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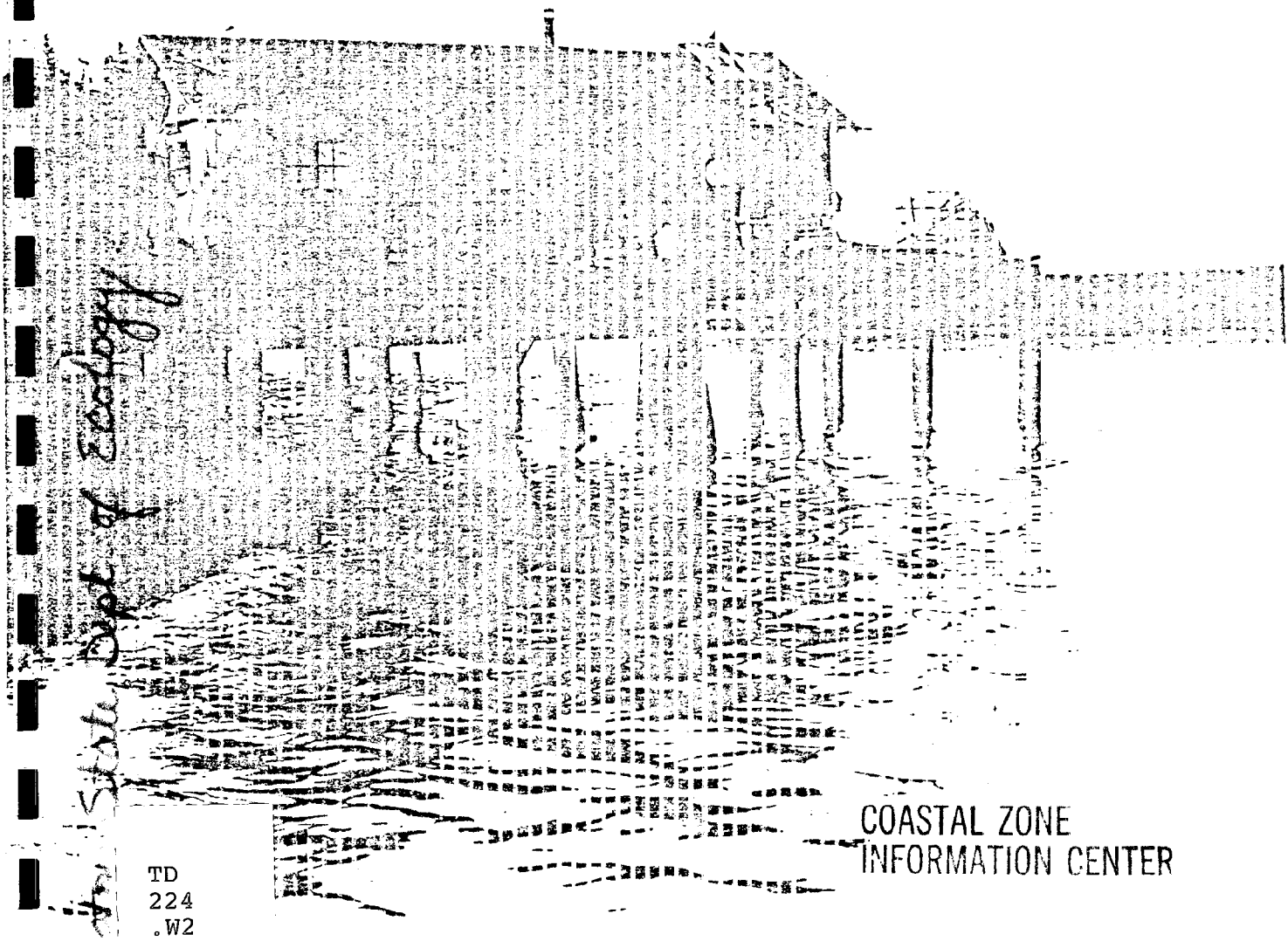

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COORDINATING USES OF THE LAND AND WATER IN TOTTEN AND SKOOKUM INLETS

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Prepared by
The Aquaculture Group
Environments: Chemistry, Ecology, and Politics
The Evergreen State College
Olympia, Washington

William Clausen
David Couch
Leigh Francis
James Kramer
Joan Lieberman
Meredith Lind

Doug M. McGeary
Richard O'Brien
Amy Poundstone
Paul Sammons
Robert Shumate
Becca Todd

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June 1977

The preparation of this report was financially aided through a grant from the Washington State Department of Ecology with funds obtained from the National Oceanic and Atmospheric Administration, and appropriated for Section 306 of the Coastal Zone Management Act of 1972.

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ACKNOWLEDGEMENTS

The members of the "Coordinating Uses of the Land and Water" project extend their appreciation to the following citizens and public agencies for making this study possible:

Jon Akin, The Evergreen State College

Monty Anderson, Mason Regional Planning Council

Mitch Brown, Mason Regional Planning Council

Pete Friedman, Thurston Regional Planning Council

Max Hayes, Department of Social and Health Services

Don Hurlbert, U.S. Department of Agriculture, Soil Conservation Service

Dan Krueger, Department of Ecology

Dave McMillan, Olympia Oyster Company

Charlie Peterson, Thurston Regional Planning Council

Don Peterson, Department of Ecology

William Petty, Mason County Soil Conservation Service

Ken Schlikte, Department of Natural Resources

A special thanks to Carolyn Dobbs and Kaye V. Ladd for their guidance.

The funds for this study were provided by the Mason and Thurston Regional Planning Councils as part of the Special Studies Section under their Coastal Zone Management Programs.

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Introduction

Totten and Skookum Inlets of southern Puget Sound are among the most productive shellfish growing areas in the country. The physical and chemical features of the inlets' water make them highly suitable for oyster and clam production. This is a result of both the geographic location of the inlets and the relatively undisturbed character of the adjacent uplands. The latter factor is crucial, for the human use of these uplands is inextricably related to the quality of the water.

Accelerating pressure for development of the shorelines and uplands of Totten and Skookum Inlets is posing serious problems. Mason and Thurston counties, the local governments with jurisdiction over the inlets, responded to this pressure by initiating the following study of land and water uses in the Totten and Skookum inlet area. The results of this study will be used by both counties as a basis for future land use planning.

Two terms recurring throughout this study are "aquaculture" and "watershed". Aquaculture is the cultivation of aquatic organisms for human consumption. For the purposes of our study aquaculture refers primarily to the culturing of clams and oysters. A watershed is the entire area providing runoff to a main stream or major body of water.

This study is only a beginning. Further information will be necessary to augment our results. Until then, this document can serve as a foundation for sound land use planning.

The following recommendations were developed in the course of this study, and are listed here to provide easy reference for the reader.

1. A year long water quality survey, including monthly samplings, should be conducted in order to obtain data for all seasons of the year.
2. A year long phytoplankton study, including more sampling stations, should be made.
3. Ecological studies of the marine organisms of Totten Inlet should be conducted, with special attention given to the affects of oyster dikes on the area ecology.
4. Future development should be located and designed in accordance with the natural characteristics of the land.
   a. Building permits should not be issued on soils incapable of supporting the proposed structures unless corrective measures are included.
   b. Residential development should not significantly disrupt existing, natural drainage patterns. Sand filters should be used to remove gross impurities from street runoff.

c. The density and amount of development should be sharply limited to protect the aquacultural productivity and aesthetics of the areas.

5. Attempts should be made to preserve agricultural and forestry lands as they are valuable assets to the economic and natural conditions of the area.

6. Measures should be taken to prevent excessive erosion from forestry, agricultural, and construction activities, particularly in those areas that are most susceptible to erosion or are very near to aquaculture grounds. These measures could include the maintenance of natural barriers and a vegetative cover near streams.

7. The use of herbicides and pesticides should be limited and supervised to prevent unnecessary damage to the terrestrial and aquatic environments. Additional information on their effects should be sought.

8. Implementation of shoreline and water quality regulations should be concentrated at the local level.

9. Mason and Thurston counties should coordinate permitted uses on both sides of the inlet, consistent with the Shoreline Management Act.

10. The counties should explore the idea of providing maintenance service for individual septic tank systems, at a cost to the owner.

11. The shoreline master programs should be revised to reflect the suitabilities and limitations of the specific shoreline in question.

12. A citizen planning group, such as the Griffin Planning Association on the Thurston County side of Totten Inlet, should be formed.

13. When land use decisions are to be made, public meetings should be held and well publicized.

14. Whenever possible, citizen surveys should be conducted.

15. Different methods for maintaining low density areas while allowing further development should be investigated. They might include cluster development and the establishment of park areas.

Chapter 1

The Water

INTRODUCTION

One of the major uses of the aquatic environment in Totten and Skookum Inlets is aquaculture. Since the aquatic environment is the one which most directly affects the ability of aquaculture organisms to live and grow, it is important for us to consider those factors which affect aquaculture. These factors may be broken down into three major categories: the physical, chemical, and biological factors.

