CHAPTER 26

EROSION AND ACCRETION ALONG CLATSOP SPIT

Harold A. Kidby, Chief, Rivers and Harbors Section
John G. Oliver, Hydraulic Engineer, Tidal Hydraulics Subsection
U. S. Army Engineer District, Portland
Corps of Engineers
Portland, Oregon

ABSTRACT

The study area encompasses 18 miles of Oregon coastline known as Clatsop Beach, which lies between the Columbia River south jetty and Tillamook Head, south of Seaside, Oregon. The physical changes (including man-made changes such as jetty construction which was initiated in 1885) that have occurred in the area since 1792 are described and presented graphically. Theories based on an analysis of the very complex joint function of sand supply and incident wind, oceanographic, and estuarine forces are proposed as to the cause of erosion and accretion over the long-time span.

NATURAL CHANGES IN THE ENTRANCE

The history of changes at the entrance of Columbia River is an important indicator of the shoreline changes that have occurred along Clatsop Beach. Clatsop Spit and the entrance to Columbia River have been in a continual state of change since the earliest surveys were taken of them 173 years ago.

In 1792 (see figure 1) the mouth of Columbia River had one channel, flanked on the south by Clatsop Spit and Point Adams and on the north by Peacock Spit and Cape Disappointment. Upstream from Point Adams in the Columbia River estuary, there were two channels, called north and south channels, separated by a shoal. By 1839 (figure 2) this two-channel system had moved downstream to the west past Point Adams and Cape Disappointment. The channels were then separated by Sand Island and the shoal area which hooked southward known as Middle Sands. During the following 40 years to 1879, the two-channel system prevailed through Middle Sands. Sand Island and Clatsop Spit moved northward during this period, and the Middle Sands area maintained its hook to the south.

By 1879 (figure 3) Sand Island had migrated northward sufficiently to cut off the channel near the Washington shore but a channel still existed between Middle Sands and Peacock Spit. This condition prevailed until the early 1880's at which time Middle Sands split into two sections, leaving three channels from the river into the Pacific Ocean as shown on an 1883 map (figure 4). The northern channel crossed between Middle Sands and Peacock Spit in a northwesterly direction; the middle and largest channel crossed the spit in a southwesterly direction, and the southern channel crossed between Clatsop Spit and Middle Sands in a southerly direction.

CHANGES DURING JETTY CONSTRUCTION

By 1885 (figure 5) at the start of construction of the south jetty, the northern portion of Middle Sands had joined with Peacock Spit, and the southern portion had joined with Clatsop Spit, leaving only the middle channel open. At this time the outer channel had an alinement that was almost north and south. As construction on the south jetty progressed, some very rapid changes took place on Clatsop Spit and through Middle Sands. The channel through Middle Sands began to move to a more east-west alinement, Middle Sands and Clatsop Spit north of the south jetty eroded and moved offshore to form an outer bar, and a deeper channel formed between Peacock Spit and the south jetty.

In 1889 (figure 6) 2 years after completion of the original 4.5-mile-long jetty, Clatsop Spit had shoaled sufficiently to be partially above mean lower low water, although even at this time there was extensive transfer of water during each tidal change in the channel over the spit near Point Adams.

Peacock Spit along the Washington shore was decreasing in size during this period, and a portion of it migrated upstream past Cape Disappointment as Republic Spit. By 1902 (figure 7) Republic Spit had joined Sand Island. At this time Clatsop Spit extended 2 miles west from Point Adams. Between 1903 and 1913 the south jetty was rehabilitated and extended to a total length of 6-1/4 miles. The general erosion offshore of Clatsop Beach continued through the period of rehabilitation and extension of the jetty.

The rapid initial buildup of Clatsop Spit took place during construction of the original 4.5 miles of the south jetty. This was followed by a period of intense erosion on Clatsop Spit during subsequent rehabilitation and extension of the south jetty. Between 1885 and 1913 the maximum amount of scour took place on Middle Sands and in the offshore area south of the jetty.

Erosion studies have been made of the position of the 0-, 20-, 30-, 40-, and 50-foot depth contours versus time for the period from 1894 to the present. The depth contour positions were determined as the perpendicular distances from the "A" line stations 0+00, 25+00, and 85+00. The "A" line is approximately parallel to the present beachline, and station A- 0+00 is approximately 200 feet south of the jetty; station A- 85+00 is 8,500 feet southeasterly of station A- 0+00. The erosion-accretion rates determined from the study denote rate of horizontal movement for the selected depths. A typical erosion rate study is shown at station A- 0+00 for the 20-foot contour off Clatsop Spit (figure 8). The graph shows that a very rapid rate of erosion occurred during and immediately after the jetty construction period. Another important characteristic of the graph is the asymptotic nature which indicates that a stable condition may be near at hand.

Depth comparisons for the area at the mouth of Columbia River are shown on figures 9, 10, and 11 for the periods 1877-1926, 1926-1958, and

1958-1962, respectively. It should be noted that the incremental scour unit on figures 9 and 10 is in fathoms whereas it is in feet in figure 11. The earliest period included the time of initial jetty construction and shows a general scouring of the underwater area south of the south jetty for about 7 miles. Scouring occurred at depths as great as 200 feet. The maximum amount of scour was about 42 feet and is shown on figure 9 about 2 miles south of the head of the south jetty. It is apparent that the big change occurred during and immediately after the 6.62-mile-long jetty construction period from 1885 to 1913. The scour that occurred offshore of Clatsop Beach for the 1926-58 period amounted to 12 feet or less and was generally less than 6 feet. For the 1958-62 period (figure 11) the area offshore of Clatsop Beach is practically stable.

Construction on the north jetty (figure 12) started in 1913 and continued until 1916. This caused a further deepening of the navigation channel and a shoaling immediately north of the north jetty.

In 1938, Jetty A (figure 12) was constructed from the most easterly point on Cape Disappointment southward to a point beyond the southern limits of Sand Island. Jetty A further increased channel depths and caused the channel to shift to a more east-west alinement but, again, no noticeable changes occurred on Clatsop Beach south of the south jetty. Since completion of the three-jetty system, the mouth of Columbia River has been reasonably stable.

RECENT CHANGES ALONG CLATSOP BEACH

Some comparatively recent surveys give an indication of what was occurring on Clatsop Beach between Tillamook Head and the south jetty during and after the jetty construction periods. Beach cross sections for the years 1934, 1963, and 1964 (figure 13), for the area south of the jetty, show that dunes 25 feet high have developed behind the beach. The buildup of these dunes is a result of onshore windblown sand and the dune stabilization program that was carried out by the Warrenton Dune Soil Conservation District between 1934 and 1944. A report of the sand-dune control is given in Circular No. 660, United States Department of Agriculture, September 1942. Another survey that indicates the results of the action of the several forces at work on the beach is shown in figures 14 through 16. These figures show by the position of the high-water line over a 25-year period the limits of erosion and accretion areas on Clatsop Beach. It appears that erosion occurred from the shoreline at the south jetty to a nodal point about 3 miles south, but accretion occurred from this point to Tillamook Head, a distance of 14.4 miles. The point of maximum accretion at Necanicum River, mile 14.7 from the south jetty, shows on figure 16. The point of maximum erosion was at the shoreline at the south jetty (mile 0). From the south jetty the erosion decreased to the nodal point (figure 15), and from this point accretion increased to Necanicum River.

EROSION-ACCRETION PROCESSES

There appears to be both a northerly and southerly littoral drift at the mouth of Columbia River and along Clatsop Beach. The northerly littoral drift is caused by the high, steep, winter waves from the south and the southerly littoral drift is caused by the flatter summer waves from the north. Normally the winter waves erode the beach, and the summer waves build the beach. From a review of the history of the mouth of Columbia River prior to jetty construction, the shifting of Middle Sands, the northward migration of Sand Island, and the northerly extension of Clatsop Spit, it appears that the predominant littoral forces off Clatsop Beach are from south to north. By considering the same area after construction of the south jetty, especially the buildup of Clatsop Spit to the south of the jetty and its following erosion, it appears that the predominant littoral forces are from north to south. A north-to-south littoral drift is further indicated by the buildup of sand behind the north jetty and the general northeast to southwest alinement of the navigation channel through the outer bar area. Also, the accretion that has taken place along Clatsop Beach could be an indication of a north-to-south littoral drift as the maximum accretion occurs at the south end of the beach. Although visible signs indicated that the predominant littoral drift could be either to the north or south, an analysis made by Ballard in the University of Washington's Department of Oceanography Technical Report No. 98, shows a predominant littoral drift based upon net energy flux in a south-to-north direction in the Clatsop Spit area. It was stated in this same report that sediment samples to the north of Columbia River had a slightly larger median diameter than sediments to the south, and that sediments both to the north and south of the Columbia estuary had their origin from Columbia River. The fact that northerly sediments have a larger median diameter does not necessarily indicate a south-to-north predominant littoral drift. However, these sediments do seem to indicate a higher energy flux per unit time from south to north. This higher energy, associated with waves from the south, is a matter of record and can be seen in wave statistics prepared by National Marine Consultants, Inc., for Portland District, Corps of Engineers. The southerly waves in general are higher and steeper than waves coming from the north. During October and December through April the net alongshore flux is to the north, and the general movement of sand is offshore. During the months of May through September and November, net alongshore flux is to the south and sand movement is onshore.

Current studies and observations near the entrance to Columbia River estuary were made in the 1930's and reported in two publications of the U. S. Tidal Model Laboratory, Berkeley, California, as follows:

> "Mouth of Columbia River Beach Erosion Investigation, Report on Experiments, Part I, July 1933-May 1935," dated June 15, 1935.
>
> "Mouth of Columbia River Beach Erosion Investigations, Summary of Observations and Results July 1933-August 1936," Technical Memorandum No. 20, dated December 24, 1936.

Both reports indicate a southerly littoral drift in the summer and a northerly littoral drift during the winter. Also, these reports indicate a somewhat southerly ebb at the mouth of Columbia River.

ANALYSIS OF EROSION AND ACCRETION

The most important change made by construction of the jetty system at the mouth of Columbia River was the restriction in width of the entrance which resulted in the stabilizing of the location of the navigation channel. As the south jetty was extended seaward, sand from Middle Sands eroded, creating a deeper channel. Material from Middle Sands moved seaward onto the outer bar and landward onto Clatsop Spit. The movement of sand onto the outer bar was probably caused both by restricted ebb currents and by winter seas from the south and summer waves from the north. That these seas from the south have had and continue to have a vast influence in these phenomena is further evidenced by the immense volume of sand that has moved north beyond Cape Disappointment and has later been carried in by the southerly littoral drift to stay between the north jetty and Cape Disappointment.

