consequently do not follow the same path. At section 72, the ebb current follows the inside of the bend, apparently because of the jetty below Pigeon Point Reef and the ebb flow out of South Slough. The flood current carries around the outside of the bend because of the direction acquired flowing in between the jetties and the flood flow into South Slough. These differently located flood and ebb streams materially affect the position and size of bay channels and the movement and distribution of bottom materials.

23. Area/Prism Ratio. As outlined above, the ebb prism from higher high to lower low water for a mean tidal cycle best expresses the average volume of tidal flow. The ratio of effective estuary cross sections area at mean tide level to the mean ebb prism above the section furnishes a guide to the mean velocity and silt carrying power of the tidal current passing the section and its ability to maintain a given channel. The other factors affecting this relation are the size of bottom material and the ratio of bottom velocity to mean velocity. The latter factor is also expressed in terms of form ratio, the ratio of channel mean depth to width, for a given

area. The area/prism ratio has been previously investigated in San Francisco Bay and found to vary from 0.82 to 1.04 for stabilized channels in alluvial deposits. (Report on Sacramento, San Joquin and Kern Rivers under Provision of Doc. 308, Plate X, Appendix on Tidal Currents and Silt. See E60 618/1.45). The value of 0.82 was applicable to channels with alluvial bottoms and rocky shores. The channel depths considered ranged from 22 to 115 feet and the bottom material size .0038 to .010.

24. In applying the concept of area/prism ratio to Coos Bay, it should be noted that only sections 45-47 and 56-59 have not been materially changed by dredging and still presumably exhibit area/prism ratios conforming to stability. Referring to Plate V, all available data on the relation of scouring velocity to bottom material size were assembled on Figure 6, where constant velocity and mean tide cycle ebb peak velocity are plotted abainst bottom material size. From these data a "limiting velocity curve" was drawn, which it was felt would assure a self-maintaining channel, if designed to produce the designated peak bottom velocity for a mean ebb tide. To fix the desired channel size, Figure 5 was drawn, showing the relation of area/prism ratio to bottom velocity for channels 25-35 feet deep. Certain of the San Francisco Bay plotted points are for channels 70 to 115 feet deep and consequently fall below the general trend for Coos Bay. As the Coos Bay channels range generally from only 25 to 35 feet in depth, the depth factor has been omitted from consideration and the relation of bottom velocity to area/prism ratio (mean velocity) has been assumed constant in this study.

25. In the selection of area/prism ratios for design, the Coos Bay channel from the jetties to Smith's Mill was studied on Plate II and divided into three portions, each fairly uniform in character within itself, as shown below. A peak bottom velocity was selected from the "limiting velocity curve," Plate V, Figure 6, corresponding to the average bottom material size and applied to Figure 5 to obtain the area/prism ratio for design. These data are tabulated below:

TABLE VI

Area/Prism Design Ratios

Section	1-15	19-41	43-76
Location	Smith Mill-Marshfield	North Bend-Pony Slough Shoal	Lower Jarvis Range-Jetty Ent.
Average bottom material, size	0.0039"	0.011"	0.014"
Lower limit, peak bottom velocity, mean ebb range	3.1	3.7	3.9
Area/prism design ratio	1.05	0.68	0.84

26. The data from which the area/prism ratios for design were derived are approximate, so that the values selected are not precisely defined. The limiting velocity curve, Figure 6, Plate II, has been conservatively drawn and the ratios selected are believed safe. It is highly desirable for future studies of this sort that experimental work be done to better define the three part relation existing between bottom velocity, material size and area/prism ratio. It should be especially noted that the ratio values tabulated above are conservatively estimated for design use and should produce channels deeper than the minimum required.

27. The area/prism design ratios derived above have been checked by computation of the ratios existing in Coos Bay before dredging, when the channel was in a presumable stable state of self-maintenance. The channel cross sections, together with outlines of the successive dredging projects, are shown on Plate III, and the original area/prism ratios are summarized in Table VII. The area/prism design ratios are seen to be lower (that is, causing deeper water) than the ratios originally prevailing on Coos Bay.

TABLE VII

Comparison of Area/Prism Ratios.

Section	Low Water Area	Area low water to M.T.L.	M.T.L. Area	Larger Mean Ebb Prism	Average Area/Prism Ratio Before Dredging	Existing Channel	Design Ratios
43-76	35,600	10,000	46,400	49,900	.93	1.07	.54
19-41	29,000	9,000	38,800	30,500	1.25	1.33	.88
1-15	8,200	6,000	14,200	6,800	2.08	2.20	1.05

28. Hydraulic Description of Channel. At Coos Bay entrance, a small horseshoe bar 1,600 feet outside of the jetties fixes the entrance depth. The controlling depth over the bar without dredging is 25 feet, through which a 9-foot cut is made each year, to a total depth of 32 feet.