The physical factors result from natural features. This would include things like the shape and contour of Totten and Skookum Inlets, their currents and tides.

The chemical factors result from the different kinds and concentrations of chemicals that exist in the aquatic environment. These chemicals may widely vary in their affects on aquaculture organisms. For instance, some chemicals are toxic while others are essential to life. There are even chemicals which are essential to life but become toxic in large concentrations. The chemical factors we considered to be most important were those reflecting water quality and will be the only ones discussed.

The biological factors result from the different kinds and densities of organisms that exist in the aquatic environment. Some organisms, like plankton, are food for aquaculture organisms. Other organisms, like starfish, prey on aquaculture organisms. However, the biological factor which we considered most important to the aquaculture in Totten and Skookum Inlets was phytoplankton and will be the only biological factor discussed.

Though the physical, chemical, and biological factors will be discussed separately, it is important to keep in mind that they are closely related. The organisms in the aquatic environment along with their physical and chemical surroundings form an ecosystem. This ecosystem is made up of complex and intertwining relationships, where a change in any part of the ecosystem will likely affect other parts. This is why it is important to consider numerous parts of the ecosystem when discussing aquaculture.

PHYSICAL FACTORS AFFECTING AQUACULTURE

There are a number of physical factors which affect aquaculture in Totten and Skookum Inlets. Some of these physical factors qualify Totten and Skookum as estuaries.

An estuary is "a semi-enclosed, coastal body of water which has a free connection to the sea and within which sea water is measurably diluted with fresh water derived from land drainage."[1] Totten and Skookum Inlets are small estuaries of the large Puget Sound estuarian system.

The semi-enclosed configuration and the resulting limited sea access are factors which allow both inlets to be highly productive for several reasons. Vegetation and bottom dwelling organisms are not subjected to agitation associated with the pounding surf of coastal waters. Further, both inlets act as nutrient traps since there is a low exchange of water in the basins with water outside the basins. The significance of this is that the nutrients, which are sources of nourishment for plants and animals, are not quickly washed away by the tide. They stay within the area and are utilized by the biological community.[2]

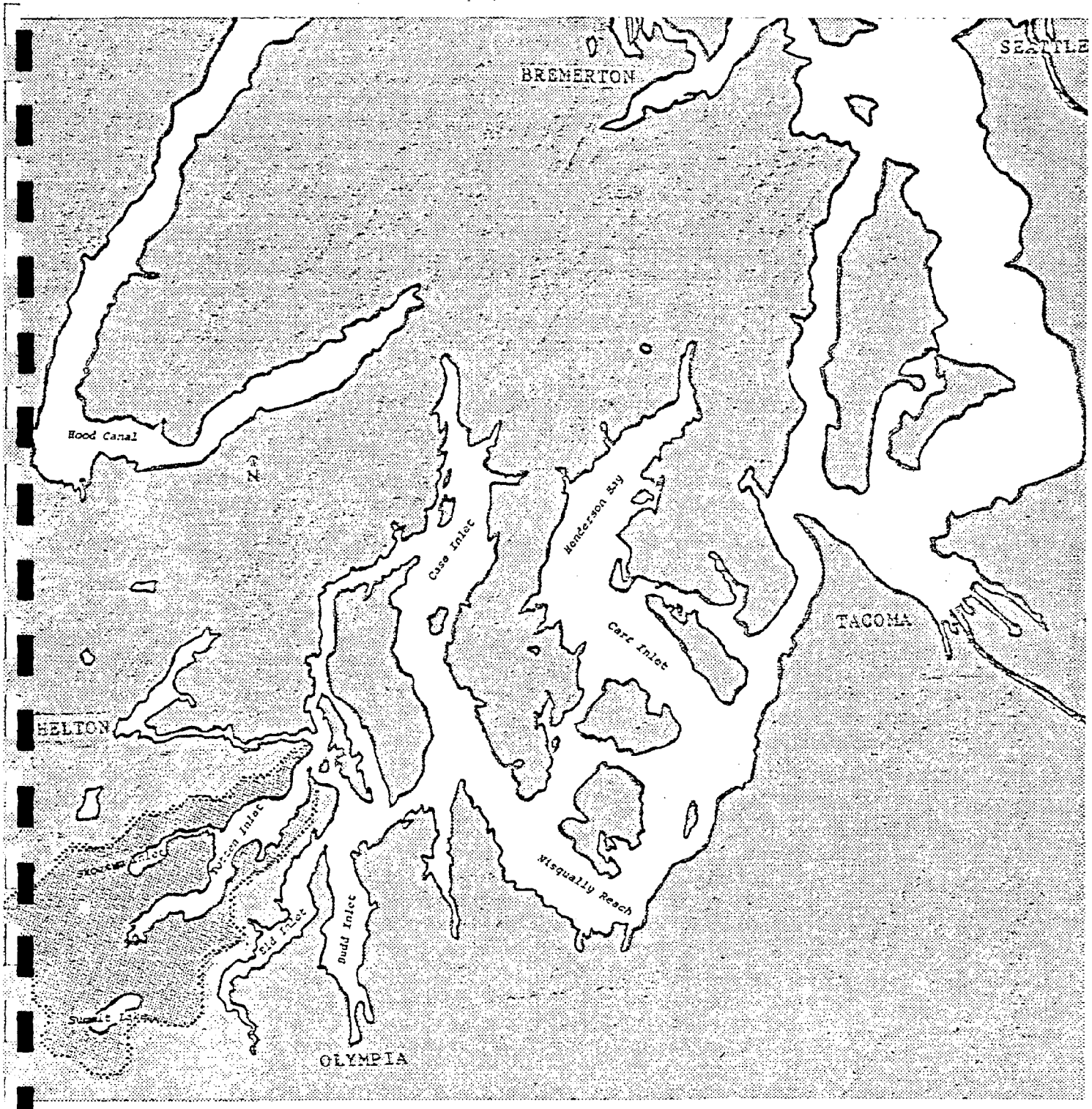
Totten and Skookum Inlets both have significant amounts of fresh water flowing into them. Kennedy and Schneider Creeks flow into Oyster Bay located at the southern end of Totten Inlet, and Skookum Creek empties into the southern end of Skookum Inlet. (see Figure p.) In addition to these major fresh water sources there are numerous smaller or seasonal fresh water sources.

Induction Currents

The fresh water flowing into an estuary presents a special phenomenon characteristic of estuaries known as induction currents.

Induction currents are observed when fresh water entering an estuary flows on top of the denser seawater. As the tide moves in, the surface fresh water continues moving seaward. This contrast in direction of flow causes small currents to form which bring part of the bottom water up to the surface and to parallel the fresh water flow (see Figure).[3]

Figure 1-1



Totten-Skookum Watershed (Study Area)

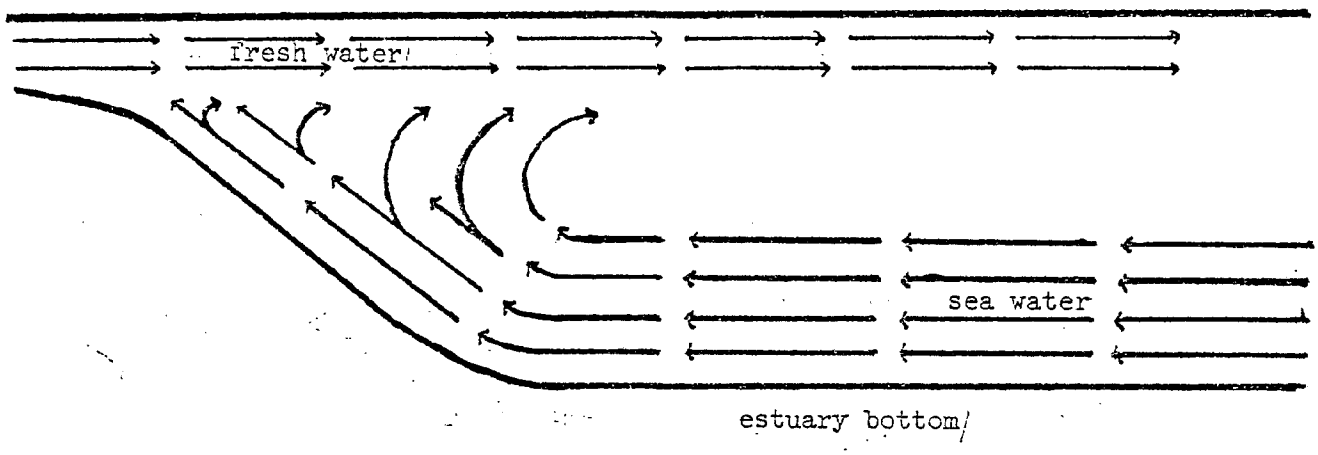


Figure 1-2. Formation of Induction Currents

The importance of induction currents to an estuary is that the sediments in contact with the bottom water are rich in nutrients. The induction currents move nutrients into the phototropic zone, the layer of water inhabited by photosynthetic organisms known as phytoplankton. The phytoplankton utilize these nutrients, and their populations increase significantly. These phytoplankton are important because they produce part of the oxygen used in respiration and are the major food source for aquaculture organisms.[4]

The effects of induction currents can be seen in the water quality data to be discussed later.

