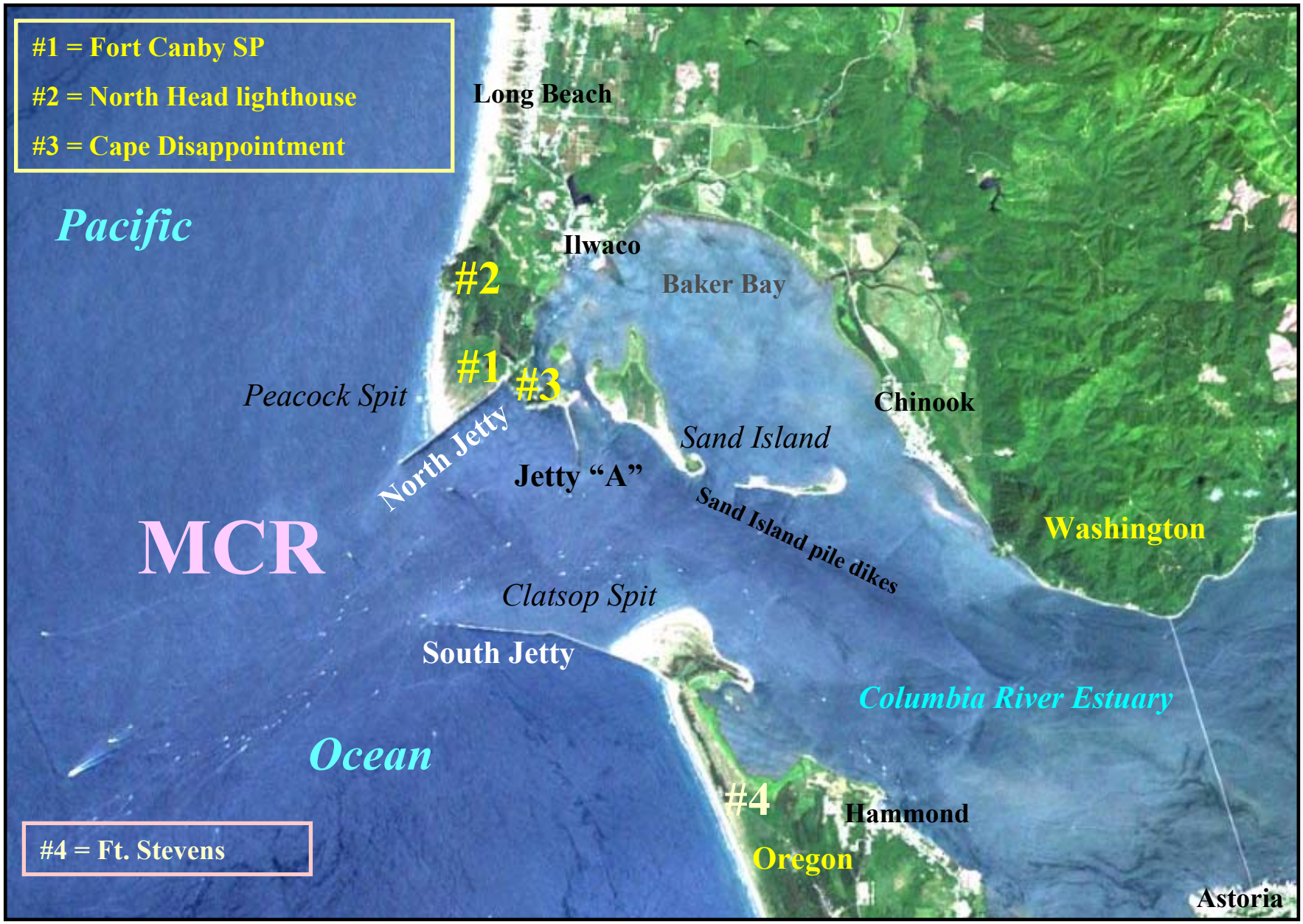
An Overview of Mouth of Columbia River

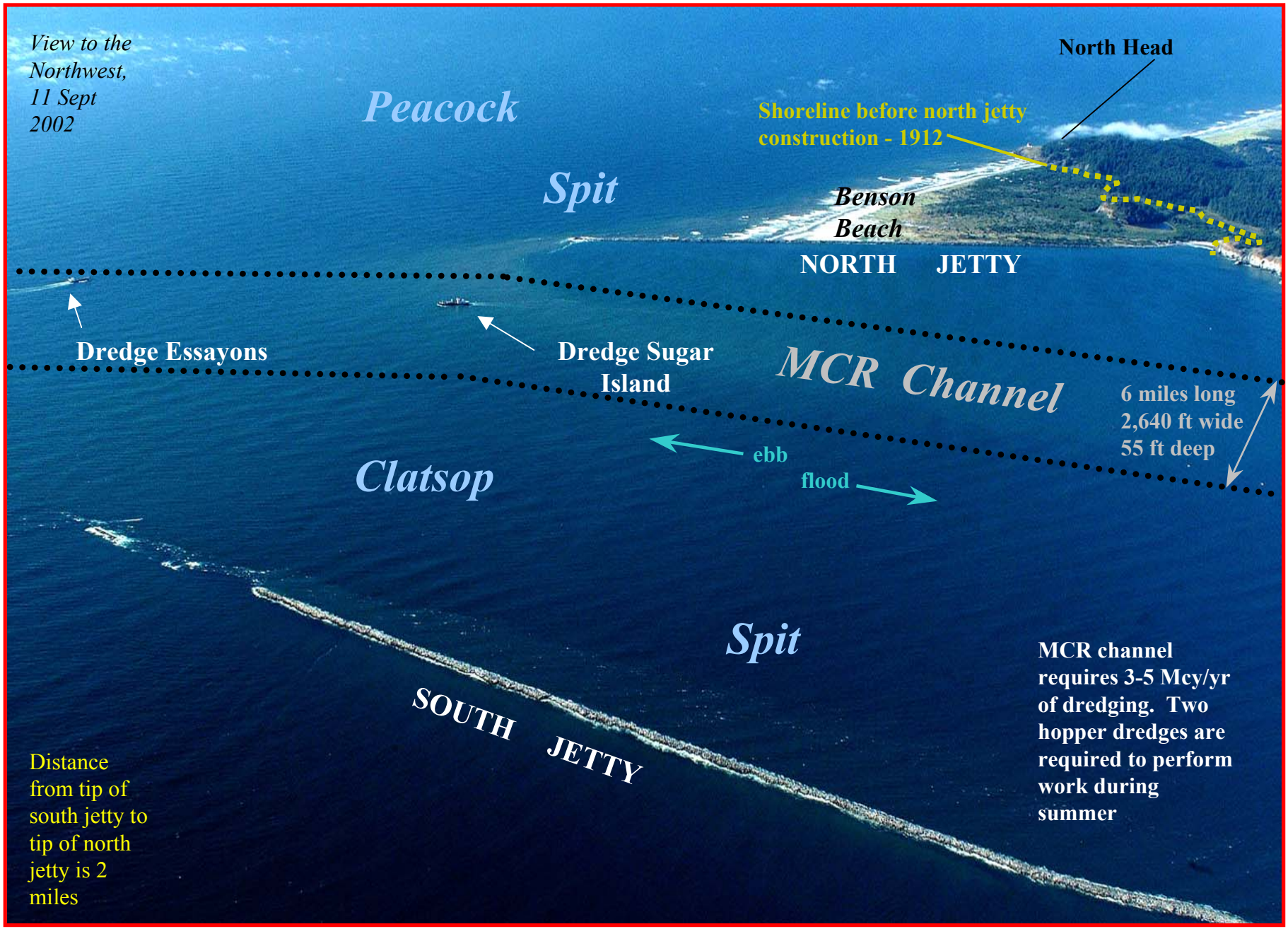
The 1200-mile long Columbia River is head-watered in the Canadian Rockies and its drainage basin is 259,000 miles^2. Pre-historic "glacial-melt" floods produced cataclysmic flows of the Columbia that exceeded 50 million cfs. Historical peak river flow exceeded 1 million cfs (1894) causing extensive damage to infrastructure and communities on the lower Columbia River, including Portland. Through flow "regulation" by dams, present peak river flow is usually less than 500 kcfs and typically ranges between 150 - 300 kcfs (since 1974). There are now 200 dams within the Columbia basin. The dams provide for flood control, power generation, irrigation, recreation, and navigation.

A 40-ft deep draft channel extends inland 104 miles from the mouth of the Columbia to Portland, OR and a 14-ft (or deeper) navigation channel extends inland 430 miles from Portland to Lewiston, ID. The Columbia - Snake River navigation systems provides for efficient movement of commerce from the western slopes of the Rockies to the Pacific Ocean. Each year, ocean-going vessels on the Columbia River transport some $14 billion worth of U.S. products to world markets and 48 million tons of cargo passes thru MCR annually . The lower Columbia River comprises the world's second largest grain export system, next to the Mississippi River. More than 40 % of the United States' wheat exports are shipped via ports on the Columbia and Willamette rivers. More than 12,000 commercial vessels and 100,000 recreational/charter vessels navigate through the MCR annually.