29. Between the entrance jetties, Coos Bay channel is 2,000 feet wide, and straight, with an average depth of 25 feet below mean lower low water. In side the jetties, between Miles 1 and 2, the ebb current follows the inside of the bend at South Slough, while the flood traverses the outside, as shown on Plate IV. A channel has been cut across Pigeon Point Reef just above and the waterway beyond is freeand open to section 47, above Empire, where a long crossing bar was formed, due to the reverse bend at Mile 6. The long bend at Mile 7 causing the ebb current to hug the west shore, forming a deep channel through this reach. At Mile 8, Pony Slough

Shoal is formed by the straight broad section, allowing a shallow depth. Around North Point, from the Southern Pacific Railroad bridge to North Bend, a fair depth is maintained by the concentrated current, due to curvature. Above North Bend, on account of the sharp reduction in tidal prism caused by taking off North, Haynes and Kentuck sloughs and Coos River, the tidal channel diminishes sharply in size. A small tidal channel carries up to Marshfield, through Isthmus Slough to Millington, 17 miles from the entrance, and beyond, the greatest lenght of the tidal estuary being about 25 miles. The broad tidal flats opposite Marshfield and North Bend, together with Haynes and other tributary sloughs which form the upper land locked estuary, furnish a tidal volume sufficient to maintain a fair sized channel through the lower estuary between North Spit and the east shore. Above North Point, however, the sharply reduced prism will not maintian a natural channel of usable size.

30. Entrance Jetties. Prior to construction of the entrance jetties, the harbor entrance lay between North Spit and a south spit extending northerly from Coos Head. The controlling depth was about 10 feet and the location of the entrance shifted seasonally with a range in position of over a mile, the south spit being built up by the summer northwest winds and cut back by the winter southerly storms. Completion of the North Jetty in 1894 provided a direct entrance normal to the coast line with a controlling depth of 20 feet. The jetty has since been beaten down and restored, the controlling bar depths having been 18-20 feet, and after 1914, 23 feet, partly secured by dredging. After completion of the south jetty, in 1930, the controlling bar depth increased to 23 feet without dredging.

31. The bar has been carried seaward ahead of the jetties and now stands generally 20 feet above the former ocean bottom, which is at elevation minus 40, as a small crescent 1,600 feet outside the jetty ends. Beyond the bar a depth of 50 feet prevails for several thousand feet seaward.

32. No information is available on the strength and direction of tidal currents across the bar, and uncertainty exists as to the nature of the coastal current off the entrance. The state of existing knowledge may be briefly summarized as follows: Offshore the Japan Current, 200 to 300 miles wide, flows nearly south-southwest, inside of which a weak northerly setting current (Davidson inshore current) exists, often masked by wind driven currents. The strong summer northwest winds produce a southerly current, which, according to some authorities, flows directly along-shore, and according to others produces a northerly eddy current inside Cape Arago. The southerly storms of winter are said to reverse this movement, but whether direct or eddy current prevails off the jetty entrance is uncertain.

33. Entrance Training Works. The problem presented by the bar consists of directing the ebb current between the entrance jetties so as to maintain the bar crest at the desired depth, in this case 25 feet below MLLW. The accomplishment of this purpose requires that a scouring

velocity be maintained to a seaward position where the littoral current will remove sand from the entrance as rapidily as it is brought out by the tide. Any improvement which builds a bar landward of this point will prove of transitory benefit and the channel will require maintanence dredg- as soon as the bar has been built up to a stable size. As the ebb velocity is rapidly dissipated in the spreading tidal stream beyond the ends of the jetty, it does not appear feasible to maintain a scouring velocity at a 25-foot depth more than 2,300 feet beyond the jetties even if the distance between jetties were narrowed to 1,300 feet, deemed the minimum practicable for shipping. A 1,300-foot jetty spacing should remove the bar to a point, 2,300 feet off the jetty ends for a 25 foot crest depth, or 25,00 feet off the jetty ends for a 23 foot crest depth, the effective cross section area in both cases being 56,300 square feet below MTL. It is reasoned that if the jetty channel were narrowed, the bar would advance seaward until an equilibrium of sand deposit and removal was established. Which of the foregoing conditions would follow a 1,300-foot jetty spacing would depend upon the ability of the littoral current at the new position to remove the deposited material from the outer face of the bar.

34. Between the jetties, a 1,300-foot channel with a mean tide section of 56,300 square feet (prism volume 67,000 acre-feet, design ratio 0.84) would occur to a depth of 40 feet. As this depth is in excess of that required for shipping and might endanger the jetties, it appears advisable in designing to concede a portion of the advantages of bar recession by designing a shallower jetty channel. A 1,600-foot channel would scour to a depth of 32 feet and maintain a 25-foot bar at 2,000 feet off the jetties, or a 23-foot bar at 2,200 feet.