In the area of maximum scour south of the south jetty prior to construction of the south jetty (figure 5), prevailing depths were between 3 and 4 fathoms. As the south jetty was constructed, this portion of the spit was shut off from the Columbia River sand supply and, as Middle Sands deepened and moved offshore, the area was subjected to concentrated wave attack. Also, as the jetty was lengthened, recirculation of the sand on Clatsop Spit in the estuary was further restricted until the sand moved offshore and then north or south from the estuary, or it could move onshore and to the south onto Clatsop Spit. There is ample evidence that these phenomena took place (figure 9). Some of the material moved offshore and to the north, some material moved inshore and to the south to form the present Clatsop Beach, and in deeper water some of the material moved south under the influence of the seas from the north and the southerly ebb of Columbia River. As time progressed and the erosion continued, Clatsop Spit deteriorated until the depths were so great over the spit and the alinement was straightened sufficiently that waves no longer focused on it. This tended to decrease the scour rate until at the present time there is very little movement of sand in the area between the node and the south jetty.

To interpret the erosion and accretion patterns that are now established off Clatsop Beach, it is necessary to review the boundary conditions of the beach and the recent records of accretion and erosion. Figure No. 17 shows Clatsop Beach bounded on the north by the south jetty at the entrance to Columbia River and on the south by Tillamook Head. Any sand that is supplied to the beach must either be from the Columbia River, from the dune area behind the beach, or from the area offshore. Since 1939 the erosion and accretion pattern has been consistent on Clatsop Beach, with erosion occurring from the jetty to a node about 3 miles south of the jetty, and accretion occurring from this node to Tillamook Head. The volume of accretion has been much greater than the erosion. It is reasonable to assume that a portion of the accretion was supplied by the eroding northern beach and some undoubtedly came from offshore as shown by the 1926-1958 offshore depth comparisons (figure 10). From the amount of accretion which has occurred it appears that material must have come around the end of the south jetty and moved southward down the coast and then been carried inshore by waves and deposited on the beach. Once in the Clatsop Beach area, distribution of the sand is governed by both summer seas from the north and winter seas from the south. The location of Tillamook Head at the south end and of the south jetty at the north end of Clatsop Beach is shown in figure 17. The projection of Tillamook Head out into the ocean has created a change in the offshore contours from those along Clatsop Beach. In general, this has resulted in decreased wave heights along the southern end of the beach for waves from the south. Likewise the south jetty obstructs waves from the north and reduces wave heights along the northern end of the beach for waves from the north. Wave refraction diagrams prepared for U. S. Army Engineer District, Portland, by National Marine Consultants, Inc., of Santa Barbara, California, in March 1961, show the effect of the south jetty, beachline curvature, and Tillamook Head on wave heights for the length of Clatsop Beach. The combination of refracting and blocking of waves from the south along with the southerly littoral drift 6 months each year is believed to account for the continued buildup of the south end of Clatsop Beach. Also it is believed that the predominant littoral drift in the erosion area is from south to north.

During winter months the seas are from the southerly quadrant and the littoral currents move the material north, but the steeper waves cause erosion of the beach and deposit offshore. This offshore movement of material could be one of the reasons for the lack of accretion from the south jetty to the node. Sand in this area is brought up-coast by seas from the south and is recirculated in a counter-clockwise direction along the south jetty, then back to the south by ebb currents from the estuary and onto the outer bar at the entrance to Columbia River by the flood currents. Another possible reason for the lack of accretion south of the jetty to the node is the inability of the waves from the north to move material into this area because it is in the lee of the south jetty. It is also interesting to note that the erosion-accretion nodal point occurs south of the jetty a distance which is approximately equal to the length of the jetty seaward of the beachline.

The erosion rate from the south jetty to the node appears to have been decreasing as the shore recedes and becomes less susceptible to angular wave attack. At the present time there are indications that this area is approaching stability.

Recent inspection of Clatsop Beach shows that sand accretion is presently occurring immediately south of the south jetty. This accretion is attributed to the extremely large deposit of debris, mainly logs and timbers, from the December 1964 floods. It is problematical as to the lasting effects of the accretion caused by the flood debris, but if the interlocked mass once is covered with sand, and beach grass and other vegetation become established, it will form a formidable barrier against wave attack and further erosion.

CONCLUSIONS

The erosion and accretion that have occurred on Clatsop Beach and in the vicinity of the south jetty offshore of the mouth of Columbia River during and since jetty construction can be considered to be at least partially the result of the south jetty. The south jetty restricted the ebb flow of the river around Point Adams to the south and caused a deepening of the area seaward of Clatsop Spit, subjecting the spit to intense ocean storm-wave attack. In addition, the jetty restricted the north and south circulation of sand on Clatsop Beach and, in general, starved the beach south of the jetty for about 3 miles. The starved portion of the beach apparently is presently approaching equilibrium, and the pattern of erosion and accretion that is now established can be explained by the seasonal littoral drift changes and the southerly ebb of Columbia River.

The investigations described and the resulting data presented herein, unless otherwise noted, were obtained from studies conducted by the United States Army Engineer District, Portland under continuing studies of accretion and erosion at the Columbia River entrance. Permission granted by the Chief of Engineers to publish this information is appreciated.

REFERENCES

McLaughlin, Willard T., and Brown, Robert L., September 1942, Circular No. 660, U. S. Department of Agriculture; Controlling coastal sand dunes in the Pacific Northwest.

Ballard Technical Report No. 98, University of Washington, Department of Oceanography.

U. S. Tidal Model Laboratory, Berkeley, California, June 15, 1935. Mouth of Columbia River beach erosion investigations, report on experiments, part I, July 1933-May 1935.

U. S. Tidal Model Laboratory, Berkeley, California, December 24, 1936. Mouth of Columbia River beach erosion investigations, summary of observations and results, July 1933-August 1935, Technical Memorandum No. 20.

National Marine Consultants, Inc., Santa Barbara, California, May 1961. Wave statistics for three deepwater stations along the Oregon-Washington shore.

National Marine Consultants, Inc., Santa Barbara, California, March 1961. Oceanographic study for Columbia River entrance.

FIGURES

9. Offshore depth comparison, 1877-1926.
10. Offshore depth comparison, 1926-1958.
11. Offshore depth comparison, 1958-1962.
12. Chart, Mouth of Columbia River, June-August 1939.
13. Shore cross sections, 1934, 1963 and 1964.
14.)
15.) Survey, Oct. 1964.
16.)
17. Chart of Clatsop Beach shoreline.

ACKNOWLEDGMENT

The investigations described and the resulting data presented herein, unless otherwise noted, were obtained from studies conducted under the Clatsop Beach Surveillance Program of the United States Corps of Engineers by the Portland District. The permission granted by the Chief of Engineers to publish this information is appreciated.

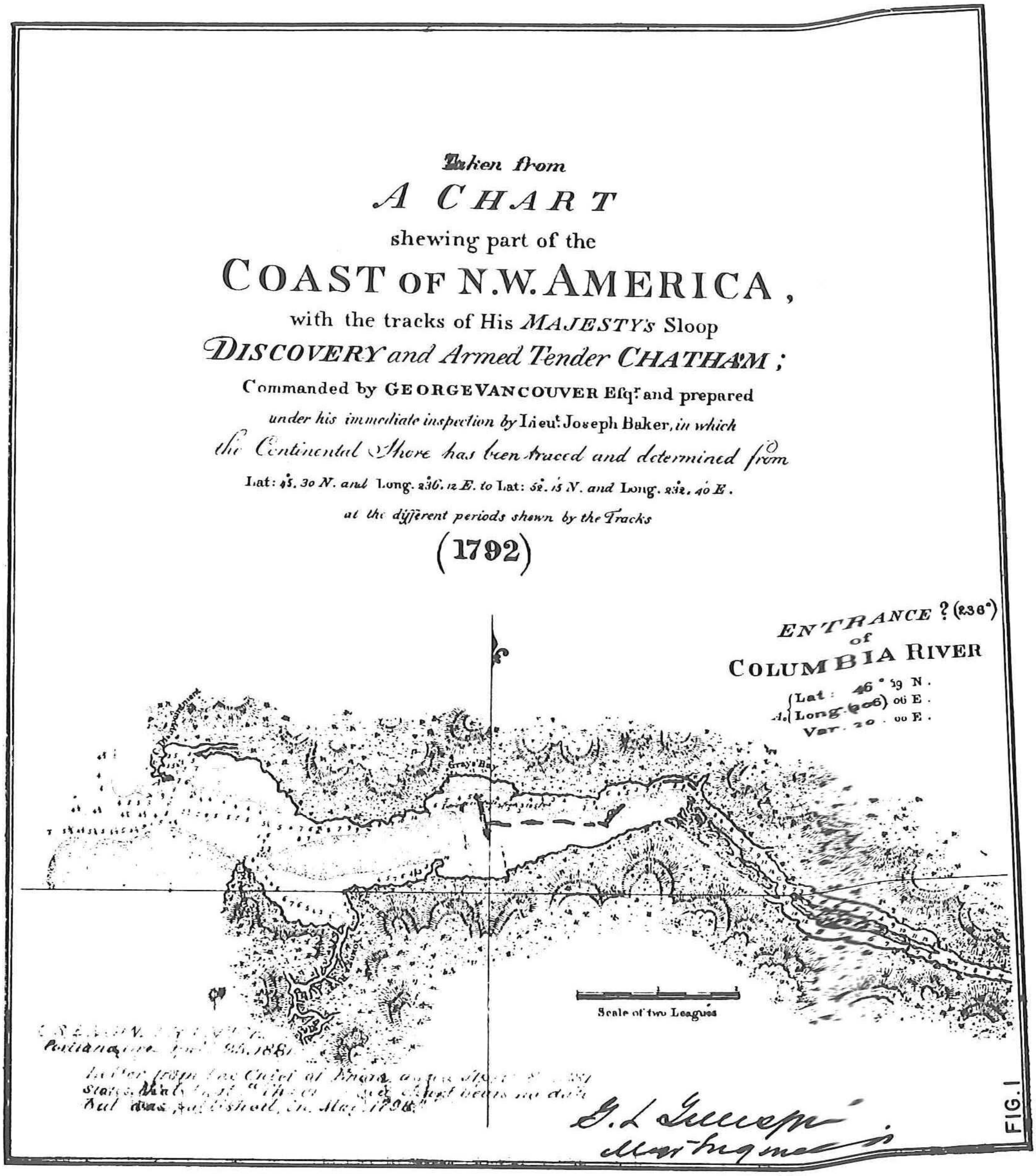

Taken from
A CHART
shewing part of the
COAST OF N.W. AMERICA,
with the tracks of His MAJESTY's Sloop
DISCOVERY and Armed Tender CHATHAM;
Commanded by GEORGE VANCOUVER Esqr. and prepared
under his immediate inspection by Lieut. Joseph Baker, in which
the Continental Shore has been traced and determined from
Lat: 45. 30 N. and Long. 236. 12 E. to Lat: 52. 15 N. and Long. 232. 40 E.
at the different periods shown by the Tracks
(1792)
ENTRANCE ? (236°)
of
COLUMBIA RIVER
Lat: 46° 19 N.
Long. (236) 06 E.
Var. 20 . 00 E.
Scale of two Leagues

