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OCEANOGRAPHIC RESOURCES OF WASHINGTON

An Inventory of Oceanographic and Marine Activities and Capabilities

U.S. DEPARTMENT OF COMMERCE NOAA
COASTAL SERVICES CENTER
2234 SOUTH HOBSON AVENUE
CHARLESTON, SC 29405-2413

JUL 17 1991

by the
Oceanographic Commission of Washington

with assistance from the
Washington Sea Grant Program Staff,
Division of Marine Resources,
University of Washington

30 June 1971

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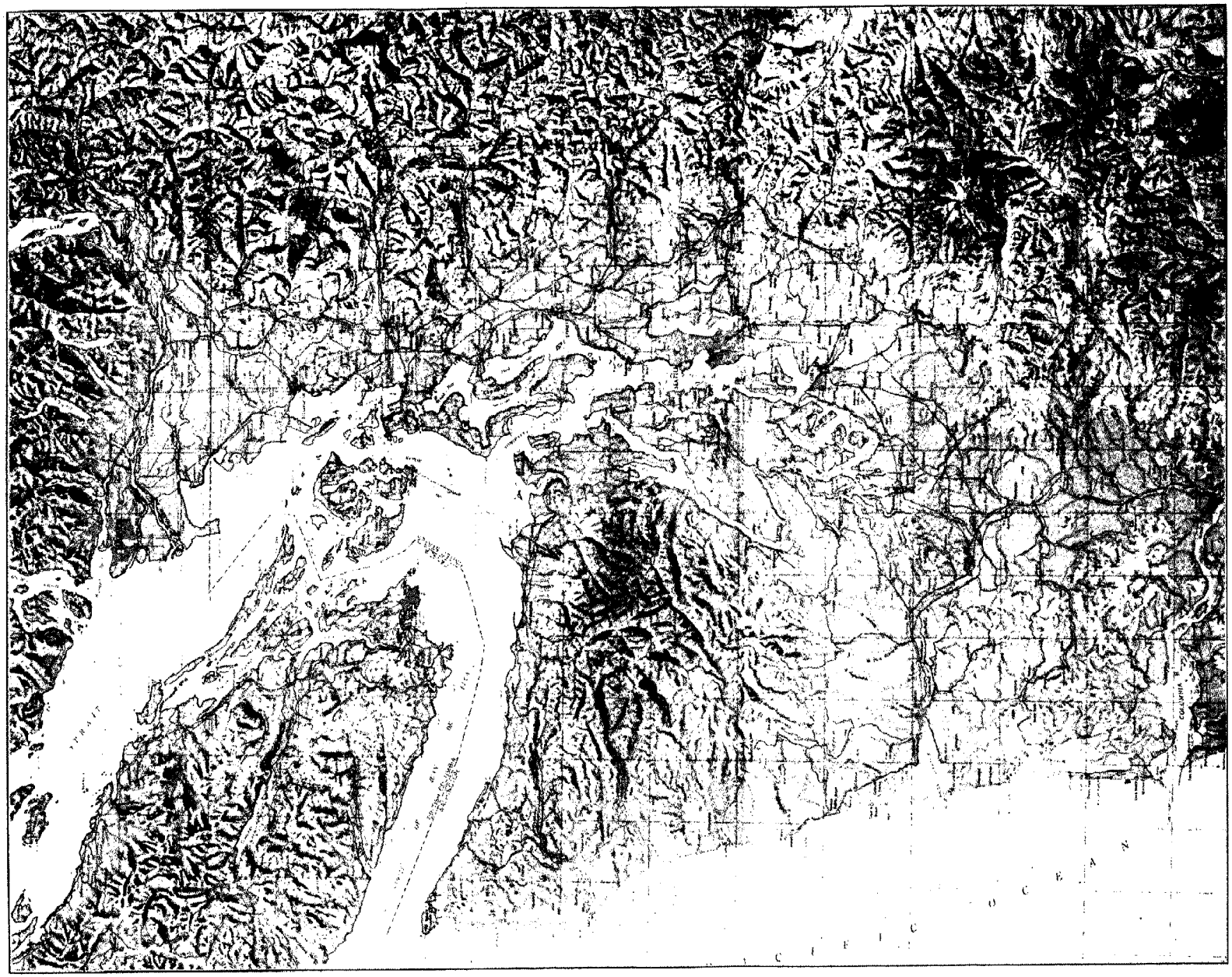

Relief Map of Northwestern Washington

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PREFACE

This manuscript was researched, written, and produced in less than six weeks, so that it could be presented in testimony to the U. S. Senate Subcommittee on Oceans and Atmosphere at its hearings in Seattle on 1-2 July 1971.

The starting point was the $10 book, Oceanographic Resources of the Pacific Northwest, published by the Oceanography Study Committee in 1967. This committee has since disbanded.

Although much of the original text has been retained, the new text focuses only on Washington and incorporates a considerable amount of new material.

In its broadest definition, oceanography is the study of the oceans and everything related to them. Although water covers about two-thirds of the earth's surface, the oceans are the least known part of that surface.

What are oceanographic resources? Are they fish, sandy beaches, research vessels, scientists, deep water? For this report, they can be any of these things. This report examines oceanographic resources in their broadest sense, from the physical oceanographer to the pleasure boater, from the marine biologist to the commercial fisherman, from research vessels to boat works. The programs, the skilled people, the vessels, the laboratories, the construction facilities, the commercial groups, and--most of all--the strong local tie to the sea are examined.

This report is not a complete catalog of facilities, personnel, and financing in the region, nor is it intended as such. Rather, it is a brief, comprehensive exposure to what exists for those who are not aware of the scope or magnitude of present activities. For all concerned, it is intended to weave together into one complete fabric the interrelationships and the vast potential of the marine sciences and endeavors radiating outward from the greater Puget Sound area.

Specifically, this report presents an overview and an index of what man in Washington has done, is doing, and hopefully will do with the oceanic frontier at his doorstep. The emphasis is on past and present activities, but the significance lies in the future--what can be done tomorrow to build our stake in the ocean and its study--in short, in oceanography.

ACKNOWLEDGEMENTS

First expressions of appreciation must go to the now disbanded Oceanography Study Committee which produced the book, Oceanographic Resources of the Pacific Northwest, in 1967. Much information from this book is still current and has been included in the present text. The Oceanography Study Committee was formed under the auspices of the Seattle Area Industrial Council in 1965. Its executive committee consisted of James R. Backstrom, Thomas E. Bolger, Edward E. Carlson (Chairman), Edward Devine, Dr. George W. Farwell, John Haydon (Vice-Chairman), Gerald A. Hoeck, H. Dewayne Kreager, John C. King, Dr. Richard A. Neve, Dr. Dixy Lee Ray (Vice-Chairman), W. Hunter Simpson, Wesley C. Uhlman, Daniel B. Ward, Lysle A. Wood, and Frank W. Woodfield. The 1967 book made special acknowledgments to William Allen, Jr., D. W. Burgess, G. L. Case, D. S. Clement, L. C. Fryant, and F. W. Moon of the Boeing Company; D. Givens of the Seattle Chamber of Commerce; and J. R. Backstrom of the Pacific Science Center.

The Oceanographic Commission of Washington expresses special appreciation to Mark Friebertshauser, research technician for the Department of Oceanography at the University of Washington, for writing Section 2, "Oceanographic Environment," and Section 4, "Commercial Fishing and Aquaculture," and to Alan Krekel, staff assistant at the Division of Marine Resources of the University of Washington, for Section 3, "Marine Research and Ocean Exploration," and Section 5, "Education." Both Mark and Alan worked on this project as staff members of the Washington Sea Grant Program, which also provided some stenographic assistance.

The Oceanographic Commission would also like to express its appreciation to the following persons for providing advice, time, and/or materials to this project:

Charles P. Allen	Star Iron and Steel Co.
R. A. Andersen	Port of Everett
Capt. William D. Barbee	Pacific Oceanographic Laboratories, NOAA
Jim Bean	Port of Willapa Harbor
Duane Blunt	State Department of Ecology
Clyde Boddy	Port of Port Angeles
William E. Bruner	State Department of Commerce and Economic Development
R. Philip Clark	Interagency Committee for Outdoor Recreation
Mark Clevenger	Lockheed Shipbuilding & Construction Co.
Fred M. Cloonan	Tacoma Boatbuilding Co., Northern Line Machine & Engineering Co.
Paul T. Dupell	U.S. Army Corps of Engineers

Dr. Alyn Duxbury	Department of Oceanography, U.W.
K. M. Engebretsen	Port of Vancouver
Dr. Richard Fleming	Department of Oceanography, U.W.
R. H. Fletcher	Port of Seattle
Valerie Foster	Environmental Protection Agency
J. H. Francis	Lake Union Drydock Co.
J. J. Galbreath	Rocket Research Corporation
Capt. H. G. Garnett	Naval Torpedo Station, Keyport, U.S. Navy
C. V. Gibbs	Municipality of Metropolitan Seattle (Metro)
T. J. Glenn	Port of Bellingham
R. A. Hardin	Skagit Corporation
Bryan K. Jacobson	Jacobson Brothers, Inc.
Dr. David Jamison	State Department of Natural Resources
Cdr. K. William Jeffers	National Ocean Survey, NOAA
B. F. Jensen	B. F. Jensen & Associates
Buzz Johnson	College of Fisheries, U.W.
Lt. F. F Kaufhold	Puget Sound Naval Shipyard, U.S. Navy
R. D. Keller	Port of Anacortes
Art Kiuchi	State Department of Ecology
Lee Lathrop	The Boeing Company
Capt. J. C. Lewis	13th Naval District, U.S. Navy
Donald D. Lumley	Todd Shipyards Corporation
Bob Lycke	Washington Iron Works
Conrad Mahnken	National Marine Fisheries Service, NOAA
Merrily R. Manthey	Marine Construction and Design Co. (MARCO)
M. J. Markey	Markey Machinery Co., Inc.
P. H. Marmont	Western Gear Corporation
Norman A. Matson	National Weather Service Forecast Office, NOAA
L. P. Menne	Nickum & Spaulding Assoc., Inc.
R. P. Mitchell	L. R. Glosten & Assoc., Inc.
J. M. Nisbet	Honeywell Marine Systems Center
Bob Palmateer	Division of Marine Resources, U.W.
John M. Patton, Jr.	Northwest Administrative Service Office, NOAA
W. J. Peterson	Port of Tacoma
Hy Pollock	Ross Laboratories, Inc.
R. James Porras	Oceanic Industries, Inc.
George H. Randolph	Port of Port Townsend
Don Reed	State Department of Fisheries
William J. Royea	Manson Construction & Engineering Co.
G. W. Sibold	Port of Olympia
Langdon S. Simons, Jr.	Hydro Drive Corporation
Capt. S. R. Simpson, Jr.	Naval Supply Center, Puget Sound, U.S. Navy
Ltjg. S. B. Smith	Military Sealift Command, U.S. Navy

Gerard J. Van Deene	Port of Grays Harbor
Mary Vaughn	State Parks and Recreation Commission
R. D. Waldo	Aerojet-General Corporation
Cdr. K. E. White	U.S. Coast Guard

SECTION 1

OCEANOGRAPHY AND THE ECONOMY

Captain George Vancouver, first European to sail through the Strait of Juan de Fuca into Puget Sound and the Strait of Georgia, wrote in his journal in May, 1792:

> To describe the beauties of this region, will, on some future occasion, be a very grateful task to the pen of a skilful panegyrist. The serenity of the climate, the innumerable pleasing landscapes, and the abundant fertility that unassisted nature puts forth, require only to be enriched by the industry of man with villages, mansions, cottages, and other buildings, to render it the most lovely country that can be imagined; whilst the labour of the inhabitants would be amply rewarded, in the bounties which nature seems ready to bestow on cultivation.

Today, some 180 years later, man has indeed labored on this land and one wonders whether the alterations that have followed were those that Captain Vancouver imagined or would approve.

While the authors of this document are surely not the "skilful panegyrists" he said would follow, still it is their purpose to examine man's efforts in oceanography and marine affairs in this region and assess its resources and potential.

At present, one very disturbing aspect of man's cultivation and development of these lands and waters is the recently announced statewide unemployment rate of 12.1%.

This has of course prompted many inquiries and studies to determine the causes and solutions of this condition. The state Department of Commerce and Economic Development provides this comment on the economic structure of Washington, its patterns, and its future.

The economic structure of Washington has developed rapidly from a rich natural resource base. Originally the State's economy was structured entirely upon the area's unique possession of raw materials. Major industrial activities revolved solely around forestry, fishing, mineral, agricultural, and marine resources. From an economy dependent entirely upon extractive industries, however, Washington State has developed gradually into a more complex, highly-industrialized urban area, engaged in secondary processing of its resources; producing some goods for its own household and industrial consumption; and manufacturing some products for export which are not entirely based upon the region's raw materials. The major industries of Washington in terms of income generation and transportation equipment manufacture, forest products, agricultural and food processing, and metal working.

The development and expansion of these primary activities has generated support for a broad spectrum of secondary activities. Washington has highly developed wholesale-retail trade and service sectors with Seattle and Spokane serving as major financial and trade centers of the Pacific Northwest. Government is also a major income source in the State with such governmental activities as shipbuilding and repair, electric power generation, water distribution and forest and fisheries management contributing to the diversity of the economy.

During the latter half of the 1960's the State experienced an unprecedented economic expansion. Employment, spurred by an aerospace boom, increased by 225,000 or 20 percent between 1965 and 1969 and Washington's rate of personal income advance during that period was among the highest in the nation. In 1969, aerospace employment levels began to plunge sharply and a national recession in late 1969 and early 1970 softened markets for Washington's lumber and metals industries. The recession in 1970 did not wipe out gains of the previous five years, however.

In spite of short-run economic difficulties, the long-run outlook for the State remains optimistic. Aerospace employment levels will stabilize soon relieving the dominant negative influence on the State's economy. A definite upswing in the level of national business activity has already begun to improve conditions in the State's wood products industry and the diversified manufacturing sectors including metals and machinery will soon experience healthier market conditions. In 1972 growth, moderate at first but gaining momentum in subsequent years, will once again be evident in the Washington economy.

TABLE 1

Economic and Industry Patterns
Washington State

POPULATION PATTERNS

Area (Square Miles)			68,192
Population (1970 Census)	Male	Female	Total
TOTAL	1,693,747	1,715,422	3,409,169
UNDER 16 years	524,058	501,904	1,025,962
16 - 21 years	197,200	188,927	386,127
22 - 34 years	303,586	300,025	603,611
35 - 44 years	185,792	188,056	373,848
45 - 54 years	193,989	198,665	392,654
55 - 64 years	150,099	154,807	304,906
65 - 74 years	86,588	104,755	191,343
75 years & over	52,435	78,283	130,718
% Change in Population Since 1960			19.5%
Average annual growth rate since 1960			1.8%

POPULATION DENSITY

(Inhabitants per square mile)

1970 average	50.0
1920 average	20.3

URBANIZATION (1970 Census)

% Population within Standard Metropolitan Statistical Areas	66.0% (Seattle, Tacoma, Spokane & part of Portland SMSA.)
% Population within Urban Areas	72.6%

TAXATION AND INCOME

STATE TAX PER CAPITA (1969)	$288.28
FEDERAL TAX PER CAPITA (1969)	$723.53
LOCAL TAX PER CAPITA (1969)	$121.84
PERSONAL INCOME PER CAPITA	
1969	$3,916
1970	$3,993

RESOURCES

POWER PRODUCTION-PACIFIC Northwest-Billions of KW Hrs produced 1970	114.7
FOREST LAND	
Millions of Total Acres (1969)	23.0
In Commercial Use (Million Acres)	19.5
Annual Production - 1970 Washington State	
Lumber (million bd.ft.)	2430.0
Plywood (million sq.ft.-3/8" basis)	1804.9
MINING	
Value of Production (1970) (million dollars)	92.7
Major Minerals	Cement, Coal, Sand, Gravel, Stone, Zinc, Lead, Uranium, Copper
FISHERIES	
Value of Catch (1970) (millions of dollars)	$31.5
Value per pound	23.1¢
Leading species	Salmon, Halibut bottom fish, oysters

AGRICULTURAL PRODUCTS

Gross Farm Income (1969) (million dollars)	910.0
Farm Production Expense	630.4
Net Change in Inventories	26.7
Net Farm Income	306.3
Value of Agricultural Production (1970) (million dollars)	
Field crops	382.7
Fruit crops	117.4
Berry crops	12.6
Vegetable crops	41.5
Livestock & Livestock Products	299.7
Specialty Products	44.8
TOTAL	898.7

LABOR FORCE AND EMPLOYMENT (1970)

(Thousands)	
Total labor force	1405.8
Total Employment	1288.1
AGRICULTURE	64.9
Manufacturing	240.5
Non-manufacturing, wage & salary	843.6
All other (Employer, self-employed, Unpaid and Domestics)	139.1

MANUFACTURING

Value added (1967) (million dollars)	3,764.2
Principal Products	Food products, lumber, plywood, pulp, paper, aircraft, ships, aluminum.
Ratio Production to Total Manufacturing Employment (1967)	.654
Total Manufacturing Employment (1967) (Thousands)	270.7
Total Wages (1967) (Million dollars)	2,119.0

In December 1970, Ned W. Weaver, a transportation economist, completed a study of Washington's current economic slump.

Weaver notes that both in terms of the number of persons employed and in the size of its payroll, manufacturing is the largest industry division of the economy in both the nation and Washington. Manufacturing accounts for approximately one-fifth of the state's labor force. Nationally, about one-fourth of the total persons employed are accounted for by manufacturing. Manufacturing salaries and wages are about one-third of the total disbursements for salaries and wages.

TABLE 2

Percent Distribution of Payrolls and Employment by Industry Division: Washington, 1967

Industry Division	First Quarter Payrolls	Mid-March Employment
Manufacturing	41.6%	34.4%
Retail trade	13.9	19.8
Services	12.0	17.3
Contract construction	8.7	6.8
Wholesale trade	8.6	7.4
Transportation, Public Utilities	8.3	6.8
Finance, Insurance, Real estate	5.8	6.1
Agricultural services, Forestry, Fisheries	0.4	0.6
Mining	0.3	0.3
Unclassified	0.4	0.6

Fluctations in the business cycle are reflected more quickly and noticeably in some types of jobs than others. The production of durable goods is generally more sensitive to economic downturns than non-durable consumer goods.

In Washington the durable goods industries account for 73% of manufacturing employment. Nationally, the figure is about 58%. In King and Snohomish counties, where Seattle and Everett are located, the figure is 82%. Thus, to no one's surprise, the state and its largest Standard Metropolitan Statistical Area (King and Snohomish counties) are less stable economically than the nation as a whole. Two-thirds of all manufacturing employment in Washington is concentrated in the three counties constituting the central Puget Sound area. In recent years this concentration increased and did so to a greater degree than the state's population increased in the same area.

Washington exports a considerable portion of its manufactures products to other states and nations. At the same time, it imports a high proportion of the materials and supplies it uses to manufacture its products. Thus, the state's economy is highly dependent on the nation's, and to some extent, the world's economy. If certain industries could be induced

to locate plants within the state, Washington could become more stable and self-sufficient economically.

Not only is Washington's manufacturing employment concentrated in one large metropolitan area, but also it is greatly dependent on one type of industry--aerospace. Weaver reports that about one-third of the state's manufacturing employment is in the aerospace industry. Aerospace industry purchases a very high proportion of its materials and supplies for production from outside the state. Aerospace employment in Washington declined from a peak of 101,500 in mid-1968 to approximately 49,600 during September 1970. By the end of 1971, the employment is forecasted to be 32,500.

The way to achieve a better balance in the state's economy, concludes Weaver, is to both diversify and disperse industry. Diversification should be in the direction of more non-durable consumer goods. Dispersion should be towards non-metropolitan areas. Weaver writes, "the greater the variety of an area's industry, the less likely that all industries will experience a downturn at the same time." Other industries would serve as alternate sources of employment when a basic industry experiences a slowdown; skilled laborers would not be forced out of the state. Washington especially needs more labor-intensive growth industries rather than capital-intensive industries because the former supply more employment than the latter.

Weaver notes that at the time of his study, Washington had neither a state-sponsored industrial development authority nor a privately-sponsored credit corporation to provide financial assistance to industry for building plants. In December 1969, thirty-one other states did have state-sponsored industrial development authorities.

Oceanography: is it the answer? Does it offer diversification? Does it produce non-durable consumer goods? Is it highly localized or will it disperse industry to non-metropolitan areas of the state? Does it import more materials and supplies than it exports products to other states and nations? Is it labor-intensive or capital-intensive?

In an oblique way, this book attempts to answer these questions by discussing this region's developed oceanographic and marine capabilities and activities and its undeveloped potential.

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"Economic Structure of Washington," unpublished letter of 8 June 1971 from William E. Bruner, Department of Commerce and Economic Development to B.G. Ledbetter, Oceanographic Commission of Washington.

Meany, Edmond S. Vancouver's Discovery of Puget Sound. 1957. Portland, Oregon: Binfords & Mort, Publishers.

Weaver, Ned W. Industrial Dispersion and Diversification for Washington State. 14 December 1970. A report edited by Rod Rolfson and submitted to the Joint Committee on Highways and the Subcommittee on Finance and Industrial Development, Washington State Legislature.

SECTION 2

OCEANOGRAPHIC ENVIRONMENT

Western Washington lies between latitudes 46°N and 49°N. It is bordered on the south by the Columbia River and on the north by the Strait of Juan de Fuca and the San Juan Islands. There are approximately 250 miles of coastline along the Pacific Ocean, 100 miles along the Strait of Juan de Fuca, and 1,100 miles of shoreline in the Puget Sound region due to its numerous islands and highly indented shoreline. Puget Sound extends from the eastern end of the Strait of Juan de Fuca southward for 125 miles and lies in a basin bordered on the east by the Cascade Mountains (average elevation 8,000 feet) which are crowned by Mt. Rainier (elevation 14,400 feet). Between the Puget Sound basin and the Pacific Ocean are the Olympic Mountains. These mountains form a precipitation barrier and create the rain forests on their south and western slopes where the annual precipitation ranges from 60 to 240 inches. This is due to the moist marine air which blows onshore and loses its moisture as it rises and cools over the Olympic Mountains.

This orographic effect also creates a rain shadow over the northeastern section of the Olympic Peninsula and the adjacent Puget Sound basin only 30 miles away. Here the annual precipitation values vary from 20 inches in Northern Puget Sound to 60 inches in Southern Puget Sound.

WASHINGTON'S COAST

The coastline along the Pacific Ocean is fairly straight except for two sheltered embayments--Willapa Bay and Grays Harbor. The shore varies from wide, low sandy beaches south of Pt. Grenville to rocky cliffs interspersed with sandy beaches north of Pt. Grenville. The continental shelf of Washington varies in width from 10 to 35 miles

and is crossed by six submarine canyons: Astoria, Willapa, Guide, Grays, Quinault, and Juan de Fuca. The Juan de Fuca canyon, which extends southwesterly from the entrance of the Strait of Juan de Fuca at Cape Flattery, is 4 miles wide and cuts 300 feet into the continental shelf.

A unique feature of the Northeastern Pacific Ocean is the seamount region 250 to 500 miles off the coast of Washington. The most thoroughly studied seamount in this region is Cobb Seamount located 270 miles due west of Grays Harbor. This volcanic pinnacle rises 9,000 feet above the sea floor to within 110 feet of the surface. It is different from other known seamounts in that its top, about 24 acres in area, is within the photic zone and furnishes an ecological niche that supports abundant life. It is accessible to scuba divers and is an ideal site for placement of remote sensing equipment which would help in the understanding of oceanic and atmospheric processes. The research presently going on at Cobb Seamount is coordinated by the Sea Use Council which has regional representation from Washington, Oregon, Alaska and Hawaii, the National Oceanic and Atmospheric Administration (NOAA), the United States Navy, and the United States Coast Guard. The Sea Use Council, through its corporate agent, the Oceanographic Institute of Washington, is proposing that Cobb Seamount be developed as a national seamount station during the International Decade of Ocean Exploration (1970-1980).

The Pacific Ocean adjacent to Washington and the inland waters are in a region of net dilution, where precipitation exceeds evaporation over the sea surface as well as the adjacent land masses. The greatest single source contribution of fresh water to the Eastern Pacific Ocean is from the Columbia River. The average discharge from this river is 258,000 ft^3/sec, or about 14% of the total annual freshwater discharge of the continental United States. During the late summer, the Columbia River effluent forms more than 90% of the fresh water entering the Pacific Ocean between the Strait of Juan de Fuca and San Francisco Bay, while in the winter the discharge amounts to only slightly more than 60%. This decrease results from the increase in discharge of numerous smaller coastal rivers responding to the wintertime increase in local precipitation. During the winter the freshwater from the Columbia River can be detected 30 to 60 miles seaward and from about 60 miles south of the river mouth northward to the Strait of Juan de Fuca. In summer this freshwater plume extends 200 to 250 miles seaward and 300 miles or more southwest. The path of this freshwater plume is indicative of the wind driven oceanic circulation that occurs along the coast. During the wintertime southwest winds create an onshore and slightly northward flow of surface water. In the summer the predominantly northerly winds impose an offshore and southerly transport of surface water which creates upwelling conditions along the coast. This upwelling furnishes dense water that works into Puget Sound in late summer to flush out its deeper basins.

PUGET SOUND

Probably the most important resource to the Pacific Northwest is the Puget Sound region. The general shape, depth, and coastal topography of Puget Sound and its many islands are products of glacial activity. The mainland and island coastlines are irregular and usually backed by cliffs. Beaches are narrow and confined to embayments, except for tidal flats on the river deltas. The entire region is navigable to deep draft ships and is well protected naturally from open sea conditions. Its highly indented shoreline, bathymetry, tidal fluctuations, varied and mild climate, and river discharge produce a wide variety of marine micro-environments.

Puget Sound is considered by some to be a "miniature ocean" and "one of the more productive bodies of salt water in the world." It is a glacially carved estuary which opens into the Strait of Juan de Fuca through Admiralty Inlet and Deception Pass. Its average depth is 220 feet and the maximum is 930 feet just 5 miles northwest of Seattle. Each of the major basins which make up the Puget Sound region (Puget Sound basin, Whidbey basin, Southern Puget Sound, and Hood Canal) have depths of 600 feet. Shallow sills are present at the entrances to Puget Sound, Southern Puget Sound, and Hood Canal. During late summer when upwelling occurs off the coast of Washington, dense water moves in from the sea to be mixed vertically over the sills and spill over into the basins replacing the older, less dense water. The replacement of the water in the upper layer is controlled by fresh water runoff and tidal mixing. The average tide range varies from 8 feet at Port Townsend to 14 feet at Olympia. On each tidal cycle about 1.9 cubic miles (28×10^{10} ft^3) of water is carried in and out of Puget Sound. The average annual freshwater discharge into Puget Sound is 140×10^{10} ft^3. This means the volume of water flowing out on the ebb tide is greater than the volume added on the flood. This net seaward flow acts to remove the near surface water and replace it gradually with water from the Strait of Juan de Fuca. Most of the water in Puget Sound is probably replaced on the average of twice a year with a shorter time associated with surface water. However, in some areas of Hood Canal where the replacement of deeper water is not very efficient the replacement time is about one year. Near anoxic conditions may develop in the deeper basin waters that are protected by shallow sills.

The transparency of Puget Sound waters is variable, depending on location and time of year. Maximum visibility occurs during late fall or early winter when the Secchi disk depth (the maximum depth at which a 14" diameter white disk can be seen from the surface) approaches 60 feet. Minimum visibility occurs during spring when the Secchi disk depth is around 15 feet. The minimum visibility is due to both the spring river runoff which carries sediment and rock flour into Puget Sound and the large springtime phytoplankton population. A yearly average Secchi disk depth would be around 26 feet which is comparable to the values found in oceanic waters along the West Coast. In various places among the San Juan Islands the water is extremely clear.

The surface temperature of the Pacific Ocean off Washington in winter varies from 35°F to 45°F and in summer from 50°F to 60°F. This is only about 5°F colder in the winter than the water off Los Angeles and 10°F colder than that off Los Angeles in the summer. In Puget Sound, because of the vertical mixing and rapid exchange of water, the water temperature approximates that of the inflowing water--generally between 47°F and 50°F. Only in the shallow portions of Puget Sound having restricted circulation do the effects of summer heating and winter cooling combine to produce temperatures significantly different. The mean annual air temperature for the Puget Sound region is about 50°F, the extreme recorded temperatures are -3°F and 105°F.

Puget Sound is very productive due to 1) inflow of cold water from the Pacific that is high in nutrients, 2) tidal mixing, 3) stability of the water column in summer caused by the inflow of freshwater (springmelt), 4) the amount of sunlight reaching the water surface in summer, 5) the transparency of the water, and, 6) the relatively unpolluted state of its waters. The large tidal fluctuations, combined with the various types of beaches and substrate, produce an abundant and diverse form of benthic and planktonic life. The Friday Harbor Laboratories in the San Juan Islands are operated by the University of Washington and are an important center for the study of marine sciences. The diversity and abundance of biological material readily available for study at the site is well known throughout the world.

Nearly all of Puget Sound waters are classified as either AA or A under the Federal Water Quality Standards Act that was adopted by the State of Washington. Some areas deviate from the AA or A classification due to man's influence or natural, seasonal variations in nutrients, dissolved oxygen, or temperature.

The uniqueness of Puget Sound as a marine testing environment has long been recognized and has led to its use as a testing area for acoustical and magnetic properties of ships and for testing acoustical guidance systems in undersea vehicles. The protected inland waters of Puget Sound and the San Juan Islands allow oceanographic studies to be performed from small vessels year round. The deep, relatively clear, ice free waters form an ideal environment for the placement and year round operation of underwater laboratories. Due to the steep underwater dropoff in various parts of Puget Sound, it would be possible to monitor underwater labs or instrument packages from shore stations rather than using mother ships.

An important tool in understanding the processes which go on in Puget Sound and adjoining waters is the vast amount of detailed historical oceanographic data that has been collected in this area. Biological studies were first started around 1904 at the Friday Harbor Laboratories, formerly the Puget Sound Biological Station. Physical and chemical oceanographic data has been collected since 1932 by the University of Washington's Department of Oceanography and various federal, state and private agencies. The Pacific Coast

area has also been extensively studied since 1961 under the A.E.C. sponsored Columbia River Effects Program. These data collections are very helpful in understanding the dynamic processes in the coastal zone as controlled by nature and man.

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SECTION 3

MARINE RESEARCH AND OCEAN EXPLORATION

The state of Washington, with its inland sea and ready access to the open ocean, has long been a growing center for marine research and ocean exploration. These areas of study have been the mutual province of industry, government agencies, and academic institutions, each pursuing types of research fitting its overall objectives. Scholars from the state's colleges and universities search side by side with scientists employed by industry in quest of additional knowledge about the ocean and its mysteries. Their efforts are augmented by those of a variety of government agencies which are discussed elsewhere in this inventory.

If the increasing number of magazine and newspaper articles, amateur marine-biology groups, and after-dinner speeches on the subjects of marine research and ocean exploration are any indication, interest among Washington residents is growing in subjects relating to the sea. Such interest is by no means new. The northwest corner of the United States has long felt a strong affinity with the sea, produced in large part by the area's relative isolation from other areas of the country. Today, that isolation is a thing of the past, what with modern airlines, railroads, and superhighways, but the ties to the sea are strong.

Researchers and scientists in virtually all disciplines relating to the sea have sought out the state of Washington as an ideal place to further their work in marine research and ocean exploration. Two primary reasons for the area's preeminence as a location for such activities are the availability of a sheltered inland sea in Puget Sound and the region's remarkable weather. Research can go on without interference from unworkable weather conditions or insurmountable logistics problems.

Organizations and individuals involved in marine research and

ocean exploration include, but are by no means limited to, university teaching and research staffs, industrial firms, naval scientists, medical researchers, geophysicists, biologists, and government conservationists.

An informal meeting of researchers is convened in the Pacific Northwest each winter to discuss planned research and report key accomplishments. The meetings are helpful in avoiding duplications of research.

Research is conducted in the following general categories:

. Descriptive Oceanography--Physical, chemical, biological, and geological oceanography in rivers, shore and coastal areas, the Gulf of Alaska, and the Northeast Pacific.

. Fisheries--Fisheries research in migration, breeding, and effects of pollution (primarily concerned with salmon, halibut, trout, crab, oysters, and clams).

. Seafood--Seafood harvesting, handling, preservation, and use as food and for other applications.

. Naval Vessels and Equipment--Noise characteristics, maneuverability, stability, and performance of naval ships, submarines, and torpedoes; research and development of associated instrumentation.

. Underwater Devices--Sonar and other underwater sensors, communications, and systems.

. Marine Mammals--Marine mammal research, including seals, otters, whales, and other cetaceans, and Pribilof Island fur seals.

. Pollution and Water Management--Pollution and water management techniques, including study of radionuclides downstream from the Hanford atomic research site, development of instrumentation, and exploratory surveys.

. Ecology--Ecological relationships in underwater communities and dependence on localized physical, chemical, and geological conditions.

. Sea-Air Phenomena--Sea-air interaction phenomena and development of instruments for their study.

. Glaciers and Sea Ice--Glacial and sea-ice growth and movement, arctic oceanography, and subsurface-current tracing and measurement.

. Adaptation of Man to the Sea--Adaptation of man to the sea, underwater engineering studies, and life-support systems for sustained submergence.

. Support Equipment--Support equipment, methods, and sensors for use in ocean operations, rescue and salvage, monitoring, and tracking.

Such work is described briefly in the remainder of this section. Two interinstitutional and interdisciplinary programs (SEA USE and Sea Grant) will be discussed first.

PROJECT SEA USE

Project SEA USE is a cooperative program designed to study the unique environment of Cobb Seamount and to test present technological capabilities to exploit it. Cobb Seamount, a pinnacle rising to within 120 feet of the surface of the Northeast Pacific Ocean, lies 270 miles west of Grays Harbor, Washington. The governing body of the SEA USE Program is the SEA USE Council, with memberships from the states of Alaska, Hawaii, Oregon and Washington and representatives of NOAA, the Navy and the Coast Guard. The Oceanographic Institute of Washington acts as corporate agent for the SEA USE Council. Other participants in various aspects of the program have included the University of Washington; Applied Physics Laboratory; Honeywell; Battelle Northwest; Seattle Marine Laboratories (now Science Engineering Associates); Pacific Science Center; Mechanics Research; the firm of Kelly, Pittelko, Fritz, and Forseen; Murphy Pacific Marine Salvage Company; NEREUS Corporation; NUMEC Corporation; Sverdrup and Parcel; Explosives Corporation of America; U.S. Navy Civil Engineering Laboratory; Ocean Systems, Inc.; Foundation Sciences, Inc.; and the Northwest Diving Institute.

A principal objective of the exploratory 1968 work was to conduct a hydrographic and geophysical survey at Cobb Seamount in order to develop the detailed bathymetry of the summit and to relate the Seamount to the regional geology of the Northeast Pacific Basin. The National Ocean Survey ship OCEANOGRAPHER carried out two investigations at Cobb during the autumn of 1968.

The 1969 expedition to Cobb Seamount was manned by eighteen scientists and technicians during a summer cruise aboard the Coast Guard cutter IVY. Primary missions accomplished were testing of an explosive anchor and installation of several navigational pingers and a surge meter. Also, a collection of oriented rock samples was made for paleomagnetic studies on the origin and history of Cobb Seamount.

In 1970, three expeditions visited Cobb Seamount. The first in the spring aboard the Coast Guard Buoy Tender CACTUS recovered the instrument packages left the previous summer: the surge meter and two pingers. Additional bathymetry was performed and a series of celestial observations pinpointed the location of Cobb more precisely than had been previously accomplished using Loran. Also, a radar reflector buoy was anchored to the top of the seamount.

The second 1970 expedition by the UW Applied Physics Laboratory

was aboard the USNS BARTLETT. Scientists successfully implanted a 1,500 pound transmitter tower on a seamount 11 miles southwest of Cobb at a depth of 3,000 feet. Plans to emplace a second tower with receiver sensors at the same level on the slope of Cobb were thwarted by rough weather. The first tower was later recovered; the underwater acoustic experiment will be attempted again in 1971.

Engineers and divers of the third 1970 expedition drilled and extracted three oriented rock cores, cemented 2-1/2" by 5' steel bolts into each hole, and after about 72 hours fail-tested one to determine its holding power. The bolt failed at about 110 tons of vertical pull; the strength of the anchor assembly has since increased over 50 per cent, strong enough to moor a ship of almost any size in normal seas.

Long-range plans call for constructing a surface-piercing mast on the summit and establishing a manned habitat as a home base for underwater exploration and scientific research. The two mast designs being considered are a 150-foot tripod, topped with a spar reaching 50 feet above sea level, or a single 200-foot spar, guyed to the summit by cables.

Data gathered from instrumentation on the mast will be used to greatly increase knowledge of air-ocean interaction and provide the nation with weather information never before available.

To bring these plans nearer realization, the SEA USE Council and its Scientific and Technical Board met in Vancouver, B.C., in November 1970. Among the many topics discussed were air-sea transport phenomena at high wind speeds; tide, tsunami, and wave climatology observations; storing and telemetering real time data; and the desired range, frequency sensitivity, and accuracy of the parameters to be measured.

SEA USE seeks support from regional and national sources, including the National Science Foundation, Maritime Administration, Advanced Research Projects Agency, and National Oceanic and Atmospheric Administration.

WASHINGTON SEA GRANT PROGRAM

Goals and methods

The goal of the Washington Sea Grant Program is to solve the problems encountered in making the sea's resources available to the people of the state of Washington and to the nation as a whole. In this statement "resources" include concepts of economic development, management for optimal yield, and preservation of shoreline areas and marine waters for food, recreation, transportation, waste disposal, and other desirable uses. The problems of developing and conserving any resource are vast and varied, and marine resource problems are no exception. They are complicated by growing conflicts in human uses of marine waters and by the conflicts of responsibilities among the traditional institutional arrangements concerning the establishment

of priorities. Even the concept of optimal yield is subject to a variety of interpretations by multiple users within the conflicts between short-term or long-term gains. Sea Grant encourages the broad spectrum of activities required. These activities include research and development, education and training, advisory services, and demonstrations necessary to reduce theory and new knowledge to improved practices.

Inescapably, the conclusion is that most problems of increased utilization of marine resources are sufficiently complex to require a team approach to foster solutions. This concept is not restricted to interdisciplinary efforts alone but frequently includes the concept of interinstitutional cooperative efforts matching the talents and interests of educational institutions, state agencies, regional elements of federal agencies, industry, and the public as a whole.

The team concept has become the keystone of Washington Sea Grant's approach to marine problems; to seek out what is going on in the problem areas, then try to apply Sea Grant resources where additional effort might do the most good.

Development of the Program

Marine-based activities have been important to people living in western Washington since its settlement. The waters of Puget Sound and the Straits of Juan de Fuca and Georgia comprise a natural shoreline of about 2,000 nautical miles in length and enclose nearly 2,500 square miles of salt water environment. These waters provide a natural harbor and terminal facility for broad based marine transportation. They also provide an annual commercial harvest of fish and shellfish of more than 100 million pounds. These marine waters have a high esthetic value and are a base for recreation for the two million people that live near their shores.

With this traditional importance, it is not surprising that the University of Washington has been involved in problems in marine affairs for a long time. The Friday Harbor Marine Laboratories were established in 1904. The University has had an active fisheries program in education and research for over 50 years. An oceanographic effort was established in 1931 and has been a principal source of marine science information for the people of the state since that time. Activities within basic sciences departments including Atmospheric Sciences, Botany, and Zoology, have long had a marine component. Resource programs within Economics, the Graduate School of Public Affairs, and the College of Engineering are providing a broad foundation of marine activities. Finally, the School of Law is currently developing a curriculum in marine law.

Following a recommendation of the Marine Sciences Committee, the Division of Marine Resources was established by the University's Board of Regents on March 24, 1967. The Division was charged with the responsibility to coordinate, supplement, and support the teaching, research, development, advisory and training programs that are a part of

or are associated with the marine resources program of the University of Washington. In addition, it is to promote coordination with related programs in other institutions of the Pacific Northwest. In particular, the Division of Marine Resources was given the responsibility to develop and manage the Sea Grant program. The assignment of this responsibility recognized the leadership of the University and the importance of involving other institutions and members of the community in the development of Sea Grant within the state of Washington.

The University of Washington received its first Sea Grant Institutional Award in February 1968. The initial effort capitalized on the University's strong background of education and research in the marine sciences and related fields.

In 1969, along with improving these existing programs in education and research, three community colleges and a vocational training institute were added to the program, emphasizing two-year training programs for technicians working in marine engineering, marine sciences, and fisheries.

In the process of further developing the Washington Sea Grant Program, there began to be a greater appreciation for the uniqueness of the Sea Grant Program and the opportunity afforded the University to closely integrate its activities in Education and Training, Research and Development, and Advisory Service in one cohesive program.

The brochure entitled, "Suggestions for Submission of Proposals" states that "institutions receiving Sea Grant institutional support will develop a program of a size dictated by their interests and ability and the requirements of the geographic regions they serve. In all cases, however, institutions participating in the institutional support program should be leaders and unifying forces within their regions in all matters of marine resource development which they undertake." This requirement that the University act as a unifying force and that the program be oriented to regional problems inevitably causes the University to reach out into the community; first to identify problems and their relative priorities and second to assist in final solution to the problems.

The proposal for 1970 included a major emphasis on the development of an advisory service and information transfer program. In addition to four community colleges and the Clover Park Education Center, participation of the University of Puget Sound was added. The Washington State Department of Fisheries became the first state agency to participate actively in the program. Other participants included Battelle Northwest, the Pacific Science Center, the Pacific Oyster Growers Association, and the naval architectural firms of W. C. Nickum & Sons and L. R. Glosten and Associates. During the course of 1970, the state Department of Natural Resources and the National Marine Fisheries Service also assumed integral roles in the Washington Sea Grant effort.

Future trends of Washington Sea Grant Program

In the future, there will be active participation in the Washington Sea Grant Program by faculties of other 4-year colleges, other agencies of state government, and personnel from regional federal laboratories. It is hoped to develop and implement community colleges in the coastal counties as centers for marine resource information. Additional industries and industrial organizations will be encouraged to participate actively. Finally, the definition and implementation of coastal zone laboratory activities for the state of Washington will be actively pursued.

The Washington Sea Grant Program--1971-72

During 1971 and 1972, Washington Sea Grant will continue to emphasize interdisciplinary and interinstitutional approaches to the priority problem areas of this region. The program as now formulated consists of eight major categories of effort. These are: Advisory Services, Administration and New Program Development within the Division of Marine Resources; New University Courses and Technician Training within education and training; and five research and development categories. Within each of these categories, particularly for research and development activities, the direction is toward development of a broad spectrum of activities ranging from more basic educational or research objectives to applied investigations leading to specific demonstration projects in cooperation with other institutions and industry.

The major efforts involved in each of these categories will be described briefly below (see Section 5 for information on New University Courses and Technician Training). Some of these efforts have reached a relatively high level of maturity, either as a result of the nature of the problem, or because of a major emphasis in the past. In this discussion, specific efforts anticipated for further program development in 1971 and 1972 will be noted.

Advisory services

Washington Sea Grant's program in advisory services was developed as a continuing two-way communications system with three distinct functions:

1. Seek out regional needs,
2. Do something--or get something done--about them, and
3. Get pertinent information to those who can use it.

The Division of Marine Resources, in addition to program direction, provides general advisory coverage through the Sea Grant Information Service and handling contact opportunities as they arise. It also provides publication and news media support.

Battelle Northwest is seeking a method economical in both cost and manpower for opening the normally clumped Pacific oyster, in such a way that a fresh rather than cooked or frozen product will result.

The Pacific Science Center is setting up a continuing Sea Grant

exhibit area centered around a working oceanographic model of Puget Sound in order to bring about greater public awareness of the Sound and its problems.

The College of Fisheries and Clover Park Education Center projects reflect a deliberate decision to emphasize fisheries advisory services through extension services to both seafood processors and commercial fishermen.

Advisory emphasis including extension effort involves appreciable commitment of resources. This approach involves a specialist on split appointment between the University's College of Fisheries and Division of Marine Resources, working with an agent operating from an appropriate field center--in this case, Clover Park Education Center.

The most important single ingredient, however, is the Fisheries Advisory Services Committee (FASC). It is made up of four people from industrial associations, three from the industry, two from unions, two directly representing fishermen, three from state and federal agencies, and five from the Sea Grant Advisory Program. The FASC helps make certain the program keeps its feet solidly on the ground.

