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FINAL REPORT

SOCIOECONOMIC, INSTITUTIONAL, AND LEGAL CONSIDERATIONS IN THE MANAGEMENT OF PUGET SOUND

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Principal Investigator: James A. Crutchfield, Professor
Department of Economics
Graduate School of Public Affairs

Associate Investigators: George Anderson, Research Associate Professor
Department of Oceanography

Francis Bartlett, Associate Professor
Department of General Engineering

Robert Bish, Assistant Professor
Department of Economics
Graduate School of Public Affairs

T. Saunders English, Associate Professor
Department of Oceanography

Max Katz, Research Associate Professor
College of Fisheries

Norman Maleng, Attorney at Law

Ernest Salo, Professor
Fisheries Research Institute

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INTRODUCTION

In common with many other marine areas of the United States, the Puget Sound region of Washington is in a process of rapid metamorphosis from wilderness to an industrialized metropolitan area. Direct and indirect competition among users of Puget Sound waters, its adjacent lands, and its tributary river systems is increasing rapidly. Growth in industrial activity and population threatens to transform limited and spotty water quality problems into an area-wide burden of major proportions. The multiplication of people, production, and pollution is encroaching steadily on the complex biological systems dependent on the Sound, its tributary rivers, and the wetlands which form an integral part of the estuarine environment. The human users themselves are coming into conflict over water quality effects of some types of activity.

In Puget Sound, as elsewhere, there is mounting evidence that these conflicts may lead to irrevocable loss of vitally important water-based resources of the region. Major controversies have arisen in the past few years over the proposed locations of an aluminum plant, an oil refinery, and a new deep-water port complex in areas that threaten further reduction of the social and economic benefits enjoyed by other users of Puget Sound. In each instance it has been made abundantly clear that basic knowledge of the

physical properties of Puget Sound and of the living populations that it supports is completely inadequate to define objectives or procedures for optimal management of Puget Sound as a whole.

In addition, the welter of overlapping jurisdictions among federal, state, and local government agencies and the private sector requires that intensive study must precede any rational planning and implementation to assure reasonably efficient use of Puget Sound waters. The present approach of frantic reaction to individual crises simply cannot guarantee that proper decisions will be made, and the present institutional structure makes it equally uncertain that the unit that should make the decisions is empowered to do so. There is urgent need for a broad-based "knowledge bank" of scientific data, economic use patterns, and jurisdictional boundaries that will free us from the necessity of treating each new conflict in usage of the Puget Sound system as a problem to be solved de novo. It is equally important that such a framework be established on a basis that permits continuous modification to meet new situations and to utilize new knowledge. By focusing attention on the most critical gaps in knowledge, a planning mechanism of this scope can also serve a vital economizing function in directing research efforts to areas of greatest need.

The problem of identifying, measuring, and monitoring the relevant physical parameters and converting these into economic and social values that can be assessed with respect to alternatives is complicated by the growing importance of recreational and aesthetic values, difficult to quantify but of critical importance to the valuation of total social benefits. Yet these non-marketed outputs of an estuarine system are probably the most susceptible to damage, much of it irreversible, and they provide values that will become increasingly scarce as the movement of population toward the coasts presses more and more heavily on limited opportunities for recreation and aesthetic appreciation of the outdoor environment.

It is obvious that the present and potential conflicts over Puget Sound and its adjacent land areas involve many kinds of users, with different reasons underlying the incompatibility of their activities. But the single most important criterion for the analysis of uses, conflicts, gaps in knowledge, and institutional arrangements is water quality. Accordingly, this report focuses on the impact of economic and population growth in the State of Washington on the level, composition, and location of human activities that bear on water quality and therefore lead to conflict. In subsequent extensions of this study, under sponsorship of the National Science Foundation, the analysis will

be broadened to include fuller recognition of the interaction of the land-sea usage; to provide a more detailed analysis of the political alternatives available for more efficient management and planning procedures; and to compile increasingly useful data for planners and decision makers concerned with environmental quality and economic development in the Puget Sound area.

The study area is defined to include the twelve counties of Washington bordering on Puget Sound and the Strait of Juan de Fuca.[1] A number of factors dictated this rather broad definition. First, it is impossible to explain the physical processes that determine the productivity and usage pattern of Puget Sound apart from the important interchange mechanism between the Strait and Puget Sound proper. Second, some of the principal outputs of the Puget Sound system are provided by the populations of salmon and steelhead that spawn in its tributaries. Since these are exploited by commercial and sport fishermen in the Strait as well as in the inner Sound, the two must be considered jointly. Third, the mobility of the population centered in the Seattle-Tacoma metropolitan area links the entire region into a single system with respect to recreational usage of its waters and living resources. Finally, the county is the smallest unit for which many of the relevant data bearing on analysis and management of the Puget Sound system are gathered.

For some purposes, the entire twelve-county area is the appropriate unit for analysis; for others, individual county data are utilized; for still others, the counties are grouped into North, Central, and Western. Map 1 indicates the counties concerned and the regional groupings.

Development of the study indicated the desirability of organizing the material in two parts. The first deals with the physical characteristics of Puget Sound, the level and prospective growth of the population and economic base of the area, and the emerging pattern of usage and conflict. Chapter I summarizes the physical dimensions of Puget Sound that bear directly on its productivity, usage patterns, and susceptibility to various types of pollution.

Chapter II presents a summary and reformulation of a number of previous forecasts of economic and demographic growth in the study area. It should be noted that these projections, though reasonably satisfactory for the state as a whole, become progressively less reliable as the size of the subunit under study diminishes. Accordingly, the amount of allocation and extrapolation required to apply these estimates to a twelve-county area, and to three regions within that area, suggests considerable caution in the interpretation of results.

Map 1

Puget Sound Study Area

In Chapters III and IV, the living resources of Puget Sound and their users are described in quantitative terms. Physical and economic dimensions of the major commercial fish and shellfish operations are developed in some detail, together with projections of expected future values. Similarly, the increasingly important sport fish and shellfish activity is described and, within the limits of present knowledge, expressed in terms of economic magnitudes. Recently assembled information makes it possible to present a fairly adequate quantitative picture of the role of Puget Sound in the production of wildfowl and resultant hunter-days.

Chapter V deals with present uses of Puget Sound other than those based on living resources. Present and prospective conflicts are discussed in Chapter VI, with emphasis on those related specifically to the impact of various activities on water quality and the sensitivity of various types of receptors to such changes.

Part I concludes with a summary of future research needs in scientific, socioeconomic, and administrative areas where present gaps in knowledge and institutions are identifiable and of significant importance in the development of action programs.

Part II considers the legal basis for management of Puget Sound and the alternative types of political entities that

may be required in making and implementing plans for efficient development and management with due regard for the protection of water quality.

Much of the material in this report parallels the voluminous intergovernmental study of Puget Sound and Adjacent Waters, undertaken by a task force directed by the U. S. Army Corps of Engineers. Unfortunately, it will not be published until late 1969, and could not be made available officially before our deadline. Members of the task force were most generous in providing assistance, but it was essential that we observe their requests not to use information still subject to review and revision.

The number of persons and agencies to whom we are indebted is simply too great to permit individual acknowledgements. Responsibility for the conclusions is, of course, our own.

The study was carried out under the overall direction of Dr. James A. Crutchfield, Professor of Economics and the Graduate School of Public Affairs. Materials on the physical and biological oceanography of Puget Sound were prepared by Dr. George Anderson and Dr. T. Saunders English of the Department of Oceanography. Analysis of the important salmon and shellfish resources of Puget Sound was carried out under the direction of Dr. Ernest Salo. Projections of economic and population growth were prepared by Dr. Robert Bish, Department of Economics and the Graduate School of Public Affairs. The material on other recreational uses of

Puget Sound water was assembled by Mr. Marshal Enderby, under the direction of Dr. Crutchfield. Professor Francis Bartlett of the College of Engineering was responsible for the material on shipping. The discussion of pollution loading and the estimates of assimilation capacity were provided by Dr. Brian Mar of the College of Engineering and Dr. Max Katz of the College of Fisheries. The legal analysis was the work of Mr. Norman Maleng, Attorney at Law, with assistance from Professor Ralph Johnson of the School of Law at the University of Washington.

CHAPTER I

PHYSICAL FACTORS AND PHYTOPLANKTON PRODUCTION IN THE MAIN BASINS OF PUGET SOUND

This chapter will summarize information on regional differences in the primary productivity of the open waters of Puget Sound and the factors responsible for these differences. Primary productivity is herein defined as the production of organic matter by photosynthesis of the phytoplankton, and is basic to many of the most significant economic values derived from Puget Sound. It will be shown that physical factors play a larger role in regulating production in these waters; therefore regional physical descriptions will be emphasized.

To begin this phase of the study, survey was made of the literature and of research carried out by other individuals and groups representing private corporations and state and federal agencies. The results would be too voluminous to report here, but will be kept on file at the University of Washington. Pertinent literature references and summaries of research activities of specific individuals or groups will be discussed under certain relevant topics. Of the many studies carried out and reports issued in the Puget Sound area, only a relatively few were considered significant to the substance of the present discussion. Many of the

studies, useful in themselves for specific purposes or tasks, have contributed little in the way of information that can be built into a theoretical framework for prediction or management purposes, either because the studies were not quantitative or because they did not entail sampling close enough in space or time to identify major factors and processes involved.

I. GENERAL DESCRIPTION OF PUGET SOUND

The most detailed description of Puget Sound available is contained in a three-volume series by the Department of Oceanography, University of Washington.[2] Although it is now out of date, nothing more recent deals with its breadth of topics. The report on "Puget Sound and Adjacent Waters," due to appear late in 1969, may alleviate this problem somewhat, but its purposes are not closely related to oceanography per se. The following summary of part of the University of Washington report will provide information necessary for subsequent discussion.

Puget Sound may be defined as the body of water lying in the northwestern section of Washington State and delineated at its inlets on the north by Admiralty Inlet -- from Middle Point, to Point Partridge, Deception Pass, and Swinomish Slough. The basin is located between two mountain ranges: the Olympics on the west and the Cascade range to the east. To the south the basin extends to the divide between the Chehalis and the Cowlitz River Basins.

The basin drains some 11,000 square nautical miles, with Puget Sound proper covering about 767 square nautical miles. The Sound has many inlets and channels but can be divided into four major areas defined as: the main basin, or northern Puget Sound, extending from Admiralty Inlet to the Tacoma Narrows; southern Puget Sound, from the Tacoma Narrows southward; Hood Canal and Dabob Bay, a narrow western finger of the Sound extending southward from Admiralty Inlet; and a series of waterways to the east of Whidbey Island.

The Sound is connected to the Pacific Ocean by the Strait of Juan de Fuca: about 95 percent of all water entering or leaving the Sound passes through Admiralty Inlet with the other 5 percent flowing through Deception Pass.

Reported geologic history extends from the Tertiary period. It is believed that two lobes from the Cordilleran ice sheet advanced through the Puget Sound Basin during the Pleistocene, deepening the old trunk valleys and carving many of the present features of Puget Sound. The ice advanced some ten to fifteen miles past the southern limits of the present Sound, depositing glacial debris that marks the southern reaches of the Puget Sound Basin. As the ice retreated, the Strait of Juan de Fuca was opened and salt water flowed into the basin.

The climatic conditions of the Puget Sound area result from the local topography, as affected by the general circulation and weather patterns coming from the Pacific Ocean. In general, the area has a temperate marine climate with mild wet winters and cool dry summers. Winter circulation is characterized by an almost continuous flow of warm moist air from the southwest, inland over western Washington. A relatively weak variable circulation is set up from May into September in the Pacific Northwest, with the flow coming from the northwest off the Washington Coast and Vancouver Island.

Since the Cascades afford an effective block to the warm continental summer air and the cold winter air, the Puget Sound region does not usually experience extreme temperature changes during the year. The average January temperature for the lowlands is 38°F., while the warmest months vary from 64° F. in the south to 61° F. in the north alongthe eastern shore of the Sound.

Dense fog is not uncommon in Puget Sound, with Olympia having up to ninety days of fog a year. There is again a southwest-northeast decrease in the number of foggy days in the Puget Sound lowlands. Fog is encountered most frequently from September to November.

Puget Sound is a positive estuary where the input of fresh water from direct precipitation and drinage is larger than the evaporation, resulting in a net outflow of water seaward over a year's time. Streams entering Puget Sound are divided into two types depending upon their peak runoff periods. Those with sources at high elevations are characterized by two peak runoff periods: the first, caused by heavy winter precipitation, lasts from October through March; the second is reached in the spring when warming temperatures melt the year's snowpacks in the higher elevations. Streams originating in lowlands are characterized by a single peak runoff from October to March caused by the heavy precipitation during this period.

The main basin of Puget Sound descends to depths of 600 to 800 feet, and 300-foot depths are not uncommon south of the Tacoma Narrows. A depth of 930 feet is found off Point Jefferson.

The four major sills in Puget Sound approximate the four major areas described previously. A 240-foot sill dividing the Strait of Juan de Fuca from Admiralty Inlet marks the entrance to the main basin, which extends to a 180-foot sill at the Tacoma Narrows. Hood Canal is separated from Admiralty Inlet by another 180-foot sill. The narrow, shallow channel of Deception Pass -- 200 yards wide and 96 feet deep -- imposes the fourth restriction on water entering the Puget Sound area.

The combination of sills, tides, and winds contributes to vigorous mixing. Incoming salt water passing over the sills encounters outflowing fresh water in a mingling that becomes violent when high winds combine with large tidal variations.

The general tidal pattern of the Sound is characterized by two highs and two lows each day, with significant variation in the height of each successive low. Tidal ranges vary from a mean tide range at Port Townsend of 5 feet and a diurnal range of 8 feet, to 11 and 15 feet, respectively, at Olympia. Seattle has a diurnal tide range of 11.3 feet. There is thus a general increase in tidal ranges southward from the Strait of Juan de Fuca. Tidal currents over the sills and through Deception Pass can be strong; velocities have been found of 4.7 knots in Admiralty Inlet, 5.1 knots in Tacoma Narrows, and 7.2 knots in Deception Pass. In the rest of the Sound tidal currents are usually less than one knot.

Overall vertical current patterns indicate a net ebb at the surface and a net flood at depth. This is explained by a net runoff of lighter low-salinity water at the surface which also carries a certain amount of salt picked up in the process of mixing with the more saline water below it. This results in a net outflow of salt which must be compensated for by a net inflow of saline water at greater depths.

Waves in Puget Sound are seldom of greater magnitude than three- or four-foot heights and three second periods. Winds usually blow up or down the Sound and can cover some 35 nautical miles in the main basin and 30 nautical miles in Hood Canal and Dabob Bay with little interference or obstruction. Where tidal currents and waves meet, a choppy sea may develop.

Puget Sound is greatly affected by the waters of the Strait of Juan de Fuca/Strait of Georgia system and is influenced by seasonal upwelling off the coast. Gradients of salinity within the main basins are relatively small, with the greatest change in the upper fifty feet. Fresh water enters into the Sound in clouds, most prominently at the river outlets but at times extending over most of the basin surfaces. Thorough mixing occurs at the Tacoma Narrows and Deception Pass and when there are strong tidal currents at Admiralty Inlet. Most of the Sound is a two-layered system (fresh water overriding denser salt water), but at times three- and four-layered systems are found. During July and August, below 200 meters, the yearly salinity maximum occurs in the Strait of Juan de Fuca, reflecting upwelling off the coast of Washington. Minimum salinity values occur in the upper water in February or March as a result of increased precipitation and in July from snow melting in the Fraser River drainage area.

Temperature distribution in Puget Sound in general parallels the salinity distribution. The cold-water source for the Sound is the Strait of Juan de Fuca, where water temperatures of less than 6.5° C. are found below 400 feet from the Pacific to the Green Point-Victoria sill in the summer. The main basin, southern Hood Canal, Port Susan, and Dabob Bay are secondary cold-water sources. This condition results from the fresh outward flow at the surface and the accompanying inward flow at depth, pushing the colder water in front of it. These secondary cold-water reservoirs range in temperature from approximately 10° to 8° C. The Sound south of the Tacoma Narrows is quite rapidly flushed, and extensive mixing takes place over the Narrows sill.

Heat is usually trapped in surface waters where mixing is at a minimum. The highest summer temperatures, found in the southern end of Hood Canal, range from 17° to 20° C. Elsewhere temperatures above 15° C. are rare. The top fifty feet have the largest temperature gradients, with relatively little change at greater depth.

In winter the range decreases, approaching isothermal conditions. The greatest temperature gradients are again above fifty feet, with a variation of only 1° C. or so below this level. During February the main basin is cooler than Dabob Bay -- 9.6° C. versus 9.2° C. -- indicating that flushing is proceeding at a faster

rate in the former. Off Point Jefferson the water column shows a temperature peak at depth during September -- 11.2° C. at 800 feet. The March minimum averages about 8° C. for the whole water column.

The density of Puget Sound water closely follows the temperature-salinity profiles upon which they are based. In summer a fairly well stratified system is set up due to an increase in salinity and a decrease in temperature with depth. For the most part this system breaks down only at the major sills. Slopes of the density gradients confirm the direction of flow in the Sound: outward on the surface and inward at depth. Because of sufficient density stratification to prevent vertical mixing in the basins, deep water must on the whole be replaced by dense incoming water. The high-density water found in the Strait in September causes a rapid flushing of the Sound.

Winter density conditions resemble those of summer except for higher density values in the basins. Vertical stability is also reduced in winter, mainly as a consequence of surface cooling. As a result of lower density gradients in the Strait of Juan de Fuca in winter, the lateral gradients across the sills are also less.

II. REGIONAL HYDROGRAPHY AND PRIMARY PRODUCTION

This section will summarize characteristics of three basins of the Sound: Hood Canal and Dabob Bay; the area south of the Tacoma Narrows; and the northern Sound from the Tacoma Narrows to Admiralty Inlet. The series of waterways east of Whidbey Island are not discussed in equal detail, because of both the diversity of environment and the lack of sufficient time-series investigations in these waters to allow generalizations.

Information on conditions in the southern and northern Sound comes largely from a study entitled "Annual Phytoplankton Production in Puget Sound Waters," directed by G. C. Anderson. This is a continuing study, begun in 1963, with support from the Public Health Service and presently funded by the Federal Water Pollution Control Administration. The Municipality of Metropolitan Seattle is engaged in an extensive and continuing monitoring program on conditions near the West Point Sewage Treatment Plant outfall and in Elliot Bay which is providing valuable information on nutrient conditions and phytoplankton production. R. E. Westley, State Shellfish Laboratory, Quilcene, has conducted important investigations on hydrography and phytoplankton production in bays of Puget Sound in relation to production and conditions of oysters. These results appear in various contributions from the Washington State Department of Fisheries.[3] Information on Hood Canal has been taken largely from

the work by Barlow[4] and Larrance[5] and unpublished work by the Department of Oceanography of the University of Washington.

A. HOOD CANAL

Time series of seasonal phytoplankton changes have been made in the main body of Hood Canal (Barlow, 1958) and in Dabob Bay (Larrance, 1964). In these areas, near-surface waters become stratified in spring and summer due to surface runoff and heating at the surface. At the time of stratification in February or March, two critical factors for phytoplankton development become favorable: light and nutrient concentration. Incident radiation increases rapidly during spring, and stratification assures that the phytoplankton population will be held near the surface where light is available. Nutrients are abundant from the mixing and flushing of waters during winter. As a result a large spring phytoplankton bloom occurs in this area of the Sound. However, the bloom rapidly depletes the nutrient concentration, especially nitrate, and in April the phytoplankton production declines and remains lower the remainder of the year. Lesser blooms may occur during times of nutrient increase brought about by increased mixing or intrusions of new water. Nutrients are returned to surface waters in late autumn, when stability decreases due to mixing and flushing of the basin, but light is by then unfavorable for growth. Thus, productivity from spring to autumn is controlled by the supply of nutrients to the upper lighted layers. Adequate data are not available to compute annual production in Hood Canal, but it is probably lower than in the southern and northern basins.

B. SOUTHERN SOUND

In the main basin of the southern Sound, vigorous vertical mixing is typical the year around. At times, stratification may exist for short periods and a weak gradient in salinity with depth may be present, but apparently vigorous tidal flushing of the basin and mixing over the sills are effective in producing at most times a rather uniform distribution of properties.

Phytoplankton growth, as in most regions of Puget Sound, is low in winter due to conditions of low incident radiation. A gradual increase of growth begins in February and reaches a maximum in March. For the most part this maximum value is sustained through the summer and a gradual decrease takes place during autumn. Small pulses may occur during periods of temporary stratification and less vigorous vertical mixing. Annual production is about 250 g C/m^2. Nutrient concentrations decrease somewhat during summer but were never observed to drop to limiting amounts.

Apparently, phytoplankton growth in this area generally reflects the distribution of the annual cycle of incident radiation. Relatively uniform dispersal of algal cells with depth prevents realization of optimal growth of phytoplankton, since the population as a whole is exposed only to the average light intensity within the water column. Only during temporary periods of stratification does light become optimal (when the population is retained in the surface layer). During these times small pulses may occur.

Since vertical mixing is prevalent, the supply of nutrients from deeper waters is abundant.

C. NORTHERN SOUND

In general, temperature and salinity are somewhat similar in both southern and northern Puget Sound. Low surface salinity in both areas from January to April reflects heavy rainfall. However, during parts of spring and summer surface salinity is lower in the north, resulting in periods of high stability made possible by greater river discharge and weaker tidal currents than occur in the south. The periodicity of such stability suggests influence by tides; it has been observed for several years that during high river discharge, in May and June, stability is greatest during periods of low tidal flushing (neap tides) and weakest during high tidal flushing (spring tides). Wind direction and velocity can modify this pattern somewhat by shifting surface layers of low salinity water horizontally and by increasing the vertical mixing.

This pattern of stability has a profound effect on phytoplankton development and is responsible for the high annual production of the area (about 450 g C/m^2). Due to the great depth of much of this area (more than 900 feet in places), stability is necessary for phytoplankton growth since continuous mixing would preclude sufficient average light in a water column of such depth.

In summary, these three major areas of the Sound constitute three quite different hydrographic environments resulting in obvious differences in patterns and level of phytoplankton development. Hood Canal exhibits high productivity during spring, but due to prolonged summer stratification phytoplankton production is severely nutrient-limited for a large part of the year. The value of its annual primary production is not known but probably is lower than that in the southern Sound which, although only intermediate in annual production of the three areas, has the highest nutrient supply to surface water because of vigorous vertical mixing. However, in that area nutrients are not fully utilized by the phytoplankton due to light limitation. The northern Sound ranks among the most productive marine areas in the world in terms of annual primary production because of its periods of strong stability, brief but sufficiently long to produce enormous phytoplankton blooms. The period between nutrient decline and nutrient resupply is short enough that nutrient limitation never becomes a serious restriction.

III. SENSITIVITY TO POLLUTION

It appears that in the main areas of Puget Sound, the open waters are not yet adversely affected by pollution mainly because of high tidal flushing in the north and south Sounds where most pollutants enter from the large cities. Some of the harbors and small bays may be badly polluted, but these instances are usually quite local. It is probably safe to say that at present the marine ecology of the major area of Puget Sound has not changed significantly due to population increase and industrialization. This viewpoint was also expressed recently by a group of marine ecologists assembled at a workshop of the Technical Conference on the Urban Coastal Region of the State of Washington and the Province of British Columbia, December 1968.

It should be emphasized strongly, however, that not only the small bays throughout the Sound but also one of the main areas, Hood Canal, is extremely vulnerable to pollution. Disposal of wastes there could cause a serious problem due to the long period without flushing and the prolonged summer stratification. Also, pollutants in the form of inorganic nutrients supplied to the surface waters could readily result in increased algal growth because of hydrographic conditions discussed earlier in this section. Obviously, extreme care should be exercised in using Hood Canal for substantial waste disposal. The waters of north and south

Puget Sound, due to high tidal flushing, are better able to assimilate wastes, although it is presently difficult to predict safe levels.[6] Certainly, spring and summer periods of intermittent stability in the northern Sound would dictate caution when considering waste discharge. For example, waste accumulations might reach undesirably high levels in surface waters during the periods of strong stratification.

Although location of thermonuclear power plants will be discussed in a later section, one effect of heated discharge on the hydrography of a particular area and its resultant influence on plankton development should be considered here. If sufficient heated discharge were to spread out as a thin surface layer in areas of southern or northern Puget Sound, a condition of prolonged stratification might develop, shutting off the supply of nutrients from below. After an initial stimulus, productivity would decline to low levels. In effect, a situation similar to that in Hood Canal during summer would be developed, so that with regard only to this one point, Hood Canal would appear better suited to receive discharges of thermonuclear plants than are other areas of the Sound. However, dissipation of heat by vigorous mixing of the waters would be low there in comparison to other areas of the Sound.

IV. SIGNIFICANCE OF RIVER DISCHARGE

The role of river discharge in the pattern of basin productivity in Puget Sound is most important. Indeed, if it were not for river discharge, primary productivity over much of the large northern Puget Sound would be very low. Its effect on timing of events in the seasonal cycles of phytoplankton needs no further elaboration. Thus, great caution is indicated in considering any alteration to the Puget Sound drainage basin which would affect the amount of river discharge or the timing of discharge. Changes of this type could conceivably exert greater effects on Puget Sound than any other of man's activities.

V. THE MAJOR ECOSYSTEMS

The various ecosystems which comprise the Puget Sound basin (including the fresh water streams discharging into the Sound) and whose social values are influenced by man's activities are subgrouped as follows:

A. MARINE

The deep areas of tidal exchange are regarded as branches of the Pacific Ocean. These are the feeding and migratory routes of the salmon and steelhead, and the breeding and living areas of the hake and other useful fish. Despite a good deal of information on the chemistry and physics of this system, little is

known of the variations (changes in water quality) which influence these organisms.

Typical of the shallow bays are Port Susan and Samish and Padilla Bays. These relatively shallow inlets, left uncovered by the low tides, are the habitat of oysters, clams, and crabs which are of significant commercial and recreational importance. In addition, many of these shallow bays are at the mouths of rivers which have important runs of salmonids.

The water-quality characteristics of these areas are of interest because the bays become quite brackish at times, with salinity varying during the seasons from a level approaching that of the open ocean to a level of almost fresh water during the winter and spring freshets. Moreover, the temperatures show the greatest fluctuations of any in Puget Sound. Yet valuable associations of animals persist.

Data obtained by careful study of these characteristics may permit forecasts of the effects -- good or ill -- of man's manipulations in other bodies of water in Puget Sound. For example, thermal discharges from nuclear power plants might conceivably be utilized to warm sections of the Sound to a temperature suitable to induce oyster spawning, or might be combined with the nutrients available from domestic effluents and pulping mills to establish a marine aquaculture. On the other hand, adequate foreknowledge could prevent the destruction of whole populations by improper placement of waste discharge.

Certain areas of Puget Sound have as yet undefined characteristics which have made them suitable as spawning and nursery areas for flatfish, herring, and hake. The chemical, physical, and biological characteristics of these areas should be determined with the goal of compensating for certain deficiencies in other areas by the manipulation of waste discharges to make them comparably suitable as nurseries for valuable resident fish, shellfish, and crustacean populations.

B. TIDAL-FLAT/MARSHLAND AREAS

There are certain important tidal-flat/marshland areas in Puget Sound, particularly off the mouths of the Nisqually and Skagit Rivers. These are known to be important spawning and rearing areas for many species of valuable fish and crustaceans, but as yet their functions in this regard are unknown. Knowledge of their relationship to the fish species in Puget Sound and the demonstration of their economically important contribution of biological resources would aid in preventing the indiscriminate development of these areas.

These marshland areas, especially in the Nisqually flats and the Skagit area, are also important way stations to ducks and geese utilizing the Pacific flyway. The loss of these areas would be a serious blow to these birds, which supply an important recreational resource to many western Washington citizens.

C. RIVER ECOSYSTEMS

Several large rivers empty into Puget Sound, affecting the chemistry, physics, and, in some degree, the circulation of its waters. They support five species of salmon and two species of trout -- the steelhead and the cutthroat.

Several of these rivers have been drastically modified -- apparently to the detriment of the salmonids -- by man's activities. A study of the ecological and water requirement of the fish in these streams is important in predicting the future of the very important salmonid populations of Puget Sound.

VI. MAJOR GAPS IN KNOWLEDGE

The gaps in our understanding of Puget Sound (or, for that matter, of estuarine systems in general) are both diverse and numerous. It is not the intent of this report to present an exhaustive list of all these deficiencies; rather we are concerned with the identification of major areas of investigation which would advance our ability to judge and to predict changes within the Sound. This entails research directed toward: (1) a better physical description, with emphasis on circulation of waters within the Sound; (2) comprehensive baseline studies (physical, chemical, and biological) of conditions as they exist

at present; and (3) the development of a theoretical framework utilizing mathematical models to describe quantitatively the interrelations of the major processes involved. Further elaboration on these topics follows.

It would be highly desirable to produce a better comprehensive description of Puget Sound utilizing all of the oceanographic data available at present. The need for such information is constantly increasing with the rapid development in domestic and industrial usage of these waters. Under a project directed by Dr. Clifford A. Barnes, an updated description of Puget Sound is being prepared, based on data from 1932 to the present; new information will be incorporated on a continuing basis and stored on computer punch cards. An atlas of oceanographic conditions within the Sound is also planned. The report of the Puget Sound Task Force on Puget Sound and Adjacent Waters, due to appear in late 1969, is intended to provide a comprehensive description of the water resources of the region.

To make optimal use of the capacity of the waters of the Sound to assimilate wastes, it is necessary to predict the movement of introduced materials by processes of advection and diffusion. This is an extensive and expensive operation which involves consideration of five external factors: (1) amount of fresh water in the system;

(2) amount and location of river runoff; (3) tides; (4) wind; and (5) density differences. Physical oceanographers believe that one approach is to break the Sound into subsections and to analyze each individually in detail. The approach is experimental and undoubtedly requires a great amount of effort. Among the significant questions in this undertaking would be how the Sound might be monitored; what elements should be monitored; and how many stations would be necessary to accomplish this effectively. The same questions arise with respect to biological monitoring.

Comprehensive baseline studies are necessary to measure the future effects of pollution in Puget Sound. There is no substitute for knowledge of prior conditions when dealing with conditions in an area subject to continuing changes in water quality (or to steadily rising abatement and treatment costs). To evaluate future effects of pollution, it is essential to understand the processes involved in the uncontaminated environment. The value of baseline studies has been demonstrated dramatically in the case of Lake Washington: when the Lake quality suddenly deteriorated due to discharge of sewage treatment plant effluents, problem identification and remedial action were greatly facilitated by comprehensive studies which had been carried out prior to 1955. During the Puget Sound Enforcement Action Hearings in 1962 and 1967, deliberations on the effect of pulp mills on the marine ecology of areas of the Sound would have benefited greatly by knowledge

of conditions prior to the beginning of these effluent discharges.

Puget Sound, especially the area off Seattle, is receiving increasing amounts of domestic and industrial wastes. The areas of open water appear to be largely unaffected by pollution, but the recent diversion of treated sewage from Lake Washington to the Sound, coupled with the rising population of the metropolitan area, may have profound effects. Indications are that the changes at first will be small and quite subtle, but sufficient information does not exist for long-range predictions. It would seem imperative to seek all possible information to evaluate further changes in the Sound. This must be in the form of time series studies which include measurement of physical-chemical factors, amounts and kinds of organisms, and physiological condition. The commonly carried out time series studies of bimonthly or even weekly sampling at a single station may not be appropriate for many parts of Puget Sound. Schedules must be planned with due regard to hydrographic conditions, tides, winds, etc., and may entail periods of intensive sampling requiring daily or even hourly observations. The number of stations needed to cover a particular system adequately deserves special investigation.

Some time series studies are already available: for example, the series taken in both the southern and northern areas of the Sound showing (as explained previously) the relation of phytoplankton production to periods of high stability brought about by the tides and river discharge. From these we can now predict reasonably well the timing of blooms over the area. However, suitable time series are not available for large areas of the Sound, including the system of waterways east of Whidbey Island.

Theoretical studies (employing mathematical models) should be carried out. For example, it should be possible to express quantitatively relationships between hydrography, water exchange, nutrients, and primary production. Time series studies would be invaluable in developing the required models and in checking the accuracy of their prediction. The long-term goal is to work toward a numerical model of an organic-matter budget for Puget Sound, based on knowledge of important species of organisms. The role of the organisms in the seabed, both in their nutrient exchange with the overlying water and as fairly sensitive indicators of changing environment, also deserves special emphasis.

These models would increase our understanding of Puget Sound in numerous ways and would give a base for setting up adequate monitoring by predicting the number of stations required and the sampling frequency necessary to cover the major variations.

Finally, a theoretical treatment would point out the important parameters that must be measured and would identify mechanisms that have been neglected or overemphasized. In short, they would greatly improve our capacity to predict changes and would provide an invaluable economizing device in clarifying the kinds of information (and detail) required. Effective estuarine management is critically dependent on data; and sound causal analysis is equally essential if data costs are to be held to manageable proportions.

CHAPTER II

PROJECTIONS OF ECONOMIC ACTIVITY AND POPULATION IN THE COUNTIES SURROUNDING PUGET SOUND FOR 1975 AND 1980

I. ECONOMIC ACTIVITY

Several recent studies have presented economic projections for the State of Washington or areas within the state. This study neither presents completely new data nor simply summarizes previous studies, but rather utilizes one of the best of the previous studies to develop projections of economic activity on the county level for the twelve counties adjacent to Puget Sound for 1975 and 1980. These are presented in Tables 1-5 at the end of this chapter. The basis for these projections is set forth below.