35. As the Coos Bar has built rapidly after each jetty addition, it may be presumed to be in a state of balance at the present time, with a controlling depth (undredged) of 23 feet. The existing jetties, spaced 2,000 feet apart, extend 3,500 feet out from the beach line, and have built up a bar with a crest 20 feet above the original bottom. The north jetty, completed in 1894, caused the bar to build up 15 feet in 7 years, since which time the average depth has remained fairly constant at 22 feet. The south jetty, completed in 1930, caused the bar near its outer end to build up 10 feet between 1924 and 1932.

36. Narrowing the jetty channel to 1,600 feet by use of groins would remove the need for dredging between the jetties and cause the bar crest to retreat seaward some 400-600 feet. As the bar has a present controlling depth of 23 feet, the immediate effect of narrowing the channel should be to lower the crest about 3 feet and provide additional storage capacity for deposited material. After the bar has rebuilt in the new location, the stable depth should be greater than 23 feet, possibly as much as 25 feet. This, however, depends upon the rate of removal of bar material, a factor which cannot be evaluated from present knowledge. The rapid growth of the bar after each jetty addition appears to indicate a relatively weak littoral current and consequent slow removal of bar material.

37. Expressed in terms of jetty cost, however the narrowed channel would be equivalent to 1,000 feet of additional jetty, costing $700,000. The cost of dumped rock groins is estimated at $360,000, the annual charge at 10 per cent being $36,000. The saving in annual maintenance dredging would range from $24,000 up to $48,000, depending upon the finally stabilized portion of the entrance bar. The studies made herein and the conclusions drawn are necessarily tentative and must remain so until additional information is had upon the currents maintaining the bar. Data gathered should include not only tide, current and wind movement, but also samples of bottom material gathered from the bar, adjacent ocean bottom and beaches. The principal value derived from such data would lie in the ability to so shape the jetty channel as to take full advantage of the littoral current in removing sediment from the bar.

38. Channel Training Works. In the harbor channel, maintenance dredging is necessary at only a few points below the Southern Pacific Railroad bridge; Lower Jarvis Range, and Pony Slough Shoal containing the two principal shoals. On Lower Jarvis Range, section 47, a long crossing bar has formed, due to the tendency of the flood current to carry in prolongation of the straight channel near Empire, while the ebb current hugs the west shore. This tendency may be noted on Plates III and IV. To direct the flood current into the ebb channel and eliminate the crossing bar, a wide dike extending from the east shore to cut off the flood channel and reduce the section area would be necessary.

39. At Pony Slough Shoal, Section 37, the section widens to such an extent that the tidal current cannot maintain a 22-foot depth. Pile dikes from both shores to contract the channel would correct this condition.

40. Above North Point, the tidal prism will maintain only a shallow channel and use of pile dikes has been considered at and near Sections 8, 15 and 19, between Marshfield, and North Bend, allowing a free channel width of 300 to 400 feet.

41. In Isthmus Slough, the tidal prism is entirely too small to permit the use of training works and dredging is the only feasible means of channel maintenance.

42. The foregoing applies to the 22-foot, 24-foot, and 26-foot channel projects. The estimated annual harbor channel maintenance dredging for the three projects approximated 0.4, 0.8, 1.2 million cubic yards, respectively, as given in Table VIII below.

TABLE VIII

Estimated Annual Maintenance Dredging
Cubic Yards

Section, Mile	0-3	5-11	11-15	Total Mile 3-15
22-foot project	600,000	106,000	230,000	338,000
24-foot project	800,000	390,000	550,000	740,000
26-foot project	not estimated	550,000	600,000	1,168,000

43. As an alternative to harbor channel maintenance exclusively by dredging consideration has been given to the use of pile dikes for training the tidal current into a more definite and narrow channel in which the existing tidal prism would be competent to maintain project depth.

44. An economic study has been made of pile dike training walls for those sections where their employment appeared most useful. The assumptions made are: (1) Annual dike cost is 6 per cent maintenance and depreciation, 4 per cent interest on investment, total 10 per cent; and (2) Annual saving due to dikes will be one-half of maintenance dredging. Cost estimates were based on use of Columbia River type permeable pile dikes of creoseted material, with necessary riprap protection.

45. This study, summarized below in Table IX, shows that for a 22-foot project, pile dikes offer no advantages over maintenance dredging, but that for 24-foot and 26-foot projects, their annual cost approximates or is lower than the savings estimated from their use.