FIG. I

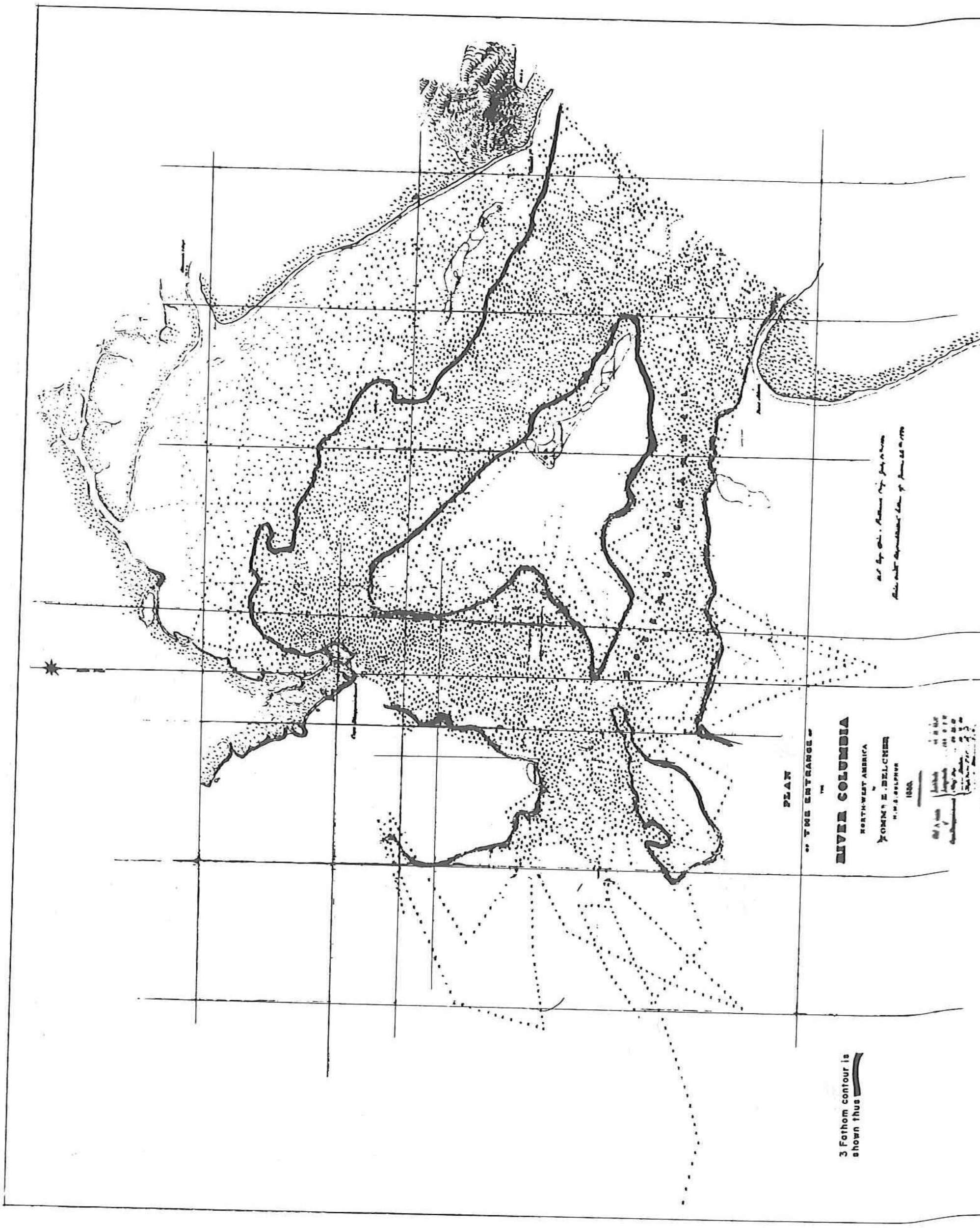

PLAN
RIVER COLUMBIA
NORTH-WEST AMERICA
3 Fathom contour is shown thus

FIG. 2

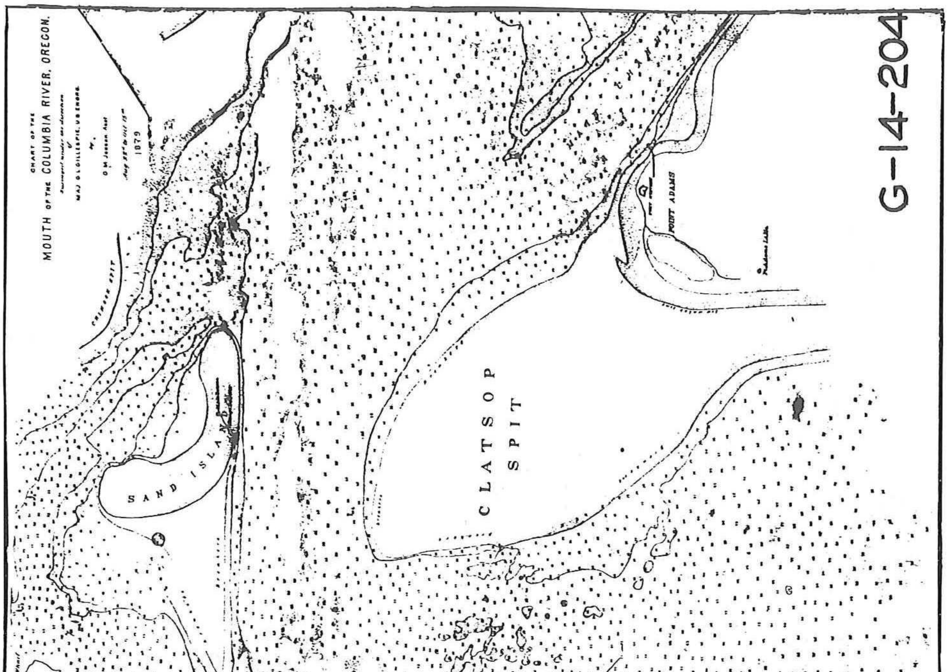

MOUTH OF THE COLUMBIA RIVER, OREGON.
1879
SAND ISLAND
CLATSOP SPIT
FORT ADAMS
NORTH BREAKERS
SANDS
G-14-204

FIG. 3

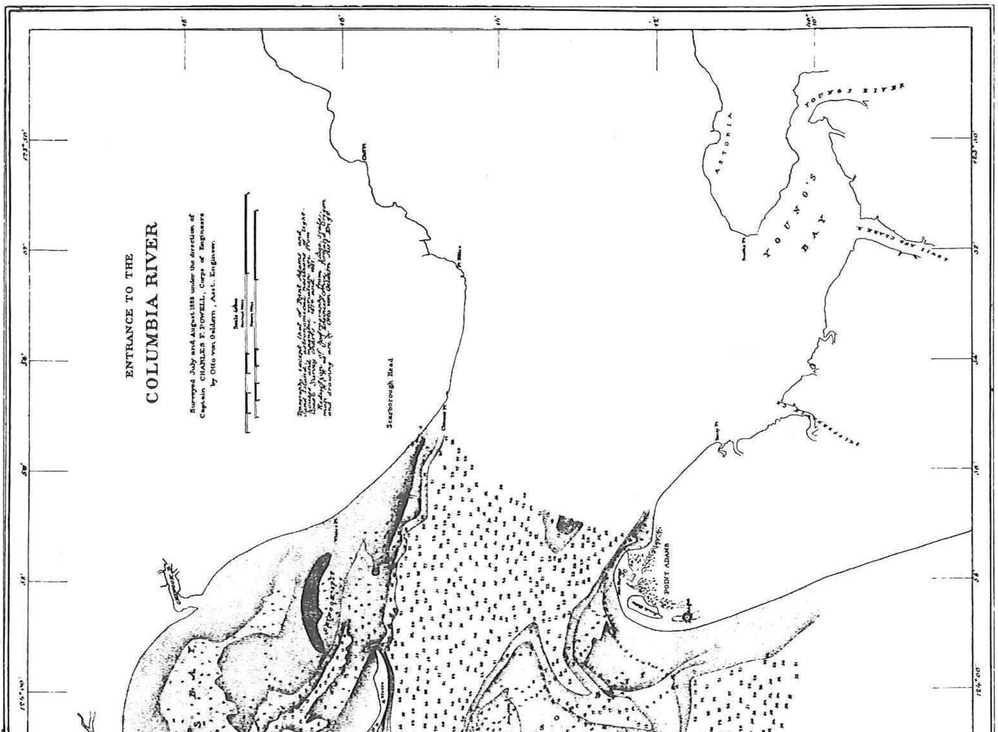

ENTRANCE TO THE
COLUMBIA RIVER
Scarborough Head
POINT ADAMS
CAPE DISAPPOINTMENT
ASTORIA
YOUNG'S BAY
J-1-18

FIG. 4

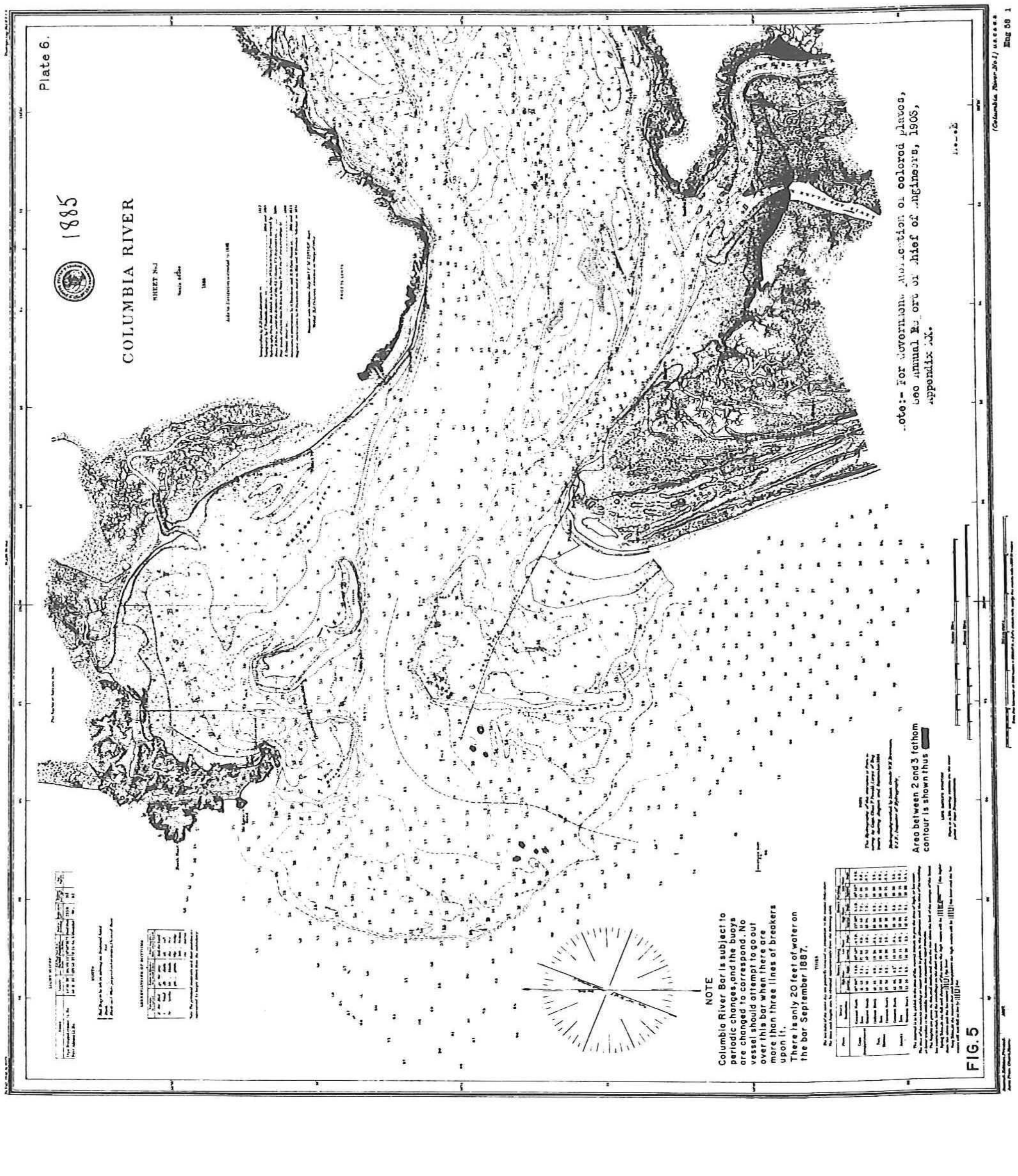


Plate 6.
1885
COLUMBIA RIVER
NOTE