Fisheries research

The aquaculture portion of the Washington Sea Grant Program is proceeding with the long term goal of the improvement of the economic potential of the waters of the state for fish and shellfish culture. The program is based on the long standing work of Dr. Lauren Donaldson emphasizing salmonid culture but also includes studies on the culture of local species of oysters, clams and shrimp. Research into inexpensive algal food for organisms in culture will assure a low cost product. Activities are located at the main campus and the Big Beef Creek field station. (For additional information on Sea Grant and other aquaculture programs of the state, see Section 4.)

The Norfish program will develop a total systems analysis of the North Pacific Fisheries, including both finfish and shellfish, something never before attempted.

Under the total utilization concept (TUC) investigators are exploring ways to market fish wastes and unwanted species by a process designed to produce kilogram quantities of fish protein concentrate by commercially viable techniques on vessels and within processing plants. When developed this will mean increased profits for the fisherman and decreased pollution near fish processing plants. (See Section 4 for information on the NMFS Aberdeen FPC pilot plant.)

The Fisheries Research program includes coordination with local programs of the National Marine Fisheries Service, the Washington State Department of Fisheries, the King Crab Institute (an association of industries), Ocean Systems, Inc., the Lummi Indian Tribe, and the Pacific Oyster Growers Association.

New resource utilization

The program to utilize new resources from the sea has as its initial goal the commercial utilization and cultivation of marine plants. The main thrusts of the effort are a study on the structural characteristics of marine polymers, especially those produced by species of marine plants which can be cultured, and a study of the areas of potential utilization for marine polymers. Working with industry, nine potential industrial uses have been identified, plus potential drug compound derivatives from marine plants. These two efforts are closely allied to the algal aquaculture program which looks at marine plants in culture from two points of view, one as a source of marine polymers, and the other as a source of inexpensive food for other marine organisms in culture. This effort is being developed in close cooperation with the forest industry, Marine Colloids, Inc., the state Department of Natural Resources, Shoreline Community College, and the Lummi Aquaculture Project.

In order to promote a seaweed industry, the state Department of Natural Resources has formed a Seaweed Council. The purpose of the council is to advise the department in the management of the state-owned tidelands and the beds of navigable waters as to the harvest and cultivation of seaweeds. Working with the department, the Sea Grant Program is developing a catalogue of those bodies of water within state jurisdiction, mainly Puget Sound, where aquaculture projects could be successful if licensed by the department.

Managing the nearshore environment

Studies of the problems encountered in managing the nearshore environment are a major developing effort of the Washington Sea Grant Program, centered about a study of the socio-economic, institutional, and legal considerations in the management of Puget Sound. When complete, the study will provide the major source of information on management of water and adjacent land resources in the Puget Sound area. As a major study of the management of a large estuarine inland waterway system, it will be of interest to researchers and policy makers elsewhere in the United States. Backing up this effort are activities to provide the essential scientific data required for good management. An index of available oceanographic and other data recently has been published jointly by the Department of Natural Resources and Washington Sea Grant. A literature survey of sources of information about Puget Sound is being completed also.

At present, a coastal zone management policy for the state of Washington is under serious examination by concerned groups of citizens, local government entities, and by groups from both the legislative and executive branches of state government. A major task of the Sea Grant Program is to provide support for these deliberations and to develop the concepts of a coastal zone laboratory.

Ocean engineering

A demonstration project to determine the feasibility of using

the natural environment of Puget Sound as a testing laboratory for vessels and ocean engineering structures has been carried on by faculty, graduate students, and commercial naval architects. A motion sensing device developed by the students has proved successful in measuring the motion of vessels. The seaway itself is being measured and described in terms of directional wave spectra at a dolphin owned by the University. Under Sea Grant, this program will emphasize education objectives in 1971 and 1972.

Marine acoustics

A research team consisting of biological oceanographers, electrical engineers, physicists, and fisheries biologists is developing marine acoustic techniques for assessing the world's fisheries and the ocean's potential as a source of human food. To facilitate obtaining such information, this team has developed a sonic device--the echo integrator--for surveying fish populations more effectively than traditional assessment methods such as directly from test catches or indirectly from catch per unit of effort.

This equipment is being used successfully in association with the Washington Department of Fisheries in surveys of immature salmon populations in lakes and hake populations in Pacific waters. The estimates of young salmon abundance are being used to forecast the magnitude of adult salmon runs. Moreover, under the auspices of the National Marine Fisheries Service, U.S. and Soviet scientists have conducted a survey of hake off the Washington coast with the aid of the integrator. Additional coastal surveys will be conducted in 1971 and 1972.

Besides this current application of the integrator to fish stock surveys, more sophisticated acoustic techniques are being developed that will enable discrimination among species of fish and between fish and other sound-scattering layers in the ocean.

An even longer range goal of this program is the development of acoustic techniques to assess other biological organisms in the sea such as plankton that form sound-scattering layers of the ocean. These sound-scattering layers are one key to understanding the ocean's upper limits as a source of food.

OTHER RESEARCH AREAS

Descriptive oceanography

Exploratory surveys, regional studies, and problem-oriented research cruises to all parts of the Pacific, Arctic, and Antarctic Oceans have sailed from Seattle in recent years. Completed over many years using continually refined techniques and oceanographic instruments, the surveys have identified seasonal, annual, and other periodicities and have correlated them with biological, meteorological,

and geological phenomena. Such surveys and studies have also acted as field classrooms in training oceanographers aboard oceanographic and hydrographic vessels of the University of Washington.

Data taken during 50 years by different ships, investigators, and equipment, are invaluable to current and future marine research. Specific characteristics of a given area, taken along with other measurements, are useful in making statistical predictions of future water-mass movements, temperatures, and so forth. On a lesser scale, but equally important, an intensive study of greater Puget Sound and its tributaries. The studies include dynamic models of major water movements and descriptions of the main types of environments found locally.

Fisheries

State, federal, and international agencies are conducting extensive research to develop, maintain, and protect fish resources of the Pacific Northwest. Much of this research is concerned with Pacific salmon, but a growing amount of research is being devoted to other fish and shellfish.

The Washington State Department of Fisheries, and the National Marine Fisheries Service are concerned with aspects of fisheries research in streams, inland waters, and the ocean. Important parts of this work are determination of fish populations and their relationship to physical oceanographic conditions, and the biomass assay of ocean waters. Population and migration studies are aided by tagging programs using newly developed coded-wire tags magnetically encoded with pertinent information. Accurate fish counts based on commercial and sport catches, special survey catches, and movements of fish through passages provide sufficient information to accurately predict populations and migratory movements.

Research is under way to improve breeds of fish, decrease the mortality rate among young fish, improve fish passages around dams, and develop suitable man-made spawning ponds to replace natural spawning grounds that have been destroyed. Fish hatcheries are being improved as a result of research studies.

The Fisheries Research Institute in the College of Fisheries, University of Washington, is studying the marine and fresh water phases of the life history of salmon in Alaska. These studies have been concerned with the development of improved methods of predicting the sizes of various Alaskan salmon runs to permit more effective regulation for maximum sustained yield. More recently, studies of pollution and of problems of invertebrate and salmon fisheries have been inaugurated in Washington waters.

Seafood

The National Marine Fisheries Service and some commercial organizations are conducting research to develop new fisheries by improving

fishing gear and developing improved techniques for processing fish for human consumption, as animal food, and for industrial applications. NMFS technologists study changes in the condition of fish from the time it is caught until it reaches the consumer, and develop methods for improving quality. Improved freezing techniques that retard oxidation and new methods of irradiation to destroy decay bacteria have been tested. Research is also developing new types of fish products to increase the demand for, and consumption of, fish. The Battelle Northwest Laboratories, along with the Institute of Fisheries, have growing roles in such research.

The Food Science Staff of the College of Fisheries is concentrating their research on seafoods to determine the effects of radiation pasteurization and of spoilage processes in chilled or frozen products. Applied studies have also been conducted on fish fermentation and on the production of a semi-conserved boiled fish product, both of importance in the processing of seafood in Southeast Asia. Fundamental investigations have also been carried out on the chemistry of non-enzymic browning reactions, on the metabolism of spoilage bacteria, on proteolysis, and on other microbiological and biochemical processes. Basic studies are being conducted on the nutritional effects in alga-daphnia systems and on marine microbiology. The occurrence, distribution, and nature of bacteria in water and sediment in the high seas and Puget Sound are being investigated. Laboratory studies are being conducted on individual bacteria and microbiological processes of degradation. Understanding of the involvement of bacteria in benthos food chains is the primary objective in these investigations.

The National Canners Association laboratory in Seattle assists the Pacific Northwest canning industry in maintaining product quality.

Ways of using fish-waste products are being sought. With proper equipment, much of what is now being wasted could be processed for industrial use.

Study of the growing shellfish industry, consisting largely of oysters, crab, and clams, has been substantial at present research facilities and will be intensified when additional state and federal facilities are completed. Of particular concern are methods of increasing shellfish production by controlling predators and pollution. Larva bioassay techniques for toxicity measurements and other research techniques are being developed to determine the causes of mass mortality that occasionally strike shellfish populations.

Naval vessels and equipment

The U.S. Navy conducts much of its development and final proof testing of torpedoes at the Naval Torpedo Station at Keyport, which has test ranges for both surface and subsurface testing using a highly sophisticated and accurate three-dimensional acoustic tracking method. An acoustic device installed in the object to be tracked transmits timed acoustic pulses and these pulses are received by bottom-mounted hydrophone arrays and relayed to range headquarters. Here the information is fed to a computer which, programmed according to the known speed

of sound in water and the known spacing of the hydrophones, calculates the position of the object at each pulse, thus plotting its path. Speed, direction, maneuverability, response to fire-control commands--all can be measured. As many as ten objects can be tracked simultaneously. The applications of the tracking capability are numerous and are augmented by the support capabilities of the Naval Torpedo Station and other Northwest facilities. (See Section 10.) The ranges make possible a wide variety of tests and projects, for which 3-D tracking provides precise geometry. Examples include:

1. Torpedo Proofing. The plotted 3-D track represents actual torpedo performance, revealing what the torpedo did, for direct comparison with what it should have done, as determined from the test plan and from internal and external records of steering and homing commands and maneuvers.

2. Weapon Systems Accuracy Trials (WSAT). During WSAT's the 3-D track serves not only to monitor weapons fired but also provides an accurate record of the position of the ship as it maneuvers on the range. Both submarine and surface ships regularly undergo WSAT on NAVTORPSTA ranges. Weapons tested and tracked include torpedoes launched by ASROC (anti-submarine rocket).

3. Noise Measurements. By showing the relative positions of torpedoes or other devices and noise-measuring equipment, 3-D tracking provides an accurate basis on which to measure noise levels and acoustic characteristics of the devices.

Such capabilities give rise to additional ones. For example, when both 3-D tracking and sound analysis capabilities exist, studies can be made of sonar interference and of the nature of sounds which will divert an acoustic homing device. The field of countermeasures is thus entered.

4. Sunken Weapon Recovery. If a weapon fails and sinks on the range, the 3-D track facilitates accurate positioning of a recovery vehicle.

Since modern underwater weapons may be air-launched or otherwise airborne during part of their travel to the target, the 3-D ranges are equipped to monitor and record their in-air as well as in-water performance.

The station has 27 support craft, including covered lighters, target boats, landing craft, torpedo retrievers, a cargo ship, harbor tug, diving boat, guard boat, and motor launch. Oceanographic equipment for developmental research programs is of course also on hand. STVP (salinity-temperature-velocity-pressure) equipment, lowered from a range craft, measures the environmental factors in water which cause sound rays to bend. Three readings per second are telemetered to the computer, where corrections are applied.

The station also tests and calibrates sound-generating and -receiving equipment at its acoustic test facility. Continuous wave, pulse, or noise calibrations and impedance measurements are made over

the frequency range from 20 Hz to 500 kHz. Transducer input power of 5 kw is available from 5 kHz to 75 kHz. Directivity patterns are drawn automatically on polar-graph paper.

In addition, the University of Washington's Applied Physics Laboratory acts as the Navy's contract laboratory for research, development, and technical monitoring of underwater-sound studies. Since the laboratory was created during World War II, its staff has been best known for precision three-dimensional tracking methods developed for torpedo studies. Such methods have been expanded for use in studying the maneuverability of submerged submarines and towed bodies, and ranges have been set up in areas as far away as St. Croix, Virgin Islands.

The Naval Torpedo Station is working on the anti-submarine torpedoes Mark 46 Mod 0 and Mark 46 Mod 1. In addition, it has a vital role in the testing of torpedoes Mark 48 Mods 0, 1, and 2. It is supporting the Naval Ordnance Systems Command in compiling information from which to select the Mark 48 torpedo to be used by the Navy.

Following a Navy survey of the entire United States from 1949 to 1951, the Puget Sound region was selected by the Navy's Ship Systems Command as the site for a noise-measurement range. Of several areas available, Carr Inlet off Fox Island in southern Puget Sound was chosen. As with Dabob Bay, the background ambient noise from natural and man-made origins is quite low. Underwater instrumentation installed on the range is used to measure noise radiated by U.S. submarines, destroyers, escorts, and other vessels. Much research on noise reduction, propeller design, and radiation of sound from complex underwater surfaces has been based on results from calibrated and carefully controlled tests on the Carr Inlet range conducted by government engineers and scientists assigned to the Puget Sound Naval Shipyard at Bremerton and the Naval Torpedo Station at Keyport.

Since 1961, research and development of hydrofoil craft have created new product lines for existing aerospace and boatbuilding firms in the Pacific Northwest. Much of the work with hydrofoil craft--highspeed vessels designed to "fly" on underwater wings--has been conducted for the Navy by Boeing's Naval Systems Division. The hydrofoil patrol craft HIGHPOINT, PC(H)-1, a fully foilborne naval vessel, was a significant Boeing contribution to hydrofoil technology. The HIGHPOINT has successfully demonstrated its rough-water capabilities. Boeing has also contributed tests of several different methods of foil control, design, and tests of various power arrangements, tests on the Boeing hydrofoil test system (HTS) of foil sections for the PLAINVIEW, and related computer studies.

Boeing's Naval Systems Division organization has also successfully developed a waterjet propulsion system for use on an 80-ton patrol craft gunboat, PGH, for the Navy. The propulsion system has had extensive testing on Boeing's LITTLE SQUIRT and has been tested on small patrol craft built by United Boat Builders. The system has demonstrated its extreme maneuverability and tight turning radius.

Another type of vessel being developed in the Pacific Northwest is captive-air-bubble surface-effect craft. Existing hydrofoil designs may be modified for use in such developments.

Surface ships constructed by Todd, Lockheed, and other shipyards undergo trials in local waters to check handling capabilities and performance. Unlike many areas, where the presence of naval ships is rare, operations for trials, reserve training, and research are common in the Pacific Northwest and attract little attention despite their close proximity to populated areas. Among such ships are submarines, aircraft carriers, and other vessels modernized by the Navy's shipyard at Bremerton.

Underwater devices

Closely associated with performance-characteristics and noise-signature work is development of underwater sensors, sonars, and electronic marine equipment. This development has been a primary activity of Honeywell's Marine Systems Center, following the Sea Scanar concept. These echo ranging and sounding devices have been used as a navigation aid and method of locating underwater objects. Continued development has led to compact and versatile equipment giving a radar-like presentation out to 1,600 feet for fisheries and oceanographic research, salvage, and underwater navigation. Other research has yielded a precision profiling sonar set for underwater surveys, marine construction, research, and coastal dredging operations.

Research has expanded the capabilities of the Marine Systems Center into underwater hydrophones and projectors and to buoy-mounted instrumentation to measure temperature, acoustic ambient, magnetic signature, and geomagnetic noise. Techniques have been developed for binary digital recording voltage-input information and serial-pulse information from frequency-output sources on 0.25 inch magnetic tape for self-contained storage of up to 600,000 data points.

A related development at Boeing's Missile and Information Systems Division has demonstrated transmission to a shore station of similar oceanographic data via the meteor-burst radio-frequency propagation mode. This demonstration used facilities and instrumentation of the University of Washington's Department of Oceanography.

Other Honeywell developments include small acoustic pingers used in tagging salmon for migration studies, acoustic command units using explosive triggering, and shipboard instrumentation.

Honeywell's wide range of underwater acoustic transducers reflects the company's experience gained from transducer research, design, and production. Types include the flexing disc, flexural beam (bender bar), extensional-flexural (Flextensional) elements, and the longitudinal and circumferential vibrator. Sizes weighing up to 7,000 pounds and 12 feet long, covering operating frequencies from 45 to several hundred kilohertz with acoustic power ratings from 1 to 3,500 watts have been

built. Among others, they have been supplied to the Navy underwater sound, research, and electronics laboratories and to Bell Telephone laboratories. Extensive transducer laboratory facilities are supplemented by sea-going research-vessel and dockside test and calibration facilities.

Transducers for specialized applications are developed by the University of Washington's Applied Physics Laboratory and by The Boeing Company. The Applied Physics Laboratory operates range instrumentation for precision-tracking and torpedo guidance (primarily in the ultrasonic range) at barge and laboratory development, test, and calibration facilities on the Lake Washington ship canal.

Boeing development work has stressed broadband (multioctave) high-power transducers and measurement hydrophones for use with small towed bodies and cables. Typical spectrum levels over the audio and low ultrasonic range are 40 to 60 decibels re 1 microbar at 1 yard. Excellent fidelity has been demonstrated with speech, music, and other complex spectra under a variety of conditions. Applications exist for underwater propagation research in lieu of explosive sources, filtered noise rather than single-frequency calibration, and other special naval uses.

Other types of sensors and transducers have been developed. Wave-height-measuring techniques have been devised and modified for hydrofoil tests. Applied Physics Laboratory deep-sea research has included measurement of several oceanographic parameters. Electromagnetic and electroconductor propagation have been investigated by Boeing in simulating submerged or buried antennas, ASW detection studies, and submarine communications. Computer-controlled and automated electro-acoustic and vibration-analysis techniques have been developed to handle growing volumes of measurements at the Carr Inlet range, Applied Physics Laboratory, and the Boeing acoustic and system test laboratories. Underwater television to monitor net and trawl gear performance has been demonstrated by the National Marine Fisheries Service.

Marine mammals

Marine mammal research touches on a number of technical disciplines. Among the institutions and agencies conducting such research is the U.S. Department of Interior's Marine Mammal Biological Laboratory, which conducts pelagic fur seal research in Seattle and Alaska, and studies whales, seals, and other marine mammals.

An exceptional study was made when a killer whale, an adult male, was captured in gill nets near Namu, B.C. The whale, dubbed NAMU, was brought to the Seattle Marine Aquarium, where he was studied by numerous researchers. Studies of the animal included behavioral observations and calibrated bioacoustic measurements. When the whale drowned after becoming entangled in his steel-net pen, postmortem tests were conducted. Some 23 killer whales have since been captured by Seattle Marine Aquarium and shipped to aquaria from Europe to Australia for display and research.

The Virginia Mason Hospital (Seattle) research staff has studied marine mammal blood circulation and body heat for several years. Early work on elephant seals and smaller mammals was continued in studies of killer whales. For the first time, researchers had the opportunity to compare large terrestrial animals with aquatic mammals, whose body weight is supported hydrostatically. Under a U.S. Public Health Service grant, studies were conducted into the differing methods used by fur seals, whales, and other cetaceans to adjust to pressure changes in rapid dives and ascents and thereby avoid the decompression problems experienced by human divers.

The number of Pacific Northwest marine mammals is extensive. Studies during the past 30 years have indicated that some mammals found in Northeast Pacific coastal waters have natural and acquired capabilities equivalent to the higher primates and domesticated animals. Some species have permanent grounds, others migrate within the region, and still others move through the area on a seasonal basis. Except for periods of excessive killing, stocks appear to be in reasonable ecological balance with nature and man. Continued research is highly probable, especially as new techniques and instruments for tagging, tracking, and remote observation develop.

TABLE 3

Marine Mammals of the Northeastern Pacific Ocean

Northern Right Whale (Eubalaena sieboldii, E. japonica)
Gray Whale (Rhachianectes glaucus)
Bowhead or Greenland Whale (Balaena mysticetus)
Humpback Whale (Megaptera novae-angliae, M. nodosa)
Blue or Sulphurbottom Whale (Sibbaldus musculus)
Finback or Razorback Whale (Balaenoptera borealis)
Sei or Rudolph's Whale (Balaenoptera borealis)
Lesser Rorqual, Minke, Little or Least Piked Whale (Balaenoptera acutorostrata)
Sperm Whale or Cachalot (Physeter catodon)
Pigmy or Lesser Sperm Whale (Kogia breviceps)
Porpoise Whale (Berardius bairdii)
Goose-Beaked or Cuvier's Beaked Whale (Ziphius cavirostris)
Saber-Toothed Whale (Mesoplodon bowdoini)
Bering Sea Beaked Whale (Mesoplodon stejnegeri)
Northern Right Whale Porpoise (Lissodelphis borealis)
Cowfish or Bottlenosed Dolphin (Tursiops gilii)
Bottlenosed Dolphin (Tursiops nuuanu)
Common Dolphin (Delphinus delphis)
Risso's Dolphin (Gramphidelphis griseus)
Blackfish (Globicephala scammonii)
False Killer (Pseudorca crassidens)
Killer Whale (Orcinus orca)
Rough-Toothed Dolphin (Steno rostratus)
Dusky Dolphin (Lagenorhynchus obliquens)

Harbor Porpoise or Herring Hog (Phocaena phocaena)
White Whale Porpoise or Beluga (Delphinapterus leucas)
Narwhal (Monodon monoceros)
Black Finless Porpoise (Neomeris Phocoenoides)
Steller's Sea Lion (Eumetopius stelleri)
Northern Fur Seal (Callorhinus Ursinus alascanus)
Common Seal (Phoea vitulina)
Harp Seal (Phoea groenlandica)
Banded Seal (Histroiphoca tasciata)
Bearded Seal (Erignathus barbatus)
Pacific Walrus (Odobaenus obesus)

Pollution control and water management

Pollution control and water management are areas of long-standing concern in the Pacific Northwest, despite their relatively recent growth to importance nationally. Pulp plants, lumber mills, placer mines, logging, and construction, among others, were recognized early as activities that could damage important natural resources, such as fish and shellfish. Consequently, state, federal, and provincial governments have sponsored studies together with university researchers, to find ways of protecting all resources. Many timber-product companies employ chemists and marine biologists to study similar problems.

Battelle Northwest Institute. Battelle Northwest is monitoring regional ground-waters and the ocean to maintain surveillance over fallout radionuclide concentrations from world nuclear-device testing. These investigations extend from study of water turnover and oxygen content in deep inlets with shallow sills to toxicity studies of different pollutants on oyster seed and trout fingerlings. Dams built to satisfy electrical-power, irrigation, and flood control needs have restricted natural upstream spawning grounds of salmon and steelhead and caused extensive fish kills as a result of supersaturation of the water with nitrogen. Extensive studies have been required to determine the total economic and ecological import of such impediments to fish migration. Improved high-rise fish ladders and bypass routes, techniques for herding migratory fish, and experimental artificial fish farms have been developed as a result of such research, but all the problems are certainly not yet solved.

With continued pressure from foreign fishing offshore, severe loss of fish through flooding and disease, and greater demands on available fresh water supplies, research must continue. The work extends over wide geographical areas, with spawning grounds and water sources many hundreds of miles inland. For example, water management on tributaries of the Columbia River in eastern British Columbia and Idaho directly affects the entire region; changes in flow can raise concentrations of normally unimportant radio-nuclide or chemical pollutants.

Pacific Northwest River Basins Commission. The Pacific Northwest River Basins Commission was established on March 6, 1967, under terms of the Water Resources Planning Act of 1965, at the request of the Governors of the States of Idaho, Montana, Oregon, Washington and Wyoming.

Principal objectives are to coordinate federal, state and local water and related land resource planning; prepare a long-range schedule of priorities for the collection and analysis of the basic data and for investigation, planning, and construction of projects; prepare and keep up to date a comprehensive joint plan for the Pacific Northwest.

Under the Western United States Water Plan (Westwide), the Commission and the Interior Department will prepare a single study for the Pacific Northwest which will satisfy the Westwide study and provide the comprehensive joint plan with which the Commission has been charged by Congress, and provide each of the five states with major components for individual water resources programs and serve local and private interests too.

Municipality of Metropolitan Seattle. The Municipality of Metropolitan Seattle (Metro), a federation of city and county governments, maintains a comprehensive water quality monitoring program in all the major water bodies in the Seattle area including Puget Sound, the Green-Duwamish River system, and the Lake Washington drainage basin. This program insures the effectiveness of Metro's pollution abatement program through demonstrated compliance with Water Quality standards, by maintaining a high degree of plant performance and by guaranteeing maximum protection to the environment.

Metro's monitoring program includes a wide variety of physical, chemical and biological tests to study the relationship of waste discharge to the receiving water environment. Such studies include the survey of primary productivity levels, changes in indicator organisms, the population density of diversity of benthic organisms, and the migration patterns of demersal and anadromous fish species. Bioassay studies of industrial waste discharges including heavy metals and mercury are an integral part of Metro's industrial waste control program. This program is designed to control the effect of industrial discharge on Metro's treatment plants as well as the environment. Metro's monitoring effort is also augmented by a cooperative monitoring program with the U.S. Geological Survey which has provided automatic monitoring of water quality in the Green Duwamish River system as well as continuous survey of the River's ecology over the past six years. A mathematical model of the Duwamish Estuary which is presently under development by the Survey will be used to predict the effect of ultimate development of Metro's other major treatment plant, located at Renton, on water quality levels in the River.

Future research programs under present development by Metro in cooperation with other local governmental agencies include a water resource management study and development of a water pollution control and abatement plan for the total drainage basin area within the Lake Washington and Green River systems. Also being planned is a cooperative monitoring program in Central Puget Sound with neighboring sewerage agencies in order to better define the effects of primary sewage effluent discharges to the Sound. Another area of vital interest to the community, the subject of storm water quality, is also under investigation by Metro. The principal objective in this case is to assess the

effect of City of Seattle's sewer separation program on Lake Washington's water quality levels.

Ecology

Much marine biology research in the Pacific Northwest has been concerned with small underwater communities. Research has included surveys of zooplankton and phytoplankton populations, survival studies in the open sea and inland waters by Washington researchers. Other work has involved marine fungi and algae, wood fungi in the Fraser River, dinoflagellates (red tide) effects, and anaerobic sediments. Extensive work, not only in the Pacific Northwest, but also in Japan, the Black Sea, Australia, and the west coast of South America, has involved interdisciplinary teams of biologists, physicists, chemists, and oceanographers. Related marine geological research extends from superhightidal-zone study of the annual deposit cycle of blue-green algae in Boundary Bay to abyssal-plane sedimentation processes extending out from the Columbia and other coastal rivers.

The Food Science section of the College of Fisheries of the University of Washington has developed a model sea-bed system that is being used to study the breakdown of crude chitin prepared from the carapaces of shrimps. Using sediments obtained from bottled samples taken off the coast of Washington and in Puget Sound, the action of chitionplastic bacteria in putting the material bound up in chitin back into the food chains is being studied. Data obtained from this equipment as well as from field studies support the proposition that the assimilative role of benthic bacteria may be extremely important in the supply of carbon to benthic communities.

Other experimental studies of ecological significance include the investigation of the relationship between environmental conditions in cultures of algae and daphnia on the rate of reproduction and the variations in protein content of the daphnia cells.

Radionuclide work conducted downstream from Hanford, Washington, in the ocean near the Columbia estuary in Puget Sound, and in freshwater lakes has provided tools for studying aquatic food chains, tracing and measuring productivity patterns, rates of assimilation of dissolved minerals, and identification and dependence on physical influences of temperature, pressure, and photic levels. Equipment techniques originally developed for naval detection studies at Boeing in low-level nuclear background dissemination and concentration techniques have proven applicable to other research.

Researchers have contributed to knowledge of the interrelationship among various clams and scallops, starfish, and octopi; migratory patterns of large food fish relative to external influences; and relationships in the intertidal zones.

Many different aquatic environments are found in the Pacific Northwest: ice-locked, freshwater, and glacial lakes; mud, sand, and gravel bottoms; and salinity ranges from open ocean to less than 20 parts per thousand. Cataloging and identifying significant factors,

even for a limited period, is a major task. Continuation of this work is necessary over long periods to detect community changes and to re-establish minor species (For more information see Section 2.)

Beyond the needs and interest of the pure scientist and the fisheries industry, marine environment data are of vital concern to industry. Most species that attack and destroy structures, vehicles, cables, or pipelines in the water have been studied. Increased understanding of methods to control or prevent such damage can lead to substantial savings.

Sea-air phenomena

The interaction of sea and air influences both the macro- and micro-ecological scales. The interaction is significant in modeling studies and affects airborne ocean surveys of surface termperatures and wave heights. The formation and continued existence of slicks despite wave action has side effects on biological growth processes and even on naval warfare. Study of sea-air interaction deals with such phenomena and various U.S. groups have been active in such research. Instrumentation is being developed to permit study of turbulence in and above the water. Other methods of tracing medium- and large-scale phenomena have been surface and subsurface use of Rhodamine B dye, nuclear trace elements, and high-altitude photographs for tracing internal wave movements.

Sea ice and glaciers

Arctic oceanographic and atmospheric interest and studies have developed in the state of Washington because of easy access to sea ice in the Arctic and Bering Seas and glaciers on Alaskan slopes and in the Cascades.

Research in the Arctic began at the University of Washington with the oceanographic work in the Bering Sea at some 160 stations during the summers of 1933 and 1934. Investigation of oceanographic parameters was pushed further north during the summers of 1937 and 1938 with studies of the northern and eastern Bering Sea and Arctic coast of Alaska (Chukchi Sea) that included occupation of 387 stations.

The Department of Atmospheric Sciences, established in 1947, began expanding its research efforts in the Arctic, just as oceanography was renewing and expanding its own efforts during the early fifties. Among the results prior to IGY were a climatic atlas of the Aleutians, some features of middle and high latitude inversions, procedures for avoiding extremely low temperatures of stored articles, and four years of intensive work on synoptic and synoptic-climatological studies of the circulation of the Arctic atmosphere. During and since IGY the Department has worked on the mass and energy budget of the Arctic pack-ice, crystal structure of ice, physical changes that occur during the freezing of seawater, the drift of the Arctic pack-ice with wind and water currents, transport of blown snow, general climatology of the Arctic, and atmospheric chemistry both at Barrow and at drifting stations Alpha, Charlie, ARLIS-I, ARLIS-II, ARLIS-III, and T-3.

In 1961, a questionnaire survey of American universities revealed that 34% of the staff members at the professional level with experience in polar research involving problems in oceanography or bordering fields were from the University of Washington.

In retrospect, the University of Washington has been building an Arctic program rather continuously over the past 37 years. In recent years someone from the University is nearly always in the Arctic; men from Atmospheric Sciences have been on every floating ice station since IGY; every area of the Arctic Ocean except for the Siberian Coast has been studied by Oceanography.

The AIDJEX (Arctic Ice Dynamics Joint Experiment) program, started in June 1970, coordinates a major experiment in the Arctic Ocean involving scientists and engineers from many institutions in the United States and Canada. An AIDJEX secretariat has been formed at the University of Washington, administered by the Division of Marine Resources and involving the Departments of Oceanography and Atmospheric Sciences.

The purpose of the AIDJEX program is to develop an understanding of the large-scale response of sea ice to its environment in order to solve many important theoretical and practical problems, ranging from the interaction between ice cover and global circulation to the passage of ships in ice-covered seas. This study was proposed to investigate the motion and deformation of Arctic sea ice in response to the driving atmospheric and oceanographic processes. Since observations from single drifting stations are intrinsically inadequate, an array of drifting stations will be established. The present plan calls for an array of five manned and ten unmanned stations which will allow the detection of events whose scales are less than several hundred kilometers.

AIDJEX has been designed to answer the following questions:

1. How is large-scale ice deformation related to the stresses exerted by wind and water currents, and what controls the momentum transfer between the three media?

2. What are the mechanisms responsible for the observed morphological features of the ice cover (such as fractures, ridges, and leads), and what information regarding past strains can be deduced from a given distribution of morphological features?

3. How do the dynamics and thermodynamics of the system interact to influence both ice production and the exchange of heat between the ocean and atmosphere?

A pilot study was completed in early 1971, with the full-scale field project planned to follow in 1972 and 1973.

The discovery of oil on the North Slope of Alaska has dramatized the importance of the Arctic as a major source of natural resources. This importance was highlighted in October 1969 by the announcement of

President Nixon's five-point program in marine sciences, one point of which is an expansion in Arctic research. It is clear that as commercial and other activities in the Arctic increase there will be a growing need for improved technology in support of research, exploratory operations, and possible future commercial and military missions. In particular, there is a need for improved mobility under adverse weather conditions for a wide variety of under-ice and over-ice missions, both for research and for the maintenance of remote observation stations.

The Arctic Technology Program was begun in June 1970 to provide for these new tools in a systematic manner by bringing together in a common effort investigators from engineering, the basic sciences, and other fields. Administered by the Division of Marine Resources at the University of Washington, the program's major activities include unmanned submersibles for Arctic applications, use of the surface effect vehicles as Arctic research platforms, and building techniques and building materials for Arctic application.

It is apparent that with the award of project AIDJEX and Arctic Technology contracts, the University of Washington will play a major role in implementing a major program in Arctic research.

Glacial studies at the University of Washington are closely tied to geological studies, climatic surveys, and research into precipitation cloud coverage. In general, these are long-term studies of relative rates of movement, and of accretion and depletion. They involve periodic observations of glaciers in remote areas and more intensive study of nearby glaciers.

Adaptation of man to the sea

Attempts to adapt man to the sea are relatively new, consisting primarily of development of diving techniques and equipment. As indicated under Marine Mammals, man's ability to descend to depths below about 50 feet and ascend quickly is inferior to the diving sea mammals. Exploratory data surveys and instrumented animal tests have shown differing capabilities among species. Research is under way to identify physiological and blood chemistry changes associated with underwater work, and data and test results have been exchanged with investigators in California and elsewhere. Ocean Systems, Inc., has conducted some observational diving research in Pacific Northwest waters to assess differences in the local underwater working environment from that of more tropical seas.

Boeing's Bioastronautics organization and Scientia Research Laboratory, Inc., in Seattle, have studied the possibility of breathing mixtures of oxygen, nitrogen, helium, hydrogen, and inert gases while underwater. Long-term effects, possible toxicity, and other phenomena have been investigated analytically in laboratory tests and with white rats in submerged test chambers. Space experiments on work functions, metabolic requirements, and maneuverability under zero-gravity conditions has led to neutral-buoyancy techniques for simulating weightlessness. Simulation facilities have been used to test man's ability to control his gross body movements and posture and to manipulate tools. Laboratory

test tanks have been used for controlled observation and photographic recording.

Support equipment

Formal research programs aimed at developing support equipment and operating techniques for ocean use are relatively new developments. The University of Washington has been a leader in the field, having done considerable work to develop information on the physical factors of underwater movement. An example of their studies is research into proper placement of anchors, a key factor in constructing floating bridges. Such research is of interest to the U.S. Army Corps of Engineers, which is faced with such problems in their canal and harbor construction work.

Support equipment for the now-abandoned Project Mohole was a challenge requiring much new design and innovation. Honeywell's Seattle Development Laboratory developed positioning equipment and techniques for use on the massive project, which was to have been an experiment in drilling through the Earth's crust at a narrow point 12,000 feet below the surface of the Pacific off Hawaii. The drilling platform was to remain in position within 500 feet for three years. Honeywell designed and built an acoustic transponder and beacons to be located on the ocean bottom around the drilling area.

Marine construction firms and their counterparts in the tug-and-tow and fishing fields have considerable practical experience with tides, beach erosion, storms, and fouled equipment.

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SECTION 4

COMMERCIAL FISHING AND AQUACULTURE

COMMERCIAL FISHING

Commercial fishing rates fifth in economic importance for the entire state of Washington. It follows behind tourism, lumber, agriculture, and aerospace. In most of the coastal towns, however, commercial fishing is the backbone of the economy. The activities of Washington's 9000 commercial fishermen range throughout Puget Sound and into the Pacific Ocean as far north as Alaska and the Bering Sea. In 1969 Washington ranked eleventh in the nation for total pounds of fish landed and eighth in the nation for dollar value of the catch. That year Washington's commercial fishermen landed 136,325,320 pounds of fish and shellfish having a wholesale value of $31,493,660. The catch consisted of salmon (21% by weight), bottomfish (34%), industrial fish (9%), other fish (17%), and shellfish (19%).

In recent years, due to improved techniques, more efficient gear, and increased number of fishermen, it has become evident that if the present fishery is not properly managed fish stocks can be seriously depleted. The commercial fishermen believe that some type of limited entry policy is necessary to provide balanced conditions within their industry. This would limit the number of boats (foreign fishing fleets included) and gear allowed to fish in certain areas. Present regulations do not restrict the number of boats or amount of gear allowed in an area. Only restrictions as to the type of gear and days of fishing for a given area are imposed. By not limiting the number of fishermen or the amount of gear in an area under the present system, depletion of fish stock and poor earnings per boat can result.

Today the fisherman's gear is so efficient that the escapement

is not sufficient to replenish the stock in some fisheries. A successful fisheries management program will provide more economic benefits to the fisherman, increase his fishing potential, and assure that our fisheries remain as a renewable resource. There are many organizations in Washington that are trying to develop a management program that will be beneficial to all, among these are: National Marine Fisheries Service, Washington State Department of Fisheries, Fisheries Research Institute, Washington Sea Grant Program, and the International Pacific Halibut Commission.

HATCHERY PRODUCTION

A recent study showed that Washington's hatchery program is the number one producer of salmon and trout in the nation. In 1969 with twenty hatcheries and one experimental hatchery at the University of Washington, Washington State produced 2,548,000 pounds of salmon and 1,500,000 pounds of trout. California was second with 147,000 pounds of salmon and 2,390,000 pounds of trout. Washington's hatchery production has increased markedly over the past few years. In 1958 the per man hatchery production was 6,000 pounds, in 1968 it was 20,000 pounds, and in 1970 it was 38,000 pounds.

FISH PROTEIN CONCENTRATE

The first large scale fish protein concentrate (FPC) experimental-demonstration plant in the United States began operation in May, 1971 at Aberdeen, Washington. The plant was designed to produce sufficient quantities of FPC, acceptable for human consumption, for utilization studies by the United States food industry and the Agency for International Development. The plant belongs to the National Marine Fisheries Service and has a processing capacity of 50 tons of raw fish (primarily hake) per day which is converted to about 7 tons of FPC per day.

AQUACULTURE

Aquaculture is still in its early stages of development in Washington. However, as a non-polluting renewable resource, aquaculture has great potential in the Puget Sound region where relatively clear, unpolluted waters, ideal circulation, and only small seasonal fluctuations in water temperature combine to support high productivity. The Washington State Department of Natural Resources, which controls and manages the beds of navigable waters (the seafloor of Puget Sound below MLLW) has indicated that aquaculture in these state controlled regions will have priority over other uses by marine associated industries which extract non-renewable resources and could be potential polluters and thus affect the productivity of these regions. The Department of Natural Resources feels that Puget Sound's economic future lies in keeping its waters of sufficient quality for aquaculture and recreation. To support and foster aquaculture the

Department of Natural Resources is offering leases for certain areas in Puget Sound and aiding parties to obtain permits for the raising of captive salmon. Some of the current aquaculture programs underway in Puget Sound involve raising and harvesting salmon, sea trout, geoducks, oysters, and seaweed.

SALMON AND SEA TROUT

One of the major projects aimed at developing the technology for successful raising and harvesting of captive salmon is being carried on by the National Marine Fisheries Service program in Manchester, Washington. This project is in its second year and is investigating floating pen culture using five species of salmon. The salmon are raised in floating pens after their initial hatchery period and are fed an artificial food which supplements the natural plankton in the water. The research on pen rearing is concerned with the design and construction of enclosures, development of appropriate feeds and feeding regimes, determination of crowding tolerances, disease control, and stock selection. The program has found that salmon can convert 1.5 pounds of feed to 1 pound of body weight, which is better than poultry (2.2:1) and far better than hogs (4.5:1) or beef (8:1). However, since the salmon's efficiency for food conversions is only high during the first year, the pen reared fish would best be harvested for market as a pan size, one-half to one pound year old salmon. This product as a specialty item would not compete with the present commercial salmon fishery as either a market item or as an additional predator of natural food supply. These fish would be marketed during late winter to further avoid competition. It is estimated that 100,000 pounds of salmon could be raised in a pen 50 by 100 by 20 feet deep.

The success of the NMFS salmon aquaculture program has encouraged Ocean Systems, Inc. to begin a commercial pilot project in salmon rearing which they hope will show the feasibility of large scale salmon farming. Certainly of great importance to the development of successful salmon aquaculture will be the results of Dr. Lauren Donaldson's recently begun experiments in selective breeding of salmon. Dr. Donaldson of the University of Washington has developed through 38 years of selective breeding the "Donaldson super trout." He began with a rainbow trout that matured in four years, weighed approximately 1-1/2 pounds and yielded about 500 eggs at their first spawning. The Donaldson super trout now averages 15 to 20 pounds at maturity after only three years and produces an average of 11,700 eggs. The progeny of one female if all survived would equal 20,000 pounds of edible fish in only one year--the proverbial "ten ton fish." He hopes to produce a salmon better adapted for the environment, as he did with the trout.

In addition to the salmon aquaculture project in Manchester, the National Marine Fisheries Service along with the Washington State Department of Fisheries is conducting research which hopefully will lead to the re-establishment of a resident population of coho salmon in Puget Sound. This is being done by holding these salmon in float-

ing pens three months longer than the normal hatchery release time in hopes to improve their survival rate from about 3 per cent to 80 per cent.

LUMMI INDIAN AQUACULTURE PROGRAM

Another pilot program underway in aquaculture is that of the Lummi Indians which began in 1969 with funds provided from federal and state agencies. The Lummi Indians are now raising Donaldson's super trout and oysters and harvesting seaweed in a diversified program. They have two research ponds of slightly less than one acre each. These ponds are diked off areas of Lummi Bay which use the tidal action to control the water circulation. They have been able to raise several species of salmon and Donaldson trout with less than 3 per cent mortality within these ponds.

The Lummis were also able to raise over 200,000 oysters in the same pond with the fish as a compatible crop. Several types of oysters are being grown including Pacific, Kummamoto, Chesapeake, and the European oyster. These oysters will be raised both for market and as seed oysters for other oyster growers. Their current research indicates they will be able to raise 5,000 pounds of fish and 200,000 oysters for each acre, or a cash crop value of more than $4,000 per acre in fish and oysters per year. They have completed construction of a holding pond for commercial production that covers 750 acres of Lummi Bay, which itself contains over 2,500 acres of potential tidal ponds. This 750 acre pond will be ready for stocking this summer.

A supplemental industry they hope to develop commercially is the harvesting of natural beds of the red alga Iridaea. Since Iridaea can only be harvested during the summer it will provide summer jobs for the Lummi youths. In 1969 Lummi divers assisted by Marine Colloids, Inc. of New Jersey surveyed the local beds of algae and located an estimated 800,000 to 1,000,000 pounds (dry weight) of Iridaea within 24 miles of the Lummi Indian Reservation that could be harvested annually. Marine Colloids estimated that this was sufficient to develop and sustain a seaweed harvest industry. The Lummis are currently investigating what the ecological impact of harvesting natural Iridaea beds will be and are improving the present methods of harvesting, drying, and shipping the seaweed.

The progress and interest shown in the harvesting of seaweed by the Lummis and various other researchers has led the Washington State Department of Natural Resources to organize the Washington Seaweed Council. This informal group meets periodically to exchange experimental results and ideas relating to culturing and harvesting of the macro algae in an effort to assure that algae remains a renewable resource in Puget Sound.

GEODUCK

Geoducks, large clams that weigh about 3 pounds and are found only on the west coast of the United States, are being commercially harvested

by Washington King Clam, Inc. This company leased 1,000 acres of sea bed within Puget Sound in the area of Agate Passage and began harvesting in July 1970. In their first ten months of operation they harvested 228,941 pounds of geoducks, which, according to the National Marine Fisheries Service, bring restaurants a price of about $2.25 a pound. The Washington State Department of Fisheries is supervising this new industry to insure it does not have any detrimental effects on the ecological or recreational value of the area. The geoduck is being marketed throughout the United States as the "king clam." The harvesters believe this name will be more appealing to its customers than "geoduck."

BIG BEEF CREEK

The University of Washington Department of Fisheries, Fisheries Research Institute, and the Washington State Department of Fisheries are experimenting with salmon, various flatfish, clams, and oysters at Big Beef Creek station on Hood Canal and at Manchester. They are using floating fish pens at Big Beef Creek to investigate the effects of various environmental parameters such as salinity on the saltwater rearing of trout and salmon. A study is planned to determine the most economic way to raise salmon with the presently known techniques. Experiments are also being conducted in hopes of conditioning salmon to come to an underwater sound source. This could eliminate the need for pens and would allow for an effective feeding program, administration of medication, and harvesting. Preliminary research has shown that it will be necessary to evaluate the upstream development and the possible damage to their watershed. This information will be invaluable as a guide to management. Improved methods are being tested at Manchester for culturing of oysters and clams. Their main emphasis in shellfish research is in developing the techniques for raising oysters on floating rafts. An integral part of this whole program is student training and participation.