Other Currents

Other currents affecting aquaculture organisms result from a combination of tidal action with the shape and contours of the basin. Moderate currents are necessary to keep a continuous flow of dissolved oxygen and food moving past the siphons of clams and oysters and to wash away waste products. Faster currents are generally better for aquaculture organisms because the faster currents increase availability of food and oxygen. The more food and oxygen available to aquaculture organisms, the greater their growth rate.

Current studies have indicated that there are strong currents in Totten Inlet which generally follow the contours of the inlet. The currents are particularly strong in the narrow sections.[5]

The fastest currents in Totten Inlet run along the area adjacent to Steamboat Island where current speeds of 1.7 miles per hour have been measured.[5, 6]

There are no data for currents in Skookum Inlet, however, estimated current speeds of 3-5 miles per hour have been observed in parts of the inlet.

Mixing and the Flushing Rate

The degree of mixing in estuarine waters is important. When an estuary is not mixed, the water forms layers of varying density. The differing densities in the water are due to differences in salt concentrations. Fresh water floats on top of saltwater, and seawater that has been diluted with fresh water floats on top of incoming seawater. These layers of water have different concentrations of nutrients and the dilution of pollutants. Good mixing occurs where strong winds, currents, and tidal action act on the topography, shape and contours of the water basin. These conditions apply in Totten and Skookum Inlets. Therefore, the waters should be well mixed.

The flushing rate of a basin is an approximation of the number of complete tidal cycles (high tide to high tide) that are necessary to exchange the water in the basin with water outside the basin. The only data on the flushing rate of Totten Inlet comes from a study done by the Department of Natural Resources and indicates that Totten Inlet has a flushing rate of 2.4 tidal cycles.[7] This would lead one to believe that Totten Inlet has a high flushing rate, however, in computing the flushing rate, 100 per cent mixing and a complete exchange were assumed. It is incorrect to assume that a complete water exchange takes place. Much of the water which leaves an estuary on ebb tide re-enters on the flood tide, a major factor that makes estuaries nutrient traps.[8] Therefore, the flushing rate which was computed is not a true estimation of actual flushing time but is more likely a number indicating the relative degree of mixing which occurs. In that case the number indicates that Totten Inlet is well mixed.

Chemical Factors Affecting Aquaculture--Water Quality

Water quality is the measurement of those chemical factors which indicate the suitability of the water for sustaining life. The water quality of an area reflects the type of activities which occur in and around the area. Water quality can be affected by the biological and physical factors of the environment. For example, a large dissolved oxygen content in a body of water may be caused by great photosynthetic activity of plankton, some kind of physical agitation of the water by wind/wave activity, or swift currents which mix atmospheric oxygen with the water. Water quality also affects the biological community that inhabits the water. For example, few organisms can survive where concentrations of the dissolved oxygen are extremely low.

Nutrients

Some of the Water Quality measurements made are measurements of nutrient concentrations. Nutrients, as used here, refer to inorganic chemicals which are essential to life in the aquatic environment. The balance between nutrient concentrations is partly responsible for the type of life found in an area. If any nutrient is limited in its concentration, the productivity of the estuary is similarly limited. Excess concentrations of certain nutrients can cause other problems known as over-enrichment problems. Over-enrichment problems occur to some degree naturally in most aquatic environments due to seasonal changes in the concentrations of some nutrients. During the fall and winter month subdued sunlight and shorter daylengths result in a significant decrease in phytoplankton populations along with their rate of nutrient consumption. Meanwhile bacteria populations are breaking down the bodies of dead organisms, releasing essential nutrients in the process. When the bright sunlight of spring arrives, phytoplankton populations, consuming this store of nutrients, increase at an uncontrollable rate, until the concentration of any one nutrient dwindles. Bacteria breaking down the bodies of dead organisms consume large amounts of oxygen needed by living organisms. Consequently, these organisms may suffocate from this lack of oxygen. The nutrients which are generally responsible for this effect are nitrate and ortho-phosphate. Since sewage is a major source of nitrate and ortho-phosphate, it is important to limit the amount of sewage which enters an estuary. Not only will the sewage have an immediate fertilizing affect, but the subsequent retention of the nutrients by the estuary accumulates this over-enrichment.[9]

Oxygen

Without appreciable amounts of oxygen in water, many different kinds of aquatic organisms cannot exist.[10] Oxygen, in aquatic environments, is mostly produced by either photosynthetic organisms or by physical exchange with the atmosphere. Oxygen is consumed by degrading organic matter in the water, as well as by the respiration carried on by the living organisms. The more organic matter in the water, the greater the consumption of oxygen. In fact, a certain amount of organic matter requires nearly an equal amount of oxygen to complete its decomposition.[11]

The dissolved oxygen saturation percentile relates the amount of dissolved oxygen in the water with the amount of oxygen that the water contains when saturated. The dissolved oxygen saturation percentiles calculated for Totten and Skookum Inlets are all over 100 per cent, indicating that the water is in an unstable state known as super-saturation. This is due to the spring phytoplankton bloom. Evidence of the phytoplankton bloom is shown in the chlorophyll and plankton survey (see Appendix B).

It is possible to attribute high dissolved oxygen and dissolved oxygen saturation percentile values to agitation of the water by winds and tidal currents. However, during both sampling occasions the water appeared to be extremely calm.

Using special techniques, the Biochemical Oxygen Demand (BOD) can be calculated. The BOD is the amount of oxygen that will be consumed by respiration occurring in the water in a given period of time. The BOD is an important factor to consider in obtaining a more complete knowledge of the biological "activities" which are occurring in the water. For example, a high BOD indicates that there is a great deal of organic material in the water.

The BOD values that were calculated for Totten and Skookum Inlets show that there is not a significant amount of organic material in the water (see Appendix A).

Phosphate

Phosphate is a chemical, consisting of phosphorus and oxygen atoms, which is essential for photosynthesis as well as other biochemical processes. Ortho-phosphate is the inorganic form of phosphate which may be utilized by photosynthetic organisms. Organic phosphate is the form of phosphate which is presently a part of living or dead organisms. It will eventually be released in the form of ortho-phosphate once the bodies of dead organisms are decomposed by bacteria. The major

sources of phosphate are drainage from agriculture and forested lands, sewage effluent, and the decomposition of organic material.[12]

The phosphate concentrations measured for Totten and Skookum Inlets are normal, indicating no significant influx of this nutrient (see Appendix A , page A-2).

Ammonia, Nitrite, and Nitrate

Ammonia, nitrite, and nitrate are forms of atmospheric nitrogen which have been chemically bound to other atoms to form molecules which are essential nutrients used in numerous biochemical processes. Generally, it is only nitrate which can be utilized by phytoplankton and other plants. Ammonia and nitrite are converted into nitrate by the metabolic processes of certain bacteria. When nitrate is "consumed" by phytoplankton, most of it goes to manufacture proteins. These plant proteins are the primary source of protein nutrition in all marine animals. When the bodies of the plants and animals are decomposed by bacteria, the nitrogen constituents of the proteins are released in the form of ammonia. Some marine animals also excrete ammonia as a by-product of their metabolism. Nitrate is the most common limiting factor to phytoplankton growth in estuarine systems. The common sources of nitrate, ammonia, and nitrite are the same as those mentioned for phosphates.

The values measured for ammonia, nitrite, and nitrate are typical for this time of year in Puget Sound (see Appendix A , page A-2). The low nitrate values indicate that it is limiting the growth of the phytoplankton population.

Other Water Quality Measurements

pH

The pH is a measure which indicates the relative aicdity or basicity of the water. The pH of pure water is 7.0 and is considered to be neutral. A pH which is less than 7 indicates that the water is acidic while a pH greater than 7 indicates that the water is basic. Seawater usually has a pH of around 8. pH is an important measurement because aquatic organisms can exist only within certain pH ranges. Accidental spillages of acids and bases have been responsible for massive fish kills. The same result is possible from land drainage from strip mines and other activities.

The pH values measured in Totten and Skookum Inlets indicate that the water is of normal pH (see Appendix A , page A-2).

Salinity and Temperature

The salinity and temperature, in addition to being used in the calculation of the dissolved oxygen saturation percentile, are useful in indicating the degree of mixing which occurs in an estuary. Salinity, itself, is a measure of the concentration of dissolved inorganic salts which exist in the sample water.

The salinity and temperature data for Totten Inlet indicates that it is well mixed. The data indicate that there are negligible fresh water effects between Burns Point and the head of Oyster Bay where Kennedy and Schneider Creeks empty. These fresh water effects disappear beyond Burns Point. The effect of the well mixed estuary is reflected in the means and standard deviations of the salinity and temperature data (see Appendix A , page A-2).