Columbia River Bar is subject to periodic changes, and the buoys are changed to correspond. No vessel should attempt to go out over this bar when there are more than three lines of breakers upon it.
There is only 20 feet of water on the bar September 1887.
Area between 2 and 3 fathom contour is shown thus

FIG. 5

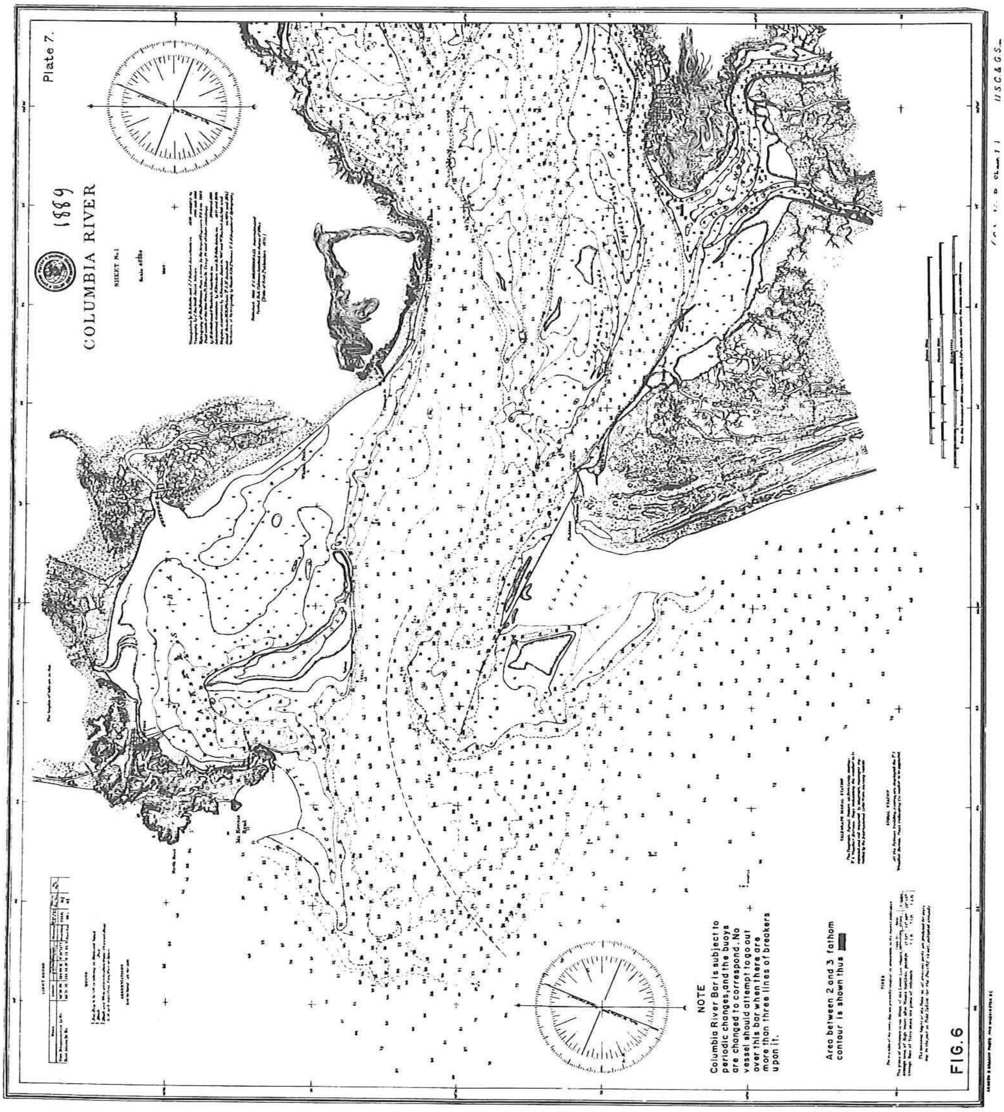


Plate 7.
COLUMBIA RIVER
1889
NOTE
Columbia River Bar is subject to periodic changes, and the buoys are changed to correspond. No vessel should attempt to go out over this bar when there are more than three lines of breakers upon it.
Area between 2 and 3 fathom contour is shown thus