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SECTION 5

EDUCATION

One of the principal marine resources of the United States is its educational institutions in which the technical and scientific personnel of marine science receive their basic training. Oceanography, unlike many of the disciplines of modern science, was integrated from its birth, calling for the application of many basic sciences--physics, chemistry, biology, mathematics, and geology, with their related branches of engineering and technology--to problems relating to the sea. Any educational institution, therefore, that offers courses in basic or applied science is a source of potential strength in marine areas.

The state of Washington has many excellent colleges, universities, and vocational-technical schools that offer training ranging from basic technical skills to doctoral study and research in science and engineering (Table 4).

TABLE 4

Washington	Location	Fall 1969
State Institutions of Higher Education		
University of Washington	Seattle	32,749
Washington State University	Pullman	13,191
Central Washington State College	Ellensburg	6,927
Eastern Washington State College	Cheney	6,345
Western Washington State College	Bellingham	9,942
Evergreen State College*	Olympia	---
*Due to open Fall 1971		
Private Colleges and Universities		
Gonzaga University	Spokane	2,701
Ft. Wright College	Spokane	447
Pacific Lutheran University	Tacoma	2,831

St. Martins College	Olympia	755
Seattle Pacific College	Seattle	1,962
Seattle University	Seattle	3,468
University of Puget Sound	Tacoma	3,421
Walla Walla College	College Place	1,713
Whitman College	Walla Walla	1,121
Whitworth College	Spokane	1,622
Community Colleges and Junior Colleges		
Bellevue Community College	Bellevue	2,583
Big Bend Community College	Moses Lake	927
Centralia College	Centralia	2,418
Clark College	Vancouver	4,014
Columbia Basin Community College	Pasco	3,357
Edmonds Community College	Lynnwood	2,626
Everett Community College	Everett	4,849
(Ft.) Steilacoom Community College	Tacoma	1,825
Grays Harbor College	Aberdeen	2,577
Green River Community College	Auburn	4,524
Highline College	Seattle	6,898
Lower Columbia College	Longview	2,307
Olympic College	Bremerton	3,719
Peninsula College	Port Angeles	1,400
Seattle Community College	Seattle	10,026
Shoreline Community College	Seattle	4,184
Skagit Valley College	Mount Vernon	3,165
Spokane Community College	Spokane	4,846
Tacoma Community College	Tacoma	6,112
Walla Walla Community College	Walla Walla	1,390
Wenatchee Valley College	Wenatchee	1,537
Yakima Valley College	Yakima	3,450

TABLE 5

COLLEGES AND UNIVERSITIES	
Enrollment (1970)	195,260
As % of 1970 population	5.7%
Earned Degrees Awarded (1970)	
Bachelor	14,457
Masters	2,950
Doctors	460
ELEMENTARY-SECONDARY	
Enrollment (1970)	817,712
As % of 1970 population	24.0%
Student/Teacher Ratio	24.1/1
Average Teacher Salary	$9,899

INSTITUTES, LABORATORIES, AND SPECIAL PROGRAMS AND FACILITIES IN THE MARINE SCIENCES

The assets of the educational institutions of the state of Washington include many special departments and institutes, laboratories, vessels, and unique equipment that relate specifically to marine science. Institutes and interdisciplinary laboratories serve many of the same functions as the conventional academic units and often provide a basic part of the student's education. The colleges and universities of Washington have five such establishments located off campus. Special laboratories and departments that are located on campus and emphasize marine science form another important category, and many of these, together with their programs, are described in the summary below.

Washington educational institutions operate research vessels ranging in size from 16-foot outboard motorboats to the 208-foot RV THOMAS G. THOMPSON recently acquired by the University of Washington. (A number of the larger vessels are listed in Section 3.) These vessels are an integral part of research operations in the marine sciences, as well as a basic factor in training qualified personnel. The existing fleet enables researchers to conduct their work anywhere from the Arctic polar regions to the southern tropics.

Off-campus facilities

The Camp Casey Biological Laboratories of Seattle Pacific College are located on the west side of Whidbey Island on the shore of Puget Sound at Coupeville, Washington. The station is self-contained with living quarters, classrooms, and research facilities. A program of summer courses is offered.

A University of Washington College of Fisheries field station at Big Beef Creek on Hood Canal provides additional opportunities for class field studies and research in stream and estuarine ecology. The stream contains established runs of chum and coho salmon and steelhead trout. Research facilities include a salmonid spawning channel, estuarine rearing ponds, and stream observation channels. Other field activities are carried on at the College's Fern Lake station in Kitsap County where special attention is given to limnology and to the influence of the watershed on the lake.

The Friday Harbor Laboratories, a component of the Division of Marine Resources, have comprised the principal marine science station of the University of Washington since its founding in 1904. The Friday Harbor Laboratories are located approximately eighty miles north of Seattle near the town of Friday Harbor on San Juan Island, on a state game preserve of 484 acres of wooded land with about two miles of shore line. The island is one of the largest of the 172 that make up the San Juan Archipelago located in the northwest section of the state of Washington between Vancouver Island and the United States mainland.

The Laboratories are close to sea waters varying from oceanic to those highly diluted by streams, with depths to 1,000 feet, bottoms varying from mud to rock, and water movements ranging from those of quiet bays and lagoons to those of swift tideways. The waters about the San Juan Archipelago abound in varied marine flora and fauna.

During spring and summer, the Laboratories offer an opportunity for independent and supervised research, as well as a varied program of instruction primarily oriented to graduate students (exceptional, advanced undergraduates are occasionally admitted). Throughout the year, use of the facilities of the Laboratories for research in various areas of marine science is encouraged.

The Marine Biological Station of Walla Walla College is located on Fidalgo Island about 9 miles south of Anacortes, Washington. The station,which includes living facilities and three laboratories, functions in instruction and research principally during the summer term.

The Marine Biology Facility of Western Washington State College, located on Lummi Island in the San Juans, is operated by the Department of Biology. This is a small research laboratory presently devoted largely to studies of osmoregulation, temperature accommodation, and photo-periodic responses of estuarine animals.

On-campus programs and facilities

University of Washington

1. Division of Marine Resources:

Founded in 1967, DMR promotes the University's interest in the exploration, development, and the use of the resources of the seas and oceans. It coordinates and supplements the teaching, research, development, and advisory service programs in marine science and engineering and cooperates in similar activities with outside agencies and institutions.

In this capacity, the Division seeks to identify educational needs in marine resources not presently being met and to stimulate the appropriate educational institutions to meet these needs. The staff of the Division assists the faculty of the University of Washington, community colleges, and other educational institutions to respond to the changing needs of the region.

DMR is responsible for the administration of the Friday Harbor Laboratories, and for the coordination and administration of the inter-disciplinary Washington Sea Grant Program. It also represents the University in such cooperative ventures as Project SEA USE, the Cobb Seamount program. (See Section on Research for more information on Washington Sea Grant and Project SEA USE.)

2. College of Fisheries:

The College of Fisheries, founded in 1919, has earned an international reputation for the education of fisheries scientists and the development of new scientific knowledge. The present student body and faculty deal actively with the problems associated with the use of living resources in the water and with food science. Full attention is given to biological, political, social, legal, and economic problems associated with the use of resources either for recreation or for food. Curricula for the bachelor's, master's, and doctor's degrees combine laboratory and classroom study with practical experience. Specialized equipment includes an outstanding fisheries-oceanography library, the 65-foot MV COMMANDO, a saltwater aquarium, a food-processing laboratory, an experimental fish hatchery, ponds connected to the Lake Washington Ship Canal by fish ladder, as well as many other specialized laboratories.

The Fisheries Research Institute is a research branch of the College of Fisheries. It is organized and equipped to pursue these objectives: (1) to promote the research and educational functions of the University of Washington in the field of fishery science; (2) to conduct scientific investigations of basic and applied fishery problems; (3) to aid in the training of fishery scientists; (4) to maintain a staff of scientists expert in fishery problems, especially the problems relating to salmon.

The Institute for Food Sciences and Technology, a part of the College of Fisheries, facilities include separate, well-equipped laboratories for food microbiology, food biochemistry, and food analysis. The food-processing and food-engineering laboratory complex is composed of several separate facilities containing equipment for teaching and experimental work in thermal processing (including canning), drying, smoking, and freezing foods. A particularly wide variety of low-temperature equipment and cold rooms is available.

3. Department of Oceanography:

The Department of Oceanography, established in 1951, is one of the major oceanographic institutions in the United States. The undergraduate program, leading to B.A. or B.S. degrees, until recently has been unique. Now a handful of institutions throughout the United States offer a B.A. or B.S. in oceanography. Instruction and thesis research for graduate students lead to M.S. and Ph.D. degrees, the traditional level for degrees in oceanography.

The Department of Oceanography has designed its programs of instruction and research to complement those of other departments and colleges. Emphasis is centered on basic theories and concepts rather than engineering applications, and on broad, integrated topics rather than highly specialized items. The oceans and their coastal regions are treated as dynamic systems, and attention is

focused on the complex processes that control the distribution of properties and produce changes with time. Theoretical investigations, laboratory experiments, and model studies are employed to supplement measurements and observations at sea to interpret the interactions that occur among the waters and the atmosphere, the solid earth, and the living organisms.

The faculty of the department directs an extensive program of research funded by federal agencies such as the Office of Naval Research, National Science Foundation, Atomic Energy Commission, and the Public Health Service. As part of this program three vessels are operated: THOMAS G. THOMPSON (208 feet long), and the two small craft, HOH and ONAR.

In addition to using these vessels for intensive studies in Puget Sound and the adjacent protected waters, detailed studies are made on the continental shelf and the waters adjacent to the coast. The THOMAS G. THOMPSON, together with opportunities to work on other vessels, makes it possible to conduct research anywhere in the world ocean.

A new research building (56,000 square feet) was completed in early 1967. A second unit, to provide new classrooms and teaching laboratories, was completed in 1969. The building also houses the International Pacific Halibut Commission and a large Fisheries-Oceanography Library housing well over 25,000 volumes.

4. College of Engineering:

This ocean-engineering program at the University of Washington was established to provide graduate students with the opportunity to acquire the education and training that they will need to pursue careers in marine-related industries or research establishments. Under-graduate students in engineering whose professional interests are directed toward these fields and who are preparing to enter the graduate program or who expect to enter a marine industry with a bachelor's degree are guided in planning their courses under this program.

The location of the University of Washington and the variety of courses it offers pertinent to the program provide unique advantages for an ocean-engineering program. A complete range of marine environments--rivers, lakes, protected bodies of salt water, and the open ocean--is readily available for testing and research. Within the University, the staff and facilities of colleges, schools, and departments outside the College of Engineering offer a variety of courses in such areas as fisheries, oceanography, atmospheric sciences, law, public affairs, economics, and others that make possible a truly interdisciplinary ocean-engineering program. Marine-related industry--industry engaged in heavy marine construction, research, the construction of small craft, and fishing, to list a few examples--and nearby governmental facilities such as the Puget Sound Naval Shipyard at

Bremerton, the NOS Pacific Marine Center, the Keyport Naval Laboratory, and the National Marine Fisheries Service Laboratory, present the student with the opportunity to observe the practical applications of his field of ocean engineering and provide him with realistic problems for his academic research.

Engineers already practicing in a marine-related industry find that the best preparation for such a career is one in which the student develops a strong competence in an important branch of engineering such as aeronautical, ceramic, civil, chemical, electrical, mechanical, metallurgical, or nuclear engineering, and, in addition, acquires specialized knowledge about the marine environment through such courses as physical oceanography, chemical oceanography, marine biology, or the effects of the sea environment on materials. Beyond this, some students may also wish to supplement these studies by taking such courses as admiralty law, economics, or public policy that may have special bearing on their own particular career goals. The interdisciplinary nature of the ocean-engineering program requires that the student give more than the usual amount of consideration to the definition of his professional objectives and to the planning of both his engineering studies and his supplementary studies in the marine sciences.

In the College of Engineering, faculty in the hydraulic engineering and the sanitary engineering divisions of the Department of Civil Engineering have shared research interests and activities with faculty in the College of Fisheries. Most of these joint efforts have involved the design of fish ladders and other structures to aid the migration of fish past man-made obstructions. Some of the efforts involving the sanitary engineering division center around the effects of pollution on the chemical and biological environment of our natural waters. The soil engineering group of this department has been doing research on the behavior of sedimentary deposits on the ocean floor.

For many years the Department of Mechanical Engineering has offered a sequence of three senior elective courses in naval architecture for students wishing to prepare for careers in naval architecture and marine engineering. Plans are now being completed to improve these educational opportunities to better serve the manpower needs of expanding marine industry in the Puget Sound area.

Faculty and graduate students from the Departments of Electrical and Mechanical Engineering have collaborated with the University of Washington Applied Physics Laboratory by assisting with the development of instrumentation and equipment needed for their underwater vehicles.

5. Center for Quantitative Science in Forestry, Fisheries, and Wildlife:

The Center was established in 1968 in recognition of the

trend towards the use of mathematical methods and models in the utilization and management of our renewable resources and in the biological field in general. Problems of sampling and the statistical analysis of data have long been of importance in the utilization and management of fisheries and forest resources. Operations research tools and dynamic programming methods may provide better ways to manage these resources in the face of increased human pressure on them and in the face of growing needs to balance multiple and competing demands. Finally, development of mathematical models represents an important step in the increased understanding of natural phenomena. Because of the complexity of the ecosystems in nature, because of the many variables and the interactions between them, systems analysis methods and high speed computers are necessary in such model building. In fact, computer-based models have already demonstrated their usefulness in the management of salmon and halibut populations, in the control of insect pests, and in the understanding of the behavior of prey and predator systems.

The Center serves as a focus for this activity in the Colleges of Fisheries and Forest Resources and will provide consultation and teaching in applied mathematics and applied statistics and conduct research in both the methodology of model building and ecological and resource management problems.

Support for this general area is provided by a Ford Foundation Grant that, in particular, provides graduate fellowships. These are for students who are working for the Ph.D. and who may major in any of a number of selected disciplines. Such students must take part of their programs in quantitative science and are expected to apply quantitative methods in their dissertation research to a problem in ecology or resource management.

6. Wildlife Science Committee:

The Colleges of Fisheries and Forest Resources have established a new undergraduate degree program in wildlife science. Students interested in the aquatic aspect of wildlife register in the College of Fisheries. The student who obtains a Bachelor of Science with a major in wildlife science applies his training to management of wildlife resources and the related environment or proceeds to do graduate work for advanced management or research positions.

7. Applied Physics Laboratory:

The Applied Physics Laboratory conducts research and development on Navy programs for the Naval Ordnance Systems Command. The laboratory is eminent in the area of underwater instrumentation, including acoustic tracking ranges. The naval tracking ranges in Dabob Bay, Washington, and St. Croix in the Virgin Islands, are laboratory developments.

At present, the laboratory is conducting investigations of the oceanographic factors that influence long-range acoustic propagation in the sea. These include the phenomena of sea state and its influence on reverberation: turbulence and other mechanisms that cause acoustic index of refraction variations; and sea-bottom characteristics that determine acoustic reflection parameters. Many of these investigations use an unmanned vehicle designed and built by the laboratory for oceanographic and acoustic research. This device carries instruments to a depth exceeding 3,000 meters at a speed of 6 knots for distances of 50 miles. The trajectory can be controlled from a surface ship with acoustic commands.

8. Laboratory of Radiation Biology:

The Laboratory of Radiation Biology, established in 1943 as the Applied Fisheries Laboratory, was created to conduct research in the overall effects of irradiation on aquatic animals. Much of the early work was directly associated with specific problems of radiation at the Hanford Works. In 1946, during Operation Crossroads, members of the laboratory staff encountered, at Bikini Atoll, the new questions of ocean radiobiology that would continue to be studied through the years as nuclear tests were conducted at Bikini and Eniwetok Atolls and at Christmas and Johnston Islands. These weapons tests, and the Plowshare programs that followed, led ultimately to studies in many other places throughout the Central and South Pacific, to Japan, the Arctic, and the Aleutians.

9. Department of Atmospheric Sciences:

The Department of Atmospheric Sciences is interested in the air-sea exchange, and instruction and research in this field, started at Friday Harbor, now is centered primarily at Seattle. Research problems of special interest are the study of fluxes of momentum, matter (especially water vapor), heat, and radiation at the sea-air interface. A natural outgrowth is the study of processes leading to ocean wave formation.

The principal item of research equipment is an instrumented buoy capable of making measurements at sea or over inland waters. Other items are telemetering links, recording instruments, and data processing facilities.

10. Department of Zoology:

The Department of Zoology emphasizes a strong program of study and research for both undergraduate and graduate students in the area of marine zoology. The University of Washington's strategic location in relation to the varied marine environments that characterize Puget Sound, the Strait of Juan de Fuca, and associated waters provides exceptional opportunities for research. Over half of the instructional staff have direct interests in the study of the animals of the sea and a wide variety of specializations is represented. The well-equipped laboratories

on campus and the Friday Harbor Laboratories provide the department with opportunities for the studies of an especially rich fauna in widely diverse marine habitats.

11. Department of Botany:

The Department of Botany possesses a wide range of equipment for marine studies. In particular, the controlled-environment facilities are used extensively for research so that in recent years it has been possible to build up a large collection of living algae and fungi, and a recently-installed Zeiss EM-9 electron microscope is being used for investigations of the fine structure of aquatic protista. In addition, the department also owns a smaller cruiser specifically designed for scuba work in marine biology.

12. School of Law:

With Sea Grant support, the Law School has developed a curriculum that leads to a Masters of Law degree in Marine Affairs. Up to six students are permitted in this program; four will graduate in 1971. No master's thesis is required, but the students perform directed research in such areas as coastal management, institutional impediments to fisheries, oil pollution control beyond territorial waters, and protection and indemnification insurance problems which are posing an economic threat to commercial fishing boast owners. The LL.M. degree does not require passage of the bar examination.

13. Other programs:

Ocean-related studies in the Department of Economics and the Graduate School of Public Affairs bear upon such areas of concern as fisheries economics and natural resources law and public policy.

Highline College. Highline College, overlooking Puget Sound halfway between Seattle and Tacoma, offers a two-year (seven quarters) technical program which prepares students for employment as professional divers and marine engineering technicians. This program provides the student with comprehensive training to permit him to work in an underwater environment when circumstances require and to permit him to operate effectively as a member of the marine engineering team at all times. The Underseas Technician Program at Highline College is unique, and when it first opened it was the only one of its kind in the United States.

The student begins his instruction in the college's new swimming pool. He then progresses to open water diving from the 200-foot college pier located on Puget Sound. Professional divers provide year-round instruction and supervision of open water diving

at the pier facilities.

In addition to his instruction in diving and seamanship, the Undersea Technician receives a full complement of instruction in engineering principles, techniques and materials presented by graduate professional engineers, operating out of modern and well-equipped shops, laboratories, and classrooms. Other instruction in welding, physical education, communications, and mathematics complete the program.

During the 1969-70 academic year the twenty students and two instructors of Highline College participated with Sea Grant support in the Tektite II project, Lameshur Bay, U.S. Virgin Islands. They assisted in emplacing the underwater habitats and setting up the required safety facilities.

From April - November 1970, they maintained an 8-hour-on, 24-hour-off shift schedule in service of the operational phase of the project. The recompression, utility, and safety diver team function required a 5-man crew on a continuous basis during the operational phase.

Seattle Central Community College. Located in the center of a major concentration of Northwest marine and fishing activity, the college is actively developing and establishing programs appropriate to the preparation of people for employment, as well as offering upgrading programs for those presently employed in the many occupational areas represented.

Seattle Central Community College is currently operating classes in marine electricity, marine refrigeration, marine diesel engine operation, and ship piloting/navigation for persons engaged in the Pacific Northwest fishing industry.

With Sea Grant assistance, additional hydraulics equipment has been purchased, allowing the hydraulics laboratory to be scheduled not only for daytime use but also for evening extension classes since the 1970 fall quarter.

The college has the S/S TRIDENT where instruction is given and hands-on experience is gained. It is planned to locate a 24 by 32-foot building on the docksite in which a diesel laboratory will be housed.

Shoreline Community College. Located on Puget Sound in Seattle, Shoreline has offered training programs for Oceanographic and Marine Biology Technicians since 1967. The Curriculum established at that time was thoroughly updated and revised during 1970 with Sea Grant assistance.

The student is trained to work with professional oceanographers aboard ocean-going research vessels and in the laboratory. Students get classroom instruction on campus and aboard an oceanographic research ship. Provisions are made for students to go on cruises to learn the fundamental operation of scientific research instruments. The student earns wages and college credit at the same time under this arrangement.

The curriculum provides for the study of the physical properties of the ocean, the movements of the sea, and the relationship between the sea, the atmosphere, and the land areas.

Shoreline Community College has recently negotiated a lease for waterfront property adjacent to the campus for a regional marine laboratory.

Peninsula College. Peninsula College enjoys a unique and favorable geographical position with respect to a fisheries program. Located in Port Angeles, which has a fine harbor on the Strait of Juan de Fuca, the college also has several fine fish producing lakes and rivers a few miles away. Local fishermen engage in trolling and gillnetting salmon, and state and federal fish hatcheries are situated nearby.

A two-year technical-vocational program to prepare a student for any of the following positions is now being offered:

A. Scientific Aide 1 (Washington State Fisheries Department)
Definition: Performs variety of skilled and semi-skilled laboratory and field work to facilitate fish research and management.

B. Scientific Aide 2
Definition: Same as Scientific Aide 1 except requiring ability to carry out assignments without direct supervision.

C. Hatchery Assistant 1 (State and Federal)
Definition: Performs variety of semi-skilled manual duties at State or Federal fish hatchery and assists in technical work.

D. Biological Aide (Federal)
Definition: Similar to Scientific Aide 1

Note: Upon completion of the course and success in passing an oral examination given by the Washington State Department of Fisheries, a graduate is usually offered a Scientific Aide 2 rating.

In addition to their classroom lectures and laboratory exercises, the students are able to engage in state, federal, and

local fisheries programs.

Each year visits are made to Hoodsport and Dungeness Hatcheries (State) and Quilcene National Fish Hatchery. Here the students participate in the selecting and spawning of five kinds of salmon. Usually 200,000 eggs from these hatcheries are taken back to the College hatchery and raised to fry stage by the students. Working closely with the Department of Fisheries, the students will plant these fish in local streams when they are ready. This provides a full two-year experience in rearing salmon. Trout are also kept in a private pond west of Port Angeles for student observation.

Once a year the class assists a local sportsman's group in marking and releasing 15,000 steelhead trout in a local stream. The class also maintains close contact with fish farmers in the area, aiding them when possible.

Grays Harbor Community College. Grays Harbor Community College was founded in 1930 to provide academic and professional courses for local residents. The college is located in one of the most important commercial fishing ports of the Pacific Coast and is now training students in a two-year Fishery Technology program and in the first two years of the B.S. degree in Fisheries Biology.

The pre-bachelor of science degree has operated successfully for a number of years; many students in this program transfer to the University of Washington to complete their degree.

The Fishery Technology program is in its second full year of operation. Some courses introduced two years ago are Fisheries Biology, Water Resources, Introduction to Fisheries, Instrumentation for Life Sciences Ecology, and Game Management.

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SECTION 6

MARINE RECREATION

NATURAL MARINE RECREATION RESOURCES

Geography and climate

The combination of natural resources in western Washington, both developed and undeveloped, which are capable of supporting marine recreation is practically unmatched anywhere in the nation. Pacific coastal waters off Washington (and in U.S. jurisdiction) total 226 square miles. The ocean shore extends about 157 miles; there are 178 miles of shoreline on the Washington side of the Strait of Juan de Fuca; and the entire tidal shoreline in western Washington extends about 3,026 miles--about the same distance from Seattle to New York City by auto.

The outstanding recreational feature of the region is the more than one and a half million acres of interior salt water which is flanked by forests, bluffs, and lowlands. The inland sea of Puget Sound extends about 90 miles from the Strait of Juan de Fuca to Olympia and is up to 8 miles wide.

More than 300 islands rise from these deep waters. The largest, Whidbey Island, is the second largest island in the contiguous United States. These islands and the complex shoreline, with its many bays and inlets, offer beauty, adventure, and shelter. Some islands have commercial, agricultural, and aquacultural importance; others are more suitable for private residences, resorts, or as destinations for recreationists. The San Juan Islands are close to large population concentrations and provide day-use as well as summer home recreational outlets for urban residents. Access limited to boats and ferries has allowed the island group to retain a major portion of its natural scenic beauty.

Puget Sound is probably the greatest single recreational attraction

in the state. It provides unending scenic variety and abundant recreational opportunities. Hood Canal is equally impressive. The natural canal extends inland about 60 miles, and its shoreline of 242 miles provides outstanding opportunities for marine recreation.

The many streams and lakes in the region are important as suppliers of municipal and industrial water, but also are important for recreation, fish, and wildlife uses. In western Washington, there are more than 2,800 lakes and reservoirs, ranging from a fraction of an acre in size to 22,000 acres (Lake Washington). Approximately 1,100 of these lakes are at elevations of not less than 2,500 feet. As the rivers leave the mountains, they lose much of their velocity and build broad deltas, sloughs, and marshes near their mouths, where migratory waterfowl find shelter.

Unlike many more densely populated states, Washington has a large amount of open space.

TABLE 6

Open Space in Washington

Area	Square Miles
Land and water area, excluding Puget Sound, the straits, and Pacific coastal water	68,192
Puget Sound, the straits, and Pacific coastal water	2,397
Land area	66,709
Types of open space	
Forest	37,294
Range (overlaps forest)	17,352
Agricultural cropland	12,300
Inland water	1,483

Climate was discussed in Section 2.

Marine fish and wildlife

The abundance and variety of marine life in the salt waters of this region is extraordinary. Marine mammals found here are listed in Section 3. At least 17 species of ducks and 6 species of geese winter in the state.

Of all the varieties of fish found in the Puget Sound region, the anadromous species are the most valuable, both commercially and recreationally. The chinook (king), coho (silver), chum, sockeye, and pink salmon, steelhead and searun cutthroat trout and Dolly Varden are produced in fresh water streams and lakes and nurtured by salt water feeding grounds. The rivers, streams, reservoirs, ponds, and lakes contain rainbow, Dolly Varden, cutthroat, and brook trout, bass,

bluegill, crappies, and yellow perch, as well as many other spiny-ray species classified as game species. The extensive hatchery system in Washington is mentioned in Section 4.

The salt water salmon sport fishery provides year-round recreation. May through October are the best months, when maturing chinook, pink, and coho salmon are migrating to their home streams and readily hit sport gear. Fishermen also seek halibut, lingcod, rockfish, sole, flounder, surfperch, and surf smelt. Many thousands of other recreationists gather clams, crabs, and oysters from some of the finest areas in the country for this purpose.

The state game department has concentrated on planting larger sized fish rather than greater numbers of fish. The trend toward larger fish is a result of improvements in food, techniques, hatchery facilities, public preference for larger fish, and the fact that larger fish are better able to survive after release.

TABLE 7

Sport Fishing Trends, 1954-1969

	Resident Fishermen (1000's)	Non-res. fishermen (1000's)	Total fishermen (1000's)	Pounds of fish planted (1000's)	Lbs. of fish planted/ fisherman	No. of fish planted (millions)	No. of fish planted per fisherman
1954	362.8	19.3	382.1	610.9	1.6	30.1	78.8
1956	370.5	22.4	392.8	723.9	1.8	28.1	71.5
1958	355.7	16.1	371.8	994.8	2.7	37.4	100.6
1960	353.9	16.7	370.6	1118.5	3.0	33.3	89.9
1962	357.4	24.7	382.1	1238.2	3.2	32.6	85.3
1964	389.9	23.0	412.9	1363.5	3.3	35.9	86.9
1966	407.0	29.8	436.9	1370.0	3.1	28.7	69.7
1968	437.3	32.8	470.0	1856.5	4.0	32.2	68.5
1969	450.2	34.8	485.1	2276.1	4.7	34.6	71.3
Change since 1954	24.1%	80.4%	27.0%	272.1%	194.0%	14.9%	-9.5%

Other sport fishing trends during the 15 year period are:

- The total number of fishermen has increased 27%. This averaged about 1.8% annually.
- The number of non-resident fishermen increased at a rate nearly 3-1/2 times that of resident fishermen.
- The total number of fish (all species*) planted annually increased only 14.9%, while the total pounds of fish planted annually increased 272.1%.
- The annual number of fish (all species*) planted per fisherman decreased 9.5%, while the pounds of fish planted annually

per fisherman increased by 194%.

* All species includes: brown trout, cutthroat trout, eastern brook trout, kokanee (silver trout), rainbow trout, steelhead trout, and silver salmon planted by the Department of Game only.

No license is required of sport fishermen for commercial fish species such as salmon. A license is required for game fish, either in salt water or fresh water. Non-resident fishing license is $20 or a 7-day license may be purchased for $6. A punch card is required and issued free for salmon, and a punch card costing $2 is required in addition to the license for steelhead trout.

The season for razor clams and legal limits must be observed, but no license is required. The season is for 7 days a week, September 16 through July 15. Daily possession limit is 18 razor clams. There is no season on butter clams or geoducks, and the limit is 20 pounds of butter clams or three geoducks per digger.

Skin and scuba diving are also popular because of the abundant and varied marine life in these rich and productive waters. The principal attractions of the ocean and its shore are the seaside scenery, boating, surf and boat fishing, scuba and skin diving, shellfish digging and gathering, swimming, camping, picnicking, hiking, waterfowl hunting, and beachcombing for driftwood, shells, glass floats, and other jetsam.

MAN-MADE MARINE RECREATION RESOURCES

National parks

The Olympic National Park on the Olympic Peninsula added a coastal strip to its boundaries in 1953. This strip extends from Queets to Cape Alava. The Olympic National Park drew 90,000 visitors in 1940; 400,000 in 1950; and 2,000,000 in 1968.

State parks

Fourteen of Washington's 39 counties have saltwater beaches. There are 40 state park sites on Puget Sound, three on the Strait of Juan de Fuca, 7 on Hood Canal, and three on the Pacific Ocean coast. In 1969-70, the state parks system added 1184 acres to its holdings of 75,950 acres.

TABLE 8

State Parks on Puget Sound and Adjacent Waters

Park	Attendance Figures 1968	1969	1970
Bayview	64,437	116,284	107,990
Belfair	361,894	210,281	427,664
Birch Bay	491,371	538,043	623,073
Blake Island	60,591	66,859	68,071
Camano Island	281,290	316,339	319,844
Dash Point	387,988	433,138	458,434

Deception Pass	932,975	1,029,188	962,056
Dosewallips	250,830	280,997	253,937
Fay-Bainbridge	169,237	198,098	216,322
Fort Casey	318,172	324,310	440,370
Fort Flagler	108,110	107,770	117,021
Fort Worden	30,082	35,966	108,125
Illahee	258,796	293,111	345,152
Jarrell's Cove	24,820	39,655	50,022
Kitsap Memorial	106,869	97,165	126,317
Kopachuck	194,441	161,955	167,598
Larrabee	300,709	343,049	338,791
Moran	111,311	88,355	149,102
Mukilteo	148,658	238,360	746,667
Old Fort Townsend	80,992	86,921	117,960
Penrose Point	106,680	113,234	162,540
Potlatch	118,134	186,486	240,826
Saltwater	818,921	731,872	927,103
7 San Juan Islands*	73,451	84,213	75,300
Scenic Beach	37,995	56,970	103,837
Sequim Bay	188,904	215,361	325,121
South Whidbey	67,295	53,844	131,428
Squaxin Island	21,458	25,118	26,754
Twanoh	419,920	411,460	513,703

*Estimated attendance--unsupervised parks

TOTALS	6,536,331	6,884,402	8,651,128

The state of Washington has several state marine parks accessible only by boat, and owns and leases several islands for the use of boaters. Only 7.5 miles from downtown Seattle is Blake Island State Park in Puget Sound. Originally held as a timber reserve, the island was purchased by the state and turned into a state park for boaters. No car ferries or bridges connect the island to the mainland, and the facilities are kept to a minimum to preserve the natural state. At the northern end of Blake Island, Tillicum Village is a summertime center for conventioners, boat owners, and tourists. In this authentic Indian village, Indian art is displayed and Indian dances are demonstrated. In the long house, dinners of smoked salmon are a specialty.

In April 1970, six underwater parks were established by the State Parks and Recreation Commission for the enjoyment of scuba and skin divers and students of marine life. These marine sanctuaries are located off state parks lands at Deception Pass in Island and Skagit Counties; Fort Casey, Island County; Fort Ward, Kitsap County; Peapod Rocks in the San Juans; Blake Island and Saltwater State parks, both near Seattle, King County. Marine jurisdiction extends one-fourth mile offshore from the extreme low tide mark.

The Department of Natural Resources' marine specialists, aided by a specially selected underwater advisory group, has been studying Puget Sound and the Strait of Juan de Fuca to identify and catalog other unique underwater areas of scientific and educational value. The department plans to conduct a meeting in the San Juan Islands on September 10-11, 1971, to create a Western Council on Underwater Reserves and Parks. Representatives from California, Oregon, Alaska,

Canada, and Mexico are invited to join the council.

The 1967 Seashore Conservation Act, as amended by the 1969 state legislature, provides that the ocean beaches in Washington should be preserved (prohibiting further sale of accreted land west of the line of 1889), conserved (decreeing that steps should be taken to maintain and construct sanitary facilities and otherwise assure proper citizen usage of the beach), and dedicated (excluding other uses not compatible with outdoor recreation). The Act decreed that the primary purpose of the beach lands was for public recreation use. The 1971 legislature passed a Shoreline Management Act that provides for the management of the state's shorelines by planning for and fostering all reasonable and appropriate uses. This Act is further discussed under "Department of Ecology" in Section 10.

The 1967 state legislature established the nation's first "scenic" and recreational highways system, a cooperative program between the Department of Highways and the State Parks and Recreation Commission. Some projects are scheduled to begin by 30 June 1971.

County and city parks

Although county and city parks are located where the need for recreation facilities is the greatest (within or near the urban centers), their acreage is only a small fraction of the total area they serve.

At the Point Defiance Park near Tacoma is a saltwater aquarium where almost all the specimens on display were caught within a 20-mile radius of the point. The facility includes a tidal pool which permits visitors to closely observe the native marine life in their actual habitat. A small colony of sea otters is housed in a recently completed sea otter building.

The City of Seattle is building a $3 million public aquarium at Golden Gardens Park.

Private outdoor recreation facilities

Privately operated areas usually offer fairly specialized services and facilities which require a high degree of public contacts and management. Well-developed large establishments offering a variety of activity options prove more profitable than smaller developments.

A 1965 inventory showed a total of 479 private operators in the Puget Sound region, some 345 of which were engaged in enterprises offering boating, fishing, waterfowl hunting, skin diving, swimming, or water skiing.

A number of the largest lumber and power companies in Washington provide facilities available to the general public, including Boise Cascade Corporation, International Paper Company, Pacific Power & Light Company, Puget Sound Power & Light Company, ITT Rayonier, Inc., St. Regis Paper Company, Seattle City Light, Tacoma City Light, Washington

Water Power Company, and Weyerhaeuser Company.

Most waterfront property along Puget Sound, freshwater lakes, and the region's many rivers and streams is privately owned.

Other

Chittenden locks, operated by the Corps of Engineers, are used without cost by pleasure and commercial craft alike as they go from the salt water of Puget Sound to the fresh water of Lake Union and Lake Washington. Lake Washington is the location of unlimited hydroplane racing. The hydroplane races, a feature of Seattle's annual Seafair, are a compelling spectator sport in which powerful boats compete at speeds greater than 100 miles per hour.

The Lummi Stommish Water Carnival, held each June, attracts members of the Lummi tribe and its northern neighbors as well as thousands of visitors.

The Pacific Science Center, a magnificent legacy of the 1962 Seattle World's Fair, provides enjoyment for thousands of visitors annually. The center plans a major display on oceanography soon; a hydraulic model of Puget Sound is expected to be installed by January 1972.

Economic impact

The Puget Sound Task Force of the Pacific Northwest River Basins Commission found that because little research has been done in the field of recreation economics, it is difficult to place a dollar value on recreation. The task force selected one aspect of recreation--tourism--in order to make a systematic and meaningful economic analysis.

In terms of employment, tourism is the fourth largest and probably the fastest growing basic industry in the Pacific Northwest. Only the food, defense, and forest products industries account for greater employment. The tourist industry is expected to be at least the number three industry in the Pacific Northwest by 1985 and may grow to be the largest industry by the year 2000.

Recreation expenditures usually increase as family income increases and the proportion of income spent on necessities such as food and shelter either remains fairly constant or declines. Tourist expenditures (not resident recreation expenditures) in the Pacific Northwest in 1964 were about $900 million; in 1985 these expenditures are expected to be about $2,210 million; and in 2010 they are expected to be some $6,765. Additional leisure time and higher incomes will allow more time and money on recreation.

It is estimated that the $900 million in tourist expenditures equals about two-thirds the total tourist and recreation spending. The other third for resident recreation spending brings the total estimated tourist and recreation expenditures to $1.3 billion for 1964 in the Pacific Northwest.

Of this amount, 45.4% was spent in Washington: $606 million. Nearly 50% of this (or approximately $300 million) was spent in the Puget Sound region.

The expenditures by government agencies for acquisition and development of recreation areas in the Pacific Northwest are increasing. During 1965, the annual recreation expenditures in the Pacific Northwest by government agencies were:

Federal	$36
State	25
Local	31
	$92 million

The sum spent by private interests such as timber companies, the Nature Conservancy, YMCA, YWCA, Boy Scouts, Girl Scouts, Camp Fire Girls, and other church, youth, and civic groups, is also significant and is probably also increasing.

A 1969 study of the impact of non-resident travel on the state's economy by Battelle-Northwest revealed additional information worth noting.

TABLE 9

Non-Resident Travelers and Their Expenditures in Washington in 1965

Purpose	Travelers (1000's)	Percent	Expenditures (1000's)	Percent
Vacation:				
Outdoor recreation	1739.9	20.8%	$30,238.9	11.2%
Entertainment	224.3	2.7	4,432.5	1.6
Other vacation	1773.1	21.2	36,643.9	13.5
Business	1403.1	16.7	92,839.7	34.3
Personal	414.9	5.0	40,753.7	15.0
Visit relatives	2434.5	29.1	60,342.4	22.3
Other	384.4	4.6	5,224.4	1.9

More people (44.7%) visit Washington for both scenic and entertainment purposes than for any other major reason. While these travelers do not spend as much as the business traveler, they do contribute significantly to the state's total economy.

The Battelle study points out these salient features of the tourist impact on the economy:

1. The projected expenditures by all travelers to the state of Washington is expected to rise from $240 million in 1963 to $614 million in 1980.

2. The projected traveler expenditure in the state will generate gross outputs rising from about $457 million in 1963 to $1.0 billion in 1980.

3. The employment generated by the traveler expenditures will rise an estimated 38,000 in 1963 to 64,000 in 1980.

4. The value-created which includes cost of labor, depreciation, indirect taxes, etc., will rise from an estimated $297 million in 1963 to an estimated $658 million in 1980.

5. The induced personal consumption generated by the traveler expenditures will rise from an estimated $139 million in 1963 to $240 million in 1980.

6. Because of the nature of the traveler expenditures in the state, the overall multiplying factor on a per dollar spent basis is approximately 2; i.e., a dollar of traveler expenditure generates about $2 worth of business activity in the state.

7. While the gross dollar output from non-resident travel is expected to more than double by 1980, the projected employment will increase only one and one-half times because of the projected increase in productivity.

This discussion of tourism in Washington and the Pacific Northwest gives some perspective to the dollar value of outdoor recreation and, more particularly, marine recreation in this state.

Recreation demands and needs

Factors influencing the demand for recreational lands, waters, and facilities of the proper type, quality, and quantity and in the right location in the outdoors are population, leisure time, income, mobility, age composition, sex ratio, education level, and occupational categories.

Trends indicate that more people are owning boats, and the boats are becoming bigger, faster, and fancier. Skin and scuba diving and water skiing are now very popular. There is a growing national appreciation of ecology and of the values of outdoor recreation and beauty. Private enterprises are playing an increasingly important role in satisfying outdoor recreation needs. Greater numbers of local agencies are supplying recreation and natural areas within and near the urban areas. Attendance records during 1969-70 indicate that there is no "off-season" in state parks any longer. While Washington's population increased by 18% from 1960 to 1969, the number of outdoor recreationists increased by 175%--nearly 10 times the population rate.

In 1960, swimming was the most popular water related activity in the Puget Sound region. During the period from 1960 to 2020, demand for water related recreational opportunities may increase from 63 million to 447 million activity occasions. Expressed in recreation

days (a term defined as a visit by one individual to a recreation development or area for recreation purposes during a reasonable portion or all of a 24-hour period), the total future outdoor recreation demands are:

1960	57,654,000 recreation days
1980	109,104,000 recreation days
2000	204,105,000 recreation days
2020	369,372,000 recreation days

Although these estimates must be used cautiously, they are of value to planning and regulatory agencies as a foundation for establishing short range objectives and providing scale and perspective to programs of longer range.

Areawise, there is an adequate supply of beaches to satisfy swimming needs until the year 1980. There are localized deficiencies within urban areas. To satisfy swimming needs by 2020, an additional 865 acres of beaches need to be made available for public use.

In the Puget Sound region about 34% of the population engages in some form of recreation boating, as compared to the national average of 20%. The per capita ownership of pleasure boats in this region is more than twice the national average. In 1966 there were 94 boats per 1000 people, compared with a national average of 41 boats per 1000. Approximately 180,000 of the estimated 223,000 private pleasure boats in the state are owned by residents of the Puget Sound region. Hence, its title as the "boating capital of the world."

The number of pleasure boats in the Puget Sound region is expected to rise at a rate one per cent greater than the average annual population growth. Pleasure craft may increase from about 180,000 in 1966 to about 1,035,000 by 2020. These boats create a great need for shoreline facilities, particularly for boat launching and moorage. The most severe shortage of facilities exists on the east shores of Puget Sound, where urbanization, industrialization, railroad rights-of-way, steep topography, and lack of sheltered areas complicate the situation. Pleasure boating, of course, has significant impact on other businesses, including petroleum companies, boat builders, repair yards, boat dealers, equipment and supply firms, boat houses and mooring facilities, and outboard motor parts and repair firms. Rental services supply anything from a rowboat to a cruiser, and a boating trip can be combined with fishing, clam digging, or camping. Although private resorts and their associated improvements are needed within the area, no data are available to accurately determine the demand and need.

Plans to meet demands and needs

Recognizing the trends in recreation and the demands and needs of the people, the state of Washington has adopted a Washington Statewide Outdoor Recreation and Open Space Plan. The comprehensive plan identifies recreation goals, identifies present supplies and potential

areas of open space and outdoor recreation facilities, estimates the needs to the year 2000, and recommends actions to achieve these needs and goals. The state Interagency Committee for Outdoor Recreation prepares, maintains, and updates the comprehensive state plan.

Water pollution

To assure the economic importance of tourism and recreation and to satisfy the recreation demands of the people, the water resources must be protected and properly developed. Outdoor recreation is a legitimate and important use of water. Water pollution has received increasing attention and research in the Puget Sound area in recent years. Fortunately, the western Washington waters are relatively unpolluted.

The inherent conflict in discharging sewage effluent into a valuable lake was brought forcefully to mind with the rapid decline of physical and biological conditions in Lake Washington in the early 1960's. Nuisance algae blooms flourished in the lake producing extremely unpleasant conditions both aethestically and recreationally. The blooms resulted from nutrient enrichment supplied by effluents from 10 sewage treatment plants.

To help combat pollution, a $100 per capita burden was assumed by voters in the Seattle metropolitan area several years ago for interception and treatment of sewage. This project, administered by the Municipality of Metropolitan Seattle (Metro), has been largely responsible for control of the serious water pollution problems which threatened the existence of many of the area's recreation resources in the late 1950's. The first stage of Metro's pollution abatement program as part of the overall Comprehensive Sewerage Plan approved by the Metro Council in 1961 was committed to two primary objectives, i.e. (1) removal of all sewage effluent from Lake Washington and (2) interception and treatment of all raw sewage discharges along Seattle's Puget Sound waterfront.