The Mouth of the Columbia River (MCR) is the ocean gateway for maritime navigation to/from the Columbia - Snake River navigation system. The deep draft navigation channel at MCR is now 6 miles long, 2640 ft wide, and nominally 55 ft deep. The U.S. Army, Corps of Engineers, Portland District, (Corps) is responsible for maintaining the deep draft channel at the Mouth of the Columbia River (MCR), where 3-5 million cubic yards of SAND is dredged per year from the 6-mile long entrance channel. The dredged sand is placed in open water disposal sites. The ocean entrance at MCR is characterized by large waves and strong currents and has been considered one of the world's most dangerous coastal inlets. The sea state at the river entrance during storm conditions is characterized by high swell approaching from the northwest to southwest combined with locally generated wind waves from the south to northwest. During October-April average wave height and period is 9 ft (2.7 m) and 12 seconds, respectively. During intense winter storms, waves can exceed 30 ft (9 m). During May-September, average wave height and period is 5 ft (1.5 m) and 9 seconds, respectively. Astronomical tides at MCR are mixed semi-diurnal with a diurnal range of 7.5 ft (2.3m). The instantaneous flow rate of estuarine water through the MCR during ebb tide can reach 1.8 million cfs (51,000 m3/sec).

Mouth of Columbia River (MCR)




View to the Northwest, 11 Sept 2002
Peacock Spit
North Head
Shoreline before north jetty construction - 1912
Benson Beach
NORTH JETTY
Dredge Essayons
Dredge Sugar Island
MCR Channel
6 miles long
2,640 ft wide
55 ft deep
ebb
flood
Clatsop Spit
SOUTH JETTY
MCR channel requires 3-5 Mcy/yr of dredging. Two hopper dredges are required to perform work during summer
Distance from tip of south jetty to tip of north jetty is 2 miles

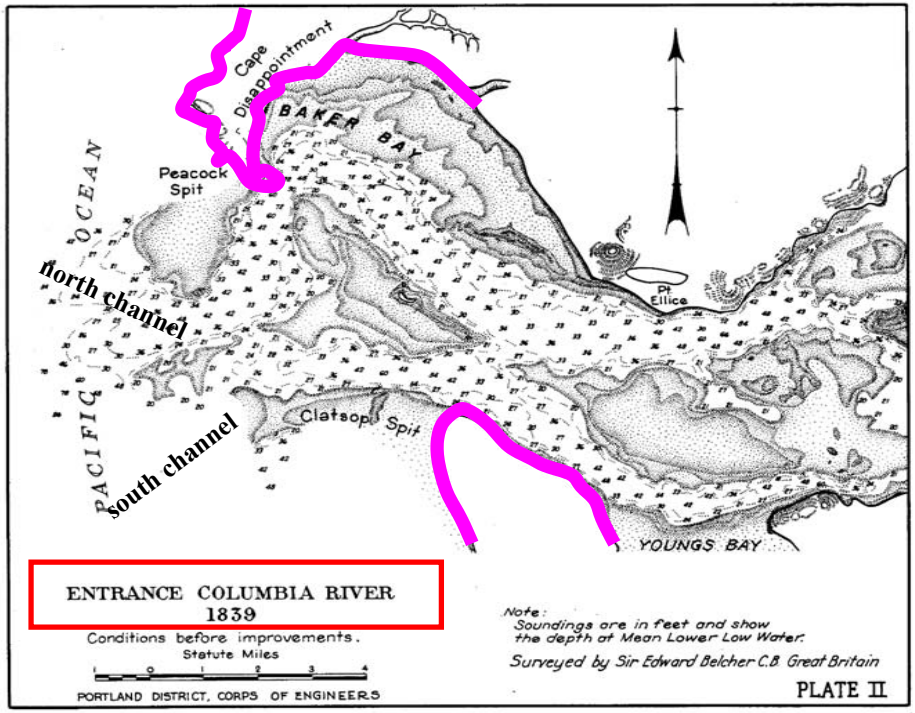
Almost 2,000 vessels of all types and 700 lives have been claimed by the treacherous waters off the MCR over the past 300 years.

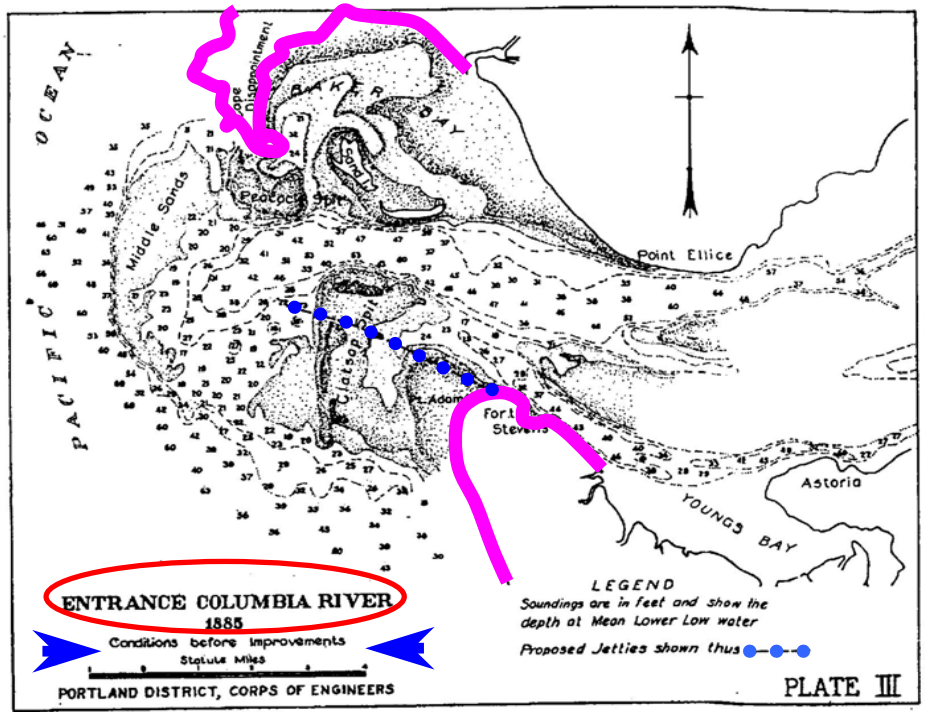
Rumors of a River of the West existed as early as 1570 when Flemish geographer Ortelius (Abraham Oertel) showed some waterway draining western North America on his map of the world. Robert Gray entered the mouth of the River of the West in the 212-ton "Columbia Rediviva" (which drew 6 to 8 feet of water) on May 11, 1792, giving the river its name. The Columbia Bar earned its moniker "Graveyard of the Pacific" during the 1849 California Goldrush.

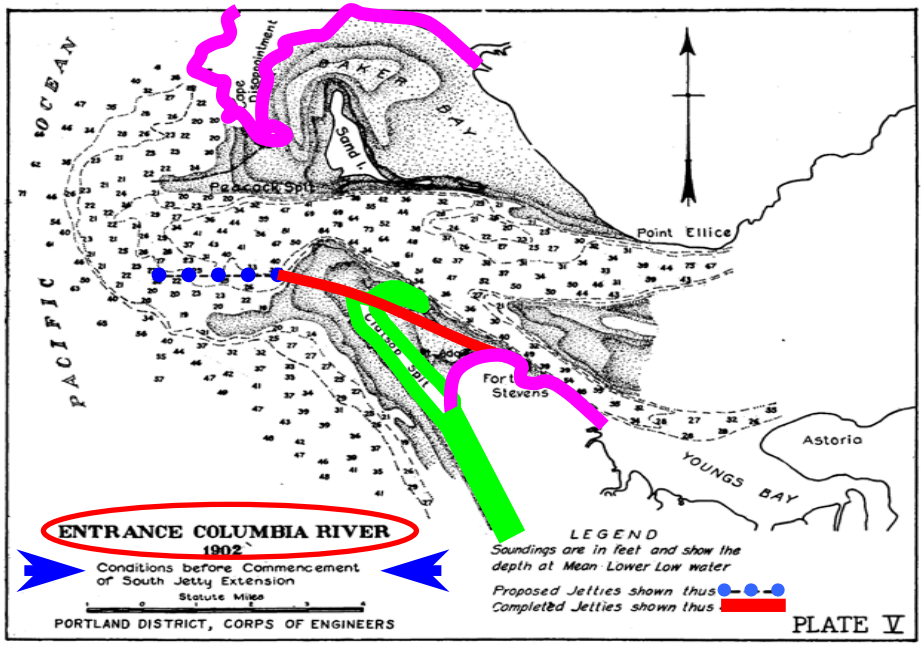
In the days before modern aids to navigation, sailors sometimes had little idea where they were in relation to the shore, especially during raging winter storms that can last for weeks. Even when visibility was acceptable, ships often had trouble traversing the Columbia River bar, the area in which the gigantic flow of the river rushes headlong into towering ocean waves. To make the business of navigating thru the MCR even worse, sailing ships had to approach either of the two natural channels (north channel or south channel) abeam to the wind and waves. The natural channels often shifted widely within the course of several tidal cycles. MCR bar pilots were highly valued and carried a mystic all their own. Lighthouses at Cape Disappointment and the North Head drastically improved the safety for mariners near the mouth of the Columbia River. Built in 1856 and 1889 respectively, the two lights drastically reduced the number of vessels and human lives lost in the waters of the Pacific. But safe and consistent navigation - commerce thru the MCR was still problematic