FIG. 6

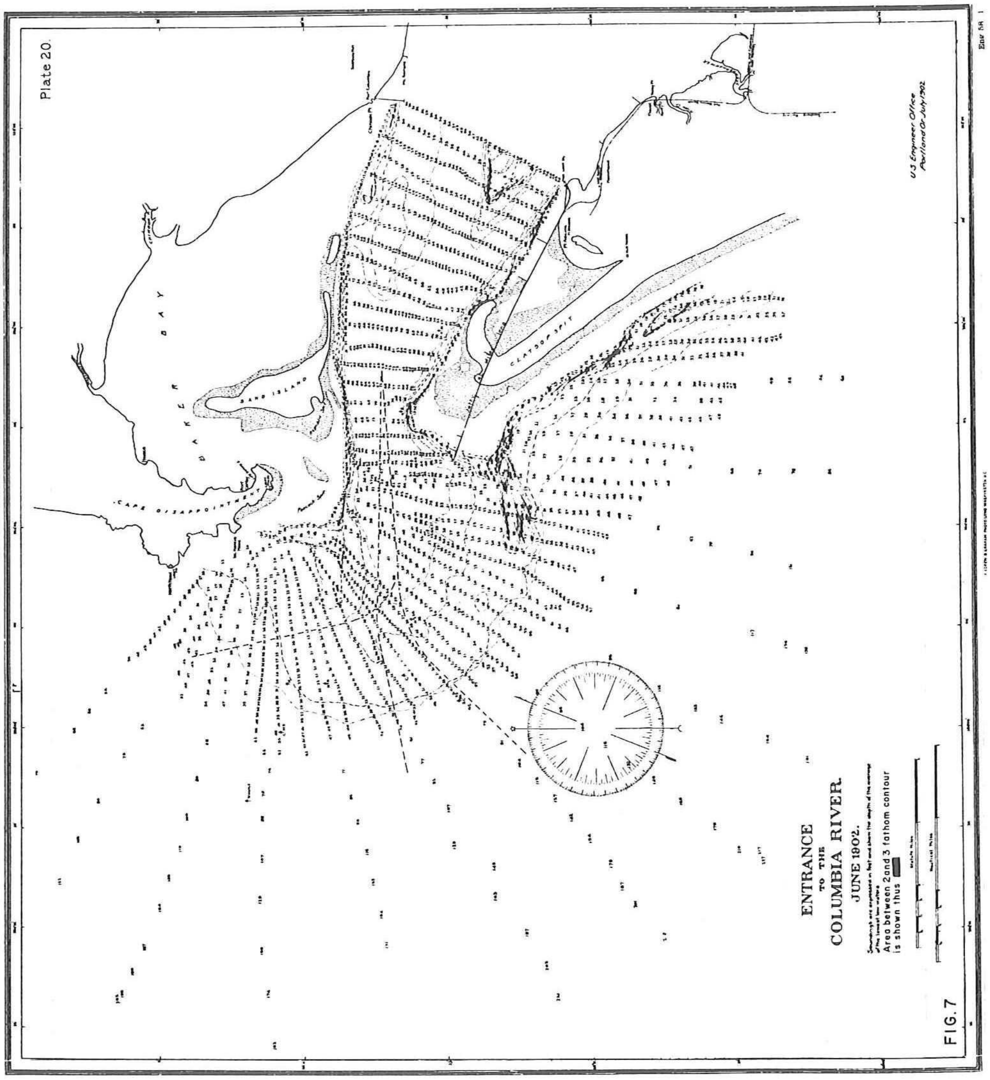
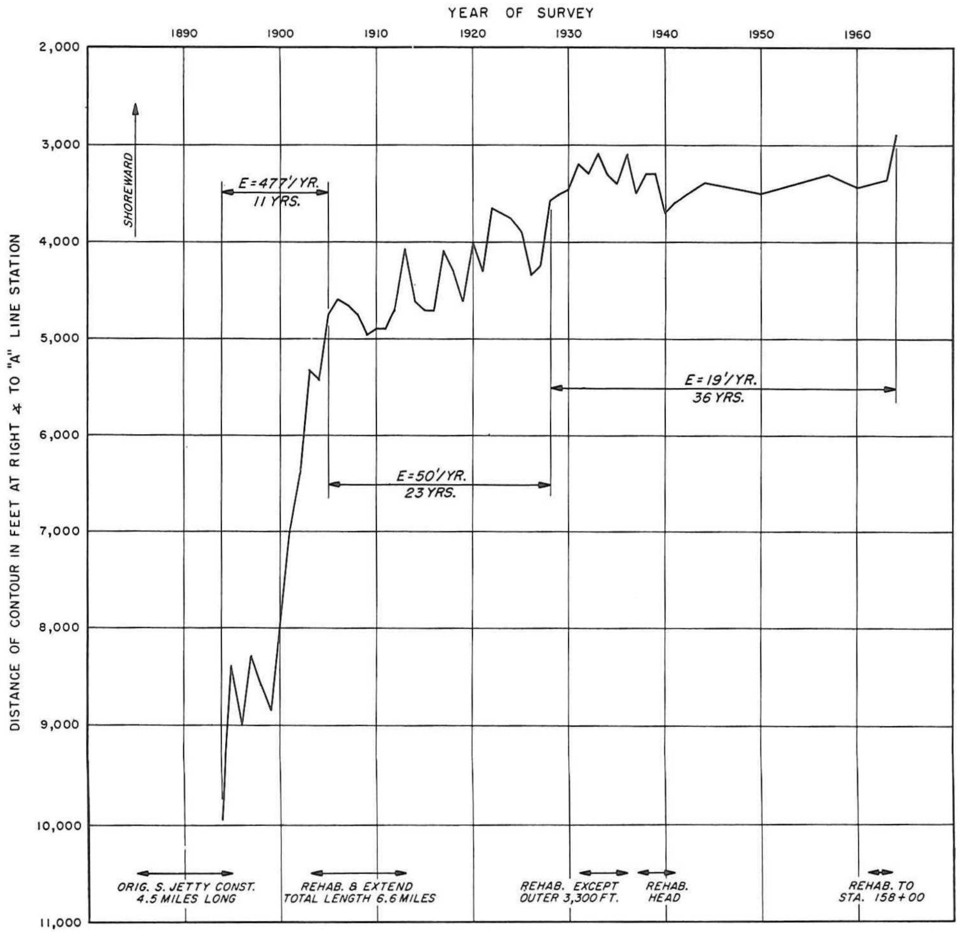


Plate 20.
CLATSOP SPIT
BAKER BAY
SAND ISLAND
CAPE DISAPPOINTMENT
U.S. Engineer Office Portland Or. July 1902.
ENTRANCE TO THE COLUMBIA RIVER
JUNE 1902.
Area between 2 and 3 fathom contour is shown thus
FIG. 7



LEGEND

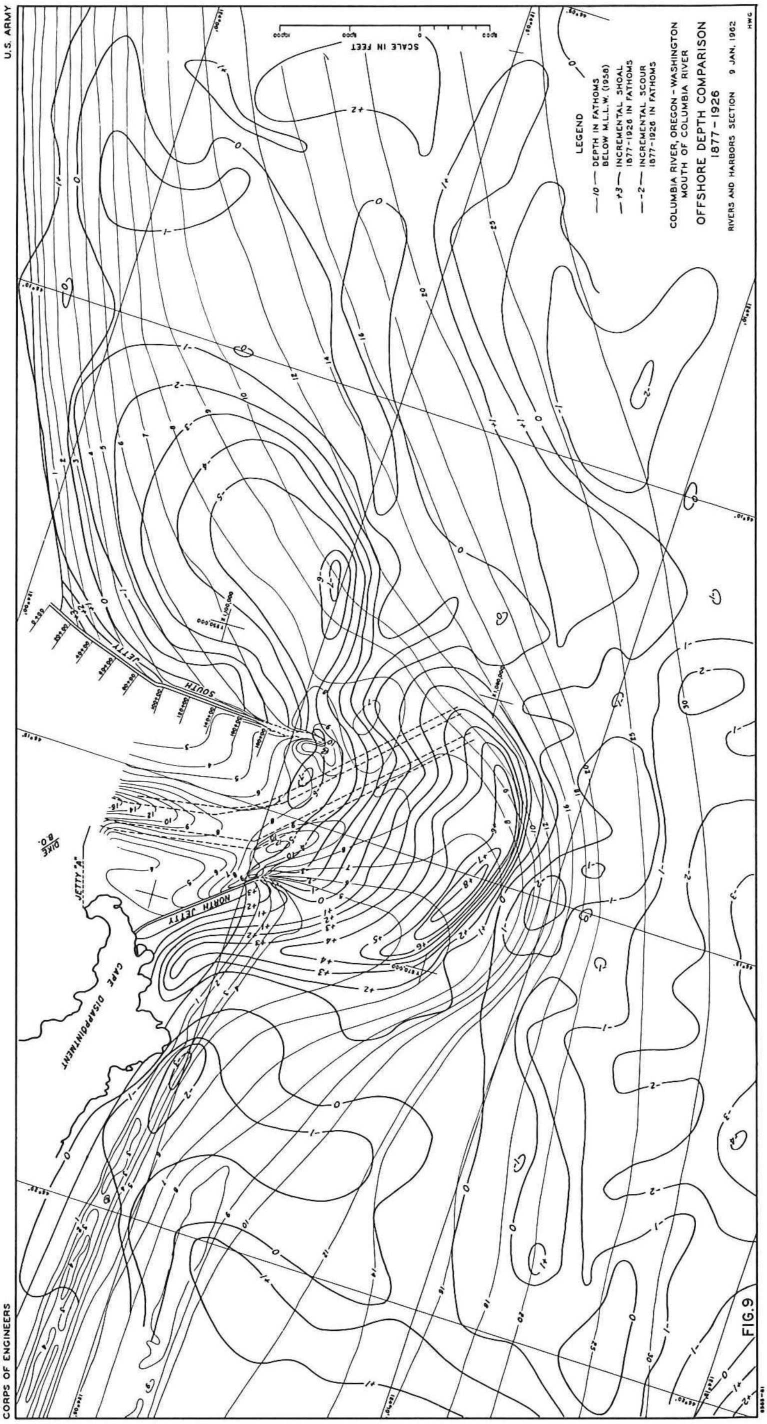
E = EROSION

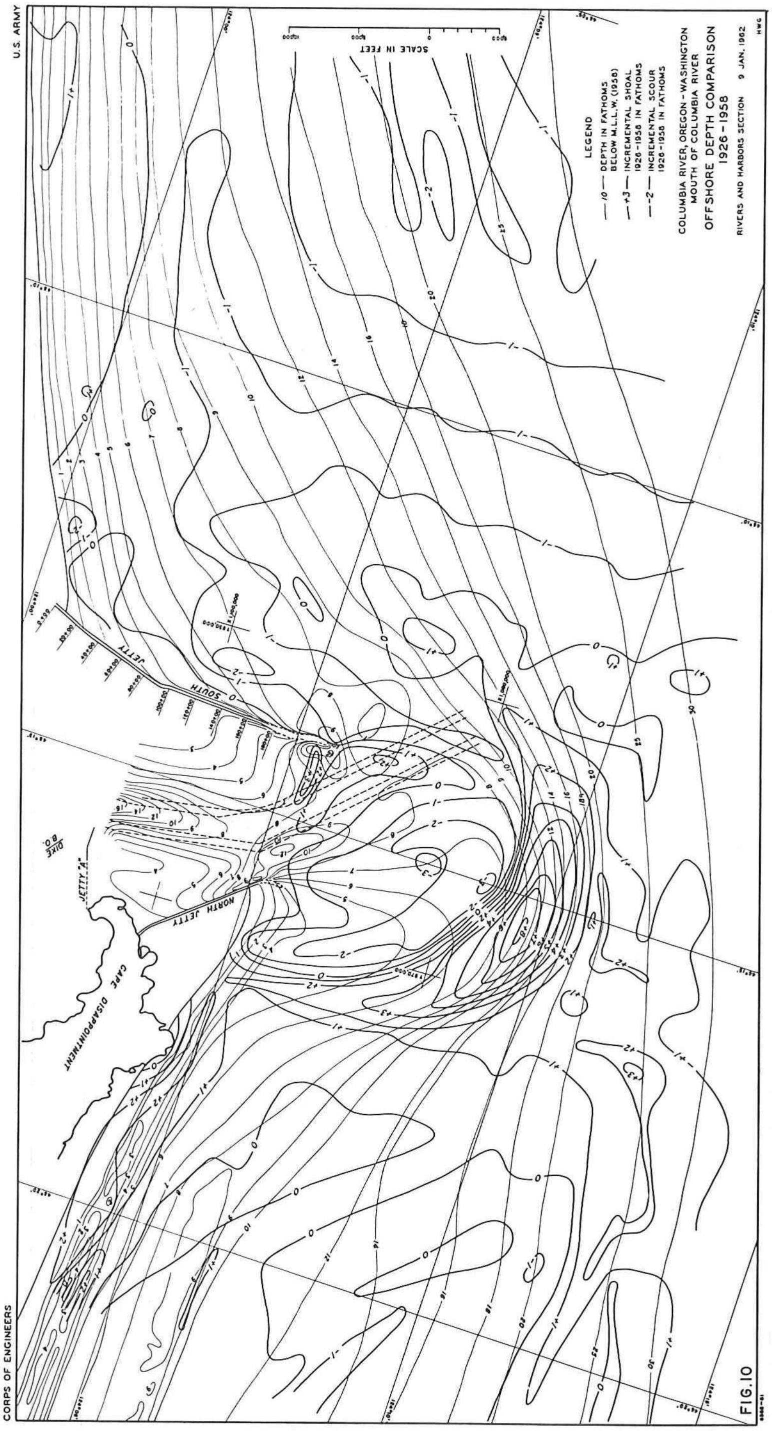
A = ACCRETION

COLUMBIA RIVER AT THE MOUTH
OREGON - WASHINGTON
CLATSOP BEACH SURVEILLANCE PROGRAM
EROSION STUDIES
STA. A- 0+00
-20 FT. M.L.L.W. CONTOUR
U.S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