The first stage program was completed in 1970 at a cost of $120 million, one year ahead of schedule and only 2% above initial design cost estimates. The diversion of effluent from Lake Washington, completed in February 1968, has resulted in definite signs of recovery of the lake with present conditions approaching those of the pre-1950's.

Many of the nuisance forms of algae have disappeared from the lake, the extremely heavy blooms have diminished, and transparency of the lake water has increased at least threefold from a summertime minimum of 2-1/2 feet to a level of 7 to 10 feet. Concurrently, phosphorous concentrations in the lake water have diminished to a level of 20 ppb indicating this constituent to be one of the prime controlling factors in primary productivity of the lake.

The rapid recovery of Lake Washington is convincing evidence of the value of sewage removal from the lake and represents the first successful rehabilitation of a large lake from the effects of domestic sewage discharges.

The interception of the major raw sewage discharges along Elliott Bay was completed in August 1970 and likewise produced a significant improvement of water quality conditions throughout the total waterfront area. In Elliott Bay, the development of much of the Bay for parks, floating restaurants and marinas can now proceed in keeping with the water uses designated for the area. The raw sewage is presently transported to Metro's largest treatment facility, the West Point Plant, for final treatment and disposal. This plant's outfall system is designed for large scale mixing of the effluent with the Sound water which together with strong tidal currents produces excellent dispersion and flushing of the wastewater from Puget Sound with no apparent effect on the environment of the Sound.

The second stage of Metro's Comprehensive Plan required to meet the demands of an expanding population has already been designed and approved to meet the area's needs until 1985. The program is estimated to cost $187 million and will include the following: (1) modifications and additions necessary to meet new and more stringent receiving water quality requirements; (2) planned enlargement of first stage facilities to meet the demands of increased population; and (3) extension of Metro's system to outlying areas not presently served by Metro.

AGENCY RESPONSIBILITIES

Those federal, state, and local agencies most directly concerned with marine recreation are described here. Others with oceanographic and marine programs and interests are described in Section 10.

Federal

Department of Interior. The National Park Service administers five areas within the Puget Sound region, Mt. Rainier National Park, Olympic National Park, North Cascades National Park, Ross Lake National Recreation Area, and San Juan Island National Historical Park. Much of the fresh water runoff into western Washington waters originates from the glaciers and heavy rains common to these national parks. In addition, the National Park Service programs include surveys concerning the preservation, protection and development of natural, scientific and historic features through archeological salvage, the National Landmark Program, and grants-in-aid assistance to the State under the Historic Preservation Act (Oct. 1966). The service also is engaged in a long-range program, Parkscape, U.S.A.

The Fish and Wildlife Service administers numerous programs in close cooperation with its state counterparts in the interest of managing the fish and wildlife resources. Such programs help fulfill the outdoor recreation demand for hunting and fishing.

The Bureau of Outdoor Recreation, through the Land and Water Conservation Act (Sept. 1964) and coordination responsibilities, assists the state, its political subdivisions and federal agencies in the acquisition and development of outdoor recreation sites and in the development of national, state-wide, and regional outdoor recreation plans.

Although to date the Bureau of Reclamation has not constructed any projects in the Puget Sound area, recreational facilities are provided when feasible at facilities constructed by this agency. The regional headquarters was located in Vancouver, Washington.

U.S. Coast Guard. The Coast Guard provides a Boating Safety Program aimed at making the operation of small craft on U.S. waters both pleasurable and safe through:

- Establishing uniform and effective safety standards for recreational boats
- Educating small boat operators concerning federal safety requirements for their craft

State of Washington

The State of Washington is directly involved in outdoor recreation through the programs of several agencies. State involvement may be broadly classified as:

- Land and facility ownership and management
- Program planning, coordination, and liaison
- Recreation enhancement
- Environment controls

Departments of fisheries and game. Both departments conduct programs of fish, shellfish, and game management and enhancement for recreational purposes. They are further discussed in Section 10.

Interagency Committee for Outdoor Recreation

The function of the committee, composed of six state agency directors and five citizen members interested in outdoor recreation in the state, is to provide grants and aid to state and local public agencies for purposes of acquisition and development of outdoor recreation and open space areas and facilities. This grants and aid function, and ideally all other public outdoor recreation capital programming, is guided by a statewide comprehensive outdoor recreation and open space plan which coordinates otherwise unrelated outdoor recreation and open space planning in this state.

The goals of the committee are to (1) provide for development and use of outdoor recreation resources in a manner consistent with preservation of the natural quality of the environment, (2) provide a system of public recreational facilities and opportunities for state residents and visitors, (3) assist local government in providing facilities which best serve local needs for outdoor recreation, and (4) encourage programs which promote outdoor education, skill development, participation opportunity and proper husbandry of recreation resources.

Washington State Parks and Recreation Commission. The primary purpose of the Washington State Parks and Recreation Commission is to acquire, develop, operate and maintain recreation areas for overnight camping, picnicking, boating, swimming, hiking, and general day-use recreation at sites throughout the state. Additionally, the commission operates group camp facilities, provides youth employment programs, coordinates the statewide historic sites preservation program, participates in a scenic and recreational highways development program, operates and maintains the ocean beaches, and provides consultative services to local jurisdictions on park and recreational programs.

The commission consists of seven members named by the Governor and selects the director of the agency to implement and administer commission policies and programs.

Consistent with the purpose of the commission, the agency goals are to (1) cause the preservation and conservation of areas and facilities needed to provide the user with recreational opportunities, (2) operate and maintain the areas under the commission's jurisdiction in a manner which will protect the resources while providing user enjoyment and safety, (3) cause the preservation and/or interpretation of the state's heritage, (4) facilitate learning experiences for greater understanding and conservation of the state's heritage and resources, and (5) provide services to others to assist them in providing recreational opportunities.

It is anticipated that the park system will host in excess of fifty million during the 1971-73 biennium. In order to accommodate these state citizens and tourists, the commission operates and maintains about 190 recreational areas encompassing over 180,000 acres throughout the state. Facilities provided at individual park areas vary, but may include overnight camping, picnicking, swimming, hiking, boating, and interpretive, group camp and outdoor education facilities.

To organize its responsibilities the Parks and Recreation program consists of three primary activities, which are agency management, resources development, and operations. Agency management includes general executive formulation, direction and control of all programs and activities, administrative services, and the execution of executive assignments not specifically delegated to other activities. Administrative services includes executive management, budget and finance,personnel, purchasing and inventory, legal services, and records and files. Within this primary activity are also the consultation and education activities of the agency, special studies, and the public information function.

The resources development activity generally includes those efforts directed at land acquisition and development including planning, research, engineering, interpretive services, capital programming, and development of external financial resources.

The operations activity includes the statewide operation and maintenance of all park areas, historic sites, group camps, interpretive centers and other facilities. It includes the shop areas for repair and maintenance of all agency vehicles and equipment, and for the construction of picnic tables, stoves, guard blocks, and similar items

required in the parks. The operation activity also includes youth employment programs such as the Neighborhood Youth Corps activities in conjunction with cities and counties, and the Youth Development and Conservation Corps.

Local

Some counties and larger cities in Washington supply recreation areas, facilities, and programs. City and county governments also have parks and recreation, health, planning, sewer, and water departments--all of which are concerned, directly or indirectly, with water resources and marine recreation.

The Municipality of Metropolitan Seattle (Metro) is a federation of government representatives from Seattle, Kirkland, Redmond, Mercer Island, Renton, smaller towns, and King County.

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SECTION 7

MARINE EQUIPMENT AND SERVICES

Among factors contributing to Washington's growing preeminence as a national maritime center is the skill and flexibility of Washington manufacturers of marine equipment and suppliers of maritime services. Originally an outgrowth of local needs, marine industry in Washington has grown to supply a worldwide market. Local research, design, and manufacturing capability makes it possible to obtain a hull, designed in the northwest for northwest waters, and to outfit it completely with gear manufactured or immediately available in Washington.

The U.S. Navy has had far-reaching influence on the maritime activity of the region and has been a substantial impetus to develop of maritime industry, including research, development, and manufacture of marine equipment. Local manufacturers and service organizations supplying marine items support the Navy's activities at the Puget Sound Naval Shipyard, the Naval Torpedo Station at Keyport, the Carr Inlet acoustic range, and other Navy facilities in the Pacific Northwest. The supervisory agency for much of this support is the Supervisor of Shipbuilding in Seattle.

This same kind of influence and impetus is being increasingly felt fr activities of National Oceanic and Atmospheric Administration in Washingto Facilities and activities of the National Ocean Survey, National Marine Fisheries Service, National Weather Service, and the Pacific Oceanographic Laboratory are described in sections 3, 4, and 10.

This section is devoted to a brief discussion of various items of marine equipment that have been the products of Washington marine industry They are by no means the only items that have been developed locally, but they are indicative of the types of design and development talent to be found in this state--the kinds of talent that contribute to the region's growth and stability as a supplier of quality products and services for us on and around the sea.

Beginning with World War II sonar developments, researchers in the Pacific Northwest have developed acoustic "fishfinders" for use on fishing boats in locating schools of fish. Antisubmarine warfare has grown until today the products, many of which are produced locally, include large acoustic transducers, sonars, hydrophones, fire-control equipment, specialized communications equipment, and torpedoes.

Development and production of depth sounders, "fishfinders," and specialized equipment for the location of underwater objects and for profiling harbors and river bottoms continues to grow in the Pacific Northwest. Starting somewhat later, but parelleling the growth of shipping, fishing, and naval activity in the Puget Sound region has been the growth of marine, fisheries, and large-scale oceanographic research. Highly specialized marine equipment, including sensors, buoys, and communication equipment to collect, process, and transmit oceanographic and meteorological data, has been developed to meet the needs of oceanographers. Systems and devices for acoustic research in the ocean and for locating and recovering underwater equipment have been a related development. For example, the Naval Torpedo Station, Keyport, has developed a specialty of recovering sunken weapons, devices, and equipment to a degree that failure to recover is rare. The available recovery systems can find and retrieve objects buried beneath the mud at depths of perpetual darkness. In-house recovery systems include SOLARIS (Submerged Object Locating and Recovery/Inspection System); SORD (Submerged Object Recovery Device), and CURV (Cable-Controlled Underwater Recovery Vehicle)II.

Design, development, and testing of such specialized equipment are greatly accelerated by having the deep waters of Puget Sound immediately available as a miniature ocean without the innumerable logistics problems and adverse weather encountered at sea.

Industries that design and manufacture deck machinery for use on large and small vessels for handling cargo, laying cable, handling fish nets, and conducting oceanographic research are major contributors to the Puget Sound economy. Equipment includes, winches, cable haulers, booms, cranes, and special high-speed replenishment systems for the Navy, Coast Guard, and National Ocean Survey. In recent years there has also been a growing use of this equipment in the petroleum industry for offshore drilling.

One local company recently entered the desalinization field. Several companies and institutions are also doing research and producing products for use in oil spill cleanup operations. One firm's undersea search, salvage, and recovery capabilities are recognized world-wide. Other firms have equal reputation in marine acoustic and communications equipment.

Diversified distribution and servicing capability is available locally for all marine equipment regardless of where it is manufactured. This business is centered in Seattle and Tacoma, but to a lesser degree is found in all ports in the region. With the large number of pleasure and fishing boa operating in Puget Sound waters, equipment suitable for smaller boats is stocked and available off the shelf. Firms manufacturing and supplying fis tags and flags, masts and paint, ship-salvage equipment, and cargo pallets are located in Washington.

Because of the diversity of equipment and supply requirements of ships and boats and the growth demands of marine activity, it is unnecessary and perhaps impossible to distinguish between marine equipment and supplies and nonmarine equipment and supplies that find their way into marine use. The same may be said of research and development leading to new techniques and equipment. While much local research and development is intended for other purposes, there is always present an underlying thought: Can it be applied to the sea?

Eleven companies have been selected to indicate the diversification of manufacturing, research, and development present in the Puget Sound region. The competitive group of Northern Line Division of Tacoma Boatbuilding Co., Inc., Marine Construction and Design Co. (see Section 9), Markey Machinery Co., Inc., Skagit Corporation, and Star Iron and Steel actually dominates the market in the United States for their marine equipment products. In addition, the Applied Physics Laboratory at the University of Washington, the Navy's torpedo station at Keyport, and a host of smaller, but no less significant, companies in the area provide marine equipment and services.

BOEING ENVIRONMENTAL PRODUCTS, INC.

In June 1971, The Boeing Company, through a subsidiary of the Seattle-based aerospace firm, joined affiliates of Reading & Bates Offshore Drilling Company and El Paso Natural Gas Company in their joint venture in the water resource and water pollution control fields.

The joint venture firm, Resourses Conservation Co., formed in January, is exploring applications of a new evaporative process and other desalinatic technology.

The newly formed Boeing subsidiary engaged in the Resources Conservatic Co. joint venture is Boeing Environmental Products, Inc.

The joint venture will market a new evaporative process for desalinatic and brine concentration applications. The brine concentrator is being deve oped as a water pollution control device to eliminate mineral salts from industrial cooling water.

Other potential applications include industrial liquid waste treatment and the recovery of industrial by-products. The new evaporative process al may play a key role in total energy systems designed to produce electrical power, heat and air conditioning and process water with one integrated faci ity.

Boeing will contribute its manufacturing and engineering capabilites t joint venture projects. Boeing is building a portable research unit utiliz ing the new process. This unit will produce 2,400 gallons of fresh water a day from seawater and will serve as a demonstrator as well as a laboratory tool.

The joint venture's first production plant, for brine concentration, is being completed at El Paso Natural Gas' compressor facility in El Paso, Texas This unit is designed to treat 50,000 gallons of cooling tower blowdown brin each day.

Resources Conservation Co. expects to be marketing both desalination and brine concentration plants by mid-summer, according to William Tyson, general manager of the joint venture. First units will be in the 50,000 to 100,000 gallons-per-day capacity.

Headquarters for the venture continues to be in Tulsa, Oklahoma, home office city of Reading & Bates.

HONEYWELL, INC.--MARINE SYSTEMS CENTER

During the past 18 years, Honeywell has established at its Marine Systems Center in Seattle one of the country's most completely equipped commercial installations for advanced underwater acoustics research and for the design, development, testing, and production of sonar and ocean-engineering equipment and systems. These facilities, augmented by the capabilities of the scientific and engineering staff at Honeywell Seattle, enable the company to carry out advanced research and analysis as well as complete programs of systems design and production.

Honeywell Seattle is located on the Lake Washington Ship Canal, with ready access to fish-water sites, in the Canal and Lake Washington and to deeper salt-water sites in Puget Sound. The facility is also conveniently close to a number of U.S. Navy installations and test ranges.

The main buildings provide 100,000 square feet of floor space for engineering, production, testing, and administration. In addition, three fixed, dockside test laboratories moored a few feet from the plant provide space and equipment for in-water acoustic testing and verification of theoretical concepts. Three instrumented vessels are used full time for deep-water research and testing.

Special Facilities include the:

- Engineering Laboratory
- Scientific Computer Facility
- Transducer Laboratory
- Transducer Test Facilities
    1. Production Test Facility
    2. Motor Vessels
    3. Dockside Underwater Test Facilities
- Enviornmental Test Facilities
- Standards Laboratory
- Production Facilities
    1. Machine and Model Shop
    2. Electrical Assembly Shop
- Plastics Laboratory and Controlled Environment Room

Honeywell's research vessels have easy access to a variety of salt-water and fresh-water test sites. Not only are depths of 200 feet in fresh water and 900 feet in salt water quickly available, but also a wide range of marine environmental conditions are also within short distances.

The MV *Response*, MV *Neper*, and test barge *Impulse* are equipped as floating test laboratories to conduct deep-water testing of underwater acoustic components and subsystems.

The *Response* is a 65-foot powered catamaran-hulled vessel especially designed for testing large underwater devices. It is completely instrumented for making pulsed and continuous-wave impedance measurements, pulsed and continuous-wave response measurements, and continuously recorded, pulsed, polar directivity patterns. A VILP is also available aboard the *Response* for making continuous impedance loops.

The *Response* has a 75-kVA diesel-motor generator and a 10-kW Savage electronic power amplifier with output impedances from 1 to 1000 ohms. It has a 10,000-pound-capacity hydraulic winch mounted inside the enclosed portion, plus a smaller slewing crane outside. The catamaran hull of the *Response* allows the center deck area to be removed in sections to provide access to the water. A choice of several transducer-shaft mounting positions is available to optimize test distance and reflection suppression. In the main work area there is adequate storage for long test cables (1000 feet) and space for a small workshop. On an upper level is a complete and spacious galley, pilot house, and sleeping provisions for six people. Navigational aids include a Honeywell Sea Scanar sonar set, radar, RDF, and a ship-to-shore and VHF radio telephone. A long anchor cable allows anchoring in 1000 feet of water.

The *Neper* is a 47-foot, seagoing research vessel equipped with navigation equipment and living accommodations which make it suitable for use in sea tests in almost any waters for continuous periods of up to a week. It has an auxiliary power plant to supply test equipment and is well equipped with deck machinery for handling gear on deck or over the side.

The *Impulse* is designed to have the most efficient handling features available as well as being completely electronically instrumented for acoustic tests. It is a steel barge with a 26-foot-long by 42-inch-wide center well. Single-selection lowering shafts at three testing stations (one outboard) permit rigging transducers to 15-foot depths in rapid order, with separation distances to 30 feet. The azimuth angle and depth of each station is remotely controlled from the main operating console, providing excellent accuracy in aligning the sonar path while observing the acoustic signal. Thus, precise positioning and rapid handling are both achieved. The acoustic console is instrumented for transmitting and receiving response measurements, polar patterns, and low- and high-level impedance data, all in a pulsed mode.

Honeywell has developed a family of products for the ocean industries. These are summarized below.

Acoustic Position Indicators - The Acoustic Position Indicators, RS-5 and RS-505, provide precise vessel position information with respect to

an in-water beacon regardless of operating depths and environmental conditions. Sixteen systems have been sold for use in offshore operations around the world.

ASK - The Automatic Station Keeping system utilizes the vessel position information provided by the Acoustic Position Indicator or other sources to generate command controls to the positioning motors. The Honeywell system is a closed loop feedback system that employs a digital computer to automatically maintain desired vessel position and heading. One ASK system is in the service of the U.S. Navy. Others will be delivered this year for dynamic positioning of offshore oil drilling ships for SEDCO and SAIPEM.

Dynamic Simulation Analysis - These studies are performed on an analog computer, which tests the characteristics of any specific hull design against simulated sea states and various wind, wave and current combinations. The results provide precise evaluation of the vessel's reactions to these forces, the thrust required to maintain station, and the effect of variations in number and location of thrusters, as well as expected stresses on any anchor system. The results can be general or detailed depending on the hull parameters supplied by you, and can be tailored to your requirements.

Subsea Control and Telemetry - These systems provide a capability to monitor and/or control and command subsea functions. Honeywell recently delivered to a West Coast petroleum company a Blowout Preventer Acoustic Control and Telemetry System (ACT). This particular system will replace all of the electrical connections and all but one of the hydraulic connections between the vessel and the subsurface BOP. Honeywell has also defined a Blowout Preventer Control System, which utilizes both electrical and acoustic telemetry where all motors, pumps, accumulators and reservoirs are located on the BOP stack itself, and the only physical connection between the vessel and the stack is a single combination strain cable, incorporating the electrical conductors.

Scanar HD-1 High Definition Sonar - This system is a high resolution, short range, scanning sonar designed as an aid for Blowout Preventer and wellhead re-entry operations, search and salvage operations and structure positioning. The High Definition Sonar is designed for operations to water depths of 1,200 feet. Scanning ranges are 10, 20, 40, 100, 200 and 400 feet.

Satellite Navigator - The MSN-316 is a basic satellite navigation system that provides periodic position fixes with an accuracy on the order of 50 meters. Estimated position can be obtained on command between passes based on manually inserted vessel heading and speed information. Automatic operation can be achieved through the use of an electromagnetic log or doppler sonar and a gyrocompass.

Scanar IIF Sonar - The Honeywell Scanar IIF Sonar is an electronic echo-ranging and sounding device which scans ahead and to both sides of a vessel, at any angle between the surface of the sea and schools of fish.

Precision Profiler - The Precision Profiling Sonar set is used in dredging operations as a control device, monitoring side slope and depth of cut. In survey operations, it is used to determine general underwater topography. In pipeline work, it is used to obtain cross sections of underwater prepared ditches or trenches, and finally, to record the pipeline position in the trench. It is also useful in determining how a particular objects rests on the bottom.

HYDRO DRIVE CORPORATION

A broad line of steerable utility mariene drives and bow thrusters is being offered to the oceanographic industry by Hydro Drive Corporation of Seattle, Washington. The company's modern plant and engineering offices are located on the Lake Washington Ship Canal in the Ballard section of Seattle. Hydro Drive thrusters and utility drives can be adapted to meet a wide variety of dynamic positioning and main propulsion requirements using electric, hydraulic, or diesel power sources from 10 horsepower to 335 horsepower.

Customers have included Westinghouse Corporation, The Boeing Company, Jacobson Brothers, Inc. the Coast and Geodetic Survey (now, National Ocean Survey), the U.S. Navy, Canadian Defence Research Establishment, the University of Washington, and other organizations and institutions looking for reliable and versatile marine propulsion equipment and systems.

In addition to its line of utility marine drives, Hydro Drive Corporation has pioneered in the development of high performance marine drives for diesel and gas turbine power sources with fixed and controllable pitch propellers. These high performance strut drives are characterized by generally superior propulsive efficiency. Models range from the FP 1000, for 300 horsepower diesel engines, to the RCP 2600 for gas turbine engines up to 3,000 horsepower continuous.

Hydro Drive Corporation is in a position to engineer and produce both prime movers and auxiliary thrusters for the efficient propulsion of a wide variety of oceanographic research, survey, and retrieval vessels.

JACOBSON BROTHERS, INC.

Jacobson Brothers, Inc. has been active in oceanographic research, underwater inspection, salvage, and recovery not only locally but throughout the world.

Jacobson Brothers operates one vessel, *SONAR BELLE*, on the west coast of the U.S. Permanentaly installed aboard *SONAR BELLE* is a J-STAR (Jacobson Submerged Television and Recovery) System, an unmanned, surface controlled, underwater vehicle with a depth capability from 100 to 3000 feet.

SONAR BELLE is a 105-foot motor vessel which is fitted with all hydraulic powered winches, bow thruster, and a heavy lift capacity *SONAR BELLE* is currently operating under a contract with the U.S. Naval Torpedo Station, Keyport, in the search and recovery of torpedoes, a field of work in which Jacobson Brothers has worked with the Navy for 10 years.

J-STAR has the followed capabilities:

- Underwater search with side and bottom penetrating sonar, magnetic detection equipment, and CCTV and video tape recording
- Underwater inspection and recovery of submerged objects with 12-ton lift capability.
- Precise sub-sea visual control unaffected by tide or current
- Sub-sea work including heavy lifting, coring, and excavation
- Oil and gas pipeline connections and sub-sea anchoring
- Deep sea salvage and offshore drilling work-over support
- Continuous submerged operations with surfacing

A portable J-STAR unit, including camera work cage, lift winch, control winch system, and diesel powered electric and hydraulic power plants, is available for use on any surface vessel or working platform around the world. This unit has been used successfully on various types of subsea operations, including search and recovery of downed aircraft.

Locally, Jacobson Brothers has been employed for its special oceanographic capabilities by the University of Washington Department of Oceanography, the Applied Physics Laboratory, National Ocean Survey, and Washington State Toll Bridge Authority. J-STAR's record of operation, however, includes accomplishments in Cook's Inlet, the Gulf of Mexico, the Caribbean, Santa Barbara Channel, and the Hawaiian Islands, as well as in Puget Sound.

Recently, Jacobson Brothers has entered the submarine cable laying business in the Pacific Northwest. The company has acquired a new, company-owned 100' by 40' steele cable laying barge which is equipped with auxiliary winches, crane, power house, and support equipment. Jacobson Brothers is currently maintaining the submarine cable laying and repair for Pacific Northwest Bell, General Telephone Company of the Northwest, and also for RCA Alaska Communications in Southeast Alaska.

MARKEY MACHINERY COMPANY, INC.

At the same Seattle location since 1907. Markey pioneered research winch development and manufacture, working with the early institutions in sea science. Today this firm continues the custom manufacture of machinery for the mooring of the vessels themselves. Emphasizing rugged construction, hydraulic and sophisticated electrical drives, reliable instrumentation and low maintenance, Markey Machinery includes BT winches, hydrographic winches, anchoring and coring winches, trawl winches, and heavy duty metering sheaves.

Automatic tension mooring winches, a world-famous line of towing winches, special products such as ice handling equipment, and contract fabricating and machining work round out the efforts of this small and flexible firm.

NORTHERN LINE MACHINE & ENGINEERING CO.

Northern Line, a division of Tacoma Boatbuilding Co., Inc., has been a quality name in oceanographic and hydraulic winches, and allied products for several years. Northern Line machinery and equipment enjoys an outstanding record of achievement in Commercial, Navy and Research vessel applications in all parts of the world.

The following types of equipment have been produced by Northern Line to meet the needs of the Marine Industry:

- Anchor Windlasses
- Jib Cranes
- Cargo Cranes
- Level Luffing Cranes
- Shipboard or Barge Mounted Cranes
- Special Hoists and Machinery
- Special Conveyors
- Complete Material Handling Systems
- Fabricated Structural Steel and Plate
- Custom Machine Work
- Weldments
- Winches:
  - Oceanographic
  - Hydrographic
  - Seine (Multi Drum)
  - Towing
  - Corkline
  - Cargo
  - Bathythermograph
- Blocks:
  - Dandelion
  - Purse
  - Towline

Custom design and manufacture of marine equipment to suit the customers requirements is an ever challenging endeavor welcomed by Northern Line. Backed by our professional staff is an extensive 35 man engineering department, plus a full complement of skilled shop personnel. In addition, our new modern facilities provide the capability of meeting the ever changing needs of the marine industry.

OCEANIC INDUSTRIES, INC.

Oceanic Industries is convinced that the oceanographic industry is in need of an instrument platform that can be accurately controlled from the surface. Oceanic Industries has developed a remote controlled Drone that can carry instrumentation to a depth of 20,000 feet. The Drone has unlimited application as it is a free running vehicle. There are no lines or cables between the surface vessel and the Drone.

The primary project for the Sea Drone has been to photograph specific areas of ocean bottom. The system tells the operator exactly where the Drone is relative to the surface vessel, thereby making it possible to determine exactly what area has been photographed by the Drone.

Properly instrumented, the Drone will follow submarine pipe lines, power cables or telephone lines. The Drone can accomplish a survey quickly and negates the possibility of endangering human life in deep water work.

Oceanics has a fully equipped surface vessel that carries the Drone to the "job" thus reducing the cost of expensive support equipment which is normally required for underwater work.

ROCKET RESEARCH CORPORATION

Rocket Research Corporation and its subsidiary Explosives Corporation of America, have been actively engaged in underwater activities for the past 6 years. As an outgrowth of its development of nonopropellant hydrazine propulsion systems for space and military use, a product line of underwater buoyancy devices and ballast control systems have been developed. As far back as September 1965, the Company successfully completed a demonstration of a new underwater recovery system in which a 16 Ft. cabin cruiser was raised from a depth of 720 feet, setting a new undersea record for intact vessel recovery. Since that time recoveries have been made from depths to 4,000 feet in conjuction with deep submersible vehicles.

The Explo-Contractors Division of Explosives Corporation of America offers a complete line of services and specialized underwater demolition and blasting operations.

Rocket Research Corporation is located in Redmond, Washington, and occupies a 90,000 foot plant which is in the process of being expanded at the present time. The plant includes well equipped chemical and testing laboratories, clean room facilities, precision and high production machine shops. Approximately 400 persons are employed. Rocket Research Corporation plans to expand its underwater activities in the coming years as new opportunities become available.

ROSS LABORATORIES, INC.

Ross Laboratories, Inc. designes and manufactures a broad line of depth finders and depth recorders for the pleasure boat and commercial markets, and specialized underwater ultrasonic equipment for research and survey applications.

The new plant is located on Lake Union and includes its own waterfront facilities. The Laboratory maintains two research vessels; the *Sportsman* for all around research, and the *Tinkerbelle* for transducer and instrumentation calibration.

In the pleasure boat and commercial markets, Ross manufactures 22 standard models which are marketed throughout the United States, and to a lesser extent in foreign contries. These equipments vary from an inexpensive portable depth finder, which is used by weekend fishermen to extremely sensitive depth recorders which can detect single fish to hundreds of fathoms.

During the past few years, Ross has been developing its fully automated Digital Survey System. This system automatically samples varying water depths in both analogue and digital form, provides precise time correlations, interfaces with accurate positioning systems, and stores the information so that it is ready to use with computers to print charts. Navigational charts which used to take two years to produce can now be completed almost overnight. Ross Survey customers include the National Ocean Survey, Army Corps of Engineers, and the Canadian Hydrographic Office.

Also, Ross Laboratories has been active in designing and developing equipment for underwater research applications. This is mainly in the area of fishery research and includes systems for studying plankton and scattering layers, migratory habits of fish, fish patterns near dams, etc.

SKAGIT CORPORATION

The Skagit Corporation, a subsidiary of The Bendix Corporation, has a 60 year history of designing and manufacturing custom machinery. Recent acquisition as a wholly owned subsidiary of The Bendix Corporation has increased the technical and scientific resources of the company. Skagit is a major supplier of marine deck machinery, including cranes, winches, steering systems and various hull machinery items.

The company is located on a 39 acre site with complete engineering and manufacturing facilities suitable for the design, development and manufacture of heavy machinery. Total shop space under roof is about 269,000 square feet and includes a cast steel foundry, fabricated steel weld shop and machine shop including complete gear cutting equipment and assembly areas.

A full range of test facilities include metallurgical, non-destructive X-ray, testing to Navy MIL-901-C (heavy weight) and test towers for hoist machinery and traction drives.

Various types of equipment for Navy weapons handling have been designed and built, along with most of the Navy's larger cranes. Oceanographic items have included several styles of bathtermograph winches and specialized deep water retrieval winches.

STAR IRON & STEEL CO.

Star Iron & Steele Co., based on the waterfront in the Port of Tacoma Industrial Yard at Tacoma, Washington, is a major U.S. designer and manufacturer of large capacity custom engineered cranes, hoists and specialized handling equipment. Extensive marine related experience over more than 40 years includes dockside, shipyard, drydock, shipboard and barge mounted cranes and equipment. Customers include the U.S. Navy, Port Authorities, Terminal Operators and major corporations at locations throughout the United States and overseas.

Star Iron & Steel Co. is the world's second largest supplier of dockside container handling cranes.

The company has furnished large capacity drydock, shipyard, shipboard and floating cranes for the U.S. Navy since 1932.

Numerous specialized cranes have been developed and furnished for marine and oceanographic applications such as:

Boat and Aircraft Cranes
Boat and Missile Cranes
Submersible and Research Equipment Handling Cranes
Pipe Laying Cranes
Winch Drum Assemblies
Specialized Hoists

Star Iron & Steel Co. offers experience, complete engineering and manufacturing capability and facilities for Development and Prototype Contracts and Production Contracts at the Tacoma location. Employment averages more than 300. Covered plant area totals over 190,000 square feet.

WESTERN GEAR CORPORATION

The Heavy Machinery Division of Western Gear Corporation, in Everett, Washington, is the largest builder of marine deck machinery in the United States. The plant utilizes a twenty-one acre waterfront site in Everett and employs approximately 500 people in design and fabrication of all types of heavy machinery used in ships. Much of this equipment is specialized, but standardized lines of ships steering gears, anchor windlasses, capstans, mooring winches, cargo winches, oceanographic winches, and submarine cable laying equipment are also produced. The steering gears and anchor windlasses are produced for both commercial and Naval vessels and range in size from equipment required for ocean going tugs and small freighters to that required for the largest Naval aircraft carriers and commercial bulk carriers.

Winches for oceanographic service include electric, diesel and electro-hydraulic drum and traction units for any light or heavy application.

Supplementing this line are linear cable haulers rated from 1000 to 20,000 pounds of pull for use in cable layers. The division is also a supplier to the growing offshore oil industry, being outstanding in the design and manufacture of equipment for deep-water drilling and laying underwater pipe lines.

The company operates a floating shock test facility actively engaged in shock testing medium and heavy weight naval shipboard equipment. A fully instrumented 100-foot test tower and other supporting equipment makes this plant the outstanding research and proving facility of its type in the United States.

The Heavy Machinery Division also supplies materials handling lines and equipment to shipyards, such as the ship transfer system recently installed for the new Litton shipyard at Pascagoula, Mississippi.

Other Western Gear Corporation facilities in Belmont, Salinas, Lynwood, Pasadena, and Long Beach, California: Houston, Texas; and Pittsburgh, Pennsylvania are available to supplement activities in the Everett plant. Also, an engineering office at Arlington, Virginia provides close liaison with customers located on the East Coast. Corporate offices are in Lynwood, California.

SECTION 8

SHIPPING AND PORT ACTIVITIES

From its first stirrings at Port Townsend, Pacific Northwest shipping has had a history of ever-increasing transoceanic trade and military activity. The region's ports are both products of, and partial reasons for, that history.

Particularly since the end of World War II, expanding overseas commerce, increasing imports from the Far East, growing tourism, and booming trade among West Coast ports have put the Pacific Northwest at the forefront among North American shipping centers.

Puget Sound--a primary Pacific Northwest shipping area--lies within one of the world's most striking climatic regions. Cradled between the Olympic mountains on the west and the Cascades on the east and south, Puget Sound is a sheltered inland sea. Ships move freely around the clock in all seasons without hindrance from severe wind, snow, or ice. To the north, in the Inside Passage, a chain of islands provides comparable protection to certain types of ships bound for southeastern Alaska.

Ships from all over the world call at Washington ports. Exports from Washington to the Orient, already substantial, are increasing, as are imports. Liners from Washington ports ply to Hawaii, Australia, Japan, China, the Philippines, Great Britain, and Europe, with calling points on the west coasts of Mexico, Central America, and South America.

COMMERCIAL ACTIVITY

The magnitude of Puget Sound shipping is primarily the product of Puget Sound's location as a midway point between the U.S. East Coast and the Orient. For example, Seattle is 688 miles nearer to Japan than Los Angeles and 334 miles closer than San Francisco; at the same time, Seattle is 954 miles closer to Minneapolis-St. Paul than the

nearest California port. Import cargoes can be on their way from Seattle to midwest or eastern destinations within eight hours after arriving by ship.

Completing the link to and from the Orient through Puget Sound ports are the railroads, highways, and airlines terminating near port facilities. Six transcontinental railways speed goods to eastern points. Seattle-Tacoma International Airport, with 12 airlines in operation, is another vital link in overseas trade. Goods brought to Puget Sound ports by ship are sped on a scheduled basis to their destinations via:

- Alaska Airlines
- Braniff International Airways
- Continental Airlines
- Eastern Air Lines
- Flying Tiger Line (all cargo)
- Hughes Air West
- Northwest-Orient Airlines
- Pacific Western Airlines, Ltd.
- Pan American World Airways
- Scandinavian Airlines System
- United Air Lines
- Western Airlines

Cascade Airways and Air Washington operate from Boeing Field in south Seattle.

Transoceanic

Vessels arriving at, and departing from, Puget Sound call at ports all over the world. The major lines all have agents in Seattle. One of the most active is the Seattle-based American Mail Line, which operates nine vessels, including five Mariner-type vessels. One of these, the SS WASHINGTON MAIL, homebound from her maiden voyage to Yokohama, Japan, in 1962, broke two long-standing international speed records.

Puget Sound shipping activity reached a new peak in March 1966, with more vessels moving across the sound than in any single month since World War II. Two hundred arrivals of 1,000 or more net registered tons and 198 departures were noted during March. The 1,111,010 net registered tons of arrivals and 1,107,953 registered tons of departures also amounted to record tonnage. The largest number of ships coming and going on Puget Sound during the record month were American, Japanese, Norwegian, and British. The Orient was the leading market with 57 ships arriving from there and 47 ships listing the Orient as destination upon leaving Puget Sound.

Large tankers come to Seattle to top off their loading because the deep-draft harbor can handle the largest vessels afloat. Recently, the 637-foot JAG JAWAN, newest ship in the Indian merchant marine and India's biggest combination ore and grain carrier, came to the Hanford Street grain terminal at Pier 25 to take on 20,000 tons

of wheat. Earlier, she had loaded 15,000 tons at Portland. When the ship sailed from Seattle, she drew about 37 feet of water, well within the 50 feet off Pier 25. In May 1965, the MANHATTAN, largest of the U.S. merchant marine supertankers, topped off with 42,000 tons of wheat, drawing 49 feet of water. In early November 1966, the MANHATTAN took on 31,000 tons of wheat at Tacoma and 45,200 tons at Seattle. Other loads of grain taken on at Pier 25 for transoceanic shipment have ranged up to 74,000 tons.

Japan. Puget Sound is the major outlet on the West Coast for exports to Asia, the Pacific, and the Far East, notably Japan. For several years, Japan has headed a list of ten principal countries as the destination of exports from the Port of Seattle. Japan is second only to Canada as the origin of imports among the top ten countries.

The American Mail Line calls at principal port cities in Japan, Korea, the Philippines, Taiwan, Okinawa, and Hong Kong. In addition, the line provides regularly scheduled service to Southeast Asia and the Indian subcontinent. Cargo is moved across the Pacific in eight days, unloaded at Pier 28 in Seattle, and placed aboard eastbound planes at Seattle-Tacoma International Airport. In this way, importers anywhere in the United States can take delivery of merchandise within twelve to fifteen days from the date of loading in Japan.

South America. Among shipping lines serving Latin America from Puget Sound are the Grancolombiana, Moore-McCormack, Grace, Royal Mail, Fern-Ville, and others. The areas served include Mexico, Central America, the Caribbean, Panama Canal, and the east and west coasts of South America. Imports from Latin America and exports to such countries as Colombia, Brazil, and Peru are significant in Puget Sound shipping totals.

Europe. European countries served by Puget Sound shipping provide a formidable volume of business. Ships from the United Kingdom and the continent, including Mediterranean ports, are constantly seen in Puget Sound ports. Among the most active shipping lines are the French Line, Royal Mail, Furness, Hamburg-American, Johnson, Blue Star, Fred Olsen, Italian Line, and East Asiatic Line.

Coastal and inland waters

Alaska. Alaska, which now ranks fifth in percentage population growth among the fifty U.S. states, makes use of a substantial portion of Seattle water and air terminals. All Puget Sound ports share in direct water transportation and trade ties with Alaska that began before the turn of the century. Some 30 percent of the value of Seattle shipments are to Alaska.

The Foss Alaska Company's container barges load at Seattle's Pier 46, a facility built specifically for the Alaskan trade. Another line, Sea-Land Service, Inc., also serves Alaska, using modern container ships for year-round service direct to Anchorage. This same firm, which is the world's largest containership operator, has a military service for the government's transpacific cargoes, and is now offering

fast containership service from Japan to Seattle for the expanding OCP (Overland Common Point) market--a trade in which Seattle now ranks first on the Pacific Coast.

Barges and tugs. Barges and tugs are seen the year around. Operating along inland waterways, the open ocean, and the coast to points in Alaska, the barge services haul both petroleum and dry cargo and operate special-purpose barges. Among towboat and barge services are Alaska Barge and Transport, Inc., American Tug Boat Co., Dunlap Towing, Foss Launch and Tug Co., Island Tug and Barge, Ltd., Northland Marine Lines, Inc., Pacific Alaska Columbia, Pacific Inland Navigation Co., Pacific Western Lines, Puget Sound-Alaska Van Lines (PSAVL) Hydro-Train Service, Puget Sound Tug and Barge Co., United Transportation Co., and Washington Tug and Barge Co.

The Hydro-Train is a super-barge that transports loaded railroad cars directly from Seattle to Whittier, Alaska, carrying up to 48 rail cars on each voyage. Sailing twice a week, this service makes it possible for any community located on a rail siding anywhere in the continental U.S. to ship directly to or from Alaska. The Hydro-Train connects with three railroads--Burlington Northern, Union Pacific, and Milwaukee Road--which, in turn, connect with railroads from all other sections of the country. Shippers enjoy the economy of direct rail shipment without costly rehandling of cargo enroute, and with the convenience of virtual doorside railcar delivery.

Inland waters and cross-sound traffic. A variety of waterborne traffic supplements this coastal barge and regular ship activity on a year-around basis. These include numerous tugs with barge or log tows, freighters, tankers, sight-seeing boats, and commercial ferries. Shipping of this type operates among ports, small terminals with docks and wharves, and government installations on a scheduled and nonscheduled basis. It provides the only means of transportation to many communities. In other cases, they are the most economical method of moving particular commodities. The immensity of these inland sea and river areas is such that traffic is noticeably heavy only at terminal points and in narrow passages.

Ferries are operated by the state of Washington and by commercial companies. Passengers, cars, trucks, freight, and mail are carried throughout the year. In more populated areas, runs vary in frequency from half-hour intervals upward. These ferry services are essentially extensions of highway systems across Puget Sound.

The ferry fleet operated by the state of Washington, the most extensive in the area, is a good illustration of the role of waterborne transportation in a growing, densely populated area. Routes include stops at several of the San Juan Islands enroute to Victoria. Frequent day-night runs provide opportunity for city workers to enjoy country living or recreation via the Fauntleroy, Seattle, Edmonds, and Mukilteo ferries to Vashon Island, Bainbridge Island, Whidbey Island, and the Kitsap Peninsula. The Puget Sound Naval Shipyard and Bremerton are served by a run to the downtown Seattle terminal. In four cases, major bridges have replaced earlier ferry lines. Three are floating concrete bridges--one across Hood Canal, a saltwater arm of Puget Sound, and two across Lake Washington. The other routes include the rebuilt Tacoma Narrows bridge and the several high clearance structures

across the Columbia River. As the Pacific Northwest develops, these patterns will continue--first ferries to open up new areas, and then permanent bridges and tunnels to eventually replace the ferries.

Black Ball Freight Service operates a daily truck freight service serving Seattle, the Kitsap and Olympic peninsulas, and Victoria, B.C. Its affiliate, Black Ball Transport, Inc., operates a daily passenger and ferry service from Port Angeles on the Olympic Peninsula to Victoria, B.C. aboard the MV COHO.

PORT AUTHORITIES

Ports and harbors along the Northeastern Pacific are, for the most part, controlled and managed by port commissions or authorities. Other port organizations include the following, each of which is a member of the Washington Public Ports Association:

- Port of Anacortes
- Port of Bellingham
- Port of Bremerton
- Port of Edmonds
- Port of Everett
- Port of Grays Harbor
- Port of Ilwaco
- Port of Kalama
- Port of Longview
- Port of Olympia
- Port of Pasco
- Port of Port Angeles
- Port of Port Townsend
- Port of Seattle
- Port of Tacoma
- Port of Vancouver, Washington
- Port of Walla Walla
- Port of Willapa Harbor

The entire membership in the association is not listed. Eleven of the eighteen listed here are discussed in this inventory.

Anacortes

Anacortes is on the northern portion of Fidalgo Island, about 93 nautical miles eastward from the Pacific Ocean, 17 nautical miles south of Bellingham, and 66 nautical miles north of Seattle.

The waterfront facilities at the port are along the south side of Guemes Channel, on Capsante Waterway, and on Fidalgo Bay; Capsante Waterway is a federally improved channel in the northwestern part of Fidalgo Bay. Guemes Channel separates Guemes Island on the north and Fidalgo Island on the south. The channel is about 3 miles long and 0.5 mile wide at its narrowest point and extends eastward from Rosario Strait to Fidalgo Bay, a shallow arm of Padilla Bay. Fidalgo Bay, a part of Anacortes Harbor, is generally shallow with depths ranging from about 8 feet in the central part to 1 or 2 feet on the tideflats near shore.

The principal waterborne commodities handled at the port are petroleum products, crude oil, canned salmon, oyster seed, bulk barite, woodpulp, sand, gravel, crushed stone, and logs.

Anchorages. No specific areas in Anacortes Harbor have been designated as anchorage grounds. Vessels may anchor off the wharves along the south side of Guemes Channel in depths of 36 to 72 feet.

Piers, wharves, and docks. Twenty-eight piers, wharves, and docks are available at the port. Two of the waterfront facilities handle general cargo in foreign and domestic trade. Both are owned and operated by the port district and are located on the south side of Guemes Channel.

Oil handling and bunkering. Four oil-handling facilities are located at the port; two are in Fidalgo Bay and two on the south side of Guemes Channel. Shell Oil Co. and Texaco, Inc., each own and operate an offshore wharf in Fidalgo Bay. These facilities serve the company-owned oil refineries and storage tanks on March Point and provide bunkering service to vessels.

Warehouses. The Anacortes Port District owns and operates two transit sheds and six 1-story storage warehouses on, and at rear of, the Port of Anacortes Commercial Avenue wharf.