Localized Deterioration of Water Quality

The water quality study indicates that there is no major deterioration of water quality in Totten Inlet. The study, however, was not designed to indicate whether there was localized deterioration of water quality near sites of substantial development. There is significant evidence which suggests that localized deterioration of water quality can occur. Such effects are evident by a study of past water quality data in Budd Inlet.[13]

Budd Inlet is located southeast of the mouth of Totten Inlet (see Figure , page). It is an estuary with a major sewage outfall located at its southern end. The Department of Ecology has collected water quality data at five sites in Budd Inlet (see Appendix A , pageA-5). If one observes the dissolved oxygen levels at those sites near the sewage outfall, it will be noted that they are often lower than sites located further away. Typically, the effects of the sewage disappear before it travels a substantial distance due to mixing and consequent dilution of the sewage. This trend is consistent and can be observed for several different sampling days. For a few of the sampling days substantial mixing from tidal action and currents masked the effects of localized deterioration of water quality. The effects of the sewage are not due to seasonal conditions since localized deterioration of water quality is indicated for each season.

Such localized deterioration of water quality as observed for Budd Inlet can also occur on a much smaller scale along the shores of Totten Inlet where faulty septic tanks drain. This presents a danger to the intertidal organisms including aquaculture organisms. This localized deterioration of water quality can be even more significant in areas of low water exchange such as bays and coves. This is

one major reason why development should not exceed the limits of the land's capability (see Chapter 2). Though most estuaries are able to survive some localized deterioration of water quality, when such effects occur on a large scale, the balance of the ecosystem is interrupted with numerous possible consequences.

Biological Factors Affecting Aquaculture--Phytoplankton

Primary productivity refers to the photosynthetic process in plants which converts nutrients and energy from sunlight to biomass. This is the basis of all food chains. The greater an area's primary productivity, the greater the number of higher organisms the area can support.

In estuaries, there are three sources for primary productivity. They are the plants which compose the salt marsh, benthic diatoms which grow on the surface of the mudflats, and phytoplankton which live in the body of water itself. Of these, phytoplankton are the important food source for oysters, since they are found in the water which the oysters filter to obtain food.[14]

Measuring the amount of Chlorophyll a in the water is a method of estimating the amount of phytoplankton in the water. Tables A-1 and A-2 on page A-2 shows the Chlorophyll a collected for Totten Inlet.

On April 12 very high levels of Chlorophyll a were recorded. On the 22nd these levels were no longer evident. Barlow has noted similar fluctuations in the Chlorophyll a content of Hood Canal.[15]

The fluctuations in the Chlorophyll a content in the Totten Inlet samples may be explained by viewing the phytoplankton as communities composed of different species of microscopic algae. There is a natural succession during the spring and early summer of three different types of phytoplankton communities (see Appendix B , page B-1). The first community flourishes and is replaced by the second community, which in turn is succeeded by the third community. The first community is the most productive of the three.[16]

The high values of Chlorophyll a recorded on April 12 were caused by a phytoplankton community of the first type. This community's presence was determined by statistical and visual observations (see Appendix B , page B-6). The predominant species of this sampling were spirals of Chaetoceros secundus and chains of Nitzschia seiata. These diatoms and certain others are illustrated on pages B-3 and B-4. The phytoplankton of this community grow best in turbulent, nutrient rich waters. The turbulance of the water and the nutrient rich state of the area makes the intertidal zones of Oyster Bay and Skookum Inlets highly suitable for the development of this community.

On April 22 another phytoplankton community prevailed in Totten Inlet (see

Appendix B , page B-4). The species Coscinocliseus wailesii characterized this sampling. This diatom appears as a large, pill box-like disk. C. wailesii and certain other diatoms are also shown on pages B-3and B-4. The values of Chlorophyll a associated with this community were not as high as those associated with the first community. These values do not follow the same distribution. As this community matures, higher values for Chlorophyll a may be recorded. This phytoplankton community has different growth requirements than the first community. Trends in the data indicate the second community would develop in different areas than the first.

The areas most suited for oyster growing are those where a maximum amount of food is available, the same areas where the first phytoplankton community develops. A phytoplankton survey with more stations would reveal a more exact geographic location for the areas where the phytoplankton production is most suitable for oyster culture.

Summary and Recommendations

The data and information presented in this chapter indicate that Totten Inlet is a well mixed, productive estuary with normal concentrations of nutrients. Consequently, there is no deterioration of water quality on a large scale. However, it is important to keep in mind that rainfall was much lower than normal for this time of year. The average rainfall for April in this area is 3.14 inches, a number much greater than the 1.27 inches of rainfall for April, 1977.[17] This substantial decrease means there is less land drainage occurring which normally may cause over-enrichment problems through the introduction of sewage from septic tanks and other nutrient sources.

As a result of our water quality and phytoplankton studies, we are making the following recommendations:

1. To get a complete picture of the overall water quality of Totten and Skookum Inlets, it would be necessary to collect monthly water quality data over a full year and to include at least one other site in Skookum Inlet. This would indicate the degree of seasonal fluctuation in nutrient levels and provide a good baseline with which to compare other water quality data.
2. Similarly, in order to understand the seasonal fluctuations in phytoplankton populations, a year long study should be done including more sampling sites to obtain a better understanding of phytoplankton distribution.

REFERENCES FOR CHAPTER 1

1. Donald W. Pritchard "What is an Estuary: Physical Viewpoint", Estuaries, ed. George H. Lauff. Publication no. 83 (American Association for the Advancement of Science: Washington, D.C., 1967), p.4.

2. H.D. Russell-Hunter, Aquatic Productivity (McMillan Publishing Co.: New York, 1970), p. 105-106.

3. Personal communication with Dr. David H. Milne, TheeEvergreen State College, Olympia, 1977.

4. Milne, 1977.

5. Aquaculture and Water Quality: Totten Inlet (The Evergreen State College: Olympia, 1975), p. 34-52.

6. Washington State Department of Natural Resources, Current and Flushing Rate Study, unpublished, 1969, p. 126-134.

7. DNR Study, p. 136-134.

8. Russell-Hunter, p. 105-106.

9. Russell-Hunter, p. 105-106.

10. Milne, 1977.

11. Stanley E. Manahan, Environmental Chemistry, 2nd edition (Willard Press: Boston, 1975), p. 20.

12. James B. Lackey, "The Microbiota of Estuaries and Their Roles", Estuaries, ed. George H. Lauff, Publication No. 83 (American Association for the Advancement of Science: Washington, D.C., 1967), p. .

13. State of Washington, Department of Ecology, Storet Retrevial Computer System.

14. J.E. Bardach, W.O. McClarney and J.H. Ryther, Aquaculture: The Farming and Husbandry of Freshwater Organisms (John Wiley and Sons, Inc. Wiley-Interscience: New York, 1972), p. 692.

15. John P. Barlow, "Spring Changes in Phytoplankton Abundance in a Deep Estuary, Hood Canal, Washington", Journal of Marine Research, 17 (November, 1958), p. 53-67.

16. Ramon Margalef, "Temporal Succession and Spatial Heterogeneity in Phytoplankton", Perspectives in Marine Biology, ed. A.A. Buzzati-Traverso (University of California Press: Los Angeles, 1958) p. 330.

17. National Weather Service, Olympia, Washington, May, 1977.

Chapter 2

The Land

INTRODUCTION

In considering the conditions of the aquatic environment, an understanding of the upland activities and their effects is necessary. The range of the uplands for this study was the watershed of Totten and Skookum Inlets (see Figure).

Certain problems related to development, such as structural instability and slippage, contamination of ground water resources, erosion, and siltation, alter the features and processes of the natural system.

By analyzing certain parameters of the natural environment, the capability of the land to support houses, roads, sewage disposal systems, or intensive timber management practices can be determined. With this in mind, steps can be taken to minimize maintenance and avoid potential problems.

It has already been noted how influential the chemical components are in water quality (Chapter 1, p.8). Many of these same components are introduced into surface and ground water systems and the soil by various human activities. It is helpful, then, to know the patterns of existing land uses and to search for relationships between those uses and water quality. It can also show general development trends which cannot be ignored when preparing recommendations for land use planning.

The following maps illustrate the land capability in terms of soil limitations for buildings, roads, and septic tanks. This section also illustrates erosion potential, and patterns of existing land uses.

LAND CAPABILITY[1]

Land capability is the suitability of the land for a specific use. In the Totten watershed one use is residential development. The limitations on the ability of the soil to support associated development such as buildings, roads, and septic tanks cannot be ignored in this area where preservation of high water quality is important.

Certain properties of soils such as slope and particulate size determine these limitations. By taking these properties into account and using proper precautions and planning, many potential problems can be avoided.

The Soil Conservation Service (SCS), a branch of the U.S. Department of Agriculture, conducts soil surveys and publishes its findings on soil types, their characteristics and locations. Three general degrees of limitation; severe, moderate, and slight, are mapped on the following pages.

A "severe" limitation means that one or more properties are unfavorable for the intended use, so construction will require special design or intensive maintenance. In most instances it would be difficult and costly to compensate for a severe degree of limitation with current methods of construction. If the problems are not overcome, undesirable consequences (eg. structural instability and slippage) may follow.