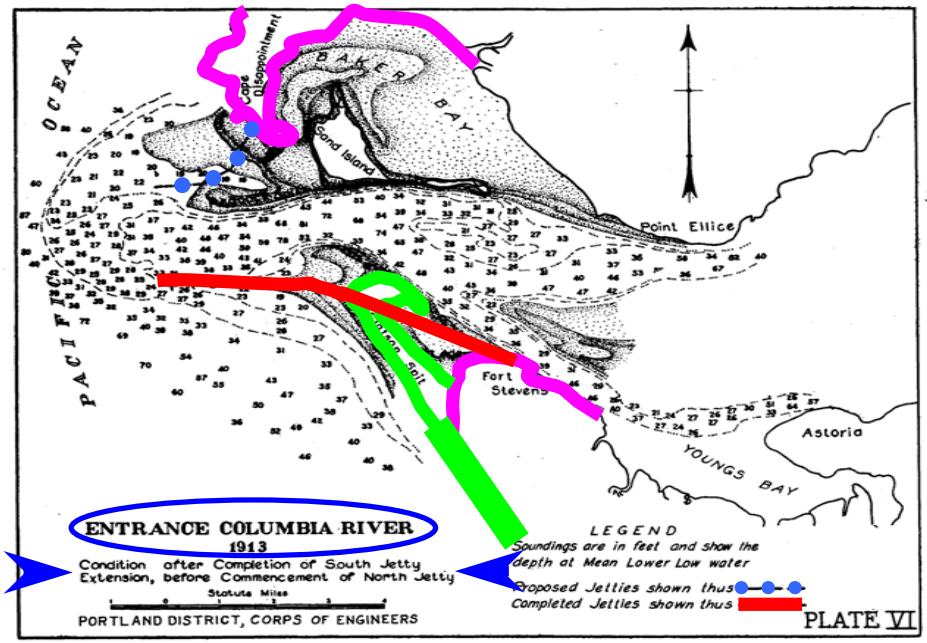
With the "opening of the west" that was occurring in America during 1860-1880, a consistent and reliable navigation channel was needed through the MCR to link inland areas of the Pacific Northwest with other parts of the country and world. During 1885-1917, two jetties were constructed at MCR using 8.8 million tons of stone. Jetty construction re-aligned the ocean entrance to the Columbia River, established a consistent 40-ft deep channel across the bar, and significantly improved navigation through the MCR. Improvements made during 1930-1942 (including the addition of Jetty "A" and the Sand Island pile dikes) have produced the present entrance configuration.

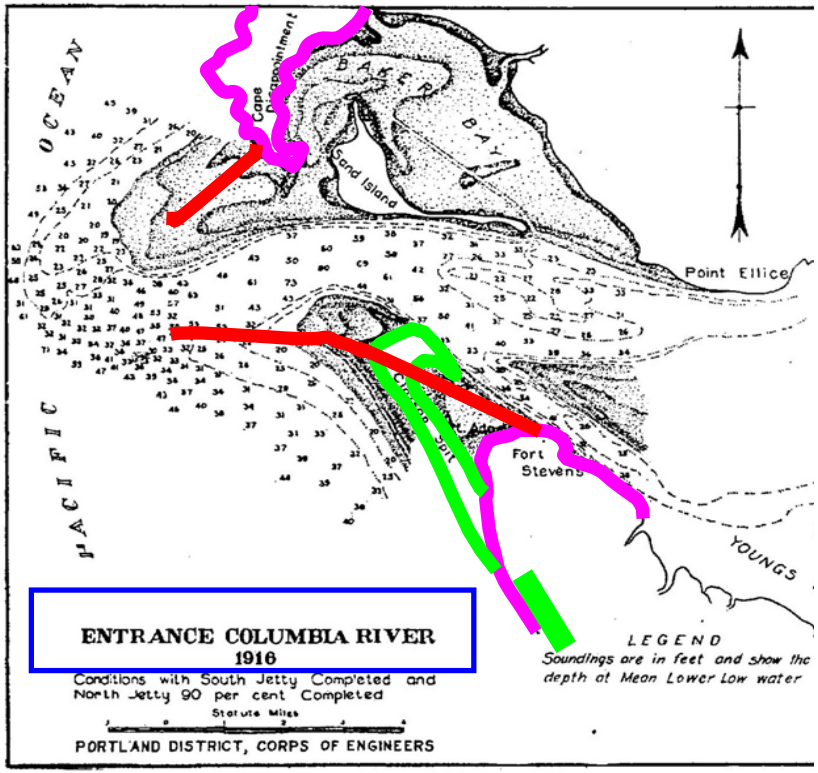
(Long Beach Peninsula Visitors Bureau Website, ***Pacific Graveyard*** by James A. Gibbs)

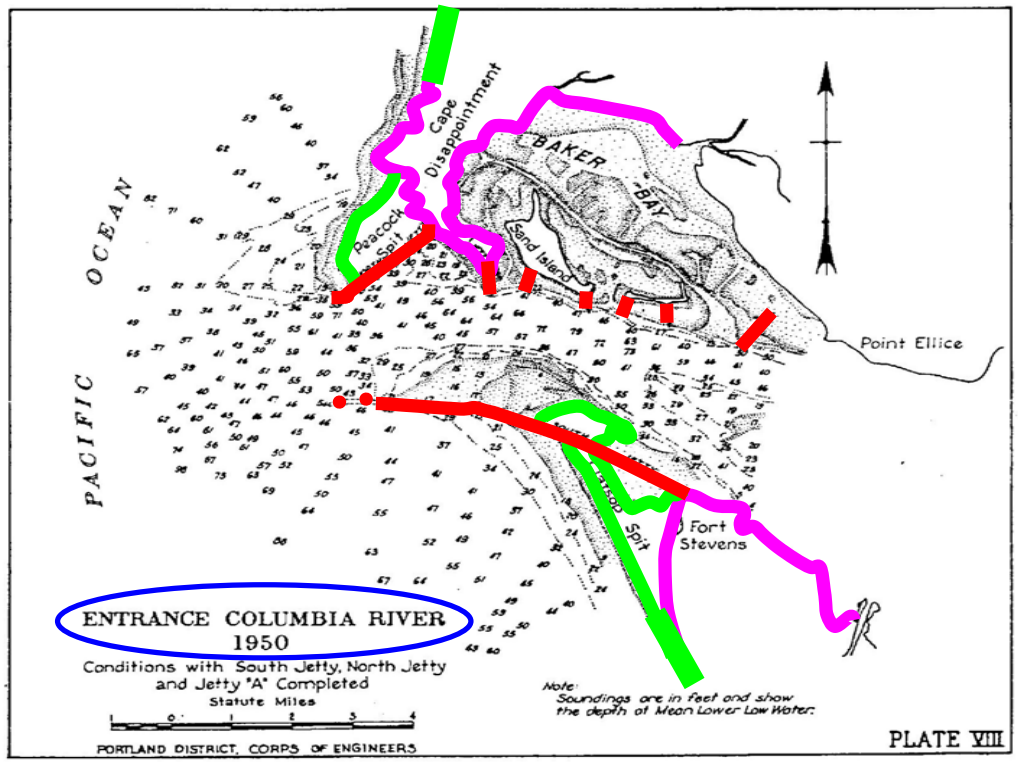

Cape Disappointment
BAKER BAY
Peacock Spit
PACIFIC OCEAN
north channel
south channel
Clatsop Spit
Pt Ellice
YOUNGS BAY
ENTRANCE COLUMBIA RIVER
1839
Conditions before improvements.
Statute Miles
PORTLAND DISTRICT, CORPS OF ENGINEERS
Note:
Soundings are in feet and show the depth at Mean Lower Low Water.
Surveyed by Sir Edward Belcher C.B. Great Britain
PLATE II


Cape Disappointment
BAKER BAY
PACIFIC OCEAN
Middle Sands
South
Peacock Spit
Point Ellice
Clatsop Spit
Fort Stevens
Astoria
YOUNGS BAY
ENTRANCE COLUMBIA RIVER
1885
Conditions before improvements
Statute Miles
PORTLAND DISTRICT, CORPS OF ENGINEERS
LEGEND
Soundings are in feet and show the depth at Mean Lower Low water
Proposed Jetties shown thus
PLATE III


Cape Disappointment
BAKER BAY
PACIFIC OCEAN
Sand I.
Peacock Spit
Point Ellice
Clatsop Spit
Fort Stevens
Astoria
YOUNGS BAY
ENTRANCE COLUMBIA RIVER
1902
Conditions before Commencement of South Jetty Extension
Statute Miles
PORTLAND DISTRICT, CORPS OF ENGINEERS
LEGEND
Soundings are in feet and show the depth at Mean Lower Low water
Proposed Jetties shown thus
Completed Jetties shown thus
PLATE V


Cape Disappointment
BAKER BAY
PACIFIC OCEAN
Sand Island
Point Ellice
Clatsop Spit
Fort Stevens
Astoria
YOUNGS BAY
ENTRANCE COLUMBIA RIVER
1913
Condition after Completion of South Jetty Extension, before Commencement of North Jetty
Statute Miles
PORTLAND DISTRICT, CORPS OF ENGINEERS
LEGEND
Soundings are in feet and show the depth at Mean Lower Low water
Proposed Jetties shown thus
Completed Jetties shown thus
PLATE VI





Design Parameter	1886-1896 (original)	1903-1913 (extension)	1931-1932	1933-1934	1935-1936	1936(stone/ asph. term)	1940	1940-1941	1941-1942 (conc. term)	1961
Stone Density (pcf)	~180 (varied)	~180/171.2	171.2	171.2	171.2	171.2	171.2	171.2	148	186/171.9
Structure Side slope (V:H)										
North Side	natural slope	natural slope	1:1.5	1:1.5	1:1.5	1:2	-	w/in conc	-	1:1.25
South Side	natural slope	natural slope	1:1.5	1:1,1:1.75,1:2	1:1.75,1:2	1:2	-	w/in conc	-	1:1.5
Crest Elevation (ft MLLW)	4 to 12	10 to 24	24	17 and 26	17 and 26	23 to 26	-	16	8 to 20	24 to 28
Crest Width (ft)	10	25	24	24	24	50	-	50 to 75'10"	50 to 75'10"	30
Armor Stone Size (tons)	7 (max)		9	10	10		10	10	Comp Str:	10
Stone Type	Basalt	Basalt/ Andesitic	Andesitic Basalt	Andesitic Basalt	Andesitic Basalt	Andesitic Basalt	Andesitic Basalt	Andesitic Basalt	-	Basalt/ Andesitic
Beginning Station	25+80	250+20	175+00	257+68.7	305+05	340+30	where	339+60	332+00	194+00
Ending Station	250+20	375+52	257+68.7	305+05	353+05	344+30	needed	341+60	343+30	249+00

