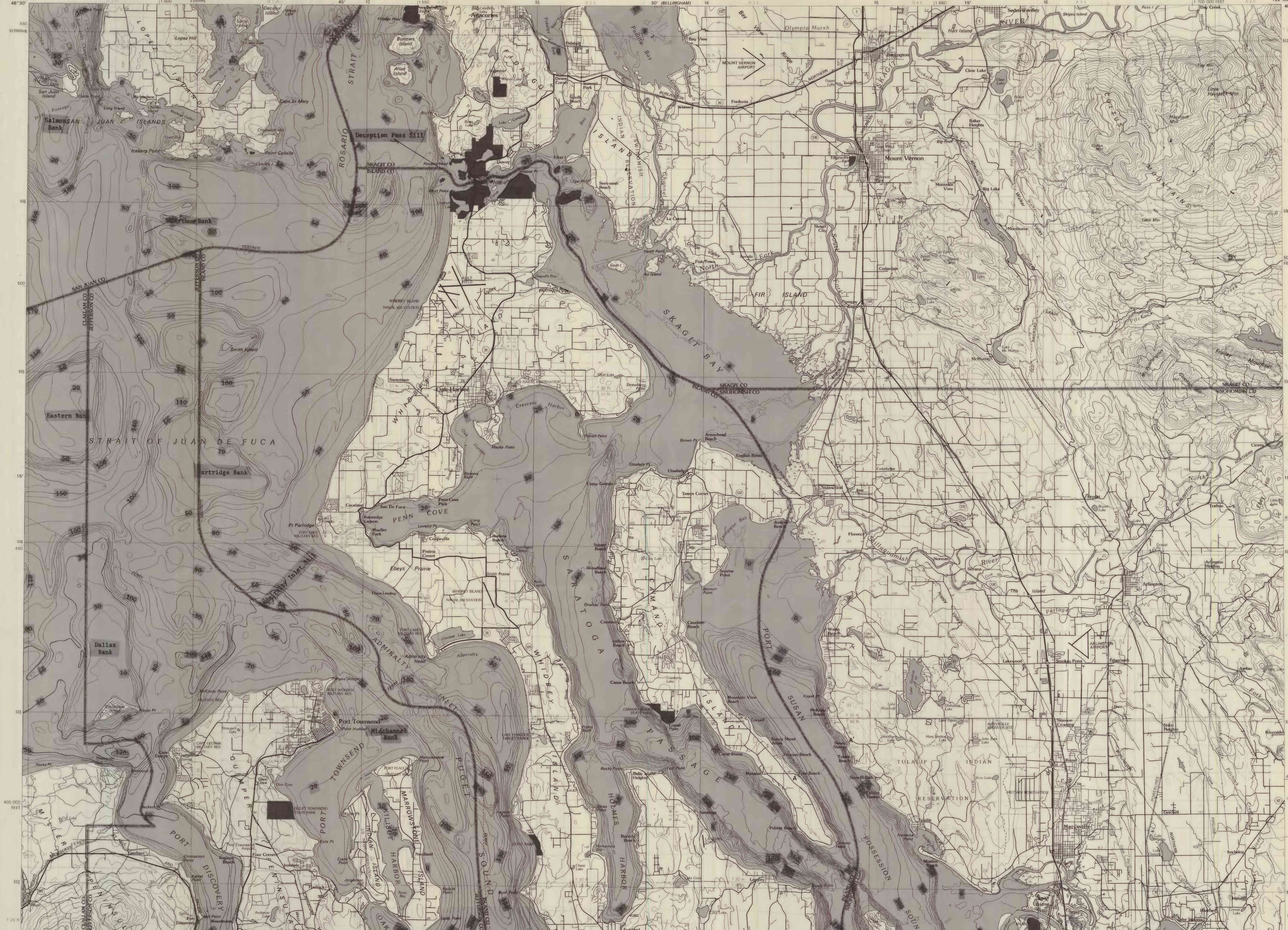
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PORT TOWNSEND QUADRANGLE, WASHINGTON
WATER-RESOURCES INVESTIGATIONS
OPEN FILE REPORT 81-1



Base from U.S. Geological Survey, 1973.

Submarine contours compiled 1979.

This map is not intended for navigational purposes.