A "moderate" limitation indicates that there may be problems associated with development, but they could be overcome or modified using special design features such as artificial drainage to reduce erosion.

A classification of "slight" indicates that limitations are minor and can be overcome relatively easily.

A soil's classification does not necessarily permit or prohibit development, rather it is an assessment of the soil's characteristics and capabilities. The ratings and maps do not eliminate the need for on-site investigation. On-site inspections are still necessary because many areas composed of a given soil type may contain small areas of other soils that have strongly contrasting properties and different suitabilities or limitations. A complete study of land capability entails more parameters than are presented here. Underlying geology, drainage patterns, groundwater resources, vegetation and wildlife distribution should also be considered. However, enough information is presented to make a good evaluation of an area's limitations for certain uses, as shall be shown in the following pages.

Soil Limitations for Buildings and Roads:

Single family dwellings and other structures not more than three stories high with similar foundation requirements comprise the category of "buildings". "Roads" refers to local roads and streets that have all weather surfacing (commonly asphalt or concrete). The factors that affect the rating of a soil for the design and construction of buildings and roads include load-supporting capacity, resistance to settlement under load, subgrade stability, and ease of excavation. The specific properties, listed in the table on the map, are explained below.

Drainage refers to the movement of water through the soil. Poorly drained soils, which are often wet, reduce the soil's stability and its ability to support a load. For example, clay soils can become more plastic or even liquid which increases the chance of slippage. If a soil has poor drainage, more problems are created by the presence of a road, since paved roads increase the amount of impervious surfaces, leading to concentrated runoff in certain areas. The Puget Sound region is noted for its normally heavy precipitation throughout the winter and spring months. As a result, soils are often saturated. Wetness is the factor most often cited by the Soil Conservation Service as presenting a severe limitation for construction in this watershed.

Poor drainage can also lead to high water tables and localized flooding. Susceptibility to flooding is a frequently cited factor determining a severe limitation. This means that a soil is prone to flooding more than once every five years.

The degree of slope often determines a soil's limitation. In this area it is the second most often cited factor influencing a soil's limitation. Slope can greatly affect ease of excavation, susceptibility to erosion and slides, and the ability of the area to revegetate. Even minor slippage can cause structural damage.

The depth of the soil to the surface of the bedrock or another impervious layer (such as hardpan) influences the installation of utility lines. Such an impervious layer prevents water from drawing, causing a rise in the groundwater table in years of high precipitation. As a result, soil wetness increases, a factor cited as a problem in the watershed.

A soil's shrink-swell potential is occasionally cited as a severe limitation factor. This refers to the change in volume of the soil in relation to its moisture content - in other words, the extent to which the soil shrinks as it dries or swells

as it becomes wet. Shrinking and swelling of soil can cause damage to building foundations, roads, and other structures.

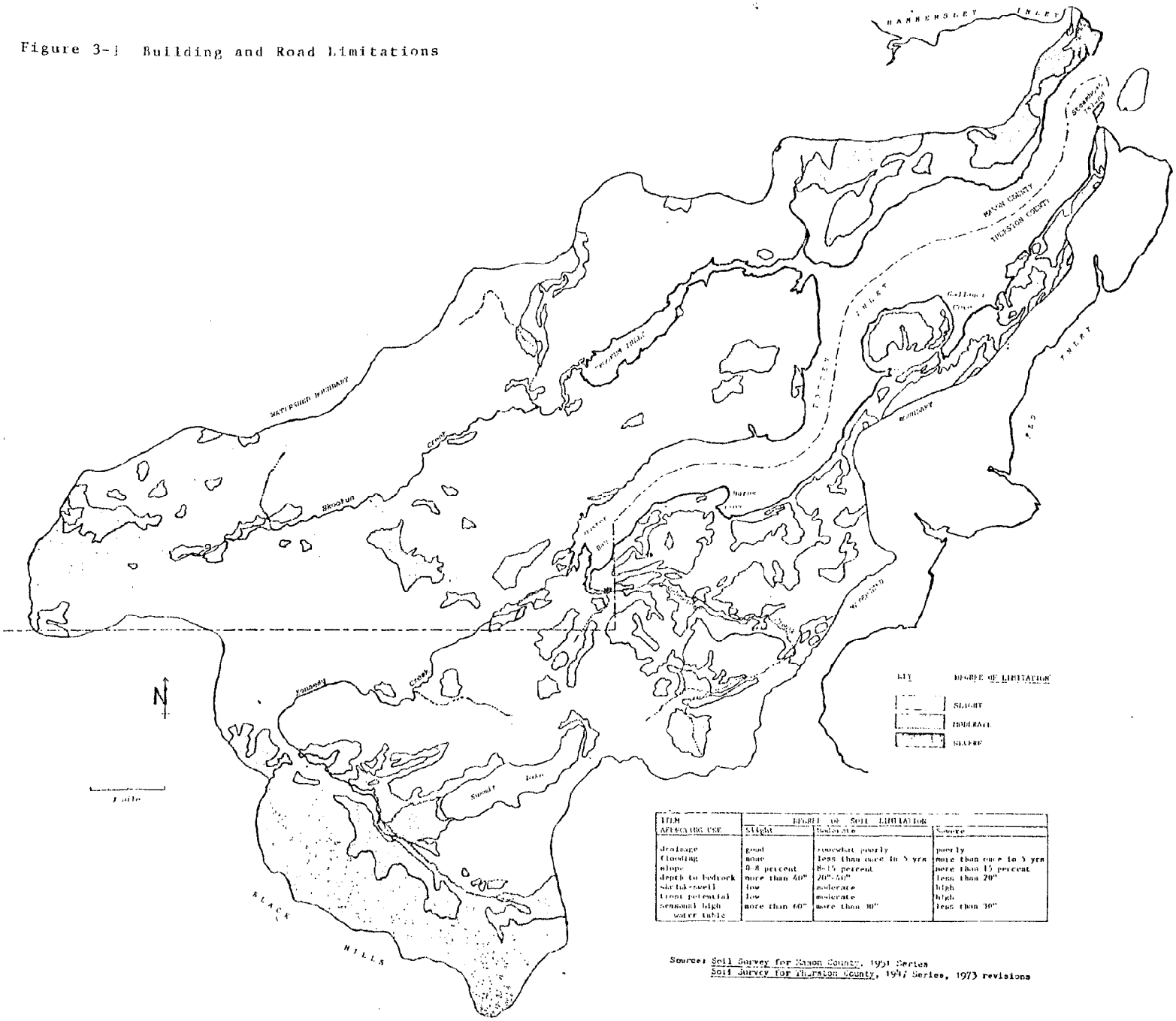
Frost potential is often cited as a limiting factor in areas of higher elevation within the Totten watershed. The frost potential is the likelihood that the soil will expand because of the formation of segregated ice lines. These are formed by freezing temperatures in soils and by the movement of soil moisture into the freezing zone. As the upper levels thaw, this water cannot drain through the frozen area below resulting in a loss of soil strength. This process can disturb foundations and cause bumps or waves in flexible pavements.

The map of Soil Limitations for Buildings and Roads (Figure 2-1, page 22) graphically illustrates that the majority of the area is severely limited by the soils for construction of buildings and roads. Areas of moderate limitation are more commonly found in Thurston County than in Mason County. They also occur more frequently in the northern lowlands than in the south where the terrain rises into the Black Hills. Along the inlets, lakes, and streams, most of the soils have severe limitations, though there are a few areas of moderate limitation along segments of Summit Lake, Kennedy and Schneider Creeks. Very few areas have slight limitations, primarily because of wetness, floodings, and slope. This does not mean that buildings and roads cannot be built, but that the potential for problems is great during construction and maintenance. It follows that the best possible precautionary and corrective measures should be employed to minimize difficulties.

Figure 2-1 Building and Road Limitations

p. 22

Figure 3-1 Building and Road Limitations



ITEM AFFECTING USE	DEGREE OF SOIL LIMITATION		
	Slight	Moderate	Severe
drainage	good	somewhat poorly	poorly
flooding	none	less than once in 5 yrs	more than once in 5 yrs
slope	0-8 percent	8-15 percent	more than 15 percent
depth to bedrock	more than 60"	20"-50"	less than 20"
shrink-swell	low	moderate	high
frost potential	low	moderate	high
seasonal high water table	more than 60"	more than 30"	less than 30"

Source: Soil Survey for Mason County, 1951 Series
Soil Survey for Thurston County, 1947 Series, 1973 revisions

Soil Limitations for Septic Tank Absorbtion Fields

Figure 2-2, a map of limitations for septic tank absorption fields, compares the relative ability of soils to absorb effluents from septic tanks. An absorption field comprises subsurface tile used to uniformly distribute effluent from the septic tank and soil to absorb and filter the drainage from the tile. Standards used to rate soils (slight, moderate, severe) are based on the ability of soil to assimilate sewage effluent in a safe and sanitary manner.

The characteristics used by the Soil Conservation Service to rate the soils in this region are percolation rate, hydraulic conductivity, depth to water table, flooding, slope and depth to impervious layers.