46. Maintenance by Dredging and Dikes. Examination of the comparative channel sections, Plate III, shows a somewhat shifting channel with silting and scour in progress at the various sections. Between the survey dates, certain sections have improved and others have deteriorated from the standpoint of navigation. Study of this condition suggests that location of the project channel within the waterway so as to take advantage of tidal scour, combined with training works designed to maintain the tidal stream within the selected channel, offers the most advantageous solution of the problem of channel maintenance, especially in connection with the 24-foot and 26-foot project.

47. The designed channel alignment may be selected after location of the thread of maximum current velocity, as shown on Plate IV, and study of the effect of various combinations of channel and training dikes, to guide ebb and flood flow along the same definite paths.

TABLE IX

Economic Study - Channel Training

Section	8	15	19	37	47	76
Mile Location	13.6 Marshfield Channel	12.4 North Bend-Marshfield	11.6 North Bend	8.2 Pony Slough Shoal	6.2 Lower Jarvis Range	0.6 Between Jetties
MTL area, sq. ft.	18,000	26,000	30,000	50,000	48,000	57,000
MTL width, feet	5,000	5,400	4,000	3,200	3,700	2,000
Mean ebb prism, acre-feet	11,000	14,500	17,000	38,000	43,000	66,000
Existing area/prism ratio	1.7	1.8	1.8	1.3	1.1	.87
Design area/prism ratio	1.05	1.05	.86	.88	.84	.84
Design MTL area, sq. ft.	11,700	15,200	15,000	33,400	36,100	55,400
Permeability of dike, %	35	35	32	35	35	-
Dike Water section area, sq. ft.	9,700	16,600	22,200	25,500	18,300	-
Clear opening water section area, sq. ft.	8,300	9,400	7,800	24,500	29,700	55,400
Clear channel width, ft.	320	380	300	940	1,140	1,790
Clear channel depth at MTL, feet	26	26	26	26	26	31
22-foot Project						
Dike Length, ft.	4,000	2,000	2,500	2,200	2,000	-
Dike cost at $25/ft.	$100,000	$50,000	$62,500	$55,000	$ 50,000	-
Annual cost at 10%	$ 10,000	$ 5,000	$ 6,250	$ 5,500	$ 5,000	-
Annual maintenance dredging cu. yds.	76,000	77,000	77,000	54,000	30,000	-
Annual dredging cost at 10¢/cu. yd.	$ 7,600	$ 7,700	$ 7,700	$ 5,400	$ 5,000	-

TABLE IX

Economic Study - Channel Training

Section	8	15	19	37	47	76
Mile Location	13.6 Marshfield Channel	12.4 North Bend-Marshfield	11.6 North Bend	8.2 Pony Slough Shoal	6.2 Lower Jarvis Range	0.6 Between Jetties
24-foot Project						
Dike lenght, feet	4,040	2,040	2,540	2,320	2,120	-
Annual cost at 10%	$ 10,000	$ 5,000	$ 6,300	$ 5,800	$ 5,300	-
Annual est'd maintenance dredging, cu. yd.	117,000	117,000	116,000	190,000	110,000	-
Annual est'd saving	$ 3,800	$ 5,800	$ 5,800	$ 9,500	$ 5,500	-
Ratio - cost/saving	1.7	0.9	1.1	0.6	1.0	
26-foot Project						
Dike lenght, feet	4,080	2,080	2,580	2,440	2,240	-
Annual cost at 10%	$ 10,200	$ 5,100	$ 6,400	$ 6,100	$ 5,600	
Annual est'd maintenance dredging, cu. yd.	133,000	133,000	134,000	280,000	130,000	-
Annual est'd saving	$ 6,600	$ 6,600	$ 6,700	$ 14,000	$ 6,500	-
Ratio - cost/saving	1.5	0.8	1.0	0.4	0.9	-

48. Location of the dredged channel along the path of maximum scour should reduce maintanence dredging, both by minimizing the initial excavation and by avoiding current scour apart from the chosen channel, which would move bottom material, later to be deposited in the deeper cut. Spoil from the dredging operations may be disposed of advantageously, either in the waterway adjacent to but outside the navigation channel in order to avoid enlargement of the cross section area, or outside the low water line to form zone dikes, as a continuation of pile dikes to be built across part of the waterway area.

49. Dredger spoil should not be dumped in the deeper portions of the waterway area where the same tidal current orignially forming the section is certain to transport the dumped material and redeposit it in the shoals whence it was dredged.

50. Ebb Pumping Overboard. In certain types of very fine bottom material, it has become accepted practice with hopper dredges to pump dredged material overboard on the ebb tide, allowing the suspended materiel to pass out of the dredged area on the tidal current. In Coos Bay, the bottom material falls into three general groups: medium sand, fine sand, and silt. The settling rates of these materials in still water have been determined by experiment with results summarized on Plate XII. Curves have been drawn through the platted points of experimental settlement rate, showing the theoretical rate of settlement, as derived from study of the movement of bodies in viscuous fluids. The possible drift of pumped material is summarized in Table X.