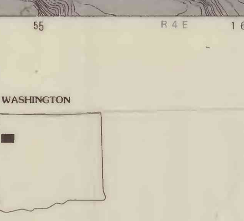
SCALE 1:100 000

TOPOGRAPHIC CONTOURS AT 50-METER INTERVALS

SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER

SUBMARINE CONTOURS AT 10-METER INTERVALS

DATUM IS MEAN LOWER LOW WATER



INTRODUCTION

A dominant physical feature of the Puget Sound region is the complex system of marine channels, bays, and inlets. These waterways have provided a growing population with transportation, fish and wildlife resources, recreation, and natural beauty. The Puget Sound region is presently developing at a rapid pace, and with this growth there has been greater focus on the resources and environmental aspects of these marine waters.

As an addition to the many maps that show surface extent and shorelines of the marine waters, this map depicts the third dimension of the water areas of the Port Townsend quadrangle through contour mapping of the bottom configuration. It is intended as a basic reference for use in scientific studies and resource planning. It will aid in interpreting regional geology, understanding marine circulation, and planning offshore development and future routes for submarine utility crossings.

Compilation of this map is part of an ongoing effort by the U.S. Geological Survey to provide earth-science and related information for such purposes as land-use planning, resource development, and environmental protection in the Puget Sound region. This map is one in a folio of map reports providing such information for the Port Townsend quadrangle.

DATA SOURCES AND COMPILATION METHOD

The principal data sources for the submarine contours are hydrographic surveys of NOS (National Ocean Survey, formerly U.S. Coast and Geodetic survey). Figure 1 is an index map that shows the hydrographic surveys used in this compilation. A more detailed map of the Port Townsend quadrangle bathymetry is presently being compiled by NOS to be issued at some future date.

The submarine contours east of long. 122° 39′ W. were compiled from copies of NOS hydrographic surveys received from NOAA (National Oceanic and Atmospheric Administration) archives in Rockville, Maryland. The 10-meter-interval contours were generated and drafted at the original scale of the survey sheets (generally 1:10,000), then photographically reduced to 1:100,000 scale and transferred by optical projection to the Port Townsend quadrangle base map. For the map area west of longitude 122° 39′ W, 10-meter submarine contours had previously been compiled from NOS survey sheets by the Canadian Department of the Environment for the publication of Natural Resource Map 15783-A, one in a series of bathymetric maps covering Canada's coastal and offshore waters. A stable-base copy of that map was made available by the Canadian agency and was photographically enlarged from the publication scale of 1:250,000 to the 1:100,000 scale of this map.

The Mean Lower Low Water (MLLW) line, the tidal and sounding datum and the line defining the offshore extent of the intertidal zone, was optically transferred from the hydrographic surveys and scale-stable copies of the following NOS nautical charts at 1:80,000 scale: 18421 (26th ed., 1977), 18441 (26th ed., 1978), and 18465 (20th ed., 1978). The MLLW line across the tidal flats of the Stillaguamish delta was supplemented with data from U.S. Geological Survey 1:24,000-scale topographic maps (Juniper Beach and Stanwood 1958, both photo-revised in 1968 and 1973).

SUBMARINE FEATURES AND BOTTOM CONFIGURATION

Formation of the Submarine Troughs

The submarine topography of the Puget Sound region is the result of geologic processes that have occurred over the past several million years. During this time sedimentation, erosion, glacial modification and, possibly, tectonic deformation have combined to shape the present-day submarine troughs, banks, and sills.

Theories of the formation of the original troughs of the Strait of Juan de Fuca and the Puget Sound system are debated. One widely accepted hypothesis involves an initial phase of valley formation by rivers and smaller streams eroding a broad plain which was the ancestral Puget lowland; subsequently, the valleys draining the lowland north and west to the Pacific Ocean directed and concentrated ice flow and, during successive advances and recessions of the ice, the troughs of the Puget Sound region were deepened and modified by glacial erosion and deposition.

An ice mass of the Fraser glaciation, the most recent period of glaciation in the area, produced the glacial features which today dominate the region's landscape and submarine topography. Based on radiocarbon dating, the so-called Puget Lobe of ice advanced into the Port Townsend vicinity about 15,000 years ago (Thorson, 1979, p. 8,9). At its maximum extent, the ice mass over the Port Townsend quadrangle area was more than 1,200 meters thick (Thorson, 1979, p. 19). The effects of localized glacial processes are recorded in the bottom features. For example, closed depressions in southern Saratoga Pasage, south of Lowell Point and near Sandy Point, probably were formed by deep glacial scour. The U-shaped cross-sectional form of Port Susan and Saratoga Passage is typical of glacially eroded valleys (fig. 2).