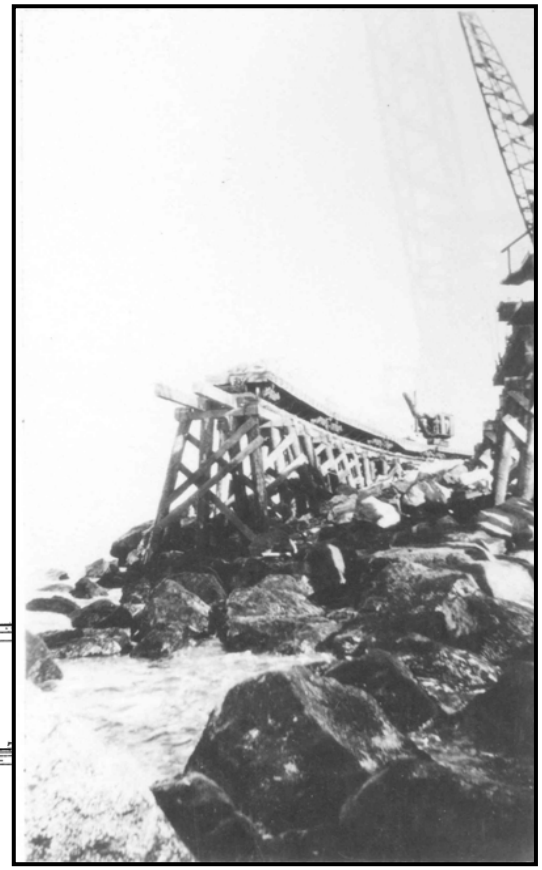
South Jetty Construction Activity

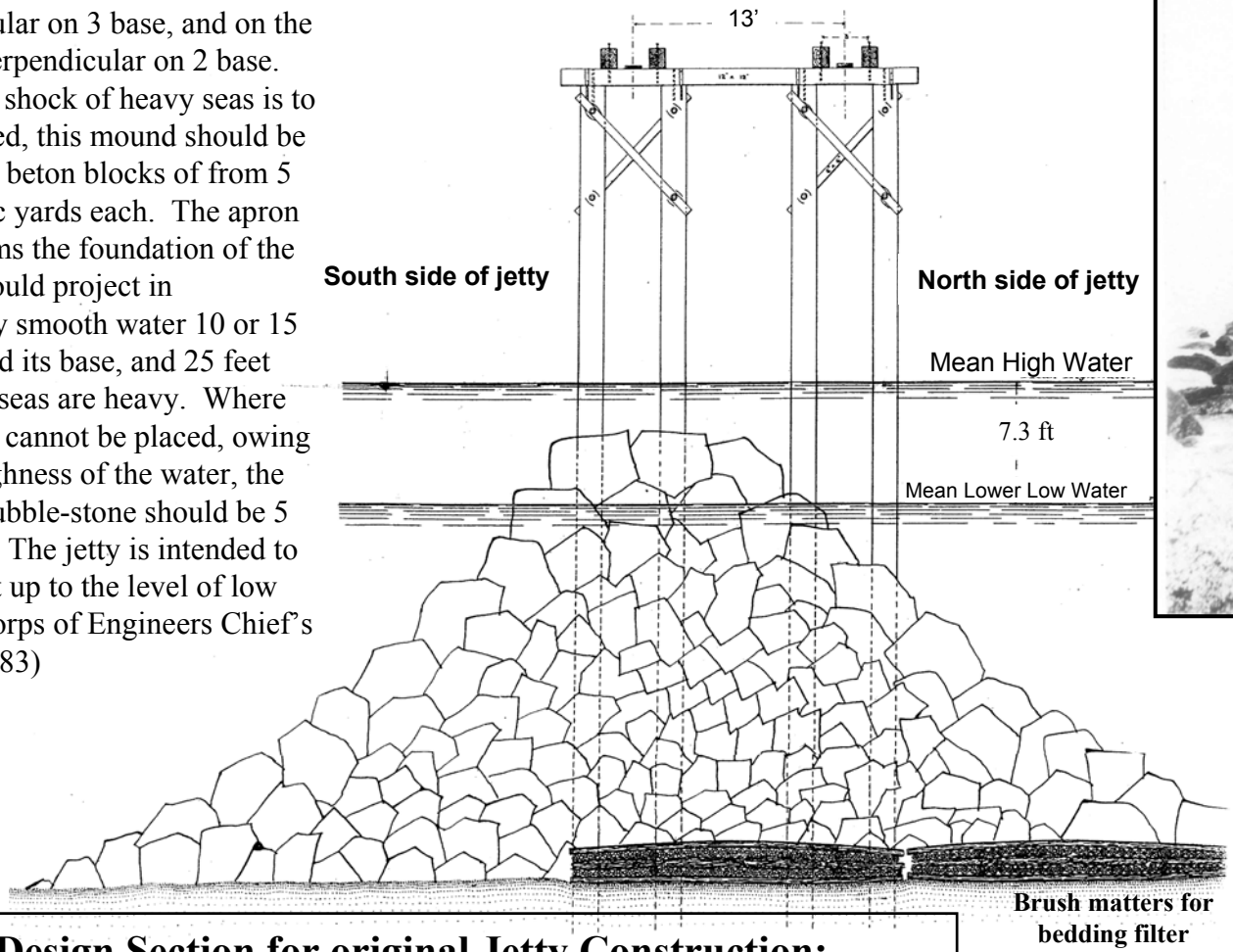
Design Parameter	1917	1939	1965
Stone Density (pcf)	167	167	167
Structure Side slope			
North Side (V:H)	1:1.5	1:1.25	1:1.5 to 1:2
South Side (V:H)	1:1.5	1:1.5	1:1.5 to 1:2
Crest Elevation (ft MLLW)	15 to 32	26	24
Crest Width (ft)	25	30	30
Armor Stone Size (tons)	50 lbs to 7 tons*	10	15 to 24
Stone Type	Andesitic Basalt	Diorite	Andesitic Basalt
Beginning Station	0+00	68+35	89+47
Ending Station	122+00	110+35	109+67

North Jetty Construction Activity

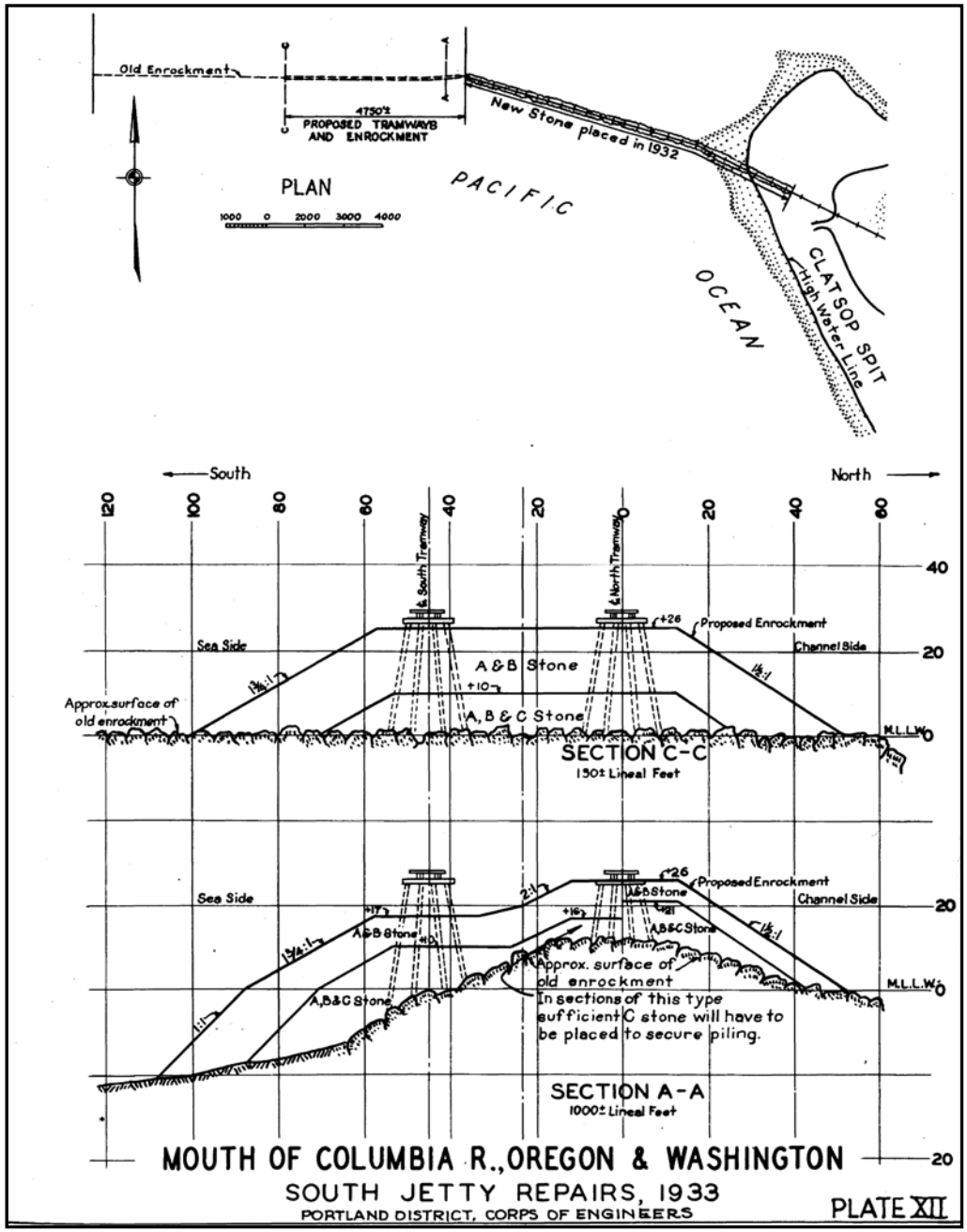
There should first be laid a very strongly built mattress about 3 feet thick, and upon this a layer of rubble-stone 3 feet thick; then a mound of stones of large size, with a top width of not less than 5 feet, the slope on the outside to be 1 perpendicular on 3 base, and on the inside 1 perpendicular on 2 base. Where the shock of heavy seas is to be sustained, this mound should be faced with beton blocks of from 5 to 20 cubic yards each. The apron which forms the foundation of the mound should project in moderately smooth water 10 or 15 feet beyond its base, and 25 feet where the seas are heavy. Where mattresses cannot be placed, owing to the roughness of the water, the apron of rubble-stone should be 5 feet thick. The jetty is intended to be brought up to the level of low water. (Corps of Engineers Chief's Report, 1883)