The "Economic Study of Puget Sound and Adjacent Waters" prepared for the Puget Sound Task Force of the Pacific Northwest River Basins Commission by Consulting Services Corporation provided the basic data for the projections presented in this section, with individual industry studies being used where greater detail was needed. The "Economic Study" itself is based on the State of Washington input-output study carried out by Phillip Bourque and others at the University of Washington for the Washington State Department of Commerce and Economic Development. The I-O study utilized field surveys of industries for 1963 and provides more

detail than is available in Census reports. Consulting Services Corporation's study provides detailed economic projections for the area containing the twelve counties adjacent to Puget Sound for 1980, and less detailed projections for 2000 and 2020. Projections of the most important two-digit SIC industries are also provided for three four-county groups. The county groups are the Northern Region (Island, San Juan, Skagit, and Whatcom counties), the Central Region (King, Kitsap, Pierce, and Snohomish countires), and the Western Region (Clallam, Jefferson, Mason, and Thurston counties).

The county-level projections presented in Table 3 of this study were obtained by breaking down the Consulting Services Corporation's four-county group projections to the single county level according to the proportion of employment in each industry in each county. Several important assumptions underlie the CSC projections and those presented in this report, and a brief discussion of the problems involved is presented here to provide some indication of the reliance that can be placed on these economic projections.

Consulting Service Corporation's area-wide projections were made using an input-output matrix combined with independent projections of key industries. The I-O framework has the advantage of taking into account the effects on all industries of a change in output of any one industry, but because it shows a static

picture of interindustry relations at a given point in time, its use in projecting implies that the same proportions of inputs will be used to produce the same output (although at different levels) in 1980 and 1963. This presents a real problem in any economy undergoing technological change. Problems also arise if the prices of the various inputs change relative to one another. Even if there were a way to escape the assumption of fixed coefficients in an input-output matrix, it would be impossible to predict specific technological changes and price changes in the future.

The problem of fixed coefficients in production is further complicated by the assumption (required because of limited data) that the share of each industry in a four-county area and in individual counties remains constant over time. This was modified in the CSC four-county area projects for some natural resource industries where independent industry projections based on supply conditions were available, but no modification was possible <u>within</u> the four-county groups. This assumption of fixed shares per area results from the method used to derive the four-county area and county-level projections. Consulting Services Corporation, in projecting for the three four-county areas, simply divided up state projections in proportion to the percent of employees in each industry in the area, based on employment data published quarterly by the Washington State Department of Employment

Security. To obtain the single-county projections presented in this study, CSC's area projections were broken down to the county level by using state employment data to apportion the four-county area industry output among the counties. As a result, the proportion of each industry per county is projected to remain constant until 1980: an unlikely assumption, but inescapable at present.

Additional caution must be used in interpreting projections for single counties because of their small sizes -- especially those in the Northern and Western regions. A shift, starting, or closing of a single large plant will strongly affect the level of economic activity and perhaps make the projections quite wide of their mark (a striking example was the tremendous impact of the decision to build the Boeing 747 in Snohomish County). This is less likely to happen in the larger four-county area or in entire area projections.

The projections presented in the following tables should, therefore, be viewed with some reservation because of the static assumptions underlying them. In Table 3 one also must take into account the small size of the units. The main justification for these projections is simply that they do indicate present trends as summarized by the best existing studies. To collect detailed county-level data combined with detailed industry projections would involve a great increase in time and effort

with no real assurance that the results would be greatly superior. History teaches only that the future is not likely to duplicate the past -- not what direction the future will take.

For some uses the more detailed industrial classification at the state or regional level is more appropriate than the broader industrial classification projections provided by county in this study. More detailed industrial classifications (to the 3- and 4-digit level) are available for the entire area in the Consulting Services Corporation Study and no use would be served by repreating them here. It is recommended that anyone desiring a more detailed explanation of the input-output analysis underlying these projections also consult the CSC study.

Three sets of tables are presented below. The first group indicates the growth in total output and employment by industry for the entire twelve-county region adjacent to Puget Sound; the second provides projections of output by industry for the North, Central, and Western regions separately; and the third shows industry-output projections for each of the twelve counties. Notes to the tables provide more detailed information on their compilation.

Table 1

Projected Output for Puget Sound Region 1963, 1975, and 1980

Industry	Output (millions of 1963 dollars)		
	1963	1975	1980
Agriculture, forestry, fish, and mining	196.8	242.2	261.1
Food and kindred products	698.4	1081.3	1240.9
Lumber and wood products	413.7	383.7	371.3
Paper and allied products	349.1	584.9	683.1
Chemicals	70.4	118.5	138.6
Petroleum refining	255.9	436.6	511.8
Stone, clay, and glass	92.3	148.9	172.5
Primary metals	118.8	401.1	518.6
Other manufactures	1984.6	4681.8	5805.0
Transportation, communication, and public utilities	615.8	1023.1	1192.8
Wholesale and retail trade	1250.3	1969.7	2269.4
Services	1149.4	1881.2	2185.9
Construction	673.8	1158.1	1359.7
Total	7869.3	14111.3	16710.6

Table 2

Projected Employment for Puget Sound Region 1963, 1975, and 1980

Industry	Employment (thousands)		
	1963	1975	1980
Agriculture, forestry, fish, and mining	23.7	19.8	18.2
Food and kindred products	15.9	18.5	19.5
Lumber and wood products	19.6	11.7	8.4
Paper and allied products	9.4	13.0	14.6
Chemicals	2.3	1.9	1.8
Petroleum refining	1.2	1.3	1.4
Stone, clay, and glass	3.8	4.7	5.1
Primary metals	4.1	6.4	7.3
Other manufactures	101.2	167.7	195.3
Transportation, communication, and public utilities	40.3	37.4	36.2
Wholesale and retail trade	133.7	176.4	194.2
Services	144.0	204.7	230.1
Construction	41.2	50.5	54.4
Total	662.2	728.5	973.0

Table 3

Projected Output by Industry by Four-County Regions for 1963, 1975, and 1980

Industry	Central (millions of 1963 dollars)		
	1963	1975	1980
Agriculture, forestry, fish, and mining	167.8	164.5	163.1
Food and kindred products	578.6	886.3	1014.5
Lumber and wood products	278.8	247.8	234.9
Paper and allied products	229.0	348.6	398.4
Chemicals	67.5	113.7	133.0
Petroleum refining	46.3	58.7	63.8
Stone, clay, and glass	82.2	132.0	152.8
Primary metals	118.6	224.9	269.2
Other manufactures	1949.2	4626.4	5741.3
Transportation, communication, and public utilities	548.2	906.6	1055.9
Wholesale and retail trade	1164.0	1821.1	2094.8
Services	1045.2	1744.1	2035.1
Construction	621.9	1056.7	1237.7
	6897.3	12331.5	14594.4

Table 3 (continued)

Projected Output by Industry by Four-County Regions for 1963, 1975, and 1980

Industry	Northern (millions of 1963 dollars)		
	1963	1975	1980
Agriculture, forestry, fish, and mining	21.2	57.6	72.8
Food and kindred products	73.1	118.4	137.3
Lumber and wood products	51.7	56.7	58.8
Paper and allied products	43.7	89.1	108.0
Chemicals	1.2	2.0	2.4
Petroleum refining	209.6	377.9	448.0
Stone, clay, and glass	9.0	15.4	18.0
Primary metals	0.2	176.1	249.3
Other manufactures	28.0	43.2	49.5
Transportation, communication, and public utilities	41.8	76.1	90.4
Wholesale and retail trade	50.0	102.2	124.0
Services	55.9	83.6	95.2
Construction	33.7	60.0	70.9
Total	619.1	1258.4	1524.6

Table 3 (continued)

Projected Output by Industry by Four-County Regions for 1963, 1975, and 1980

Industry	Western (millions of 1963 dollars)		
	1963	1975	1980
Agriculture, forestry, fish, and mining	7.8	20.1	25.2
Food and kindred products	46.7	76.6	89.1
Lumber and wood products	83.2	79.2	77.6
Paper and allied products	76.4	147.2	176.7
Chemicals	1.7	2.8	3.2
Petroleum refining			
Stone, clay, and glass	1.1	1.5	1.7
Primary metals		0.1	0.1
Other manufactures	7.4	12.2	14.2
Transportation, communication, and public utilities	25.8	40.4	46.5
Wholesale and retail trade	36.3	46.4	50.6
Services	48.3	53.5	55.6
Construction	18.2	41.4	51.1
	352.9	521.4	591.6

Table 4

Projected Output by Industry by County for 1963, 1975, and 1980

Central Region
(millions of 1963 dollars)

Industry	County					
	King			Kitsap		
	1963	1975	1980	1963	1975	1980
Agri.,for.,fish & mining	105.4	164.5	102.4	4.4	103.3	4.2
Food & kindred products	392.0	886.3	687.3	4.1	600.5	7.1
Lumber & wood products	90.6	247.8	76.3	7.2	80.5	6.1
Paper & allied products	43.2	348.6	75.1		65.7	
Chemicals	33.3	113.7	65.6		56.1	
Petroleum refining	15.2	58.7	21.0		19.3	
Stone, clay & glass	57.5	132.0	107.0	1.4	92.4	2.5
Primary metals	83.8	224.9	190.3		159.0	
Other mfgrs.	1788.4	4626.4	5267.6	3.9	4244.7	11.5
Trans.,com., & P.U.	432.5	906.6	833.1	12.3	715.3	23.8
Whsle. & retail trade	856.7	1821.1	1541.8	34.9	1340.4	62.8
Services	800.6	1744.1	1558.9	27.7	1336.0	53.9
Construction	427.6	1056.7	850.9	19.6	726.4	39.0
Total	5126.8	12331.5	11377.3	115.5	9539.7	210.9

Table 4 (continued)

Projected Output by Industry by County for 1963, 1975, and 1980

Central Region
(millions of 1963 dollars)

Industry	County					
	Pierce			Snohomish		
	1963	1975	1980	1963	1975	1980
Agri.,for.,fish & mining	30.1	30.4	30.2	27.2	26.6	26.4
Food & kindred products	130.5	199.9	228.8	52.1	79.8	171.7
Lumber & wood products	99.3	88.2	83.6	81.7	72.6	68.8
Paper & allied products	68.5	104.2	119.1	117.4	178.7	204.2
Chemicals	33.4	56.3	65.8	0.8	1.4	1.7
Petroleum refining	31.1	39.4	42.8			
Stone, clay & glass	11.3	18.1	20.9	12.0	19.3	22.4
Primary metals	33.8	64.1	76.7	0.9	1.8	2.2
Other mfgrs.	89.7	212.8	264.1	67.2	159.6	198.1
Trans.,com., & P.U.	64.4	106.5	124.1	38.9	64.4	75.0
Whsle. & retail trade	188.6	295.1	339.4	83.8	131.1	150.8
Services	155.2	295.0	302.2	61.1	102.0	119.1
Construction	101.3	172.2	201.7	73.4	124.7	146.0
Total	1038.1	1646.2	1899.4	616.5	962.1	1106.0

Table 4 (continued)

Projected Output by Industry by County for 1963, 1975, and 1980

Northern Region
(millions of 1963 dollars)

Industry	County					
	Island			San Juan		
	1963	1975	1980	1963	1975	1980
Agri.,for.,fish & mining	0.2	0.5	0.6	0.7	2.0	2.5
Food & kindred products				0.4	0.7	0.8
Lumber & wood products	0.7	0.8	0.8	0.2	0.3	0.3
Paper & allied products						
Chemicals						
Petroleum refining						
Stone, clay & glass						
Primary metals						
Other mfgrs.	0.5	0.8	0.9	0.3	0.4	0.5
Trans.,com., & P.U.	2.4	4.4	5.2	1.1	1.9	2.3
Whsle. & retail trade	4.1	8.4	10.2	0.8	1.6	1.9
Services	4.9	7.4	8.4	2.5	3.7	4.2
Construction	0.7	3.8	0.9	0.4	1.7	0.4
Total	15.0	26.0	30.6	6.9	12.3	14.5

Table 4 (continued)

Projected Output by Industry by County for 1963, 1975, and 1980

Northern Region
(millions of 1963 dollars)

Industry	County					
	Skagit			Whatcom		
	1963	1975	1980	1963	1975	1980
Agri.,for.,fish & mining	6.7	18.3	23.1	13.6	36.9	46.6
Food & kindred products	39.5	63.9	74.1	32.2	53.7	62.3
Lumber & wood products	30.3	33.3	34.5	20.5	22.5	23.3
Paper & allied products	10.9	22.3	27.0	32.8	66.8	81.0
Chemicals	1.0	1.6	1.9	0.2	0.4	0.5
Petroleum refining	157.2	283.4	700.1	52.4	94.5	112.0
Stone, clay & glass	4.2	7.1	8.3	4.9	8.3	9.7
Primary metals	0.1	58.1	82.3	0.1	117.9	167.0
Other mfgrs.	12.2	18.9	21.7	14.9	23.0	26.4
Trans.,com., & P.U.	14.0	25.4	30.2	24.4	44.4	52.7
Whsle. & retail trade	17.6	36.0	43.6	27.5	56.3	68.3
Services	18.1	27.0	30.7	30.5	45.6	51.9
Construction	9.1	16.2	19.1	21.5	38.2	45.2
	320.9	611.5	732.5	276.5	608.6	746.9

Table 4 (continued)

Projected Output by Industry by County for 1963, 1975, and 1980

Western Region
(millions of 1963 dollars)

Industry	County					
	Clallam			Jefferson		
	1963	1975	1980	1963	1975	1980
Agri., for, fish & mining	1.2	3.2	1.0	0.5	1.0	1.2
Food & kindred products	5.0	8.1	9.4			
Lumber & wood products	34.3	32.7	32.0	4.7	4.4	4.3
Paper & allied products	76.4	147.2	176.7			
Chemicals						
Petroleum refining						
Stone, clay & glass	.2	0.3	.3			
Primary metals						
Other mfgrs.	.4	0.6	.7	2.6	4.2	4.9
Trans., com., & P.U.	8.8	13.7	15.8	1.3	2.1	2.4
Whsle. & retail trade	10.0	12.8	14.0	2.0	2.5	2.7
Services	14.5	16.1	16.7	1.9	2.1	2.2
Construction	3.8	8.7	10.8	4.2	9.6	11.9
Total	154.6	243.4	280.4	17.2	26.0	29.6

Table 4 (continued)

Projected Output by Industry by County for 1963, 1975, and 1980

Western Region
(millions of 1963 dollars)

Industry	County					
	Mason			Thurston		
	1963	1975	1980	1963	1975	1980
Agri.,for.,fish & mining	4.4	11.3	14.2	1.8	4.6	5.8
Food & kindred products	1.7	2.8	3.2	40.1	65.7	76.4
Lumber & wood products	21.6	20.6	20.2	22.6	21.5	21.1
Paper & allied products						
Chemicals				1.7	2.8	3.2
Petroleum refining						
Stone, clay & glass	0.1	0.1	0.1	0.8	1.2	1.3
Primary metals						
Other mfgrs.	1.8	3.0	3.5	2.6	4.4	5.1
Trans.,com., & P.U.	1.8	2.8	3.2	13.9	21.8	25.1
Whsle. & retail trade	3.8	4.9	5.3	20.5	26.2	28.6
Services	4.7	5.2	5.4	27.1	30.0	31.2
Construction	1.4	3.2	3.9	8.7	19.9	24.5
Total	41.3	53.8	59.0	139.8	198.0	222.3

Table 5

Standard Industrial Classification Numbers

for Industry Groups Used

Industry	SIC
Agriculture, Forestry, Fisheries, and Mining	01-04
Food and kindred products	20
Lumber and wood products	24
Paper and allied products	26
Chemicals	28
Petroleum refining	29
Stone, clay, and glass	32
Primary metals	33
Other manufactures	19, 21, 22, 23, 25, 27, 30, 31, 34-39
Transportation, communication, and public utilities	40-49
Wholesale and retail trade	50-59
Services	60-67, 70-89
Construction	90-94

II. POPULATION

Several population projections have been made for the State of Washington and the Puget Sound area. This presentation will compare two separate projections: those of the Washington State Census Board, based on the cohort-survival technique; and those of Consulting Services Corporation, based on the number of employees needed to carry out projected economic activity.

The cohort-survival is one of the more sophisticated and expensive techniques available for population projections. Detailed historical data on age- and sex-specific base population, mortality, fertility trends, and migration trends are used to project the three components of population change -- fertility, mortality, and net migration -- from which population projections are derived. The main disadvantage of the cohort-survival technique from an economist's point of view is that it fails to recognize economic variables and thus implies that future economic patterns -- especially as they affect migration -- will be identical with those when the historical demographic data were compiled. The population projections for the twelve counties adjacent to Puget Sound as derived by the Washington State Census Board via the cohort-survival technique are presented in Table 6.

Table 6

Population Trends and Forecasts for 1965, 1975, and 1980

Area and County	1965 High	1965 Medium	1965 Low
Central Region			
King	1,040,787	1,024,048	1,007,294
Kitsap	90,174	89,443	88,694
Pierce	356,946	352,105	347,243
Snohomish	205,040	198,285	191,515
Total	1,692,938	1,663,833	1,634,708
Northern Region			
Island	23,962	23,050	22,120
San Juan	2,925	2,895	2,846
Skagit	55,750	55,093	54,415
Whatcom	74,428	74,048	73,655
Total	157,063	155,057	153,039
Western Region			
Clallam	32,254	32,035	31,797
Jefferson	9,983	9,897	9,790
Mason	17,317	17,187	17,029
Thurston	60,689	60,003	59,301
Total	120,243	119,118	117,917
Total All Cases	1,970,244	1,938,008	1,905,664

Table 6 (continued)

Population Trends and Forecasts for 1965, 1975, and 1980

Area and County	1975		
	High	Medium	Low
Central Region			
King	1,305,673	1,229,194	1,152,697
Kitsap	106,690	102,849	98,989
Pierce	446,762	423,703	400,621
Snohomish	286,860	260,808	234,745
Total	2,145,588	2,016,030	1,886,456
Northern Region			
Island	34,316	30,814	27,295
San Juan	3,206	3,050	2,877
Skagit	67,319	64,260	61,188
Whatcom	86,189	83,680	81,152
Total	191, 028	181,776	172,509
Western Region			
Clallam	38,567	37,272	35,960
Jefferson	11,371	10,889	10,391
Mason	20,316	19,568	18,802
Thurston	75,159	71,806	68,434
Total	145,413	139,532	133,587
Total All Cases	2,482,029	2,337,338	2,192,552

Table 6 (continued)

Population Trends and Forecasts for 1965, 1975, and 1980

Area and County	1980		
	High	Medium	Low
Central Region			
King	1,469,097	1,355,544	1,241,973
Kitsap	116,075	110,405	104,714
Pierce	501,976	467,683	433,375
Snohomish	336,926	299,174	261,401
Total	2,423,379	2,231,967	2,040,541
Northern Region			
Island	40,453	35,414	30,364
San Juan	3,368	3,145	2,902
Skagit	74,388	69,871	65,331
Whatcom	93,146	89,347	85,534
Total	211,340	197,742	184,124
Western Region			
Clallam	42,349	40,398	38,434
Jefferson	12,279	11,562	10,826
Mason	22,160	21,048	19,912
Thurston	82,760	78,763	73,746
Total	160,548	151,771	142,918
Total All Cases	2,795,267	2,581,480	2,367,583

The population projections presented in Consulting Services Corporation's "Economic Study of Puget Sound and Adjacent Waters" were derived by a completely different technique. Beginning with projected economic output for 1980 and allowing for productivity increases, CSC calculated the number of employees required to carry out the economic activity as forecast. After allowing for unemployment (4 percent), labor force participation ratios were used to estimate total population for each four-county area and for the entire Puget Sound region. The disadvantage of population projections based on projected economic output is that no consideration is given to demographic variables -- in effect implying that fertility, mortality, and migration (especially migration) will adjust to economic activity. The Consulting Services Corporation population projections are presented in Table 7.

A comparison of the dual projections indicates that for two of the three regions the CSC projections fall within the high and low Census Board projections. CSC projections are slightly above the Census Board low projections for the Northern region and slightly below the Census Board's high projection for the Central area. The CSC projection for the Western area is considerably below (14.3 percent) the Census Board's low projection.

Table 7

Population Projections by Four-County Region

For 1963, 1975, and 1980

Region	1963	1975	1980
Central	1,603,000	2,179,000	2,418,900
Northern	151,000	175,400	185,500
Western	116,000	120,600	122,500
Total	1,870,000	2,475,000	2,726,900

Population and economic activity in a specific area are probably causally related in both directions; thus, ideally, the same projection model should include both economic and demographic variables so that they simultaneously affect one another. No attempt at reconciliation of the two different population projections will be attempted in this review, although casual observation would indicate that the best-guess projections lie between the low and medium Census Boards for Northern counties, between medium and high Census Board projections for Central counties, and close to the low Census Board projection for the Western counties.

CHAPTER III

THE LIVING RESOURCES OF PUGET SOUND AND THEIR USES: THE COMMERCIAL FISHERIES

As indicated in Chapter I, the waters of Puget Sound and its tributary streams are rich in living matter. The commercially important species are, however, relatively limited in number. A recent study of the economic value of the fisheries of Washington indicated that salmon accounted for more than 80 percent of the value of Puget Sound landings while another 17 percent was contributed by shellfish -- oysters, crabs, and clams.[7] Virtually all of the remainder is taken by a small trawl fishery for sole, flounders, and other demersals.

Total employment directly related to the commercial fisheries of Puget Sound is simply impossible to estimate precisely. Latest published figures[8] show 4,800 fishermen in the Puget Sound district, but few of these devote full time to fishing, and an undetermined proportion of the fishing time of these men is spent in areas other than Puget Sound. A rough estimate would place the full-time equivalent employment in the fisheries of the Sound at 2,000 with another 6,000 men in secondary employment in processing and marketing firms directly dependent on Puget Sound landings.

I. SALMON

A. THE FISHERY[9]

The Puget Sound salmon fishery is based on annual runs of five species of mature salmon that pass through the Strait of Juan de Fuca and Puget Sound on their way from ocean feeding grounds to spawning areas on the coast of Washington and British Columbia. Virtually all of the sockeye or red salmon taken in this fishery spawn in the Fraser River system; all of the others -- pink, chum, coho, and chinook -- originate in other rivers emptying into Puget Sound as well as the Fraser. The fish are taken along their entire migration route in both Canadian and U. S. waters (see Map 2). In addition, chinook and coho salmon are subjected to an intensive troll fishery in the open ocean and at the mouth of the Strait of Juan de Fuca. Chinock and coho salmon (and, to a lesser extent, the pinks) are also the object of a major sport fishery extending from the ocean feeding grounds throughout the Strait and Puget Sound areas. The fishery is characterized by a peculiar annual distribution of the runs. Although the sockeye and pink salmon are the most important species, the latter is available only in odd-numbered years. For reasons not clear to biologists, no runs can be expected in even-numbered years despite intensive efforts to establish them in rivers that produce excellent catches in odd years.

Map 2

Commercial Salmon Fishery Areas Of Puget Sound

Source: Washington State Department of Fisheries

The conditions under which the various species of salmon enter the commercial fishery and move through to their spawning streams play a major part in determination of the activities of both the industry and the regulatory agencies. The Puget Sound fishery, like that of Alaska, is confined to a limited period of time in each area through which the fish pass. One factor of major concern is the variability in timing of entry into the fishery and the subsequent peak runs in the several regulatory areas, which may vary by several weeks from year to year. This is caused in part by fluctuations in oceanographic conditions and in part by the complex racial composition of some major species. Though almost all sockeye are Fraser River fish, for example, the "Fraser River run" actually comprises a number of distinct stocks or races that spawn in the five major lake systems, and a larger number of minor ones within the Fraser River drainage. Since each race has its own migration pattern, variations in the relative size of each group alter the timing of the run as a whole. Fluctuations in the timing of the other species are even greater, since they depend not only on Fraser River fish but on those of many other spawning streams spread over a rather wide geographic area. Similar variations exist in the time of travel through the Strait and Puget Sound areas and -- most important -- the estuarine areas at the mouths of the spawning streams.

The significance of these variations, which collectively can produce very substantial deviations from mean values, is accentuated by the dispersion of fishing gear over the entire area in question. Three major types of gear are employed -- purse seines, gill nets, and reef nets. Since the effectiveness of each gear type depends on different conditions, they are typically fished in overlapping but somewhat separate subareas. Consequently, variations in the timing of arrival of runs and in travel time through the fishery, will alter the composition of the catch by gear and the aggregate technical efficiency of the combined fleets.

The relatively long exposure, geographically and temporally, of the salmon to the Puget Sound fishery and the multinational character of the industry lend particular importance to the matters of timing discussed above.

In several important respects the setting of the Puget Sound salmon fishery confronts both industry and regulatory authority with unique problems. From the very outset the salmon industry has faced a formidable set of competing water users in rivers, estuaries, and bays. As indicated below, the activities of the forest-product industries and of agriculture, and the concentration of rural and urban populations along the spawning rivers and at their mouths, have altered the ecology of the Puget Sound river systems in many ways, most of them detrimental

to the highly sensitive salmonids. While only a few of the rivers have yet been developed for hydroelectric power production, some flood control projects have already contributed to the decline of the salmon runs. The most serious effect, according to competent biologists, has been the relentless destruction of small spawning creeks by urban construction and the rising tide of municipal and industrial pollution.

Apart from the discouraging portent of these factors for the long-run future of the salmon runs, they complicate enormously the research effort required to link fishing effort to long-term productivity. At our present (and prospective) levels of knowledge, it is simply impossible to disentangle the separate effects of changes in habitat and environment and changes in the level and composition of fishing effort on the salmon stocks of Puget Sound and the Fraser River system.

A detailed analysis of the salmon regulations of the International Pacific Salmon Fisheries Commission and of the State of Washington is beyond the scope of this paper. One element that is of direct significance is the reservation of certain waters as salmon preserves. These areas are shown in Map 3. Details of the regulatory program and an assessment of its effectiveness are set forth by Crutchfield and Pontecorvo (1969).[10]

Map 3

Salmon Preserves in Puget Sound

Source: Washington State Department of Fisheries

B. STATE OF KNOWLEDGE

A substantial body of scientific literature exists on the ecology of salmonids and the status of their stocks. An annotated bibliography of such information relating to Puget Sound estuaries gathered by C. D. Becker under the terms of a grant from the National Institute of Health, U. S. Public Health Service, is on file with other background documents used in this study.[11] The Technical Committee of the Pacific Salmon Interagency Council also has compiled an excellent status report of the salmon resources in Washington. The Fisheries Research Institute of the University of Washington is presently compiling a compendium of allavailable literature on salmon. This includes microfilm copies of all articles and a retrieval system by topic. At the present time the literature has been assembled through 1959.

Complete and consistent time series are included in the Washington State Department of Fisheries Annual Reports. These contain the adult escapements of chum, silver, pink, and chinook salmon to the various hatcheries as well as periodic information on index areas for streams which do not contain hatcheries.

For the purposes of this report it suffices to note that: (1) abundant published literature and other assembled information is available on the status of the stocks of the Puget Sound salmon; (2) the data are quite reliable and are becoming increasingly comprehensive; (3) in some cases the information is sufficient for management of the stocks; (4) gaps exist in some instances permitting variances in interpretations -- particularly in the case of chinook salmon; and (5) forecasting needs to be improved.

Although the reports of recent years are complete, the status of the stocks at the time of initial exploitation is not clear. For example, some scientists claim that most chinook runs in southern Puget Sound resulted from introductions and that the only truly indigenous stock is the one in the Skagit. Recent research, however, supports the belief that chinook salmon were originally present in most of the watersheds of Puget Sound, although in far smaller supply than in the Columbia and Sacramento Rivers. The larger rivers in the southern part of Puget Sound such as the Nisqually, Puyallup, the Green, the White, and the Cedar probably all contained fall chinook salmon and some may have supported spring and summer-run chincoks. Egg-taking stations were established on the Green and the White as early

as 1900;[12] their compiled and intact records date back to 1903. It is unlikely that any runs introduced by man could have supported egg-taking stations at that time.

Changes brought about by man, with the aid of natural phenomena, have resulted in major alterations of watersheds. Some of the most drastic of these changes occurred in the Green River and Lake Washington drainages. The Green-Duwamish system originally drained an area exceeding 1,600 square miles, including the watersheds of the White, Green, Black, and Cedar Rivers, and the Lake Washington basin. At the beginning of the present century, the White River flowed into the Green River immediately above Auburn; the Black River drained Lake Washington, flowing from its southwest corner through what is now the Renton airport and entering the Green River near Tukwila; the Cedar River flowed through the present site of Renton and joined the Black River before its confluence with the Green. A severe flood in 1906 diverted the White River into the Stuck River and the Puyallup system. The diversion was made permanent by construction of a concrete dam and subsequent filling of the dry channel; the drainage area of the Green-Duwamish was thereby reduced by 870 square miles.

Negotiations were under way at this time for the construction of a canal leading from Lake Union, then unconnected to Lake Washington, to Salmon Bay in northwest Seattle. The United States Congress provided authorization and $2,275,000 in funds for the initial construction of the canal in the River and Harbor Act of June 1910. Plans included provisions for construction of a double lock in the canal, dredging of a deep passageway from the locks to Puget Sound, and excavation of another canal from Lake Union into Lake Washington. The Government Locks and the Lake Washington Ship Canal, as they are now known, were opened in 1916; the level of Lake Washington was subsequently lowered about eight feet, so that its waters no longer flowed down the Black River into the Duwamish. The Cedar River was diverted into Lake Washington, and the dry channel of the Black River was filled soon after. These geographical modifications reduced the Green-Duwamish drainage basin from 1,600 to its present 474 square miles. The effects of these changes upon the salmon stocks have not been documented.

The bulk of the catch in the Puget Sound district consists of sockeye and pink salmon which are primarily under regulation and management by the International Pacific Fisheries Commission in established United States and Canadian convention waters. Non-Indian

fisheries for sockeye and pink salmon of convention waters are under management of the Washington Department of Fisheries. The southern limit of United States convention waters in Puget Sound corresponds to the "Initiative 77 line" established in November 1934. This line may be described generally as beginning at Angeles Point (near the mouth of the Elwah River), extending easterly to Partridge Point on Whidbey Island and, in effect, along the northwestern shore of Whidbey Island to longitude 122° 40' west, and thence northerly along this line of longitude. In the Puget Sound district, Initiative 77 eliminated over two hundred salmon traps, specified the types of gear which could be fished inside the line, and authorized the Director of Fisheries to establish regulations for this area, and if necessary to shorten the commercial fishing season. The history of commercial fishing seasons, deadlines, preserves, and gear regulations is far too complex to summarize briefly. Generally, these management tools have been used to implement the best available judgment of a proper balance of catch and escapement for a sustained yield, but they have not dealt with economic efficiency factors affecting the industry under regulation.[13]

Puget Sound salmon runs have been augmented by means of ten hatcheries, one egg-taking stations, and two saltwater rearing

stations. In 1964, thirty-four controlled natural rearing (nursery) areas for juvenile salmon were also in production or under development. A number of these have been discontinued, however, because it developed that the need for artificial diet supplements and the implementation of sophisticated disease control cancelled out the hoped-for economic advantages of the so-called "natural areas" over conventional hatchery systems.

C. INDIVIDUAL SPECIES

Figures 1, 2, and 3 show in graphic form the history of salmon catches in Puget Sound waters. The same information, in tabular form, is contained in Table 8.

Sockeye. Much the most important component of the Puget Sound commercial salmon fishery, in value terms, is provided by the sockeye runs. The Fraser River is the major producer of sockeye salmon for the United States commercial fishery inside Cape Flattery. Runs to the Skagit River and to the Lake Washington drainage have been comparatively insignificant. However, in the last year or two, a substantial increase in the number of sockeye produced by the Lake Washington drainage has led to the opening of a new fishery.

The dominant Fraser River runs are shared on equal terms by American and Canadian fishermen. The sockeye fishery very nearly disappeared in the early part of the century,

Figure 1

Total United States Commercial Catch of Salmon in Puget Sound 1913-1968

Source: Washington State Department of Fisheries

Figure 2

United States Commercial Catch of Pink Salmon in Puget Sound 1913-1967 (odd years only)

Source: Washington State Department of Fisheries.