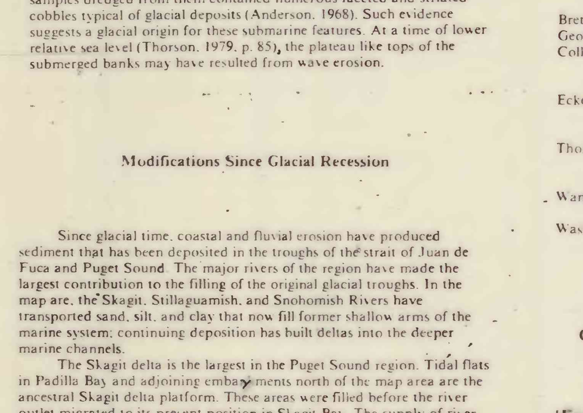


FIGURE 2.-- Cross section of the Port Susan trough between Tyee Beach and Sunny Shores. The 'U'-shaped cross sectional form reflects the glacial history of the submarine topography

By approximately 13,000 years ago, the southern Puget lowland was free of ice and the ice margin had receded to the vicinity of Port Townsend (Thorson, 1979, p. 39). Thereafter, the ice continued to melt and recede northward [illegible]. Although the recession of the ice was probably rapid, pauses or still-stands of the ice [illegible] presence of submerged banks which may be remnants of recessional deposits along the [illegible] ice margin in the eastern Strait of Juan de Fuca. These banks include Partridge, Eastern, Salmon, and McArthur Banks and Hein Bank. The origin of these banks remains uncertain, but samples dredged from them contained numerous faceted and striated cobbles typical of glacial deposits (Anderson, 1968). Such evidence suggests a glacial origin for these submarine features. At a time of lower relative sea level (Thorson, 1979, p. 85), the [illegible] tops of the submerged banks may have resulted from wave erosion.

Modifications Since Glacial Recession

Since glacial time, coastal and fluvial erosion have produced sediment that has been deposited in the troughs of the Strait of Juan de Fuca and Puget Sound. The major rivers of the region have made the largest contribution to the filling of the original glacial troughs. In the map area, the Skagit, Stillaguamish, and Snohomish Rivers have transported sand, silt, and clay that now fill former shallow areas of the marine system; continuing deposition has built deltas into the deeper marine channels.

The Skagit delta is the largest in the Puget Sound region. Tidal flats in Padilla Bay and adjoining embayments north of the map area are the ancestral Skagit delta platform. These areas were filled before the river outlet migrated to its present position in Skagit Bay. The supply of river-borne sediment to Skagit Bay is abundant, and Skagit Bay possibly would have been filled [illegible] tidal flat but for the tidal currents in the embayment that remove the supplied sediment and maintain a longitudinal channel. This narrow, moderately deep (40-80 m) channel [illegible] is maintained by strong [illegible] tidal currents. According to Collias and others (1974, p. 3), tidal-current gyres and jet action scour the depressions north and southeast of Hope Island.

The Stillaguamish delta is not significantly influenced by tidal currents, but the [illegible] delta platform is subject to strong wave energy due to the orientation of Port Susan with respect to prevailing southeasterly winds.

The Snohomish delta is noteworthy in having delta-front slopes averaging about 20 percent, one of the steepest delta-fronts in the Puget Sound region (Bortleson and Chrzastowski, ~~1979, in preparation~~ unpublished data). This steep front is probably maintained by the strong tidal currents that parallel the delta front and are constricted by the submarine ridge southeast of Gedney Island.

Other continuing modification of the original troughs includes sediment input from coastal erosion. The erosion of bluffs surrounding the marine waters is supplying the basins with fine-grained sediment. The coarser materials are reworked and transported longshore, occasionally filling offshore areas and building spits such as the one at the entrance of Kilisut Harbor and the one extending into Tulalip Bay. Prominent artificial modifications of the marine areas include various dredge-and-fill projects, such as the Port Townsend canal linking Port Townsend and Oak Bay, the channels providing navigation access to each end of the Swinomish Channel, and the port facilities in Port Gardner at Everett.

The submarine areas will continue to be modified by river-borne alluvium, as well as by coastal and marine processes, and they may be significantly altered by man's activities.