Percolation rate is measured by filling a hole with water and measuring the rate of the drainage. The greater the rate, the less the limitations. If the percolation rate is too slow the field can clog and force untreated effluent to the surface. Caution must be used when interpreting percolation rates because of the wide range of possible moisture conditions.[2]

The smaller the depth to the water table from the drain field, the more severe the limitation. If the water table is too high the waste will not drain sufficiently through the soil to purify it.

Septic Tank

The susceptibility of the soils to flooding presents severe limitation to the use of absorption fields because floodwaters can carry away inadequately filtered wastes. Flooding is frequently cited as a charcteristic of severely limited soils in the area. Even with rapid percolation and good groundwater conditions, flooding causes problems when protection is not included in the design of the drainage field.

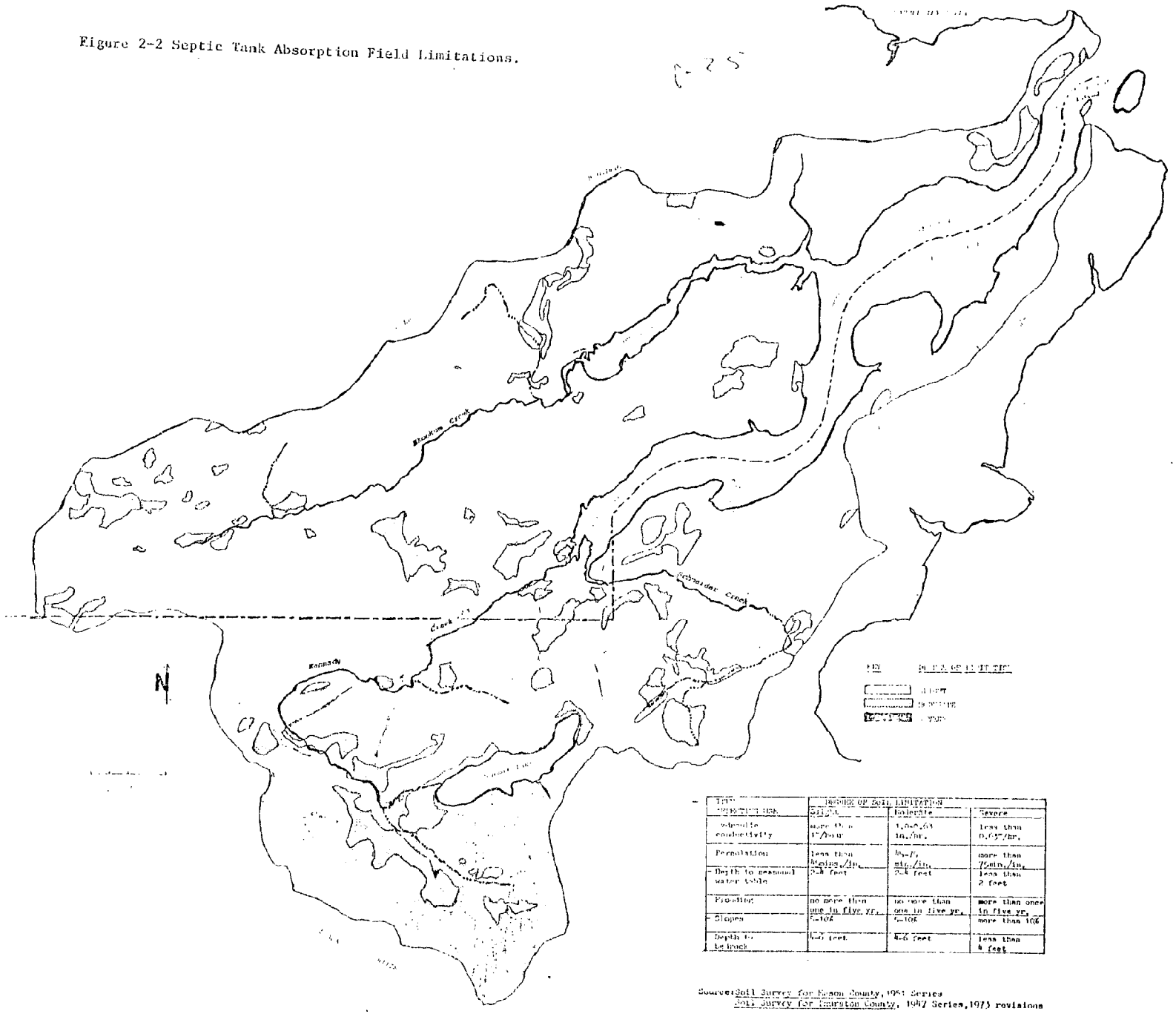
As slope increases more septic problems such as lateral seepage and downward flow occur. Construction and mechanical problems of layout are complex in areas of steep slopes. In the watershed of Totten Inlet, slope was the most frequently cited reason for the severe limitation classification.

Depth to impervious layers is important to waste distribution. If an impervious layer is too close to the drain field, effluent will not be uniformly distributed. When the waste filters down to the layer, it collects and is not sufficiently absorbed by the soil. When occurring in areas with a steep slope, runoff problems may occur.

The septic tank limitation map (Figure 2-2) for the watershed shows that most of the area is severely limited for septic tank absorption fields. The major limiting

factors in our study area are slopes, depth to impervious layer, moist soil conditions, and susceptibility to flooding. This does not mean septic systems should not be used, but adequate precautions must be incorporated in construction of the absorption field if these systems are to sufficiently treat sewage effluent.

Figure 2-2 Septic Tank Absorption Field Limitations.



TYPE OF RESTRICTION	DEGREE OF SOIL LIMITATION		
	Slight	Moderate	Severe
Hydraulic conductivity	more than 1"/hour	1.0-0.64 in./hr.	less than 0.63"/hr.
Percolation	less than 30min./in.	45-75 min./in.	more than 75min./in.
Depth to seasonal water table	2-4 feet	2-4 feet	less than 2 feet
Flooding	no more than one in five yr.	no more than one in five yr.	more than once in five yr.
Slopes	0-10%	0-10%	more than 10%
Depth to bedrock	4-6 feet	4-6 feet	less than 4 feet

Source: Soil Survey for Mason County, 1951 Series
Soil Survey for Thurston County, 1967 Series, 1973 revisions

EROSION POTENTIAL[4]

Erosion is the wearing away, by wind or water action, of soil and rock material. A minor amount of erosion occurs in undisturbed, forested watersheds, but disturbance of land surfaces greatly increases it. In most cases, human activities such as building and road construction and maintenance, logging, grazing, and crop production contribute substantially to erosion.

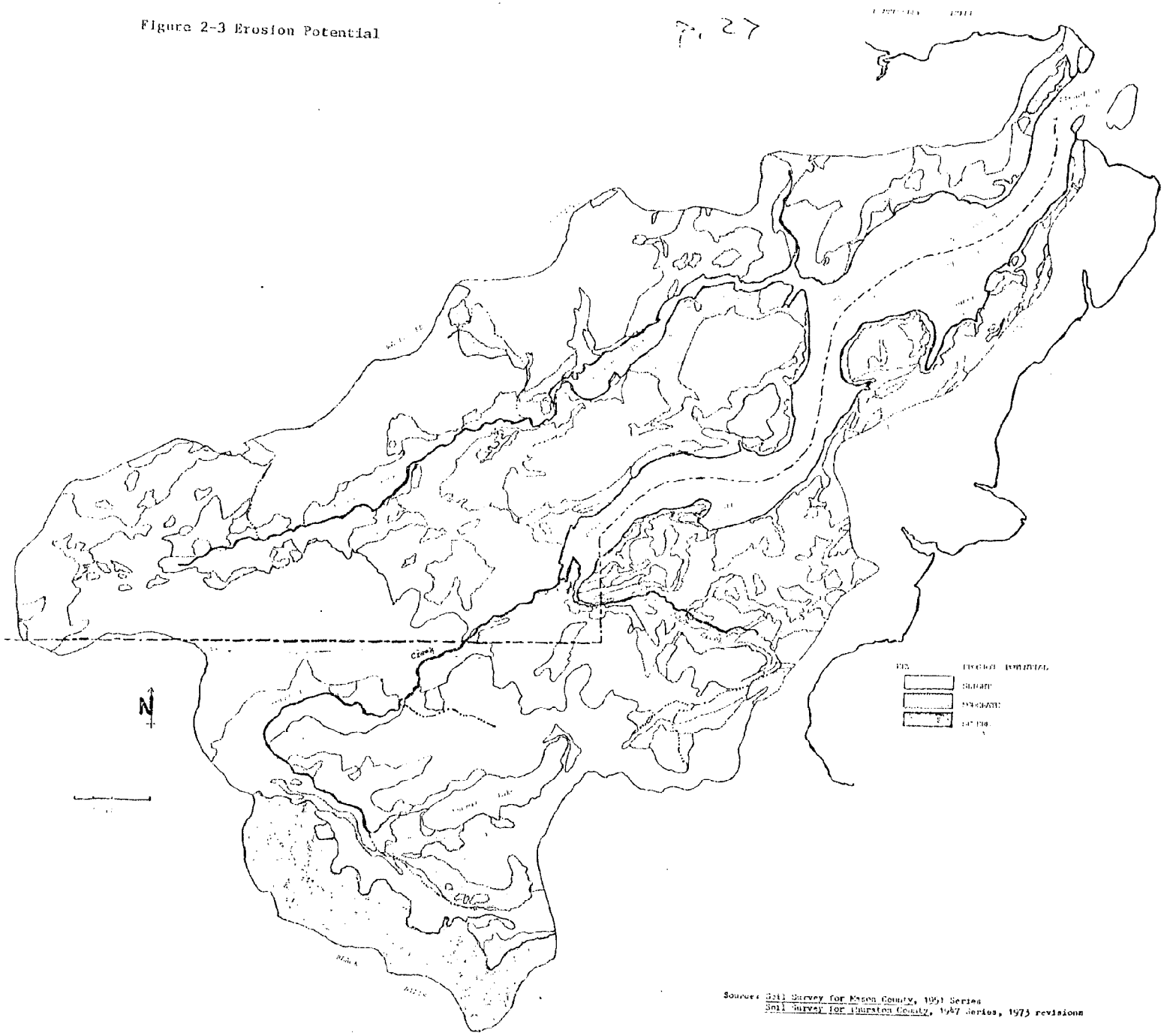
On a microscopic level, erosion removes nutrients and fine particulate matter (silt) from one area and deposits it in another. Nutrients washed away from agricultural and forest lands contribute to the over-enrichment of coastal waters. Silt deposited in estuarine shellfish beds can cover shellfish settling grounds and smother clams and oysters.