Hoisting facilities ashore and afloat. General cargo at Anacortes usually is handled to and from vessels by ships' tackle. Crawler and truck cranes may be obtained from crane rental services in Anacortes and Mt. Vernon. No floating cranes or derricks for making heavy lifts at shipside are based at the port.

Floating equipment. Tugs and towboats are operated by two towing companies based at the port; services of these companies extend beyond the limits of the port to other points on Puget Sound and its tributaries.

Marine repair plants, drydocks, and marine railways. No facilities are available for making major repairs, drydocking, or hauling out large deep-draft vessels.

Three marine repair plants are equipped to make above- and below-waterline repairs to fishing boats, tugs, barges, recreational craft, and other small vessels. Bryant's Marina, Inc., maintains one 25- and one 4-ton vertical boat hoist. Murphy's Marina, Inc., operates a 50-ton-capacity marine railway. The Pacific Tow Boat Company operates one 500-ton- and one 50-ton-capacity marine railway.

Rail lines. Anacortes is served by the Burlington Northern Railway.

Marinas. The Cap Sante Small Boat Haven provides protected moorage for approximately 600 commercial and pleasure vessels. This boat haven is located in Fidalgo Bay at the westerly end of the Cap Sante waterway.

Bellingham

Bellingham is located on the northeasterly shore of Bellingham Bay. The bay, approximately 12 miles long and 3 miles wide, is open to the south and southwest. Bellingham Harbor has a deepwater approach ranging from 96 feet in the outer part to 24 feet near shore, except in the northerly portion, where tideflats extend about 0.25 to 0.5 mile from shore, and where the bottom slopes gradually to deep water. These tideflats merge with the delta of the Nooksack river at the end of the bay. The port also operates the airport and small-boat harbors at Bellingham and Blaine.

The port of Bellingham is about 108 nautical miles from the Pacific Ocean, 80 nautical miles north of Seattle, and 63 nautical miles north of Everett, and 70 nautical miles south of Vancouver, B.C., Canada.

Waterfront facilities at the port are located on Bellingham Bay, Whatcom Creek Waterway, I & J Street Waterway, and Squalicum Creek Waterway. The principal waterborne commodities handled are logs, lumber, aluminum ingot, pulpwood, woodpulp, petroleum products, seafoods, cement, sand, alumina, gravel, and crushed stone. Controlling depth at mean lower low water is 30 feet for a width of 363 feet.

Small-boat basin adjacent to Squalicum Creek Waterway. The Rivers and Harbors Act of September 3, 1954, authorized construction and maintenance of two rubblemound breakwaters with a combined length of 3,900 feet, removal of the existing breakwater, and maintenance of a 12-foot depth in the entrance channel. Construction was completed in 1959. Dredging was completed by the Port of Bellingham in 1958. As of November 1963, the controlling depth in the north entrance channel was 12.2 feet for a width of 100 feet, and 15.3 feet in the south entrance channel for a width of 90 feet. All depths refer to the plane of mean lower low water.

Anchorages. Two federally designated anchorage areas (general and explosives) have been established in Bellingham Bay. The bottom consists of a thin accumulation of mud over hardpan and is not good holding ground in heavy weather.

Piers, wharves, and docks. Fifty-three waterfront facilities are available at the port of Bellingham. Eighteen are located on Bellingham Bay, 11 along the sides and inner end of Whatcom Creek Waterway, four on the southeast side and inner end of I & J Street Waterway, 11 in the Squalicum small-boat basin, seven on Squalicum Creek Waterway, and three on the Strait of Georgia between Sandy and Cherry points.

The Port of Bellingham owns and operates two general cargo terminals. North terminal wharf has 1,255 feet of berthing space along its face with a water depth of 34 feet alongside at mean lower low water and 300 feet of space at the rear of the wharf with a water depth of 25 feet alongside at mean lower low water. The wharf has a transit shed with 8,000 square feet of storage space and an adjacent

12-acre, paved, open storage area with an additional 52,000 square feet of warehouse space. Two diesel-electric full-portal gantry cranes travel along the southern side of the wharf; each crane has a 130-foot boom with lift capacity of 50 tons at a 55-foot radius. Combined, the cranes have a lift capacity of up to 80 tons. Surface tracks at the terminal connect with three trunkline railroads.

The Port of Bellingham also owns and operates South Terminal, the ex-Pacific American Fisheries facility in South Bellingham. While the facility is undergoing reconstruction and redevelopment, one 450' long berth with -30' MLLW depth is available. Sprinklered warehouse space exceeds 110,000 square feet, with connection to Burlington Northern Railway. Smaller berths, marina services, a public boat launch ramp and a small marine park are also available.

Oil handling and bunkering. Seven waterfront facilities are equipped to handle bulk petroleum products. Five serve eight oil companies, and one serves a paper manufacturing plant.

The Mobil Oil Co., Division of Socony Mobile Oil Co., Inc., provides bunkering service at the company's offshore wharf on the Strait of Georgia between Sandy and Cherry points. Fuel is supplied to deep-draft vessels at berth in the harbor by tank barges based at Seattle; these barges are operated by Foss Launch and Tug Co., the United Transportation Co., and the Washington Tug and Barge Co. Petroleum is stored in several tanks at the port.

Warehouses. Two companies operate public warehouses having a total of 129,000 square feet of dry storage space and 3,605,500 cubic feet of cold storage space.

Hoisting facilities ashore and afloat. General cargo at the port usually is handled to and from vessels by ships' tackle. For making heavy lifts, the Port of Bellingham maintains equipment at the terminal and crane wharves.

Floating equipment. The Bellingham Tug and Barge Company operates towing, docking, and undocking services.

Marine repair plants, drydocks, and marine railways. Facilities are not available at the port for making major repairs or drydocking large deep-draft vessels.

Six waterfront marine repair plants are located at the port. Five are equipped to make above- and below-waterline repairs to fishing boats, recreational craft, and other small vessels. One repair plant installs and repairs diesel and gasoline marine engines, fishing gear, and deck equipment. The Post Point Industries, Inc., operates a 200-ton marine railway that has handled vessels up to 100 feet in length. Wrang Shipyard Co. operates one marine railway with haulout capabilities of 20 tons. Weldcraft Steel and Marine Co., operates a 150-ton marine railway that has handled vessels up to 86 feet in length.

The Marine Sales and Equipment Co. owns and operates a 30-ton

electric vertical boat lift at its marine repair plant located on the northwest side of Whatcom Creek Waterway. This lift has a 44- by 12-foot platform, has handled vessels up to 40 feet in length, and has a water depth of 8 feet at mean high water over the platform when submerged.

Rail lines. Bellingham is served by two trunkline railroads--the Milwaukee Road and the Burlington Northern Railway.

Everett

Everett Harbor is located on the east side of Port Gardner Bay at the mouth of the Snohomish River. Port Gardner is the easterly arm of Possession Sound which lies between Whidbey Island on the west and the mainland on the east. Possession Sound connects with Puget Sound on the south and Saratoga Passage and Port Susan on the north. Everett is the first major port to be reached after entering the Puget Sound from the Straits of Juan de Fuca and proceeding south. The city of Everett is 28 miles north of Seattle and 105 nautical miles from the Pacific Ocean.

The harbor extends southward approximately four miles from Preston Point at the mouth of the Snohomish River. The northerly 2.5 miles being essentially located on the Snohomish River has a breakwater on the west side causing the waterfront in this area to be fresh to brackish water river flow. West of the training dike which channels the Snohomish River are approximately 2,200 acres of island and shallows which generally bare at low tide. The major flow of the river is southward to Port Gardner Bay by means of a training dike while the river flows due west at high tide. The Snohomish River flows north along the east side of the city of Everett and west along its northern limits to a natural outlet at Preston Point. Smith Island is a delta formation on the north side of the river at its mouth.

Waterfront facilities for deep draft vessels are in the southern portion of the harbor on Port Gardner and the east waterway. Facilities for small vessels, barges, and log rafts are available in the northern portion of the harbor opposite the training dike between Preston Point and the foot of 21st Street and along the left bank of the Snohomish River. The principal waterborne commodities handled at the Port are logs, wood pulp, plywood, paper, lumber, alumina ore, and various general cargoes.

Piers, wharves, and docks. The Port of Everett owns and operates Pier 1 and Pier 3 for handling general cargoes in foreign and domestic trade. Pier 1 has 140' of berthing space along the face, 520' along the south side and 640' along the north side. Pier 3 has 195' of berthing space along the face, 560' along the south side, and 450' along the north side. The warehouse on Pier 3 has 113,760 square feet of storage space. The water depth at Pier 1 south side is 35', on the north side is 40'. On Pier 3 the water depth on both sides is 35' all at MLLW.

A transit shed extending from the west end of Pier 1 to the east end provides 57,960 square feet of storage space. A warehouse on the inner end and adjacent to Pier 1 provides 36,000 square feet of storage space. A storage silo having a diameter of 245' adjacent to Pier 1 provides ground storage for 55,000 tons of bulk alumina ore. A multi-purpose crane which straddles the warehouse on Pier 1 leaves a full width of pier apron on the north and south side and provides a 150' boom with a lifting capacity of 35 tons, on its extreme end discharges bulk alumina ore from 37,000 ton ore carriers, depositing into a closed conveyor system traveling east/west on Pier 1 and transferring to a second conveyor belt, which carries the material to the top of the silo and deposits same. Bucket size is 20 cubic yard utility bucket.

This crane built by Star Iron and Steel Co., of Tacoma, is an all purpose crane which has a capacity to handle logs, modular homes, containers, heavy lifts, unitized and general cargo.

There is an open paved storage area of approximately 1-1/2 acres. There are double rail tracks along the north side of Pier 1 and single rail tracks on the north side of Pier 3. All terminal trackage is owned by the Port and is served by the Burlington Northern and Milwaukee Road. In the east waterway there exists private berths at Pier B and Pier E. Both are finger piers with 30' of water at MLLW. There are private berths at Scott Paper Company dock and at Weyerhaeuser Mill dock.

Oil handling and bunkering. There are four waterfront facilities equipped to receive petroleum products. They are owned and operated by industry to receive fuel oil by barge for plant consumption and one is used by the Mobil Oil Co. to receive products for distribution. There are no waterfront facilities for deep draft vessels for fueling; fuel can be supplied to vessels at the berth in the harbor from Snohomish County based tank barges bringing fuel from storage areas in South County in the Edmonds area. Barge towing companies located in the area are Pacific Tow Boat Co., American Tug Boat Co., Wick Towing Co., and Foss Towing.

Warehouses. Warehouse space available in addition to aforementioned buildings include 580,600 cubic feet of cooler and freezer space offered by American Ice and Cold Storage Co., plus 38,500 square feet in the 13th Street area (marina).

Marine repair plants, dry dock, and marine railway. There is a 400 ton marine railway facility located in the Everett boat marina area and operated by Fishermen's Boat Shop. There are no facilities at the Port for major repairs by dry docking large deep draft vessels. Waterfront marine repair plants are equipped to make above water line repairs on deep draft vessels, also facilities for above and below water line repairs may be accomplished to fishing boats, tugs, recreation craft and other small vessels. Northwest Boat Yard operates two 20 ton capacity marine railways. Riverside Boat Works operates one 20 ton capacity marine railway. There are several machine,

electrical and welding concerns located off the waterfront that make above water line repairs to vessels berthed at the Port. Each maintain shop and portable equipment. The Everett Boat House maintains a seven ton capacity elevator to lift boats for transferring recreational craft into and out of the water.

Hoisting facilities ashore and afloat. General cargo at Everett is usually handled to and from vessels by ships tackle. However, shore based hoisting facilities for servicing containers and heavy lifts are performed by the all purpose dock crane on Pier 1. Additionally, there are two 100 ton rubber tired cranes offered by Shaefer Crane and Rigging.

American Pile Driving Co., Inc., operates a diesel floating crane with a 105' steel boom having a lift capacity of 60 tons at 35' radius.

Floating equipment. Tugs and tow boats are operated by three towing companies based at the Port. These are American Tug Boat Co., Pacific Tow Boat Co., and Wick Towing.

Rail lines. Everett is served as the western terminus of the Burlington Northern as well as served by the Milwaukee Road.

Anchorage. There is specified anchorage area due west of the Port docks located in water 38 to 55 fathoms.

Small boat basin. Port of Everett operates a small boat basin north of the deep vessel harbor located between 13th and 18th Streets on the river channel, protected from the westerlies by the training dike and the 2,000 acre island. This boat basin has facilities to handle in excess of 1,000 boats and offers both covered and open moorage, fuel, ship stores, marine warehouse, restaurant facilities. Included are approximately 225 commercial fishing vessels permanently based in this moorage.

Grays Harbor

Grays Harbor is in the southwestern part of the state of Washington. The deepwater entrance to the harbor from the Pacific Ocean lies between Point Brown on the north and Point Chehalis on the south, each of which is the terminus of a narrow sandy peninsula. This entrance is 40 nautical miles north of the mouth of the Columbia River and 93 nautical miles south of the entrance to the Strait of Juan de Fuca. The harbor serves the communities of Hoquiam, Aberdeen, Cosmopolis, and Westport, and a number of small communities.

Grays Harbor is roughly pear-shaped, diverging from the Chehalis River at Aberdeen, Washington, into a broad, shallow bay, and spreading out into North Bay and South Bay to a total width of about 13 statute miles. Its length from the ocean entrance easterly to Aberdeen is about 15 statute miles. Other rivers flowing into the harbor are the Humptulips, Hoquiam, Wishkah, Johns and Elk rivers.

The port's waterfront facilities are at Hoquiam, Aberdeen,

Junction City, Cosmopolis, Markham, and Westhaven Cove on Point Chehalis. The principal waterborne commodities handled at the port are logs, lumber, wood pulp and chips, petroleum products, sand, gravel and crushed rock, and port facilities are used extensively by sport and commercial fishermen.

Anchorages. No specific areas in Grays Harbor have been designated as anchorage grounds. The best area is southward of Sand Island Shoal in depths of 35 to 40 feet; the holding ground is good.

The Port of Grays Harbor owns and operates Pier 1 for handling general cargo in foreign and domestic trade, receipt of petroleum products, and for supplying bunker oil to deep draft vessels.

The Port also owns and operates Terminal 4, a facility designed for log loading. An addition to this pier is expected to be completed in the spring of 1972. Weyerhaeuser, ITT Rayonier and Anderson-Middleton each own and operate docks for shipping of their products.

Oil handling and bunkering. Five operators at three waterfront facilities receive and ship petroleum products at the port of Grays Harbor. Deep draft vessels can obtain bunker fuel at two of the facilities.

Hoisting facilities ashore and afloat. General cargo usually is handled to and from vessels by ships' tackle. Hoisting equipment ashore is available to the public at the Port of Grays Harbor Pier 4. Two level-luffing diesel-electric cranes have a capacity of 50 tons each and a reach of 65 feet from the bull rail. A 40 ton capacity high speed log crane with a reach of 113 feet is planned for operation on the pier addition. Two crane barges are available to the public, each carrying two cranes of 45 ton capacity. Several mobile cranes, ranging in capacity up to 50 tons, are based at the harbor.

Warehouses. The A. A. Star Transfer Co., Inc., in Aberdeen, Washington, owns and operates two warehouses with a total of 24,000 square feet of space. The Port of Grays Harbor occasionally has space available for long-term storage in its 47,200 square foot transit shed on Pier 1 and in its 29,000 square foot Warehouse "A."

Floating equipment. The Allman-Hubble Tug Boat Company performs towing, docking, and undocking services for vessels at the port. This company owns and operates six tugs and towboats with ratings up to 1,050 horsepower. Quiggs Bros.-McDonald, Inc., operates three tugs with ratings up to 220 horsepower; the tugs are used primarily in the private business of the operator, but are available to the public by special arrangement.

Marine repair plants, drydocks, and marine railways. There are no facilities for making major repairs, drydocking, or hauling out large deep draft vessels at the port. The nearest such facilities are at Seattle.

Four marine repair plants are equipped to make above- and below-waterline repairs to fishing boats, tugs, barges, recreational craft, and other small vessels. Chilman Shipyard at Hoquiam maintains three marine railways with haulout capacities ranging up to 250 tons; Pakonen and Son in South Aberdeen operate one 100 and one 75 ton capacity marine railway. Westport Shipyard in Westport operates a travel lift with a capacity of 40 tons.

Rail lines--assembly, classification, and storage yards. The port of Grays Harbor is served by three trunkline railroads--the Milwaukee Road, the Burlington Northern, and the Union Pacific Railroad.

Commercial and sport fishing. Commercial and sport fishing are of considerable importance. The principal products are Dungeness crab and salmon. Salmon fishing from Westport Charter boats has become a nationally famous tourist attraction. Commercial fisheries have been boosted by the fish protein concentrate plant in Aberdeen, a federally sponsored experimental project, which in years to come may help to relieve malnutrition in many parts of the world.

Research and education. Grays Harbor Community College has a training program for technicians in fish and game management. Working under a Sea Grant, faculty and students are also engaged in research on the use of Eastern Bay clams as crab bait and on the life cycle of ghost shrimp, which may lead to better control of this species which is damaging to the oyster culture.

Olympia

Olympia harbor is at the head of Budd Inlet, the southernmost arm of Puget Sound. The inlet is approximately 6 miles in length and has an average width of 1 mile. Natural depths in the inlet decrease from 100 feet at the entrance to 30 feet at the entrance of the dredged channel extending to the turning basin opposite the Port of Olympia terminal. The port is 50 nautical miles southwest of Seattle and 168 nautical miles from the Pacific Ocean.

Most waterfront facilities at the port are on or near the peninsula in the central part of the harbor, and the remainder are along the lower 1.5 mile portion of the west side of the inlet on West Bay Drive. The principal waterborne commodities handled at the port are timber and timber products, petroleum products, and general commodities.

Anchorages. No specific areas in Olympia Harbor have been designated as anchorage grounds. Good anchorage in muddy bottom may be found anywhere in Budd Inlet north of Olympia Shoal. A restricted area for a reserve fleet of the U.S. Maritime Administration lies on the east side of the inlet north of Priest Point. (Effective until mid-1972 when the fleet operation discontinues.)

Piers, wharves, and docks. The Port of Olympia Commission owns

and operates the only ocean terminal, a 4-berth pier backed by 30 acres of open storage area and 100,000 square feet of transit/warehouse space and a refrigerated warehouse of 136,700 cubic foot capacity. Numerous shallow draft piers are operated in the harbor, principally in the West Bay, for the receipt by water of domestic petroleum products and sand and gravel. Other waterfront facilities are for berthing of tugs and barges, for log dumping and rafting. Several areas in the harbor are also set aside for log raft storage.

There are no waterfront facilities at Olympia for bunkering ocean-going vessels. Vessels are served at berth in the harbor by tank truck or by barges from Tacoma or Seattle by several towing companies.

Hoisting facilities ashore and afloat. General cargo at the port usually is handled to and from vessels by ships' tackle. However, hoisting facilities ashore are available for making heavy lifts at the Port of Olympia terminal. This equipment consists of two 50-ton electric full-portal gantry cranes. No floating heavy-lift equipment is based at the port.

Marine repair plants, drydocks, and marine railways. There are no facilities for making major repairs, drydocking, or hauling out large deep draft vessels at the port. The nearest such facilities are at Seattle. The Reliable Welding Works operates a marine repair plant on the west side of Budd Inlet. This plant maintains a wharf and shop for making repairs to barges, tugs, and other small vessels. In addition, the plant has portable equipment for making repairs aboard vessels at berth.

Floating equipment. The Foss Launch and Tug Company maintains tugs at the port for towing, docking, undocking, and shifting vessels. The Olympia Towing Company operates three diesel-operated towboats.

Transportation. Olympia is served by two trunkline railroads--the Burlington Northern and the Union Pacific, is served by numerous truck lines with easy access to north-south Freeway I-5, and Highway 410 to the ocean and the Olympic Peninsula.

Port Angeles

Port Angeles Harbor is on the south shore of the Strait of Juan de Fuca, about 62 nautical miles eastward from the Pacific Ocean, 69 nautical miles northwest of Seattle, and 19 nautical miles south of Victoria, B.C. This is the pickup and discharge point for marine pilots for ships coming in to Puget Sound ports from the Pacific.

Port Angeles Harbor lies within the city limits of Port Angeles. The harbor is open to the strait on the east and is protected on the north and northwest by Ediz Hook--a low narrow sandspit that curves about 3 miles eastward from the mainland. The harbor is about 3 miles long and about 1.5 miles wide at the entrance, decreasing in width to its head. Central depths range from 90 to 180 feet, decreasing to the 30-foot contour line abreast the port's waterfront facilities on the south shore.

The principal waterborne commodities handled are logs, lumber, pulpwood, woodpulp, and newsprint paper.

Anchorages. No specific areas in Port Angeles Harbor have been designated as anchorage grounds. The best anchorage is off the wharves in depths of 42 to 72 feet. There are no mooring buoys in the harbor.

Piers, wharves, and docks. Thirty-one waterfront facilities are available at the port. Two are located at the east end of the harbor; 14 along the south side of the harbor near the business section of the city; 5 at the west end of the harbor; and 10 along the inner side of Ediz Hook.

The Port of Port Angeles owns and operates Pier 1 for the receipt and shipment of general cargo in foreign and domestic trade, shipment of lumber and logs, and receipt of petroleum products. The pier has about 600 feet of berthing space along the southeast and northwest sides. Water depths alongside range from 30 to 40 feet at mean lower low water. Three surface tracks on the northwest side of the pier connect with the Milwaukee Road. The pier has a 5-ton electric traveling hammerhead crane straddling one of the three rail tracks. Two open storage areas are nearby. In addition, the Port operates Terminal #3, a T-shaped pier log handling facility.

Oil handling and bunkering. Five waterfront facilities are equipped to receive petroleum products at Port Angeles. Three are owned and operated by industries to receive fuel oil for plant consumption, and two are used by oil companies to receive products for distribution.

No waterfront facilities at Port Angeles are equipped for supplying fuel to ocean-going vessels. Oil can be supplied by tank barges based at Seattle. These barges are operated by the Foss Launch and Tug Co., the United Transportation Co., and the Washington Tug and Barge Co.

Warehouses. The Port of Port Angeles operates two warehouses with a total of 20,000 square feet.

Marine repair plants, drydocks, and marine railways. Facilities are not available at the port for making major repairs or drydocking large deep draft vessels.

Angeles Shipyard operates a marine repair plant in the southeast corner of the Port of Port Angeles boat haven. This yard makes above- and below-waterline repairs to fishing boats and other small vessels and has a machine shop, welding units, power tools, diving equipment, a marine railway and hoist handling boats up to 40 tons, and a timber grid on which boats are placed for making below-waterline repairs at low tide. On Ediz Hook, R. J. Johnson maintains a pier, a 25-ton marine railway, and two timber boat grids for use of small boat owners who make their own repairs.

The Angeles Machine and Welding Works operates a shop and portable equipment for repair of marine engines, gear, and machinery aboard

all types of small vessels anywhere in the port.

Hoisting facilities ashore and afloat. General cargo at the port is usually handled to and from vessels by ships' tackle. The Port of Port Angeles maintains, for public use, a 5-ton electric hammerhead crane on Pier 1. The crane travels on rails the full length of the northwest side of the pier, and is equipped with a boom having outboard reaches of 45 feet over the northwest side and about 75 feet over the face of the pier. Other cranes, derricks, and special handling equipment on the piers and wharves in the port are not for public use.

Floating equipment. Floating equipment based in Port Angeles harbor includes seven tugs and towboats with ratings up to 900 horsepower. The services of three towing companies operating this equipment extend beyond the limits of the port to other points on Puget Sound and its tributaries.

Rail lines. Port Angeles is served by the Milwaukee Road.

Port Townsend

Located on the northeastern tip of the Olympia Peninsula at the junction of the Strait of Juan de Fuca and Puget Sound, the Port of Port Townsend considers itself the hub of the inland waters of Western Washington since it is within 40 miles via water of all major Puget Sound ports except Tacoma and Olympia. The area encompassed by the Port District includes over 200 miles of shoreline and a wide spectrum of marine and oceanographic environments, including the Pacific Ocean and Hood Canal.

Piers, wharves, and docks. The Port of Port Townsend does not operate any public piers; however, Crown Zellerbach Corporation maintains a dock for the export of their woodpulp products and the import of wood chips and other raw materials.

Boat building and marine repairs. Skookum Marine Construction manufactures fiberglas fishing boats, 34' to 50', repairs boats, and sells engines and other boat equipment. Of the three firms in the area which repair boats, one has a marine railway.

Rail lines. Port Townsend and the upper Olympic Peninsula are served by the Milwaukee Railroad via rail barge with the terminus in Port Townsend.

Marine industry. Guilford Packing Company in Port Townsend processes hard shell clams and other seafoods. Coast Oyster and other smaller firms located in the Dabob-Quilcene Bay area as well as elsewhere along Hood Canal are engaged in the production and marketing of oysters. Many of these firms also produce oyster seed, as this area, especially Dabob Bay, is one of the few areas on the West Coast where oyster seed business can be carried out on a commercial basis. This area supplies some seed for other oyster producing areas such as Grays Harbor and Willapa Harbor.

Marinas. The Port of Port Townsend operates a boat haven in Port Townsend (capacity about 500 boats) and a small facility located at Quilcene. The Port also operates transient havens at Hadlock and Mystery Bay. Two havens are operated by the Port on a lease basis. One, located at Point Hudson in Port Townsend has boatel, restaurant, beach, recreational facilities, and such, while the other is located at Mats Mats Bay.

Many private marinas are located in the area, including Pope and Talbot's large development at Port Ludlow which features a restaurant, boatel, club house, etc. Others are located on Marrowstone Island and Pleasant Harbor.

Seattle

The Port of Seattle, Washington, is on Puget Sound, 124 nautical miles from the ocean entrance of the Strait of Juan de Fuca. The port has an outer harbor and an inner harbor. The port is managed by a commission of five elected officials, whose responsibilities extend to control of the Seattle-Tacoma International Airport and Shilshole Bay Marina.

Outer harbor. The tidal, saltwater portion of Seattle's port includes Elliott Bay, an indentation on the east side of Puget Sound; the East, West, and Duwamish waterways; Shilshole Bay; and the waters of Puget Sound adjacent to Ballard on the north of the entrance to Elliott Bay and West Seattle on the south. The main harbor is in Elliott Bay between Magnolia Bluff on the north and Duwamish Head on the south. The East and West waterways are dredged channels at the south side of Elliott Bay. Harbor Island, a man-made island, is located between two waterways. The Duwamish waterway extends southward from the south end of the West waterway for 5.12 miles to a turning basin at the upstream limit.

Inner harbor. The nontidal, fresh water portion of the port consists of Lake Union and Lake Washington, which are reached from Puget Sound through the Lake Washington ship canal. The Hiram M. Chittenden locks, operated by the Army Corps of Engineers, are located at the westerly end of the ship canal between Shilshole Bay and Salmon Bay. The distance from deep water in Puget Sound to deep water in Lake Washington is about 8 miles. Lake Union, in the geographical center of the city of Seattle, has a fresh water frontage of about 3 miles and an area of approximately 800 acres. Lake Washington, which forms the eastern boundary of Seattle, is approximately 23 miles long, from 2 to 4 miles wide, with depths up to 200 feet.

Piers, wharves, and docks. A 1963 report prepared by the Board of Engineers for Rivers and Harbors (Corps of Engineers, U.S. Army) and covering the Port of Seattle, lists 215 piers, wharves, and docks. Of these waterfront facilities, 106 were located in the outer harbor, 103 in the inner harbor, and 6 on Puget Sound.

Foreign trade zone No. 5. The Port of Seattle Foreign Trade Zone is located at Pier 20 on Harbor Island in the heart of Seattle's

bustling waterfront, where it is conveniently accessible to the industrial and central business districts. The zone is part of a five-berth terminal complex that accommodates ocean-going vessels for direct discharge or loading of cargo. Maximum security is provided by U.S. Customs during business hours and by an electronic burglar-detection system when the zone is closed.

Established in September 1949, the zone is one of eight in the United States. It is designed primarily to serve business firms using imported materials in manufacturing, export, re-export, import, and transshipment. During a normal year, merchandise is received from some 24 countries.

Oil handling and bunkering. Of the more than 20 oil-handling facilities at the Port of Seattle, most are in the inner harbor, with the balance in the outer harbor and on Puget Sound. About one-half the facilities provide oil-bunkering service. Deep draft vessels at berth in the port are supplied with bunker fuel by more than ten tank barges.

Grain elevators. Two waterfront grain elevators with a total capacity of more than 6 million bushels serve the port, each equipped to load vessels and rail cars. One elevator has two rail car dumpers, and the other has rail car pits with power shovels. The Pier 86 grain elevator is owned by the Port of Seattle and operated by Cargill, Inc. Fisher Flouring Mills Company owns and operates an elevator on Harbor Island along the east side of the West Waterway.

The Port of Seattle's Pier 86 facility is described as the world's finest, most completely automated grain terminal. Costing in excess of $13 million, Pier 86 is unique in that it has a ship-loading rate of 3,000 tons per hour and is located on extremely deep water (73 feet at berthside at low tide). The largest grain carriers afloat can load here quickly, and to full capacity, at dockside. Pier 86 is leased to Cargill, Inc., one of the world's largest grain dealers. It went into operation in December 1970.

Hoisting facilities ashore and afloat. In the fast developing container trade, Seattle has emerged as the load center of the Pacific Northwest for this modern cargo handling technique. Five special, high speed container cranes now operate on the Seattle piers, with four more under construction. Other cargo is handled by the West Coast's largest array of cranes, with capacities of from 30 tons to 200 tons.

Warehouses. Twenty-five companies and the Port of Seattle operate warehouses having a total of 1,271,590 square feet of dry storage space and 5,606,858 cubic feet of cooler and freezer space used largely for fish and other seafoods. All but one of the warehouses have rail-road connections, and all are easily accessible to arterial highways.

Marine repair plants. Of 33 marine repair plants in Seattle, nine are in the outer harbor, and 24 in the inner harbor. The repair plants, 25 of which have haulout or drydock facilities, construct, repair, and convert ocean-going vessels, fishing boats, tugs, recreational craft,

and other small vessels. A number of the plants have portable equipment for above-waterline repairs, and to install equipment, gear, and machinery on all types of craft.

Drydocks and marine railways. Fifteen floating drydocks, 16 marine railways, and ten vertical lifts are located at 25 of the waterfront marine repair plants. Lifting capacities of the drydocks range from 85 to 20,000 tons, haulout capacities of the railways are from 15 to 450 tons, and the vertical boat lifts range from 12 to 600 tons.

Shipbuilding, repair, and conversion represent a local industry of approximately $100 million in gross annual business.

Floating equipment. Floating equipment based at the Port of Seattle includes 23 tugs and towboats with ratings up to 5,000 horsepower. The services of the towing companies operating this equipment extend beyond the limits of the port to points in Puget Sound and along the Pacific coast. Three companies operate ten pump-equipped tank barges to deliver bunker fuel to vessels at berth; these barges have capacities ranging up to 13,500 barrels. Port-based tugs and towboats are used for towing, docking, and shifting vessels.

Rail lines. Seattle is served by three trunkline railroads--the Milwaukee Road, Burlington Northern, and Union Pacific Railroad--and by one local line, the Pacific Coast Railroad. This local line serves industries in the greater Seattle area and in Renton, Washington, and connects in Seattle with the trunkline railroads. The Canadian Pacific Railway reaches Seattle via its steamship line operating between Victoria, British Columbia, and Seattle.

Shilshole Bay Marina. Owned and operated by the Port of Seattle, Shilshole Bay Marina was constructed for the thousands of recreational boating fans in the Puget Sound area. It lies near the north end of the saltwater waterfront, behind a 4,440-foot-long breakwater. The marina helps meet the ever-growing demand for moorage facilities in Seattle, which has more pleasure craft per capita than any other major city in the world. Acclaimed as one of the finest and most functional boat centers in the U.S., Shilshole has berthing space for 1,200 boats, ranging in length from 12 to 120 feet, a new type concrete pier, electric outlets and fresh water outlets at every berth, haulout facility of 30-ton capacity, launching ramps, service pier, and a restaurant.

Port developments. During the past few years, the Port of Seattle has literally picked itself up bodily and moved down the street several blocks. Seattle's ocean commerce was once handled at deep-water finger piers along the downtown waterfront. Today, these historic piers from King Street north are almost totally given over to restaurants, fish companies, boat chandlers, and import shops. The old piers are outmoded and a new port, with new organization and new construction, has taken their place. The new port stretches from the Pier 46 container terminal at Jackson Street south along the waterfront to Spokane Street. It takes in both the East and West waterways along Harbor Island and

includes a complex of modern ocean terminals designed to handle large ships and container cargo.

In the past four years the Port of Seattle has launched an extensive pier development program on the Duwamish River, between Spokane Street and the First Avenue South bridge. Terminals 102 East, 102 West, 105, 106, and 115 are in operation or nearing completion. They include a modern container freight station, a log export facility, one of the Pacific Northwest's largest storage warehouses, acres of open storage for imported automobiles and a new multiple-use facility--Terminal 115--which will encompass more than 100 acres and will be Seattle's largest single terminal for ocean vessels.

Foresightedness on the part of the Port of Seattle management prompted the Port to invest extensively in facilities for the storage, loading and handling of containers, several years before competing ports began such programs. As a consequence, Seattle was ready with nine modern container berths when the new transportation mode hit the shipping world. A fourth container terminal is now under construction and will add two more berths to Seattle's total. Other areas are earmarked for container development in the future.

Tacoma

Tacoma Harbor is at the head of Commencement Bay, a southeasterly arm of Puget Sound 25 nautical miles south of Seattle, Washington, and 143 nautical miles from the Pacific Ocean. The port includes all of Commencement Bay.

Commencement Bay is bordered by hills on the southwest and northeast, and by extensive tidal flats on the Puyallup River delta on the southeast. The bay is about 4 miles wide at the entrance between Point Brown and Point Defiance, has an average width of 2 miles, and a length of approximately 2.5 miles from Point Brown to the head of the bay. Most of the land bordering the bay is within Tacoma city limits. The waters in Commencement Bay range in depth from 570 feet at the entrance to 100 feet at the head, where they shoal abruptly to tidal flats. Eight waterways have been dredged in the tidal flats and the spoil has been used to fill adjacent land. These waterways, named in order from southwest to northeast, are City, Middle, St. Paul, Puyallup, Milwaukee, Sitcum, Blair (formerly Port Industrial), and Hylebos. The City, Blair and Hylebos waterways are included in the existing federal navigation project. The Puyallup river, a glacial stream about 50 miles long, is the major tributary to Commencement Bay.

Waterfront facilities for deep draft vessels have been provided along the southwest side of Commencement Bay, on City Waterway north of the 11th Street Bridge, on Milwaukee, Sitcum, and Blair waterways, and along the southwest side of the Hylebos Waterway. Terminal facilities located elsewhere on the Tacoma waterfront are designed to meet the needs of tug, barge, and log raft traffic. Average depth in the harbor and channel is 30 feet at mean lower low water. The tidal range between mean lower low water and mean higher high water is 11.8 feet; the extreme tidal range is about 20 feet.

Anchorages. Vessels are authorized to anchor outside of the harbor line in any part of Commencement Bay not used by vessels arriving at or departing from any pier. The depths, as a rule, are too great for convenient anchorage, but vessels occasionally anchor under the northern shore about one mile east of Point Brown. Vessels may anchor in about 60-foot depths 450 yards north-northwestward of the outer end of Puyallup Waterway's west jetty. The city maintains one mooring buoy just eastward of the entrance to City Waterway.

Piers, wharves, and docks. Of the 89 piers, wharves, and docks at Tacoma, 10 are located along the southerly side of Commencement Bay between Point Defiance and the entrance to City Waterway; 70 are along the banks of other waterways; and the remaining 9 are on the bay at the outer ends of land areas between the waterways.

Nine of the waterfront facilities handle general cargo; one also handles lumber and has pipeline connections for the receipt of fuel oil. Fourteen wharves receive and ship petroleum products; one also is used for the receipt of ore concentrates and shipment of refined copper, one for receipt of wood chips, one for the shipment of industrial chemicals, and one for the receipt of bulk salt and shipment of caustic soda.

Sixteen deep water berths are operated by the Port of Tacoma: nine for the handling of general cargo, lumber and bulk, four berths specialize in log handling and one dock each is used in the handling of grain, bulk liquid (tallow) and alumina ore. The Pier 4 facility at the Port of Tacoma consists of a 1,242 foot long concrete pier, a multi-purpose crane rated at 50 tons at a reach of 115 feet from dockside, with over 30 acres of paved open storage backup area for handling container cargo.

Cold storage and refrigeration. The Port of Tacoma operates a cold storage facility with a capacity of 1,850,000 cubic feet, adjacent to keep water berths and rail having a quick freeze capability of 320 tons in 24 hours. A commercially owned cold storage plant with a capacity of 760,000 cubic feet is adjacent to the Port facility. Three dockside cool rooms with a capacity of over 30,000 cases of fruit are also operated by the Port of Tacoma.

Alumina ore facilities. Two storage domes, having a capacity of 150,000 tons, modern dockside to storage conveyor systems, served by a 50 ton multi-purpose crane are operated by the Port of Tacoma at its Pier 7 facility.

Bulk liquids. The 100,000 gallon bulk liquid facility operated by Fore Terminal, Inc., at the Port of Tacoma features heated tanks and piping and both rail and truck shipping and receiving stations with two dockside services.

Oil handling and bunkering. Fifteen waterfront facilities are equipped to receive and ship petroleum products at Tacoma. Six are owned and operated by companies using fuel oil products, and the remaining nine are used by ten oil companies. There are no waterfront facilities at Tacoma for bunkering ocean-going vessels. Vessels are

served at berth in the harbor by three tank barges operated by the Foss Launch and Tug Company. The barges are loaded with bunker fuel at the Standard Oil Company's dock.

Grain elevators. The United Grain Company operates a 4.5 million bushel grain elevator on Commencement Bay between the entrances to Sitcum and Blair waterways. The elevator, owned by the Port of Tacoma, consists of 62 circular concrete silos, and two reinforced concrete grain storage warehouses. Vessels can be loaded with grain through any two of the seven spouts at a combined rate of 33,000 bushels per hour. The wharf provides 712 feet of berthing space with a water depth alongside of 45 feet at mean lower low water.

Hoisting facilities ashore and afloat. The Port of Tacoma maintains ten 45 ton gantry cranes, two 7.5 ton hammerhead cranes and two 50 ton multi-purpose cranes. All are electric, traveling, full portal cranes.

The Foss Launch and Tug Co. owns and operates a floating derrick with a lifting capacity of 60 tons. Puget Sound Tug & Barge Co. has cranes available to place on barges by arrangement.

Warehouses. Six companies operate eight warehouses having a total of 102,000 square feet of dry storage area and 2,614,667 cubic feet of cooler and storage space. All warehouses have railroad connections and are accessible to arterial highways.

The Port of Tacoma has five covered dockside warehouses having a total of 457,000 square feet of storage space.

Marine repair plants, drydocks, and marine railways. Eleven waterfront marine plants at Tacoma construct, repair, and convert fishing vessels, barges, tugs, and recreational craft. Several plants produce marine drive shafts up to 30 feet in length, and have portable equipment for repairing and installing equipment, gear, and machinery on all types of craft anywhere in the port. In addition, several machine, electrical, and sheet metal shops, iron and steel foundries, and welding concerns not located on the waterfront are equipped to make repairs aboard vessels at berth.

Facilities for making major repairs and conversions and for drydocking and hauling out large, deep draft vessels are available at nearby Seattle.

Two floating drydocks and nine marine railways are at six of the eleven waterfront marine repair plants. Lifting capacities of the drydocks are 1,000 and 1,200 tons , with the larger drydock handling vessels up to 225 feet in length. The haulout capacities of the railways range from 15 to 1,000 tons; they will handle vessels up to 203 feet in length.

Floating equipment. Floating equipment based in Tacoma harbor includes 26 tugs and towboats with ratings up to 1,200 horsepower. The services of the four towing companies operating this equipment

extend beyond the limits of the port to other points on Puget Sound and its tributaries. The Foss Launch and Tug Company operates three tank barges equipped with pumps for supplying bunker fuel to vessels at berth and to points on Puget Sound and adjacent inland waters. The barges have capacities ranging up to 13,500 barrels.

Rail lines--assembly, classification, and storage yards. Tacoma is served by three trunkline railroads--the Milwaukee Road, Burlington-Northern, and Union Pacific Railroad--and by one belt line, the Tacoma Municipal Belt Line Railway. The belt line performs switching service for the railroads, and serves the waterfront facilities along Sitcum and Blair waterways and the west side of Hylebos Waterway.

Future port developments. The Port of Tacoma is now beginning the demolition of Pier 22 in the first phase of a project to replace the 2,800 foot long structure on the northeasterly side of the harbor end of Blair Waterway. A 1,200 foot long concrete pier is nearing completion on Blair Waterway. This facility will be for the handling of bulk materials. Other projects underway or planned for the immediate future include the following:

1. Construction of the first phase of the Pierce County Terminal Complex located at the end of Blair Waterway. Phase 1 consists of an 800 foot pier, one 100,000 s.f. warehouse, a 50,000 s.f. warehouse, with paved open storage area. This facility will ultimately consist of a 1,600 foot concrete pier serviced by two 50-ton cranes, two 45-ton cranes, a 100,000 s.f. dockside warehouse, four backup 100,000 s.f. warehouses, four 50,000 s.f. warehouses, on a 150 acre site with paved backup storage area and all necessary rail, roads, and utilities.

2. Extension of the Pier 4, General Cargo and container facility by the addition of 1,200 feet of concrete pier with a back up storage area.

3. Addition of two multi-purpose cranes having a rated capacity of 50 tons at an outreach of 115 feet from the pier face.

4. Extension of Pier 7 by an addition of 900 lineal feet of concrete pier, with paved backup storage area and all necessary rail, roads, and utilities.

5. Construction of complete sanitary sewerage and additional water distribution systems (in a joint project with the City of Tacoma) to service the Port Terminal area, Industrial Yard and 2,800 acres of Port Industrial Development District.

Vancouver

The Port of Vancouver (Washington) is a major deep water seaport serving a trade area of 6 million people in a region the size of New England. Vancouver is located on the Columbia River just above the confluence of the Columbia and Willamette Rivers. A natural water

grade route extends from the Pacific Ocean 100 miles to Vancouver and beyond that (by barge, rail, and truck) to inland points.

The Port of Vancouver accommodates the largest ocean-going vessels, with modern terminal facilities and cargo-moving equipment. The port also boasts a wide range of auxiliary services such as international banks, warehouses, custom house brokers, foreign freight forwarders, ship chandlers, foreign consuls, stevedore firms, pilotage services, and crating, marking, and sampling services.

One of the 12 leading ports on the Pacific Coast, the Port of Vancouver is a hub of Columbia River water traffic, rail and truck lines serving the Portland-Vancouver Metropolitan Area. Having gained Terminal status in 1963, the Port now serves 350 ships in a typical year, with a million tons of cargo over the docks. Terminal status assures guaranteed steamship service and is based on sufficient traffic and dock facilities. The designation is authorized by the Steamship Conferences and approved by the Federal Maritime Commission.

The Spokane, Portland, and Seattle Railway (now a subsidiary of Burlington-Northern, Inc.) maintains its principal shops and freight yards at Vancouver. Locomotives, freight and passenger cars are brought here for major servicing and repairs. In the SP&S marshalling yards about one thousand cars are handled daily. The cars are switched to and from some 60 industries in Vancouver, served by nearly 10 miles of track. All major railroads serving Vancouver cooperate for the benefit of local shippers with common user trackage and reciprocal switching agreements to absorb all switching charges regardless of origin or destination.

Vancouver is served by 61 steamship lines calling on Columbia River ports, eight airlines at Portland International Airport, 82 Oregon-Washington truck lines, plus 17 tug and barge lines in the Columbia River. Vancouver enjoys "preferential rate" for truck service into southern Washington, Oregon, Montana, southern Idaho and northern Utah.

Terminal II consists of three general-cargo berths, an oil berth, and two berths at the grain elevator dock. Three cranes are now in operation at Terminal II.

Leading commodities exported are lumber, paper, flour and grain. Plywood leads the items imported from foreign countries, followed by veneer, fertilizer, tapioca starch, hardwood lumber, alumina, bauxite and steel.

Direct waterfront payroll runs about $1.5 million per year, plus secondary benefits to the local economy of $20 million per year.

Willapa Harbor

Willapa Harbor is a tidal estuary located in Pacific County in southwestern Washington. The entrance to the harbor is 28 nautical miles north of the mouth of the Columbia River and 12 miles south of Grays Harbor.