The greatest difficulty encountered was the maintenance of the trestle, without which it would be impossible to place stone in the jetty, and it became necessary to raise the crest of the enrockment to the level of high tide and even higher in places in order to support the trestle and at the same time to supply the stone required to feed the slopes as they became flattened by wave action and other causes.





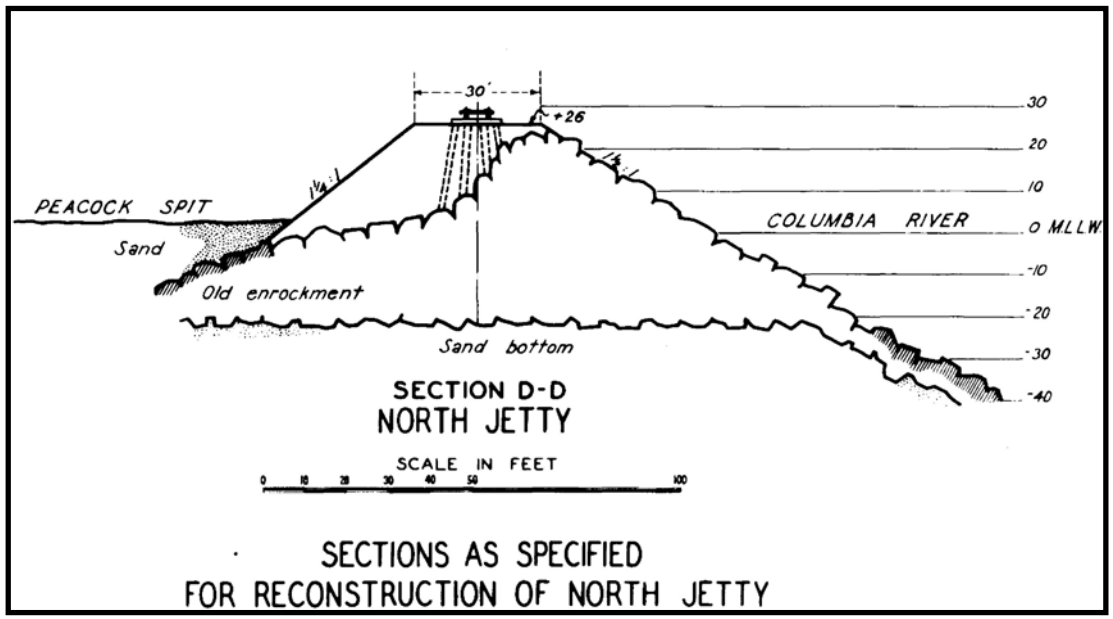
Design Section for original Jetty Construction: North/South