TABLE X

Settling Rates - Coos Bay Bottom Materials

Section	1-15	19-41	43-76
Description			
Average material size, inches --------	0.0055	0.011	0.014
Average settling rate, ft./min., from curve - $V = 64,000\ d^2$ -------------	0.88	7.7	12.8
Average section mean ebb peak, bottom velocity, ft./sec. -----------	1.73	2.41	3.44
Estimated average depth of channel, feet ---------------------	8	15	10
Time in suspension, minutes ----------	9.1	1.9	1.4
Average distance travelled at mean ebb peak bottom velocity before settling to bottom, feet ---	944.0	222.0	291.0

51. The distance traveled by pumped sediment is shown above to be only a few hundred feet under the most favorable conditions at the peak ebb flow. Assuming an average lateral dispersion, due to turbulant flow, of 20 per cent, there is little opportunity for the sediment to drift out of the dredged channel before reaching bottom. Practically all pumped sediment will settle almost immediately in the dredged channel.

CONCLUSION

The following conclusions are drawn from the tidal current study:

1. Study of the entrance bar, with a view to narrowing the jetty channel through use of groins if the conclusions here tentatively set up are verified, is desirable.

2. In connection with 24-foot or 26-foot projects, location of dredged channels to take fullest advantage of tidal scour is desirable.

3. Training dikes will aid in channel aligment and in reducing the cost of maintenance dredging under 24-foot and 26-foot projects. However, the estimated savings under the 24-foot project are so small and problematicalas not to warrant farther consideration of dikes for that depth.

4. Ebb pumping overboard will not effectively remove dredged material from the navigation channel.

Oscar O. Kuentz,
Major, Corps of Engineers,
District Engineer.

Current Survey, Coos Bay, Oregon
February 4, 1932

Section No.	Mean Flood Velocity	Mean Ebb Velocity	Mean Depth MLLW	Control--ling Depth MLLW	Higher High Water	Lower High Water	Higher Low Water	Lower Low Water
1	.50	.78	17.0	23	7.5	5.6	1.9	1.5
2			17.6	25				
3			15.8	24				
4	.53	.57	19.4	25	7.3	5.6	2.1	0.5
5			17.2	25				
6			15.5	23				
7	1.35	.63	13.8	23	7.5	5.7	2.3	-0.6
8			20.3	20				
9			12.2	24				
10			13.4	24				
11	1.19	1.39	17.4	27	7.9	5.9	3.0	-1.0
12			16.5	24				
13			16.4	29				
14			14.4	25				
15	.91	1.09	9.8	25	7.3	6.5	3.5	-0.3
16			15.4	23				
17			18.4	25				
18			16.6	26				
19	1.11	0.77	20.1	24	7.6	6.8	2.5	1.3
20			16.4	24				
21			16.4	29				
22			13.4	28				
23	1.10	1.07	12.7	29	7.7	5.7	1.1	1.0
24			11.7	27				
25			16.6	28				
26	1.38	1.41	9.9	36	9.2	6.6	3.0	-0.2
27			12.5	29				
28	1.18	1.24	14.1	25	8.2	6.1	2.0	1.4
29	1.56	1.47	10.4	24	8.8	6.8	3.2	-0.7
30			13.4	28				
31	1.46	1.33	14.3	26	7.8	7.1	2.2	0.4
32			16.6	24				
33	1.38	1.13	18.6	25	5.9	5.7	2.8	-0.3
34			16.9	25				
35	.94	.98	16.3	26	7.6	7.0	3.4	0.5
36			10.8	24				
37	1.02	.70	16.8	23	6.7	5.3	3.0	1.5
38			16.1	25				
39	1.16	1.28	13.3	29	7.0	4.7	1.5	-1.5
40			15.7	30				