FIG. 8

7823-64


U.S. ARMY
CORPS OF ENGINEERS
SCALE IN FEET
LEGEND
—10— DEPTH IN FATHOMS BELOW M.L.L.W. (1958)
—+3— INCREMENTAL SHOAL 1877-1926 IN FATHOMS
—-2— INCREMENTAL SCOUR 1877-1926 IN FATHOMS
COLUMBIA RIVER, OREGON - WASHINGTON
MOUTH OF COLUMBIA RIVER
OFFSHORE DEPTH COMPARISON
1877-1926
RIVERS AND HARBORS SECTION 9 JAN. 1962
HWG
SOUTH JETTY
NORTH JETTY
JETTY "A"
CAPE DISAPPOINTMENT
FIG. 9


U.S. ARMY
CORPS OF ENGINEERS
SCALE IN FEET
LEGEND
10 — DEPTH IN FATHOMS BELOW M.L.L.W. (1958)
+3 — INCREMENTAL SHOAL 1926-1958 IN FATHOMS
-2 — INCREMENTAL SCOUR 1926-1958 IN FATHOMS
COLUMBIA RIVER, OREGON-WASHINGTON
MOUTH OF COLUMBIA RIVER
OFFSHORE DEPTH COMPARISON
1926-1958
RIVERS AND HARBORS SECTION 9 JAN. 1962
SOUTH JETTY
NORTH JETTY
JETTY "A"
DIKE 80.
CAPE DISAPPOINTMENT
FIG.10

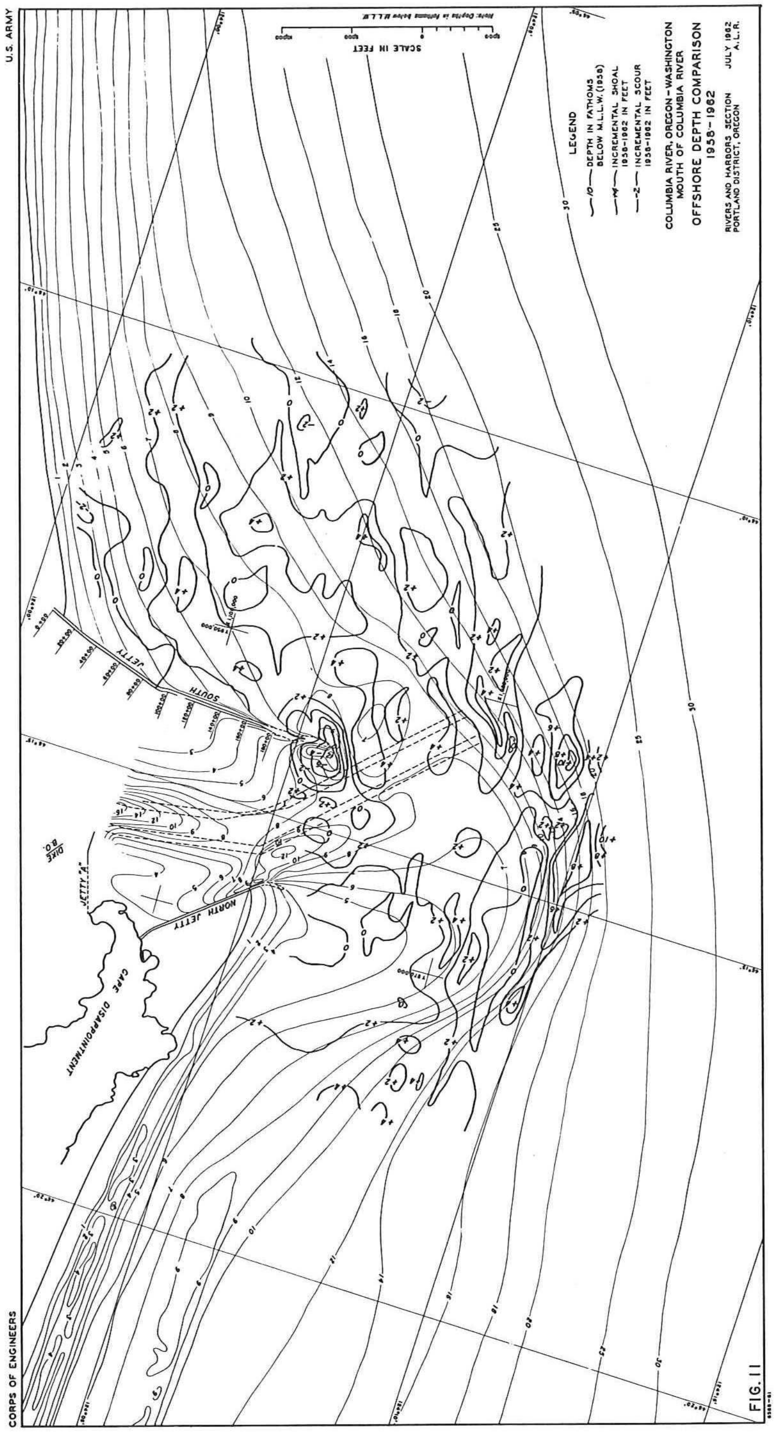
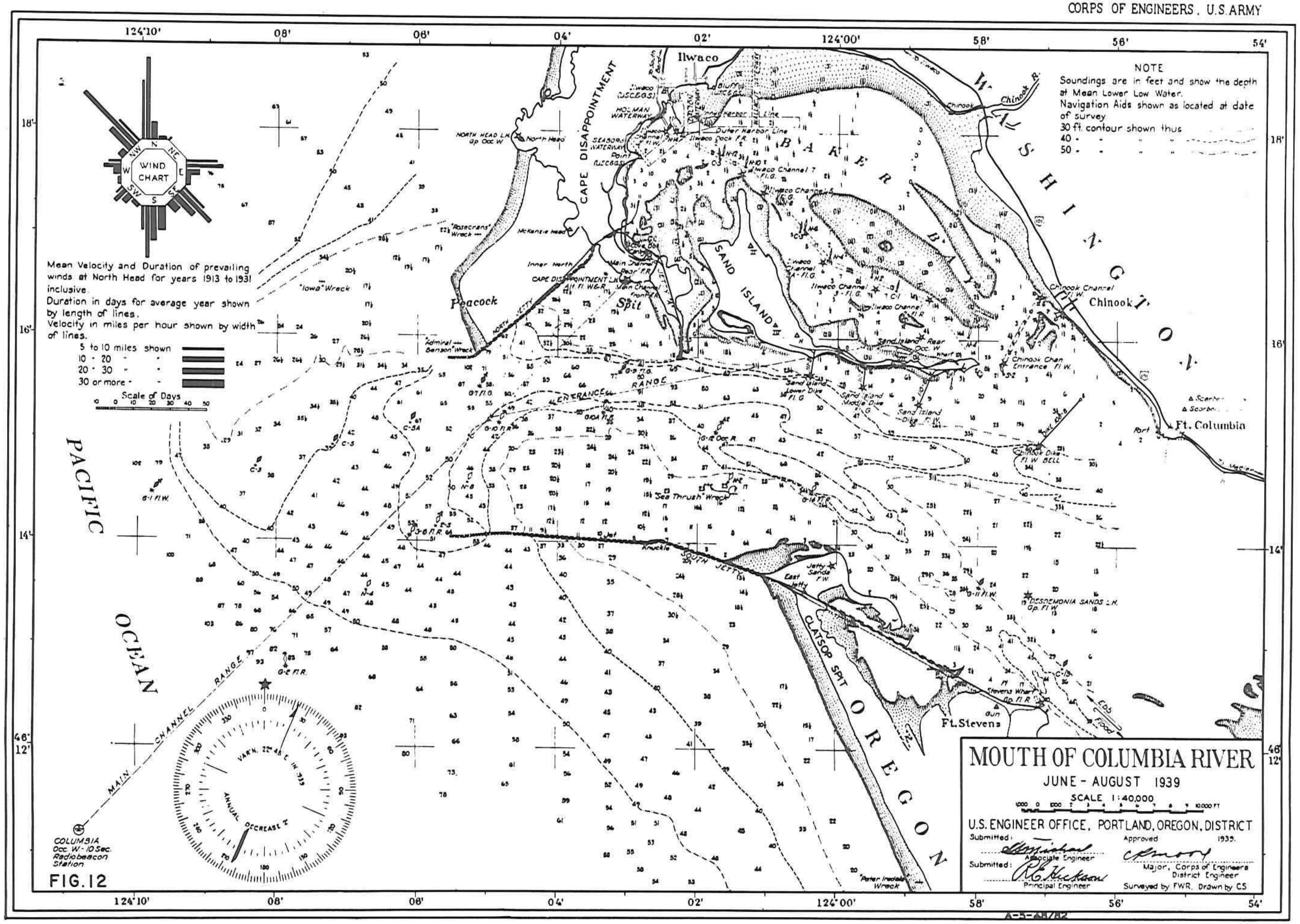

U.S. ARMY
CORPS OF ENGINEERS
SCALE IN FEET
LEGEND
DEPTH IN FATHOMS BELOW M.L.L.W. (1958)
INCREMENTAL SHOAL 1958-1962 IN FEET
INCREMENTAL SCOUR 1958-1962 IN FEET
COLUMBIA RIVER, OREGON-WASHINGTON
MOUTH OF COLUMBIA RIVER
OFFSHORE DEPTH COMPARISON
1958-1962
RIVERS AND HARBORS SECTION
PORTLAND DISTRICT, OREGON
JULY 1962
A.L.R.
SOUTH JETTY
NORTH JETTY
JETTY "A"
CAPE DISAPPOINTMENT