Figure 3

United States Commercial Catch of Sockeye, Silver, Chum, and Chinook Salmon in Puget Sound, 1913-1968

Source: Washington State Department of Fisheries

Table 8

Catch by Species, Puget Sound, 1913-68[a]
(thousands of fish)

Year	Chinook	Chum	Pink	Silver	Sockeye	Total
1913	290	605	15,908	1,225	21,599	39,627
1914	426	1,686	75	1,499	3,451	7,138
1915	301	1,884	7,369	1,109	804	11,467
1916	301	1,884	68	1,109	804	4,167
1917	441	1,095	13,345	936	4,962	20,779
1918	477	1,157	78	1,638	561	3,911
1919	348	1,475	4,668	1,363	747	8,601
1920	218	683	20	569	653	2,197
1921	269	270	4,402	762	1,135	6,838
1922	208	502	32	892	506	2,141
1923	225	638	5,534	887	482	7,766
1924	246	860	100	947	747	2,899
1925	284	535	6,665	869	1,243	9,596
1926	253	1,064	24	703	432	2,476
1927	288	527	6,526	1,029	988	9,357
1928	243	1,044	9	761	609	2,666
1929	312	1,486	7,433	807	1,248	11,286
1930	280	1,011	17	575	3,327	5,121
1931	208	682	8,132	513	723	10,258
1932	180	1,092	9	457	819	2,556
1933	211	504	6,040	536	1,575	8,866
1934	209	867	13	451	2,648	4,189
1935	76	719	4,994	577	535	6,901
1936	79	783	6	247	452	1,567
1937	93	774	4,168	348	870	6,253
1938	58	802	8	321	1,408	2,598
1939	61	331	3,946	359	548	5,244
1940	71	565	5	261	652	1,554
1941	72	673	1,452	276	1,548	4,020
1942	42	644	2	180	2,923	3,791
1943	57	396	757	218	196	1,624
1944	68	320	4	299	326	1,018
1945	88	421	5,769	389	718	7,375
1946	62	1,251	-	206	3,100	4,619
1947	37	595	9,274	469	76	10,451

Table 8

Catch by Species, Puget Sound, 1913-68[a] (continued)
(thousands of fish)

Year	Chinook	Chum	Pink	Silver	Sockeye	Total
1948	41	941	-	371	922	2,275
1949	52	440	6,755	426	909	8,581
1950	46	887	10	606	1,217	2,766
1951	52	796	5,393	423	1,129	7,793
1952	60	773	2	654	1,114	2,601
1953	59	346	5,360	342	1,961	8,067
1954	59	423	-	214	4,758	5,454
1955	57	212	3,838	300	934	5,313
1956	46	105	-	409	900	1,461
1957	49	103	2,986	294	1,689	5,121
1958	50	421	3	352	5,255	6,081
1959	55	361	2,427	348	1,808	4,999
1960	65	135	-	104	1,191	1,495
1961	81	133	688	384	1,378	2,664
1962	48	174	-	414	754	1,391
1963	94	295	5,672	233	1,315	7,609
1964	75	247	-	402	463	1,188
1965	96	192	624	405	1,023	2,340
1966	102	402	-	634	1,339	2,477
1967	99	272	3,697	288	2,095	6,450
1968	108	464	289	450	901	1,924

[a]Puget Sound includes U.S. waters inside and east of Neah Bay. Cape Flattery seine, gill net, and troll catches are excluded from this table.

Source: Annual Reports, State of Washington, 1960-68, Department of Fisheries(1960 issue contains historical summary).

and its resurgence is due largely to the successful research and management program of the International Pacific Salmon Fisheries Commission.[14] The stocks are now well established, and -- barring a major change in British Columbia policy toward development of the Fraser River -- the fishery should continue indefinitely at or slightly above its present catch level.

Since a very high proportion of the United States catch of sockeye in Puget Sound is made up of Fraser River fish, it is not particularly vulnerable to water-quality and land-use problems in Puget Sound. Moving through the Straits and Sound fairly rapidly, the mature fish are unlikely to rest in any given area long enough to be threatened by existing or prospective water quality problems along their migration routes until the estuary of the Fraser is reached. Less is known of the possible pollution dangers to young sockeye as they emerge from their lake environment into salt water.

Because of the intensive management program, knowledge of the Puget Sound and Fraser River stocks is unusually complete; and the IPSFC, with its own research staff, continues to refine that knowledge and to improve the efficiency of its management program.

Chinook. The Fraser and Skagit Rivers, together with ten hatcheries maintained in the Puget Sound region by Washington State Department of Fisheries, are the major producers of chinook salmon. The history of the commercial catch (Figure 3) shows a steady decline from 1915 to 1940 followed by a leveling-off until the present. Meanwhile, the sports catch has surpassed the commercial catch since the year 1949. The major contributing factor in this shift was the enactment of Initiative 77, which resulted in a sharper decline in the commercial catches of chinook than in any of the other four species landed in Puget Sound. Some Puget Sound hatcheries have made significant contributions to the maintenance of chinook runs, although the relative success of the fall rearing program has not yet been fully evaluated, as more than half of the production of the hatcheries are transplanted to streams other than the hatchery stream. The combined commercial and sports catch at present ranges between 200,000 and 300,000 fish, which approximately equals the commercial catch between 1925 and 1930. Thus chinook production in Puget Sound, although not large compared to other species, has held up rather well over the past forty years and recently has been augmented by an increase in use of streams in the south Sound area for the production of chinook and a resultant growth in regional recreational fishing.

Prior to 1922, the legal size limit for chinook for the commercial fishery was fifteen inches. An eighteen inch size limit then remained in effect until 1949, when it was increased to twenty-six inches except that chinook between eighteen and twenty-six inches could be kept for canning purposes only. This special provision was rescinded in 1948, and a twenty-six inch size limit has since remained in effect. In 1958, the size limit for the sport fishery in Puget Sound was raised from twelve to sixteen inches.

In the primary commercial net fishery, chinook are only incidentally caught during the major fisheries for sockeye and pink salmon, but they are specifically exploited in Skagit Bay, West Beach, and by the Indian fisheries on the major Puget Sound streams. Landings from Skagit Bay, West Beach, Point Roberts, and the Nooksack and Puyallup Rivers now constitute the bulk of the annual commercial catch.

There are conflicting interpretations on whether the yields are continuing to decline in the net and sport fisheries. "Declining yields" are variously attributed to an increased ocean troll fishery, gradual loss of productive fresh water environment, reduction in commercial fishing areas and seasons, increased minimum size limits in the sport fisheries, and pollution. In addition, reports do not agree on the question of escapements to index areas. Some of the conflicts may be explained by either

the presence or absence of Indian fisheries. Also, there has been a recent trend toward over-escapement to existing Puget Sound hatcheries. A notable success has been achieved in the creation of a chinook run by the laddering of an impassable falls in the Deschutes River near Olympia.

In summary, the total harvest of chinook in Puget Sound has once again reached the harvest of the 1920's and 1930's, at a level of 200,000 to 300,000 fish. The greatest harvest recorded was between 1915 and 1920, with a catch of some 450,000 fish. Thus, the total production has not declined as alarmingly as superficial examination of the figures may suggest. The geographical origins of the stocks and the timing of the runs have been changed, and fall chinook have been substituted for the summer and spring run races.

Chum. Puget Sound streams contribute to the production of chum salmon, although the stocks of the southern and the northern streams appear to respond as separate groups. The principal commercial fishing areas are the San Juan Islands, Point Roberts, West Beach, Skagit Bay, Admiralty Inlet, and the Seattle-Tacoma area.

Chum salmon landings were virtually unaffected by the elimination of traps by Initiative 77; however, the catches have shown a persistent decline since 1915. From 1913-1932, annual catches exceeded one million fish during eleven of the years; since 1932 this figure has been reached only once. Since 1952 the catch has been below 500,000 fish annually and in recent years has fallen well short of this mark. The reduction is apparently common to all areas from Oregon to southeastern Alaska and the causes -- although apparently oceanic -- are unknown.

The short fresh water life history of chum salmon should make it one of the least affected by changes in the fresh water environment. Less than 10 percent of the total annual egg take at Puget Sound hatcheries is of chum salmon, and production from controlled "natural-rearing areas (saltwater lagoons)" has been unsuccessful.

Pink. The major producers of pink salmon for the United States commercial fishery inside Cape Flattery are the Fraser, Skagit, Stillaguamish, and Snohomish rivers. In addition, American fishermen in Puget Sound catch approximately half of the large Fraser River run. Principal non-Indian commercial fishing areas are the San Juan Islands, Point Roberts, West Beach, Skagit Bay, and Port Susan. The Puget Sound streams have runs only during odd-numbered years, and the species has an invariable two year life history.

Since 1913, when the commercial catch was 15.9 million fish, the odd-year catches of pink salmon have shown three periods of decline. The smallest catches were made in 1921, 1943, and 1961, followed by peak catches in 1931, 1947, and 1963. Inside Cape Flattery the 1963 commercial catch was 5.7 million fish and the sport catch 0.4 million. Of the total run of 16.1 million pinks which were estimated to have entered Convention waters, 10.3 million were produced by Puget Sound streams.

Prior to their elimination by Initiative 77 in 1935, traps accounted for about 40 percent of the total catch; therefore, the 1947 catch was a record year for other types of gear in the Puget Sound district. The fishery inside the Initiative 77 line accounted for about 15 percent of the total annual catch from 1935 through 1959 but claimed over 30 percent of the catch in 1961 and 1963. The Indian fishery on the Skagit, Nooksack, Stillaguamish, Snohomish, and Puyallup rivers took an average of 20 percent of the annual commercial catch from 1935 to 1951, but the percentage has increased steadily to 65 percent in 1961.

The declines in abundance of pink salmon have been attributed to overfishing, poor escapements, unfavorable spawning conditions, and relatively poor survival of fry and fingerlings. No positive correlations have been associated with the long-term fluctuations, although some progress is being made on "parent to progeny" runs.

In 1957 Canada and the United States ratified a Protocol to the existing sockeye salmon treaty, and the International Pacific Salmon Fisheries Commission assumed management of the pink salmon fisheries in Convention Waters. In addition, the Protocol required that the two countries conduct a "coordinated investigation of pink salmon stocks which enter Convention Waters for the purpose of determining the migratory movements of such stocks." Reports on this cooperative research program by the IPSFC, Fisheries Research Board of Canada, and the Washington Department of Fisheries have now been published by the IPSFC as Bulletins 15 and 17.[15] The 1959 program was the most intensive program of its type ever carried out on Pacific salmon. More than 53,000 tags were applied along the migration route, 32,000 of which were recovered from the 5.6 million fish examined for tags in the catches and on the spawning grounds. To enumerate escapement to the major streams an additional 52,000 pinks were tagged and over 360,000 carcasses examined for tags.

These tagging programs have provided valuable detailed information on the destination, migration routes, times of passage, catch, and exploitation rates of pink salmon stocks moving through fishing areas adjacent to Convention Waters, migrating to streams located in Convention Waters, and passing through Convention Waters en route to streams in outside areas. Of the 10.3 million pink salmon that entered the joint study area

in 1959, 3.8 million came from the north via Queen Charlotte Strait, and 6.5 million approached via the Strait of Juan de Fuca. Of the total 1959 run, 6.5 million (63 percent) were destined for the Fraser, 2.5 million (25 percent) for other Canadian streams, and 1.3 million (12 percent) for the United States streams.

In Washington, relatively few pink salmon have been reared in hatcheries, and no returns have been obtained from plantings in controlled natural-rearing impoundments (lakes and saltwater lagoons). Attempts to establish even-year runs have been unsuccessful.

Coho. Virtually all streams in Puget Sound contribute to the production of coho salmon. The principal non-Indian commercial fishing areas are the San Juan Islands, Point Roberts, West Beach, Skagit Bay, Admiralty Inlet, Port Susan, and the Seattle area. The fishery, generally peaking during the last week of September, is preceded by peak catches of sockeye and pink. However, the fishing period for coho corresponds quite closely with that for pinks. Coho catches and fishing effort have tended to be somewhat higher on the odd "pink" year and in the dominant four-year sockeye cycle.

Commercial catches have remained relatively constant since enactment of Initiative 77 in 1935, and escapements as indicated by index area counts since 1951 have not yet shown a definite trend. The catch by gear other than traps (which

were outlawed in 1935) has remained at the same general level since 1920, and during this period has only three times exceeded 500,000 fish -- in 1935, 1950, and 1952. The peak catch (1.64 million) occurred in 1918.

In spite of increased fishing intensity, sport catches of both cohos and chinooks have decreased sharply since 1958, when the size limit was changed from twelve to sixteen inches, although the anglers are now getting larger fish for their efforts. A significant increase in the percentage of the total catch taken by the Indian fisheries became especially apparent after 1957.

Outside the "77 line" the bulk of the commercial catch of cohos is taken by purse seines, but during the past ten years gill netters have shown a definite increase in numbers and gear efficiency, and share of catch. Inside the line the harvest is taken primarily by gill nets. Preserves in Bellingham and Skagit Bays can be fished only by gill-net gear, and the Initiative 77 Law does not permit purse seines to fish the inner Sound prior to October 5 (except in Admiralty Inlet during August of odd years), just after the peak of the coho run in "inside 77" areas. From 1935 until 1947 about 60 percent of the total Puget Sound commercial coho catch was taken "inside 77." From 1948 to 1959 the inside fishery averaged about 40 percent of the total; as in the case of chinooks, the inside fishery thereafter resumed its former relative importance.

The fishery for coho stocks native to Puget Sound streams and the Fraser River is jointly exploited by United States and Canadian fishermen but is not regulated by the International Pacific Salmon Fisheries Commission. Since the stocks intermingle in both United States and Canadian waters, there is a lack of management control of the catch and escapement of individual stocks. In 1957 both governments banned high seas net fishing for salmon in the eastern Pacific Ocean, and a provisional line was drawn between Tatoosh Island and Bonilla Point at the extreme western end of the Strait of Juan de Fuca to separate "inside" and "oceanic" waters. This eliminated a rapidly expanding United States net fishery off shore in the Swiftsure area but did not as seriously affect the Canadian catches, since the greater portion of the runs of coho salmon, as well as of sockeye and pink, move into the Straits on the Canadian side. These can be readily fished just inside the line in United States waters in the Strait area but are not as accessible.

Since the 1957 ban on ocean net fishing, the United States catches have noticeably decreased when expressed as percentages of the total United States-Canadian catch of coho apparently destined for streams inside the Strait of Juan de Fuca. This could be one of several factors which apparently are responsible for the less significant correlation in recent years

between commercial catches of coho and stream run-off during their first year of life. Inshore changes in fishing intensity and regulations have also affected the relative accuracy of the forecasts based on this correlation. It is evident, however, that coho salmon are exploited more intensively during the odd-year pink salmon runs.

During 1957 and 1958, an investigation was undertaken jointly with Canada to compare the Swiftsure stock with those at various points inside the Bonilla-Tatoosh line with regard to composition, maturity, and extent of eastward migration of feeding coho. Tagging experiments, size composition studies, and studies on feeding and maturity were carried out on coho caught in both Canadian and United States waters from Swiftsure to Sooke. Throughout the study area (inshore to Sooke-Tongue Point) the fishery, at least in some years, may operate on a milling, maturing group of fish that are feeding and growing rapidly. Since there is some evidence that a large majority of the coho caught off the west coast of Vancouver Island are destined to spawn inside the Bonilla-Tatoosh line and that the Canadian Strait fishery is possibly detrimental to Puget Sound stocks, the research most urgently needed relates to the origin of the stocks.

The Washington Department of Fisheries planned a tagging study in 1963 to determine the origin of coho taken in the Straits and San Juan Islands area and the effect of the Canadian

Strait fishery on United States stocks, but the project was unsuccessful because of a poor coho run that year and interference by a huge pink salmon run. Other studies which could further knowledge of the status of the stocks include concurrent tagging experiments off the west coast of Vancouver Island and a study of the effect of concentrating Canadian fishing effort within various areas inside the Strait. To analyze completely this management problem, it will be necessary to determine the length of time and in what magnitude the sockeye, pink, and coho runs are available to the fishery during a given fishing season and how the seasonal abundance pattern may shift from year to year with changes in racial composition of the stocks, oceanographic conditions, and other variables. From a biological viewpoint, a net-fishing line from Sooke to Tongue Point would probably allow for increased coho growth and greater stock separation. Since the present salmon treaty requires equal division by the United States and Canada of catches of pinks and sockeye in Convention Waters, seasonal or permanent closure of the net fishery outside such a line to permit substantial migration of coho out of the area would be possible only if adequate harvesting of the sockeye and pink runs can be made inside the line. In any case, a prediction is required of the numbers of the three species which would be available to the Straits fishery.

An extensive coho hatchery rearing program has been maintained for many years in the Puget Sound district. Rearing to the yearling stage has yielded the greatest success, and survival from fertilized eggs to liberation as yearlings has average 69 percent (range 65 to 72 percent). However, during the past ten years, adult returns to the hatchery weirs have steadily declined from 1.0 percent to 0.35 percent (range 0.05 to 2.00 per catch) of the eggs reared. This decrease has been attributed to a higher catch to escapement ratio and to a disease resulting from feeding unpasteurized salmon products during hatchery rearing. Recent introduction of a new diet is expected to increase survival substantially. Production of coho from controlled natural-rearing areas (nursery ponds or "fish farms") has been more successful than for chinooks, but the authors of an evaluation report concluded that "if the program is viewed as a single unit, the ratio of benefits to costs is so low that controlled natural rearing, under current methods, must be regarded as economically unfeasible."[16] They also concluded that fresh water rearing areas show more favorable benefit-cost ratios than saltwater rearing areas, and that a controlled natural-rearing program is unlikely to meet the full test of economic feasibility.

D. GAPS IN KNOWLEDGE OF PUGET SOUND SALMON STOCKS

Despite decades of work, much remains to be learned about the salmon populations of Puget Sound. Some of these gaps are of scientific interest only, but many of them relate directly to the resolution of water and land use conflicts and to the establishment of criteria and operating procedures that provide optimal accommodation of waste assimilation and fish producing capacities of Puget Sound as a system.

The principal gap with respect to the salmon stocks is the inadequate knowledge of the life history of the young salmon. Observation and analysis of the stocks of adult salmon are well along, but the behavior, growth, and survival of the progeny of these adults and their downstream migration and estuarine existence are documented only in sketchy fashion. Some progress has been made, as reported in the estuarine ecology studies conducted by the University of Washington under contract with the Federal Water Pollution Control Administration.[17] Nevertheless, the impact of degradation of water quality, siltation of spawning streams, elimination or alteration of spawning beds, and similar environmental changes cannot be fully evaluated until knowledge of the early life history of the salmonids has improved, since it is highly likely that much of the damage occurs in these early phases.

Another major gap is the ability to explain fluctuations in the abundance of pink and chum salmon. As indicated above, the chum populations along much of the Northwest coast have declined for reasons only partially related to man's activities. Oceanic parameters apparently are of considerable importance, but the exact nature and weight of the various negative influences is unknown at present. For reasons that are elaborated fully in the literature, certain aspects of the life cycle of the pink salmon produce wide variations in the size of the odd year runs that are found in Puget Sound. Moreover, ocean sampling techniques (and budgets) have not yet progressed to the point where it is even possible to forecast accurately the size of the runs. It is believed that both eggs and fry of the pink salmon are pecularily vulnerable to water conditions in spawning streams, and possibly to estuarine conditions as well, and that wide variations around mean values are characteristic of the species even in the absence of human inroads.

These unfilled pages in the story of the Puget Sound salmon account in large part for the frustrating inability to derive firm estimates of damage functions relating incremental changes in water quality with incremental reduction in salmon productivity. In effect, the ability to disentangle one small signal from the multitude of noises generated by other factors affecting the size of the salmon runs has made it most difficult

to assess dollar damages associated with different levels of water quality degradation. The significance of this for water quality management is discussed in a later chapter. At this point, we merely note that the precise effect of changes in any of the dimensions of water quality on living organisms is always difficult. The nature of the environment in which the life cycle of the salmon is fulfilled may make it too expensive - and perhaps impossible - to derive damage functions precise enough to permit fine adjustment of waste disposal benefits to losses of anadromous fish. Their economic value may therefore dictate the soundness of a safe minimum standard approach, even at some increase in costs of pollution abatement.

II. SHELLFISH

Table 9 presents a summary of catches of shellfish by commercial harvesters in recent years. Two facts are apparent: the shellfish resource is of substantial importance to producers; and it is almost entirely confined to oysters, crabs, and clams.

Map 4 shows the principal areas in Puget Sound where shellfish are taken commercially. Hood Canal, and southern Puget Sound account for the major share of the catch, with other centers around Dungeness, and Discovery and Bellingham bays.

Table 9

Commercial Shellfish Catch in Puget Sound
(thousands of pounds)

Year	Oysters Pacific	Oysters Olympia	Crab	Clams	Shrimp	Other	Total
1967	2,831	42	872	1,135	30	37	4,947
1966	2,600	35	972	1,334	50	24	5,016
1965	3,642	41	1,562	1,426	64	42	6,777
1964	3,664	34	1,564	1,382	70	36	6,750
1963	3,442	31	1,529	1,482	46	75	6,605
1962	3,478	31	1,017	1,608	32	133	6,299
1961	2,958	38	1,638	1,572	27	27	6,260
1960	3,710	45	1,142	2,014	24	33	6,968
1959	4,038	41	568	1,866	55	130	6,698
1958	3,475	32	467	1,547	73	110	5,704
1957	3,318	18	331	1,410	70	37	5,184

Source: Annual Reports, Washington State Department of Fisheries, 1958-1968

Map 4

Commercial Shellfishing Areas

Source: Washington State Department of Fisheries.

The oyster is one of the most thoroughly studied of all marine animals, and the Puget Sound stocks are no exception. The native Olympia oyster, once the mainstay of a small but valuable fishery in southern Puget Sound, has declined almost to the vanishing point. Meanwhile, the production of Pacific oysters, largely from Japanese spat, has grown into an important industry.

The reasons for this shift are still a matter of controversy. Even after a series of studies by competent scientists, the allegations of severe damage to oysters, particularly the Olympias, by the pulp and paper industry are disputed. It is, however, highly likely that the hardier Pacific oyster is less susceptible to water quality degradation and to unfavorable water and air temperatures. A factor of equal or greater importance in the shift away from Olympia oysters is the ability to cultivate Pacific oysters on a much larger scale and to mechanize many of the operations. Olympias require a great deal of unskilled manual labor which is simply unavailable on terms that would make operations profitable.

Puget Sound appears to offer favorable conditions for cultivation of oysters in racks, and this method may point the way to modest expansion of production in the future. Both this and more conventional methods will be under heavy pressure from competing users of tidelands and adjacent waters, the most important being the recreation home and water sport enthusiasts. In addition, some of the best production areas are close to present or prospective sources of industrial and municipal pollution.

On the positive side, the discharge of waste heat from thermal power plants may increase shellfish production substantially in areas where water temperatures are marginally low. At the moment, however, this is only a hypothesis, bound up in a series of much more serious issues in siting thermal plants.

The only crab harvested commercially in Puget Sound is the Dungeness. Major catching areas are around Dungeness and the Blaine-Point Roberts district. Much larger quantities are taken in the ocean fishery off the coast, and the "bay" or inside commercial crab fishery must share the resource with a growing sport fishery.

Butter clams and little neck clams make up the bulk of the commercial clam harvest. They are also eagerly exploited by recreational diggers. Both are produced fairly widely around the Puget Sound area. Future prospects are similar to those facing the oyster growers. Competition from recreational users and private beach owners, and the threat of water quality deterioration must be offset, if at all, by improved management and more efficient cultivation techniques.

The general state of knowledge of the shellfish of Puget Sound is good. Both federal and state governments maintain shellfish laboratories in the area, and other research is carried on by private firms and the University of Washington. There is, of course, need for continued research if shellfish production is to be maintained

or increased in the face of heavier utilization of the Puget Sound system for other purposes.

III. DEMERSAL FISHES

This section is based almost entirely on material relating to the Washington State Department of Fisheries. Their most recent published statement is in the Annual Report for 1967. A new series called Groundfish Data Report, begun in August 1968 and with the second number issued in December, has been established as a means of compiling for reference the statistical and biological data collected by the Department's Groundfish Investigation Studies. These data fall into two general categories: (1) catch and effort statistics obtained via a system of interviews with fishermen and logbook reviews; and (2) biological data collected through market samples, sampling at sea, and tagging cruises. The intent of the series is to make such information available much earlier than via formal publication and to include data that, by themselves, are not suitable for publication. These reports are not considered scientific publications, but they may be cited when referring to material contained in them. This series will be of increasing value as the observations are continued over time. Similar data for earlier years are available, but less accessible.[18]

In recent years there has been an effort to improve monitoring of the commercial fishery for demersal fishes. During 1965 and the first seven months of 1966, the number of groundfish biological samples collected was limited. No systematic sampling program was in effect, and sampling was generally done only in conjunction with specific studies. In June, 1966, a groundfish tagging and market sampling program was initiated through funding under the Commercial Fisheries Research and Development Act of 1964 (PL 88-309). This enabled an increase in personnel and the development of a systematic market sampling program to begin. Tagging studies coupled with special emphasis on Pacific Ocean perch and Puget Sound Pacific hake sampling in 1967 also contributed to a substantial increase in the number of biological samples collected during the last half of the three year period.

Almost all information about the commercial fishery for demersal species comes from trip tickets filed by the skippers of the vessels and from trip interview sheets obtained by state personnel. The trip ticket system was begun to give a basis for taxing the fishery. Statistical areas have been established offshore and in Puget Sound by the Pacific Marine Fisheries Commission; Washington State Statistical Areas have been established in Puget Sound.

One hundred seven otter trawl licenses were issued in 1967. About one hundred boats operate outside and only four or five operate predominately inside Puget Sound. Of the 107 boats licensed, about forty account for about 95 percent of the catch. These facts have led to hopes of delimiting the area of catch and the species composition.

Biological samples of eleven commercially important groundfish species began in 1965. Three kinds of samples are made: market or port samples, which are portions of landed commercial catches; boat samples, which are collected at sea; and tagging samples. Lengths, weights, and hard-structures forage determination are collected.

Total Washington State trawl landings in 1967 were over seventy-seven million pounds; 57 percent consisted of food fish, 34 percent was reduced, and 9 percent was processed into animal food. Approximately 22 percent of the total landings and 84 percent of reduction and animal food landings were handled by Puget Sound ports, but most of the catches were taken in other waters. Unfortunately, it is not yet possible to break down these data accurately by area of capture.

At present, soles, flounders, cod, and rockfish are the most important species taken by trawlers in the Sound. Recent developments in the technology of large midwater trawls has given rise to a new fishery for hake, which are reduced for fish meal

(and, hopefully, for fish protein concentrate for human use). While the hake fishery will center on offshore populations, a large quantity of the species is also available in Puget Sound.

This element of the commercial fishery of Puget Sound is not expected to show much growth in landings or values except for the hake operation. The bottomfish trade is dominated by low-priced imports, and any expansion of the Northwest trawling industry must come in the form of larger, all-weather vessels operating in the richer grounds of the Gulf of Alaska and even farther north.

IV. ZOOPLANKTON AND MICRONEKTON

The zooplankton-micronekton, in the present context, are pelagic organisms taken in plankton nets and midwater trawls. These organisms are not important commercially, so almost the only information available has been obtained by research activities of the University of Washington, of industries, and of agencies of the state and federal governments. They are discussed in this section because they contribute to the complex of relationships that yield commercially valuable species and because of their potential usefulness in monitoring the effects of environmental changes.

These organisms are very imperfectly known in Puget Sound, especially in the early stages of their life history, and in ecology and dynamics of their population. Several research reports have been completed, mostly in the form of theses at the University of Washington. No continuing or coordinated program has been pursued or is contemplated by any of the individuals or agencies contacted.

The zooplankton and micronekton organisms have been sampled with a variety of gear: horizontal and vertical plankton nets, open types and closing types; midwater trawls, primarily of the Issacs-Kidd variety; plankton pumps; and recently with acoustic techniques. The samples are not comparable in any clear way, primarily because each set of samples was taken with a limited research objective, often related to some program not primarily concerned with zooplankton and micronekton.

It seems clear that we have not identified all of the species or the life history stages. We do not know the distributions of abundance as related to depth, area, or season for any single species. We know little of present population levels and nothing of natural or man-caused variations in abundance. We do not have information on food and feeding relationships, nor do we know which predatory species these organisms support. Consequently there is little hope at present of predicting or measuring changes in the populations of these pelagic organisms.

The obvious gaps in our knowledge of zooplankton-micronekton in Puget Sound can -- and should -- be filled by research, to assess the effects of present pollution and to predict its future effects.

The primary need is for baseline studies, beginning with a consideration of sampling equipment and the design of adequate sample surveys. Considerations of the allocation of costs and resources should be imbedded into the design of sample surveys.

The cause of population changes is often complicated by economic factors, most importantly the activities of fishermen. The estimation of fishing effort is itself complicated by many factors widely discussed by workers in that field. The advantage of studying species primarily affected by environment is obvious. Secondary effects of predation and other food and feeding relationships can never be ignored, but the effects of economic factors are much reduced in these populations. Further, it is much easier to envision a comprehensive sampling and monitoring program for the smaller noncommercial species; the difference in size, weight, and cost of sampling equipment is a first-order effect of such size differences.

The baseline studies imply gaining an understanding of the magnitudes and periodicities, if not the causes, of natural variations in populations of interest. Clearly, the

environment must be monitored on a scale of areal coverage and intensity over time appropriate to the changes expected and observed. An eventual desirable refinement would be to conduct experiments attempting to diminish or increase the numbers of organisms in populations of interest. There is good reason to believe that pollution which impairs the desired use by one user can cause an increase in one or more populations of organisms.

V. THE ECONOMIC CONTRIBUTION OF THE COMMERCIAL FISHERIES OF PUGET SOUND

The preceding sections have described in some detail the fishery resources of Puget Sound of economic significance to commercial fishermen. This section presents an evaluation of the economic importance of the industries based on these resources, drawing on the most current information available.

The task is considerably more difficult conceptually than it appears at first glance. Economic analysis of a fishery and its associated processing and marketing sector on the basis of a strictly geographic definition of boundaries is inevitably arbitrary, and the resulting problems become more acute as the study area is narrowed to a region as small as Puget Sound. Some fish spawned in or dependent on the rivers and saltwater of the Puget Sound system are taken by fishermen in other areas, particularly in the

troll fishery for chinook and coho salmon. On the other hand, much of the income received by fishermen and employees of processing and marketing firms located in Puget Sound is derived from fish landed in Puget Sound ports but taken in waters outside the state. In addition, Puget Sound processing firms add value to large amounts of fish imported in fresh or frozen form from other countries, particularly Canada, but these plants would not exist in the absence of a local fishery.

A study recently completed for the State of Washington's Department of Fisheries provides a detailed analysis of value to fishermen, value added by processing, total wholesale value, and net income generated for the commercial fisheries of the State of Washington for 1965 and 1966.[19] It is possible to break these data down with tolerable accuracy to indicate the values accounted for by fish and shellfish taken in Puget Sound.

Details of these calculations may be found in the reference cited above. Their significance for the present study may be summarized as follows. The wholesale value of products processed from Puget Sound landings, plus value added by local canners, primary fish wholesalers, and by-product manufacturers to fish landed elsewhere but moved into the Puget Sound, represents an estimate of gross value produced by the industry, measured at points where fishery products pass out of the hands of specialized processors and handlers. It indicates the

aggregate economic importance of the industry. An additional highly useful measure may be derived from these data to show net income accruing to residents of the area as a result of the existence of the commercial fisheries. For the state as a whole, this requires deduction of processing and marketing margins on fish consumed within the state and of induced "imports" of materials required by the industry and purchased from other areas. These figures are summarized in Tables 10, 11, and 12 for the state as a whole, and in Table 13 for the Puget Sound district only.

A third measure of the economic value of the commercial fishery is the net economic rent derived from it -- that is, total value received by fishermen, net of associated costs. Analytically, this is the proper concept of net economic benefit -- the amount by which gross national product would be reduced if the fishery were to disappear. Unfortunately, the data are not available to estimate this importnat magnitude accurately, but earlier studies permit estimates covering about 90 percent of the total landed value of Washington State commercial fisheries. These suggest a potential net economic yield of $7 to $10 million for the state and of $5 to $8 million for Puget Sound alone.

Table 10

Summary of fishery wholesale values in 1965 in Washington State

Species	Value to fishermen	Wholesale value - Washington landings: Canned	Other processed	Fresh and frozen	Total	Value added to imported fish[a]	Total wholesale value
Salmon							
Chinook	$1,972,537	$477,184	$1,436,035	$1,197,035	$3,323,534	$655,331	$3,978,865
Coho	3,373,144	1,261,699	62,500	3,810,027	5,467,926	732,330	6,200,156
Pink	580,506	1,901,942	---------	---------	1,909,562	249,196	2,158,758
Sockeye	2,041,881	3,951,108	---------	---------	3,951,108	404,324	4,355,432
Chum	421,205	318,839	---------	260,988	592,909	342,971	935,880
Halibut	2,954,287	---------	---------	---------	3,747,541	2,257,541	6,005,263
Bottomfish	2,934,601	---------	---------	---------	4,556,572	---------	4,556,572
Tuna	688,450	1,504,195	---------	---------	1,504,195	1,241,138	2,745,333
Oysters	1,576,957	764,886	2,858,540	2,100,695	5,836,621	---------	5,836,621
Crabs	1,436,585	300,266	---------	2,367,734	2,668,000	1,658,350	4,326,350
Clams	296,525	85,604	---------	416,573	502,177	17,873	520,050
Other fish and shellfish	653,265	---------	---------	---------	653,265	---------	653,265
By-products	---------	---------	---------	---------	4,500,277	---------	4,500,277
Totals	$18,929,943	$10,565,723	$4,357,075	$10,153,052	$39,213,587	$7,559,235	$46,772,822

[a] Includes fish shipped to Oregon, valued at ex-vessel prices.