Current Survey, Coos Bay, Oregon (continued)
February 4, 1932

Section No.	Mean Flood Velocity	Mean Ebb Velocity	Mean Depth MLLW	Controlling Depth MLLW	Higher High Water	Lower High Water	Higher Low Water	Lower Low Water
41	.97	.87	15.8	30	6.8	4.8	2.5	1.8
42			14.3	35				
43	1.60	1.72	16.7	30	7.3	6.2	1.7	-1.0
44			17.0	30				
45	1.00	1.06	16.9	24	7.0	5.0	2.6	1.8
46			16.3	24				
47	1.06	1.34	17.0	20	7.4	5.0	3.3	0.2
48			13.3	20				
49	1.57	1.66	15.4	24	8.4	6.8	3.5	0.4
50			13.6	23				
51			18.4	25				
52	1.53	1.80	16.0	28	7.5	4.8	2.5	-0.9
53			17.4	25				
54			17.2	29				
55			17.0	29				
56	1.48	1.60	17.0	25	7.0	5.8	2.4	0.1
57	1.54	1.70	14.4	24	7.7	5.8	2.7	-1.7
58			14.0	23				
59	1.10	1.11	14.5	24	6.6	5.8	3.6	0.6
60			15.7	24				
61			17.4	29				
62			17.0	25				
63	1.28	1.35	16.1	21	6.8	6.2	2.6	0.5
64			13.5	21				
65			14.1	27				
66			15.9	23				
67	1.49	1.72	19.2	24	7.4	5.0	2.3	-2.5
68			21.4	25				
69			24.1	26				
70			24.3	37				
71			19.7	34				
72			21.3	43				
73			19.6	43				
74			24.3	37				
75			21.8	28				
76			24.8	31				
77			24.5	29				
78			27.8	34				

APPENDIX E

OCEANOGRAPHY OF COASTAL HARBORS

This appendix has been reproduced from the following document:

O'Brien, M. P.
n. d. [Oceanography of Coastal Harbors.] On file U. S. Army, Corps of Engineers, Beach Erosion Board, Washington, D. C. (Unpublished.)

COOS BAY:

GENERAL DESCRIPTION-- The Coast Pilot published in 1926 contains the following description:

"Cape Arago, 29 miles northward of Cape Blanco, is an irregular, jagged joint projecting about one mile from the general trend of the coast. The seaward face of the cape, 2½ miles long north and south, is a narrow sparsely wooded tableland 50 feet high with rugged and broken cliffs and outlying rocks of the same height which formerly were a part of it. Immediately off the cape are reef extending northwestward for about one mile."

"Coos Head, 220 feet high, is the southern point at the entrance to Coos Bay and lies 1 and 3/4 miles north eastward from Cape Arago Lighthouse. The cliffs are about 100 feet high and terminate in several small rocky points with sand beaches between them."

"From Coos Head to Heceta Head, about 48 miles, the coast consists of sand dunes backed by moderately low wooded hills. In the northern portion the dunes are quite high and conspicuous from contrast with the dark trees with which they are partly covered. Back of these wooded dunes are a number of lakes drained by small creeks through the sand beach."

"Coos Bay is about 13 miles in length by one mile in width with a tidal area of about 15 square miles."

The general character of the coast south of Coos Head is illustrated by the photographs on page 2 . North of the entrance is a long sand spit gradually increasing in elevation towards the dunes shown on page 5 .

Several sloughs drain into the bay proper and the topographic map indicates a rather heavy run-off which would tend to keep the entrance open. The mean annual rainfall at Fort Umpqua is 67 inches.

The 30 fathom contour lies 3.5 miles off the ends of the jetties and the 60 fathom contour is out approximately 7 miles. Sufficient soundings to define the deep water contours have not been made.

TIDES, TIDAL AREA, and TIDAL PRISM--- The mean range and the diurnal range of the tide as given the Tide Tables for 1930 is as follows:

	MEAN RANGE (FEET)	DIURNAL RANGE (FEET)
Coos Bay Entrance	4.8	6.4
Empire	4.9	6.7
North Bend	5.1	6.8
Marshfield	5.2	6.9

The tide is diurnal with the long run-out following the higher high water.

In computing the tidal prism, the U. S. Engineer Office at Portland used the low water area plus half the area between high water and low water. On this basis the tidal area is 16.1 square miles and the tidal prism between mean lower low water and mean higher high water is 90.16 square mile feet.

The area of the channel between the ends of the jetties is 41,850 square feet below MLLW and 52,210 square feet below MHHW.

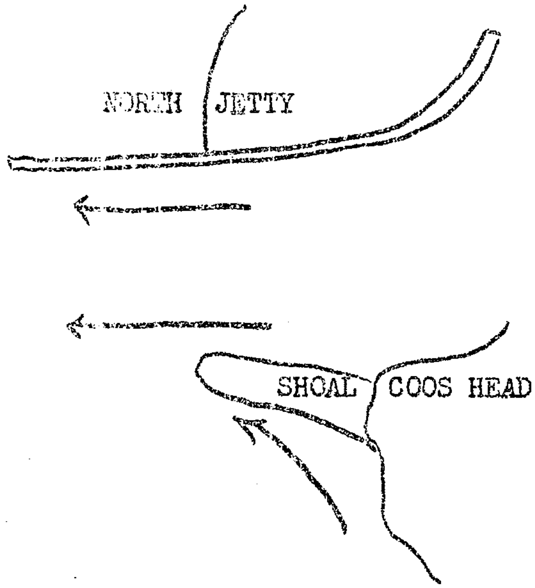
WAVES and CURRENTS--- The wave action at Coos Bay seems to be extremely violent in comparison with the reported meterological conditions. At the time of the inspection, the waves were peaking up so as to almost touch the cross members of the trestle although no unusual winds had been indicated on the Weather Maps during the preceeding period. The violence of the waves is also indicated by the damage done to the jetties. In 1914, dumping was done between the fairway and the sea buoy. This patch shoaled to 37 feet and waves broke over it. During storms the waves are said to break in 60 to 80 feet of water.