Submarine Sediments

The sediments that blanket the submarine surface in the Port Townsend quadrangle are shown in figure 3. Following recession of the Puget Lobe, the troughs of the Strait of Juan de Fuca and Puget Sound were mantled with proglacial deposits, glacial outwash, and (or) glacial till. Subsequent blanketing with river-borne alluvium and sediments from coastal erosion has occurred where supply and current conditions allow deposition. Nearly all the Whidbey Basin (the entire marine area east of Whidbey Island) is blanketed with sand and finer sediment derived from river transport and coastal erosion. West of Whidbey Island, various embayments are blanketed with fine sediments, and a plume of fine bottom sediment extends from the west end of Deception Pass. The plume orientation suggests transport and deposition of Skagit River sediment through Deception Pass by tidal currents during ebb tide. However, most of the submarine surface west of Whidbey Island is covered by sand, gravel, rock and hard bottom, or some mixture of these. Fine sediments are scarce due to tidal current reworking or the absence of major river supply. In these areas the coarse-sediment cover probably is a remnant of glacial processes.

Submarine environments of erosion or nondeposition are common in the map area where waves, tidal currents, and gravity cause erosion, or prevent accumulation, of sediments. Examples of such nondepositional environments include Admiralty Inlet, Deception Pass, San Juan Channel, and the steep slopes of other marine troughs. The moderately steep submarine slopes are environments of temporary deposition when supply exceeds transport energy or currents become weaker (Wang, 1955, p. 45).

USE OF THE MAP

Further Scientific Studies

Some geologic structures and processes in the map area are reflected in the configuration of the land surface and the sea bottom. Because this map shows both the submarine and terrestrial topography it will aid geologists in extending the knowledge gained from geologic mapping on the land into the marine areas. For this purpose, the map may be used in interpreting the origin of irregularities in the sea floor and in selecting locations for bottom sampling and traverses for marine geophysicl exploration. Possible applications of the map to marine-resource and oceanographic studies include the delineation of water-depth zones favored by various marine species and the portrayal of deep-water circulation patterns. For example, the banks at the eastern end of the Strait of Juan de Fuca have long been commercial fishing sites, and the broad sill across the entrance of admiralty Inlet and the sill near Deception Pass regulate the deep-water circulation in the entire Puget Sound system (Barnes and Ebbesmeyer, 1978, p. 218).

Coastal-Zone Planning

The map provides guidance for general planning for the coastal zone, including the intertidal areas. The shoreline corresponds to the approximate Mean High Water (MHW) line, and the zone between the shoreline and the tidal datum (MLLW) constitutes the intertidal zone. Where this zone is wider than approximately 45 m it is shown by a stippled pattern. The most prominent intertidal zones of this map area are the tide flats of the Skagit, Stillaguamish, and Snohomish River deltas. These three deltas have approximate intertidal areas totaling 83 square kilometers (km²). The 55 km² tidal flat of the Skagit River delta remains the largest continuous intertidal zone in the entire Puget sound region (Bortleson and others, 1979).

Flat lands along the marine shorelines of the region are not extensive, and delta tidal flats have historically been attractive sites for landfill and construction of commercial and port facilities. In future planning, however, the value of these delta flats as a fragile, nonrenewable resource probably will receive greater recognition. These zones are a habitat of vital importance to a diversity of fish, shellfish, and wildlife. Moreover, tidal flats are natural buffers against open-water wave energy and provide shore protection to fragile salt marshes.

Some of the intertidal areas may be poorly suited physically for most development. Experience elsewhere has demonstrated that, during earthquakes, poorly compacted deltaic sediments are susceptible to liquefaction, subsidence, and failure to provide structural support (Eckel, 1970). Further study is needed to assess the seismic stability of the intertidal lands.

Energy and Utility Facilities

The map area includes submarine parts of several routes that have been considered for pipelines to transport crude oil into or through the Puget Sound region. Other submarine utility crossings may be planned in the future. Knowledge of the submarine features provided by this map may assist in avoiding exceptionally steep slopes, anticipating sediment conditions, and choosing more feasible routes. The map also shows several least-depth crossings of the deep troughs; for example, the broad sill across Admiralty Inlet, from McCurdy Point to Point Partridge, provides a least-depth crossing from the Quimper Peninsula to Whidbey Island. A smaller sill exists across the north end of Holmes Harbor on Whidbey Island. The most pronounced feature providing a least-depth crossing is the submarine ridge between Camano Island and Gedney Island. This ridge demonstrates that Gedney is practically a continuation of Camano, separated only by this submerged saddle.

REFERENCES

Anderson, R.E., 1968, Seaward terminus of the Vashon continental glacier in the Strait of Juan de Fuca, in Marine Geology, v. 6: Amsterdam, Elsevier Publishing Company, p. 419-438.