Willapa Bay has a southerly arm roughly 19 miles long and an easterly arm 12 miles long. Both arms have numerous shoals and tideflats with channels formed by the discharge of tributary streams.

Environmental agencies indicate that Willapa Bay, as an estuarine area, is probably the least affected by man's activities of all the major bays on the West Coast of the United States. Except for developments along the Willapa River and a few minor ones elsewhere on the bay, Willapa Harbor remains practically the same as when discovered over 120 years ago.

The main ocean terminals are located in Raymond which is situated at the head of tidewater on the Willapa River roughly 20 miles from the Ocean. The Port of Willapa Harbor maintains a dock for handling deepwater cargo which consists mainly of forestry products. Twin Harbors Lumber Company has a dock for lumber shipping. About 400,000 tons are shipped from the harbor each year.

Willapa Bay has about 42,000 acres of tideland of which 28,268 acres are privately owned. Approximately 15,000 acres are used in oyster culture. Washington State oyster reserves amount to another 9,700 acres. Generally Willapa Bay produces about 50% of the oysters grown on the West Coast. The bay also produces Dungeness crabs and a small fishery on hard shell clams. A large gillnet fishery on the bay produces Chinook, Coho and Chum Salmon and sturgeon, flounder and other minor species.

The ocean waters adjacent to Willapa Harbor support a troll fishery for salmon as well as the large "drag boats" for bottom fish. Commercial crab fishermen also operate in these waters; their landings reached an all time high in 1969.

According to the latest Washington State Fisheries statistics the landings for 1969 were as follows:

	Pounds	Value to Fishermen
Crab	4,341,330	$1,003,543.00
Oysters	3,101,149	1,096,822.00
Salmon	773,249	298,158.00
Misc.	143,434	13,097.00
	8,359,162	$2,411,620.00

Seafood processing. Major seafood plants on Willapa Harbor are Nelson Crab, Inc. at Tokeland which employs about 100 people and operates nearly all year in processing crab. Bay Center has the Harbor Bell plant which is slightly smaller than Nelson's but handles a great deal of crab each year. Major oyster processing firms are Coast Oyster Company and East Point Seafood who have large canneries at South Bend and Nahcotta. There are also 8 other smaller operators on the bay which operate on a part time schedule.

Of particular interest to oceanographers is the erosion of Cape Shoalwater at the north side of the harbor entrance.

The major change in Willapa Bay during the past 100 years has been the northward migration of the entrance channel. Comparison of data taken from 1891 to 1970 shows that the entrance channel and the Cape Shoalwater shoreline have moved northward approximately 11,000 feet. Millions of tons of sand have been washed out to sea and a prime recreation area has been lost forever.

The sand is deposited offshore of the harbor entrance and the channel over this bar averages about 20 to 24 feet in depth.

Although the authorized project depth is -26 feet, all of the dredging by the Army Corps of Engineers is unable to maintain this depth due to the shifting sand. Ships are limited to 20 feet of draft and can cross the bar at or near high water.

The inability to cross in or out of Willapa Harbor with a fully loaded ship is probably the most important single reason why this area is not more developed.

Anchorages. No specific areas of Willapa Harbor have been designated as anchorage grounds. The best area is southward of Tokeland where the holding ground is good in depths of 25 to 30 feet.

Oil handling & bunkering. There are no permanent bunkering facilities for deep draft vessels on Willapa Harbor although fuel can be provided at the Port Dock by tank trucks. Several oil companies have small boat fueling floats.

Hoisting facilities. All cargo is handled with ships gear although the Port does have crawler cranes with lifting capacity up to 40 tons.

Floating equipment. Harbor Rock Company furnishes towboat service for the harbor. Their tugs range in horsepower up to 500 in the "Omar" which is used in ship handling.

Marine repairs. There are no facilities for major repairs to ships. There are two boat repair shops for boats up to 100 feet in length.

Rail lines. The Port of Willapa Harbor is served by two railroad lines: the Milwaukee Road and the Burlington Northern.

GOVERNMENT ACTIVITY

The federal government's role in the Pacific Northwest includes much shipping and port activities. Detailed discussions of the National Oceanic and Atmospheric Administration, U.S. Army, U.S. Coast Guard, and U.S. Navy appear in Section 10.

SECTION 9

SHIPBUILDING AND MARINE CONSTRUCTION

Harbor Island, on the south shore of Elliott Bay, lies in the industrial heart of Seattle and is one of several large Pacific Northwest centers for commercial construction, repair, and conversion of heavy vessels. At Bremerton, the Puget Sound Naval Shipyard is the U.S. Navy's center for similar work. Tacoma, Bellingham, and Vancouver are other Washington ship construction centers.

Of equal significance, if smaller scope, are the many shipyards, boat builders, and repair docks along the Washington coastline. These may be engaged in building or repairing an ocean-going yacht for competitive racing, your neighbor's pleasure craft, a government agency's research vessel, or a commercial fishing boat for Bering Sea operation. A multitude of these companies dots the state map, making all manner of marine craft and equipment. Any vessel, from the largest sea-going tanker to the smallest punt, can be built, outfitted, and kept modern in Washington shipyards.

Other firms specialize in the associated field of marine construction--dredging; construction of piers, wharves, breakwaters, bulkheads, and bridges; searching and surveying the sea floor; laying underwater cables and pipelines; and assembling oil drilling rigs. Despite a continually increasing volume of construction in fresh water, a high percentage of this work involves salt water, extreme tidal ranges, and storm conditions.

Washington activities relating to the sea have increased during the past decade both in product interest and in dollar volume. Research and development in ocean-oriented programs have shown definite growth, providing a vital nucleus of experience, facilities, and specialized personnel. Because of aerospace and governmental industries in the area, large numbers of additional skilled engineering, manufacturing, and research workers are available for marine and oceanographic programs that may develop in the future.

The coordinating forces over much shipbuilding and marine construction activity are such federal activities as the U.S. Navy, Coast Guard, and Army and the U.S. Maritime Commission. The roles of the Navy's Thirteenth Naval District are illustrative in their impact on the area, its shipbuilding, and support industries. The following descriptions emphasize activities in the Puget Sound region, because they represent the greatest volume and diversity.

SHIPBUILDING

Large-vessel construction

Among shipyards regularly engaged in construction, conversion, repair, and activation of large vessels are the Puget Sound Naval Shipyard, Lockheed Shipbuilding and Construction Company, and Todd Shipyards Corporation, Seattle Division. These three are representative of the large-vessel capabilities to be found in the Pacific Northwest.

Puget Sound Naval Shipyard. Located on the Kitsap Peninsula, directly across Puget Sound from Seattle, the Puget Sound Naval Shipyard is the "master builder" for the U.S. Navy in the Pacific Northwest. Stretching along 9,500 feet of Sinclair Inlet waterfront, the yard is a maze of drydocks, warships, cranes, and buildings. In addition to the approximately 200 military personnel assigned to the shipyard, there are more than 8,600 civilian employees receiving an annual payroll of $115 million.

In 80 years of service to the fleet, the yard has grown from an initial $9,500 investment to become a leader among the Navy's shipyards, with a replacement value of more than $500 million.

The yard's design division is one of the best among Navy shipyards. Its designs include the amphibious assault ship USS IWO JIMO (LHP-2), the Polaris submarine tender USS SIMON LAKE (AS-33), and the fast combat support ship USS SACRAMENTO (AOE-1). The SACRAMENTO is 793 feet long, weighs 53,500 tons, and is a combination fleet oiler, ammunition ship, and supply vessel.

Side by side with the new design and construction capability is the capability for overhaul and conversion of both surface ships and submarines, which constitute the bulk of the current workload. Yard work is done at six drydocks, one of which is the world's largest, 15 piers, and various shops, all connected by more than 35 miles of railway tracks. Any repair job can be handled by the yard's electrical, electronic, outside machine, inside machine, shipfitters, and pipe shops. Among other principal shops are the boiler, central tool, forge, foundry, galvanizing, paint, pattern, power plant, sheet metal, welding, and temporary service shops.

In 1949, the yard began a carrier-conversion program that became a milestone in ship rehabilitation. The program involved rebuilding World War II carriers to handle the Navy's new, heavier, and faster jets. Millions of dollars were saved by converting carriers at one-fourth the cost of new construction. A program for renovating all ships of the line to handle advanced weapons is continuing at the yard.

Today, Puget Sound Naval Shipyard is involved in maintenance and upkeep of the Navy's nuclear-missile fleet. Its highly diversified workload of overhaul and conversion abounds in modern weapon systems that characterize the rapid transition of the Navy from gunnery to missilery and from diesel to atomic power.

The Fleet Ballistic Missile program added broader dimensions to the shipyard's mission. In 1964, the Polaris Materiel Office, Pacific, was commissioned at the shipyard and assigned the task of logistic support for all Polaris submarines and support craft assigned to the Pacific Fleet.

Puget Sound Naval Shipyard is staffed and equipped for design, construction, conversion, and overhaul of all types of naval vessels, both surface and submarine. Work recently accomplished or presently under way that is of oceanographic interest includes:

- Testing, evaluation, and modification of the hydrofoil ships HIGH POINT and PLAINVIEW
- SUBSAFE overhaul of submarines
- Design, installation, and testing of sonar and other underwater electronic and communication systems
- Investigation of marine borer activity in local waters using submerged wood test panels, which are removed periodically and analyzed by a commercial laboratory

In addition to facilities normally associated with ship construction and repair, Puget Sound Naval Shipyard has the following capabilities of interest to oceanography:

- The shipyard maintains an engineering and design division employing about 700 persons in a number of sections, each of which specializes in some aspect of ship design (for example, hull structure, main propulsion, ventilation, hydraulic operation, electrical power, electronics, and interior communications)
- The shipyard maintains complete diving facilities for both shallow and deep diving that include a diving boat (YTL) and a decompression chamber.

Reserve Fleet, Bremerton Group, maintains Navy reserve fleet units--the mothball fleet. The group's mission is to deactivate, preserve, and (when needed) reactivate its vessels. The largest ship assigned is the battleship USS MISSOURI, which is open to the public as a floating tourist attraction. In recent months, several naval ships have been deactivated after use in Far East waters. This includes the battleship USS NEW JERSEY, as well as other ships of the line. Extensive practical knowledge in cathodic protection and other techniques for the preservation of ship underwater bodies has been developed. Studies of seawater salinity levels, tidal and seasonal changes in salinity, and conductivity of sea water are of particular interest to the reserve fleet group.

Other U.S. Navy support. The Supervisor of Shipbuilding, Conversion, and Repair, USN, 13th Naval District is located at the site of the Naval Support Activity, Sand Point. Resident offices are maintained at Lockheed Shipbuilding and Construction Company, Seattle, at Bellingham, Tacoma, and Portland, Oregon.

The mission of the Supervisor of Shipbuilding is to:

- Administer Department of the Navy and other Department of Defense shipbuilding, design, conversion, and facility contracts at assigned private shipyards;
- Procure and administer overhauls, repairs, alterations, activations, and inactivations performed on naval vessels at assigned private shipyards under the Naval Ship Systems master contracts for repair and alteration of vessels;
- Perform contract administration services for all Department of Defense contracts awarded to plants assigned in accordance with the plant cognizance program;
- Perform prescribed industrial mobilization planning functions;
- Ascertain that satisfactory production is maintained and scheduled completion dates are met;
- Require conformance to contract terms, plans, and specifications;
- Ensure that Government-owned facilities are efficiently utilized and maintained;
- Ensure that economy is practiced and that the Government's interests are protected in the administration of all contracts;
- Supervise installation of ordnance equipment on merchant ships at private yards;
- Under the Commander, Naval Ship Systems Command, prescribe tests to ensure the proper functioning of installations in which the Naval Ordnance Systems Command has primary interest;
- Ensure conformance to approved plans and specifications for weapons material;
- Perform all industrial degaussing services within the 13th Naval District, except at the Puget Sound Naval Shipyard, on Government or privately-owned vessels; and
- Administer at designated plants, machinery, equipment, and floating drydock leases and to perform such additional duty as may be directed by higher authority.

The Seattle offices of the Supervisor of Shipbuilding have done much toward advancing ship technology, as illustrated by construction, testing, and development locally of the Boeing hydrofoils PC(H)-1, Fresh-1, and PGH; and the Lockheed hydrofoil AG(EH)-1.

Lockheed Shipbuilding and Construction Company. The Lockheed Shipbuilding and Construction Company, a subsidiary of Lockheed Aircraft Corporation, operates two shipyards: a 23-acre facility on Harbor Island and a 50-acre facility across the West Duwamish Waterway in West Seattle, representing the largest privately owned shipyard facilities in the Northwest. The company is the second largest industrial employer in Seattle. Waterways provide access to both the Harbor Island and mainland plants. The company is involved in the building and conversion of large ships; ship repair; heavy steel fabrication and processing;

and marine engineering. In addition, Colby Crane, a wholly-owned subsidiary, designs, manufactures, and repairs heavy cranes and material handling equipment. Seattle is also headquarters for the company's heavy construction division that builds dams, bridges, highways, and tunnels throughout the western United States. The company has also entered the marine equipment field, initially marketing a patented plastic lashing socket cap to the Navy and commercial customers. The company also operates quarries in King County.

The shipyards, acquired by Lockheed in 1959, have built some 160 ships. Since 1959, Lockheed has delivered 28 ships to the U.S. Navy in addition to three Washington State Ferries, three State of Alaska Ferries, and a roll-on/roll-off ship for the U.S. Maritime Administration. Other vessel construction has included barges and offshore drilling rigs.

Lockheed in March 1969, delivered the AGEH-1 PLAINVIEW, the world's largest hydrofoil, to the U.S. Navy. It is now undergoing test and evaluation at the Puget Sound Naval Shipyard, Bremerton, Washington. The ship features all aluminum welded structure, dual gas turbine power plants, a foil control system, and a flight autopilot. It is 220 feet long and displaces 310 tons. Its speed is rated in excess of 45 knots. The PLAINVIEW serves as the prototype of future fast Navy and commercial hydrofoil vessels.

Since taking over the shipyard, Lockheed has spent in excess of $20 million to upgrade and build new facilities. It has three shipways to 700 by 100 feet and three floating drydocks to 18,000 tons. In addition, it has extensive and modern steel processing, handling, and automatic cutting facilities and related sheet metal, machine, electronic, pipe, and other shops.

Lockheed recently installed a third generation computer system that, along with advanced modular construction techniques, makes it the equal with any medium sized shipyard in the nation in its capabilities.

The parent corporation, Lockheed Aircraft, and its divisions have a substantial capability in ocean sciences and industry. Lockheed has built and launched the research submarine DEEP QUEST, capable of operating at 8,000 feet, and two Deep Submergence Rescue Vehicles for the U.S. Navy. It maintains several oceanographic laboratories in California, operates an oceanographic research vessel, markets a widely-used line of marine anti-corrosion devices, and has done pioneering work in the ocean sciences.

Lockheed Shipbuilding recently completed the last of seven amphibious assault transports and currently is building DE-1052 Class destroyer escorts for the Navy. The last ship in a five-ship DE contract will be delivered in mid-1972. Lockheed thus has started a strong drive for commercial shipbuilding contracts, while keeping an eye on possible future Navy business. In addition to bidding on commercial freighters, tankers, and ferries, Lockheed will market several ships of its own design, including advanced tankers and E-Ships. Ecology ships, developed out of a company-financed study to find new uses for

surplus Maritime Administration ship hulls, would house domestic and industrial waste water treatment plants. The concept has attracted wide interest and potential funding, although it faces the same difficulty in marketing as do most new developments and innovations in the fragmented ecological marketplace.

Lockheed's capabilities also transcend the field of shipbuilding. Its shops can provide many of the types of cranes, booms, and heavy equipment required by modern vessels. The company also installs and checks out special marine electronics.

Todd Shipyards Corporation, Seattle Division. Todd Shipyards Corporation maintains its home offices in New York City. The Seattle Division, the oldest major shipyard in the Pacific Northwest, is located on 40 acres of Harbor Island and specializes in heavy ship construction, modification, and repair. Shipbuilding capabilities in Seattle include steel surface and submersible ships, hydrofoils, and vessels up to 550 by 130 feet. The major facilities of the division are one building way and three floating drydocks.

During World War II, the division produced 46 destroyers for the U.S. Navy, the largest being 391 by 41 by 19 feet. The division is lead yard for construction of 26 DE-1052-class destroyer escorts for the Navy, seven of which will be built in Seattle. In early 1966, the division had 34 engineers on its professional staff, 863 skilled production workers, 78 semiskilled workers, and 47 other employees, which is a typical proportion for all yards.

Todd Seattle has five piers, affording over 1,000 linear feet each and two piers with 500 feet each for ship berthing. Seven whirley-type giant cranes serve the berths. The three floating drydocks have a lifting capacity ranging from 5,000 to 17,000 tons; the largest accommodates vessels up to 650 feet long. Two shipbuilding ways enable construction of vessels up to 535 feet. The construction and repair work force includes some 15 crafts.

The Seattle Division recently built a unique $14 million oceanographic research vessel, the USNS HAYES (T-AGOR-16), for the U.S. Navy. The HAYES is a catamaran vessel with great stability. Hatches open between two hulls into a center well which permits protected entry and egress from the sea for both divers and instrumentation.

The HAYES has an overall length of 246 feet 6 inches, is 75 feet wide with 24 feet beam (each hull), and displaces 3,080 tons. Its sustained speed is 15 knots, creep speed (with auxiliary propulsion) is 2-4 knots, and endurance speed is 13.5 knots for 6,000 miles. When its scientific gear is completely installed, it will be one of the most automated ships in the world. It will do general oceanographic and acoustic work for the Military Sealift Command. Its laboratory space is double that of any previous AGOR vessel. Over 7,000 square feet is available for research vehicles and deck gear such as two anchoring winches with 20,000 feet of cable on each. The HAYES has accommodations for 11 officers, 33 crew, and 30 scientists.

Todd's recent new construction projects also include 7 modern destroyer escorts for the U.S. Navy, 6 of which have already been delivered.

Todd Seattle will begin construction in July 1971 on the first of two 440-foot ferries for the Washington State Highway Commission under a $17,788,000 contract. Work begins on the second vessel in October.

The ferries are double-bottomed and powered by 8,500 horsepower diesel-electric engines capable of delivering a speed of 20 knots. Each ferry is equipped with a propeller and rudder at each end of the vessel. These vessels are 58 feet longer and carry 46 more cars than the four HYAK class ferries now in service. Each new ferry will carry up to 2,000 passengers and 206 autos. Nickum and Spaulding Associates of Seattle designed the vessels.

On January 26, 1971, Todd Seattle was named low bidder on a $32.5 million contract to convert five "Seamaster" freighters of the American President Lines into 664-foot vanships with capacities to carry 884 standard 20-foot cargo vans each. The jumboizing project calls for insertion of a 90-foot sleeve into each hull and conversion of all holds to full containerization.

Small-vessel construction

A number of specialized shipbuilders and developers are located around Puget Sound. Among them are Boeing's Naval Systems Division, Marine Construction and Design Company, and Lake Union Drydock Company, all of Seattle; Western Boat Building Company, J. B. Martinac Shipbuilding Corporation, Aerojet-General Corporation, Martinolich Shipbuilding, and Tacoma Boatbuilding Co., Inc., in Tacoma. The following are typical of such companies.

Aerojet-General Corporation. Aerojet's Surface Effect Ships Division, located in Tacoma, Washington, is a United States pioneer in air cushion supported high speed craft. Two significant firsts have accrued to Aerojet:

1. a contract to design, build and test a more than 90 mile per hour rigid sidewall surface effect ship for the Navy,

2. a contract to design, build and test a 50 knot air cushion vehicle amphibious assault craft for the Navy.

The rigid sidewall craft will undergo test in the Puget Sound during the fall and winter of 1971.

These two craft are forerunners of operational craft for both military and commercial purposes. Design and operational/economic studies have been completed for surface effect ships suitable for high speed passenger ferry operations in the Puget Sound. Also air cushion vehicles for operations in undeveloped areas have been thoroughly investigated.

The Boeing Company, Naval Systems Division. The Boeing Company began work in 1959 in research and development of advanced marine systems, with emphasis on hydrofoils. Boeing's initial hydrofoil work was conducted by its Advanced Marine Systems organization. Early in 1971 the company's Aerospace Group formed the Naval Systems Division to apply Boeing skills to Navy requirements by combining the majority of the company's Navy activities and Navy-oriented personnel in one organization. The division also is exploring the use of commercial hydrofoils as a form of rapid transit in ports throughout the world.

The basic relationship of aerodynamics to hydrodynamics is the key to the Boeing interest in hydrofoils. Aircraft and hydrofoils provide similar problems of fluid dynamics, stability, control, structures, electronics, hydraulics, and propulsion.

The first Boeing hydrofoil was the PCH-1, a 110-ton patrol craft, ordered in 1960 by the U.S. Navy. Delivered in 1963, the PCH-1 HIGH POINT was the world's most advanced hydrofoil. Navy and Boeing experience with this vessel advanced hydrofoil state-of-the-art considerably. The aluminum craft is powered by two gas turbine engines driving four propellers for foilborne operations.

A fully submerged system uses flat foils like airplane wings. The foils ride below the surface of the water, unaffected by waves and chop. This type of foil system, with its aileron-like control surfaces, uses an electronic control system or autopilot to actively cancel the effects of waves enabling operation in any weather. Because of its rough-water ability, this type of hydrofoil has major military potential. All of Boeing's hydrofoil development work has been with fully submerged foil systems.

In 1961 Boeing received a Navy contract for FRESH-1, a 15-ton craft designed to carry out foil research. The world's fastest hydrofoil, FRESH-1 is powered by a single turbofan engine. It was designed to test full-size foil systems at speeds up to 100 knots.

In 1961 Boeing built the first of its two research craft. Called a Hydrodynamic test system, the 38-foot hydroplane was used as a marine "wind tunnel" to obtain hydrodynamic force data on foil models at speeds of up to 80 knots.

In 1962 Boeing built its second research craft, LITTLE SQUIRT, a 2.7 ton hydrofoil powered by a water-jet propulsion system. The 50-mile-an-hour craft is a valuable research tool and has provided data on a wide variety of development projects.

In 1966 Boeing won a competition to design and construct a Navy hydrofoil gunboat. The prototype craft, designed for high speed operations in rough seas, may be the forerunner of a fleet of swift Navy craft. This hydrofoil, called the TUCUMCARI (PGH-2), is noteworthy for several reasons: the Navy's newest hydrofoil; an advanced foil system designed for high speed turns; a new concept in fighting vessels; the first major use of a new propulsion system. The 71-foot TUCUMCARI uses a water-jet propulsion system for both hullborne and foilborne speeds of more

than 50 knots. A diesel engine operates a separate centrifugal pump for hullborne propulsion. The water-jetpropulsion system was selected for the advanced craft because of its simplicity, reliability and low maintenance requirements.

The TUCUMCARI has undergone extensive, highly successful Boeing tests of its performance in all types of sea conditions. The craft was delivered to the Navy in 1968 for further tests and evaluation. The TUCUMCARI has operated on both coasts of the United States, and in Southeast Asia. Currently the TUCUMCARI is deployed to Europe where she is demonstrating her hydrofoil technology and systems to members of NATO.

The Navy has requested funds in the fiscal year 1972 defense budget for concept-definition for a proposed tactical-missile gunboat hydrofoil. Boeing envisions a craft of about 200 tons capable of high-speed, all-weather operation. The company intends to use its experience in building the TUCUMCARI in bidding for new Navy hydrofoil work. Boeing also is studying another potential Navy hydrofoil program which might call for a 100-knot craft of 1,000 to 2,000 tons.

Boeing is in the third year of a five-year research, development, test and evaluation contract from the U.S. Navy's Naval Ship Research and Development Center to provide technical support to the Navy's Hydrofoils Special Trials Unit. The Unit is based at the Puget Sound Naval Shipyard in Bremerton, Washington. This unique group has been the principal testing ground of new naval hydrofoil technology for a number of years. Under the contract Boeing, in a continuing research and development program, helps design and conduct the Navy's test program which in addition to hydrofoil development covers high-speed naval operations ranging from towed systems to combat tactics. The Unit operates the world's first advanced hydrofoil, the 110-ton PCH-1 HIGH POINT and the world's largest hydrofoil, the 320-ton AGEH-1 PLAINVIEW.

In November 1970, the Italian Navy ordered the prototype of an improved version of the TUCUMCARI. The contract was awarded to Advanced Marine Systems--Alinavi S.p.A., which was formed in 1964 by Boeing, a corporation of the Italian IRI group, and the Italian shipbuilder Carlo Rodriquez. The organization's purpose is developing in Europe advanced commercial and military marine vehicles.

The Naval Systems Division is actively studying hydrofoil commercial applications and has contacted a number of potential customers.

The State of Hawaii has shown considerable interest in Boeing Hydrofoils for airport to Waikiki Beach and interisland transportation. Boeing studies revealed that a hydrofoil fleet could profitably carry more than half of the 16,000 tourists who now travel the route to and from the Honolulu airport daily at a fare comparable to that of taxis or limousines.

Hawaii's interest in a water-based system stems from the fact that the narrow corridor of land between mountains and sea upon which Honolulu rests leaves little room for more highways to carry the increasing

traffic projected for the airport-Waikiki route.

The proposed Hawaii hydrofoil has been designed to carry 190 passengers and their baggage, and to cruise at a smooth 45 knots, even in rough water. The State of Hawaii has been investigating such a proposal since early 1970--the result of an independent study authored for the state by Kentron Hawaii, Ltd., a wholly owned subsidiary of LTV Aerospace Corp.

The Boeing commercial "Jetfoil" is qualified by the Urban Mass Transportation Administration under the Urban Mass Transportation Act for capital grant assistance to qualified transportation authorities.

Both the noise and pollutant emittance levels are well below applicable motor vehicle levels proposed for 1975. Contaminated fluids or waste is never discharged into the water. The Jetfoil leaves no wake to disturb the shorelands or small boats.

The Naval Systems Division is studying anti-submarine warfare (ASW) both tactical and strategic systems--in the air, surface and undersea areas.

The Boeing Company has had extensive experience in electronic systems and acoustics of aircraft, helicopters, ships, missiles and space boosters. This experience has been extended by studies on structural isolation and noise aspects of ship design, including hydrofoil craft, and of towed cables and underwater shapes. Sonar-system parametric studies have been conducted for naval escort ships and marine surveillance aircraft, helicopters and buoys. Studies on underwater sound continue for advanced applications.

The Boeing plants related to the activities of the Naval Systems Division are located at the hub of Puget Sound industry with ship, rail and air transportation facilities right to the factory doors. The abundance of navigable fresh and salt water suitable for research and test of all types of marine vehicles and subsystems makes this region ideal for such work. Facilities include Plant 2 and the Developmental Center, which are bordered by the Duwamish Waterway, and are adjacent to Boeing Field, and the Renton Plant bordering the south shore of Lake Washington and adjacent to the Renton Air Field. The Naval Systems Division's offices are located at Plant 2.

Lake Union Drydock Company. Located in a fresh water lake near the business district of Seattle, Lake Union Drydock Company engages in drydocking, repairing and converting vessels and other floating equipment. The U.S. Government Locks provide easy access by large vessels. There are seven drydocks ranging up to 3,600 tons. Voyage and topside repairs can be completed on vessels of any size.

The company takes pride in its well maintained facility and efficient operation. Recently major repairs have been made to drydocks, and new equipment has been installed in the machine shop. Maintenance work is balanced with productive work to maintain a stable nucleus of capable experienced men. Average employment is about 100 men, but has gone as high as 1,200 men.

In past years the plant was engaged in shipbuilding. They built the Lake Union "Dream Boats," the sternwheeler "W. T. Preston," several large well-known yachts, both 75 and 165 foot Coast Guard cutters, and 20 Navy minesweepers.

Lake Union Drydock Company has completed many major overhaul and conversion jobs, including work for the Navy, Coast Guard, National Ocean Survey, Military Sealift Command, National Marine Fisheries Service, private companies engaged in research, geophysic and exploration work, as well as barges, tugs, ferries, fishing and refrigerated processing vessels, commercial vessels of all types and University of Washington and University of Alaska research vessels.

Management is optimistic that the future development and sophistication of maritime industries and activities in the Northwest will bring a greater demand for quality workmanship and service.

Marine Construction and Design Company (MARCO). MARCO, Seattle, was founded in 1953 for the purpose of applying engineering principles to the fishing and small commercial boat industries. By 1960, MARCO was known throughout most of the modern fishing nations for its work in the mechanization of net hauling and handling of fish on board fishing vessels.

First in the line of revolutionary developments was the Puretic Power Block, for which MARCO holds patents in 33 countries. The Puretic Power Block was the first successful means for mechanically hauling large fishing nets. More than 10,000 vessels throughout the world are now using Puretic Power Blocks.

Other developments by MARCO include entire systems of mechanization, which have increased the efficiency of work aboard large fishing vessels by as much as 500 per cent.

Further, MARCO engages as a consultant, and participates in fisheries projects in developing countries, which include Chile, Peru, Columbia, Argentina, Ecuador, and Brazil. In Chile, the company's operations are expansive, including boat building, fish meal production, purse seine and trawl fleet operations.

MARCO has designed and built some 200 vessels of varying sizes and function since 1955. Included are wooden yachts from 31 to 61 feet in length, 16- to 104-foot steel fishing boats, 32-foot aluminum gillnetters, and steel tug boats ranging in length from 16 to 80 feet.

Other vessel types built by MARCO or MARCO licensees are anchovy seiners, distant-water and medium-range tuna seiners, coastal stern trawlers, combination seiner/trawlers, crab fishing vessels, work boats, seine skiffs, special craft, and drydocks.

One tug, completed in 1965, was the 80-foot SISIMAN, powered by 750-horsepower Twin Kort nozzle propulsion. This tug was designed and constructed at the Seattle plant for the Philippine government.

A recently completed vessel is the KOYUK, a 78-foot triple-screw aluminum beach lighter constructed for the Pacific Inland Navigation Company early in 1966. Two 66-foot tugs and a 39-foot personnel launch were under construction in mid-1966 for the Philippine government.

Another tug is under construction as of spring 1971.

The Seattle plant is equipped for construction of wood, steel, and aluminum vessels up to 100 feet in length. Drydocking facilities include a 75-ton lift dock and a 250-ton floating drydock. Conversions can be handled at dockside for ships up to 250 feet in length.

MARCO is also engaged in the ocean engineering field and is one of the largest suppliers of oceanographic winches and specialized equipment for fisheries research in the United States.

The following organizations operate 33 oceanographic and fisheries research vessels with MARCO equipment aboard: National Marine Fisheries Service (12), U.S. universities (7), private corporations (6), U.S. Navy (5), State of California, Department of Fish and Game (1), Food and Agriculture Organization of the United Nations (1), and Germany (1). The company has also designed and supplied several shipsets of oceanographic winches for research vessels as well as buoy-handling winches and bow-thrustor drives for Coast Guard buoy tenders.

Tacoma Boatbuilding Co. Tacoma Boatbuilding Co., Inc. prides itself on its versatility. Commercial and government construction programs completed over the past 40 years have resulted in the design and production of wooden fishing vessels and Minesweepers; steel tuna ships, including the Apollo (2,000 ton capacity--258 feet in length), largest tuna boat to date. It has also developed and constructed aluminum hulled high speed patrol ships with fiberglass deck houses, being propelled with jet aircraft engines modified for marine application, for the U.S. Navy.

With its new shipyard completed in 1970, it stands ready to serve many facets of the marine industry. A recent program in the construction of a Surface Effects Ship for the U.S. Government attests to the capabilities of its experienced engineering and production staff.

The Northern Line Machine & Engineering Division has established an enviable reputation for developing and building dependable commercial and military material handling and deck machinery systems (see Section 7).

The ship repair division active in the Puget Sound area provides 24 hour a day service to the marine industry.

Naval architecture

Supporting all of this activity on the professional level are

naval architects, marine engineers, and marine surveyors. These specialists are registered by examination under the state of Washington Professional Engineers Act, Section 18.43 and listed in an annual register.

Naval architecture firms in the Puget Sound area enjoy a world-wide reputation for the quality of their designs and for their innovations. Many designs for research vessels are based on proven trawler designs. The Pacific Northwest is considered as a center of fishing and oceanographic vessel design in the country.

Edwin Monk, yacht and fish boat designer, enjoys world-wide reputations for comfortable and practical designs with a definite "salty" look to them. Many of their designs could be modified to auxiliary research vessels and still retain the pleasant design features.

In addition to the firms and individuals in practice as naval architects dealing directly with users of naval architectural services, numerous other individuals, trained in naval architecture, perform their services for private companies as full-time employees.

Nickum and Spaulding Associates. The firms of W. C. Nickum & Sons and P. F. Spaulding and Associates, recently combined forces to originate the new corporation of Nickum & Spaulding Associates, consolidating some of the best naval architectural and marine engineering talent and experience into the largest naval architectural firm in the United States outside of the New York area. The list of successful design projects completed by this firm and its predecessors includes the design of more research vessels than any other firm of naval architects in the United States. In addition it and its predecessors are responsible for the design of many special purpose vessels such as cable laying ships, hydrofoils and vehicle and passenger ferries, including the largest and fastest double-ended vehicle and passenger ferries in the United States.

L. R. Glosten & Associates, Inc. The firm of L. R. Glosten & Associates, Inc., consulting naval architects, marine engineers, and ocean engineers, was organized in 1958. During the past thirteen years it has built a steadily growing reputation as a designer of numerous commercial and research vessels and ocean platforms. In addition to carrying out straightforward ship design projects, the firm has frequently been retained to make extensive feasibility studies and to plan entire marine transportation and ocean engineering systems.

While the technical staff now numbers ten people, of whom six are graduate naval architects and marine engineers, it has been a matter of policy with the firm to resist rapid growth, so as not to lose the close personal involvement with clients and their problems which is considered to be the essential basis of sound consulting.

In addition to having carried out design projects for many of the commercial marine operators on the West Coast and in Alaska, the organization has conducted a modest, self-supported research program

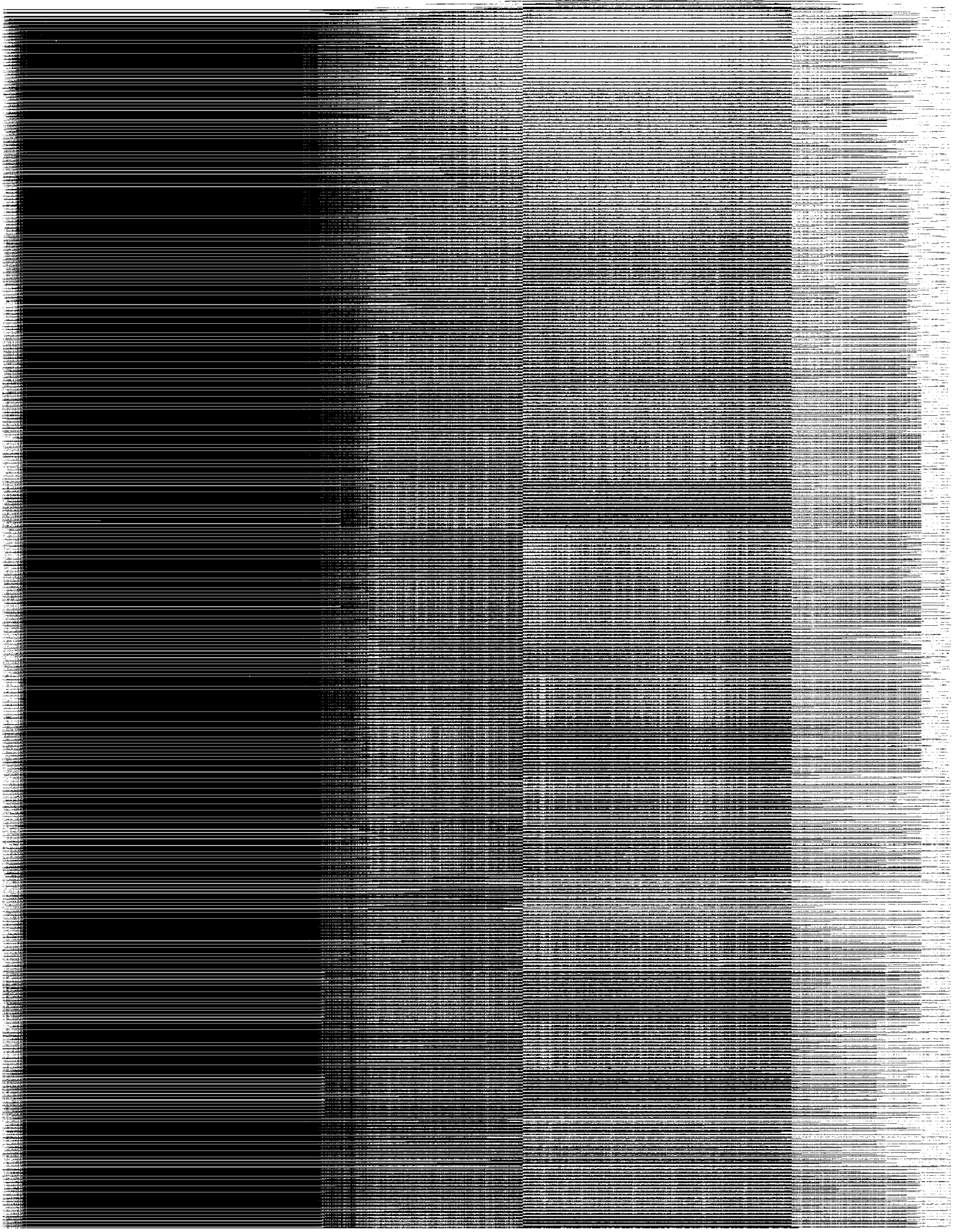

TABLE 10

NAVAL ARCHITECTURE AND MARINE ENGINEERING
Typical Products of Pacific Northwest Firms

Firm	Vessel	Length (feet)	Breadth (feet)	Depth (feet)	Displacement (tons)	Total Horsepower	Owner
Nickum & Spaulding Associates	E. L. BARTLETT	193	53	19	1480	3400	State of Alaska
	TUSTAMENA (Jumboizing)	296	60.5	21.5	3140	3200	State of Alaska
	Vehicle & Passenger Ferry	235	57	19	1900	4000	State of Alaska
	Vehicle & Passenger Ferry	408	79.5	25.5		20000	State of Alaska
	MALASPINA (Jumboizing)	408	74	26.5	5000	8000	State of Alaska
	YRST-4 NAUBUC	105.5	33.5	16.5	873	5400	U.S. Navy
	AGOR-16	246.5	75	34	2876	5400	U.S. Navy
	AGOR 9 & 10 (Repowering)	208	39	21.5	1297	1000	U.S. Navy
	Evergreen State Class Ferries	310	73	23.5	1500	2500	Wa. State Highway Commission
	Hyak Class Ferries	382	73.5	24.5	2500	8000	Wa. State Highway Commission
	440' Cross Sound Ferries	440	87	25	4336	8500	Wa. State Highway Commission

B. F. Jensen	PEGGY JO (Fishing Vessel)	99.5	28	12	228	765	Oscar Dyson and Seldon Nelson, Alaska
	SEA ERN (Fishing Vessel)	88	26	9	148	490	Axel Buholm, Seattle
	Fishing Vessel	88	26	9	148	490	George Johnson, Alaska
	Fishing Vessel	88	26	9	148	490	Clair Heiner, Alaska
	Planned	85	24	12		500	
L. R. Glosten & Assoc.	FLIP	355	35	20	560		Scripps Inst. of Oceanography
	Experimental Ocean Buoy	15	10	36	6		Univ. of Washington
	R/V ALPHA HELIX	133	31	14	512	820	Univ. of California
	Research Vessel (planned)	100	30	13	381	480	Nat. Mar. Fish. Svc.
	Oceanographic Research Barge	160	50.5	13.5	830		Scripps Inst. of Oceanography

MARINE CONSTRUCTION

Requiring skills similar to those of shipbuilding, and specialized experience and equipment beyond that used for land construction, are the marine construction firms. The Manson Construction and Engineering Company and elements of the Lockheed Shipbuilding and Construction Company, including Colby Crane and Manufacturing Company are among the larger local firms. Others specialize in underwater cables and pipelines, dredging, and piledriving (for example, General Construction Company and Puget Sound Dredging).

This broad classification of oceanic activity includes construction, by governmental and commercial agencies and companies, of port and harbor facilities--warehouses, bulkheads, locks, bridges, barges, piers, breakwaters--and fish hatcheries, dams, dikes, and laboratories, among others. Many of the larger general contracting firms engage in these types of tasks and maintain Pacific Northwest offices and operating units (among them, Morrison-Knudsen Co., Inc., and Peter Kiewit & Sons).

Specialized skills and construction equipment have been developed, requiring greater-than-average investment by the marine contractor. Delays due to traffic, tides, and weather must be anticipated as well as a minimum of reliable engineering data on subsurface conditions and localized water currents. A few of the major construction tasks in the Pacific Northwest have been the Lake Washington concrete floating bridges, the 6,470-foot Hood Canal floating bridge over salt water, the enormous underground pipelines for METRO with outfall lines into Puget Sound, and the creation of Harbor Island. Requiring similar skills in heavy construction and underwater emplacements are the bridges across Tacoma Narrows and the Columbia and other rivers.

Other developments--large and small--range over the entire Pacific Northwest. Enormous dams on inland rivers have been constructed. Cable ships for telephone and power companies lay and maintain cables in several hundred feet of water across inlets, straits, and rivers. These skills carry over to other activities as in the selection of marine construction companies by the Navy to install its extended underwater tracking range off St. Croix, Puerto Rico.

During the next 50 years, as the continental shelves, to depths of 200 meters or more, become more fully utilized, Washington firms will be well represented in marine operations. One firm that has located on Puget Sound to meet the need for underwater inspection and services best handled by divers is Ocean Systems, Inc. The resources and extensive research on better diving techniques of its parent companies will be applied to the problem of prolonged operation at depths of several hundred feet. On a smaller scale are a number of diving firms--scuba and hard hat--as well as rescue and salvage firms, some specializing in locating torpedoes with underwater TV at naval ranges.

To illustrate the type of work involved and its diversity, two examples have been chosen: the U.S. Army Corps of Engineers as the primary governmental design and supervision agency, and Manson Construction and Engineering Company as a typical marine construction contractor.

U.S. Army Corps of Engineers

This agency is responsible for river and harbor construction, flood control projects, operation of the Hiram Chittenden Locks on the Lake Washington ship canal, development of small boat harbors, and other activities relating to Pacific Northwest waterways. Federal law requires that permits must be secured from the Corps of Engineers for all work such as construction of facilities, dumping of earth, and the like, in navigable waters at any point beyond mean high tide (salt water) or ordinary high water (lakes and rivers). Examples are piers, jetties, dolphins, mooring buoys, and dredging. Corps of Engineers approval is required for the discharge of waste material into the navigable waters.

Small-boat harbor responsibility in the United States was specifically assigned to the Corps of Engineers by a 1962 amendment to the 1960 Rivers and Harbors Act. About $1 million each year is spent in constructing navigation projects and another $1.5 million to operate them. Since 1956, the federal government has put roughly $7.3 million into the building of boat harbors; this, combined with $4.7 million of nonfederal funds, represents an investment of $12 million. Boat harbor activity is limited to construction of harbors by dredging and installation of breakwaters, dikes, and jetties. Such work has been completed in at least nine locations on Puget Sound and three along the coast of Washington state. Facilities within these boat harbors were installed by local interests.

The Corps' compilation of port facilities (the PORT SERIES) shows by charts and tables the details of waterways, pier dimensions, and the like. The PORT SERIES provides an important reference for the major ports of Seattle, Tacoma, and Everett, and for smaller harbors, such as Grays Harbor. The reference also gives information on existing construction projects, progress of work, and cost of construction.

The Corps of Engineers has jurisdictional responsibility over all marine construction undertaken by both the federal agencies as well as private firms in the United States, especially when navigable waters are involved. The Corps works with construction firms, engineering consultants, and other government agencies. In addition, their work involves design, analysis, review, and supervision over river drainage and flood-control projects. They work with their Canadian counterparts in overlapping areas (for example, the upper Columbia and Yukon river drainage areas).

Within the states, related work on inland marine construction projects is carried out by various agencies. For example, the Washington State Department of Fisheries has an engineering and construction section that constructs and renovates department facilities. During 1965, their work included installation of hatchery water filters and spring supply lines, and repair and construction of fishway dams. Similar attention is given to fisheries aspects of large dam and waterway construction at federal and state levels.

Manson Construction and Engineering Co.

Manson is a Seattle-based marine construction and design firm operating in and around ports from San Francisco, California, to Nome, Alaska. With a work force ranging from 100 to 500 in the Puget Sound area, Manson is one of the largest, and oldest, marine construction firms on the Pacific Coast. The work force normally includes from 3 to 6 engineers, although as many as 25 engineers have been employed on such large jobs as construction of Superdrydock 6 at Bremerton. The remainder of the work force ranges from plumbers, to derrick operators, to day laborers, depending on the project type.