Table 11

Summary of fishery wholesale values in 1966 in Washington State

Species	Value to fishermen	Wholesale value - Washington landings: Canned	Other processed	Fresh and frozen	Total	Value added to imported fish[a]	Total wholesale value
Salmon							
Chinook	$2,368,541	$423,845	$1,506,372	$1,558,521	$3,690,238	$967,805	$4,658,043
Coho	4,162,218	962,097	51,875	4,557,935	5,926,147	825,395	6,751,542
Pink	29,850	9,967	---------	32,975	42,972	647,393	690,365
Sockeye	3,198,248	6,193,331	---------	---------	6,273,451	154,491	6,427,942
Chum	964,140	269,663	---------	1,047,436	1,317,099	375,667	1,692,766
Halibut	2,940,333	---------	---------	---------	3,658,112	2,817,337	5,811,449
Bottomfish	3,158,330	---------	---------	---------	4,875,615	---------	4,875,615
Tuna	204,751	514,913	---------	---------	514,913	2,817,237	3,332,150
Oysters	1,830,675	582,481	3,114,503	1,874,587	5,684,071	---------	5,684,071
Crabs	1,718,192	624,416	---------	3,030,423	3,654,839	2,954,838	6,609,677
Clams	264,186	28,643	---------	419,670	448,313	26,980	475,293
Other fish and shellfish	330,524	---------	---------	---------	591,328	---------	591,328
By-products	---------	---------	---------	---------	4,032,470	---------	4,032,470
Totals	$21,169,988	$9,609,356	$4,672,750	$12,521,547	$40,709,568	$10,923,143	$51,632,711

[a] Includes fish shipped to Oregon, valued at ex-vessel prices.

Table 12

Economic value of the commercial fisheries of Washington

in 1965 and 1966
(thousands of dollars)

	1965	1966
Value to fishermen	$18,930	$21,170
Wholesale value		
Washington landings	39,214	40,710
Value added to imported fish	7,559	10,923
Total wholesale value	$46,773	$51,633
Net addition to state incomes[a]	$43,764	$48,604
Potential net economic yield[b]	7,000 to	10,000

[a] Wholesale value minus processing - marketing margins on fish consumed in state and value of goods and services imported from other states and countries.

[b] Value to fishermen minus estimated harvesting costs.

Table 13

Economic value of the commercial fisheries of Puget Sound

in 1965 and 1966
(thousands of dollars)

	1965	1966
Value to fishermen	$ 7,060	$ 8,733
Wholesale value		
Puget Sound landings	18,987	23,580
Value added to imported fish	7,000	10,923
Total wholesale value	$25,987	$34,503
Net addition to state incomes	$24,000	$32,000
Potential net economic yield	$ 5,000 to	$ 8,000

With respect to the importance of the commercial fisheries to the Puget Sound region, these figures speak for themselves. With due recognition of the wide variances around mean values for landings of some of the most important species, particularly salmon, it would appear that commercial fisheries based on Puget Sound stocks generate from $24 to $32 million in income for residents of the state of Washington, and their complete elimination would reduce net economic yield (hence, GNP) by $5 to $8 million annually.

An overwhelming proportion of the total catch value in Puget Sound is accounted for by salmon, oysters, and clams, all of which may be regarded as highly vulnerable to pollution and to destruction of natural habitat. Indeed, only Dungeness crabs and the relatively small quantities of bottom fish taken might be regarded as highly tolerant of saltwater conditions.

It is not surprising that the impact of growth in economic activity and population, when translated into increased waste loading and alteration of the related saltwater and fresh water environment, is of critical importance to the fishing industry and to the firms directly dependent upon it. Note that the conflicts involved go far beyond pollution in the narrow sense of the term. Pressure on the natural reproduction capability of the salmon stocks, for example, probably results more from unwise and unnecessary destruction of environmental conditions required for spawning and for early phases of the life cycle in small feeder streams and in the upper stretches

of the tributaries of Puget Sound than on the commonly measured elements of water quality in the estuarine and open waters of the Sound. Similarly, shellfish production is influenced as much by competition for recreational usage of tidelands and adjecent waters as it is by deterioration in water quality conditions. The mere fact that some losses of fish and shellfish, at least via natural production, are the inevitable price of economic growth simply underlines the need to take proper precautions to minimize such losses and to prevent their compounding by deterioration in water quality.

VI. FUTURE DEVELOPMENTS OF THE COMMERCIAL FISHERIES

The future level, composition, and value of commercial fish and shellfish catches from Puget Sound will depend on the rate of growth and direction of the demand for seafoods in the western regional and national markets in which they are sold and on the extent to which supplies are expandable. Increases in demand obviously will result in some mixture of greater physical output and higher prices, the exact combination depending on the extent to which yields from the stocks in question can be expanded on a sustained basis.

From the standpoint of demand, the commercial fisheries of Puget Sound face a bright future. The demand for fresh and frozen salmon is expected to increase at a rate somewhat greater than the growth in population, and the market for better grades of canned salmon, which has been strong for the last decade, should continue to improve with the distinct possibility of increased pressure on tuna supplies and prices. Essentially the same facts apply to major shellfish resources of Puget Sound. The demand for crab and oysters continues to be very strong, both regionally and nationally. In both cases, moreover, demand is expected to expand more rapidly than population, since both salmon and shellfish are high-priced specialty items of the sort increasingly in demand as per capita income rises.

The impact in the case of salmon is likely to be felt much more in prices than in production. Given market demands, the price of salmon is largely determined by production in Alaska, which accounts for about 90 percent of the total American catch; but for all North American production, including that of Puget Sound, a realistic appraisal suggests that we would be doing well indeed if landings can be held at present or very slightly higher levels. On the positive side, some progress has been made in a number of approaches to salmon enhancement; improvements in hatchery techniques and the construction of artificial spawning channels offer considerable promise. On the other hand, all species of Pacific salmon are unusually vulnerable to the sort of environmental changes inevitable with economic expansion and population growth in the Puget Sound area. Deterioration in water quality is one adverse influence, but not the only one; increasingly, anadromous fish must compete with other users of good quality water.

This process of erosion of the natural production of Puget Sound salmon stocks could doubtless be reduced or possibly reversed by a better resource management policy geared explicitly to recognition of the interdependence of land and water usage. If, for example, the damaging effects on salmon spawning areas of poorly planned tract housing developments, highway construction, and flood control measures, could be minimized, the amount of salmon might be increased somewhat;

at least, further declines could be checked. But with the best of policies, it must be recognized that the carrying capacity of the spawning streams tributary to Puget Sound is inherently limited, and the limitations will grow over time. Thus, we are faced with the prospect of offsetting declines in natural production, which costs nothing, by way of increases in artificial production, which are achievable only at rising costs and which have been largely ineffective for three of the five major species.

In this respect, coho seem to have fared quite well; both hatchery and natural-rearing techniques have been most successful with this species. Success with hatchery operations has been spotty for chinook, but recent indications of much better production, hence lead to the forecast of a slight increase in supply.

It seems unlikely that sockeye production can be increased by more than a small amount. The great bulk of the northwest catch of this species comes from the Fraser River system, and the future of the fishery is inevitably bound up in the success of the management program of the International Pacific Salmon Fishery Commission. It would appear that the major gains have already been achieved from clearance of the block at Hell's Gate and the application of modern management techniques to the various runs that comprise the Fraser River resource. Incremental gains are still possible as both scientific knowledge and regulatory techniques are improved, but a

leveling off of potential sockeye yield from the Fraser at levels no more than 10 percent above average catches appears likely. This is predicted on the assumption that the Fraser River and its major tributaries remain free of major multipurpose dams and that adequate measures are taken to protect water quality.

Any major flood control and/or power development projects on the Fraser would reduce the long-term prospects for sockeye by varying amounts, depending on the extent of development and the care with which fish passage and protection are handled.

The largest part of the Northwest catch of pink salmon is also based on Fraser River runs, although to a lesser extent than in the case of the sockeye. Regulation of the Fraser River runs by the International Pacific Salmon Commission began only in 1957, and there is reason for some optimism about the possibility of expanding catches from this important resource, perhaps by as much as 20 to 25 percent. Catches from other Puget Sound and coastal rivers are not likely to increase above present levels, although the erratic nature of the pink salmon runs will continue to produce exceptional-year catches from time to time. There is no evidence that even-year pink runs of commercial size can be established artificially in the Fraser or in the Puget Sound rivers.

Landings of chum salmon have declined alarmingly in recent decades, and the reasons are not known. They may well be rooted in natural factors as much as in excessive fishing pressure. On

the assumption that present plans for expanded research are implemented, a forecast of sustained catch levels at about the average of the past five years would appear reasonable. Any significant expansion seems improbable, but a substantial increase in research and development efforts would appear warranted by the recent trend toward much higher prices per fresh and frozen marketing than for canning.

As indicated, the demand for good quality shellfish continues to grow rapidly. Rising per capita incomes, together with improved methods of handling and packaging, have contributed to strong national and regional markets for shrimp, crab, and oysters. Although Northwest producers of oysters and shrimp participate in a national market in which much larger quantities are available from other regions, thus putting a partial ceiling on demand for these products from Puget Sound, overall demand has been so strong that this has not constituted a limit on production. It is, therefore, important to determine the limitations on physical availability in estimating the long-run potential from these products.

Biological information on the Dungeness crab is insufficient to permit any present definitive conclusion about maximum sustained yields available in the Northwest. Crab populations fluctuate widely in response to natural conditions, and the impact of fishing mortality is difficult, if not impossible, to isolate. Changes in abundance caused by natural factors will continue to affect levels of catch as in the past. With respect to <u>average</u> sustained yields, production in Washington may well be at or very close to maximum.

This is almost certainly true of bay crabs, taken inside Puget Sound. Except for refinement in management that might follow more detailed knowledge of the biology of the Dungeness crab, little can be done to increase production of either ocean or bay crabs.

As in any kind of specialized farming, the principal limitation on production of Pacific oysters is the availability of suitable tidal areas with proper growing conditions. Moderate increases in production can be achieved by utilizing new areas and by improved techniques in older areas.

On the other hand, the Pacific oyster, though hardy by comparison with the Olympia, is susceptible to many kinds of water pollution. Perhaps more serious, the tremendous demand for water-based outdoor recreation in the Northwest is claiming ever larger amounts of waterfront property, including many areas suitable for oyster growing. Over time, it seems certain that many oyster areas will be driven out of production simply because recreational use yields greater financial returns from the land and water in question. On these grounds, only a moderate long-run net increase in total oyster production is anticipated.

It is not believed that any other shellfish will assume significantly greater importance than at present, with the possible exception of clams. Moderate increases in hardshell clam production should be possible through the application of more intensive farming methods and fuller utilization of subtidal stocks. As in the case

of oysters, intensive development of waterfront property for recreational housing will cut into clam supplies and lead to more pressure to allocate a larger proportion of the catch to those digging for sport. Some moderate increases in shrimp production may be achieved, but the absolute quantities and value will remain small.

We conclude that a near-term projection of landings and value of the Puget Sound fisheries could be summarized as follows:

Salmon. Potential increase in landings would require higher levels of expenditure by state and federal agencies than at present. Values, however, should increase by 20 to 30 percent with increasing shifts to higher valued usage and rising relative prices.

Shellfish. No increase in total landings. Values will increase, but more slowly than for salmon because of dominant influence of production from other areas and imports.

Bottomfish. No increase in total landings or values.

CHAPTER IV

THE LIVING RESOURCES OF PUGET SOUND AND THEIR USES: SPORT FISHING AND HUNTING

I. SALMON[20]

The most important sport fishery in Washington State waters is based on Pacific salmon, primarily chinook and coho, but with an increasing and fairly substantial number of pink in odd-numbered years. Historical trends in the magnitude of the sport salmon fishery in Washington State are indicated in Figure 4 and Table 14. After a long period of expansion the catch dropped in 1958, partly due to an increase in the size limit, and reached a low in 1960. By 1965-1966 catches had again reached the 1955-1957 levels, where they tended to level off. The proportion of chinook and coho taken by sport gear has increased steadily relative to the commercial catch of these species.

A more significant criterion of economic and social significance of sport fishing, is its intensity as measured in angler days, since the basic economic "output" of a recreational fishery is not fish, but fishing. The fact that salmon fishing also produces a highly desirable food makes the sport more attractive,

Figure 4

Sport Salmon Catches and Angler Trips, 1946-1968

Source: Washington State Department of Fisheries.

Table 14

Estimated Annual Sport Catches and Effort on Juan de Fuca Strait, the San Juan Islands and inner Puget Sound (Washington Marine Waters adjacent to Cape Flattery and Eastward, excluding the Pacific Ocean to the South).

Year	Angler Trips	Chinook	Coho	Total Salmon[a]
1946	316,000	61,000	107,100	168,100
1947	343,000	82,400	120,000	221,700
1949	531,300	92,500	214,800	395,400
1950	536,800	98,100	198,500	296,600
1951	609,500	131,700	208,900	369,200
1952	650,600	147,800	230,500	378,300
1953	631,700	121,400	190,200	385,500
1954	697,600	179,400	208,600	388,000
1955	695,800	163,400	214,400	467,900
1956	757,200	207,700	248,900	456,600
1957	775,900	251,000	301,500	631,500
1958	647,100	165,100	203,600	368,700
1959	577,200	122,600	160,500	322,300
1960	600,800	105,200	53,200	158,400
1961	775,900	132,000	122,300	291,800
1962	845,100	129,200	114,400	244,000
1963	1,157,100	175,300	178,000	773,800
1964	978,100	108,500	112,800	221,300
1965	961,912	117,599	149,471	306,957
1966	840,642	136,218	158,148	294,366
1967	887,411	113,567	101,348	259,395
1968	709,598	118,164	105,142	223,366

Source: Development of Washington State Salmon Sport Fishery Through 1964, State of Washington, Department of Fisheries. Fisheries Research Bulletin No. 7, May 1967. Washington State Sport Catch Report from Punch Card Returns, 1965-1967. State of Washington, Department of Fisheries, by letter, 1968.

[a] Includes pink and a few chum and sockeye.

but is by no means its only appeal or the most significant. As Figure 4 indicates, the number of angler days devoted to s almon fishing in Puget Sound increased steadily until 1958.

The drop in 1958 and 1959 reflects the increase in the minimum legal size mentioned above. The number of angler days then resumed its rapid increase. Only in recent years has it drifted downward slightly because of the shift in interest of the newly developed (and more productive) ocean sport fishery off Ilwaco, Westport, and La Push. The increase in angler days in a response to several factors: population growth; rising personal income (and associated increases in leisure time and mobility); improved boating equipment; and the development of better marinas and improved accommodations a t fishing centers.

A third measure of the economic importance of sport fishing to the State is the number of anglers who participate. Unfortunately, data are not available for a long enough period to indicate time trends in participation. It was only with the initiation of the punch card system in 1964 that it became possible to estimate the number of salmon anglers with reasonable accuracy. Two facts stand out in the figures set forth in Table 15. One is the high proportion (almost 10 percent) of all Washington State residents who take out salmon punch cards and fish at least occasionally; the other is the very high proportion of total punch card holders who reside in Washington State (82percent) or in Oregon.

Table 15

Origin of participants in the 1967 Washington sport salmon fishery

	Number	Per cent
Total punch card holders	435,825	100
Washington residents	356,700	81.9
Out-of-state residents		
Oregon	35,850	8.3
All other states	37,850	8.7
Foreign	5,425	1.1
Total out-of-state	79,125	18.1

Source: Nye and Ward, Washington salmon sport catch report from punch card returns in 1967.

It is also noteworthy that punch card holders are distributed by county of residence in a pattern surprisingly parallel to population. Though the salmon resource is used more intensively by residents of the Columbia River, coastal, and Puget Sound counties, it is truly a state-wide asset for anglers.

The data in Table 16 show the area structure of the sport salmon fishery for 1968. Two characteristics are immediately apparent. First, catches per trip are markedly lower in Puget Sound and the inner Straits (Areas 5-12) than on the ocean grounds (Areas 1-4). Second, proximity to population centers produces very intensive fishing effort, despite very poor success ratios, in Areas 7-12.

A. MEASURES OF ECONOMIC VALUE

Much of the confusion over the value of sport fisheries to the national and regional economies stems from a failure to define accurately the product itself and each of the several evaluation concepts actually being employed.

Since the output of a sport fishery is fishing, rather than fish, the market value of the salmon caught is not relevant except to establish an irreducible minimum figure. The fact that hundreds of thousands of people choose to spend more than a million angler days in the State of Washington fishing for salmon rather than buying it at the local market is an indication that market value of salmon as food is not a proper measure of its economic importance to sportsmen.

Table 16 The 1968 Washington Sport Salmon Catches, Number of Angler Trips, Salmon Per Trip for Marine Areas and Total Freshwater Catch[a]

Area	Number of Chinook	Number of Coho	Estimated Total Salmon	Percent Chinook	Percent Coho	Marine Angler Trips	Salmon Per Trip
Ilwaco (Area 1)	37,870	172,823	210,693	18.0	82.0	130,204	1.62
Westport (Area 2)	91,750	192,975	284,923	32.2	67.8	177,851	1.60
La Push (Area 3)	6,368	16,582	23,075	27.6	72.4	24,246	.95
Neah Bay (Area 4)	8,497	64,912	73,556	11.6	88.4	51,499	1.43
Sekiu & Pillar Point (Area 5)	26,522	41,212	67,734	39.2	60.8	80,227	.84
East Juan de Fuca Straits (Area 6)	17,090	19,155	36,245	47.2	52.8	89,826	.40
San Juan Islands (Area 7)	21,069	4,420	25,489	82.7	17.3	101,162	.25
Skagit Bay - Deception Pass (Area 8)	2,863	758	3,621	79.1	20.9	22,548	.16
Admiralty Inlet - Possession Sound (Area 9)	18,369	27,082	45,511	40.4	59.6	136,133	.33
Seattle - Bremerton (Area 10)	11,060	6,725	17,785	62.9	37.1	101,773	.17
South Puget Sound (Area 11)	15,286	3,849	19,135	79.9	20.1	122,860	.16
Hood Canal (Area 12)	5,905	1,941	7,846	75.3	24.7	55,069	.14
TOTAL	262,649	552,434	815,613[b]			1,093,398	.75
Freshwater			61,663				
GRAND TOTAL			877,276				

[a] areas 5-12 are included in the Puget Sound/Straits study area.
[b] Includes 474 pink, 41 sockeye, and 23 chum salmon

Source: State of Washington, Department of Fisheries (mimeo)

Attention is focused in this section on: (1) gross expenditures by sport fishermen; (2) their contribution to incomes in the state; and (3) net benefits generated by the sport fisheries. As in the case of the commercial fisheries, the latter figure is of greater significance since it indicates the loss in the value of national output that would result if the fishery were curtailed or eliminated; and, in this particular case, the bulk of the loss in national output would correspond to a loss in regional output as well.

There are both conceptual problems and data limitations in generating measures of the gross and net economic values of the sport fisheries of the State of Washington that would permit direct comparison with the commercial values discussed in the preceding section. Not only is a different economic good involved -- the service of a day's fishing rather than a commodity -- but there is no direct measure corresponding to the price paid for fish that would indicate the "gross price" of a day's salmon fishing. The nearest approximation would be an estimate of average expenditures by salmon fishermen on all goods and services required to carry on sport fishing over a specified period (perhaps a year). This is still incomplete since no charge is made for the right of access to the fishery itself, but it would serve as a rough indication of the total economic impact of sport fishing on the state economy and on specific areas within the state.

As in the case of commercial fisheries, it should be emphasized strongly that gross value figures in this sense do not represent a complete loss to the economy of the nation or the state if the fishery were to be curtailed or eliminated, since many of the expenditures for travel, accommodations, tackle, bait, etc., would simply be diverted into other products and services, most of them within the state. It does, however, indicate the kind of readjustment that might be called for if the fishery were to change substantially in magnitude, since different people in different locations would be affected, favorably or adversely.

Estimates of gross expenditure. Estimates of gross expenditure by salmon fishermen could be made on several bases. First, a study conducted by Crutchfield indicated an average expenditure of approximately $125 per year per salmon angler in 1962.[21] This figure, multiplied by current estimates of punch card holders and adjusted to reflect increases in the general level of prices since 1962 and the shift toward ocean fishing, would indicate gross expenditures of approximately $50 million annually. Since angler days in the study area averaged about 78 percent of the state total, approximately $39 million annually could be attributed to the Sound and Straits areas.

A second method of estimating the expenditure would be to extrapolate the information developed in the study of the Oregon salmon and steelhead fishery by Brown, Singh, and Castle.[22]

The Oregon research team estimated total expenditures by Oregon sportsmen at $18 million in 1962, or about $100 per capita on an annual basis. It would be expected, however, that the Washington figure would be considerably higher, since daily costs and travel expenses to the important coastal fishing centers are greater than these for Oregon anglers. The $100 estimate, applied to the average number of Washington sports salmon fishermen for the past three years, would indicate a gross value of about $41 million per year for Washington State or $32 million for the Puget Sound Strait area.

Estimates of net economic benefits. For comparison with other water uses and as a basis for a more rational division of the salmon catch between sport and commercial fishermen, the net economic benefit concept is of primary importance. This relates to the value of the overall recreational experience, and cannot be inferred directly from data now available. It is, therefore, necessary to simulate a demand function measuring the number of user-days that would be forthcoming if the right to participate in sport salmon fishing were priced at different levels, taking as given the other factors determining the satisfaction derived from sport fishing (such as income, population, and quality of fishing). It would then be possible to determine the combination of price and user days that produces the largest net benefit achievable by the fishery in recreational usage; or, expressed in other terms, the true net loss to the economy if the fishery were to be eliminated.

It is anticipated that studies now under way in the Department of Fisheries, in collaboration with University of Washington personnel, will produce reasonably accurate estimates of net benefits from salmon fisheries in different locations within the state, from which more general estimates of net benefits from the fishery as a whole can be developed. For the moment, however, it is necessary to extrapolate from the only closely comparable work available, the Oregon State University study of the value of sport fishing for salmon and steelhead in Oregon.

It is recognized that there are weaknesses in this approach. Specifically, the net benefit figures from the Oregon study will tend to overstate values in Washington in view of generally lower access costs in Oregon. On other grounds, however, they understate values; e.g., the average catch per angler day is lower in Oregon, and both per capita income and total population are smaller than in Washington. On balance, it appears that the latter effects would yield a conservative estimate of the net value of the Washington sport salmon fishery.

As a first approximation, the total net benefit estimated for the Oregon fishery ($3,122,000 in 1962), adjusted for changes in independent variables to 1966 values, could be converted to a per-fish basis and the resulting figure multiplied by the average Washington State sport catch in the past three years. This would yield an estimate of $11.09 per fish from the Oregon study and a net value for the Washington catch of approximately $8 million annually as of 1967.

Alternatively, if we assume that the elasticity of demand for sport fishing is the same in Washington as in Oregon (a reasonable assumption since the two areas are similar in alternative recreational opportunities and in socioeconomic structure) the net value of the Washington State fishery could be estimated by converting the adjusted Oregon figures to a per-day basis and multiplying by the average number of angler days in Washington during the past three years. This procedure gives an estimate of approximately $4.6 million.

There is no way to reconcile these estimates completely, particularly in view of the rather rough assumptions that have to be made in either case. The major reason for the discrepancy, however, appears to lie in the implicit assumption underlying the $4.6 million estimate: that catches per day are similar in both states. Since the Washington catch per day has averaged 0.6 in current years, double the 1964 Oregon figure, the first estimate is probably more accurate. On balance, an estimate of $ 5 to $8 million as the current annual net economic benefit from sport salmon fishing in Washington appears reasonable and conservative. Again, about 75-80 percent of this amount would be attributable to the Puget Sound study area.

Additions to state incomes. Contrary to common opinion, the saltwater sport fisheries of Washington are far more important as a source of recreation for the people of the state than as a tourist attraction or "export" industry. Approximately 83 percent of salmon punch card holders in 1966 were residents of the state, and it is unlikely that all out of state residents who participated in the salmon fishery were attracted to Washington by

the salmon fishing opportunity alone. At least a substantial proportion of them doubtless went salmon fishing as an adjunct to a trip or vacation period that included a variety of other recreational and business activities.

Nevertheless, even the relatively small percentage of out of state participants generates a significant source of money flow into the state simply because of the magnitude of the sport fishery and the rather high average expenditures for a day's salmon fishing, particularly for a visitor.

Some generalizations drawn from our presently inadequate data serve to emphasize the point. The total gross value to fishermen of the commercial catch of chinook and coho was approximately $5.3 million in 1965 and $6.5 million in 1966. This would have provided a net money inflow to the state averaging about $5.5 million per year for the two years.

Punch card data show that approximately 79, 125 out of state anglers participated in the sport fishery for salmon in 1967. On the basis of preliminary estimates of average daily expenditures the contribution to state incomes from sport fishing for chinook and coho would be as great as from the total commercial catch of these species if the average out of state resident had fished for only two or three days per year.

While these data are admittedly inconclusive, they suggest the possibility that the "export" value of the sport fishery, though very small relative to the internal use of the resource, is probably equal to or exceeds its potential value in commercial channels. The comparison would be even more favorable to sport fishing if the figures for the commercial catch could be adjusted to show income generated only by the portion of the catch taken in areas where the two user groups are in direct competition.

B. FUTURE PROJECTIONS

A forecast of the future of salmon sport fishing in the state must take account of three groups of variables, none of which can be estimated accurately at present. First, assumptions must be made about the supply of fish available and, therefore, the behavior of angler success ratios over the future decades. Second, the influence of population growth and higher per capita income, both tending to increase the demand for sport fishing, must be evaluated. Third, the increased pressure for participation, coupled with assumptions about the availability of fish, has direct effects on angler success and on congestion in major fishing areas. These factors will discourage sport fishing if their combined effects outstrip the ability (or willingness) to provide more fish for recreational usage.

The alternatives could also be stated in somewhat different terms. There is no doubt that the economic value of salmon for sport fishing will increase over time. But there is a large question as to what form that increase should take. Is it better

to provide more angler days at a cost of less satisfying fishing? Or should we restrict the number of angler days (by direct rationing, lower catch limits, or increased license fees, for example) to permit better catches and more open space -- thus maintaining the high quality of fishing enjoyment now attainable?

The following discussion illustrates the range of possibilities that might be expected under different but reasonable assumptions as to changes in supply, demand, and rationing techniques.

Supply. With respect to supply prospects, the following major conclusions are indicated. Some increase in the supply of fish available for sport fishermen can be achieved with minimal requirements in terms of improved natural habitat or competition with other users by greater expenditures on artificial propagation. Recent technical developments in salmon hatchery operations suggest the possibility of increased supplies, particularly of coho salmon, at a benefit-cost ratio of better than unity. Similarly, the new national and state emphasis on stringent receiving-water quality standards will improve the total productive capacity of many important streams in Washington and may lead to reduced salmon mortality in estuarine areas.

Expansion by the Department of Fisheries experiments of "spot" harvesting of otherwise unutilized salmon should provide a useful supplement to sport fishing supplies in the future. The recent emergency harvesting of pink salmon in the Dungeness River and coho jacks in the Washougal River show the results of flexible management and public

education in dealing with the inevitable local "overruns" that must accompany any salmon management program, however sophisticated. Further additions to the supply of fish for sportsmen can presumably be realized, at some additional cost for planning, facilities, and public education, from a number of rivers, including some without hatcheries.

The number of salmon available for sport fishing can be increased without further demands on competing water usage by reducing the commercial catch of chinook, coho, and pink in areas and at times when the two uses are competitive. Though there is a tendency for the general public to overstate the degree of competition between commercial and sport usages of salmon, it does exist. It is clear, however, that adult salmon become harder and harder to catch with sports gear as they approach their spawning stream, and sport fishermen in Puget Sound simply could not harvest the periodic surpluses that show up regularly in returns to certain rivers and hatcheries. Severe problems of equity would arise from any legislative action designed to further limit certain of the net fisheries in inner Puget Sound or to raise the proportinn of ocean fish going to sport fishermen beyond the increases already occurring under competitive conditions. Nevertheless if it appears that there are significant differences in the economic contributions of the two to the welfare of the State of Washington and its residents, these decisions may have to be considered. At present, we do not know the extent to which the supply of salmon for sport fishing could be increased by curtailment of commercial fishing.

In short, protection of the existing supply of salmon for recreational use, in the face of mounting population and industrial growth, will require continuously increasing expenditures to maintain the essential water quality and flow conditions in streams and lakes. Natural rearing can be supplemented, but again only at steadily increasing cost, by artificial propagation. The most promising avenue at the moment appears to lie in the expansion of modern hatchery operations. On balance, it would appear that only modest increases can be anticipated in the total amount of fish available for recreational use and that angler success ratios can be maintained, even over as short a period as ten to fifteen years, only by curtailment of competing commercial operations and an expanded hatchery program.

Demand. Forecasting the long-term demand for salmon sport fishing is even more precarious. A definite upward trend is clear in both catch and angler days since 1945, but the gross figures conceal a number of divergent crosscurrents. On the one hand, the catch per angler day has been declining, particularly in the last six to eight years, in virtually all areas close to the metropolitan area of Puget Sound. The overall stability of the catch per angler day statewide has been maintained because of a sharp increase in the relative importance of the salmon fishery at the mouth of the Columbia, in the ocean, and at the entrance to the Strait of Juan de Fuca, areas in which the catch per angler day is substantially higher than in the Sound.

General influences pushing per capita demand for salmon fishing upward are rising incomes, increased leisure, and the mobility associated with wider ownership of automobiles and improved highway facilities in the state. If the ratio of catch per angler day could be maintained at present levels, it would appear reasonable to argue that the number of angler days would increase at a rate somewhat faster than the increase in the total state population (assuming no saltwater license fee). Over the past fifteen years the average annual increase has been about 8 percent.

But projections of this rate of increase would give only a maximum estimate of the number of angler days that might be expected. The preceding section makes it clear that the supply of fish available to sportsmen could keep pace with demand only by heroic salmon propagation measures, coupled with a large diversion from commercial to sport usage. On more realistic assumptions, the catch per angler day can be expected to decline over the next two or three decades.

In essence, the demand for sport fishing will continue to rise in response to income, leisure, mobility, and technological developments but will grow less rapidly than these factors would suggest because of the resulting decline in catch per angler day.

Another important aspect is that sport fishing for salmon, though less plagued by crowded conditions than many other sport fisheries, is being hampered by congestion in more and more areas. Even at present, popular fishing areas in the inner Sound, such as Possession Point, Eglon, Shilshole Bay, and Point No Point, are so

crowded on weekends that the enjoyment of the individual angler is substantially reduced, and during peak fishing periods even areas as remote as Neah Bay become congested. The legendary aversion of fishermen to crowded conditions (when combined with the projected decline in catch per angler day) may well slow down the rate of increase in the demand for salmon sport fishing.

Some sense of the future can be gleaned from the above formulation if two alternative assumptions are made about catch in the year 1985, for example, In Case 1, it will be assumed that angler catch in 1985 is the same as that for 1965, about 940,223 salmon. For this to be true it must be the case that angler success declines at the rate of about one percent per year. Under these circumstances, angler days for the state in 1985 are estimated to be 1,680,000 as compared with about 1,360,000 in 1965.

Under Case 2, it is assumed that by intensive hatchery operations or by a reallocation of commercial to sport catch it is possible to increase the sport catch 25 percent above 1965 levels. Under these circumstances, angler success will decline at a relatively slower rate of about .5 percent. Catch per day in 1985 will be about .62 whereas in Case 1 it will be about .56 as compared with the .69 level of success for 1965. Given the assumptions of Case 2, the angler days in 1985 will be about 1,896,000, a modest increase over the Case 1 projection.

The following conclusions seem warranted. First, the ranges of our estimates of the present net value of the sport salmon fishery make it critically important to examine <u>all</u> competitive relations

between sport and commercial usage and to explore all techniques for reducing conflict and increasing total net benefit from the resource. Second, the potentially rapid increase in income, population, and mobility -- factors that stimulate the demand for sport fishing -- coupled with the sensitivity of demand to fishing success, suggest that the relative importance of sport fishing will increase over time. Third, the values indicated provide strong justification for further research and production expenditures on artificial propagation, particularly for coho and chinook salmon and for protection of water quality and other environmental conditions necessary for both natural and artificial production.

II. OTHER SALTWATER RECREATIONAL FISHERIES

The salmon fishery dominates the saltwaters so completely in Washington that most fishermen tend to ignore the existence and potential recreational use of other saltwater resources of the state. At present, available data simply do not permit any meaningful estimate of their present or prospective economic significance.

Bottomfish stocks have very real potential for meeting, at least in part, the increasing demand for recreational fishing, particularly in Puget Sound, and thus relieving pressure on such biologically limited species as salmon and steelhead. Such a diversion of sports fishing time to bottomfish will, of course, diminish the projected increase in the economic value of the salmon fishery; but this will be compensated by economic values attributable to angler days in the new activity.

It is not worthwhile to project such effects in the face of limited data and the high degree of uncertainty that surrounds the future development of the minor sport fisheries. Experience in other saltwater areas (California, for example) suggest that this type of substitution will take place and that it will ameliorate the lessening enjoyment of a salmon fishery in which the angler will steadily be working harder to achieve less success. The comparison is between two recreational activities of widely different appeal and/or accessibility. The challenge and pleasure of bottom-fishing may be increased as specialized techniques are developed for light tackle fishing; but the sport can never be considered fully equivalent to salmon fishing.