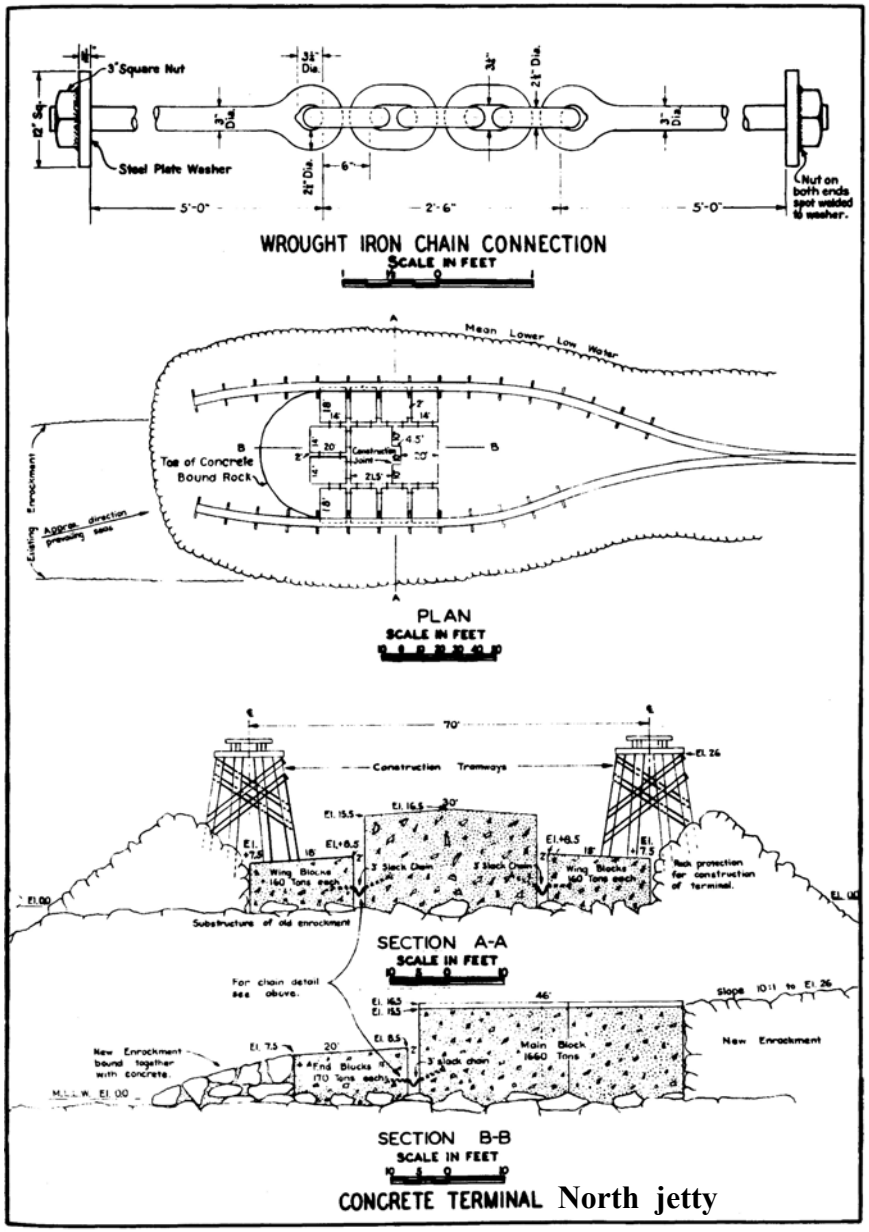


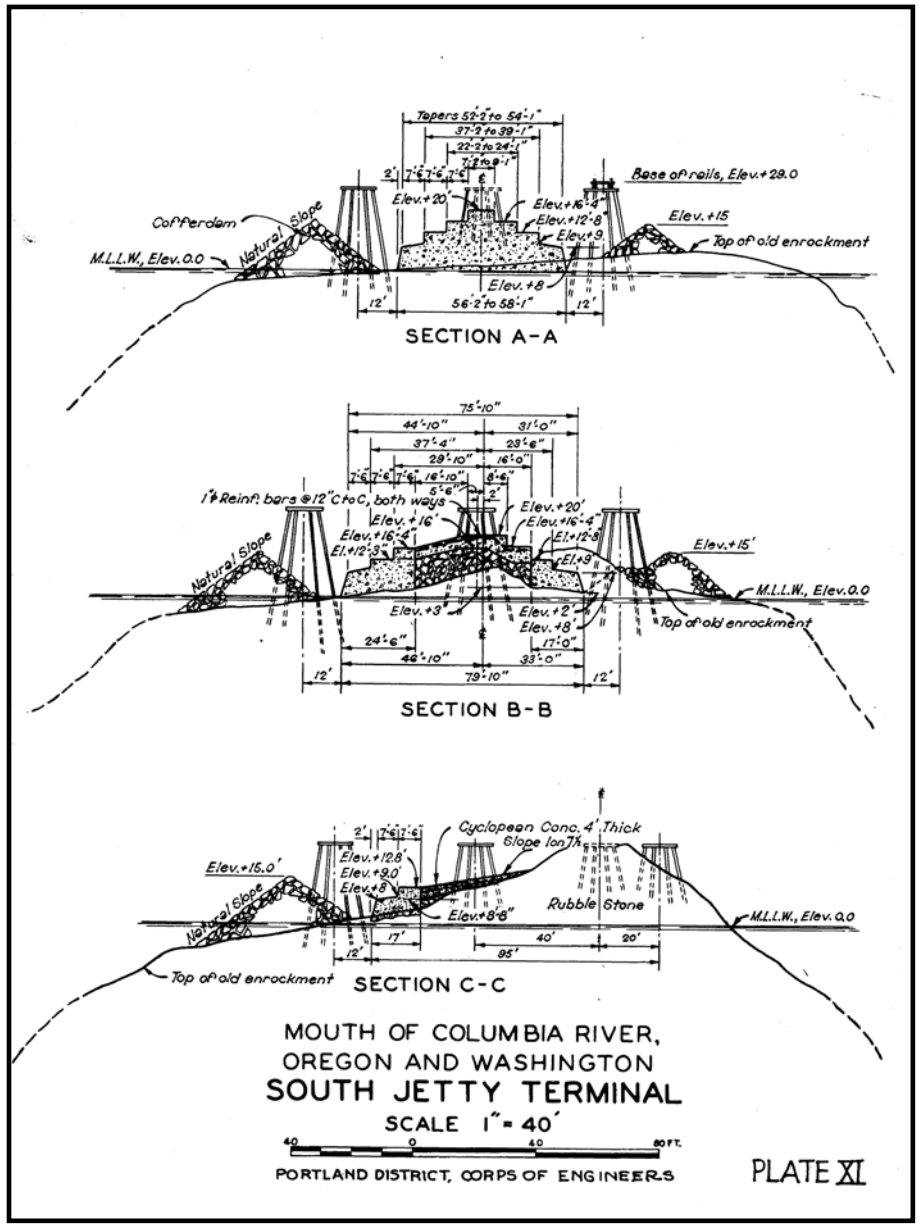
Mouth of Columbia River, Oregon; south jetty; old enrockment 2½ miles west of Clatsop Spit; rock in place at least 21 years; July, 1934. 200′ wide on top.

Mouth of Columbia River, Oregon; retopping south jetty; tracks 45 feet between centers; July, 1934.

Mouth of Columbia River, Oregon; south jetty; finished section near the knuckle; Oct. 25, 1932. Single track.


30'
+26
30
20
10
0 MLLW
-10
-20
-30
-40
PEACOCK SPIT
Sand
Old enrockment
Sand bottom
COLUMBIA RIVER
SECTION D-D
NORTH JETTY
SCALE IN FEET
0 10 20 30 40 50 100
SECTIONS AS SPECIFIED
FOR RECONSTRUCTION OF NORTH JETTY





Concrete terminal details - An attempt to anchor the heads of jetties in a high energy environment with an unstable foundation (due to scour)

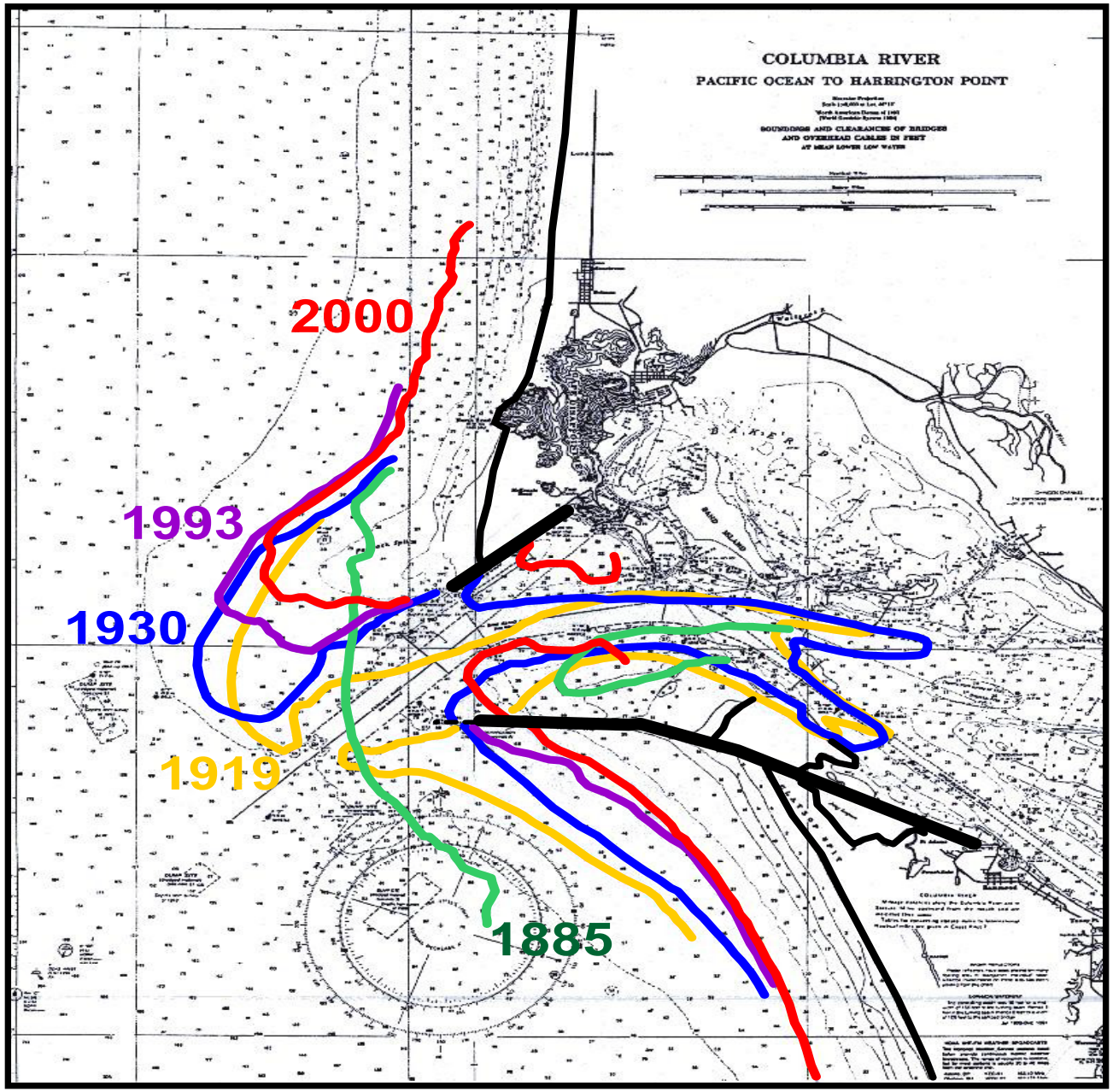
To combat constant jetty head deterioration, concrete "terminals" were built into the heads of the north and south jetties during 1939-1942.

The amount of concrete used in jetty head terminal construction was substantial.

North Jetty Terminal: 1,900 cubic yards of concrete

South Jetty Terminal: 15,000 cubic yards of concrete

South Jetty: Concrete Terminal



During 1993 to 2000, the 40 ft contour on Peacock Spit receded landward at a rate 7x faster than during 1930 to 1993.

As the offshore shoals recede, the wave/current regime at the entrance and jetties will change

MCR jetties were built on tidal shoals 1885-1917 that are now eroding. Stability of jetties is compromised due to scour-based failure.

US Army Corps of Engineers ®
Portland District

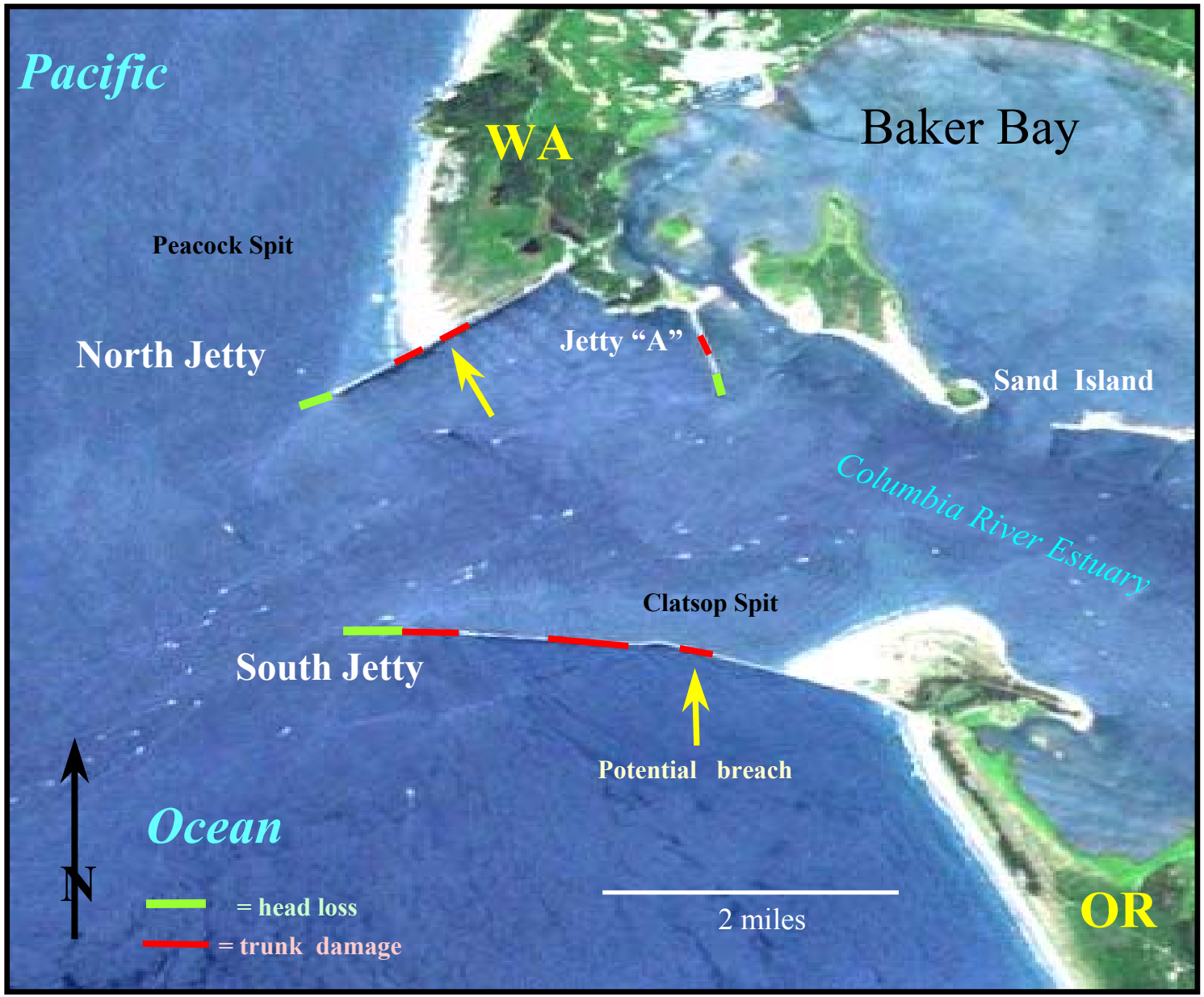
General Components of a Coastal Jetty & Damage Trends