In Totten and Skookum Inlets, siltation has been only an isolated problem, primarily affecting low-intensity, undiked oyster beds.[3] It is important, however, to consider the potential for erosion in the drainage basin. Figure 2-3, a map of the Totten and Skookum basin, shows areas with slight, moderate, and severe erosion potential. These erosion ratings are based on factors of slope and soil texture. Generally, the soils in the Black Hills and along the shorelines erode easily, while those in the creek bottoms and the flatter uplands near the inlets pose less of an erosion hazard.

A variety of methods exist for lessening the impact of human activities on soil stability and stormwater runoff. In cases where sound soil conservation techniques are employed, some disturbance can occur without significantly increasing the rate or impact of erosion. A severe erosion potential designation does not prohibit development, but it does indicate that the utmost precaution should be exercised to prevent degradation of aquacultural production grounds.

Figure 2-3 Erosion Potential

p. 27



Source: Soil Survey for Mason County, 1951 Series
Soil Survey for Thurston County, 1947 Series, 1973 revisions

EXISTING LAND USE

The Existing Land Use map of the Totten and Skookum Inlet watershed shows present areas of human activity. By determining existing land use and identifying development trends, this map can help Mason and Thurston counties to predict the location and types of land use most likely to occur in the future.

Most of the aquaculture in this area is concentrated in Oyster Bay and Skookum Inlet. The commercial aquaculture includes clam grounds and diked oyster beds with both Pacific and native Olympia oysters. Sport fishing in the inlets includes coho and chum salmon. Kennedy, Schneider, and Skookum creeks are major salmon streams.

As can be seen from the map, most of the residential development is along the shorelines and includes eight subdivisions. (See Figure 2-4, page 30) Concentrated areas of residential development are not only along the inlets, however. Both Summit Lake and Fawn Lake are surrounded by summer and fall time residences. Areas marked "uncommitted" on the map are owned by private or corporate interests and are primarily unimproved parcels of land, "realty" land is that which is owned for investment purposes. Future residential development will most likely occur on these "uncommitted" and "realty" lands.

Commercial development in the watershed is minimal. Gas stations, cafes, grocery stores and small businesses make up the commercial services. Presently most of these services are located along Highway 101. Expansion of commercial services will probably occur on main transportation corridors such as Highway 101 and Highway 8, within easy access to residents and travelers.

Most of the agricultural lands are located along Skookum Creek. Small farms and pasturelands are scattered along Schneider Creek and in other areas of the watershed.

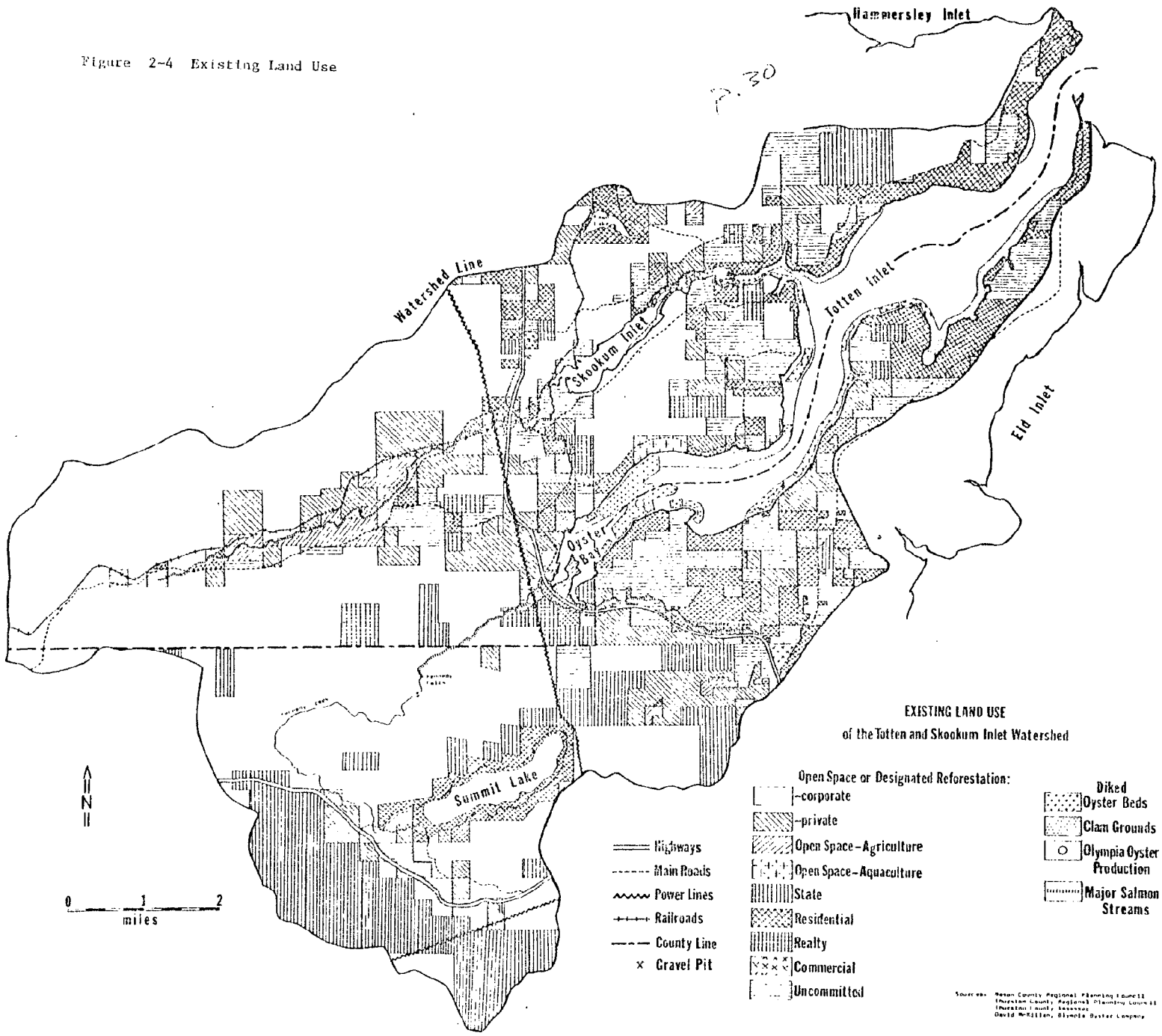
Indigenous vegetation in the watershed is primarily Douglas Fir forestland. Presently, timber management is the largest land use in the watershed. Timber management includes tree thinning, clearcutting for harvest, and replanting. Timber companies own most of this land. Most of the state land within the watershed is timber. Private timber land is owned by individuals or small groups.

A large portion of the land within the watershed is under a special classification known as "Open Space"[5], and "Designated Reforestation"[6] and have a tax assessment which is lower than that for "uncommitted" land. "Designated" lands are parcels greater that 20 acres. The current use of these lands is for growing and harvesting

timber, and they are assessed for property tax purposes on this basis. The "Open Space" category includes not only forests, but also areas of aquaculture and agriculture. Lands under this classification must be kept in their assigned use for a period of ten years.

As the map shows, land use within the watershed is not intensive. There is a large amount of land available for future development. Most of this development will occur along the shorelines. With orderly planning and growth, human uses of the uplands, shorelines and water can minimize problems.