The initial steps in this direction have already been taken, In 1966 a survey of sport fishing for bottomfish (primarily rockfish lingcod, and greenlings) showed a catch of 240,483 fish landed in the Puget Sound study area. Significantly, approximately 57,000 fish were taken by anglers who devoted 23,255 trips specifically to bottomfish.[23] The greatest numbers of such trips were recorded in the San Juan Islands (a major recreational area where salmon catches per angler day are typically low) and in the heavily fished Sound Puget Sound and Seattle-Bremerton waters.

III. RECREATIONAL USE OF OYSTERS, CLAMS, AND CRABS

The clams and oysters of Puget Sound support an active and widely enjoyed sport "fishery." The number of user days has never been accurately surveyed, but it is certainly in the hundreds of thousands annually, and is limited more by access and available

supplies than by demand. Less than fifty miles, of the approximately 1,600 miles of Puget Sound shoreline, are suitable shellfish beaches in public ownership. By far the greater portion of the shoreline is in private hands with varying degrees of access to the public. Railroad lands, especially on the east side of the Sound, are available for clam digging, beachcombing, hiking, and recreation, as are many other privately owned beaches. On the contrary, the private beaches of the west side -- especially around Bainbridge Island, the Poulsbo-Bremerton area, and Hood Canal -- are zealously guarded, often with weapons.

The need for additional beaches is critical, and management policies on existing public beaches need to be reviewed and updated. Some action has been taken to increase the acquisition of tidelands, although only one parcel has been purchased since 1955. In that year, under sponsorship of the legislature's Interim Fisheries Committee, the Washington Department of Fisheries, and the Department of Public Lands, legislation was passed permanently reserving from sale ten beaches on Puget Sound and Willapa Harbor, most of them presently accessible only by water. In addition to these, recreational fishing for shellfish is available at some state, county, and city parks.

The literature on shellfish on public lands is surprisingly sparse. A survey on some of the existing public lands was made in 1965 by personnel of the Washington State Department of Fisheries.[24] Previous studies by Donaldson (1942),[25] Bowler and Lindsay (1954),[26] and Westly, Lindsay, and Woelke (1964)[27] report similar surveys but most of their figures are now out of date. No one source contains an

adequate description of all public tidelands, and the need is acute for a comprehensive survey on the use of all tidelands.

Management policies need to be defined by general area, and should be available for both publicly and privately owned lands. The ownership of seed stocks is not clear. In many instances, they may be subtidal but, in other cases, they may be mostly intertidal; hence one person' management policies may affect another's stock of shellfish. Stock management and cultivation can perhaps be offered as an extension-type service if areas can be managed as a whole.

A summary description of public clam and oyster beaches, taken from the 1965 report and updated with additional information by interview with Mr. Aven Andersen and from a literature review compiled by Mr. Terry Riley is on file with other documents underlying this report.

III. FRESHWATER FISHERIES IN PUGET SOUND TRIBUTARIES

A. SALMON

Although small by comparison with the activity in saltwater, salmon fishing in the rivers of western Washington is an important form of outdoor recreation. The bulk of this effort, however, is expended in the Columbia River and its tributaries. Of the streams tributary to Puget Sound, only the Skagit supports a sizable river fishery for chinook and coho salmon, averaging 1,500 to 2,000 fish

per year. Smaller numbers of fish are taken by anglers in the Stillaguamish River and in Lake Washington and Lake Sammamish (from Sammamish and Cedar River stocks).

As suggested above, the possibility of harvesting "overruns" returning to state salmon hatcheries may provide some further opportunities for freshwater salmon fishing, but the potential increase is limited.

B. STEELHEAD

Steelhead trout support the major freshwater sport fishery based on anadromous stocks. Almost all rivers flowing into Puget Sound, the Pacific Ocean, and the Columbia River enjoy steelhead runs. The fishery is particularly important to outdoor recreation in the state at seasons when most other waterbased activity is at a low ebb. In addition, the steelhead is considered one of the truly great game fish of the world. The popularity of the sport has grown rapidly in recent years with the introduction of spinning tackle and artificial lures that permit less expert anglers to take steelhead. Good natural production, enhanced by a successful hatchery program, makes the Puget Sound rivers major contributors of steelhead. Five of them -- the Skagit, Green, Puyallup, Skykomish, and Stillaguamish Rivers -- are always among the top producers in the state.

Data for this sport fishery are less complete than for salmon. There are no estimates of angler trips for steelhead, but only yearly estimates by the Game Department of the number of fishing licenses sold (most steelhead fishermen must purchase a fresh water

fishing license and all must carry and fill out a free punchcard); the number of steelhead fishermen; and the annual catch by river. Further, the estimates of the number of licenses sold each year do not indicate the trend in demand for any given type of freshwater fishing, since many of them are combination hunting and fishing licenses, and since the various types of licenses available have changed frequently, making it difficult to compare one year's license sales with another. Data do not permit separate identification of anglers using Puget Sound streams.

The total steelhead catch figures from 1947-1948 to 1967-1968 are given in Table 17. Table 18 indicates the relative importance, in terms of fish production, of the top ten steelhead rivers in the 1966-1967 and 1967-1968 seasons.

The order of these rivers, in terms of total catch, is a result of both productivity and accessibility. The Skagit, for example, is easily reached from the heavily populated Everett-Seattle-Tacoma areas, but it also supports excellent runs of steelhead over a long season. The high ranking of the Green, Puyallup, Skykomish, and Snohomish, on the other hand, is directly due to their proximity to the Seattle-Tacoma-Everett metropolitan areas, since success per angler day is probably much lower on these than on other rivers in less accessible areas. It is also clear, however, that <u>all</u> steelhead waters of the state are utilized in some degree, and that the steelhead angler is highly mobile.

Table 18

Top Ten Winter Steelhead Rivers

1966-1967 Winter Season		1967-1968 Winter Season	
1. Skagit	24,833	1. Skagit	31,524
2. Green	15,271	2. Green	18,906
3. Puyallup	13,462	3. Puyallup	14,581
4. Cowlitz	13,300	4. Cowlitz	13,079
5. Skykomish	12,739	5. Skykomish	10,103
6. Lewis	8,457	6. Humtulips	6,893
7. North Fork, Stillaguamish	7,814	7. Lower Columbia	8,497
8. Lower Columbia	7,504	8. North Fork, Stillaguamish	7,631
9. Toutle	6,929	9. Toutle	6,679
10. Humptulips	6,893	10. Lewis	5,750

Note: The Skagit, Green, Puyallup, Skykomish, and Stillaguamish are Puget Sound streams.

Source: Washington State Department of Game, "Summary of Steelhead Catch, 1967 and 1968".

An upward trend in the number of steelhead fishermen in Washington is evident in Table 19. If it can be assumed that the average steelhead fishermen takes at least as many fishing trips at present as in the past, it is obvious that the demand for steelhead fishing is increasing over time, in response to the increase in leisure and per capita real income of Washington state residents. As in the salmon fishery, however, congestion and decline in angler success would modify these effects increasingly in the future.

Only a rough projection of user days in steelhead fishing can be made, since no time series indicating the average number of days fished is available. Two surveys, one conducted in 1963 and one in 1964, indicate an average of 9.6 and 10.8 days per angler per year respectively. Assuming that these figures remain representative and that the ratio of steelhead fishermen to total population remains constant, the number of user days in the state as a whole would reach about two million by 1980 and 2.5 million by 2000 if angler success could be maintained and congestion did not increase. The actual increase will be somewhat lower, since neither assumption is likely to hold.

The supply prospects for steelhead are mixed. On the one hand, steelhead fishing is peculiarly vulnerable to quality deterioration through congestion. In any given stream are only limited numbers of fish-holding and fishable areas, and overintensive use of such areas reduces severely the satisfaction of any one participant.

Table 19

Number of Steelhead Fishermen
1948-1968

Year	Total Steelhead Fishermen
1948-1949	33,200
1949-1950	41,500
1950-1951	41,500
1951-1952	51,875
1952-1953	64,150
1953-1954	74,125
1954-1955	75,025
1955-1956	73,450
1956-1957	70,800
1957-1958	70,875
1958-1959	70,100
1959-1960	72,950
1960-1961	77,475
1961-1962	144,980
1962-1963	151,692
1963-1964	160,375
1964-1965	171,400
1965-1966	187,525
1966-1967	202,666
1967-1968	202,750

Source: Washington State Department of Game, "Summary of Steelhead Catch", 1948-1968.

As indicated in Table 20 the catch per angler has tended to decline in recent years.

On the other hand, numbers of good fishing spots are presently closed by lack of public access. The effective supply of steelhead fishing can be increased by continuation of the Game Department's program of land acquisition and stream bank improvement to provide more access to good fishing drifts. Such opportunities are, however, inherently limited, and to some extent the increased catches from newly opened stretches of river bank are simply deducted from potential catches upstream. The supply of steelhead for sport fishermen can also be expanded through increased hatchery operations and more intensive management of some steelhead streams. The Game Department has had real success in many of its steelhead enhancement projects, and, given adequate financial support, there is still considerable leeway for further expansion.

Although steelhead, like salmon, impose rigid requirements on water supply and water quality during critical periods of their life cycle, the impact of the fishery on competitive users of water is much smaller. The bulk of the Washington steelhead population, being made up of winter-run fish, is less exposed to low-flow conditions than are the various salmon populations. Consequently, any expansion in fishing opportunities through artificial propagation, improvement of stream habitat, and increased public access will place minimal additional demands on water supply.

Table 20

Average Catch per Steelhead Fisherman
1948-1968

1948-1949	1.20
1949-1950	1.36
1950-1951	1.45
1951-1952	2.28
1952-1953	1.91
1953-1954	2.27
1954-1955	1.74
1955-1956	2.20
1956-1957	1.70
1957-1958	1.99
1958-1959	1.80
1959-1960	2.03
1960-1961	1.52
1961-1962	1.33
1962-1963	1.30
1963-1964	1.48
1964-1965	1.02
1965-1966	1.33
1966-1967	1.11
1967-1968	1.11

Source: Tables 16 and 18

C. SEA-RUN CUTTHROAT TROUT

A smaller but highly prized fishery for sea-run cutthroat trout flourishes in many of the tributaries of Puget Sound and at many places in the Sound itself. Camano and Whidbey Islands, Hood Canal, and areas adjacent to the mouths of the Snohomish, Stillaguamish, Skagit, and Samish Rivers are typical saltwater fishing grounds for these fish from late spring through the summer. These and many other rivers flowing into the Sound also provide excellent fresh water fishing, with the peak activity in the early fall.

The only information on the number of people who fish for sea-run cutthroat is an estimate of 65,000, developed from a 1963 questionnaire mailed to holders of fresh water fishing licenses. No estimate of their catch is available.

This species has received increased attention in the management program of the Department of Game; it has been gradually expanded to a current level of about 500,000 yearling fish annually. Most of these are planted in streams, primarily for the purpose of increasing a fishery on adult fish, both in the marine and fresh water areas. Unfortunately, results from the program have not been substantial and there is concern over continuing the program at present levels without improved results. The species does fit nicely into the overall sport fishery management program by providing a very desirable fish as a "resident" fish in streams. It has been determined that cutthroat do not return to the parent stream as do other anadromous fish but seem to go in and out of different river systems.

The Department of Game is now constructing a one and one-half acre rearing pond at its Shelton Hatchery with a production goal of 200,000 downstream migrant cutthroat annually. These fish will be released into streams and tributaries to lower Hood Canal and a creel census will be used in an effort to obtain information on catch, both in marine and fresh water areas. It is hoped that a sufficient catch will occur to justify continuation and expansion of the program.

Basically, sea-run cutthroat utilize the smaller stream areas and, consequently, are among the first fish to be damaged by urban development. It is an extremely fine trout for sport fishermen, and fills a major niche between salmon and steelhead. Its preservation and enhancement will involve careful attention to environmental protection.

V. RECREATIONAL USE OF WATERFOWL DEPENDENT ON PUGET SOUND

The Washington State Department of Game estimates waterfowl harvest annually from a game questionnaire mailed to 10 percent of all hunters. The data below present an average of computed harvests for the years 1962-1968, exclusive of 1963, which was an unusual year in terms of state waterfowl conditions. The waterfowl harvest for each county adjoining Puget Sound has been converted to hunter days of recreation by use of a "game-harvest hunter conversion table" provided by the Department of Game. The annual average hunter days of recreation (totaled for all counties) is 171,957 for the period covered.

There were two problems in arriving at this figure. First, for ten of the twelve counties adjoining Puget Sound it cannot be assumed that the duck harvest reflects the total number of ducks dependent on estuarine areas, since some of the ducks in these counties remain inland. Members of the Department of Game therefore calculated percentages of the ducks in these counties dependent on estuarine areas. In King County, for example, the percentage was 20 percent and only that proportion of the average harvest of King County was used in computing hunter days of recreation. Similar adjustments were made for nine other counties. This problem was ignored for geese on the assumption that virtually all use estuarine areas.

The second problem involved the counties of Clallam and Jefferson, only part of which adjoin Puget Sound. The Department of Game estimated that 80 percent of the waterfowl in these counties use areas contiguous to the Sound; and that percentage of the counties' average harvest was used in the computations of hunter days.

The Puget Sound region is principally a wintering area for ducks and geese originating in British Columbia, the Northwest Territory, Alaska, and eastern Russia. Large concentrations of ducks (averaging about 355,000) and geese (about 50,000) are winter residents in the Puget Sound region, and approximately an equal number delay their migration for a period up to a month or more in the area prior to drifting farther south to spend the remainder of the winter. Local production primarily mallard and wood ducks, is much smaller, averaging about 61,000.

The large protected saltwater area of Puget Sound, with its extensive shoreline and abundant shoal-water estuaries, provides an ideal feeding and resting environment for water-associated birds. Dabbling ducks (mallard, teal, pintail, and widgeon) concentrate in the tidal zone near mouthsof rivers and do much of their feeding inland. As ephemeral water in fields increases, these concentrations of ducks disperse somewhat into the river valleys and use freshwater areas more extensively.

A large flock of snow geese and small numbers of western Canada geese winter in Puget Sound, resting in open saltwater bays and

feeding in or near the tidal zone. Brant use virtually the whole Puget Sound area at some time during the winter period. This smallest of geese remains entirely on saltwater, depending heavily on submerged eelgrass beds for food.

Waterfowl hunting in and adjacent to Puget Sound is a major recreational activity in fall and early winter. Aside from the numerous and varied species of ducks, snow geese and brant provide a unique hunting experience. A flock of 20,000 to 30,000 snow geese the only concentration of these geese found in Washington winters in Skagit Bay. Geese are the most highly prized of waterfowl species because they are more difficult to bag, but the dabbling duck group provides by far the most recreation. Nearly one third of the state's duck and goose hunting occurs in the Puget Sound region. Waterfowl harvests and recreational use are indicated in Table 21.

A detailed inventory and analysis of waterfowl in the entire Puget Sound area is now in process. The following summary of the important Skagit-Samish delta area indicates the nature of the information being developed. This delta, including the brackish sloughs, marshes, and adjacent Skagit, Samish, and Padilla Bays, is perhaps the most important winter concentration area for waterfowl on the West Coast of both the United States and Canada. Nowhere else in Washington do snow geese remain more than a few days; yet 20,000 to 30,000 of these fasincating birds make the annual flight from nesting islands off the northeast coast of Russia to winter in Skagit Bay. Western black brant find Padilla and Skagit Bays to their liking, and numerous species of ducks use the whole lowland area and adjacent

Table 21

Waterfowl Harvest and Hunter Days

(Averages for 1962, and 1964 through 1968)

County	Waterfowl Dependent on Estuarine Areas		Total	Hunter Days
	Ducks	Geese		
Clallam	13,853	797	14,650	11,867
Island	16,248	413	16,661	13,495
Jefferson	4,736	166	4,902	3,971
King	5,783	383	6,166	4,995
Kitsap	8,656	108	8,764	7,099
Mason	11,093	140	11,233	9,099
Pierce	10,975	262	11,237	9,102
San Juan	2,435	18	2,453	1,988
Skagit	67,814	5,003	72,817	58,982
Snohomish	35,265	2,225	37,490	30,367
Thurston	9,936	80	10,016	8,113
Whatcom	14,794	1,110	15,904	12,882
Total	201,588	10,705	212,293	171,957

Source: Estimates provided by Washington State Department of Game.

adjacent salt water estuaries extensively. Skagit County leads all western Washington counties in waterfowl harvest and ranks second in the state. Duck hunting occurs throughout the lowland agricultural area, but is particularly concentrated on the three bays and on adjacent marshlands influenced by tides.

Except for limited nesting and brood production on woodland beaver ponds, waterfowl use is restricted to the river valleys, saltwater marshes and bays, lowland lakes, and agricultural lands. The delta marsh and adjacent farmlands at the mouth of the Skagit River provide excellent feeding grounds for winter-migrant as well as winter-resident waterfowl which rest on nearby Skagit, Padilla, and Samish Bays.

Many dabbling ducks which use this area in fall and early winter move to other western Washington areas later in the year. To determine the character of these duck movements, the main concentration (resting) areas are counted periodically during the fall and winter months. An eleven-year average, 1956 through 1966, of these periodic counts is shown in the following table.

These bay area counts reveal a steady buildup of the popular hunting species into early November, then a steady decline as part of the ducks move on to other feeding areas. The turnover of birds coming in and others leaving during this buildup and decline is not known.

Wintering populations of migratory waterfowl are determined nationally during a midwinter inventory. These counts show an average total of about 125,000 waterfowl using the subregion at that period.

Table 22

Periodic Census of Mallard, Pintail, Green Winged Teal, and Widgeon on Skagit, Padilla, and Samish Bays, Average, 1956-1966

Counting Period	Skagit Bay	Pardilla Bay	Samish Bay	Total
Early October	40,155	24,500	8,100	72,755
Late October	46,050	45,612	13,400	105,062
Early November	47,832	52,809	25,027	125,668
Late November	32,200	36,371	18,300	86,871
Early December	23,786	23,357	16,514	63,657
Early January (Annual Inventory)	27,000	26,742	15,938	69,680

Source: Washington Department of Game.

As an indication of the species and relative abundance of waterfowl using the area, the following birds were observed during the 1965 Skagit County inventory: mallard - 10,072; American widgeon - 33,973; green-winged teal - 2,781; pintail - 5,935; redhead - 107; canvasback - 404; scaup - 15, 271; golden-eye - 1,886; bufflehead - 5, 250; ruddy duck - 1,048; harlequin - 20; eider and scoter - 12,300; oldsquaw - 370; merganser - 135; coot - 546; snow goose - 25,300; Canada goose - 14; black brant - 13,094; whistling swan - 28. An additional 286 miscellaneous ducks, including a few shoveler and ring-necked, were counted for a subregion total of 129,330.

An average midwinter inventory of 125,000 waterfowl, plus a harvest of about 76,700 ducks and 5,200 geese and an unknown tally of ducks stopping over here briefly in early fall and winter, emphasizes the importance of the Skagit subregion as a waterfowl area.

As in the other drainages of the Puget Sound region, and, in fact, all of western Washington, the numbers of locally-raised ducks is small in comparison with winter migrants. As inventory of the waterfowl breeding-habitat types and the productivity of each reveals an average annual subregion production of about 9,000 ducks. The mallard is by far the predominant species of these, with wood duck and teal next in order of abundance.

The only snow geese wintering in the state rest primarily in Skagit Bay and are hunted extensively along the tide flats and adjacent agricultural fields. Four to six thousand of these white geese may peridoically separate from the main flock and use Port Susan and Padilla Bays, providing hunting in and adjacent to these bays as well. Seldom do these geese venture any great distance inland.

Brant are less inclined than snow geese to form large highly concentrated flocks and, consequently, are more widely dispersed throughout much of northern Puget Sound. Eelgrass beds, prevalent around Samish Island and in Padilla and Samish Bays, attract considerable numbers of these small geese in midwinter, where they provide outstanding hunting. The previously mentioned average annual harvest of 76,700 ducks and 5,200 geese provides about 65,000 man days of highly prized outdoor recreation.

Department of Game control and management of 12,192 acres of estuarine habitat in Skagit Bay enhances winter carrying capacity and provides extensive public hunting. Management of the Skagit Game Range includes the retention of natural marsh and the raising of cereal grains for duck feed on cultivatable, diked land. Ducks fly from resting areas in Skagit and Port Susan Bay to feed in the marsh and unharvested grain fields of the game range.

CHAPTER V

OTHER USES OF PUGET SOUND

I. GENERAL WATERFRONT DEVELOPMENT

A detailed study of land ownership and land use is being prepared as part of the "Puget Sound and Adjacent Water Study," and will be available in late 1969. Since it would be useless and expensive to duplicate this work, a brief summary is presented below. Only those land use categories affecting estuarine areas are included. A fairly complete analysis of land use by major categories in the waterfront of the Seattle Metropolitan Area is also available.[28] Urban buildup accounts for 5 percent of total land use in the Puget Sound area. Most of the urban development is found adjacent to the shores of Puget Sound and in the lowlands. Heavy industry is concentrated along the shores of Commencement Bay and Elliott Bay on the tideflats near the mouth of the Puyallup River, and in the lower Duamish River area. Developed lands are concentrated in the Central Division, where the Seattle-Tacoma-Everett metropolitan and industrial complex and various small cities and suburban residential areas account for approximately two thirds of the area's total urban land use. The present pattern of land ownership in the area is 41 percent federal, 11 percent state and local, and 48 percent private. Most of the federally-owned lands lie in the national forests and parks.

As the cities of Everett, Seattle, and Tacoma continue to expand, they ultimately will form a single urban area. Elsewhere, the shoreline of the Puget Sound is relatively undeveloped with respect to urban and industrial usage. However, the past decade has brought an accelerated construction of second homes, recreational structures, and permanent dwellings for commuting urban workers. Much of Whidbey, Camano, and the waterfront on Vashon, and Banbridge Islands is already highly developed along these lines, and good low-bank frontage now commands prices ranging up to $250 per front foot. The San Juan Islands are also being developed rapidly, and a surprisingly high proportion of the recreational homes there are owned by out of state residents.

As indicated above, only a handful of parcels of tideland are publicly owned, and these -- together with state, county, and city parks bordering the Sound -- provide very limited access for many types of saltwater and beach recreational activities. The relatively sparse population of the study area does not imply the availability of large amounts of undeveloped low-cost waterfront property. On the contrary, the already heavy concentration of population in Snohomish, King, Pierce, and Kitsap counties foreshadows a certain increase in value for the marine lands of Puget Sound and for their derived recreational and esthetic benefits.

II. SHIPPING

Statistical data on shipping and associated shorebased facilities in Puget Sound are relatively complete but not very current. A detailed summary and analysis of these data will also be published as part of the "Puget Sound and Adjacent Waters Study." This section is, therefore, focused on broader trends in shipping that may alter significantly the level and location of activity on Puget Sound and the potential impact of such changes on other users.

The effects of shipping on Puget Sound and its environs are and will continue to be complex and diverse. The ships and other craft need facilities for their operational requirements; in addition, the cargoes that must be transferred between ship and shore require handling, processing, and transportation. All necessary installations utilize land areas usually located near the land-water interface, in many instances on the river estuaries, where large areas at low elevations are available or can be developed for low-cost construction. New technology and equipment are continually changing the status of the shipping industry as a whole, and it is clear that a thorough analysis of the effects of shipping and of changes in the flow of cargoes on Puget Sound must precede any rational planning of future development in the area.

A generalized picture of shipping trends in the United States can be drawn from Figure 5 which displays the changes that have taken place in the total commerce passing through United States ports 1959-1966. The cargoes comprise the following groups: foreign imports, foreign exports, coastwise, internal, and local cargoes. Coastwise cargoes move from and to major port centers along the United States coast, such as New York to Galveston or Los Angeles. Internal cargoes move to and from ports on large internal waterways; e.g., Baltimore to Norfolk or Oakland to Sacramento. Local commerce applies to shorter movements, such as Hoboken to North River piers of Manhattan or Harbor Island to Pier 91 in Seattle. Projections of foreign imports and exports provide a basis for evaluating possible future activities. This foreign commerce is a function of American needs; shipping provides the vehicles for transporting these needs; and the assumption is that the other cargo groups will reflect growth trends similar to those of the foreign commerce.

The gross information of Figure 5 is further developed in Figure 6 where the cargo group -- foreign imports -- is shown to be composed of the subgroups, tanker, liner, and non-liner cargoes. The total of United States waterborne foreign imports and an estimate of its breakdown by subgroups is shown for the years 1959-1966. In addition, that portion handled on the West Coast as well as the total imports into Puget Sound is shown by subgroups. Projections of activities are indicated for the next twenty years.

Figure 5

Volume and Composition of Total Cargo Moved Through United States Ports

Source: Litton Systems, Inc. Ocean Borne Shipping: Demand and Technology, 1968.

Figure 6

Volume and Composition by Subgroup of Total United States, West Coast and Puget Sound Waterborne Imports

Source: Litton Systems, Inc. Ocean Borne Shipping: Demand and Technology, 1968.

The three subgroups describe different kinds of cargoes: tanker cargoes consist of liquid bulk, such as crude petroleum and refined products, and compose the greatest portion of foreign imports; liner cargoes include broken-bulk cargoes (i.e., almost anything shipped by sea) but in rather small quantities and in vessels that follow regular, published schedules on well-defined routes. The non-liner cargoes include dry-bulk items such as grains, coal, iron and steel scrap, metallic ores of various kinds, sugar, gypsum, and plaster rock.

Figure 7 is a similar display of United States foreign exports. It should be noted that tanker export trade is minor, and especially negligible on the West Coast.

The different types of ships required by the subgroups of cargo have differing effects on shoreline utilization. Tankers range in size generally from 10,000 tons carrying capacity to over 300,000 tons. Liners are high-speed, sophisticated ships capable of carrying almost any kind of commerce: dry, refrigerated, or liquid cargo, passengers, etc.; much of the liner trade is now shifting to container-type vessels carrying all contains (20 to 40-foot boxes), containers and trailers on wheels, or all wheeled vehicles (i.e., roll-on-roll-off vessels) and in addition to new lighter-aboard-ship types now being introduced, all of which require landing facilities ashore substantially different from those for the older conventional broken-bulk cargo. Non-liners carrying dry-bulk cargoes range up to

Figure 7

Volume and Composition by Subgroups of United States, West Coast and Puget Sound Waterborne Exports

Source: Litton Systems, Inc. Ocean Borne Shipping: Demand and Technology, 1968.

200,000 tons capacity; many are designed to handle both liquid and dry bulk and are associated with large shoreside facilities needed for handling and processing the cargo.

Figure 8 shows the make-up by cargo groups of the total waterborne commerce handled on Puget Sound for the years indicated. For the year 1965 an estimate was made of the volume of cargoes in the three subgroups for foreign and for coastwise commerce. Table 23 indicates the ports handling the majority of subgroup cargoes in 1965 in thousands of short tons. It is unfortunate that detailed records of cargo movements on Puget Sound are not available beyond 1966, since a number of changes in handling facilities since then could significantly alter the patterns shown in the figures.

As previously noted, the cargo subgroupings relate directly to the types of vessels carrying such commerce in foreign trade and also are associated with various types of facilities for discharging and loading the ships as well as with the divergence in processing, transportation, and handling facilities required ashore. Modern trends toward specialization are most evident in foreign trade operations. In general the assumption is that projections of foreign trade will be paralleled in coastwise and domestic cargo movements; however, possible changes in land transportation methods and procedures must not be disregarded.

Figure 8

Volume and Composition of Puget Sound Cargoes With Estimates of Values by Carrier Type, 1965

Source: Waterborne Commerce of the United States, Department of the Army Corps of Engineers, 1966.

Table 23

Cargoes Handled by Puget Sound Ports, 1965

	Foreign Imports	Foreign Exports	Coastwise Receipts	Coastwise Shipments
TANKER CARGOES				
Anacortes	928	20	679	3764
Seattle	86	3	2627	174
Tacoma	443	13	54	51
TOTAL	1457	36	3476	3962
LINER CARGOES				
Anacortes	13	199		
Bellingham	320	95		198
Everett	154	325		
Olympia		104		33
Port Angeles	58	345	9	
Seattle	591	360	315	652
Tacoma	740	654	3	
TOTAL	1901	2082	329	883
NON-LINER CARGOES				
Port Townsend	51			
Seattle	435	748		
Tacoma	136	439		
TOTAL	622	1187		

Source: Waterborne Commerce of the United States, Department of the Army, Corps of Engineers, 1966.

A number of observations can be drawn from the above data. Tanker cargoes dominate the import commerce nationally and on the West Coast, but appear to be less significant thus far in Puget Sound. Tanker exports are much less important nationally, and are negligible on both the West Coast and in Puget Sound, which are deficit areas for petroleum. Significant amounts of oil move in the coastwise and internal routes. Liner cargoes form a rather minor portion of both the export and import trade nationally and on the West Coast, but in Puget Sound they account for a substantial portion of the total foreign trade. Competitive shore transport facilities, trucks, and piggyback rail equipment create an indefinite situation in relation to the amount of liner cargoes moving in coastwise and internal shipping. However, it should be recognized that in spite of the general conviction that American coastwise shipping has been slowly dying ever since World War II, the container ship business is leading to a considerable revival. The non-liner cargo subgroup forms a substantial portion of national imports and exports, a minor part of West Coast imports, and a major part of its exports. On Puget Sound these cargoes are important. Information is scanty about coastwise and internal movement of this subgroup.

During 1965 a total of 1513 dry-cargo ships and 590 tankers having drafts of over twenty feet entered various ports of Puget Sound. Since an unknown number of these ships may have entered more than one harbor on one voyage, however, this information is of dubious value. In addition to these ships, 5,000 dry-cargo barges, 4,000 barges, and 74,000 tugboats and other craft entered various ports on Puget Sound during the same year. Many of these vessels were built during

the same year. Many of these vessels were built on Puget Sound and may never have left its waters.

When considering the impact of shipping on the management of Puget Sound estuarine resources, a number of physical characteristics of the area must be recognized. Sailing distances from Cape Flattery to Alaska, Japan, and southeast Asia are shorter by more than a day's run than from other West Coast ports of the continental United States. Puget Sound is the only port area on the continental West Coast able to receive the largest ships in the world today and into the foreseeable future. At present, however, it has limited facilities for handling and maintaining very large commercial vessels.

Because population density is substantially lower in Puget Sound than in other West Coast port areas, large areas are available for future development of all kinds. Rail and highway transportation is well established on the east side of the Sound, but not to the west. The recent installation of a major aluminum processing plant north of Bellingham, the attempt to develop another on Guemes Island, and the construction of a major deep water bulk-grain facility in Seattle all suggest important future potentials.

The evolving changes in trading and cargo-handling patterns will, of course, influence development in the region. Facilities must be readied to handle the various components of world trade, an important one of these being the vast quantity of oil projected to be shipped from the recently discovered fields on the northern slope of Alaska.

Expectations are that this will overshadow the increasing flow of oil now being marketed from southern and southwestern Alaska. Another change involves the methods for handling brokenbulk cargoes.. Traditional small-unit methods are giving way to larger transfer units in the form of various containers. Specialized methods for handling lumber cargoes and the transportation of wheeled vehicles in vessels where they can be rolled on and off are now becoming common. Such changes stem from demands for greater efficiency and higher utilization of equipment as well as the need to provide cheaper transportation services to customers. These, in turn, have much broader effects, such as the creation of unit trains for the delivery of containerized cargoes between the central United States and the Pacific Rim countries via the West Coast.

Many of the above changes are directly related to the evolution of ships designed to carry the trade of the world. In the past five years, there has been a major trend toward building very large liquid-bulk-carrying ships. The largest under construction today can carry 370,000 tons of cargo (oil). In 1967 one third of the tankers being built had capacities over 150,000 tons and these accounted for over 50 percent of the total carrying capacity of all tankers then under construction throughout the world. As of December, 1968, the following numbers of tankers were on order throughout the world, according to deadweight capacity: under 50,000 tons - 43; 50,000-100,000 tons - 42; 100,000-150,000 - 28; 150,000-200,000 tons - 41; 200,000-250,000 tons - 110; 250,000-300,000 tons - 30; over 300,000 tons - 5. It can be

seen that over 60 percent of the total capacity of new tankers will be carried in ships having deadweight capacities of over 200,000 tons. Ships of this size require harbors more than sixty feet deep. The magnitude of shore installations requisite to cope with those large ships can be judged from new facilities at Bantry Bay, Ireland, where one million tons of oil (four large ship loads) can be stored and where pumping capacities are about 13,000 tons per hour, sufficient to discharge large ships in less than twenty-four hours. Additional facilities for transshipping the oil are an important part of this complex.

Specialized dry-bulk vessels are also increasing in size. As of December, 1969, over 50 percent of the carrying capacity of ships of this type on order throughout the world was in 30 percent of the ships, each having a capacity of over 50,000 tons deadweight. The kinds of shorebased facilities required for these vessels have already been mentioned. The transition to containerized-cargo vessels entails considerable change in dockside facilities to provide large paved parking areas with mechanized container handling and transshipping equipment. The traditional covered docks on finger piers with narrow aprons can no longer serve. In addition, the large ships require specialized service and maintenance facilities including massive dry-docks and cranes. How Puget Sound will eventually be affected by all these developments is a matter of conjecture at this time.

Estimates of oil reserves in the new Alaska fields run from a very conservative 5-10 billion barrels up to 30-40 billion barrels.