FIG. 11

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



MC-4-1/85

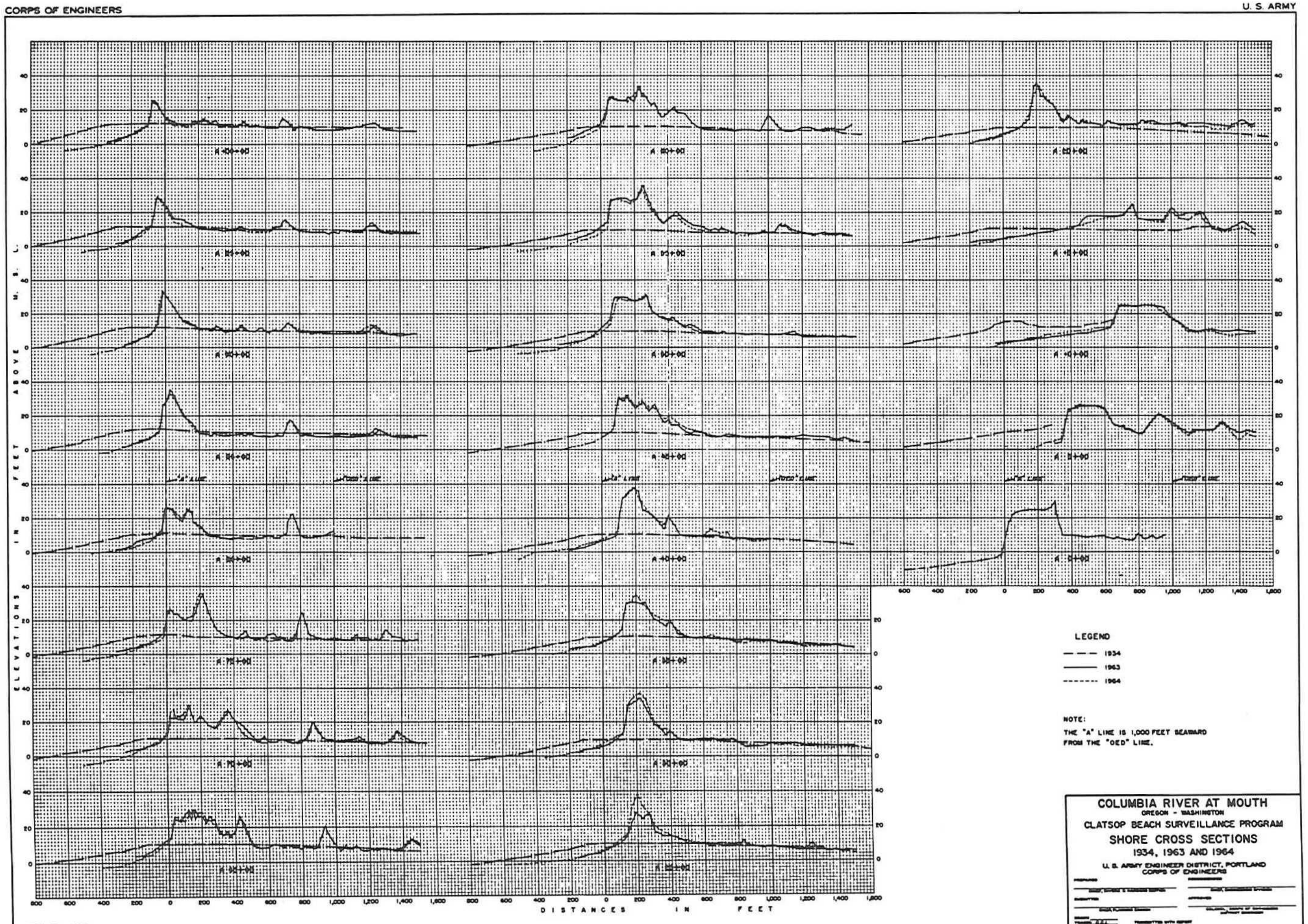

CORPS OF ENGINEERS
U. S. ARMY
ELEVATIONS IN FEET ABOVE M. S. L.
"A" LINE
"OED" LINE
DISTANCES IN FEET
LEGEND
1934
1963
1964
NOTE:
THE "A" LINE IS 1,000 FEET SEAWARD FROM THE "OED" LINE.
COLUMBIA RIVER AT MOUTH
OREGON - WASHINGTON
CLATSOP BEACH SURVEILLANCE PROGRAM
SHORE CROSS SECTIONS
1934, 1963 AND 1964
U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

FIG. 13

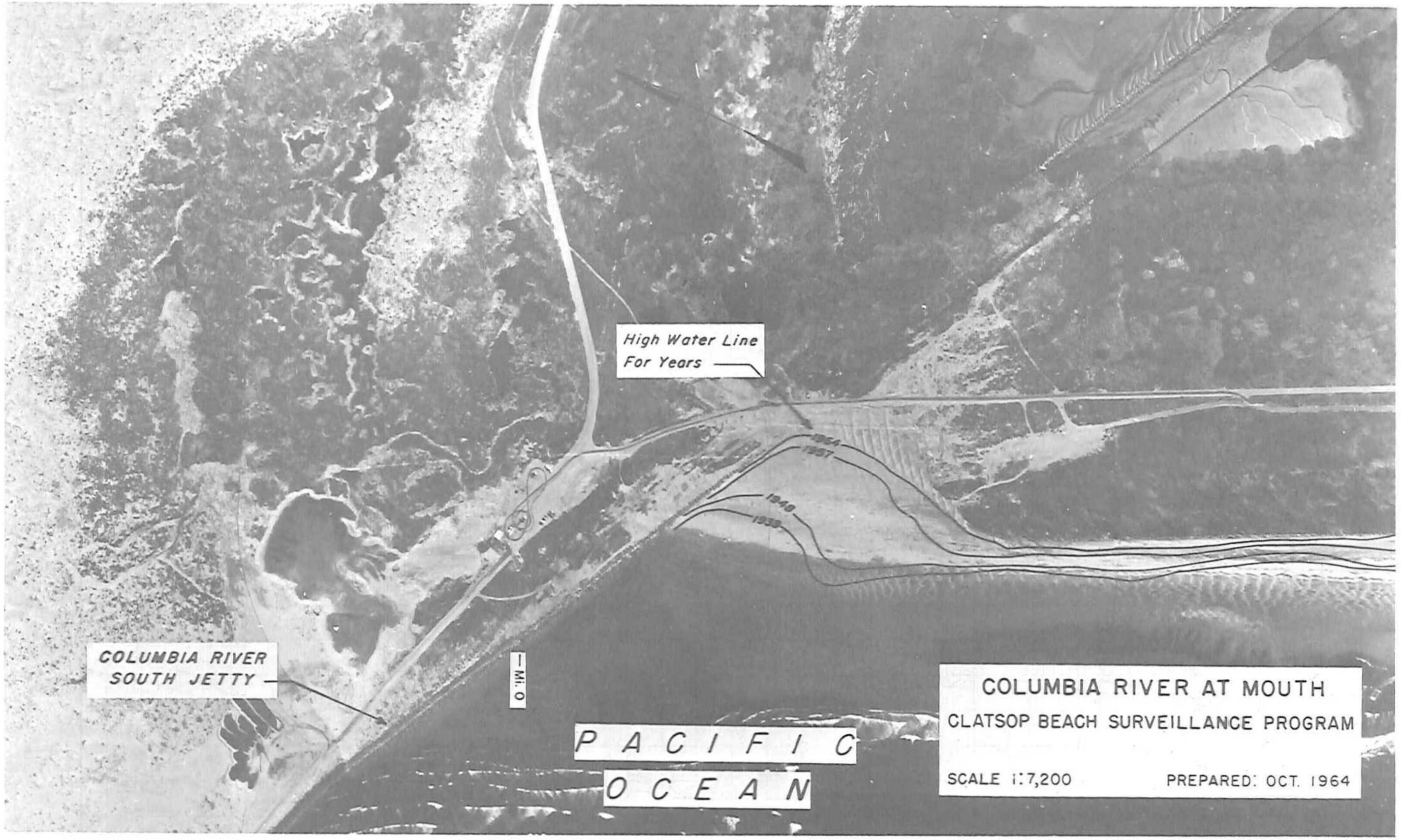

High Water Line
For Years
1964
1957
1949
1939
COLUMBIA RIVER
SOUTH JETTY
MI. O
PACIFIC
OCEAN
COLUMBIA RIVER AT MOUTH
CLATSOP BEACH SURVEILLANCE PROGRAM
SCALE 1:7,200
PREPARED: OCT. 1964