Barnes, C.A., Ebbesmeyer, C.C., 1978, Some aspects of Puget Sound's circulation and water properties, in Kjerfve, Björn, ed., Estuarine Transport Processes: Columbia, University of South Carolina Press, p. 209-228.

Bortleson, G.C., Chrzastowski, M.J., and Helgerson, A.K., 1979, Historical shoreline and wetland changes in eleven major deltas in the Puget Sound region, Washington: U.S. Geological Survey Hydrologic Atlas HA-617, in press.

Brett, J.H., 1951, Glaciation of the Puget Sound Region, Washington: Washington Geologic Survey Bulletin 8, 244 p.

Collias, E.E., Barnes, C.A., and Lincoln, J.H., 1973, Skagit Bay study, dynamical oceanography, final report: Seattle, University of Washington, 197 p.

Eckel, E.B., 1970, The Alaska earthquake, March 27, 1964: Lessons and conclusions: U.S. Geological Survey Professional Paper 546, 57 p.

Thorson, R.M., 1979, Isostatic effects of the last glaciation in the Puget lowland, Washington: Seattle, University of Washington unpublished Ph.D. thesis, 151 p.

Wang, F.H., 1955, Recent sediments in Puget Sound and portions of Washington Sound and Lake Washington: Seattle, University of Washington unpublished Ph.D. thesis, 160 p.

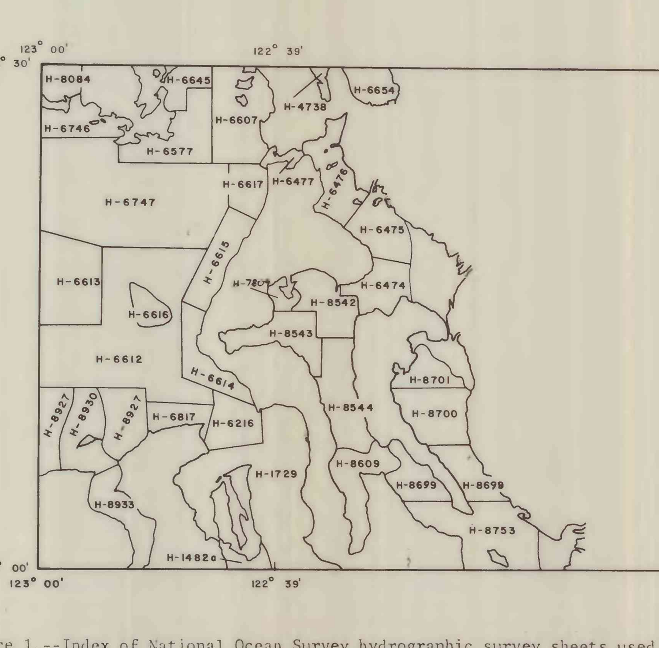
CONVERSION FACTORS FOR INTERNATIONAL SYSTEM UNITS (SI) TO U.S. CUSTOMARY UNITS

[For use of those readers who may prefer to use U.S. customary units rather than metric units, the conversion factors for the terms used in this report are listed below.]

To convert from	To	Multiply by
Length		
meter (m)	feet (ft)	3.281
fathom (fm)	meter (m)	1.83
kilometer (km)	mile (mi)	0.6214
Area		
kilometer² (km²)	mile² (mi²)	0.3861

Hydrographic surveys for map area west of longitude 122° 39′

Number	Date	Scale
H-8033	1967	1:10,000
H-8930	1967	1:10,000
H-8927	1967	1:20,000
H-8543	1960	1:10,000
H-8084	1953-55	1:10,000
H-6817	1943	1:10,000
H-6816	1942-43	1:10,000
H-6747	1941	1:20,000
H-6746	1941-43	1:10,000
H-6645	1939-40	1:10,000
H-6617	1940-41	1:10,000
H-6616	1940-41	1:10,000
H-6615	1940-41	1:10,000
H-6614	1940-41	1:10,000
H-6612	1940-41	1:20,000
H-6607	1939-40	1:10,000
H-6477	1939	1:10,000
H-1729	1885-86	1:20,000
H-1482a	1880	1:10,000