"The jetty is a long, thin, narrow backbone of solid material, resting upon a very doubtful foundation, against which the forces in action at the locality have accumulated large quantities of the shifting sands.

These shoals in turn have been able to break the force of the waves and protect the jetty from destruction. Jetty integrity and the permanence of the present favorable condition of channel over the bar depend upon the amount of this sand that can be accumulated." (USACE, 1903).

US Army Corps of Engineers
Portland District

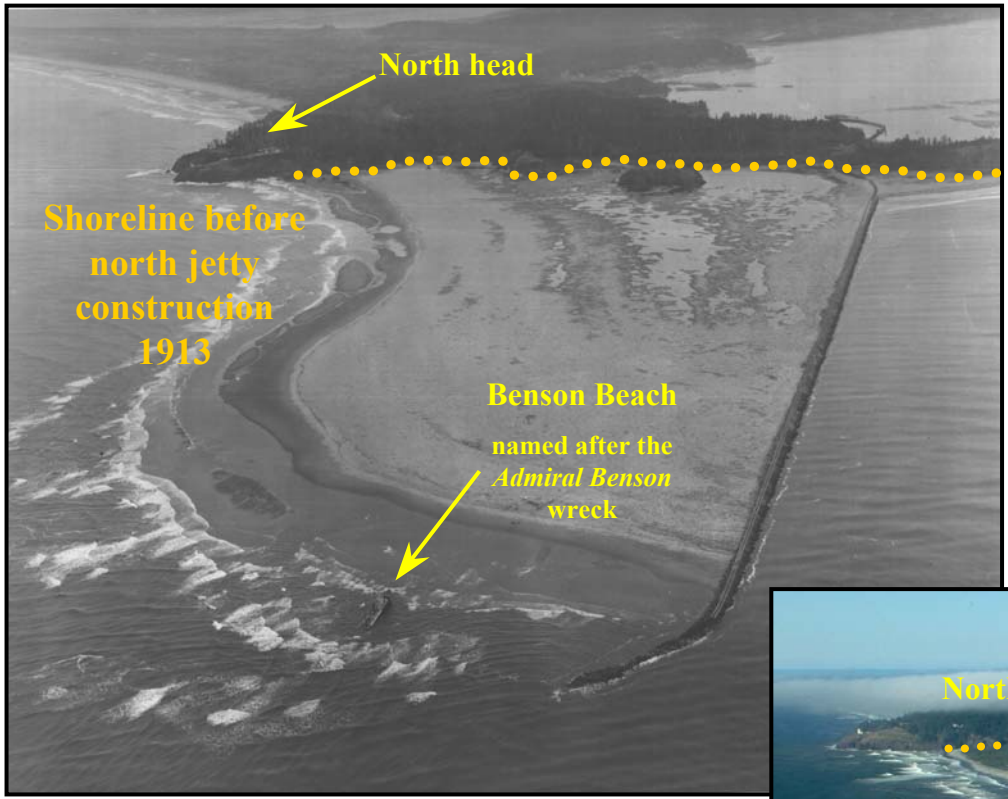
Jetty Deterioration at MCR



Original Construction 1913-17, 2 miles offshore from Cape Disappointment: 2.9 million tons of stone placed

3 Subsequent Repairs 1938-65: 360,000 tons of stone

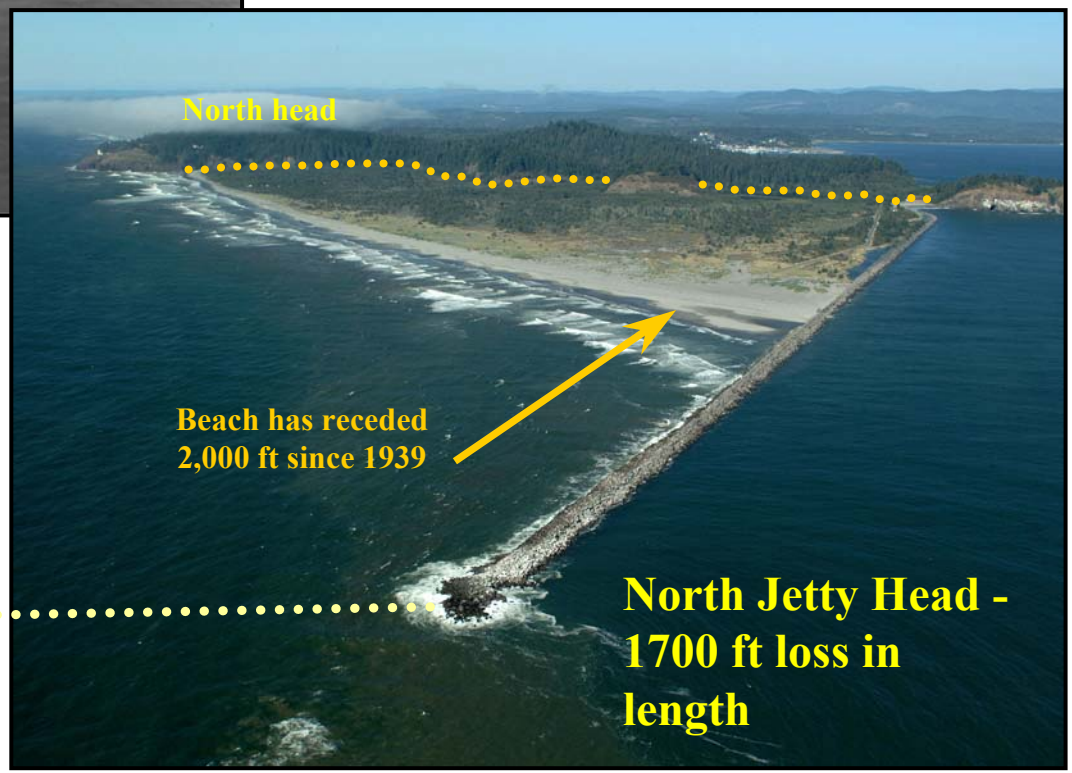
Total stone placed 1913-65: 3.3 million tons

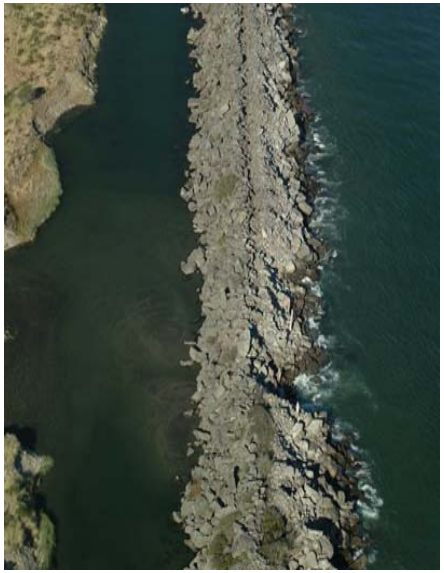


1939

What was a "spending beach" for wave action along the ocean side of the north jetty no longer exists. Now waves and currents act directly on much of the north jetty. The north jetty is now compromised along much of its length.