The rates of exploitation depend on firming up these reserve estimates; at present, substantial movements of oil from the northern slope are not expected to start until 1972. Shipment of this oil to markets in the United States (high costs preclude sales to Japan) can follow several paths, among which are: by pipeline to Valdez and thence by ship to the East and West Coasts; by pipeline through connections with Canadian lines to the Great Lakes area; and by ship around northern Canada to the East Coast. Prospects appear quite good for the construction of a pipeline to Valdez, having a capacity of one to two million barrels per day. Estimates of the flow of this oil based on estimated reserves, according to an article in the March, 1969, Fortune Magazine, vary from 500,000 barrels per day for the low estimate in 1972 to 2.5 million barrels per day by 1980; this flow increases according to the higher estimate to one million barrels per day in 1972 and to five million barrels per day in 1980. From these data the impact of Alaskan oil on West Coast shipping can be estimated. The lowest estimate of flow approaches the total anticipated West Coast tanker imports in 1972, and this would drastically affect the normal flow to these ports. When the highest estimate of flows is considered together with the use of very large tankers, the impact on these ports assumes almost alarming dimensions.

The projection of 500,000 barrel per day at Valdez means that two 225,000 ton tankers would be loaded there each week; at the highest estimated rate of flow, twenty similar tankers would be loaded each week.

Tankers of this size are much too large,because of their draft requirement, to enter any West Coast ports except Puget Sound. The potential need for transshipping facilities becomes apparent if such a route is chosen and if ships of this size or larger are used. It appears that Alaskan oil will have a profound effect on Puget Sound regardless of how it is to be shipped, since little time is available until the flow starts and the quantities are so tremendous.

To evaluate the impact of Alaskan oil on Puget Sound, the following assumptions are made: (1) the pipeline across Alaska to Valdez is built, and initial oil flow is 500,000 barrels per day in 1972, building up to 5 million barrels per day by 1980; (2) the oil is shipped in very large tankers to Puget Sound for discharge into storage, thence into a major pipeline to the central United States or into ships bound to San Francisco and Los Angeles. To handle the initial flow, two 225,000 ton tankers would enter the Sound each week; at full production a maximum of twenty tankers per week would be required. Since ships of this size cannot be accommodated in the California ports, smaller vessels and barges could be used to move products to these terminals. The remainder of the oil could be shipped by pipeline. Since foreign-built vessels cannot be used to carry cargoes between American ports because of the Jones Act, ships would have to be built for this service as well as facilities for their servicing and maintenance.

This tremendous flow of oil carries pollution potentials of serious proportions. Estimates by Dr. Max Blumer of Woods Hole indicate that approximately 0.1 percent of the oil transported by water is lost in transit or in port. This would amount to 21,000 gallons per day at the low-flow rate and 210,000 gallons per day at the maximum rate. A casualty to one of the ships could cause catastrophic pollution.

With respect to liner cargoes, normal growth patterns can be anticipated, with possible upward adjustment of West Coast liner trade resulting from the inauguration of container services to the Orient and of unit trains carrying containers to and from the central United States. The fact that Puget Sound has only the advantage of shorter distances to the Orient and is in a questionable position concerning transshipping containers when compared with other West Coast ports raises doubts about growth of this area of shipping activity. The future expansion of container cargoes to Alaska as a result of the increased oil activity is as yet indeterminate. The Port of Seattle has made substantial progress in providing container facilities, and they are estimated to be adequate for the time being. An important factor in the liner trade is the level of containerization; many cargoes will remain uncontainerized because of high freight rates relative to the value of the cargo, the volume of movement, the extent of handling facilities at terminals, etc. The lighter-aboard-ship idea is as yet untried and in its early stages of development; it is too early to comment seriously on this concept.

The non-liner trade is expected to increase for exports but not drastically for imports. Since this trade is also tending to use much larger ships, the harbor depths give Puget Sound a relative advantage.

The projections for increases in vessel size, weight, and draft also indicate the future need for deeper and wider channels, since experience has indicated that adequate depth is the first requirement of safe navigation in a waterway. These must be carefully planned with respect to mutual effects of tidal forces in the channels and of the channels on the tidal regime.

Engineering works cause major changes in tidal currents, sediment movements, shoreline configuration, and mixing processes. Channel deepening in estuary areas can also produce intrusion of tidal saltwater above those points where intakes draw freshwater from channels for municipal or irrigation supplies, and by changing significantly the channel dimensions or flow characteristics may cause an upstream movement of the saltwater wedge.

In summary, the relative stability of the volume of shipping in Puget Sound conceals internal changes in structure that may raise serious problems for other users. If the advantages of Puget Sound for deep water harbors are to be realized, provision must be made for larger ships and different kinds of shoreside facilities; at a minimum, further encroachment on the remaining waterfront is inevitable.

At least one of the most likely areas of growth -- the petroleum trade -- poses a constant threat of pollution from spills, collision, and irreducible minimum leakages in handling unless stringent precautions are imposed at the outset. Finally, the impact of these new usage patterns on the scenic beauty of the water and shoreline must be given serious consideration.

III. RECREATIONAL BOATING

Puget Sound offers an extraordinary opportunity to enjoy all types of pleasure boats, sail and powered, large and small. While the open Sound can be treacherous for small craft, the area as a whole offers numerous sheltered bays and inlets where even the smallest boats can be enjoyed.

As indicated in Table 24, ownership of boats requiring Coast Guard registrations has climbed rapidly since licensing began in 1960. Unfortunately, the figures for 1961 through 1965 are biased upward because the firm doing the study for the United States Coast Guard failed to delete changes and expirations; thus only the figures for 1960, 1966, and 1967 can be considered unbiased.

A very detailed study recently published gives much useful detail on the present magnitude of private boating and related service activities in the Puget Sound study area.[29] Its major findings are summarized below.

Table 24

Boats Over Ten Horsepower - Puget Sound 1960-1967

1960	49,757
1961	61,845
1962	71,061
1963	78,481
1964	89,408
1965	96,719
1966	85,881
1967	87,614

Source: U.S. Coast Guard, Seattle.

Registered boats in the area are estimated to be responsible for over 95 percent of the demand for Puget Sound pleasure boating facilities. Therefore the United States Coast Guard register is considered to be a reasonable base from which to measure facility demand. Approximately 1,600 questionnaires were mailed to a random sampling of boaters living within the study area (Puget Sound as defined in the study) and nearly 70 percent were returned. This high return rate, together with a telephone survey of non-respondents indicates a high degree of reliability for the reported statistics.

An estimated 186,000 pleasure boats over five horsepower were owned by residents of the Puget Sound area in 1967. The total number of boats was estimated to be 230,000, or 94 boats per 1,000 population in the Puget Sound area as compared to 40.8 nationwide and 53 in the Strait of Georgia area of British Columbia. The nearly two million persons in the study area owned 186,000 boats in the following categories.

Inboard	18,200
Outboard	94,400
Auxiliary sailboat	1,400
Sailboats without power	6,300
Miscellaneous (row, etc.)	65,700

A total of 167 marinas supply 15,941 rental moorages, while 185 trailer boat ramps with 221 launching lanes are scattered throughout the study area. An estimated nine miles of shoreline are occupied by public and private pleasure boat facility developments, and an additional two hundred miles of shoreline are suitable for development. Over 36,000 boat owners now use or would use new saltwater picnicking facilities, and approximately 22,000 now use or would use new saltwater camping facilities.

This rapidly growing activity is expected to maintain its present rate of expansion for some time. The supply of used boats has now grown to levels that make ownership appealing to a much broader middle-income base than in years past. Demand for boating is inherently sensitive to rising per capita disposable incomes, mobility, and the effects of changes in boat and motor technology that increase reliability and reduce maintenance requirements.

Projections for an increase in pleasure boat ownership are as follows:

1966	186,000
1980	290,000
2000	550,000

Recreatinnal boating raises two primary issues with respect to water quality. On the one hand, the association of boating with fishing, water skiing, swimming, scuba diving, and other water sports indicates a related demand for maintenance of water quality, even though boating per se is affected only if smell or discoloration are

involved. On the other hand, the tendency of boaters to congreate in sheltered areas poses a threat of its own. A study is now under way of the effects of small boat waste discharges in selected areas of Puget Sound, but no quantitative estimates of the severity of the potential problem are yet available.

Fortunately, both these elements are likely to be subordinated to other aspects of a rational management policy for Puget Sound waters. Water quality adequate for protection of salmon and shellfish is very likely to meet the requirements of recreational users, including pleasure boaters; and the techniques required to minimize hazards from waste disposal by boaters themselves can be enforced with relatively little cost or difficulty. This is probably the least of the potential dangers to water quality in Puget Sound.

IV. SALTWATER PARKS

Strictly speaking, the saltwater parks in the Puget Sound study area are not users, but publicly owned sites where access to a wide range of waterbased recreational activities is provided. Fishing, boating, shellfish gathering, beachcombing, picnicking, camping, and swimming (for the hardy) are available in varying combinations and with varying degrees of development. They are, of course, the same activities enjoyed by thousands of private owners of waterfront property.

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A number of city and county parks perform part of this useful function, but data indicating usage rates are not available. Much the largest source of public access to Puget Sound waters is provided by the saltwater state parks. The following listing groups these parks by general area:

Puget Sound: Bayview, Birch Bay, Blake Island, Camano Island, Dash Point, Fort Casey, Fort Flagler, Fort Ward, Fort Warden, Jarrell Cove (Gerald's Cove) Mukilteo, Old Man House, South Whidbey, Saltwater

Hood Canal: Belfair, Illahoe, Kitsap Memorial, Kopachuck, Old Fort Townsend, Penrose Point, Pleasant Harbor, Scenic Beach, Sequim Bay

San Juan and Whidbey Islands: Deception Pass, Jones Island, Larrabee, Lime Kiln Point, Matia Island, Reid Harbor, Secua Island, Turn Island.

Detailed data on saltwater park usage and its future needs have been compiled by the Washington State Parks and Recreation Commission and the Bureau of Outdoor Recreation of the Department of the Interior.

Table 25 provides a summary of attendance at the saltwater state parks for the years 1958-1959 and 1963-1964 to 1967-1968. Every category of use shows a marked upward trend, and an undetermined but large number of people is turned away because of congestion at peak periods. Studies by the Bureau of Outdoor Recreation point up the desirability (and very high cost) of acquiring additional sites in view of the obvious prospects for continued growth in demand and diminishing availability of suitable beach property.

Table 25

Attendance at Saltwater Parks of Puget Sound

Year	Day Visitors	Tent Campers	Trailer Campers	Groups	Total	Per Day Boats Moored
Oct. 1958-Sept. 1959	2,194,831	158,038	41,961		2,394,830	
July, 1963-June, 1964	3,450,918	148,883	89,320	44,413	3,733,534	11,220
July, 1964-June, 1965	4,087,980	160,832	131,051	70,701	4,450,564	15,905
July, 1965-June, 1966	4,416,952	171,599	165,406	23,568	4,777,525	31,621
July, 1966-June, 1967	4,892,569	175,486	170,579		5,238,634	62,008
July, 1967-June, 1968	5,168,832	200,547	223,049		5,592,428	63,546
Average	4,035,347	169,231	136,894		4,364,586	36,860

Source: Washington State Parks and Recreation Commission, Olympia, Washington.

The conclusions need not be labored. It is manifestly impossible to develop, within prospective budget limits, saltwater park facilities at a rate that will keep pace with the demand of an increasingly affluent and mobile population with an increasing amount of leisure time.

The socioeconomic values provided by these facilities will therefore increase over time. Sound management of the overall Puget Sound system clearly requires not only that water quality in the park areas be maintained, but also that land use be patterned to protect the scenic beauty and isolation of some parks. This is no idle concern. To an alarming degree, the controversies over the siting of shoreside industrial plants, thermal power plants, and port facilities have hinged on the impact on land usage, with little concern for costs imposed on water users and still less for the effects on general environmental attractiveness.

Saltwater parks are, admittedly, expensive in terms of the alternative costs of the valuable beach frontage required, but they are an integral and important element of the social vaues, not readily measurable in economic terms, to be weighed in developing and managing the waters and adjacent lands of Puget Sound.

V. MARINE RESEARCH

One of the most significant of the several outputs of the Puget Sound system that defy economic quantification is its utility for conducting saltwater research activities.

Two primary reasons account for the breadth of the marine research work now carried on in the Puget Sound study area: the availability of a sheltered inland sea and the mild marine climate that permits most activities to be continued throughout much of the year. The logistics problems involved in supporting research in the open ocean are far greater than those encountered in Puget Sound, yet much of the work can be carried on equally effectively in the sheltered areas. As indicated in Chapter I, the Sound offers a remarkable assortment of depths, bottom conditions, mixing processes, and biota, all of which are of prime interest to researchers in academic institutions, government agencies, and industry. Obviously, some of these research projects can be carried on without conflict with other users of the environment; indeed, many of them are in direct support of these users. Many others, however, require conditions of vertical and horizontal water space and unimpeded access from the shore that make it essential to exclude other activities. Similarly, many of the research areas are relatively independent of water quality conditions short of gross degradation, whereas others require severe standards of water quality.

Research is conducted in the following general categories in the Puget Sound area:

1. Descriptive oceanography -- physical, chemical, biological, and geological.

2. Fisheries -- seafood, harvesting, handling, and processing.

3. Naval vessels and equipment -- underwater sensors and communication devices.

4. Pollution and water management techniques -- ecology, life support systems, and underwater engineer studies relating to adaptation of man to the sea.

Among the major contributors to these elements of research in the Puget Sound area are the following: Bureau of Commercial Fisheries: ESSA - Coast and Geodetic Survey; Department of Health, Education, and Welfare (Northwest Shellfish Laboratory); University of Washington; Washington State Department of Fisheries; Washington State Pollution Control Commission; Honeywell Corporation; The Boeing Company; Battelle Northwest; and Virginia Mason Research Center.[30]

VI. WASTE DISPOSAL

A. INTRODUCTION

It may seem contradictory to list waste disposal among the uses of Puget Sound, in a study oriented to the impact of degraded water quality on the socioeconomic values derived from the study area. In fact, however, optimal use of the capacity of the Puget Sound system to assimilate waste of various kinds (including heat) is an integral part of any sound management program.

There are four major types of wastes that affect water quality in Puget Sound: (1) wastes originating from the watersheds of the rivers that drain into Puget Sound; these include domestic and industrial wastes produced by the industries and municipalities in the water sheds and those derived from physical mismanagement of the watershed; (2) domestic wastes, treated or untreated, that are discharged by the municipalities on Puget Sound, directly into the Sound or in the sections of rivers influenced by the tide; (3) wastes discharged from commercial and recreational shipping; (4) industrial wastes generated by firms located on the banks of the Sound.

Water of undesirable quality that is discharged into the Sound by river flows may be the result of normal ecological variations; e.g., waters warmer than desirable may be discharged

during an unusually warm dry summer. It may be due to the familiar pattern of land management that is difficult if not impossible for a water regulatory agency to identify, let alone control. Typical instances are heavy silt loads, carried by the winter freshets, that are caused by logging activity many miles away from tidewater; careless farming practices; or flood control or channeling programs on a river. Extensive damage to clam and oyster beds may result from siltation or a severe esthetic loss may be inflicted but abatement activity, if any, must be taken by authority other than water agencies alone. These occurrences are so commonplace that they are regarded as part of the seasonal ecology in many areas.

The only degradation of water quality in Puget Sound that is under active consideration by the regulatory agencies is that resulting from domestic and industrial wastes and the wastes discharged from vessels. The general public participates by being actively and vocally concerned with industrial waste discharges, especially those generated by the pulp and paper industry, and by protesting against the establishment of any industries in some areas regarded as essentially recreational or residential. There is a surprisingly general belief that the water in Puget Sound is of extremely low quality, and that it is marginal as a fish habitat. Many firmly believe that Puget Sound is a "cesspool."

There is no doubt that the Puget Sound is receiving wastes that either could or do impair its quality; but outside of areas in the immediate vicinity of plant outfalls, it is maintained by some authorities that there is little acceptable evidence, direct or indirect, that the desirable organisms in Puget Sound or its desirability as a recreational resource has been harmed by waste discharges except in limited local areas. Others sincerely believe that massive clean up measures are needed immediately. Neither group is able to document its position, at least to the satisfaction of the courts, on the basis of present knowledge.

B. PRESENT KNOWLEDGE

The permit system of the State Water Pollution Control Commission allows precise identification of waste dischargers making use of Puget Sound waters and of rivers emptying into Puget Sound.

A general summary of the wastes now being discharged into Puget Sound and its tributaries is shown in Table 26. It is evident that the marine waters are receiving the bulk of these wastes, and that relatively low treatment efficiencies characterize the entire area. The work of the State Water Pollution Control Commission, the Federal Water Pollution Control Administration, individual researchers in the fields of sanitary engineering and fisheries at the University of Washington and a number of other sources provide a voluminous mass of information on physical aspects of pollution in Puget Sound. These are available as required.

Table 26

Summary of Municipal and Industrial Wastes in Puget Sound Area

Basin	Untreated Waters Population Equivalents			Discharged Wastes Population Equivalents			Treatment Efficiency (Percent)		
	Fresh	Marine	Total	Fresh	Marine	Total	Fresh	Marine	Total
NOOKSACK-SUMAS									
Municipal	5,400	55,000	60,000	2,000	33,000	35,000	63	40	42
Non-Seasonal Industrial	20,000	1,746,000	1,766,000	20,000	1,744,000	1,764,000	None	None	None
Seasonal Industrial	130,000	59,000	189,000	46,000	59,000	105,000	65	None	44
Recreational	15,000	5,000	20,000	3,700	1,200	5,000	75	76	75
SKAGIT-SAMISH									
Municipal	23,000	8,300	31,300	14,400	5,000	19,400	37	40	38
Non-Seasonal Industrial	25,000	789,000	814,000	25,000	786,000	811,000	None	None	None
Seasonal Industrial	116,000	78,000	194,000	116,000	78,000	194,000	None	None	None
Recreational	14,000	5,000	19,000	3,600	1,200	5,000	74	76	74
STILLAGUAMISH									
Municipal	5,600	-	5,600	2,200	-	2,200	61	-	61
Non-Seasonal Industrial	-	-	-	-	-	-	-	-	-
Seasonal Industrial	335,000	-	335,000	221,000	-	221,000	34	-	34
Recreational	6,500	1,200	8,000	1,600	300	2,000	75	75	75
SNOHOMISH									
Municipal	16,000	95,000	111,000	9,400	33,000	42,400	41	65	62
Non-Seasonal Industrial	77,000	6,906,000	6,983,000	61,000	6,644,000	6,705,000	21	3.8	4.0
Seasonal Industrial	48,000	10,000	58,000	39,000	3,400	42,400	19	66	27
Recreational	22,000	7,000	29,000	5,500	1,800	7,000	75	74	76

Table 26

Summary of Municipal and Industrial Wastes in Puget Sound Area (continued)

Basin	Untreated Waters Population Equivalents			Discharged Wastes Population Equivalents			Treatment Efficiency (Percent)		
	Fresh	Marine	Total	Fresh	Marine	Total	Fresh	Marine	Total
CEDAR-GREEN									
Municipal	202,000	380,000	582,000	49,000	187,000	236,000	76	51	59
Non-Seasonal Industrial	121,000	136,000	257,000	97,000	136,000	233,000	20	None	9
Seasonal Industrial	55,000	-	55,000	29,000	-	29,000	47	-	47
Recreational	37,000	12,000	49,000	9,000	3,000	12,000	76	75	76
PUYALLUP									
Municipal	214,000	152,000	366,000	140,000	95,000	235,000	35	38	30
Non-Seasonal Industrial	88,000	336,000	424,000	64,000	336,000	400,000	27	None	6
Seasonal Industrial	39,000	10,000	49,000	32,000	10,000	42,000	18	None	14
Recreational	21,600	3,800	25,000	5,400	1,000	6,000	75	74	76
NISQUALLY-DESCHUTES									
Municipal	3,000	55,400	58,400	100	40,000	40,100	97	28	31
Non-Seasonal Industrial	200	62,300	62,500	200	57,300	57,500	None	8	8
Seasonal Industrial	-	-	-	-	-	-	-	-	-
Recreational	14,000	4,000	18,000	3,600	900	4,500	74	78	75
WEST SOUND									
Municipal	-	75,000	75,000	-	53,000	53,000	-	29	29
Non-Seasonal Industrial	-	126,000	126,000	-	119,000	119,000	-	6	6
Seasonal Industrial	-	2,000	2,000	-	2,000	2,000	-	None	None
Recreational	17,000	17,000	34,000	4,000	4,000	8,000	76	76	76

Table 26

Summary of Municipal and Industrial Wastes in Puget Sound Area (continued)

Basin	Untreated Waters Population Equivalents			Discharged Waters Population Equivalents			Treatment Efficient (Percent)		
	Fresh	Marine	Total	Fresh	Marine	Total	Fresh	Marine	Total
ELWHA-DUNGENESS									
Municipal	-	25,000	25,000	-	23,000	23,000	-	8	8
Non-Seasonal Industrial	-	3,234,000	3,234,000	-	3,234,000	3,234,000	-	None	None
Seasonal Industrial	-	-	-	-	-	-	-	-	-
Recreational	4,600	1,500	6,000	1,100	400	1,500	76	73	75
SAN JUAN ISLANDS									
Municipal	-	800	800	-	800	800	None		None
Non-Seasonal Industrial	-	-	-	-	-	-	-		-
Seasonal Industrial	-	2,800	2,800	-	2,800	2,800	None		None
Recreational	-	7,000	7,000	-	1,700	1,700	76		76
WHIDBEY-CAMANO ISLANDS									
Municipal	-	11,500	11,500	-	7,400	7,400	-	36	36
Non-Seasonal Industrial	-	-	-	-	-	-	-	-	-
Seasonal Industrial	-	-	-	-	-	-	-	-	-
Recreational	600	11,300	12,000	200	2,800	3,000	67	75	75
TOTALS									
Municipal	469,000	858,000	1,327,000	217,000	477,000	694,000	54	44	48
Non-Seasonal Industrial	331,000	13,335,000	13,666,000	267,000	13,060,000	13,330,000	19	2	2
Seasonal Industrial	723,000	162,000	885,000	483,000	155,000	638,000	33	4	28
Recreational	152,000	75,000	227,000	38,000	18,000	56,000	75	76	75

Source: Preliminary estimates, appendix VIII, Water Quality Control, Puget Sound and Adjacent Waters Study.

The State of Washington Water Research Center is now working on a quantitative compilation of industrial and commercial wastes in the State of Washington from all points and conversion of the information into management objectives. The initial study focuses on the effects of major withdrawals from the Columbia River, but the methodology is generally applicable, and is now being extended to other rivers in the state and to Puget Sound. The following discussion is drawn largely from the unpublished preliminary report emerging from these studies.

Waste production data were obtained by multiplying regional economic forecasts by coefficients of waste per unit of production. While use of such coefficients is probably too conservative, they satisfy the criteria for "worst case" analysis. Coefficients were developed for all important waste dischargers in the State of Washington, and the distribution of various industries for each basin was based on waste discharge permit data and the analysis of manufacturing industries. Waste production for future years by area was then derived from regional economic forecasts.

Preliminary results of these analyses are now available for all of the major rivers emptying into Puget Sound. Of greater importance for purposes of this study is the following discussion of the potential waste disposal problem in Puget Sound and several of its most vulnerable subareas.

For reasons implicit in earlier chapters of this report, this approach to defining waste assimilation capacity and identifying danger points is much more difficult to apply in the estuarine environment. Precise estimation would require ability to predict the complex

cycle of events in the marine system in response to pollution loads; and quantification of the amount of water available for dilution involves the whole complex of factors bearing on flushing time of the estuaries, the impact of tidal action, and mixing of the pollutants. Nevertheless, there are sufficient data to provide a very gross picture of the assimilative capacity of the marine waters of Puget Sound.

The quantitative results of the BOD discharges to marine waters of Puget Sound are shown in Table 27. Since oxygen-demanding wastes can be removed either by flushing or by addition of oxygen from the atmosphere to satisfy demands, two separate evaluations can be made. The first evaluation assumes that the body of marine water was isolated from both the atmosphere (no oxygen addition) and the sea (no flushing) and the projected waste loads discharged. These results, shown in Table 27, column marked Case I, indicate that severe degradation would rapidly occur if the assumed conditions could exist. These would be the maximum implausible conditions. Without the supply of oxygen, flushing would not noticeably change the conclusions shown for Case I. Rough estimates place the flushing of the Puget Sound volume at three or four years, which is much longer than the five months required to consume the dissolved oxygen in the Sound. Fortunately, organic-waste oxygen demand can be satisfied by the addition of oxygen from the atmosphere by regeneration. Case II for the contribution of oxygen from

Table 27

ESTIMATION OF THE IMPACT OF FUTURE BOD DISCHARGES ON MARINE WATERS OF PUGET SOUND

Area	Estimated BOD Produced (Tons/Day)			Case I With 2020 Conditions Time to Deplete if Plugged & Covered	Case II Estimated[a] Reaeration Capacity Tons/Day	Treatment Required under Perfect Mixing		
	Present	1980	2020			Present	1980	2020
Puget Sound	190	342	1293	5 months	2600	0	0	0
Possession Sound	725	1360	6100	14 days	400	45	70	93
Bellingham Bay	192	354	1590	2 days	150	20	57	90
Commencement Bay	73	117	271	2 months	75	0	36	72

[a]Based on defecit allowed by standard.

reaeration is also shown in Table 27. The values were estimated using an oxygen transfer rate of 1.8×10^3 tons of O_2/naut. mi.^{2}/ppm deficit/yr where the oxygen deficit was defined as saturation minus the Washington water quality standard for the water of concern.

While such a gross evaluation of a large area like Puget Sound reveals little oxygen problem, enclosed areas or near-shore zones may become severely degraded in oxygen content. Each of the heavily populated zones -- such as the Tacoma, Seattle, Everett, and Bellingham marine waters -- lacks adequate flushing or reaeration to assimilate naturally projected waste loads, and treatment will be required to remove organic waste. The periodic upwelling of sea water low in oxygen content will present a serious problem if oxygen-demanding wastes are discharged to the bottom waters to exert their demand before they can be reaerated at the surface. It is projected that unless secondary treatment is provided for discharges to the marine environment in these regions, oxygen content will drop to unacceptable levels in the next twenty years.

While these projections are first order estimations, it does not appear that the waters of Puget Sound, Possession Sound, or Bellingham Bay can be assumed to have infinite waste assimilation capacity compared to the projected waste loads for the next twenty to fifty years.

For these projections to be valid the waste discharge must be mixed and discharged uniformly in the receiving waters. The practice of local discharge near shore will obviously create severe local water quality problems.

As with the saltwater BOD analysis, the saltwater coliform analysis cannot be simply stated without a set of heroic assumptions. Even if all domestic wastes could be collected and uniformly mixed with all available marine water, some treatment would still be required to meet state standards. Table 28 presents the results of an analysis based on complete mixing. If the problem of recreation homes on the Sound isconsidered, any beach with more than one person per four miles of frontage discharging raw wastes or more than one person per 200 feet of frontage discharging treated or septic tank effluent would fail to meet the existing water quality standards. Since such population densities are often exceeded, and there are numerous discharges from pleasure craft, the coliform standards may be exceeded more and more frequently in the future.

A more serious problem of a local nature is the practice of collecting domestic waste from large regions and discharging this at a single point in marine waters. Obviously, those waterfront areas where discharges are discontinued will see improvement, but it is not apparent that collection, treatment, and discharge at another point will allow the standards to be met at the discharge point. Thus, the requirement for removal of coliform must be closely connected to the allowable size of the mixing zone at the point of discharge.

Table 28

Estuaries - Coliform Summary [a]

Area	Population ($x10^3$)			Coliform Conc., Without Treatment (MPN/100 ml)			Allowed Coliform Concentration (MPN/100 ml)			Required Coliform Removal (Percentage)		
	Present	1980	2020	Present	1980	2020	Present	1980	2020	Present	1980	2020
Puget Sound	849	1239	1994	110	161	259	70	70	70	36	57	73
Hood Canal	90 [b]	90 [b]	90 [b]	70 [b]	70 [b]	70 [b]	70	70	70	0 [b]	0 [b]	0 [b]
Possession Sound	47.8	70.0	112.5	72	106	169	70	70	70	3	34	59
Bellingham Bay	31.6	46.2	74.3	1010	1474	2370	1000	1000	1000	1	32	58
Commencement Bay	210	330	852	1350	2120	5500	1000	1000	1000	26	53	82

[a] Assuming perfect mixing.

[b] Allowable population before treatment. Populations in excess of 90,000 (evenly distributed) will necessitate treatment.

A note of concern is the observation that coliform multiply rapidly in industrial waste treatment processes and that treatment of combined domestic and industrial wastes may breed coliform rather than kill them.

C. HEAT DISCHARGED FROM THERMAL POWER PLANTS

The State of Washington is rapidly approaching the point where rising demands for power must be met from thermal plants. Moreover, as the change in the relative importance of hydropower to thermal proceeds the latter will ultimately provide the basic source of power, and the Columbia River hydroelective system will shift to a peaking operation. Power demands indicate a market for non-hydroelectric power sources which is expected to require plants of approximately 1,000 megawatt capacity to be added each year in the Pacific Northwest over a period of at least thirty years, staraing in the late 1970's. Each of these installations requires a major financial investment of several hundred million dollars and a lead time of about ten years for development. Thus, siting of the first plant may be decided soon based upon information that is presently available or can be acquired on the basis of short term studies.

A number of economic, engineering, political and environmental problems are involved. One major environmental question is concerned with the disposal of waste heat. It is expected that most of these thermal plants will be built where they can be cooled with sea water. Althought the use of cooling towers or artificial lakes may permit competitive siting in some inland areas, Puget Sound,

and the Strait of Juan de Fuca are the most logical locations for at least some of these plants. Assuming sound engineering design and construction, in accordance with Atomic Energy Commission standards, thermal plants may affect other users of Puget Sound in several ways. The prime concern in the public mind appears to center around the potential threat to aquatic life. Three basic questions must be answered:

1. What happens to organisms drawn through or against protective devices on the cooling water intake?

2. What changes in the complex of living organisms may result from the discharge of heated water (presumably free of other contaminants)?

3. How large an area would be affected?

In Puget Sound, with its impressive contribution to the natural beauty of the land-sea environment and increasingly important recreational activities, it is also mandatory to weigh the impact of alternative sites on these outputs.

The issues involved in the impending controversies over the choice of locations for needed power capacity are far too complex to be dealt with in this study. We simply raise the following points, all of which support the urgent need for an extensive multidisciplinary, and continuing study of the process of expanding power output to meet regional demands, with full analysis of all social costs involved.

1. The knowledge base is wholly inadequate to answer any of the three questions raised above.

2. Assessment of each site sequentially as an individual decision will guarantee a very poor system in the end. From the standpoint of economic efficiency in the narrow sense, it is essential that alternative combinations, in time and space, be weighed to determine the most desirable system of thermal plus hydroelectric power. The injection of potentially serious ecological and aesthetic costs makes this approach even more imperative.

3. Though the State of Washington is moving rapidly to develop an organization to deal with these problems, it cannot ignore the complex local and federal involvement - economic, legal, administrative, and operational. Both the decision-making process and the appraisal of alternative political organizations to implement decisions call for much more detailed study. We have not, after all, been able to deal efficiently with far less complex cases involving environmental damage from industrial location.

CHAPTER VI

CONFLICT AND RESOLUTION: A PRELIMINARY SUMMARY

I. PATTERNS OF CONFLICT

This chapter summarizes the earlier discussion of currently identifiable major conflicts of interest -- present and potential -- and presents some preliminary conclusions in the management framework required to deal with them.

A number of conflicts involve direct impact by one user on another; i.e., the activities of one operation increase the costs, reduce the value of outputs, or both, for other users of the Puget Sound system. In the industrial sector, the principal conflicts of this type arise from the waste discharges of a small number of industrial plants, most of them located directly on Puget Sound. The pulp and paper industry has had a long history of conflict -- real and imaginary -- because of its discharges of waste liquor and solid materials. The principal receptors appear to have been fish, shellfish, and -- in varying degrees -- those residents of affected areas whose aesthetic enjoyment of waterfront and seascapes is curtailed by discoloration and odor. It is also possible that some types of wildlife may have been affected in some areas.

The acrimonious attempts to ameliorate the effects of pulp mill discharges need not be reviewed here, since developments of the past four years give hope of substantial relief in the near future.

The most promising aspects have been the impact of federal legislation requiring the states to establish receiving water quality standards and the reaction to that legislation by the State of Washington. While the time schedule now contemplated for major reduction of waste discharges by pulp mills on Puget Sound may be subject to disagreement, the general position of the state (and, through its power of review of standards and enforcement procedures, the federal government) has been made clear. In addition, technological developments in the pulp and paper industry will operate to reduce the problem of water quality degradation. From the standpoint of cost savings and product improvement alone, new plants established by the pulp industry have shifted to processes and scales of operation which make it economical to recover chemicals used in the pulping process and to prevent solid waste discharges of damaging proportions. This line of development has been given additional impetus, of course, by the impending regulatory action induced by the federal legislation of the 1900's. In short, no legal or economic reason appears why new pulp mills should present water quality problems in the Puget Sound area, and the time now allowed existing firms to shift to processes and equipment that meet the same standards does not appear unreasonable. Thus, even though tremendously difficult (perhaps insoluble) problems remain for establishing precise incremental damage functions relating pulp mill activities to loss of fish and shellfish, the basic issue appears on the way to solution.