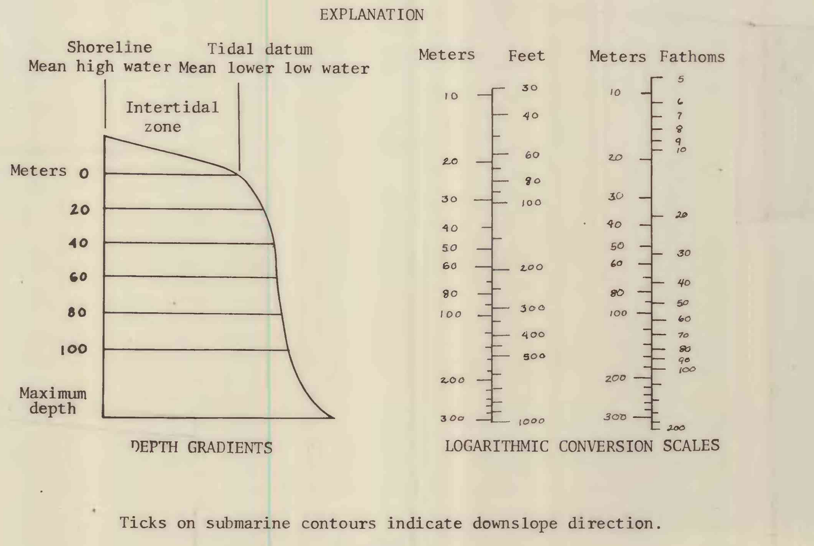


Hydrographic surveys for map area east of longitude 122° 39′

Number	Date	Scale
H-8753	1963	1:10,000
H-8701	1962	1:10,000
H-8700	1962	1:10,000
H-8669	1961-62	1:10,000
H-8609	1960-61	1:10,000
H-8544	1960	1:10,000
H-8543	1960	1:10,000
H-8542	1960-62	1:10,000
H-7809	1951	1:10,000
H-6654	1940	1:10,000
H-6477	1939	1:10,000
H-6476	1939	1:10,000
H-6475	1939	1:10,000
H-6474	1939	1:10,000
H-4738	1927	1:5,000
H-1729	1885-86	1:20,000

Figure 1.--Index of National Ocean Survey hydrographic survey sheets used in compilation of the submarine contours for the Port Townsend quadrangle. Contours west of longitude 122° 39′ were compiled by the Canadian Department of the Environment for publication of Natural Resource Map 15783-A

EXPLANATION



Ticks on submarine contours indicate downslope direction.

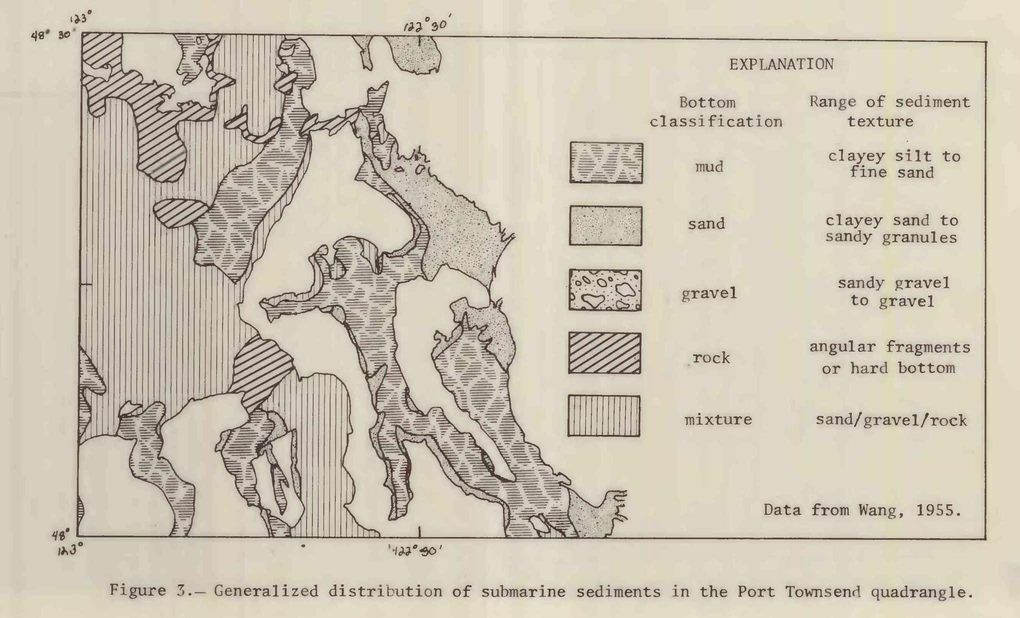


Figure 3.- Generalized distribution of submarine sediments in the Port Townsend quadrangle.

SUBMARINE FEATURES AND BOTTOM CONFIGURATION IN THE PORT TOWNSEND QUADRANGLE, PUGET SOUND REGION, WASHINGTON

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1980