2002





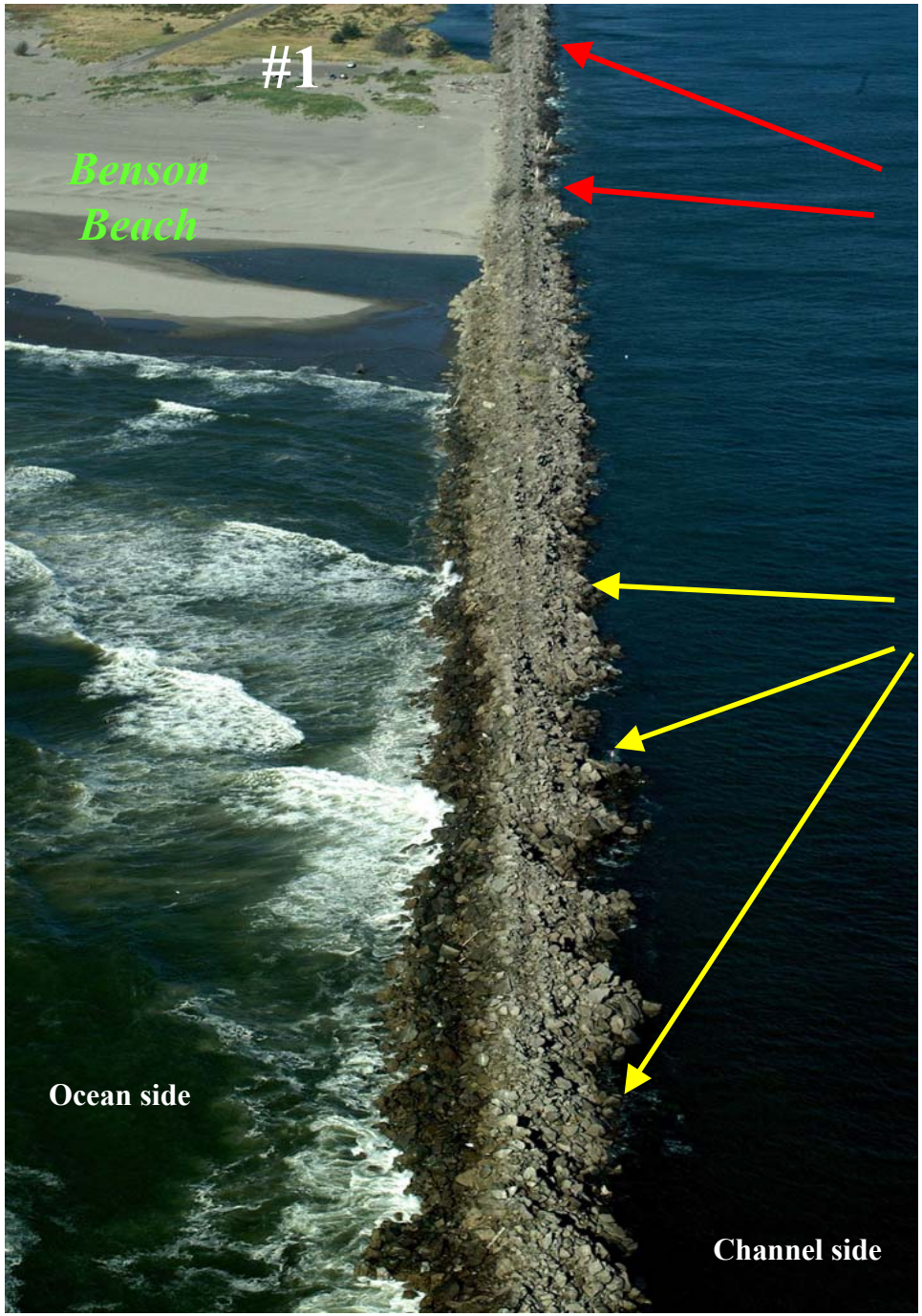
North Jetty original section - 400 ft shoreward of image to right

Original construction crest elevation varied from 15 ft to 32 ft, MLLW.

Original foundation elevation varied from 0 to –48 ft, MLLW, with average around –25 ft.

Existing foundation elevation ranges from 0 to –76 ft, MLLW.

Loss of seabed elevation along jetty toe (due to scour).



Transition to Unrepaired Landward Half of North Jetty- Severe damage with potential for breach

Damaged Areas along Trunk

Cape Disappointment

Damaged root - north jetty

Stop # 1

Benson Beach

Wave run-up along beach & jetty combined with wave action on channel side of jetty produces "sink holes" along beach side of jetty. Stone sinks into beach/shoal, jetty slope steepens & jetty armor layer fails.

Wave and current induced scour along channel side of jetty causes toe failure, slope steepens & fails, lowering crest and elevation exposing core stone to wave action.

Loss of jetty crest elevation & x-section allows more stone displacement and wave overtopping. Breach thru jetty will likely result.

Stop # 2

Cape Disappointment Overlook

Benson Beach

Subaerial Peacock Spit

Exploration of the Columbia River began when the Spaniard Martin d'Aguilar reported seeing an opening or entrance of a great river north of Cape Mendicino (California) in 1603.

John Meares named the cape to the north of the mouth of the Columbia River as Cape Disappointment in 1789 because he did not find Aguilar's great river at that location.

Replacement of North Jetty in Today's Costs = $340 million

Note the irregular nature of the jetty crest and fact that the north jetty is perched on the southern lobe of a large ebb tidal shoal.

The first official survey of the Columbia Bar was made by Sir Edward Belcher of the H.M.S. "Sulphur"in 1839. The first official American survey of the river was by Lieutenant Charles Wilkes of the U.S. Navy in 1841.

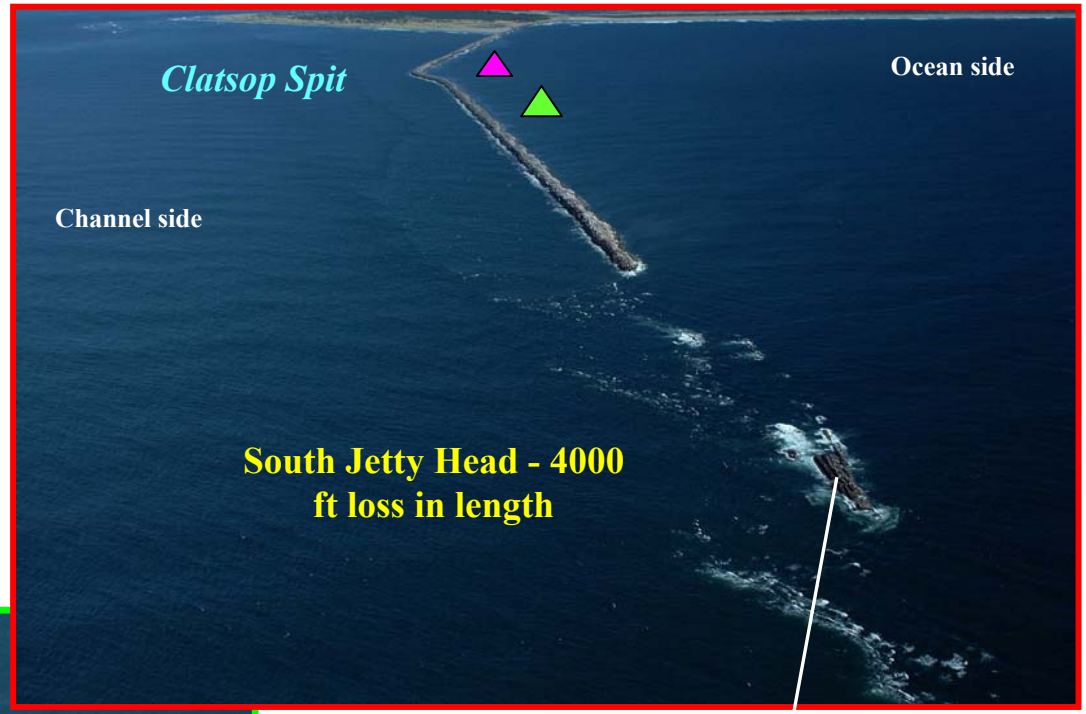
In the 1880's the depths of the mouth were maintained by two boats dragging a gigantic chain across the channel.

North Head Overlook

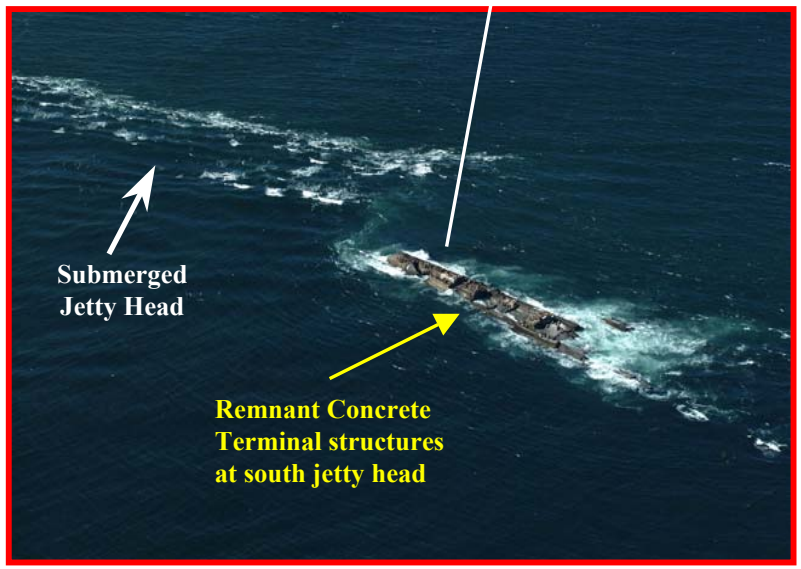
The U.S. Coast Guard has a long operational history out of Station Cape Disappointment, including its National Motor Life Boat School. Training is conducted in the heavy surf of Clatsop Spit.


Severe damage areas -
view from ocean side


Severe Damage Area -
view from channel side


Clatsop Spit
Ocean side
Channel side
South Jetty Head - 4000
ft loss in length


Clatsop Spit
South Jetty
Severe Trunk
Damage Areas -
potential breach
Channel side


Submerged
Jetty Head
Remnant Concrete
Terminal structures
at south jetty head

Stop #5 - South Jetty

Magnitude of construction effort to produce a 6-mile long jetty extending into a ferocious environment. Within two years after the completion of the South Jetty, the value of the shipping tonnage passing over the Bar more than doubled the value of the previous decade.

Replacement of South Jetty in Today's Costs = $550 million