The superdrydock completed by Manson and three other prime contractors in 1962 at Bremerton's Puget Sound Naval Shipyard was perhaps the most spectacular of Manson projects. Total cost of the drydock project was $23 million and more than a million man-hours were required to complete the project. The job required removal of some 600,000 cubic yards of material to make room for sand and gravel as a base for the foundation, which consisted of 250 concrete blocks, each 24 feet wide, 40 feet long, and 7 feet thick. The entire project required 155,000 cubic yards of concrete, more than 10 million pounds of sheet piling ranging from 50 to 112 feet in length, and 718,000 cubic yards of fill material along the sides and in the 60-foot-diameter cells that formed the temporary coffer dam on the outboard end. The basin that forms the drydock is 500 feet wide by 1,500 feet long, truly a massive construction task. The structure is wide enough to give 155 feet of paved work area along both sides of the drydock's "dry" area.

Other Manson projects include:

For Port of Seattle--Concrete wharves at Pier 5, Terminal 18, Pier 21, Terminal 86

For Port of Tacoma--Concrete wharves at Pier 4, and Blair Waterway Terminal

For Port of Anacortes--Concrete marginal log handling wharf

Marine facilities--For Shell Oil Refinery, March Point, Washington; for Texaco Oil Refinery, March Point, Washington; and for Italco Aluminum Plant, Cherry Point, Washington

For Washington State Highway Department--bridge across the Columbia River, Yakima River, Snohomish River, Duwamish River, Chehalis River, Skagit River, Puyallup River, Ebey Slough as well as the Fox Island and Agate Pass bridges.

For Oregon State Highway Department--Willamette River Bridge at Newberg, Oregon and Morrison Street Bridge at Portland, Oregon

In joint ventures with General Construction Co. of Seattle, construction of:

Evergreen Point Floating Bridge approaches and Arboretum Interchange both in Seattle for Washington State Department of Highways.

Army Street Terminal, a $15 million marine facility for the Port of San Francisco.

In a joint venture with Cope Construction and General Construction Co., a $10 million project for the construction of the silos and marine facilities at Terminal 86, Seattle, Washington, for Cargill, Inc., was completed in January 1971.

Uncompleted projects in which Manson Construction & Engineering Co. is now involved are:

Blair Waterway Terminal for Port of Tacoma--$2.5 million
Terminal 25 for Port of Seattle--$40 million
Through Taku Constructors, a joint venture, construction of Snettisham Dam, powerhouse and tunnel, for U.S. Engineers--a $20 million project at Snettisham, Alaska
Through Manson-Osberg, a joint venture, projects near Juneau and Skagway in Alaska
Through Manson-General, a joint venture, projects in the San Francisco Bay area and Eureka, California

Manson's floating equipment includes six tug boats, eight floating derricks with capacities up to 200 tons, and a number of barges and scows. The company operates three truck cranes, three land cranes, and assorted general construction equipment.

In its many operations, the company works with the Corps of Engineers, various port commissions and authorities, and the Bureau of Public Roads. In addition, the company does approximately half of the construction and repair work on ferry landings for the Washington State Ferry System.

Manson equipment is also used for soundings and test borings by various laboratories involved in oceanography and related testing activities.

SECTION 10

RELATED GOVERNMENTAL ACTIVITIES

The contribution of the government's many agencies to the oceanographic and marine activities in Washington can hardly be overstated. This section briefly describes the functions, responsibilities, and programs of these agencies as they relate to water and apply locally.

FEDERAL

U.S. Army

The Army's role in ocean-related activities takes two distinct forms: (1) construction and maintenance of river and harbor improvements, and (2) operation of port and harbor facilities.

The Corps of Engineers is the Army's agency for construction of small-boat harbors, clearance of hazards from rivers and harbors, and operation of water-front facilities. Federal law requires that permits must be obtained from the Corps for construction of piers, jetties, dolphins, mooring buoys, and bridges in navigable waters at any point beyond high tide (salt water) or high water (lakes and rivers).

Harbor construction. The Corps' responsibilities for small-boat harbors are the result of a 1962 amendment of the 1960 Rivers and Harbors Act. The Corps has constructed at least nine harbors in the Puget Sound area and three along the Washington coast. The Corps constructs only the harbor itself by dredging and installing breakwaters, dikes, and jetties; facilities within the harbors are installed by local interests. Approximately $12 million has been spent by the Corps in such construction in the past several years. The marine construction activities of the Corps are also discussed in Section 9.

Pollution Control. The Corps operates a 163-foot snag boat, the W. T. PRESTON, carrying a crew of 14, to clear debris from harbors (outside the pier-head line) and to clear floating debris, snags, and deadheads from Puget Sound waters and tributaries. Air and water pollution are matters of concern to the Corps, but are left to local authorities for regulation. The Corps is a participant in a current study of air pollution, and has been concerned in the past with protests arising from the burning of debris and driftwood cleared from local waters. Burning of the debris was discontinued in 1965. Oil pollution of Puget Sound waters is a concern of the Coast Guard, which investigates reported violations and turns its evidence over to the Justic Department for disposition.

Research. The Corps of Engineers is the Army's respresentative in the Columbia Basin Interagency Committee, which has recently conducted two related studies: *Comprehensive Study of Puget Sound and Adjacent Waters and Comprehensive Water Resource Study*, which also concerns the Puget Sound area. The Corps maintains charts and tables setting forth the details of waterways, piers, and so forth, for ports in the area. The Corps is also involved in the Puget Sound Regional Planning Council's *Project Open Space*--a study of the marine shoreline aimed at preserving salt water and tideland resources.

The Corps has done considerable research into the currently unsolved problems of the erosion of North Cove at the entrance to Willapa Bay, the erosion of Ediz Hook at Port Angeles Harbor, and the supersaturation of river waters with nitrogen (caused by dams and responsible for a high percentage of fish kills of migrating salmon).

Marine recreation. Through its civil works program, the Corps makes an important contribution to the water-oriented recreation opportunities. By engaging in the activities described here, the Corps helps meet the recreation needs of the peope.

Facilities. The government's Chittenden Locks leading from Lake Washington and Lake Union through the ship canal to Puget Sound are operated by the Corps of Engineers. These locks, constructed in 1916, provide the Puget Sounder with a vital link between fresh water and salt water. Much of the watergoing activity of the Puget Sound area is based on the availability of such a link.

The Corps of Engineers constructed a protected harbor on Whidbey Island. Keystone Harbor, owned by the federal government, is leased to the Washington State Parks and Recreation Commission, which operates the facilities as a public park. Facilities are provided for picnicking and camping, and the Navy operates an observation post for an air-to-sea torpedo range.

Vessels. A 163-foot snag boat, the W. T. PRESTON is used to clear snags and deadheads from Puget Sound waters, its tributaries, and harbors. It carries a crew of 14.

The DAVIES is a 30-foot survey boat used for condition surveys at Corps projects throughout Puget Sound and for checking shoal and project design depths. It carries a crew of one.

A 65-footer, the Mamala is a survey boat used in making condition surveys of Corps projects at Grays Harbor and Willapa Harbor. It carries a crew of three.

On loan from the Navy is a 104-foot salvage vessel (YSD) with deck-mounted 25 ton crane. It is being converted by the Corps into a snag boat which will operate with a crew of five, assisting the PRESTON.

Fiscal data. The Corps of Engineers spends approximately $1 million annually for construction of navigation projects and about another $1.5 million to operate them. Since 1956, the Corps has spent roughly $7.3 million in building boat harbors. When $4.7 million of non-federal funds are added, the total investment runs to $12 million. Some $40.5 million have been invested in flood control in the past 10 years.

The table following indicates 12 of the breakwater projects undertaken by the Corps of Engineers in the past 19 years to form small boat harbors on Puget Sound.

U.S. Coast Guard

The Thirteenth Coast Guard District, with headquarters in Seattle, encompasses all of Washington, Idaho, Oregon, and Montana. Personnel in the district include some 2200 active-duty personnel and nearly 2500 reservists.

The Seattle headquarters controls all Coast Guard units operating within the district; provides logistics support for such units; and coordinates with regional, public, and private agencies concerning matters of interest to the Coast Guard.

The Coast Guard's assignment in the Puget Sound country is one of guarding the lives and property of users of Puget Sound's waterways. The job is a large one, involving law enforcement and aid to vessels in distress. The service has the authority to control the anchorage and movements of vessels in U.S. waters to protect the security of naval ships. It enforces the Oil Pollution Act of 1961, and is the federal government's agent in cleaning up oil spills. Other enforcement activities involve conservation laws which deal mainly with deep-sea fishing.

Major Puget Sound Activities. Coast Guard headquarters exercises its responsibilities primarily through four major facilities within the greater Puget Sound area. These activities are the Seattle Station, the Coast Guard Air Station at Port Angeles, the Coast Guard Base in Seattle, and the Marine Inspection Office in Seattle.

As is true of most Coast Guard activities in the Puget Sound area, the Seattle Station's job, broadly interpreted, is to protect the lives and property of Puget Sounders when they venture out of port. The station's responsibilities include law enforcement and security matters, and personnel are on the lookout for dangers to the public that result from accidents or, in an an extremity, sabotage. They maintain communication systems and reularly patrol local waters to spot trouble and assist

TABLE 11

Breakwater

Project	Type	Length (ft)	Size of Moorage Basin (acres)	Depth Below MLLW (ft)*	Estimated Cost ($) Federal	Non-federal	Total	Date Completed
Bellingham	Rock	3900	48	12	1,323,700	621,523	1,945,232	1959
Anacortes	Wood Pile	940	13	12	152,000	20,533	172,533	1957
Lake Crocket	Rock	800	6	18	260,240		260,240	1948
Port Angeles	Wood Pile	1170	13	15(12)	470,873		470,873	1959
Quillayute	Wood Pile	1100	8	10	521,850	10,000	541,850	1957
Westhaven Cove	Wood Pile	3020	54	16	442,400	280,000	772,400	1959
Tokeland	Bulkhead & Groin	500	4	15	109,200	58,900	168,100	1958
Nahcotta	Rock	1500	13	10	251,600	35,000	286,600	1959
Blaine	Rock	2350	20	12	346,650		346,650	1957
Shilshole	Rock	4440	62	15(10)	2,575,092	3,432,803	6,007,845	1961
Port Townsend	Rock	2500	17	12(10)	480,899	85,223	566,122	1964
Kingston	Rock	1040	10	13.5(8)	345,000	155,000	500,000	1966
					7,279,504	4,708,982	11,988,486	

*Where entrance channel depth differs from moorage basin, the depth of moorage basin is added in parentheses.

in rectifying it. Navigational aids come wihin their purvue, as does liaison with other agencies concerning navigational problems.

The Coast Guard Air Station, Port Angeles, operates and maintains Coast Guard helicopters and long-range fixed wing aircraft and supports air detachments and shipborne aircraft in the Puget Sound area. Small craft are used in search and rescue missions, and station personnel tend and maintain navigational aids in the vicinity of the station. Elements of the Coast Guard's fleet and facilities in the Seattle area are repaired, serviced, maintained, and operated by personnel at the Coast Guard Base in Seattle. Among the duties of the Marine Inspection Office, Seattle, are inspecting merchant vessels, licensing and certifying Merchant Marine officers and seamen, conducting casualty investigations and shipping commissioner activities, regulating the numbering of small boats, dealing with violations of navigation laws, and reviewing plans, when required, for vessels and marine equipment.

Light Stations. Coast Guard light stations are located strategically along all shipping lanes in the Puget Sound area. Personnel are constantly on duty to service, tend, and maintain the lights, radio beacons, and fog signals. Many of the stations are useful in oceanographic activities. Typical stations in Washington include:

- Point Robinson Light Station, Burton;
- Alki Point Light Station, Seattle;
- West Point Light Station, Fort Lawton, Seattle;
- New Dungeness Light Station, Sequim;
- Mukilteo Light Station, Mukilteo;
- Point No Point Light Station, Hansville;
- Point Wilson Light Station, Port Townsend

Floating units. The following units, under overall command of the Thirteenth Coast Guard District commander, have oceanographic capabilities in varying degrees:

- Cutter NORTHWIND (WAGB-282), Seattle
- Cutter STATEN ISLAND (WAGB-278), Seattle
- Cutter KLAMATH (WHEC-66), Seattle
- Cutter WINONA (WHEC-65), Port Angeles
- Cutter WACHUSETT (WHEC-44), Seattle
- Cutter FIR (WLM-212), Seattle
- Cutter POINT COUNTESS (WPB-82335), Port Angeles
- Cutter POINT GLASS (WPB-82336), Tacoma
- Cutter POINT BENNETT (WPB-82351), Port Townsend

Two "Wind" class Icebreakers operate out of the Northwest, the NORTHWIND and STATEN ISLAND. These powerful ships participate in research and resupply missions from the Northwest Passage to the Antarctic Ice Shelf.

The vessels have received numerous awards for their contributions to scientific research. Typical of the range of observations made by these ships are bottom samples, water samples, magnetic measurements, upperair soundings, communications experiments, hydroacoustic studies, and plankton

samples. The emphasis on ecology and the discovery of high latitude oil reserves has lead to still another series of adventures. Whether escorting icebreaking supertankers through the Northwest Passage or measuring the propagation of oil spills in the icy Arctic water, these ships contribute to the frontiers of knowledge on every mission.

These ships are equipped with the latest navigational equipment for accurate sampling and have large and well stocked oceanographic laboratories staffed by both military and civilian experts.

The use of aircraft from the flight decks of the Icebreakers has added another dimension to the capabilities of the ships. Airborne sampling and the discovery of the best ways to push ever farther into the ice are but two of the many uses of the helicopters on the scientific missions of these knife-hulled explorers.

The Northwest's three High Endurance Cutters are the WACHUSETT, the WINONA, and the KLAMATH. These ships can sail through any weather on their varied missions which often combine scientific research, search and rescue of mariners in distress, and navigational assistance to passing aircraft.

The usual assignment of these ships is to the various Ocean Stations of the North Pacific. These are continuously-manned points, usually as far as possible from land, at which the Coast Guard has been collecting samples and making observations as well as providing navigational beacon and tracking services for many years. The long range data on the changes in the atmosphere and ocean make up the major knowledge available today on the seasonal and yearly changes in the water and air of the open sea.

These ships conduct a daily Nansen-bottle sample of the water at the Ocean Station, and often stop to make samples every few hours on the long runs from Ocean Station to their home ports. In addition, many special projects have been carried out. Radioactivity sampling, sea life reports, testing of new oceanographic techniques and hardware, and gathering data on sunlight and surface temperature are just a few of the many oceanographic capabilities of these ships. Each one has a modern oceanography laboratory where samples are prepared and evaluated.

Occasionally, these ships are called upon to patrol the fisheries of the Pacific Coast and Gulf of Alaska, and wherever they sail, they continue to gather oceanographic data and weather information to add to our knowledge of the seas.

The Coast Guard has many specialized vessels to aid in its mission of maintaining aids to navigation. Typical of these buoy tenders is the Cutter FIR, a familiar sight to Puget Sound sailors, as she cleans and repairs the many buoys and markers in the Sound.

The FIR's boom can lift 40,000 pounds and she has two small boats to assist in the working of buoys. With the emphasis on the development of new buoy systems to collect and sample oceanographic data, the buoy-handling capability of Coast Guard ships can be a valuable resource. And like all Coast Guard ships, wherever the FIR sails continuous observations on the

weather and sea are made, all adding to our knowledge of the sea and the inland water of Puget Sound.

Coast Guard oceanographic efforts. The oceanographic activities in which the Coast Guard takes part are directed on a national level by the Federal Council for Science and Technology. Activities to be undertaken each year are developed by a permanent committee of the council, the Interagency Committee on Oceanography. The committee's job is to review current federal activities and planned programs of individual agencies in terms of the government's long-range plans, and to prepare a budget and recommend expenditures for each year's undertakings. The Coast Guard, representing the Treasury Department, is one of nine governmental departments and independent agencies making up the committee.

The Coast Guard's congressional mandate for oceanographic efforts is set forth in Title 14 of the United States Code, Chapter 5, which states, roughly, that the Coast Guard is to undertake such oceanographic work as may be in the national interest. The mandate calls for cooperation with other governmental agencies and other entities not necessarily of a governmental nature.

The Coast Guard's aim is to develop a scientific and technical force capable of directing and conducting oceanographic programs, to provide suitable facilities for oceanographi research, and to provide competent manpower to accomplish oceanographic goals. Coast Guard facilities, such as offshore light stations and ocean-station vessels, are ideal platforms for oceanographic research and much data can be obtained at minimal cost. Unmanned air-sea observation stations, polar oceanography, and airborne data collection are other ventures that the Coast Guard, because of its existing facilities, is able to undertake efficiently and with considerable competence.

It can be seen that the Coast Guard's intentions in oceanography are diversified and extensive. An idea of how well they have progressed in developing the capabilities desired can be gained from the following items.

- An oceanographic unit has been established in Washington, D.C., with a scientific and technical staff capable of developing and supporting oceanographic programs and conducting oceanographic research.
- Oceanographic capabilities have been provided aboard ocean-station vessels and WIND-class icebreakers.
- New offshore light structures have been developed in a standard oceanographic configuration, with laboratory and recorder rooms and provisions for installing wave and tide gages and a system for handling oceanographic sensors.

An additional indication of the Coast Guard's commitment may be gained from a review of activities already undertaken. The activities fall into four primary categories:

- Ocean stations;
- Special patrols, including polar operations, law enforcement patrols, and international ice patrol;

- Coastal studies;
- Cooperative facilities.

Other indications are the educational contributions that have been made by the Coast Guard, including postgraduate training for qualified officers at the University of Washington, Oregon State University, and the U.S. Navy Postgraduate School at Monterey, California. The postgraduate study normally leads to an M.S. or Ph.D. degree in oceanography. Petty officers whose shipboard duties require a technical knowledge of oceanographic methods and instrumentation are trained in a resident course at the Coast Guard Training Center in Groton, Connecticut.

Environmental Protection Agency

This agency, established on 2 December 1970, is an independent agency in the Executive Branch. The following federal agency components and/or functions combined to form EPA:

- Federal Water Quality Administration (FWQA), Department of the Interior
- National Air Pollution Control Administration (NAPCA), Bureau of Solid Waste Management, Bureau of Water Hygiene, and part of the Bureau of Radiological Health, all formerly in the Department of Health, Education and Welfare
- The pesticides research and standard-setting program of the Food and Drug Administration, Department of Health, Education and Welfare
- The pesticides registration authority of the Department of Agriculture
- The Environmental radiation protection standard-setting function of the Atomic Energy Commission
- The functions of the Federal Radiation Council

Prior to EPA, pollution control activities were conducted by many departments and agencies. Each was typically concerned with a single pollutant or source (radiation, pesticides), a single environmental medium (air, water, food), or a limited aspect of the total problem (health or economic effects aesthetics). The result was fragmentation of effort with omissions and overlap, some delay in recognition of new problems, and inefficient management of federal resources. EPA was created to carry out federal programs dealing with environmental pollution through an integrated approach that recognizes the critical relationships among the many forms of pollution and pollution control techniques.

As of 1 July, the Region 10 EPA headquarters will officially establish its office in Seattle. This office which will include certain laboratories transferred from other locations in the Pacific Northwest to Seattle, will eventually employ about 200 persons.

U.S. Department of Health, Education and Welfare

As the health agency of the Federal Government, the Public Health Service provides counsel and advice on matters relating to health and

sanitation for other federal agencies planning or constructing recreation facilities. The department is mandated to preserve and improve the physical environment in order to promote the health and welfare of man through programs designed to reduce levels of exposure of people to the hazards of improper housing and use of space, noise, rodent and insect vectors, occupational and community accidents, radiation, waste accumulation, and waterborne disease.

The Bureau of Water Hygiene establishes criteria and recommends standards of water quality for the protection of the nation's health; establishes certain standards for potable water used by carriers subject to Federal Quarantine Regulations; and develops and conducts comprehensive studies to determine the safe criteria and minimum standards for water quality. It establishes and maintains a national register of Public Water Supply Systems. It also develops and conducts a program of technical assistance to public and nonprofit institutions engaged in the operation of public water supply systems and use of water resources; interprets the effects of water pollution upon man's health, and enforces the Interstate Quarantine Regulations for water supplies for public carriers.

Under a specific memorandum of agreement with the National Park Service, Public Health Service personnel are assigned to actively assist in designing public water supply and sewage disposal facilities at public use areas. In addition, annual inspections are provided for water supply, waste disposal, food handling, solid waste disposal and other items of sanitary significance at public park installations.

U.S. Department of the Interior

Under the jurisdiction of the Assistant Secretary for Fish and Wildlife, Parks, and Marine Resources, the Office of Marine Resources is

Office of Marine Resources. Under the jurisdiction of the Assistant Secretary for Fish and Wildlife, Parks, and Marine Resources, the Office of Marine Resources is set up to advance and coordinate the department's marine resources policies, programs, plans, and legislation.

Office of Saline Water. This office conducts research and development of practical means for the economical production, from sea or other saline water, of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses.

Office of Water Resources Research. This office's program provides for promotion and support of extramural research programs and training in the study of water resources and of resources which affect water, and for operation of a water resources scientific information center for the dissemination of information about water resources developments and research accomplishments to the nation's water resources community.

Fish and Wildlife Service. The Bureau of Sport Fisheries and Wildlife is responsible for federal programs concerning sport fisheries, wild birds, and marine and other mammals. The Bureau manages 6 wildlife refuges in Washington. Local offices and laboratories are located at Sand Point in Seattle.

National Park Service. Discussed in Section 6.

Geological Survey. The broad objectives of the Geological Survey are to perform surveys, investigations, and research covering topography, geology, and the mineral and water resources of the United Staes; classify land as to mineral character and water and power resources; furnish engineering supervision for power permits and Federal Power Commission licenses.

The Geological Survey also determines the source, quantity quality distribution, movement, and availability of both surface and ground waters. This work includes:

- investigations of floods and droughts, their magnitude, frequency, and relation to climatic and physiographic factors
- the evaluation of available waters in river basins and ground water provinces, including water requirements for industrial, domestic, and agricultural purposes
- the determination of the chemical and physical quality of water resources and the relation of water quality and suspended sediment load to various parts of the hydrologic cycle
- special hydrologic studies of the interrelations between climate, topography, vegetation, soils, and the water supply
- research to improve the scientiric basis of investigations, and techniques; scientific assistance in hydrologic fields to other federal agencies

As prescribed by Bureau of the Budget Circular No. A-67, the Geological Survey coordinates federal water data acquisition activities. This includes designing and operating a national water data network, organizing the national network data, and maintaining a central catalog of information on water data and acquisition activities. The results of these investigations are published in the series of Geological Survey publication.

Bureau of Land Management. The bureau carries out a coordinated program for the conservation, development, and utilization of water in order to preserve and protect the soil and water resources. The program is a combination of land treatment and structural practices which support multiple-use management. It regulates surface water runoff to control accelerated erosion and to stabilize the resources.

Bureau of Outdoor Recreation. Discussed in Section 6.

Bureau of Reclamation. Discussed in Section 6.

Bonneville Power Administration (BPA). Through a regionwide interconnecting transmission system, BPA markets electric power and energy from federal hydroelectric projects in the Pacific Northwest. These generating p projects are constructed and operated by the Corps of Engineers or the Bureau of Reclamation. BPA, in cooperation with the Corps of Engineers, represents the United States in implementing the provisions of the Columbia River Treaty with Canada for the joint development of the Columbia River. Major BPA field offices in Washington are loacted in Seattle, Wenatchee, and Walla Walla.

National Oceanic and Atmospheric Administration (NOAA)

Of all the governmental agencies engaged in marine activities in Washington, NOAA is the one most directly concerned with oceanography.

The growth of oceanography in this state is closely tied to the programs of NOAA and its own growth and success. If the state is to diversify its economy by developing its marine resources, it will most likely do so by cooperating with and promoting NOAA and by coordinating its own programs with those of NOAA.

Sub-organizations of NOAA located in this state are the National Ocean Survey, National Marine Fisheries Service, National Weather Service, Pacific Oceanographic Laboratories and the Northwest Administration Service Office.

National Ocean Survey (NOS). The Pacific Marine Center is a Seattle facility of the National Ocean Survey that is engaged in a broad cross section of activities relating to oceanography. Included are operation of hydrographic and oceanographic research ships, surveys of ocean content and composition, hydrographic surveys, tidal surveys, current measurements, and deep-ocean oceanography.

The Center's oceanographic work includes geophysical surveys, surveys of the physical and chemical content of the sea, and using coring and other bottom-sampling techniques, determination of the composition of the sea bottom. This work is done in deep-ocean waters and on the continental shelf.

Hydrographic efforts include surveys to develop and update nautical charts of the West Coast, Alaska, and the Hawaiian Islands. Such charts are authoritative references for Pacific shipping, fishing, and recreational navigation. Hydrographic survey vessels are generally required to perform a variety of other survey operations which include astronomic observations, triangulation, topographic surveys, photogrammetry, magnetic surveys, tide and current measurements.

Tides are measured with a system of standard gages and recorded at sea level and mean lower water level as a base datum for charting programs. Selected tide stations operate as a part of the Pacific seismic sea-wave warning system. Tidal currents along the shores are measured and charted for the information of maritimte traffic, including fishermen and sport-boating enthusiasts.

The facilities at Pacific Marine Center include an administration building, boat shed, shops, electronic data processing, radio station, and a laboratory. Two piers with 2,394 feet of berthing space accomodate the Center's fleet of seven ships and the National Marine Fisheries Service vessels, GEORGE B. KELEZ and MILLER FREEMAN. Two small piers, each 100 feet long, provide space for the small boats.

TABLE 12

NOS Ships Home-ported in Seattle

Ship	Length (Ft.)	Function	Year Built
OCEANOGRAPHER	303	Oceanography	1966
SURVEYOR	292	Oceanography	1960
PATHFINDER	229	Hydrography	1942
FAIRWEATHER	231	Hydrography	1968
RAINIER	231	Hydrography	1968
DAVIDSON	175	Hydrography	1967
McARTHUR	175	Hydrography	1966

These are the only National Ocean Survey ships homeported on the west coast. They are instrumented with the most modern survey and research equipment, including fathometers, radar, Loran A, Loran C, Hi-Fix, Navigation Satellite, oceanographic winches, and such specialized oceanographic equipment as deep-sea probes, magnetometers, gravity meters, geological echo profilers, and various types of bathythermographic gear.

The ships are heavily automated for more efficient collection and processing of data. Each ship carries from two to four survey launches, in addition to other small craft, for use on inshore surveys and in shallow water. A brief description and resume of recent activities of each vessel follow.

The OCEANOGRAPHER (OSS-01) was built by Aerojet-General Shipyards, Jacksonville, Florida in 1966. Because she investigates a global oceanic system OCEANOGRAPHER has a global capability. She is of welded steel construction, with structural reinforcing for operations in floating ice. All enclosed quarters and work areas are air-conditioned for maximum efficiency during tropical investigations. Her maximum cruising range is 13,000 nautical miles at a sustained speed of 16 knots. OCEANOGRAPHER sailed from Jacksonville in March 1967 on a world cruise to Seattle, arriving at Pacific Marine Center, Seattle, in December.

The OCEANOGRAPHER's mission in 1970 involved a variety of projects and many ports of call. Among the ports visited were Papeete, Tahiti; Valparaiso, Chile; Buenaventura, Colombia; Guayaquil and La Liberdad, Ecuador; Canal Zone, Panama; Easter Island; Mazatlan, Mexico; Midway Island; and Honolulu, Hawaii. Projects undertaken included coring, heat-flow, and seismic reflection profiling investigations of the East Pacific Rise; water property and bathymetric investigations of the Panama-Basin; internal wave studies off Vancouver Island, British Colombia; and magnetic-bathymetric studies in the West Pacific. Special projects included biological studies by scientists of the University of Guayaquil, sea-water particle analysis, a land gravity survey of Easter Island, and meterological observations. In addition, OCEANOGRAPHER's satellite navigation system enabled her to check and correct the charted locations of several islands. Scientific institutions represented during the year included Pacific Oceanographic Laboratory, Massachusetts Institute of Technology, University of Washington, University of Oregon, University of Guayaquil, and the Colombia Oceanographic Commission.

In the Spring of 1971, the OCEANOGRAPHER conducted a geophysical study in the Northeast Pacific, including detailed investigations in a region of abyssal hills located between the Murray and Mandocino fracture zones Northeast of Hawaiian Islands, the Chinook trough, the fracture zones and magnetic anomalies in the Gulf of Alaska, and a seismic reflection survey of the Queen Charlotte Island fracture zone.

Other 1971 projects include internal wave studies off Vancouver Island, British Columbia; a bottom water study off the Washington coast; and a geophysical study of the Juan de Fuca fracture zone.

The SURVEYOR (OSS-32) was built by National Steel and Shipbuilding Company, San Diego, California in 1960. The SURVEYOR is an ocean survey ship designed for combined operations in the oceanic basins, over the continental shelf, and in estuarine waters. She can steam over halfway around the world at a cruising speed of 15 knots.

Two major projects were undertaken by SURVEYOR in 1970. The ship was engaged in a confidential geophysical survey for the Navy off the California coast the first half of the year. The second half of the year was devoted to National Ocean Survey's SEAMAP project Northeast of Hawaii. SEAMAP, the Systematic Exploration and Mapping Program, is a systematic deep ocean survey seaward of the Continental Shelf. The project was begun in 1961, and was expanded in 1969 to include the area between the Western Hemisphere land masses and the 180th meridian, and from the equator North to and including the Bering Sea. Work consists of both underway (Phase I) and on station (Phase II) operations. Phase I underway operations generally entail bathymetric, gravimetric, magnetic and seismic measurements as well as meteorology and bathythermograph. Phase II on station operations include Nansen casts, bottom coring, biological sampling, bottom photography and special research assignments.

In 1971, the SURVEYOR completed a detailed hydrograpnic survey of Pago Pago Harbor, American Samoa, and the approaches to the harbor. Enroute on an assigned trackline to Samoa, the ship collected water samples at various depths on ten stations in support of a continuing effort by Battelle-Northwest Institute to define the concentration of the various radionuclides which have entered the ocean as a result of nuclear weapons testing. THis phase of the project is associated with the overall program of the Atomic Energy Commission to determine both the inventory and the behavior of radionuclides in the ocean. On completion of the Samoa survey, the SURVEYOR conducted a geophysical traverse across the South Pacific from the South Fiji Basin and Tonga Islands to the Galapagos Rift Zone.

SURVEYOR will spend the remainder of 1971 in operations on SEAMAP off the Oregon-Washington coasts.

The PATHFINDER was built by Lake Washington Shipyard, Houghton, Washington. She is equipped to carry out a variety of oceanographic, hydrographic, and geophysical operations, from deep-water bathymetry to precise surveys ashore. Her cruising range is 4,200 nautical miles at 12.5 knots.

Among PATHFINDER's accomplishments in 1970 were ship and launch hydrography off the West Coast of Hawaii Island, a geodetic traverse along the Southwest coast of Lower Cook Inlet, Alaska, a triangulation scheme measured across Lower Cook Inlet, and launch hydrography in Kamishak Bay, Alaska.

In the Spring of 1971, PATHFINDER accomplished ship and launch hydrography in Clarence Strait, Southeast Alaska. In the Summer, she will resume hydrographic surveys in Kamishak Bay and Lower Cook Inlet. PATHFINDER will return to Hawaii in the Fall and resume hydrography off Hawaii Island.

The FAIRWEATHER (MSS-20) was built by Aerojet-General Shipyards, Jacksonville, Florida. She has a cruising range of 8,000 nautical miles and a maximum speed of 14.5 knots. The FAIRWEATHER was designed for hydrographic surveys and some oceanographic operations. Her ice-strengthened hull permits operations in floe ice, and she is fully air-conditioned for efficiency in warmer latitudes.

In 1970, FAIRWEATHER completed a hydrographic survey in Peril Strait, Alaska; hydrographic and photogrammetric surveys in Glacier Bay; engaged in photogrammetric operations in Cross Sound and Icy Strait; and relocated several navigational aids in Clarence Strait, Alaska. The ship returned to Seattle in late Summer and completed a detailed hydrographic survey of Elliott Bay and Duwamish Waterway. In addition, 27 reported hazards to navigation and corrections to charts were investigated in the Puget Sound area, and a special survey for the Corps of Engineers was conducted on the north side of Ediz Hook, Port Angeles, Washington.

From early Spring to late Summer, 1971, FAIRWEATHER will be involved in hydrographic surveys, photogrammetric operations and tidal measurements in the vicinity of Cape St. Elias and Controller Bay, Alaska. She will then shift operations to Felice Strait, Southeast Alaska for a hydrographic survey of the area.

The RAINIER (MSS-21) is the twin sister of the FAIRWEATHER. RAINIER spent most of 1970 in Alaska, operating in the Bering Sea and Norton Sound. Enroute to Dutch Harbor, she collected water samples at six stations in support of the Battelle-Northwest Institute project to define the concentration of various radionuclides in the ocean resulting from nuclear weapons testing. The ship conducted bathymetric mapping and geophysical surveys in the southeast Bering Sea and in Bristol Bay until the ice breakup permitted her to begin operations in Norton Sound. RAINIER worked in Norton Sound all summer on hydrographic and geophysical surveys in cooperation with the U.S. Geological Survey.

RAINIER will be engaged in hydrographic surveying and photogrammetric operations in Shelikof Strait, Alaska til late Summer, 1971. In the Fall, she will be working on a continuing hydrographic survey project of the Southern California coast.

The DAVIDSON (CSS-31) was built by Norfolk Shipbuilding and Drydock Corporation, Norfolk, Virginia. Her primary function is hydrographic and coastal surveying. DAVIDSON has a range of 4,500 nautical miles at a

sustained speed of 13.5 knots. Her ice-strengthened steel hull permits operations in Alaska waters, and she is fully air-conditioned for working in warm latitudes. Although hydrographic surveying is her principal mission, the DAVIDSON is equipped to handle sophisticated oceanographic research projects. In 1967, for example, she engaged in a two-month study of ocean currents and water temperatures in the Caribbean Sea, geological dredging off Baja, California, and bottom coring and sediment sampling in Monterey Bay, California.

During 1970 the ship DAVIDSON performed hydrographic surveying operations in Southern California and in Keku Strait, Southeast Alaska. She also assisted the FAIRWEATHER on the photogrammetric project in Cross Sound and Icy Strait.

DAVIDSON will be in Alaska through the Spring and Summer of 1971, working on hydrographic surveys in Sumner Strait and on photogrammetric projects in Cordova Bay, Tlevak Strait, and Clarence Strait. In the Fall of 1971 she will conduct hydrographic surveys on the Umpqua River in Oregon.

The McARTHUR (CSS-30) is the sister ship of the DAVIDSON. Honolulu, Hawaii was home-port for McARTHUR from 1967 to 1969. During this period, she completed hydrographic surveys around Molokai and Lanai Islands and off the northwest coast of Hawaii Island.

McARTHUR's projects in 1970 included hydrographic surveys off the Southern California coast and Nichols Passage, Southeast Alaska, and photogrammetric surveys in Cordova Bay.

In 1971, McARTHUR will be busy the entire year in a bottom gravity survey off the West Coast of the United States, extending from Cape Flattery, Washington southward to Monterey Bay, California.

National Marine Fisheries Service (NMFS). Formerly the Bureau of Commercial Fisheries, the National Marine Fisheries Service has long had its regional offices and laboratories in Seattle. At its Montlake facility are its biological, exploratory fishing and gear research, pioneer research, and technology laboratories. The Marine Mammal Biological Laboratory is located at the Naval Support Activity, Sand Point.

Some NMFS programs and activities are discussed in sections 3 and 4.

National Weather Service. The Weather Service Forecast Office at Seattle issues marine forecasts and warnings for (1) coastal waters out to 50 miles seaward from the coast between Tatoosh Island and North Head, (2) the Strait of Juan de Fuca, and (3) the inland waters of Western Washington. Forecasts are issued regularly at six-hour intervals, and warnings of severe weather, strong winds, heavy swell, and storm tides are issued as needed. Marine weather information is distributed by radio over the NWS Puget Sound continuous VHF weather broadcast, through Coast Guard and telephone company marine radiotelephone broadcasts and by commercial broadcasters. Warning signals are displayed at numerous coastal warning display stations. Cooperators, especially the Coast Guard, furnish current reports of weather and wind at coastal and island locations of interest to mariners in western Washington.

Pacific Oceanographic Laboratories (POL). The Pacific Oceanographic Laboratories (POL) is a component of the National Oceanic and Atmospheric Administration's (NOAA) Environmental Research Laboratories. POL's function is to conduct the research essential for an understanding of the oceanic processes and conditions which determine the state of the ocean and its estuaries. Models and hypotheses proposed to explain observed conditions are tested and developed with the view toward applying successful theories for prediction purposes. Currently, research topics include sea-air energy exchange, internal wave generation and propagation, dynamics of continental shelf and estuarine processes, thermal structure and heating of bottom waters, tsunami generation and propagation and the structure and characteristics of the Pacific Ocean basin.

The laboratories' headquarters and offices are on the University of Washington campus in temporary quarters. A laboratory and additional offices are at NOAA's Pacific Marine Center on Lake Union. Tsunami research is centered at the University of Hawaii at Honolulu. A new facility to consolidate the Seattle group on the University of Washington campus is in preliminary planning stage.

The laboratory employs 24 professional oceanographers and technicians of whom 17 are in Seattle. Research projects are supported at sea by the ships, officers and technicians of the National Ocean Survey, based at the Pacific Marine Center. Studies are conducted jointly with personnel of the University of Washington and other institutions engaged in oceanographic research. A formal NOAA-University of Washington agreement fosters such joint endeavors between those two groups. Plans for the Laboratories foresee an expansion in the number of full-time scientists and technicians, with facilities available for additional visiting scientists and graduate students to engage in NOAA sponsored research. As additional laboratory space and personnel are acquired the intensity of this Seattle-based research effort will increase in the fields of estuarine and coastal zone oceanography, atmosphere-ocean energy exchange and ocean basin characteristics. These three fields can be successfully developed in this region because of the unique combination of scientific, industrial and environmental resources available.

Northwest Administrative Service Office. This pilot administration office is the only one of its kind within NOAA. Presently staffed by about 50 employees, largely drawn from other organizations within NOAA, this office is testing reorganization ideas in search of more coordinated, efficient methods of operation. If successful, NOAA may permanently establish such regional offices throughout the United States. Surplus naval property at the Naval Support Activity, Sand Point, Seattle and the ex-Naval Transmitter Station, Bainbridge Island, have been publicly mentioned as potential sites for NOAA's regional facilities.

U.S. Navy

Seattle is the headquarters for the THIRTEENTH Naval District--the largest of the naval districts, and hence is the center of Navy activities in the northwestern United States. The District encompasses the States of Washington, Oregon, Idaho, Montana and Alaska. Approximately one-half of the 80-odd naval activities are in the Puget Sound area. Total

naval personnel in the district number approximately 14,000 on active duty and nearly 20,000 naval reservists. The Navy employs many civilians as well.

The overall mission of the various naval activities is to support the operating forces of the U.S. Navy.

The major naval facilities located in the area are:

Naval Air Station, Whidbey Island
Naval Supply Center, Puget Sound
Naval Torpedo Station, Keyport
Polaris Material Office, Pacific
Puget Sound Naval Shipyard (discussed in Section 9)

Naval Supply Center, Puget Sound

The Naval Supply Center, Puget Sound (NSCPS) was established on 2 October 1967 and became the eighth Supply Center under the Naval Supply Systems Command. NSCPS consolidated under one command the former Naval Supply Depot, Seattle, including the Manchester Fuel Annex, and a portion of the Puget Sound Naval Shipyard Supply Department. Today the center is organized into two distinct divisions.

The NSCPS Headquarters Division is located on 30 acres within the perimeter of the Puget Sound Naval Shipyard, on Sinclair Inlet, Bremerton, Washington. Here are performed the traditional stock point functions in support of Navy shore stations and ships in port in the Thirteenth Naval District and Alaska. NSCPS places particular emphasis on the logistic needs of the Fleet Ballistic Missile Forces in the Pacific and the adjacent Puget Sound Naval Shipyard. Also a special customer of NSCPS is the USS SACRAMENTO (AOE-1), a resupply ship, which is homeported in Bremerton.

Approximately 140,000 items, valued at $90,000,000, are carried in stock. An average of 32,000 items are issued each month with an additional 30,000 customer requisitions being supported through the Center's experienced Purchase Department or by referral to other inventory control centers.

In addition to providing a full range of supply support, NSCPS is also a centralized accounting activity for 14 naval activities within the Thirteenth Naval District. This responsibility includes the processing of payrolls and paychecks for over 1,500 civilian employees.

NSCPS also supports ships of other government services such as the National Ocean Survey, the National Marine Fisheries Service and the Coast Guard.

NSCPS's Manchester Fuel Division is located approximately 18 road miles south and east of Bremerton in an idyllic setting on 235 acres bordering Clam Bay near Manchester, Washington. Although this important fuel depot is manned by only 35 of NSCPS's employees, its mission, seaport facilities, and environmental role deserve detailed coverage due to the nature of this publication.

When construction began on this facility in 1939, the below ground fuel storage was designed as a defensive measure against aerial bombardment. And though this strategy has been somewhat outstripped by mushrooming progress in missile development, a peripheral benefit of the plan has been the preservation of the area's unspoiled natural beauty. If preservation of natural resources was an unintentional side effect of the fuel depot's original planning and construction, more purposeful efforts are being made today.

The primary mission of the Manchester Division is, of course, supplying the fuel and oil that keep local ships and aircaraft in operation. Customers come from the Puget Sound Naval Shipyard, the Naval Support Activity at Sand Point, the Naval Air Station at Whidbey Island, the Coast Guard, the Military Sealift Command and any other active naval ships in the area.

This mission, as with most supply facilities, entails receiving, storing and dispersing goods. But Manchester's particular concerns are the volatility and pollution potential of its products.

With almost two million barrels of fuel stored at Manchester, 1,700,000 below ground, the facility is involved in pumping or moving an average of 600,000 barrels a month. The six types of fuel currently on inventory are aviation gasoline, marine diesel, arctic diesel, aviation jet fuel (JP-5), NSFO (Navy Special Fuel Oil), and its planned replacement, Navy Standard Distillate Fuel. Ships are fueled alongside a 1,100 foot pier or by any of the three NSCPS operated fuel barges. The pier can accommodate ships up to and including the SACRAMENTO Class AOE.

The three-year Navy project of converting its fuel burning ships to the cleaner new distillate fuel is scheduled for one-third completion by the end of 1971. So far, six destroyers plus the aircraft carrier, the USS CONSTELLATION (CVA-64), already have been converted to burn the new fuel. This conversion process involves tightening all seals due to the lesser viscosity of the new fuel, plus changing nozzles on the feeder lines.

Manchester, along with all other Navy fuel depots, gradually is being converted to distillate fuel at about the same speed as the overall Navy project, with eventual completion planned by 1973. Just as in ship's fuel systems, the storage tanks involved have to be cleaned out and new seals installed. About 300,000 barrels of distillate fuel, received mostly from the Middle Eastern nation of Kuwait, are now stored at Manchester, compared to 600,000 barrels of NSFO.

Initial costs for distillate fuel are almost 50 percent higher than for NSFO and, though significant savings will accrue in other areas--such as less maintenance, better engine efficiency, and even improved crew morale--the conversion process now being conducted seems largely to represent the Navy's new consciousness of environmental pollution.

In November 1970, the fuel facilities at the former NSCPS Seattle Division were closed. As a result, many ships which previously fueled at Seattle, now visit the Manchester Division to "gas-up." The Seattle closure also brought about an increase in barging requirements. Due to environmental

concern a second factor which has brought about an increase in work load--the requirement to offload ballast and waste oil from ships operating in the area and those visiting the Puget Sound Naval Shipyard--has suddenly surged upward.

The Fuel Department at Manchester has been actively involved in the ecology field in recent months. Testing of many pollution solution devices has been accomplished and the Fuel Department personnel are frequently called upon for advice and assistance on pollution matters by other local military activities.

A significant demonstration of this new awareness can be seen in the increased work load at Manchester, specifically the rapid rise in the volume of oil waste products received by the facility.

The volume of oil waste products received there from ships since January 1971 has increased to a rate of 25,000 barrels a month. Prior to January 1971, Manchester rarely received more than 2,000 barrels of waste oil per month. New Navy regulations, aimed at preventing ships from pumping oil wastes into open waters, have made the difference in these volumes.