The Coast Pilot makes the following statement regarding the currents:

"There is usually a current sweeping either to the north or south just off the jetty and this current should be guarded against, especially with vessels passing out."

Men at the Coos Bay Coast Guard Station stated that the flood current comes in uniformly over the whole entrance but the ebb tide usually sets southwestward. Mr. Cole, Assistant Engineer, U. S. Engineer Department, who is in charge of the jetty construction stated that the ebb tide runs straight out but that the flood current comes in extremely strong around the north jetty. There is a slight discrepancy in the two statements but both indicate a general southward component. However, floating materials dumped in the bay are usually found on the north beach.

Previous to the construction of the south jetty, an eddy occurred on the ebb tide south of the inlet as shown in the accompanying sketch.



This current persisted during the first two-thirds of the ebb current. It is the opinion of the coast guardsmen that the general offshore current is south in summer and north in winter which agrees roughly with the studies of Thorade. Mr. Cole stated that at all points below Yaquina Bay, the prevailing current is southerly. The charts of the U. S. Hydrographic Office are somewhat contradictory as regards the coastal current. The current charts show a southerly current but the current arrows nearest the shores on the charts of average meteorological conditions by months are northward.

Whatever the currents offshore may be, the writer is convinced that the littoral current are towards the inlet from both sides, whenever a current exists. This current may be a part of a main southerly current, a first-order eddy induced by the ebb tide or a result of oblique wave action but the net effect is the same.

<u>SAND SAMPLES</u> and <u>PROFILES</u>-- Sand samples were taken on both sides of the entrance at the time of the inspection but the sample from the bar had been obtained several years previously. The analysis showed the following results:

LOCATION	NUMBER	MEDIAN DIAMETER (INCHES)
NORTH BEACH	N-22	0.0103
BAR	N-23	0.013
SOUTH BEACH	N-24	0.0094

The variation in size is slight but perhaps indicative of the sand movement. The coarsest material was found on the bar and the next coarsest on the north beach. This distribution agrees with the conclusion that the main sand drift is from the north.

The beach is hard packed and has a slope of about 2 degrees.

SAND MOVEMENT-- The first survey of the entrance was made in 1861 but the only map of it available to the writer had been corrected to 1889 and the extent of the corrections is not known. Other surveys made in 1878, 1879, 1885, 1889, 1901, 1907, 1912 and 1914 appear in Appendix XV.

SUMMARY of CHANGES at ENTRANCE:

1861 - 1863-- Least distance between Coos Head and low-water line on north spit, 2000 feet. Distance to high water 4700 feet. Depth at throat, 60 feet. Depth over bar 13 feet. Main channel passes within 800 feet of Coos Head and then runs N 45° W.

1878-- Least distance Coos Head to low water North Spit, 1800 feet. Maximum depth at throat, 56 feet. Depth over bar uncertain but appears to have been as little as 7 feet. Channel, 500 feet from Coos Head and has swung around towards north spit since 1861.

1879-- Low water line on North Spit moved south 600 feet since 1878 and now almost over laps Coos Head. Distance Coos Head to low water, 1200 feet. Depth at throat, 55 feet. Main channel parallels north spit. Depth over bar uncertain but as little as 10 feet in spots.

1885-- Between 1879 and 1885, a spur dike, 1500 feet long was constructed on the east side of the channel and appears to have had a very pronounced effect. The main channel was forced into a more nearly east and west direction and the low water line on the North Spit receded about 800 feet. The main channel passed within 400 feet of Coos Head and then ran N 39° W. The minimum depth over the bar was 9 feet and the depth at the throat was only 40 feet. Between 1861 and 1885, the highwater line on the North Spit receded 1500 feet.

1889-- Between 1885 and 1889, low water line advanced southwestward 800 feet, constructing channel and increasing depth at throat to 47 feet. The main channel has swung southward to N 58° W and the least depth on the ranges was 21 feet.