Fig. 14

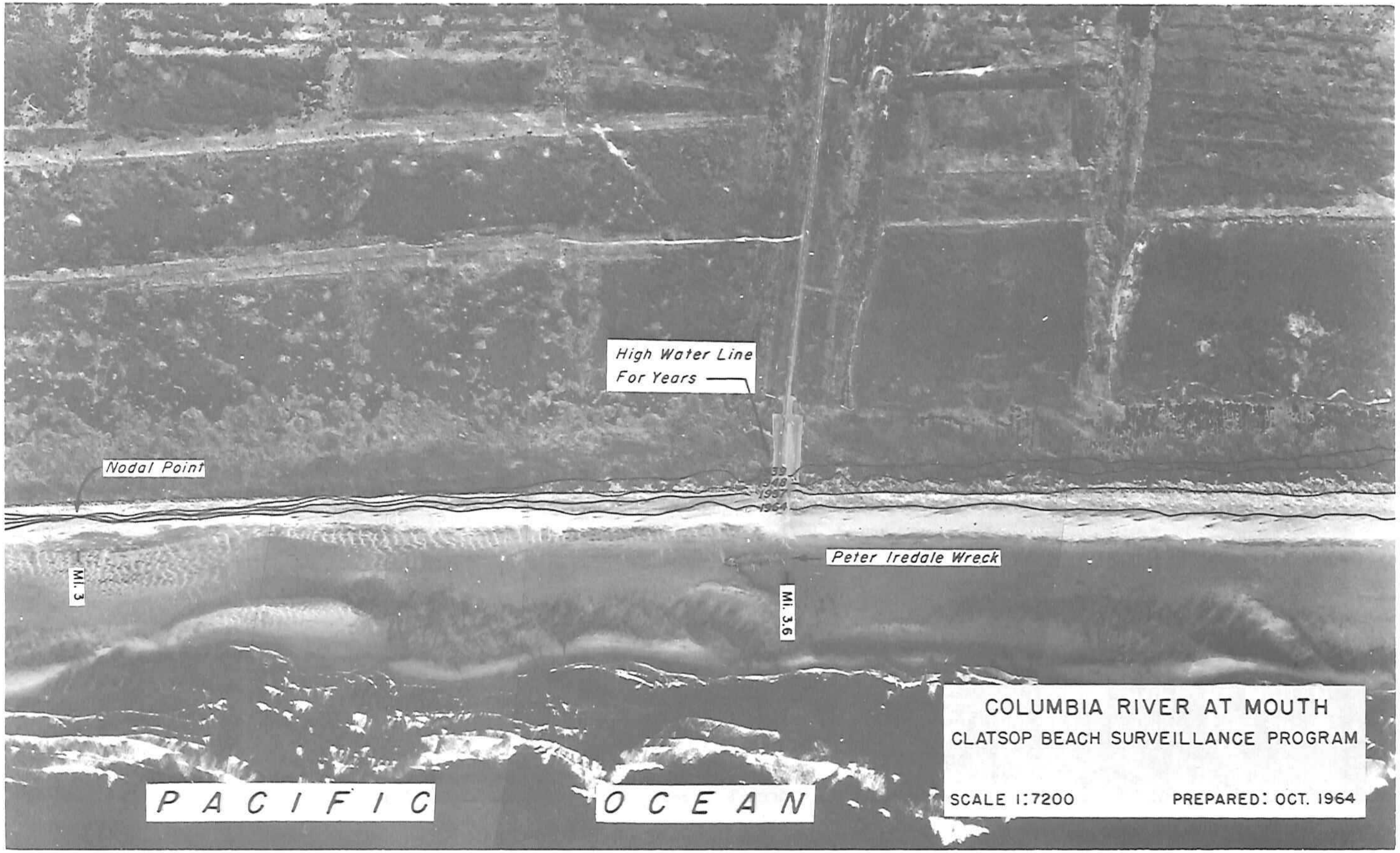

High Water Line
For Years
Nodal Point
1948
1957
1964
Peter Iredale Wreck
Mi. 3
Mi. 3.6
COLUMBIA RIVER AT MOUTH
CLATSOP BEACH SURVEILLANCE PROGRAM
SCALE 1:7200
PREPARED: OCT. 1964
PACIFIC
OCEAN

Fig. 1

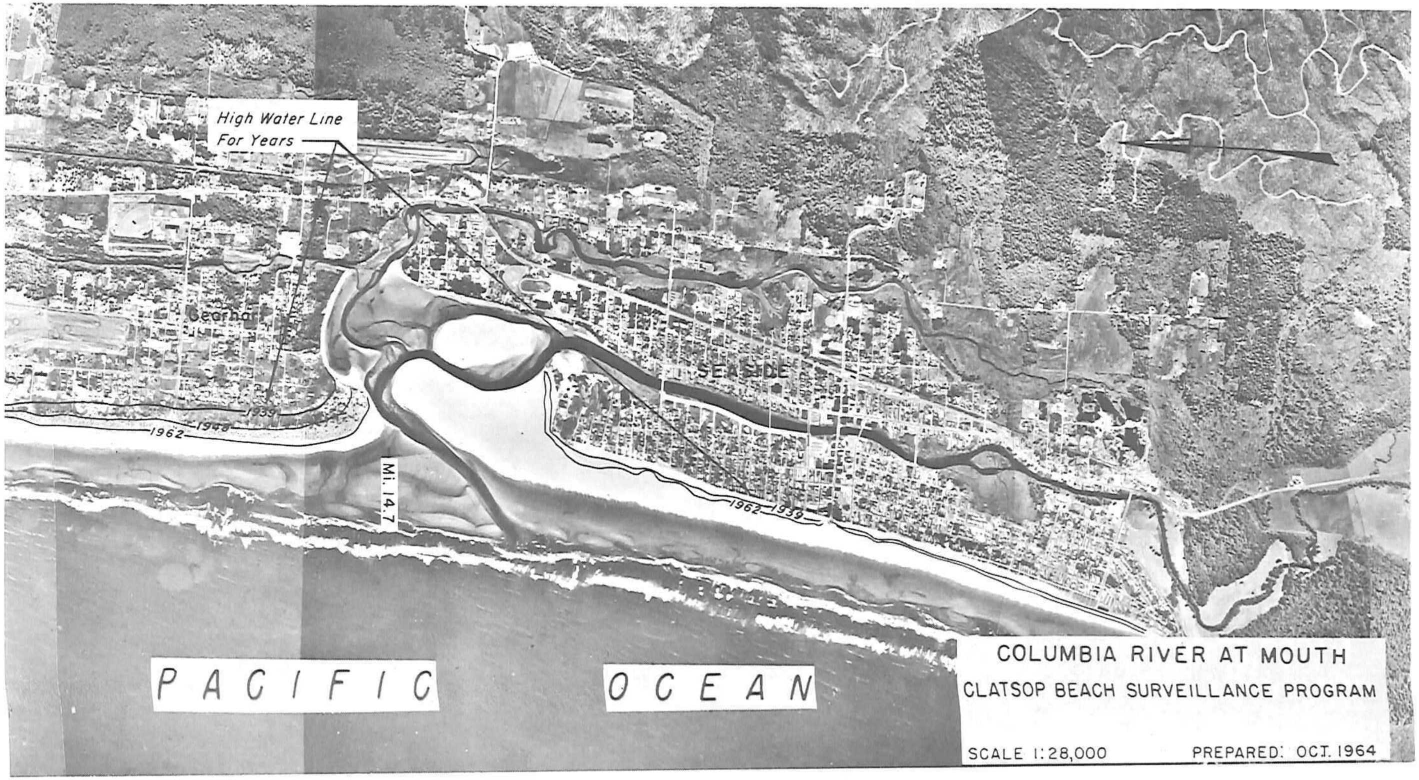

High Water Line
For Years
Gearhart
SEASIDE
1939
1949
1962
1962
1939
Mi. 14.7
PACIFIC
OCEAN
COLUMBIA RIVER AT MOUTH
CLATSOP BEACH SURVEILLANCE PROGRAM
SCALE 1:28,000
PREPARED: OCT. 1964

Fig. 16

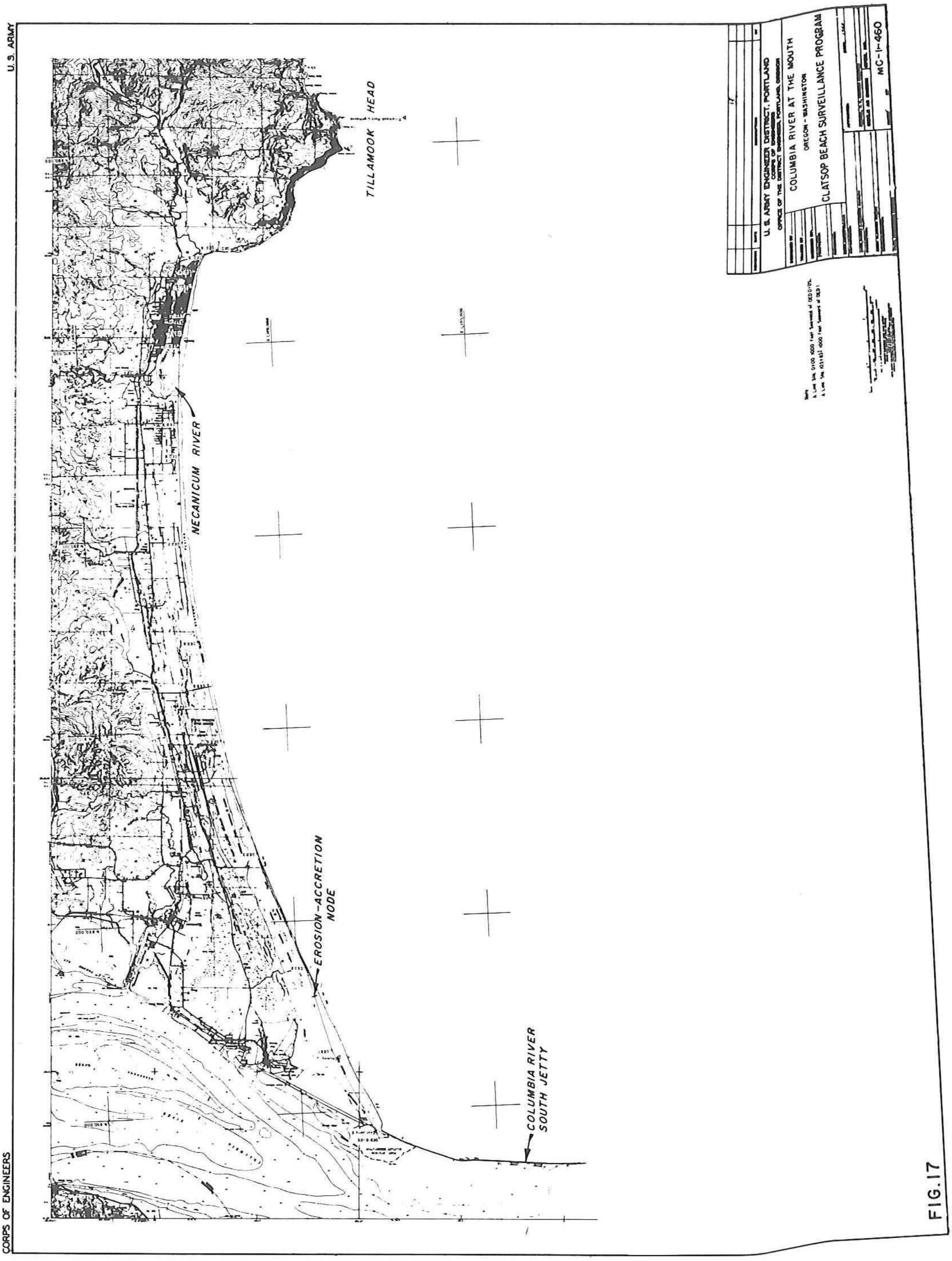

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FIG. 17