Persistent, though less serious concern, has been occasioned by the food processing industry, particularly fruit and vegetable processors. These seasonal operations discharge larger amounts of organic waste into Puget Sound and the lower reaches of its tributaries. A number of milk processing and meat packing firms also dispose of wastes in the Puget Sound system. None of these are of major proportions, however, and the technology exists to eliminate entirely any serious conflict with other water users. Again, recently imposed state water quality standards can be translated into effective control of this source of trouble. The same comments apply to metalworking firms, whose discharges have caused fish kills in the past.

The petroleum refining industry presents an interesting contrast between its Puget Sound operations and those in other parts of the country. Although the industry has had its difficulties with water pollution in the past, it has made a determined effort to incorporate in the design of all the plants recently built in this area safeguard against damaging discharges. As a result, the only problems encountered have been of a highly localized and temporary nature; and there is no reason to anticipate any greater difficulties from refining operations per se if the Alaska oil discoveries result in the establishment of more Puget Sound plants.

Petroleum does pose a problem, but of an entirely different character. As indicated in Chapter V, the level of shipping activity

in Puget Sound has not grown appreciably, but its character is changing and is expected to change even further. This is particularly marked with respect to bulk transport of petroleum products by water. Thus, even though a refinery operation can be designed to eliminate major threats to the water environment, the tremendously increased prevalence of supertankers leads to potential water quality degradation from leakage, spills, collision, and the mere construction of the new deepwater facilities required to handle such vessels. Environmental damage resulting from this set of factors is likely to be much more difficult to deal with. The problem of spills and collision is contingent in nature, and the impact of dredging and waterfront construction on the living resources of the marine environment is subtle and difficult to identify.

The recent controversy over the establishment of a petroleum refinery at the head of Port Susan Bay emphasizes the conflicts of interest involved. While there was no reason to doubt that the refinery and its facilities would be built with strictest regart to water quality protection, the proposed location adjoins a highly developed recreational area with characteristics of water circulation that raise reasonable doubts as to the safety of the operation, even if pollution were confined to occasional episodes. Thus, the regional interests of commercial and sport fishermen, together with the local interest of the multipurpose recreational homes that make intensive use of the Port Susan Bay area, were ranged in direct opposition to

the firm which had chosen the location as optimal for its operations and the many businesses that would have stood to benefit during both construction and operation phases.

This particular controversy, one of many to be developed in the second phase of this study, brings out most of the elements of the unsatisfactory situation prevailing at present with respect to the utilization of the Puget Sound system. A preliminary examination of the evidence suggests strongly that neither side was basing its argument on all the relevant variables. Rather, each was arguing for an optimal solution from the standpoint of a selected group of interested parties. It is equally clear that neither group possessed objective data adequate to support its position; it would be surprising if they had, since the tenor of this report is that much of the necessary information does not yet exist, nor are the underlying causal relations fully understood even where adequate time series are available.

We were presented, in effect, with the classic dilemma of multipurpose development and use of a complex system of natural resources: The necessary information to make optimal allocations is lacking. The groups that can exert the greatest pressure advocate specific solutions that do not represent the interest of the public as a whole. And the decision making unit with jurisdiction over the dispute -- the county -- is entirely inappropriate from the standpoint of the range of costs and benefits to be evaluated.

In summary, Puget Sound need not be endangered by moderate

use of its waste-assimilative capacities by industrial firms. Those discharges which result from regular production processes and can therefore be controlled and monitored are most likely to be dealt with satisfactorily under present control techniques and standards. There is less certainty about the adequacy of protection against environmental damage from disturbance by waterfront construction and by accidental spills and discharges that occur on a once-for-all or completely sporadic basis.

The situation with respect to municipal waste is mixed. On the one hand, Puget Sound is still receiving substantial amounts of waste with little or no treatment, and some of it is concentrated in areas where it poses present dangers to fish, shellfish, and some recreationists. With respect to both BOD and coliform count, additional treatment is required now or most certainly will be required in the near future if present standards are to be met over time.

On the other hand, the concept, planning, and execution of the Metro system serving Seattle and adjacent communities has been so successful that its extension to other areas, as the situation demands, is likely to be accomplished without the major battles that preceded the establishment of Metro. The principle of concentrating waste for treatment and discharge is generally accepted for reasons of both economy and effectiveness of control, and the existence of mechanisms for financial aid to municipalities should ease the burden of transition to increased secondary treatment.

A more serious problem, despite the much smaller physical quantities of waste involved, is presented by the indiscriminate use of Puget Sound as a receptacle for the waste from individual homes and recreational developments in the less developed areas bordering Puget Sound. It was noted in Chapter V that the increase in this waterfront usage has been phenomenal and promises to continue at that rate.

The dangers arising from this situation are accentuated by the tendency to concentrate many types of waterbased recreation, including water contact sports, in the very areas where discharges are greatest. One of the key studies to be developed in the next stage of this project deals with the San Juan Islands, perhaps the major recreational area of Puget Sound. The number of people who now reside in the Islands, particularly during the summer, coupled with a geological structure that make septic tanks relatively ineffective, is already a matter of concern with respect to waste disposal, and the problem will assume much greater proportions within the next five to ten years.

The threat posed by uncontrolled use of the Sound for waste disposal in small increments stems from institutional weaknesses in the arrangements under which individual landowners have access to this privilege. From the standpoint of the individual cabin owner or small developer, the waste load contribution is so small that the simplest kind of facilities are regarded as adequate -- properly so, if only his own activities are considered. He has neither the capacity

nor the responsibility for assessing the combined impact of many such individual decisions. At the same time, the counties having jurisdiction over these areas, under pressure to achieve greater economic development and employment, are most reluctant to impose burdens in advance of identifiable small-area need lest the developer and his dollars go elsewhere. Yet in the long run the total cost imposed on the individual landowner will certainly be greater if necessary control measures are taken only after reasonably full development has taken place. The concept of regional water quality management is obviously of great present and even greater potential significance to Puget Sound with respect to household and municipal discharges; yet no effort is in evidence to implement the concept except in the major urban centers.

Two minor but persistent forms of annoying discharge should be mentioned. One is the growing quantity of oily waste, generated in small quantities by a variety of businesses and households, which is disposed of in ways that lead into Puget Sound and its tributary streams. Discharges of this sort are likely to grow proportionately with population in urban areas, and if concentrated by the disposal system, could become important enough to cause difficulties for some of the fish populations and recreation in Puget Sound.

Another persistent source of local difficulty is an unusual type of "pollution" from floating logs and deadheads. Much of the shoreline of Puget Sound, from high bank to high bluff, is forested

to the water's edge. Steady deposits of trees and stumps are inevitable. In addition, logs regularly drift loose from stationary boom areas and from rafts being towed to waterfront mills. The number of deadheads in the water has also increased perceptibly as a result of careless handling of debris from waterfront residential developments. Both pleasure craft and small commercial vessels have suffered repeated damage from these obstacles, and occasional serious accidents are bound to occur.

Over the long run, the greatest threat to optimal use of the Puget Sound system is not posed by direct water quality effects of industrial and municipal discharges of waste, but by failure to identify and evaluate estuarine effects of land use, not only on the waterfront but upstream. All of the important fish and shellfish resources of Puget Sound are vulnerable to this kind of careless development. Salmon, steelhead trout, and cutthroat trout require extensive systems of small feeder streams that are being systematically destroyed by improperly regulated land use far away from Puget Sound itself. Dyking and channel alteration designed to improve the carrying capacity of rivers and to alleviate flood damages may have serious adverse effects on fish spawning and resting areas. Although such effects are supposed to be assessed in the course of review by the Department of Fisheries, it is only with the utmost vigilance that the Department can be sure that all instances are brought to its attention.

The forest products industries have a long and undistinguished

The area is adjacent to a major port complex urgently in need of expansion and modernization, particularly if it is to accommodate new deeper-draft vessels. But the area is also a major sanctuary for wildfowl and includes an estuarine subarea of vital importance to the production of both game and commercial fish. Its preservation is also advocated on grounds of its unique ecological significance. As in the case of the Kayak Point refinery proposal, the vehemence of the controversy far outruns its factual basis. We simply do not know, at present, what alternatives might be considered for industrial development in the area and what the impact of these alternatives might be on local fish and wildlife. Reaching farther afield, it may well be that the handling of deep-draft vessels and the linking of them into an integrated land-sea transportation system might best be done by developing entirely new facilities away from present port areas.

Even if these alternatives could be subjected to accurate benefit-cost analysis, sources of conflict remain. The benefits and costs will accrue to different groups of people, without possibility of compensation in any practical sense; and the several agencies of local, state, and federal governments concerned, charged with different missions and judged by their accomplishment of those missions, will seek significantly different objectives in settling the controversy. Thus, what starts as a question of zoning for land use may well end by doing irreparable damage to saltwater environment adjacent to the

record of destruction, blockage, and reduction in carrying capacity os streams essential to anadromous fish. In theory all logging operators are subject to regulations that should prevent such damage; in practice, enforcement procedures and penalties involved have been inadequate to the task of eliminating destructive practices.

In general, any land use that involves moving substantial amounts of earth in or near water courses is potentially destructive of the anadromous fish of Puget Sound; and, less directly, it may effect shellfish production and other uses because of siltation or changes in water flow and temperature regimes at river mouths.

Again, the same problems emerge of identification, jurisdiction, and implementation of policy. No single agency of federal, state, or local government is charged with the responsibility for tracing out the interaction of resource use in the areas bordering Puget Sound. Even where such identification has been achieved, the functional alignment of agencies at both state and federal areas makes it extremely difficult to force the lead agency to include a full accounting of the impact of its own mission on costs incurred in areas subject to another agency.

Two examples may be cited to illustrate the point. The flats at the mouth of the Nisqually River are now the center of a bitter controversy, with shipping and general business interests in Tacoma and Olympia arrayed against commercial and sport fisheries groups, the Departments of Fish and Game, and many groups of conservationists.

area simply because the economic and political weights of the antagonists are so different.

A similar situation is posed by the development plan recently formulated by Snohomish County, in the interest of expanding its industrial and employment basis. The county contemplates the construction of a major industrial complex at the mouth of the Snohomish River, but the river system supports major runs of salmon, steelhead, and sea-run cutthroat trout, and its sloughs are used by large numbers of waterfowl. Quite apart from the effects of the industrial complex itself, the inevitable accompanying concentration of commercial and residential development upstream from the industrial area would impose further losses of living resources in the river system.

II. PRELIMINARY CONCLUSIONS

Although the management of an estuarine system like Puget Sound must ultimately be directed toward maximizing socioeconomic values, the basic alternatives to be evaluated involve data that must be generated by physical and biological oceanographers, fishery scientists, engineers, and other specialists dealing with physical interaction. Data required for even gross formulation of alternatives in cases such as those described above are not adequate at present, in either total or incremental form. The latter requirement is of critical importance, since an economically sensible interpretation of the term "multiple use" implies examination of tradeoffs at the

margin when conflicts arise rather than consideration only of mutually exclusive usage. Thus, though the objectives of a management unit for Puget Sound are geared to human welfare and must employ economic and noneconomic measures of social value, a major part of the actual research effort required to permit rational decision making falls on the shoulders of the several scientific and engineering disciplines concerned with estuarine analysis. It is of critical importance that this essential multidisciplinary effort be expanded if the problems implicit in the preceding chapters are to be resolved efficiently.

It seems clear that more than a little exaggeration has entered the discussion of the degraded state of water quality in the Sound, but this offers no comfort for the long run. The absence of proved damage to living resources from deterioration of water quality stems only in part from the comforting fact that some of the major organisms are more tolerant than we had thought. It also reflects, to a much larger degree, the inherent difficulty of establishing conclusive cause/effect relationships and of quantifying damage functions to the satisfaction of the courts. Moreover, the preceding chapters emphasize that local problems already exist, some of them pressing.

The rate of growth in population and industry, the change in structure of the economic base of the area, and weak spots in our knowledge of some of the crucial parameters relating waste assimilation to other competing uses of Puget Sound all drive home the fact that

the area has time to prepare for, but not to ignore, the conflicts inherent in declining water quality.

The very nature of these conflicts also gives rise to special concern. Many of the important activities dependent on the waters and adjacent lands of the area are relatively insensitive to water quality. For example, commercial shipping and industrial uses of waterfront and of saltwater for cooling find production possibilities and costs to be largely independent of water quality (at least over relevant ranges). Pleasure boating and the scenic enjoyment of the area may also be insensitive to water quality unless waste loading brings about offensive changes in color and odor. The most important losses associated with declining water quality are clearly those involving anadromous fish, shellfish, some types of waterbased recreation, and migratory waterfowl (although in the latter case it is the loss of feeding and resting areas rather than water quality *per se* that does the most damage). Unfortunately, these outputs of the Puget Sound system are notoriously difficult to evaluate in economic terms and are likely to suffer, for lack of visibility and political pressure, in competition with users who can present objective estimates of net economic benefits from their activities. This lack of comparability becomes even more important since the "amenity" demands for Puget Sound appear to be highly elastic to increases in per capita income, leisure time, and mobility, while the supply of alternative natural resource combinations is inherently limited. Thus, Puget

Sound, like other estuaries, may well suffer a steady nibbling away of irreplaceable assets for two reasons. First, the mechanism for economic and political choice does not reflect accurately the strength of people's desire for preservation of environmental quality and of certain types of living organisms. Second, the effects are so diffused as to prevent effective political action by those on whom the loss is inflicted.

This suggests the possibility that framing the water quality problem in terms of "safe minimum standards" may be economically efficient as well as manageable. Given the fact that both physical and economic losses associated with declining water quality are extremely expensive (and sometimes impossible) to measure, it becomes critical to determine how much it would cost to adopt policies that insure water quality adequate to meet the requirements for maintenance of anadromous fish and shellfish stocks at present levels of productivity. Once safe minimum standards were achieved for these resources, it seems certain that water quality requirements for every other use would be met. The sole exception might be coliform limitation for protection of those engaged in water contact sports, but this is easily incorporated into a system of receiving water standards. If major industrial and municipal sources of waste loading are given a <u>firm</u> time schedule within which to meet requirements designed to maintain water quality in Puget Sound at these design levels, the cost of requisite product changes, process changes, and locational changes

may be surprisingly small at this early stage when pollution problems in the saltwater environment are still relatively limited. Moreover, the approach could be geared to estimates of growth in population and economic activity, to permit adequate advance notice of future tightening of requirements on the individual plant or firm. It is certain that if water quality is allowed to deteriorate in enough areas to impose really serious losses on the community as a whole, the cost of adjustment to a more satisfactory level (and, inevitably, the political opposition to such policies) would grow very rapidly indeed.

It must also be pointed out that the preceding chapters, though geared primarily to conflicts arising out of water quality changes, have already identified many other types of conflict over use and development of the Puget Sound system that are largely independent of water quality. Examples include the allocation of resources between competing sport and commercial fisherman; between oyster growers and recreationists; between private waterfront residents and those who would reserve larger areas for public access; and between industrial and recreational or scenic utilization of the shoreline. Even with full protection of water quality at levels that satisfy the requirements of most users, there will be cases of incompatible use at the margin that require adequate knowledge, effective planning and decision making, and the means to implement decisions once reached. While water quality is an important consideration in the framing of plans for the development and use of an estuarine system such as Puget

Sound, the ultimate determination of the best possible use of such a complex of natural resources is of much broader scope. In addition to deepening the analysis of some of the questions raised in this initial survey, the second phase of this study will look to these broader issues.

III. POLITICAL ORGANIZATION FOR ESTUARINE MANAGEMENT

This study has identified useful outputs from the Puget Sound system stemming from the Sound itself, from tidelands lying partially or wholly beneath the water, from marshy wetlands, from the adjacent perimeter of land, and from the drainage basins of the rivers tributary to the Sound. Many of these uses are nonconsumptive and noncompetitive, but most impinge, in greater or lesser degree, on the costs or outputs of others. Most users of Puget Sound operate at least partially within the public sector; that is, some of their inputs or outputs are not sold in the marketplace, or the operations of the market mechanism are modified by government intervention to take at least partial account of institutional and economic factors that prevent it from providing accurate signals to producers and consumers.

It follows that the development of the resources of Puget Sound cannot simply be left to the normal forces of supply and demand. But if we are to intervene consciously in the public interest, it is mandatory that objectives be specified clearly and that the form of intervention and the agencies to do the job must be appropriate. This is the area in which a survey of the present status of Puget Sound must

be viewed with real concern. At present, jurisdiction is shared among fifteen essentially single-purpose state agencies; a number of federal agencies (including the Corps of Engineers, ESSA, the U. S. Fish and Wildlife Service, the Department of Health, Education, and Welfare, and the Federal Water Pollution Control Administration, to mention only the most important); over thirty cities; twelve counties; and many special districts organized for waste disposal, water production, or flood control. An inventory of the legal mission of these agencies exists, together with considerable amounts of descriptive material. Unfortunately, however, no attempt has yet been made to analyze how the many agencies function [illegible] as a system to determine patterns of alternative use of water and adjacent lands when conflicts arise. Even a cursory review makes it clear that many of their missions involve conflicting and overlapping objectives, and that the legal mission and the actual operation of the agency frequently are widely different.

The situation is not unique to Puget Sound; on the contrary, it is typical of every major estuary on the coasts of the United States. There is no area of which we have knowledge -- and certainly not the Puget Sound are -- in which this complex of governmental units has been integrated in satisfactory fashion, whether for research, planning, regulation, or promotion of new activities.

The most thorough general analysis of the problems of the estuaries and of organizing the several levels of government to deal with them is contained in the report of the Commission on Marine Science, Engineering, and Resources. The key recommendations emerging from

that report (and, more specifically, from the report of the Panel on Environmental Monitoring and Management and Development of the Coastal Zone) were the following. First, it called for the creation of coastal zone authorities whose functions should include planning, regulation (including zoning where necessary), funding, acquisition, and development and enforcement. Second, the coastal zone authority should be a state agency, endowed with considerable flexibility to meet the special requirements of individual estuarine and coastal situations. Third, the guidelines governing the formation and operation of the coastal zone authorities must meet federal standards and approval to be eligible for federal assistance. Finally, the federal role should be the establishment of such standards and the provision of broad technical assistance, financial support, and assistance in planning interstate compacts where required.

The basic elements of any estuarine management system must be: (1) the establishment of agency responsibility; (2) research and planning; (3) the creation of control mechanisms and of guidelines for their use; (4) coordination of the many agencies whose activities bear only peripherally on the estuarine environment; and (5) funding. The coastal zone authority concept appears to have a great deal of merit within the Puget Sound setting with respect to political trauma that would result from assigning responsibility sufficiently broad to deal with all relevant alternatives to a lead agency already in existence, whether federal or state. Moreover, the fact that virtually all

operating agencies of government, state and federal, are organized along functional lines makes it very difficult to deal with estuarine problems, The proper scope of the task is geographic rather than functional, and overlapping missions and functional specialization militate against effective performance by a single lead agency.

The coastal zone authority concept provides for a major coordinating function only with respect to activities truly peripheral to the central problems of the estuarine system. Those activities of direct concern would be under direct control. As an aside: the setting up of coordinating committees to deal with the central problems of Puget Sound would be an invitation to paralysis. Such organizations are inevitably hamstrung by the historic and legal missions of the fostering agencies, and their budgetary subservience further minimizes the possibility of effective independent action. Above all, a coordinating committee lacks the indispensable power to reallocate support among various functions: that is, to reduce or eliminate old programs in favor of new and more promising ones.

Under a truly effective coastal zone authority, federal funding and review would provide an essential unity now sadly lacking in planning, management, and regulating activities. Perhaps most important, it would provide reasonable assurance that the interests of all beneficiaries and of all who bear costs of development of the estuarine resources would be considered at all stages from planning to execution. This essential power simply cannot be exercised as long

as important areas of decision making remain under the jurisdiction of county and municipal governments of of single-function state agencies.

A coastal zone authority, with direct or supervisory control over marine-oriented activities, would also help to resolve another major difficulty that now plagues individual state agencies concerned with the estuaries: The general tendency to link estuarine with non-estuarine activities. For example, many of the state agencies dealing with outdoor recreation make no distinction between marine and freshwater-based recreation or between water-based and other types of recreation. Yet the problems are frequently very different, and the interface with other activities involving recreational users differs greatly in the marine environment. Similarly, the problems of water quality management are related but far from identical in fresh and saltwater.

On balance, it would appear that the state is an appropriate unit to exercise control over the Puget Sound system. It is large enough to encompass most of the relevant alternatives to be weighed, and since Puget Sound lies within the boundaries of the state, no need arises for coordination with other states (the interrelation with British Columbia, however, is important). Moreover the state is a unit capable of maintaining a fairly sizable core of personnel trained in estuarine research, analysis, and development, and it can draw on the research facilities of the federal government and of state universities as well. While both guidelines and supporting technical

services and funding would be required from the federal government, the state's own experience in the development and management of Puget Sound would enable it to make effective use of such aid.

It must be stressed that these are only tentative conclusions, based on a very limited examination of various possibilities. The second phase of this study, with support from the Sea Grant Program of the National Science Foundation, will be heavily oriented toward the economic, political, and administrative aspects of regimes for development and management of the Sound. This will involve the application of modern organizational theory to the problem, both in general terms and in terms of a series of detailed case studies of conflict and conflict resolution. Progress reports and the final report under this expanded program will be made available to the Federal Water Pollution Control Administration and to other interested agencies.

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PART II

REGULATION OF WATER QUALITY IN PUGET SOUND

By

NORMAN K. MALENG*

* Member, Seattle and Washington State Bar Association.
B.A., 1960, LL.B., 1966, University of Washington.

REGULATION OF WATER QUALITY IN PUGET SOUND

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REGULATION OF WATER QUALITY IN PUGET SOUND

INTRODUCTION

This paper examines the legal framework for regulating water quality and abating pollution in the Puget Sound region. The development of an effective water pollution control program is dependent on a number of inter-related factors -- many of these involve the expenditure of substantial public funds. An adequate research program is needed to develop improved technological processes to abate pollution and to minimize the costs of such processes. Municipal governments operating sewage disposal and treatment plants in the Puget Sound region require substantial financial assistance to construct new facilities and to improve and maintain existing works. Incentives such as tax credits are helpful in stimulating industrial and commercial operations on the Sound to expend funds to abate their pollution discharges. These financial programs are indeed crucial to a water pollution control program. The fundamental base of a control program, however, is the legal framework which exists to regulate water quality

and abate pollution. Regulatory measures, by themselves, can be utilized to improve and upgrade water quality within the limits defined by available technology and financial resources. The infusion of additional resources into water pollution control, coupled with a tightening of governmental regulation will, of course, lend to further progress.

The financial programs available for controlling pollution in the Sound are not discussed in this report; rather, attention is focused on the regulatory framework which exists to control water quality in Puget Sound and its tributaries.

Each level of government--federal, state and local--has a role in this regulatory process. Chapter I of this report contains a detailed description of federal legislation designed to regulate water quality, with specific reference to its applicability to Puget Sound.

The primary responsibility to prevent and control water pollution rests with the state government. Chapter II outlines the regulatory legislation of the State of Washington. The legal tools available to the state to regulate water quality in Puget Sound are critically examined. A brief appraisal of the effectiveness of the

state regulatory program is set forth in Chapter III.

Local governments operate sewage disposal and treatment facilities which discharge waste into the Sound. Most of these facilities are operated by traditional units of government--municipalities (cities and towns) and special sewer districts. In 1958 a unique form of regional government was created in the Seattle metropolitan area to collect and treat sewage for the whole area. This unit of government, the Municipality of Metropolitan Seattle (popularly called Metro), includes several cities and parts of two counties within its boundaries. The functions and jurisdiction of Metro and its role in pollution control is examined in Chapter IV.

CHAPTER I

THE FEDERAL GOVERNMENT AND WATER POLLUTION CONTROL IN PUGET SOUND

This chapter examines the role of the federal government in regulating water quality and abating pollution in Puget Sound. The general background of federal legislation is set forth in Section I. Sections II and III contain a detailed description of federal legislation designed to regulate water quality and abate pollution. The applicability of federal jurisdiction to Puget Sound is examined throughout this discussion. A summary of federal jurisdiction with respect to Puget Sound is contained in Section IV.

I. GENERAL BACKGROUND

Congressional authority to enact pollution control legislation is based on the commerce clause of the Constitution,[1] which gives Congress jurisdiction over the navigable waters of the United States. Congress under the commerce clause would appear to have the power to substantially pre-empt state action in the water pollution control field.[2] However, Congress has explicitly rejected such a federal role. Rather, the

primary thrust of federal legislation has been to support, strengthen, and encourage state and local water pollution control programs.

The first comprehensive water pollution control legislation was enacted by Congress in 1948. This Act, known as the Water Pollution Control Act of 1948,[3] was enacted for a five year period; it was subsequently extended for an additional three years to June, 1956. In 1956, the Federal Water Pollution Control Act[4] was passed; it established the basic federal framework for water pollution control. It has subsequently been amended by the Federal Water Pollution Control Act Amendments of 1961,[5] the Water Quality Act of 1965,[6] and the Clean Water Restoration Act of 1966.[7] This package basically sets forth current federal law on water pollution.[8]

The present Act specifically declares that "it is . . . the policy of Congress to recognize, preserve, and protect the primary responsibilities and rights of the States in preventing and controlling water pollution."[9] The federal functions authorized by the Act were designed to supplement state programs and to be implemented in close cooperation with state and

local governments.

Programs authorized by the Act include research functions and federal grants. This paper, however, is limited to an examination of federal jurisdiction to regulate water quality and abate water pollution, with specific reference to Puget Sound.

II. FEDERAL REGULATION OF WATER QUALITY

A. WATER QUALITY STANDARDS JURISDICTION.

The Water Quality Act of 1965 gave each state until June 30, 1967, to adopt water quality criteria and standards for interstate waters. If a state failed to comply by this date, or if the criteria were not approved by the Secretary of Interior, the Secretary was authorized to promulgate water quality standards for interstate waters within such state.[10] The act specified that the standards "shall be such as to protect the public health or welfare, enhance the quality of water. . . ."[11] Factors to be considered in establishing such standards included "their use and value for public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial and other legitimate uses."[12]

The Act carefully preserved the Congressional

policy that the primary responsibility for pollution abatement rests with the states. The Act preserves the jurisdiction of the states to adopt water quality standards but permits the federal government to assert its jurisdiction if the state fails to perform this function effectively.

The provisions of the Act relating to water quality standards are applicable only to interstate waters. Interstate waters are defined in the Act as "all rivers, lakes, and other waters that flow across or form a part of state boundaries, including coastal waters."[13] Coastal waters have been defined as the "ocean water along straight coasts and the waters along indented coasts which are subject to the ebb and flow of the tides."[14]

Puget Sound is clearly within the term "coastal waters" and subject to the federal water quality standards jurisdiction. The status of rivers entering the Sound is somewhat ambiguous. Presumably, rivers flowing into the Sound are subject to standards upriver as far as the tides ebb and flow.[15] The Act does not provide for water quality standards beyond this point.

However, that portion of rivers entering the Sound

which are not included within the federal water quality standards jurisdiction are subject to a measure of federal authority under the pollution abatement provisions of the Act.

B. WATER QUALITY ABATEMENT JURISDICTION

The present Act gives the Secretary of Interior limited power to enforce water quality standards for interstate waters which includes, of course, Puget Sound. The Act provides that the discharge of matter into interstate waters which reduces the quality of such waters below the established standards is subject to the abatement provisions of the Act.[16] Such discharges are subject to abatement regardless of whether it is discharged directly into interstate waters or whether it reaches such waters after discharge into tributaries. Federal water quality abatement jurisdiction is therefore broader than the federal water quality standards jurisdiction. Standards are required only with respect to interstate waters. Abatement jurisdiction, however, extends not only to discharges into interstate waters but also to discharges into their intrastate tributaries. Thus, federal water quality abatement jurisdiction is applicable not only to Puget Sound but also to the

entire reach of rivers and streams entering the Sound, including that portion beyond the point where the tides ebb and flow.

Although federal abatement jurisdiction is broad, federal authority under the Act to enforce water quality standards is not unlimited--it is sharply circumscribed. The scope of federal enforcement authority depends on whether the violation of water quality standards results in interstate or intra-state pollution.

Interstate pollution occurs if it adversely affects the health or welfare of persons in a state other than that in which the discharge originates.[17] If a water quality violation results in interstate pollution, the Secretary of Interior is authorized to initiate abatement proceedings after giving 180 days notice to violators and other interested parties.[18] If appropriate remedial action is not taken within this period, the Secretary may request the Attorney General to bring a suit to abate the pollution on behalf of the United States.[19] However, if the pollution is intra-state (affects persons only in the state in which the discharge originates)

the Secretary may initiate abatement proceedings only with the written consent of the Governor of such state.[20]

It appears that violation of water quality standards in Puget Sound could only result in "intrastate" pollution. In providing for federal water quality authority, Congress very carefully differentiated between pollution which affects the health and welfare of persons only in the state of discharge (intra-state pollution) and pollution in other states (interstate pollution). It would appear that interstate pollution could occur only in those waters that flow across into another state or form a part of a state's boundary with another state. Since the Sound is wholly within the State and does not border on another state, it is inconceivable that interstate pollution could occur within the meaning of the Act. Thus, federal jurisdiction to enforce water quality standards in Puget Sound appears to be entirely dependent on state approval (consent of the Governor).

III. OTHER FEDERAL POLLUTION ABATEMENT AUTHORITY

A. JURISDICTION.

The Water Quality Act of 1965 gave the federal government several new weapons to combat water pollution

by providing for the promulgation of water quality standards and limited federal enforcement authority. In addition to the water quality provisions, the present Act also retains an older and more cumbersome and time consuming abatement procedure which is applicable to waters such as Puget Sound and its tributaries.[21]

The Act provides that "the pollution of interstate or navigable waters in or adjacent to any state or states (whether the matter causing or contributing to such pollution is discharged directly into such waters or reaches such waters after discharge into a tributary of such waters), which endangers the health or welfare of any persons . . ."[22] is subject to abatement as provided for by the Act.

Federal abatement jurisdiction under this section includes "navigable waters", in addition to the basic jurisdictional element of "interstate waters."[23]

B. INITIATION OF ABATEMENT PROCEEDINGS.

The abatement procedures authorized by this section may be initiated in several ways.

1. Interstate pollution. If pollution is believed to endanger the health or welfare of a state other than that in which the discharge takes place, the

affected state may request the Secretary to initiate abatement proceedings or the Secretary may on his own initiative commence action.[24]

2. Intra-state pollution. If the pollution endangers only the citizens of the state in which the discharge originates, abatement proceedings may be initiated only upon the request of said state -- the Secretary may not initiate action on his own initiative.[25]

3. Shellfish and International Pollution. There are two exceptions to the general rules set forth above. First, the Secretary may initiate abatement proceedings if "he finds that substantial economic injury results from the inability to market shellfish or shellfish products in interstate commerce because of pollution,"[26] regardless of whether the pollution is interstate or intra-state. Similarly, if pollution within the United States endangers the health or welfare of citizens in a foreign country, the Secretary may, on the request of the Secretary of State, initiate proceedings, provided that the foreign government extends similar rights to the United States.[27]

As discussed previously, discharges into Puget Sound can apparently result only in intra-state pollution.

In addition, international pollution could occur since the Sound borders on Canada. Therefore, abatement proceedings may be initiated only upon the request of the State of Washington unless the pollution comes with the terms of the shellfish provision or results in international pollution. In the latter two cases, federal jurisdiction to commence abatement proceedings could be invoked by the Secretary on his own initiative.

The abatement procedures authorized by this section are cumbersome and time consuming in contrast to the federal water quality enforcement jurisdiction. The first step is the calling of a conference by the Secretary.[28] Parties invited include the water pollution control agency of each state involved and interstate agencies, if any.

Following the conference the Secretary may recommend to the appropriate state water pollution control agency that it take necessary remedial action. The state is given six months to take the recommended action. If the state fails to act within this period, the Secretary may call a public hearing before a Hearing Board composed of five or more persons

appointed by the Secretary with each affected state having the opportunity to appoint one member.

The board, on the basis of evidence presented, makes findings and recommendations. If abatement action is recommended, the Secretary is directed to forward them to the alleged violators and to the state where the pollution is originating, together with a notice specifying a reasonable time to secure abatement of such pollution, which time shall be not less than six months.

C. ENFORCEMENT OF ABATEMENT RECOMMENDATIONS.

If abatement is not taken within the time specified, federal enforcement action is authorized. In the case of interstate pollution, the Secretary may request the Attorney General to bring suit to secure abatement. But in the case of intra-state pollution, the suit may be maintained only with the written consent of the Governor of such state.[29] The consent of the Governor would be required in intra-state pollution cases arising under the shellfish provision, even though the Secretary could commence abatement proceedings on his own initiative in such cases. The consent of the Governor to maintain a suit, however, is never required in any

proceedings involving international pollution.

With respect to Puget Sound, therefore, no suit to abate pollution could be maintained without the consent of the Governor with one exception -- international pollution affecting Canada. And it should be noted that the veto power of the Governor is so extensive that he would appear to have the power to block a federal suit to enforce recommended abatement action even in an intra-state pollution case in which the state itself had initiated and requested the abatement proceedings.