1901-- Although the U. S. Engineer Office at Portland stated that the north jetty was begun about 1880, it is believed that this is incorrect as the first map to show this jetty is dated 1901. The spur dike was begun about 1880. Main channel runs N 60° W. Depth at throat 40 feet. Depth over bar 20 feet. Map indicates fill on north side of north jetty and recession northward of low water line of 1500 feet. Minimum distance between jetty and Coos Head 1900 feet. Crest of bar 1500 feet beyond end of jetty.

1907-- Channels runs N 66° W. Maximum depth in throat 70 feet off old spur dike. Depth over bar 19 feet. Deep hole shown at end of jetty. Shoreline has built out about 800 feet on north side of north jetty since 1901. Spit beginning to build on east side of Coos Head.

1912-- Channel runs N 64° W. Depth in throat 60 feet. Depth over bar, 15 feet. Erosion north of jetty but filling occurred on channel side. Crest of bar 1100 feet off jetty. Pronounced sand spit on east side of Coos Head now 2000 feet long.

1914-- Erosion north of jetty and fill on channel side continue. Depth at throat, 46 feet. Depth over bar 20 feet with crest at about end of jetty. Channel runs N 65° W.

1929-- Date of issue of U. S. Coast and Geodetic Chart No. 5984, May 1929. Controlling depth over bar at this date, 25 feet. Depth in throat, 56 feet off spur dike. South jetty completed and accretion has built beach 450 feet seaward of cliffs.

Briefly, the entrance channel was very unstable previous to the construction of the north jetty and exhibited a tendency to swing around to the northward. Between 1861 and 1879, the inlet experienced a considerable sand pressure on the north side and the spit built southward very rapidly. Between the date of construction and 1907, an accretion occurred on the north side of the jetty but this was followed by an erosion and a simultaneous filling on the channel side. It is believed that the jetty weathered down during this interval and that sand began to leak through it. Although the North Jetty, was unable to secure a stable depth of more than 14 feet over the bar, it did fix the direction of the Main Channel within rather narrow limits.

The sand drifts easily under wind action when dry. Beach grass planted on the north side appears to be successful in decreasing this wind drift.

The long sand spit on the north side of the entrance and the general configuration of the shore indicate that the sand movement in the past has been southward. This conclusion is also substantiated to some extent by the variations in the sand samples.

The following quantities were dredged from the Coos Bay entrance after 1924:

YEAR	QUANTITY
1924 -- 1925	1,242,000 cubic yards
1925 -- 1926	1,160,000 cubic yards
1926 -- 1927	1,023,000 cubic yards
1927 -- 1928	675,000 cubic yards
1928 -- 1929	301,000 cubic yards

STRUCTURE-- Very little information was obtained regarding the spur dike on the east side of the channel. It was 1500 feet in length and was built between 1881 and 1885.

The North Jetty was begun about 1891 and completed in 1895. The inner portion was deflected northward to act as a training wall opposite the original spur dike. The length of the straight portion acting as a jetty was about 4000 feet and the crest appears to have been above high water. Little information could be obtained regarding the original height, cross-section or character of stone used. By 1924, the jetty, had weathered down to about +4' above MLLW and the outer end was down to -30' as shown in the profile. The outer end was very wide and appeared to have been spread out. The inner portion is said to have settled.

The work of re-constructing the North Jetty was begun in 1924 and is still in progress. Up to October 1929, 689,000 tons of stone had been placed and the crest of the sea-end was then at elevation +20'. Over most of its length, the crest has an elevation of +10'. The available stone for jetty construction is of inferior quality and appears to fracture easily. The unit weight is 160 pounds per cubic foot.

The South Jetty was started in 1924 and is still under construction. The present length is about 3500 feet. The crest at the outer end was at +20' above MLLW on November 1, 1929, but the general elevation on that date was about +12'. The sea-end has already been re-worked three times without much success. Between November 1928 and November 1929 the storms moved the sea-end bodily landward and formed a blunt end. This pile of rocks is shown in one of the photographs. Up to 1928 about 860,000 tons of rock had been used or an average of approximately 250 tons per foot of length. The rock used is a soft gray sandstone having a unit weight of 150 pounds per cubic foot.

The distance between the jetties is about 2000 feet. From the curve showing the relation between the tidal prism and the area of the entrance section it appears that the maximum area below mean sea-level that can be expected is 70,000 square feet or an average depth of 35 feet at this stage. Since the diurnal range is 6.7 feet, it is reasonable to expect that the jetties will maintain a depth of about 32 feet.

In conclusion, the writer is of the opinion that the jetties are spaced properly but that the specific gravity of the stone used is not sufficiently great to stand the wave action and that attempts to hold the sea-ends with this stone will be futile. Since the jetties do not act as breakwaters, there appears to be little advantage in maintaining the crests at the sea ends much above MLLW since this interferes with the flood tide and cuts down the tidal prism.