In order to handle this new responsibility, a $250,000 spill prevention and waste oil treatment project has also been authorized for the Manchester Division. A new oil-water separator will replace the 20-year old model now in operation and will be used for collecting petroleum products generated from depot operations and for reclaiming oil from sludge. It is predicted that this new equipment will be capable of recovering significant amounts of oil for reuse while pumping separated water back into the Sound without tell-tale "rainbow" traces of waste.

Another $250,000 is slated for the construction of an incinerator which will burn unusable residual fuels and recycle all smoke and gases to minimize air pollution.

These new devices will aid in reducing the possibility of large scale oil contamination of the Puget Sound. For the staff at Manchester, the threat of such an occurrence, due to the large volumes of oil handled, is an ever-present anxiety. Many of these employees are local residents who take a personal interest in preserving the natural beauty of the area.

Recent Puget Sound oil spills have added impetus to other pollution control measures and an additional $40,000 was added to the Manchester budget during April of 1971. This amount was earmarked for the installation of additional valves and control capabilities on the fuel pier and the replacement of all fuel hoses, which are usually the weakest links in the system. These additions represent increased Navy emphasis on "no material failures."

Another safety measure connected with this important fueling responsibility is the requirement that the fuel officer, senior civilian supervisor and base police and fire chiefs maintain full-time residence at the fuel depot.

Naval Torpedo Station, Keyport

The Naval Torpedo Station at Keyport, an activity of the Naval Ordnance Systems Command, is located on a sheltered arm of Puget Sound about 15 miles west of Seattle and 12 miles north of the Puget Sound Naval Shipyard at Bremerton.

In 1970 the Station annexed the Naval Ammunition Depot (NAD) Bangor. Included in this annexation were the main Bangor base, located on the east bank of Hood Canal four miles west of Keyport; an explosive buffer zone two miles further west across Hood Canal; and Indian Island, 35 miles north at the entrance to Admiralty Inlet.

At the annex, ammunition moves directly to and from the marginal wharf by ship, rail, and truck, with minimum handling. All ships berth directly alongside the marginal wharf, further reducing handling costs. The marginal wharf accommodates at dockside the largest United States ships afloat and can handle any presently planned. Total berthing length of the wharf is 1447 linear feet and there is a controlling depth of 45 feet at MLLW. The pier at Indian Island Annex accommodates a cargo ship or an escort carrier.

Bangor Annex is served by highway, rail, and water transportation. State Highway 3, running north from Bremerton, joins the Clear Creek Road, a hard-surfaced county road, and leads to the Bangor Annex main gate. A Navy-owned railroad spur from Shelton, Washington, serves the station and runs to shipside at the marginal wharf. The water access to the wharf is via Hood Canal, a deep-water approach handling the largest ships afloat. Nearest passenger train and airline terminals are in Seattle. Private automobile, bus, and truck transportation are used extensively. The closest bus terminal is at Bremerton.

The Naval Torpedo Station was commissioned in November 1914 as the Pacific Coast Torpedo Station. The Naval Ammunition Depot at Bangor was established in 1944 as a magazine facility.

In 1970, in addition to annexing NAD Bangor, NTS Keyport assumed functions and added personnel from the Naval Ordnance Station (NOS), Forest Park, IL. Civilian employment climbed from 1500 to 2300.

Professional engineering and scientific personnel at the Naval Torpedo Station include 72 general engineers, 80 mechanical, electronic, and electrical engineers, 35 physicists, 31 mathematicians and math statisticians, and 25 others, a total of 243, supported by some 700 technicians and tradesmen.

The physical plant at Keyport is a modern industrial complex which includes manufacturing facilities; torpedo and weapon overhaul and repair shops; a quality evaluation laboratory with optical, chemical, electronic, simulated environmental, and physical test equipment, including the largest centrifuge in the Northwest; a portable recompression chamber for divers; and an automatic data-processing department. A Honeywell Model 2200 computer is used to process 3-D data. Standard programs are available to compute velocity, acceleration, deflection, and advance.

In addition to its main 3-D tracking facilities (discussed in Section 3), the station has four ranges available for supplemental and auxiliary use:

1. The Dabob Bay 250-kHz Range, the range originally installed in the bay. It is still operational, but has been largely superseded in use by the 75-kHz range.

2. The Jervis Inlet Range, in British Columbia north of the Nanoose range. It is the deepest of the ranges, 2400 feet, and is sheltered. Access is by boat or plane. No shore installations exist.

3. The Hood Canal Range, readily accessible alongside the ship berthing area at Bangor. Containing transit sites, sonar bearing targets and radar targets, it is valuable for such tests as sensor-alignment checks--for example, those conducted during dockside phases of Weapon Systems Accuracy Trials.

4. The Keyport Acoustic Range, off the station waterfront. Its firing tower stands on the station's pier 1. This range is the station's original one and is shallow, designed for testing anti-shipping torpedoes. Its primary asset is accessibility.

Military Sealift Command. The Military Sealift Command at present has a fleet of special project ships engaged in such activities as telemetry of space vehicles, ocean surveys, collection of hydrographic and oceanographic data, Antarctic research, and support of special Department of the Army programs.

Ships are operated by the Military Sealift Command for agencies and departments of the federal government, as the central shipping management agency in the Department of Defense.

There are no special project ships operating out of the Puget Sound area. All special project ships in the Pacific area are under operational control of Commander, Military Sealift Command, Pacific, Oakland, California. If an oceanographic research-type ship were operated under Naval auspices in the area, Military Sealift Command Office Seattle would be the agency exercising control, scheduling, and support. Military Sealift Command Office Seattle is the military coordinator for ocean cargo moving in MSC and commercial vessels for troop movements on MSC vessels.

Seattle Branch WESTNAVFACENGCOM/DDCE. The Director, Seattle Branch, is the designated representative of the Commanding Officer, Western Division, Naval Facilities Engineering Command in the Seattle Area with Additional Duty to Commandant, Thirteenth Naval District as Deputy District Civil Engineer.

He performs the functions assigned to the DDCE in support of the Commandant, Thirteenth and Seventeenth Naval Districts including general engineering, family and bachelor housing, real estate, and environmental engineering matters.

He issues plans, specifications and other bidding data; receives and opens bids; transmits bid results and forwards bid documents to WESTDIV for all major construction, demolition repair and other contracts to be accomplished in the Thirteenth and Seventeenth Naval Districts for which the Commanding Officer, WESTDIV is the designated Officer in Charge/ Officer in Charge of Construction.

He provides engineering services as required to implement the various programs of the Office of Civil Defense, under the direction of the Corps of Engineers and the Naval Facilities Engineering Command.

Naval Reserve. Nearly 60 percent of the total administrative effort of the commandant's headquarters staff is devoted to naval reserve matters. Naval reserve activities in the district include 13 training centers and 23 training facilities, the farthest from Seattle being 1000 miles away at Miles City, Montana. Ships assigned to the commandant for naval reserve training include one destroyer, three destroyer escorts, one minesweeper, and three inactive submarines. The reservists in training programs other than air are assigned to 96 selected reserve pay units and 30 specialist nonpay units.

Department of Ecology

Reflecting the public awareness of and their own appreciation for the threats to the quality of life in Washington and the necessity for the social and political institutions of the state to take immediate and determinate actions to preserve and restore the environmental resources of Washington, the 41st Legislature created the Department of Ecology.

The department was established July 1, 1970, to provide a consolidation of the responsibilities of the Department of Water Resources, the Water Pollution Control Commission, the Air Pollution Control Board, and the solid waste program of the Department of Health. Since its creation the new agency has established four operating offices--the Office of Administration, the Office of Planning and Program Development, the Office of Technical Services, and the Office of Operations.

Office of Planning and Program Development. This office:

- Develops water standards, classifications and water plans for all streams and bodies of water in the state.
- Establishes state guidelines for shoreline management, reviews local shoreline management plans, and develops a state master program for shoreline management, under the Shoreline Management Act of 1971. Although this act takes effect immediately, it will be placed on the 1972 state general election ballot along with Initiative 43, "Shoreline Protection Act," for approval or rejection by the voters. By that time the Shoreline Management Act will be well underway, but not all its provisions will have been completed. Should the Shoreline Management Act be rejected by the voters in favor of Initiative 43, the Department of Ecology would assume much broader responsibilities and power for coastal management.
- Assists local agencies in developing detailed pollution control and abatement plans within each of 62 separate drainage basins in the state.
- Assists local communities in qualifying for federal pollution control facilities construction grants.

Office of Technical Services. This office:

- Operates a water quality laboratory, provides field survey services in support of a water quality and quantity monitoring program and conducts technical studies concerned with water related investigations and problems
- Evaluates data collected from a network of ground water test wells
- Collects data on the sedimentation yield of various basins and the transport characteristics of their respective streams

Office of Operations. This office:

- Reviews Corps of Engineers' permits
- Issues industrial waste permits, general permit certifications, and registers water rights
- Conducts water rights adjudications
- Establishes and regulates flood control zones
- Monitors municipal and industrial waste treatment, and waste interception
- Operates a network of ground water test wells
- Investigates complaints, inspects facilities, initiates enforcement proceedings and recovers damages
- Approves construction grants for municipal waste treatment facilities on a 30% federal 15% state participation basis
- Collects, investigates, performs surveillance over, removes, contains, treats, or disperses oil discharged into water of the state. The office does this either by department staff, equipment, and material or by contract with others. The office also administers a revolving fund called the coastal protection fund for these purposes.

Department of Fisheries

The department protects, propagates, perpetuates, and manages food fish and shellfish resources of the state to maximize utilization for commercial and sports purposes without impairing the capacity of stocks to reproduce at optimum levels. The director of the department is empowered to establish and enforce state laws, rules and regulations to control the commercial and sports harvest and to protect stocks.

Hatchery facilities engaged in artificial fish reproduction are constructed, maintained, and operated by the department. It also evaluates the design, construction, operation, and maintenance of fish passage facilities that are required for the continuation of natural fish reproduction. The department improves streams for better fish habitat and opens up new streams for expanded natural fish reproduction.

Department of Game

The State Game Commission is the governing board of the department and establishes its policies and regulations. The director is selected by the commission to administer the department and the rules and regulations of the commission. The department is the primary state agency responsible for management of the game fish and animals, and other wildlife resources of the state.

Environmental management. In this regard, the department:

- Inventories land and water environments throughout the state; documents the occurrence of water, plants, and animals
- Assists in the management and protection of water and water-related resources

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Environmental Management [illegible] the department:

- Inventories [illegible] environments [illegible] the state; [illegible] water, plants and animals
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- Evaluates the impact on wildlife and fish from development of public hydro-electric, irrigation flood control, and/or water storage projects
  Evaluates water right permits
- Determines low flow standards for spawning, rearing, and harvest of game fish
- Develops techniques for increasing wildlife and fish numbers to replace losses incurred from development projects
- Determines economic values of fish and wildlife and their habitats in order to equate these resource values with other potential land and water resource use values
- Develops methods of surveying public attitudes and demands in order to evaluate potential of conflict over proposed development sites

Fisheries management. The department:

- Operates game fish hatcheries owned by the Game Department
- Promotes, manages and regulates sport fishing on Department controlled waters of the state
- Conducts research on fish nutrition and disease
- Rehabilitates lakes and develops natural rearing ponds

Wildlife management. The department:

- Acquires and maintains public access to waters throughout the state.

Department of Highways

The department conducts stream channelization, bank stabilization and land fill operations in connection with road bed and bridge construction activities.

Interagency Committee for Outdoor Recreation. Discussed in Section 6.

Department of Natural Resources.

Agriculture, grazing and miscellaneous land management. The department evaluates irrigation potential of present dryland agricultural sites and promotes and develops the use of irrigation systems for state-owned lands.

Log patrol. The department polices the branding of logs and the recovery of lost logs in Washington waters.

Marine land management. The department:

Is the manager for the bed of Puget Sound and other beds of navigable waters of the state as well as the 40% of tidelands of the state that represent the state-owned aquatic lands.

- Works with local interests in establishing the goals for longrange development of Puget Sound under a philosophy of multiple use.
- Conducts detailed inventories of the present uses of Puget Sound and the environmental factors necessary for aquatic land management decisions.
- Develops detailed management plans for state-owned aquatic lands.
- Implements the management plan through a leasing system.
- Maintains ownership records of state aquatic lands.
- Fosters and supports the development of all forms of aquaculture which could be carried out on state aquatic lands.
- Establishes harbor lines.
- Provides water access only wilderness beach recreation areas from funds derived from commercial aquatic land leases.

Recreation. The department plans constructs, maintains, and operates outdoor recreation sites for camping and water access. Upland access developments provide public access to state owned tide and shore land where no other agency plans to meet the local demand. Sites are developed with the aid of matching funds from the Interagency Committee for Outdoor Recreation.

Reforestation. The department is responsible for insect and disease protection on state and private forest lands and management of state-owned forest lands. It uses insecticides for insect control. Rodenticides, herbicides, and fertilizers are used in the production of forest crops.

Oceanographic Commission of Washington

The Oceanographic Commission of Washington was established by Senate Bill 49, Chapter 243, Laws of 1967. This law came into being as a result of preliminary studies of the Puget Sound Oceanography Study Committee which recognized the need for proper, systematic development and utilization of the marine resources of the sea coast and adjacent continental shelf of the state and Puget Sound.

This legislation further specified the membership of the Oceanographic Commission of Washington would be comprised of 12 members as follows: five to be appointed by the Governor from the public at large, at least one of whom shall be representative of higher education, one representative of private industry, and one representative of labor; three members of the state Senate, no more than two of whom shall be members of the same political party, to be appointed by the President of the Senate; and three members of the House of Representatives, no more than two of whom shall be members of the same political party, to be appointed by the Speaker of the House. The Chairman of the State Marine Resources and Development Committee is an ex-officio member without a vote. Members serve for terms of five years expiring on January 15. The law stipulates that the position of any legislative member shall be deemed vacated whenever such members cease to be a member of the House or Senate from which he was appointed. Moreover,

any vacancies occurring in the membership of the commission shall be filled for the remainder of the unexpired term by the appointive power of the position vacated. The agency is funded by the Legislature and is responsive directly to the Legislature. All policy decisions made by the Commission are guided by the Constitution of the State of Washington.

The Oceanographic Commission of Washington does not have any subordinate programs. However, the legislature recognized that the commission should devote itself to policy matters, and therefore in the original legislation empowered the commission to create a public non-profit corporation, to be known as the Oceanographic Institute of Washington. This corporation is in effect an agency of the commission and was incorporated in the State of Washington and in King County in April of 1968. The institute is so designed as to be able to accept or receive the same financial in-puts as is the commission, except that it will not receive or administer funds appropriated by the legislature.

Membership on the Board of Trustees of the Oceanographic Institute is further defined in the enabling legislation, which stipulated that members of the commission shall be members and trustees of the institute as long as they are members of the commission. The commission members of this corporation also shall accept by majority vote additional members of the corporation so that the total membership, therefore, including commission members, shall be comprised of not less than 13 and not more than 20 members.

The law states that the commission shall have the following powers, duties, and functions:

- Encourage, assist, develop and maintain a coordinated program in oceanography for the benefit of the citizens of the state and the nation
- Encourage private industrial enterprise to utilize the Puget Sound area as a base for oceanographic work
- Promote national interest in Puget Sound as a base for national oceanographic programs
- Assist in developing educational programs to provide the professional and technical graduates required by oceanographic expansion in the area
- Undertake projects designed to inform the citizenry of the importance of oceanography to the development of the area
- Assist in the study of problems of waterfront development, pollution, and parks and recreation areas for public use
- Accept funds, gifts, bequests, and devices from any lawful source given or made available for the purposes of this Act, including but not limited to grants of funds made with or without a matching requirement by the federal government
- Encourage, supplement and assist the development of programs under the National Sea Grant College and Program Act of 1966 by the University of Washington and other participating educational institutions of the State

and region. The programs admission of the commission and its institute are not to be in duplication of the existing program of the University of Washington or other educational institutions of the state in oceanographic research, training or public service, or of the program developed under the National Sea Grant College and Program Act of 1966.

.Make annual reports to the Washington State Legislature, or to the appropriate interim committee thereof, all activities undertaken in connection with the power, duties and functions assigned in this section together with any recommendations for new legislation designed to accomplish the purposes of the Act which created the commission and institute.

.Delegate within its discretion and to the extent permitted by the State Constitution, any of the first eight powers and duties set forth above to the Oceanographic Institute of Washington.

To fulfill these mandates, the commission and institute have engaged in numerous activities and programs in recent years. The commission made the first grant to the Lummi Indians in support of their aquaculture project. Operating on donated services and time under the guidance of the SEA USE Council, the institute has led three oceanographic expeditions to Cobb Seamount in as many summers. Each summer's operations consisted of several cruises to the seamount; perhaps the most successful was the August 1970 cruise which tested and proved the feasibility of installing permanent anchor bolts in basalt. In January 1971, the commission submitted a recommendation to the National Oceanic and Atmospheric Administration that it test and evaluate its low-capabilities buoys (part of the National Data Buoy Project) in and through the waters of western Washington. In June 1971, the commission and the Pacific Marine Center approved guidelines for a cooperative program whereby the commission acts as clearinghouse for requests from local citizens, firms, educational institutions, and agencies needing survey and water quality data about Washington waters. Such information will be provided by National Ocean Survey vessels based in Seattle in conjunction with their normal survey operations. This role as an interface agency is becoming increasingly important to the commission. In 1970, a task force formed by the commission produced a set of guidelines for the state on coastal management. These were used by the 1971 legislature in drafting its Shoreline Management Act and under the provisions of that Act are now being used by the Department of Ecology in drafting the official state guidelines. Finally, the institute is seeking federal funding to support its proposed comprehensive study of oil transportation and handling in the state. Other projects and programs of the commission and institute are discussed in the annual reports to the 1969, 1970, and 1971 sessions of the legislature.

Pollution Control Hearings Board

The board, consisting of three members, is established to provide resolution of appeals of decisions made by the Department of Ecology and state air pollution authorities by a body independent of those agencies.

Department of Social and Health Services

The Department of Social and Health Services is a consolidation of five formerly separate state agencies, which are the Department of Institutions, Division of Vocational Rehabilitation, Veterans Rehabilitation Council, Department of Health, and Department of Public Assistance. The consolidation took effect on 1 July 1970. The department is the executive arm of state government charged with providing a comprehensive program of social and health services to all the citizens of this state.

In the field of environmental health, the department:

- Evaluates and certifies areas for commercial shellfish harvesting.
- Closes hazardous areas to both commercial and sport shellfish harvesting
- Regulates commercial shellfish processing
- Establishes health standards of municipal and domestic water supplies, and for public swimming pool construction and operation
- Evaluates plans and operations for municipal sewage collection and treatment facilities
- Provides professional training for sewage treatment plant operators
- Provides laboratory testing for domestic and municipal water supply samples
- Evaluates water quality for outdoor recreation activities
- Monitors pesticide run-off from agriculture and forest areas on the selective basis
- Monitors selected drainage areas for heavy metals
- Evaluates potential impacts of radioactive contamination of thermal power plant cooling waters

State Parks and Recreation Commission. Discussed in Section 6.

Superintendent of Public Instruction

This office develops school curricula on environmental education which include the study of water and its role in the eco-system. A portion of the budget goes to the Pacific Science Center in Seattle, which provides facilities, programs, and services not otherwise available to students and school personnel. The center is now preparing a major display on oceanography. A hydraulic model of Puget Sound will be a principal item in the display. The model will aslo be available for research.

Thermal Power Plant Site Evaluation Council

The council, consisting of fourteen member agencies, is responsible for evaluating applications for siting of thermal power plants within the state. Based upon its evaluations, the council recommends to the Governor approval or disapproval of the applications.

The goal of the council, through its evaluation of siting applications, is to seek courses of action that will balance the increasing demands for thermal power plant locations and operations in conjuction with the broad interests of the public to minimize adverse effects on the environment resulting from such sitings.

Within its goal, the council intends to seek courses of action to (1) assure citizens of the state that, where applicable, operational safeguards are at least as stringent as the criteria established by the federal government and are technically sufficient for their safety and welfare, (2) preserve and protect the quality of the environment; enhance the public's opportunity to enjoy the esthetic and recreational benefits of the air, water, and land resources; promote air cleanliness; and pursue beneficial changes in the environment, and (3) provide abundant low cost electrical energy.

WSU Water Research Center

The center conducts all forms of water resource research related to quantity, quality, location, planning, use, and management. The center is a cooperative effort of Washington State University and University of Washington; its main facilities are located at Washington State University.

Regional and local

There are 15 regional planning agencies in Washington whose functions include:

- Coordinating the local, state, and federal government planning activities in their respective multi-county regions
- Acting as clearinghouses for federal-aid grant applications
- Inventorying and analyzing water and sewerage facilities throughout their respective regions
- Maintaining regional land-use plans

The activities of the Municipality of Metropolitan Seattle (Metro) were discussed in sections 3 and 6.

City and county governments maintain numerous departments which are in various ways concerned with marine resources; e.g., fire, health, parks and recreation, power and light, planning, road and street, sewer, and water departments.

A number of special districts have equally varied interests and responsibilities that are related to marine resources; commercial water, diking intercounty diking and drainage, drainage (or diking or sewerage) improvement, ferry, flood control, flood control zone, health, industrial development, irrigation or reclamation, metropolitan municipal corporation, mosquito control, parks and recreation, port, public utility, public waterway, county road improvement, sanitary, sewer, soil and water conservation, township, water, water distribution, and county or intercounty weed districts.

SECTION 11

SUMMARY

In 1792, Captain George Vancouver wrote of this region that its bounties of nature seemed ready to bestow ample rewards on those who would but cultivate them.

This inventory of the oceanographic resources of Washington seems to echo that thought. The waters of western Washington form an ocean laboratory unequalled anywhere else in the nation. The character and interplay of the air, sea, and land are unique. Here deep waters are found just offshore, reducing the distance, time, and cost of transit between logistic shore stations and test sites. Here one can choose between the laboratory several micro-environments, depending on the experiments or tests to be performed. Southern Puget Sound is perhaps the least oceanic of these environments; the main Puget Sound basin is less sheltered; the Strait of Juan de Fuca is even more oceanic; the waters surrounding the San Juan Islands are rich with a wide variety of marine life; and the waters off the Washington coast are of course truly oceanic. Countless bays and inlets along the 3,026 miles of shoreline provide endless combinations of oceanographic conditions.

Certain areas of research and development are particularly suitable to this ocean laboratory: sea farming, studies of upwelling, earthquakes, tsunamis, beach dynamics, sea floor spreading, acoustics, cold water diving, air-sea-land interactions, nuclear power plants, primary production, the effects of the Pacific Ocean on the climate of the United States, pollution effects, and other standard investigations made by biological, physical, chemical, and geological oceanographers.

Both the United Nations and the National Oceanic and Atmospheric Administration are considering major studies of these waters because they are relatively unpolluted and thus can serve as reference standards for

understanding natural processes and assessing the effects of pollution in the marine waters of the world.

Federal and state governments have enacted laws and regulations designed to protect these natural resources and maintain high water quality, while permitting orderly, intelligent development and progress.

Most people would not dispute the assertion that the National Oceanic and Atmospheric Administration and the University of Washington lead the oceanographic efforts in Washington. But the use of marine resources is also well-established in other academic institutions, governmental agencies, and industrial elements. Together they form a broad base of talent, personnel, experience, and expertise which has earned the worldwide reputation for being capable of supporting almost any oceanographic task from beginning to end. And the state's excellent educational system is continually producing more oceanographers and marine technicians who join the already substantial technical and technological pool of talent located here.

There seems to be no reason why this region should not be the oceanographic center of the nation. Only one factor seems lacking in the equation for such success: commitment.

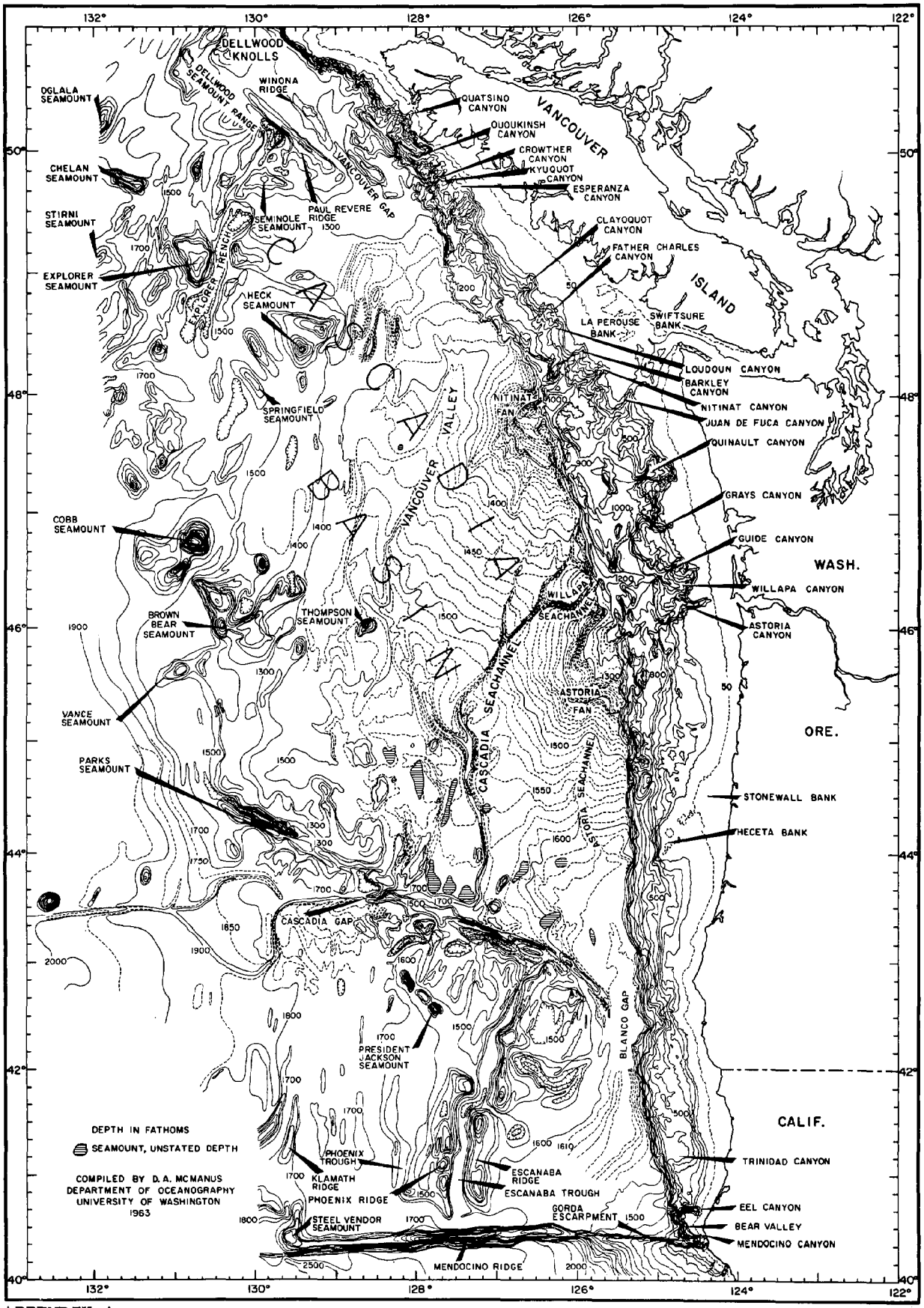
The Chairman of the Senate Subcommittee on Oceans and Atmosphere, Senator Ernest F. Hollings (D-S.C.), reportedly labeled 1960-1970 the "Decade of Ocean Rhetoric." National commitment, not lip-service, is needed.

But needed even more is commitment by the state of Washington. For even here--where a dedicated few have achieved considerable success and where there is such a long history and tradition of water transportation, recreation, research, construction, farming, and fisheries--most government officials, legislators, and other citizens seem unconvinced of the promise of oceanography. In the midst of a recession that sees 12.1% of the state's labor force unemployed and prompts economists to preach diversification and dispersion, there is no mass movement or inclination to invest in and systematically develop the marine resources already lapping our shores each moment of each day.

Dr. Dixy Lee Ray, an oceanographer and the director of the Pacific Science Center in Seattle, has said that "public understanding must precede public support of science."

Perhaps this is the missing factor in the formula. In this state, for example, most people living east of the Cascade Mountains probably find it difficult to realize how the oceans affect their largely rural and agricultural way of life. Yet how important to them is the weather and therefore the Pacific Ocean and therefore oceanography!

This book has attempted to make Washington's marine resources, natural and man-made, more apparent than before. Perhaps it will prompt more Washington citizens, like young salmon on an ancient course downstream, to rush to the sea for a new life. And perhaps others in the nation will follow.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OGLALA SEAMOUNT
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OUOUKINSH CANYON
CROWTHER CANYON
KYUQUOT CANYON
ESPERANZA CANYON
CLAYOQUOT CANYON
FATHER CHARLES CANYON
CHELAN SEAMOUNT
STIRNI SEAMOUNT
SEMINOLE SEAMOUNT
PAUL REVERE RIDGE
VANCOUVER GAP
EXPLORER SEAMOUNT
EXPLORER TRENCH
HECK SEAMOUNT
SPRINGFIELD SEAMOUNT
VANCOUVER ISLAND
LA PEROUSE BANK
SWIFTSURE BANK
LOUDOUN CANYON
BARKLEY CANYON
NITINAT CANYON
JUAN DE FUCA CANYON
QUINAULT CANYON
NITINAT FAN
VANCOUVER VALLEY
GRAYS CANYON
GUIDE CANYON
WASH.
COBB SEAMOUNT
BROWN BEAR SEAMOUNT
THOMPSON SEAMOUNT
WILLAPA SEACHANNEL
WILLAPA CANYON
ASTORIA CANYON
ASTORIA FAN
CASCADIA SEACHANNEL
VANCE SEAMOUNT
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PARKS SEAMOUNT
STONEWALL BANK
HECETA BANK
ASTORIA SEACHANNEL
CASCADIA GAP
BLANCO GAP
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COMPILED BY D. A. MCMANUS
DEPARTMENT OF OCEANOGRAPHY
UNIVERSITY OF WASHINGTON
1963
PHOENIX TROUGH
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PHOENIX RIDGE
ESCANABA RIDGE
ESCANABA TROUGH
TRINIDAD CANYON
GORDA ESCARPMENT
EEL CANYON
BEAR VALLEY
MENDOCINO CANYON
STEEL VENDOR SEAMOUNT
MENDOCINO RIDGE
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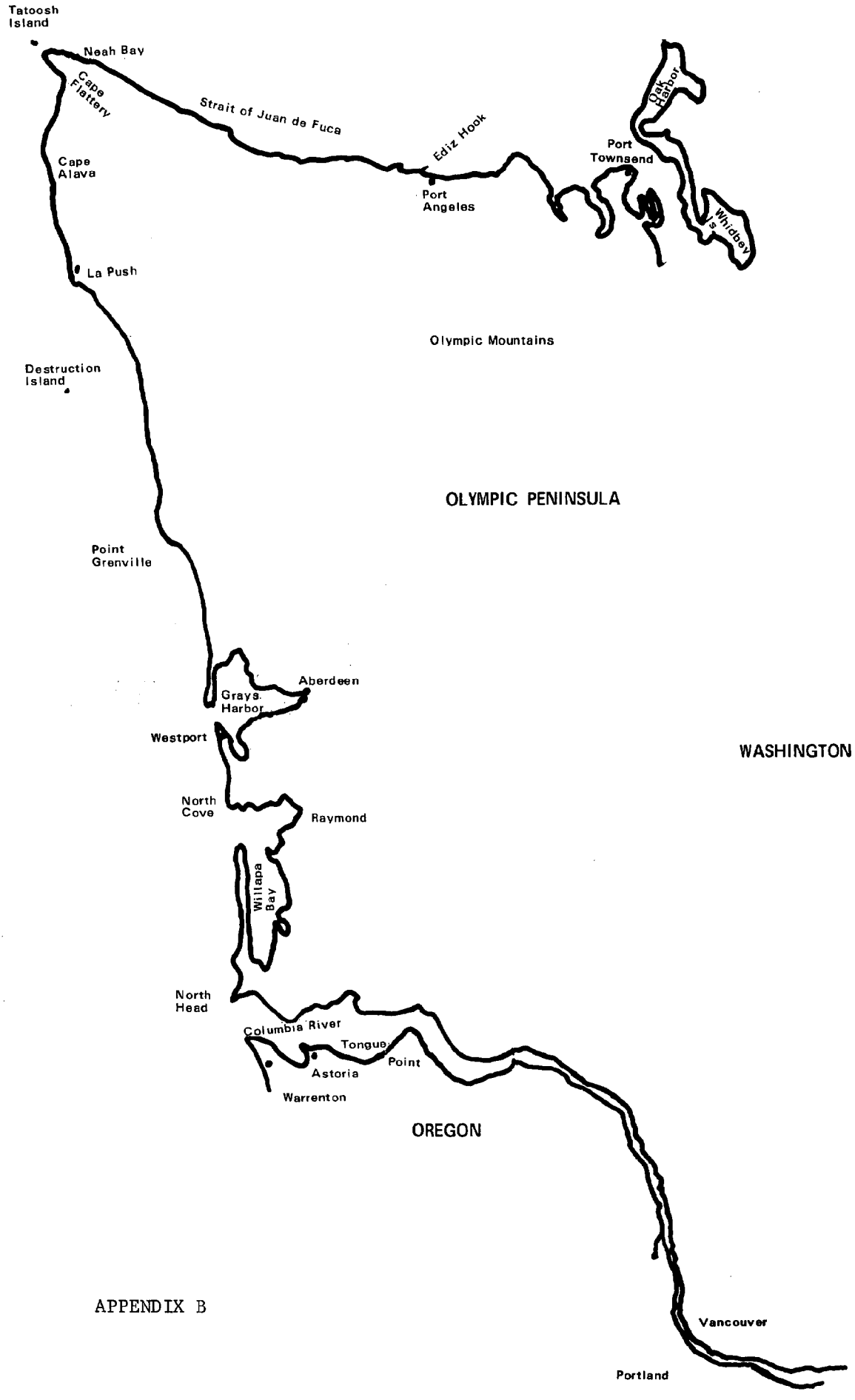
APPENDIX A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Destruction Island
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Westport
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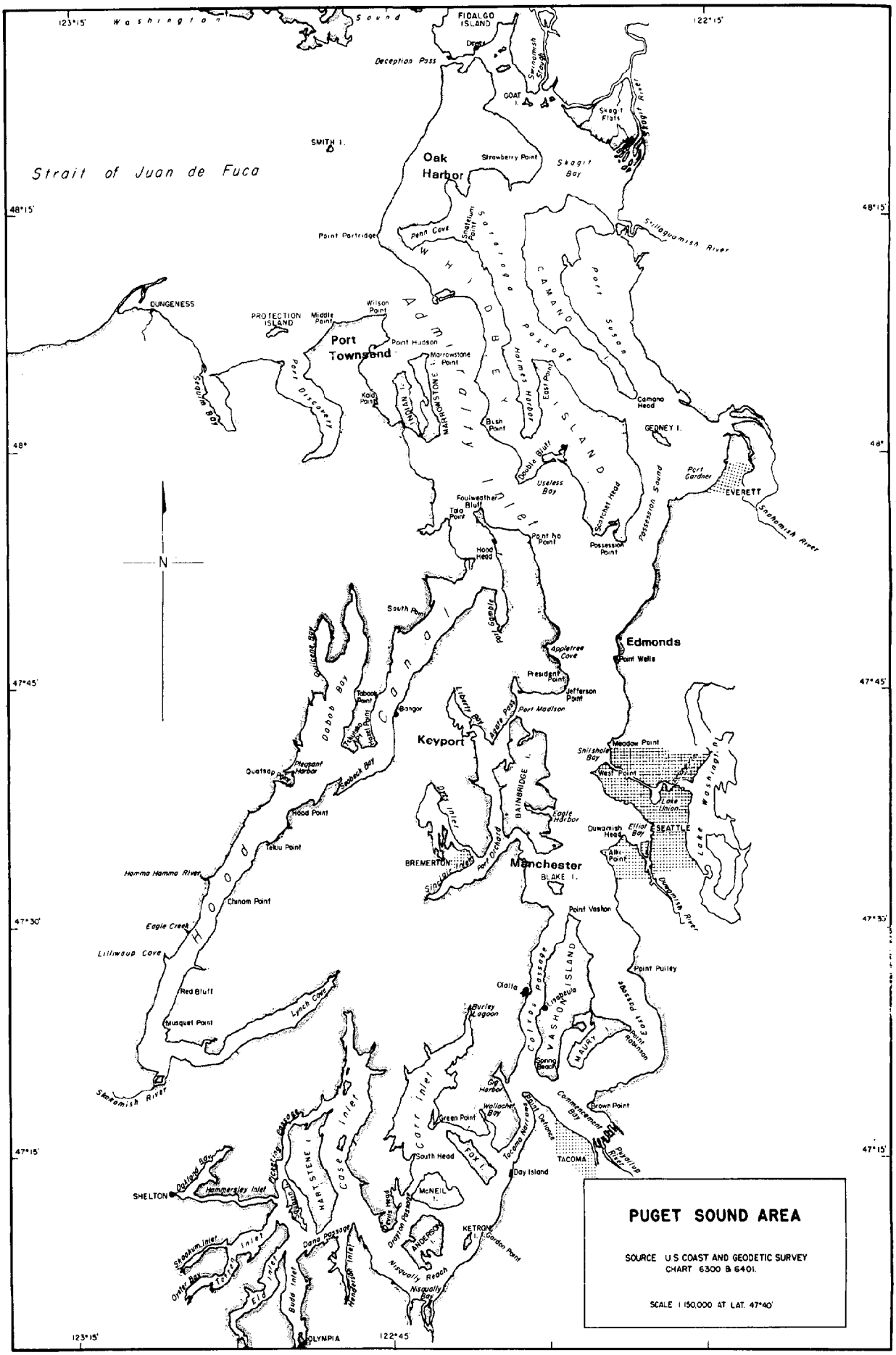
APPENDIX B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SEATTLE
EVERETT
TACOMA
OLYMPIA
SHELTON
BREMERTON
Admiralty Inlet
Hood Canal
Puget Sound
Whidbey Island
Camano Island
Vashon Island
Bainbridge I.
Blake I.
McNeil I.
Fox I.
Maury I.
Harstene I.
Deception Pass
Skagit Bay
Saratoga Passage
Possession Sound
Port Susan
Port Gardner
Port Madison
Dabob Bay
Quilcene Bay
Hood Canal
Lynch Cove
Case Inlet
Carr Inlet
Colvos Passage
Dana Passage
Nisqually Reach
Commencement Bay
Elliott Bay
Lake Washington
Duwamish River
Puyallup River
Skokomish River
Hamma Hamma River
Eagle Creek
Lilliwaup Cove
Dungeness
Protection Island
Smith I.
Goat I.
Gedney I.
Camano Head
Point Partridge
Point Hudson
Marrowstone Point
Kala Point
Bush Point
Double Bluff
Useless Bay
Foulweather Bluff
Point No Point
Possession Point
Hood Head
South Point
Tarboo Bay
Tarboo Point
Bangor
Quatsap Point
Pleasant Harbor
Eastbay
Hood Point
Toandos Peninsula
Toteva Point
Chinom Point
Red Bluff
Musquet Point
Lofall
Termination Point
Pulali Point
Liberty Bay
Agate Pass
Jefferson Point
President Point
Appletree Cove
Point Wells
Meadow Point
Shilshole Bay
West Point
Magnolia
Queen Anne
Union
Elliott Bay
Duwamish Head
Alki Point
Eagle Harbor
Port Orchard
Dyes Inlet
Sinclair Inlet
Point Vashon
Point Pulley
Olalla
Burley Lagoon
Spring Beach
Gig Harbor
Wollochet Bay
Green Point
South Head
Day Island
Point Robinson
Brown Point
Ketron Island
Gordon Point
Anderson I.
Devils Head
Drayton Passage
Hammersley Inlet
Totten Inlet
Eld Inlet
Oakland Bay
Skookum Inlet
Budd Inlet
Henderson Inlet
Squaxin Island
Fidalgo Island
Swinomish Slough
Skagit Flats
Skagit River
Stillaguamish River
Snohomish River
Wilson Point
Middle Point
Port Discovery
Sequim Bay
Mutiny Bay
Admiralty Bay
Penn Cove
Strawberry Point
Smith Island
N
PUGET SOUND AREA
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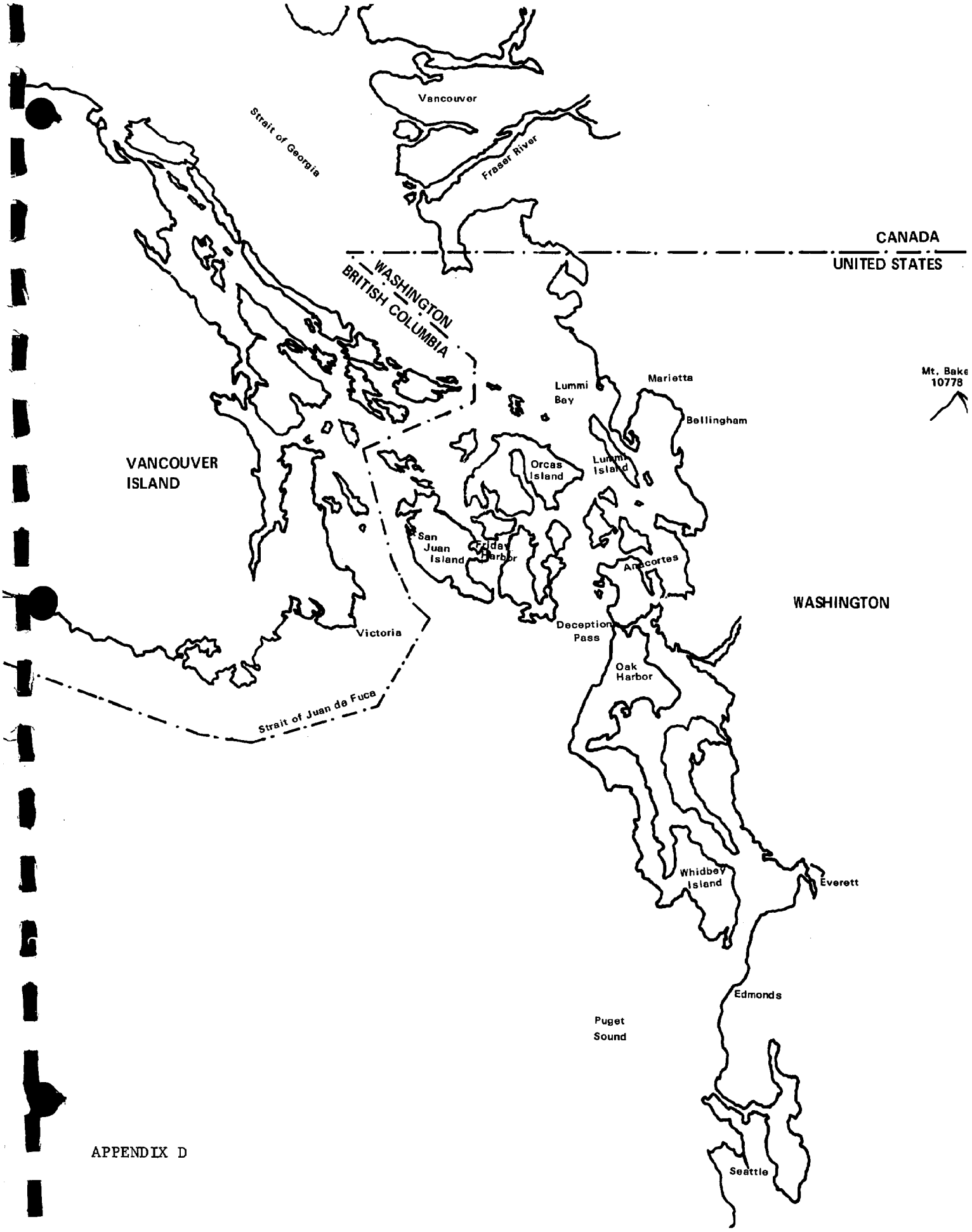
APPENDIX C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VANCOUVER ISLAND
Orcas Island
Lummi Island
San Juan Island
Friday Harbor
Anacortes
WASHINGTON
Victoria
Deception Pass
Oak Harbor
Strait of Juan de Fuca
Whidbey Island
Everett
Edmonds
Puget Sound
Seattle

APPENDIX D

OCEANOGRAPHIC RESOURCES OF WASHINGTON, An Inventory of Oceanographic and Marine Activities and Capabilities

OCEANOGRAPHIC COMMISSION OF WASH.

30 June 1971

OCEANOGRAPHIC COMMISSION OF WASHINGTON
312 FIRST AVENUE NORTH
SEATTLE, WASHINGTON 98109

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