IV. SUMMARY OF FEDERAL JURISDICTION TO ABATE POLLUTION IN PUGET SOUND

A. WATER QUALITY PROVISIONS OF THE ACT.

1. Water Quality Standards Jurisdiction.

Federal Water Quality Standards are applicable to Puget Sound and to tributaries entering the Sound upriver as far as the tides ebb and flow.

2. Water Quality Abatement Jurisdiction.

Federal Water Quality abatement jurisdiction is broader than the federal standards jurisdiction; it extends not only to discharges into interstate waters but also to discharges into their intra-state tributaries. Therefore, the entire reach of tributaries entering

Puget Sound is subject to the federal water quality abatement provisions of the Act.

Although the water quality abatement provisions of the Act cover the whole of the Sound and rivers entering it, federal authority to enforce water quality standards is sharply circumscribed. It appears that violation of water quality standards in Puget Sound could only result in intra-state pollution. Thus, a federal suit against violators of water quality standards could be commenced only with the consent of the Governor. Federal water quality enforcement authority is therefore dependent upon state approval and cannot be exerted independently.

B. OTHER FEDERAL ABATEMENT AUTHORITY.

In addition to water quality provisions, other provisions of the Act authorize abatement of pollution of interstate or navigable waters which endanger the health or welfare of any persons. These abatement procedures are cumbersome and time consuming. With respect to Puget Sound, abatement procedures authorized by these provisions, including a conference, hearing and formulation of recommendations, could be initiated in general only upon the request of Washington State

since pollution of these waters could only have intra-state effects. However, the Secretary could initiate action on his own motion if the pollution caused substantial economic injury to the shellfish industry or resulted in international pollution. However, a federal suit to enforce recommended abatement action could be maintained only with the written consent of the Governor except in cases involving international pollution. Thus, with this one exception, the ultimate federal weapon to abate pollution in Puget Sound -- a suit by the Attorney General -- is dependent on state approval in the form of gubernatorial consent.

CHAPTER II

THE STATE GOVERNMENT AND WATER POLLUTION CONTROL IN PUGET SOUND

This chapter examines the role of the state government in regulating water quality and abating pollution in Puget Sound. The general background of state legislation applicable to Puget Sound is set forth in Section I. Section II contains a brief description of the character and scope of the state's jurisdiction to regulate water quality. The applicability of water quality standards to Puget Sound is examined in Section III. Sections IV and V contain a detailed description of the legal tools which are available to implement and enforce a water pollution control program in Puget Sound. A summary of state jurisdiction and regulatory programs with respect to Puget Sound is set forth in Section VI.

I. GENERAL BACKGROUND

The first comprehensive water pollution control legislation was enacted by the Washington State Legislature in 1945.[31] This Act, known as the Water Pollution Control Act, has been significantly supplemented or amended on two occasions, in 1955[32] and in 1967;[33] these amendments have vitally strengthened the state pollution abatement program. The ultimate objective of this legis-

lation may be derived from the policy section of the Act, which has remained unchanged since enunciated in 1945.

> "It is declared to be the public policy of the state of Washington to maintain the highest possible standards to insure the purity of all waters of the state consistent with public health and public enjoyment thereof, the propagation and protection of wild life, birds, game, fish and other aquatic life and the industrial development of the state, and to that end require the use of all known available and reasonable methods, by industries and others to prevent and control the pollution of the waters of the state of Washington.[34]

This policy section provides a clear and broad mandate for an aggressive and comprehensive program of pollution abatement for all waters of the state including Puget Sound. Substantive provisions of the Act, discussed infra, provide effective tools to attain these objectives.[35]

II. ADMINISTRATIVE AND JURISDICTION

The Water Pollution Control Act created a statutory commission to administer the Act, presently composed of the directors of the Department of Water Resources, Fisheries, Game, Health and Agriculture.[36] The commission's activities are administered by a director, appointed by the Governor and removable at his pleasure.[37]

The Act vested the Commission with primary jurisdiction to control and prevent the pollution of the

waters of the state, which include, of course, Puget Sound and its tributaries.[38]

The Act has centralized state regulation of water quality in the Water Pollution Control Commission. Other state agencies and municipal governments are concerned with pollution abatement but their activities are primarily related to health regulations and operation of local sewage disposal systems. Thus, the Commission is the agency with primary jurisdiction to regulate water quality in Puget Sound.

III. WATER QUALITY STANDARDS

The Commission is vested with broad powers to promulgate "such rules and regulations as it shall deem necessary to carry out the provisions of this chapter, <u>including but not limited to rules and regulations relating to standards of quality for waters of the state</u>..."[39] The term "waters of the state" includes interstate waters.[40] The Commission is, therefore, enpowered to adopt water quality standards for Puget Sound.

Although it was unnecessary the 1967 Amendments to the Act also made it clear that the Commission was the agency of state government vested with the power to

adopt water quality standards for interstate waters as contemplated by the Federal Water Quality Act of 1965. An amendment provided:

> "The commission is hereby designated as the State Water Pollution Control Agency for all purposes of the Federal Water Pollution Control Act as it now exists or shall hereafter be amended and is hereby authorized to take all action necessary to secure to the state the benefits of that act."[41]

In compliance with the terms of the Federal Water Pollution Control Act, the Water Pollution Control Commission adopted regulations establishing water quality standards for the interstate and coastal waters of the state and a plan for implementation and enforcement of such standards.[42] Detailed standards with respect to Puget Sound are included in the regulations. Standards were also promulgated for that portion of rivers entering the Sound which are included within the term "interstate waters."

IV. IMPLEMENTATION TOOLS

The Water Pollution Control Act provides the Commission with several legal tools to implement a pollution control program in Puget Sound, including ensuring compliance with water quality standards.

Principal implementation tools available to the

Commission to regulate water quality in Puget Sound include (1) Waste Disposal Permits applicable to commercial and industrial operations, (2) Review and Approval Authority over municipal sewage disposal, and (3) Commission Orders.

Enforcement tools available to the Commission to secure compliance with their implementation program for Puget Sound include (1) injunctive relief, (2) civil penalties, (3) criminal proceedings and (4) civil damages. These powers are discussed in Section V.

A. WASTE DISPOSAL PERMITS

The Waste Disposal Permit system provides the Commission with a particularly effective means of controlling commercial and industrial waste discharges into Puget Sound. The Act requires each commercial or industrial operation which discharges waste into state waters to secure a permit from the Commission.[43] The Commission is directed to reject a permit application if the proposed discharge "will pollute the waters of the state in violation of the public policy declared in RCW 90.48.010."[44] The Commission is not limited to acceptance or rejection of permit applications. In addition, permits may be issued subject to specified conditions to prevent

pollution in excess of tolerable limits.[45] The time limit on permits is five years.

The power to accept or reject permit applications is a powerful tool in the control of industrial and commercial pollution. The authority of the Commission, however, does not end at the issuance stage. The Commission also has extensive authority to terminate or modify permits previously issued. Permits may be terminated if procured by misrepresentation, if the conditions of the permit have been violated or if there has been a material change in the quantity or type of waste disposal.[46] This "termination" power is an important means of enforcing the conditions of the permit.

A permit may not be terminated solely on the ground that the condition of state waters has materially deteriorated. In such a case, however, the Commission may "modify permit conditions or specify additional conditions in permits previously issued."[47] The power to modify permits is a significant Commission power. Without this authority the issuance of a permit would preclude Commission action for the life of the

permit even though subsequent events resulted in a marked deterioration in water quality.

B. DOMESTIC DISCHARGES

The Act provides the Commission with several substantive tools to abate and control pollution by municipalities or other agencies operating domestic sewage disposal systems which discharge waste into Puget Sound waters. All plans for the construction of new sewage systems and disposal and treatment plants or improvements to existing works must be submitted to and be approved by the Commission before construction begins.[48] In addition, a proposed method of future operation of said facilities must be submitted to the Commission for approval.[49] The Commission may not approve the plans and specifications and methods of operation and maintenance unless it is satisfied that they adequately protect the quality of the state's water.[50]

Other means available to the Commission to control municipal pollution include:

1) Authority to delineate and establish sewage drainage basins.

2) Preparation of comprehensive water

pollution control and abatement plans for each basin, and

3) Authority to require compliance with the plans by any municipality or person operating or constructing a sewage treatment or disposal works.[51]

This sewage drainage basin authority should be a particularly useful tool in improving water quality in Puget Sound. Rather than proceeding solely on a case by case method, systematic and comprehensive plans can be developed for each basin. The Water Pollution Control Commission is presently drafting guidelines to be followed in establishing sewage drainage basins in Puget Sound. Basins will probably be established around the major river networks entering the Sound.[52]

C. COMMISSION ORDERS

The permit system and approval authority over municipal disposal works are the primary substantive tools available to the Commission to enforce water quality standards and to abate pollution in Puget Sound. This pre-discharge approval authority is a most important and significant weapon. If

the Commission were limited to investigating and issuing complaints after discharges occurred, the burden of initiating pollution abatement would rest solely on the Commission. However, by requiring permission before discharge, the initiative for abating pollution rests with the Commission--the burden for proceeding is placed squarely on the polluters. In a very real sense, the burden of demonstrating compliance with water quality standards is shifted to the "dischargers."

In addition to the methods described above, the Act provides the Commission with general authority to issue administrative orders to abate pollution.[53] Of course the Commission may utilize orders (described below) to enforce the terms of waste disposal permits and construction plans and specifications. But the use of administrative orders is not limited to these two methods of pollution abatement; they may be issued to remedy any violation of the Act. Thus, orders may be utilized to secure compliance with a general and catch all provision of the Act making it unlawful for any person to discharge into any of the waters of the state any matter that shall cause or tend to cause

pollution of such waters according to the determination of the commission.[54]

If the Commission believes that a violation of the Act has or is about to occur, the Commission is directed to notify the alleged violator of its determination. The party then has 30 days in which to file a "... report stating what steps have been taken and are being taken to control such waste or pollution or to otherwise comply with the determination of the commission."[55] After this period the Commission issues the appropriate order or directive.

Like most administrative rulings, Commission orders are subject to review. The action of the Commission in issuing, denying, terminating or modifying waste disposal permits is deemed for purposes of review to be an order.[56] Any party aggrieved by an order who has an interest of an economic or noneconomic nature may request and is entitled to a hearing before the Commission or its designated hearing examiner.[57] Such request must be filed within 30 days following the issuance of the order. In an effort to minimize delaying tactics by polluters, the Act provides that the Commission shall not stay its order pending completion of the hearing

and the issuance of a final order, unless the Commission upon application for a stay determines in its own discretion that such a stay would not be detrimental to the public interest.[58]

The decision not to stay the initial order as well as the final order of the Commission is subject to review in the Superior Court.[59] Since the Washington Administrative Procedures Act[60] is applicable to all proceedings under the Water Pollution Control Act,[61] the test to be applied by the court in reviewing a Commission order is whether such order is "clearly erroneous in view of the entire record as submitted and the public policy contained in the act of the legislature authorizing the decision or order."[62]

In summary two determinations of the Commission are subject to appeal: (1) a decision not to stay an initial order and (2) the final order issued after completion of the hearing. In both cases the court may not reverse the courts determination "unless it is clearly erroneous."

Under certain circumstances, summary abatement procedures may be utilized, thereby shortening the order process described above. Summary abatement of discharges is authorized "whenever it appears to the

director that water quality conditions exist which require immediate action to protect the public health or welfare..."[63] If such an emergency exists, the Director may issue an order, without any prior notice or hearing, which affords the polluter an alternative of either (1) immediately discontinuing or modifying the discharge or (2) appearing before the Commission. In the latter case, the polluter is only entitled to 24 hours notice. If a majority of the Commission ratifies the director's initial order, a written order is issued. The court may not stay the order "...unless the court finds the Commission to have acted capriciously or arbitrarily..." The order is, however, subject to judicial review in the same manner as all other Commission orders.

V. ENFORCEMENT TOOLS

The primary methods available to the Commission to implement a program of pollution control in Puget Sound are waste disposal permits, approval authority over municipal disposal works, and Commission orders. The Act, of course, also provides the Commission with several tools to enforce compliance with the foregoing substantive provisions. These include injunctive relief, civil penalties, criminal proceedings, and

civil damages.

A. INJUNCTIVE RELIEF

The Act specifically provides that the Commission is authorized to seek injunctive relief to carry out the provisions of the Act.

> "The commission, with the assistance of the attorney general, is authorized to bring any appropriate action at law or in equity, including injunctive relief, in the name of the people of the state of Washington as may be necessary to carry out the provisions of this chapter."[64]

The Commission may therefore initiate actions requesting injunctive relief to prevent commercial and industrial discharges without permits, to enforce the terms of waste disposal permits and other Commission orders, and to require compliance with the provisions of the Act by municipalities and others operating domestic sewage works.

B. CIVIL PENALITIES

Another enforcement tool available to the Commission is a provision for civil penalties.[65] This provision is applicable to anyone who either violates the terms or conditions of a waste disposal permit or operates without one when required. Civil penalties may also be levied against those who violate a Commission order

based on the catch-all provision of the Act, which makes it unlawful to discharge any matter into state waters that shall cause or tend to cause pollution of such waters according to the determination of the Commission.

Under this civil penalty provision, the director of the Commission may levy a fine of $100 per day for each violation, and each violation is a separate offense. The director must send a written notice describing the offense and advising the violator of the penalty due. If the amount of the penalty, which is subject to mitigation or remission by the director, is not paid within 15 days after receipt of notice, the director may request the Attorney General to bring an action in Superior Court to recover the penalty.[66]

This civil penalty section should be a particularly effective means of abating unlawful discharges into the Sound by "small" polluters. A $100 fine for each day a violation continues is a significant sum to a person of modest means or a small business; the levy of such a fine or even the threat of "fining" should ensure compliance with Commission orders and directives.

Of course, the amount of the fine, itself, may not be a significant deterrent against the large polluter, such as a large industrial mill. However, during a period of deep public concern in the Puget Sound region over enviromental quality, the publicity generated by the levy of a fine should be a significant weapon to force compliance with the Act. And, of course, the Commission may also seek injunctive relief if civil penalties are insufficient.

C. CRIMINAL PENALTIES

The Act also provides for criminal penalties for wilful violations of the Act. Persons found guilty of wilfully violating the Act may be fined up to $100 or imprisioned for not more than a year, or both.[67] The statute also provides that each day upon which a wilful violation occurs may be deemed a separate and additional violation.

The provision for criminal penalties is probably not a significant enforcement tool in abating pollution in Puget Sound. First, it is difficult to prove a wilful violation. And perhaps an even more important reason why criminal penalties are generally ineffective is the historic reluctance of governmental officials to file

and prosecute criminal charges in essentially civil regulatory matters, except in cases of flagrant violations. In such cases, criminal penalties would be useful enforcement tools.

D. CIVIL DAMAGES

In addition to the enforcement tools described above, the Commission also has authority to initiate an action for damages against theose who violate the provisions of the Act and cause thereby the death of or injury to fish, animals, vegetation or other resources of the state, or otherwise damages the waters of the state.[68]

VI. SUMMARY OF STATE JURISDICTION TO ABATE POLLUTION IN PUGET SOUND

A. JURISDICTION

The Water Pollution Control Commission is vested with primary jurisdiction to control and prevent the pollution of waters of the state including Puget Sound and its tributaries. Other state agencies and municipal government are concerned with pollution abatement but their activities are primarily related to health regulations and operation of local sewage disposal systems. Thus, the regulation of water quality in Puget Sound waters is centralized in one body--the

Commission.

B. WATER QUALITY STANDARDS

The Water Pollution Control Commission is vested with broad powers to promulgate necessary rules and regulations, including water quality standards. Detailed standards have been established for Puget Sound waters, including that portion of rivers entering the Sound which are included within the term "interstate waters."

C. IMPLEMENTATION TOOLS

Principal implementation tools available to the Commission to implement a pollution control program in Puget Sound include (1) Waste Disposal Permits applicable to commercial and industrial operations, (2) Review and Approval Authority over municipal sewage disposal and (3) Commission Orders.

D. ENFORCEMENT TOOLS

Principal enforcement tools available to the Commission to secure compliance with their implementation program for Puget Sound include (1) injunctive relief, (2) civil penalties, (3) criminal proceedings, and (4) civil damages.

CHAPTER III

AN APPRAISAL OF THE FEDERAL-STATE LEGAL FRAMEWORK FOR REGULATING WATER QUALITY IN PUGET SOUND

The regulation of water quality in the Puget Sound region involves the process of federalism. The existing federal-state legal framework, which is outlined in Chapters I and II, appears to provide an efficient and adequate regulatory mechanism for controlling water quality and abating pollution in Puget Sound. This chapter briefly examines the adequacy of the federal and state regulatory process.

I. FEDERAL CONTROLS[69]

Federal water pollution control legislation is based on a longstanding Congressional policy that the primary responsibility for pollution abatement rests with the states. Thus, in providing for a federal role in the establishment of water quality standards in interstate waters, Congress carefully preserved the jurisdiction of the states to adopt water quality standards by permitting the federal government to assert its jurisdiction only if the state fails to meet its responsibilities. This concept of limiting federal intervention to those instances in which a state fails to perform

a task adequately is a familiar, efficient, and well-accepted regulatory procedure. To be fully effective, however, federal jurisdiction to intervene in proper cases and to perform the function should be complete and unhampered. Thus, if a state fails to perform a function adequately, the assertion of federal jurisdiction should clearly not be contingent on that state's approval.

Unfortunately, in any case in which the state failed to adequately enforce water quality standards in Puget Sound, federal enforcement jurisdiction is dependent on state approval.

Previously it was observed that violations of water quality standards in Puget Sound could result only in "intra-state" pollution. Thus, under the present Act, the Secretary of Interior could initiate a suit to enforce water quality standards only with the written consent of the Governor. This restriction on federal enforcement jurisdiction is clearly unwarranted and unjustified, for it permits the state to block federal enforcement in those very instances in which it has inadequately performed a function.

Federal enforcement jurisdiction under the older abatement procedures specified in the Act is also similarly circumscribed. A federal suit to enforce pollution abatement recommendations concerning Puget Sound may be maintained only with the consent of the Governor with one exception---international pollution.

The present distinction between "interstate" and "intrastate" pollution in the federal Act is unjustified and should be eliminated. The federal government should be authorized to maintain an enforcement suit without the requirement of state approval whenever the state failed to perform this function adequately, regardless of whether the pollution is "interstate" or "intrastate" in character.

II. STATE CONTROLS[70]

The State of Washington has the primary responsibility to regulate water quality and abate pollution in Puget Sound and its tributaries. The present state regulatory framework appears to provide effective procedures and substantive tools to fulfill this function.

Primary jurisdiction to control and prevent the pollution of state waters is vested in one agency---the Water Pollution Control Commission. The Act provides the Commission with broad powers to implement a pollution control program in Puget Sound. The policy section of the Act, itself, provides a clear and broad mandate for pollution abatement. In addition, the Act provides the Commission with effective legal tools to abate pollution, including commercial and industrial waste discharges and domestic discharges.

Waste disposal permits and commission orders are two of the principal pollution abatement tools available to the Commission. Commission orders, of course, are subject to judicial review. Although the language of the Act appears to vest broad power and wide discretion in the Commission, the precise extent and scope of their power cannot be established until the major provisions of the Act are tested in a court decision.

Unfortunately, the Commission to date has not initiated test litigation against a major polluter to define the scope of its power. Previously, it was noted that the basic test to be applied by the court in reviewing a commission order is whether such order is clearly erroneous. Obviously, such a test vests the commission with considerable discretionary power. But the precise extent of such discretion awaits judicial interpretation.

As indicated previously, the Water Pollution Control Act appears to provide the Commission with adequate legal tools to regulate water quality and abate pollution in Puget Sound. Litigation, however, should be instituted immediately to secure a judicial decision on the major provisions of the Act.

CHAPTER IV

METRO AND WATER POLLUTION CONTROL IN PUGET SOUND

Primary jurisdiction to regulate water quality in Puget Sound is vested in a state agency -- The Water Pollution Control Commission. Local governments, however, have a key role in abating pollution in Puget Sound for they operate the sewage disposal and treatment plants which discharge waste into Puget Sound waters. Most of these facilities are operated by traditional units of government -- municipalities (cities and towns) and special sewer districts. In 1958, however, a unique form of government was created in the Seattle metropolitan area to collect and treat sewage on a regional basis. This unit of government, the Municipality of Metropolitan Seattle (popularly called Metro), includes several cities and part of a county within its boundaries. As the population of Puget Sound increases, Metro may well serve as a model for other metropolitan areas bordering on the Sound. This chapter briefly examines the role of Metro in providing sewage services to the Seattle area. The general background of Metro's development is set

forth in Section I. Section II contains a short description of the functions and jurisdiction of Metro.

I. GENERAL BACKGROUND[71]

The rapid growth in population in the Seattle metropolitan area during the 1950's soon overwhelmed the capacity of existing forms of government to successfully attack and solve serious area-wide problems. A particularly urgent problem confronting this region was sewage disposal. Lake Washington was becoming a virtual cesspool as growing suburban communities east of Seattle discharged treated wastes into the Lake. Because of Seattle's combined sewerage system, raw sewage frequently overflowed into the Lake along with storm water when the lake front interceptors became overtaxed. The water pollution problem, however, was not limited to Lake Washington. Scores of outfalls were discharging untreated sewage directly into Puget Sound.

Sewage services at this time were provided solely by municipalities (cities and towns) and a number of special sewer districts. None of these units of government, by itself, had sufficient jurisdiction or financial resources to solve this growing regional problem.

In addition to sewage, other community problems were rapidly becoming regional in character; these

included transportation, planning, water, parks, and garbage disposal. Many individuals concluded that a new form of government was needed that would enable existing local governments to join together and cooperate in the planning, financing, and providing of area-wide services. In 1956, a citizens' committee, following a long and exhaustive study, urged the State Legislature to pass an Act enabling cities and counties in metropolitan areas to join together in a metropolitan council to provide specified services.[72] Responding to this request, the Legislature in 1957 passed the Metropolitan Municipal Corporation Act.[73] This Act enables the voters in certain metropolitan areas to form a Metropolitan Municipal Corporation. If such a municipal government is formed, it is governed by representatives of the elected officials from the cities, towns and counties in the area.[74] The Act authorizes the Council to perform one or more of six area-wide functions at the discretion of the voters.[75]

Pursuant to the provisions of the enabling Act, an election was held in the Seattle area in 1958 to authorize the creation of a metropolitan municipal corporation to perform the function of sewage disposal. The proposal was approved by the voters, resulting in the establishment of the Municipality of Metropolitan

Seattle (Metro).[76]

II. JURISDICTION AND FUNCTIONS OF METRO

The Enabling Act gives metropolitan municipal corporations authorized to perform the function of sewage disposal broad powers to eliminate pollution from adjacent waters. In addition to a general grant of power providing that "a metropolitan municipal corporation shall have all powers which are necessary to carry out the purposes of the metropolitan municipal corporation and to perform authorized metropolitan functions,"[77] the Enabling Act also grants a metropolitan municipal corporation performing the sewage disposal function certain specific powers. These include power to (1) prepare a comprehensive plan, (2) acquire or construct and to operate and regulate the use of metropolitan facilities, (3) require local systems to connect to metropolitan facilities (4) fix rates and charges for use of metropolitan facilities and (5) establish minimum standards for the construction of local sewer facilities and approve plans for their construction.[78] Other significant powers include authority to raise necessary funds through the issuance of bonds.[79]

Exercising the powers granted under the Enabling Act, Metro has moved rapidly to fulfill its primary function of eliminating pollution from the environmental

waters of the Seattle metropolitan area.[80] Metro presently embraces an area of approximately 254 square miles, all located within King County. Fourteen cities and fifteen sewer districts are located within its boundaries. Counting sewage services provided to agencies outside its physical boundaries, Metro serves eleven cities and eighteen sewer districts located in two counties containing 390,000 customers (900,000 people) over a 290 square mile area.[81]

Although it has authority to collect sewage from individual residential or commercial customers,[82] Metro has restricted its scope of operations to a "wholesale" function -- the conveyance and treatment of sewage collected and delivered to it by local sewerage agencies. Thus, Metro is performing the function which it was designed to fulfill -- providing existing local governments with services which are beyond the capacity of each to provide by itself.

Seattle's Metro has received nation-wide acclaim. It recognizes that many problems in our urbanized centers are area-wide. A Metro-type government has the jurisdiction to attack and solve these problems on a regional basis. As the population of Puget Sound increases, municipal sewage disposal problems will be intensified throughout Puget Sound. A

government, such as Metro, may well be formed in other growing metropolitan areas bordering on the Sound.

FOOTNOTES

1 U.S. Const. art. I, § 8 (3).

2 A detailed analysis of the constitutional basis for federal water pollution control legislation is beyond the scope of this paper. For a general discussion of this subject, see Bermingham, The Federal Government and Air and Water Pollution, 23 Bus. Law. 467 (1968) and Edelman, Federal Air and Water Control: The Application of the Commerce Power to Abate Interstate Pollution, 33 Geo. WASH. L. REV. 1067 (1965).

3 Act of June 30, 1948, ch. 758, 62 Stat. 1155.

4 Act of July 9, 1956, §§1-14, 70 Stat. 498.

5 Act of July 20, 1961, 75 Stat. 204.

6 Act of Oct. 2, 1965, 79 Stat. 903.

7 Act of Nov. 3, 1966 §206, 80 Stat. 1250.

8 For an excellent analysis of the historical development of major federal legislation pertaining to water pollution control, see Stein, Regulatory Aspects of Federal Water Pollution Control, 45 DEN. L. J. 267 (1968).

9 33 U.S.C.A. §466(b) (Supp. 1968).

10 33 U.S.C.A. §466g(c)(1), (2) (Supp. 1968).

11 33 U.S.C.A. §466g(c)(3) (Supp. 1968).

12 Id.

13 33 U.S.C.A. §466j(e) (Supp. 1968).

14 Guidelines for Establishing Water Quality Standards for Interstate Waters, U. S. DEPARTMENT OF INTERIOR, FEDERAL WATER POLLUTION CONTROL ADMINISTRATION, May 1966.

15 The term "coastal waters" is not defined in the Act. The federal position (Dept. of Interior) is that coastal waters include all inland waters in which the tide ebbs and flows. Several commentators have argued that Congress intended the term to include only the waters beyond the low mark of the sea. This is the position of the State of California. See Bermingham, The Federal Government and Air and Water Pollution, 23 Bus. Law. 467, 473 (1968). With respect to Puget Sound, the dispute is somewhat academic since the Pollution Control Commission, in establishing water quality standards, has adopted the federal definition. A Regulation Relating to Water Quality Standards for Interstate and Coastal Waters of the State of Washington and a Plan for Implementations and Enforcement of such Standards, WATER POLLUTION CONTROL COMMISSION, STATE OF WASHINGTON, December 4, 1967.

16 33 U.S.C.A. §466g(c)(s) (Supp. 1968).

17 33 U.S.C.A. §466(g)(1) (Supp. 1968).
In defining federal enforcement authority, the statute does not utilize the terms "interstate" and "intrastate" pollution. Such terms are used by the writer as convenient descriptive labels. The term "interstate pollution" is applied to that pollution which adversely affects the health or welfare of persons in a state other than that in which the discharge originates. The term "intrastate pollution" is used to describe pollution which affects persons only in the state in which the discharge originates.

18 33 U.S.C.A. §466g(c)(5) (Supp. 1968) and 33 U.S.C.A. §466g(g)(1) (Supp. 1968).

19 33 U.S.C.A. §466g(g)(1) (Supp. 1968).

20 33 U.S.C.A. §466g(g)(2) (Supp. 1968) (Emphasis Added).

21 For an excellent description of these procedures, see Stein, Regulatory Aspects of Federal Water Pollution Control, 45 DEN. L. J. 267, 275 (1968).

22 33 U.S.C.A. §466g(a) (Supp. 1968).

23 Id.

24 33 U.S.C.A. §466g(d)(1) (Supp. 1968).

25 Id.

26 Id.

27 33 U.S.C.A. §466g(d)(2) (Supp. 1968).

28 The abatement procedures are set forth in 33 U.S.C.A. §466 g (d)(e)(f) (Supp. 1968).

29

33 U.S.C.A. §466g(g)(1)&(2) (Supp. 1968).

30

33 U.S.C.A. §466g(d)(2).
This section reads in part: ". . . The Secretary, through the Secretary of State, shall invite the foreign country which may be adversely affected by the pollution to attend and participate in the conference, and the representative of such country shall, for the purpose of the conference and any further proceeding resulting from such conference, have all the rights of a State water pollution control agency."

This language appears to accord to foreign nations the same status as states affected by pollution originating in another state. Accordingly, international pollution appears to be treated in the same manner as interstate pollution and the Secretary of Interior could, therefor, maintain a suit without the consent of the Governor.

31

WASH. REV. CODE ch. 90.48 (1962).

32

Wash. Sess. Laws, 1955, ch. 71.

33

Wash. Sess. Laws, 1967, ch. 13; Wash. Laws Ex. Sess. 1967, ch. 139.

34 WASH. REV. CODE §90.48.010 (1962).

35 For an excellent analysis of the historical development of major state legislation pertaining to water pollution control, see Comment, Water Pollution Control in Washington, 43 WASH. L. REV. 425 (1967). This article also reviews the Washington Pollution Control Commission's attempts to secure improved water quality in the Puget Sound area, with special emphasis on the Commission's activity with respect to the pulp industry.

36 WASH. REV. CODE §90.48.021 (Supp. 1968).

37 WASH. REV. CODE §90.48.023 (1962) and §90.48.025 (Supp. 1968).

38 WASH. REV. CODE §90.48.030 (1962):

> "The commission shall have the jurisdiction to control and prevent the pollution of streams, lakes, rivers, ponds, inland waters, salt waters, water courses, and other surface and underground waters of the state of Washington."

39 WASH. REV. CODE §90.48.035 (Supp. 1968) (Emphasis Added).

40 WASH. REV. CODE §90.48.020 (Supp. 1968) For an opinion of the Washington State Attorney General on the authority of the Commission to adopt water quality standards for "interstate waters" within the state of Washington, see A G O 1967 No. 39.

41 WASH. REV. CODE §90.48.260 (Supp. 1968).

42 A Regulation Relating to Water Quality Standards for Interstate and Coastal Waters of the State of Washington and a Plan for Implementations and Enforcement of such Standards, WATER POLLUTION CONTROL COMMISSION, STATE OF WASHINGTON, December 4, 1967.

43 WASH. REV. Code §90.48.160 (Supp. 1968).

44 WASH. REV. CODE §90.48.180 (Supp. 1968).

45 Id.

46 WASH. REV. CODE §90.48.190 (Supp. 1968).

47 WASH. REV. CODE §90.48.195 (Supp. 1968).

48 WASH. REV. CODE §90.48.110 (Supp. 1968).

49 Id.

50 Id.

51 WASH. REV. CODE §90.48.270 and §90.48.280 (Supp. 1968).

52 Interview with the Honorable James P. Behlke, Director, Water Pollution Control Commission, in Olympia, Washington, June 13, 1969.

53 WASH. REV. CODE §90.48.120 (Supp. 1968).

54 WASH. REV. CODE §90.48.080 (Supp. 1968).

55 WASH. REV. CODE §90.48.120 (Supp. 1968).

56 WASH. REV. CODE §90.48.210 (Supp. 1968).

57 WASH. REV. CODE §90.48.135 (Supp. 1968).

58 Id.

59 Id.

60 WASH. REV. CODE ch. 34.04 (1965).

61 WASH. REV. CODE §90.48.230 (Supp. 1968).

62 WASH. REV. CODE §34.04.130(6)(e) (Supp. 1968).

63 WASH. REV. CODE §90.48.240 (Supp. 1968).

64 WASH. REV. CODE §90.48.037 (Supp. 1968).

65 WASH. REV. CODE §90.48.144 (Supp. 1968).

66 Id.

67 WASH. REV. CODE §90.48.140 (1962).

68 WASH. REV. CODE §90.48.142 (Supp. 1968).

69 This discussion is based on the analysis set forth in Chapter I.

70 This discussion is based on the analysis set forth in Chapter II.

71 The general background on the development of Metro was obtained primarily from LEAGUE OF WOMEN VOTERS OF KING COUNTY, THE MUNICIPALITY OF METROPOLITAN SEATTLE (3rd ed. 1965), and METROPOLITAN ENGINEERS, MUNICIPALITY OF METROPOLITAN SEATTLE, REPORT ON OPERATIONS (1968).

72 LEAGUE OF WOMEN VOTERS OF KING COUNTY, THE MUNICIPALITY OF METROPOLITAN SEATTLE 2(3rd ed. 1965).

73 WASH. REV. CODE ch. 35.58 (1965).

74 WASH. REV. CODE §35.58.120 (Supp. 1968).

75 WASH. REV. CODE §35.58.050 (1965).

76 LEAGUE OF WOMEN VOTERS OF KING COUNTY, THE MUNICIPALITY OF METROPOLITAN SEATTLE 4-6 (3rd ed. 1965).

77 WASH. REV. CODE §35.58.180 (Supp. 1968).

78 WASH. REV. CODE §35.58.200 (1965).

79 WASH. REV. CODE §35.58.450 and 460 (Supp. 1968).

80 See generally, METROPOLITAN ENGINEERS, MUNICIPALITY OF METROPOLITAN SEATTLE, REPORT ON OPERATIONS (1968).

81 Id. at 2.

82 Id. at 8.

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