Figure 2-4 Existing Land Use



SUMMARY

The existing land use map of the study area (Figure2-4) shows that residential development is the most intensive use of the land and timber management comprises the the largest portion of the watershed. Both land uses are influenced by the natural features of the environment. The three limitation maps (Figures 2-1,2-2,2-3) indicate the sensitivity of the study area to disturbance by human activities. Steep slopes and high moisture conditions of the soils are frequently the cause of this sensitivity. These two factors must be considered when planning new development in the watershed to avoid future problems and expenses.

The current trend of residential development is along the shorelines. The limitation maps show these areas to be the most susceptible to problems. This is especially true because of the minimal buffer zone between the developments and the waterways. For instance, the use of a septic tank on the shoreline in front of a large drainage basin creates the potential for sewage effluent to be carried away with insufficient filtering during heavy rainfall. The limitation maps show the relative sensitivity of the soils in their undisturbed state. As the use of the land increases, so will the potential for problems because of the additional stress put on the soils. Future development of the watershed must be designed in accordance with the natural features, or the land may become overloaded resulting in severe hazards to the public health and environment.

REFERENCES FOR CHAPTER 2

1. Information used in the Land Capability sections was obtained from the following sources:

   A Comprehensive Plan for Cooper Point, Cooper Point Association, 1972

   Griffin Sub-Area Plan, Land Use Policies and Density Alternatives, The Evergreen State College, 1975.

   United States Department of Agriculture, Soil Conservation Service, Guide for Intreperting Engineering Uses of Soils.

   Charles Limeberry and Carl McMurphy, "Guide to Land Use Planning", Soil Limitations and Suitability, Thurston County Soil and Water Conservation District, Olympia, Washington, 1972.

   United States Department of Agriculture, Soil Conservation Service, Soil Survey for Mason County, Washington, Series 1959, no. 9, Washington, D.C., 1960.

   United States Department of Agriculture, Soil Conservation Service, Soil Survey for Thurston County, Washington, Series 1947, no. 6, Washington, D.C., 1958.

   United States Department of Agriculture, Soil Conservation Service, Soil Survey Interpretations for Mason County, Washington, Washington, D.C., 1973.

   United States Department of Agriculture, Soil Conservation Service, Soil Survey for Thurston County, Washington, Northern Part, Washington, D.C., 1973.

2. Soils with rapid percolation have slight limitations, but a contamination hazard may exist if water supplies, streams, lakes or other water sources are nearby. The Thurston-Mason Health District uses a rapid percolation standard as a severe limitation. This is not the same as Soil Conservation standards.

3. Personal communication with Fred Clark, Clark Oyster Co., Olympia, Washington, April 11, 1977.

4. The map of erosion potential was drawn using the maps in the Soil Survey for Mason County (1958) and the Soil Survey for Thurston County, (1958 land revisions of 1973) published by the U.S. Department of Agriculture Soil Conservation Service. Each soil series was described as having a "slight", "moderate", or "severe" erosion hazard as determined from the erosion hazard ratings for woodland suitability in the Soil Survey Interpretations for each county. The erosion hazard ratings for those series in the southern part of the Thurston County side of the study area, which had not already been rated, were determined by Glenn

Hough, Area Engineer for the Soil Conservation Service. These determinations were based on the texture of the soils and their slopes.

5. Washington, Department of Revenue, "1975 Annotated Property Tax Code", Revised Code of Washington, section 84.33.

6. Washington, Revised Code of Washington, section 84.34, 1970.

Chapter 3

The Water & The Land: Their Interrelationships

INTRODUCTION

The largest land use within the Totten and Skookum Inlet watershed is forestry. Smaller areas of agriculture and residential and commercial development also exist, while the inlets themselves are used for shellfish growing and some recreational boating and fishing. Presently, these activities occur side by side with only minor conflicts. However, in order to facilitate future planning, an understanding of the relationships between these activities is necessary.

The relationships between the land and water uses are of particular importance. The aquaculture industry depends upon clean water for its survival. Clean water in turn is dependent upon proper management of the land. This section discusses the major land and water uses with emphasis placed on understanding their effect on water quality.

TIMBER

The presence of the timber industry has a great effect on the natural and economic conditions of the study area. The timber industry is both the biggest landowner in the area and the biggest taxpayer in Mason County. Most of the land currently under timber management is located to the south and west in the Totten and Skookum Inlet watershed (see map p. 30). Activities related to forest management can greatly affect the terrestrial and aquatic environments of the forest as well as the estuarine environment of Totten and Skookum Inlets. This section will describe these practices and activities, their environmental effects and some of the administrative measures related to forest management.

Commercial timber operations in the study area can be characterized as two basic types. Small logging companies which do not own much land derive much of their business logging land owned by others. The vast majority of the timberland of the watershed is owned by large timber interests. The three largest landowners are the Simpson Timber Company, the Port Blakely Mill Company and the State of Washington.

Mixed stands containing species such as Western Red Cedar, Alder, Western Hemlock and Douglas Fir are clearcut, where all of the trees from the harvest are cut, whether marketable or not. The purpose of this is to clear the way for a new, even-aged stand of the most economical species. Following the harvest, the "slash" is disposed of, by one of several methods of burning, in order to reduce the chance of a forest fire and to remove any impediments to the new stand. Usually the following winter, the area is replanted with seedlings of Douglas Fir, which is the most economical species to the industry because of its market value and rapid rate of growth. The law requires this be done within three years. Approxmmately every five years while the stand is still young, it is sprayed aerially with herbicides to eliminate competing vegetation. When the stand is five to ten years old, a pre-commercial thinning will take place to even out the distribution of the best "crop" trees. After approximately sixty years, the mature stand of Douglas Fir trees will be clearcut for harvest, and the process will repeat.[1]

Many of these activities, particularly related to the harvest, can be great contributors of pollution to the terrestrial, aquatic and marine ecosystems and can, therefore, affect their productivity. The three largest creeks in the watershed--Kennedy, Schneider and Skookum--all pass through commercial forestland.

They can be recipients of pollution and transport it to the inlets. A study by Allee and Smith, for example, has shown that forest clearcutting has long range effects in limiting salmon productivity.[2] This could have an impact on salmon spawning in the creeks. Among the water pollutants originating from forestlands are soil sediments, organic matter, nutrients, herbicides, and thermal pollution.

Soil sediment, the most important of these pollutants, is a result of erosion. Erosion can occur up to five years after a harvest or construction of a logging road. Rain runoff transports sediments into surface waters and carries with it pesticides and nutrients. These can alter biochemical processes, and the sediments, themselves, can physically damage the shellfish habitat of Totten and Skookum Inlets (see Erosion Potential discussion, p. 26).

Organic matter of vegetative and animal origin can also enter surface water through runoff. Much of this consists of vegetation from the harvest. Such organic matter can be a nuisance and can physically interfere with the environment (e.g. floating debris disrupting spawning beds). It can also alter biochemical processes. An example of this is the depletion of the oxygen in the water by decomposing vegetation affecting the survival or reproduction of fish.

Nutrients such as nitrogen and phosphate, are present in soils and decaying vegetation. When they enter surface water through sediments or debris, they promote the growth of algae which consume dissolved oxygen (see Water Quality, p.9). In addition, various nitrogen compounds, in sufficient quantities, are toxic to fish.

Herbicides are, by design, toxic to some forms of plant life. Their application from the air can directly contaminate streams through drift or runoff. Complete understanding of the effects of herbicides requires knowledge of several factors--the toxicity of the chemicals to non target species, their rates of degradation, chemical and biological byproducts from degradation and mode of transfer through the environment to other species.[3]

Another potetnial effect of timber harvest is thermal pollution of streams and the inlets into which they drain. This is a result of the removal of vegetative cover along the streams exposing them to the sun and raising their temperature. This can alter the habitat necessary for aquatic and marine life, as has occurred in Schneider and Skookum Creeks which have had their vegetation removed and, consequently, can no longer support salmon spawning.

Among the legislation and administrative regulations directly affecting the timber industry are the Forest Practices Act of 1974[4], the shorelines master pro-

grams for Mason and Thurston counties and laws determining land use taxation.

The Department of Natural Resources is in charge of administering the Forest Practices Act and therefore determines permissable forest management activities.[5] Its enforcement relies primarily on the personnel and financial resources as well as the discretion of the department.

Kennedy Creek, for a stretch of roughly one and one half miles north of Kennedy Falls is designated a Natural Environment by the Shorelines Master Program for the Thurston Region. The regulations for the Natural Environment do not permit commercial timber management within two hundred feet of the shoreline. The section of the Creek immediately upstream from that, for approximately five miles, is designated a Conservancy Environment. The Shoreline Master Plan for Mason County designated the land within two hundred feet of Skookum Creek a Conservancy Environment from its origin downstream to Highway 101. The remainder of the Creek to Skookum Inlet is a Rural Environment. Regulations for these environments are generally adopted from the Forest Practices Act of 1974.

There is some concern by members of the timber industry that as land values increase with residential development, the pressure to sell much of the land will also increase. While the Forest Tax Law of 1971 gives special consideration to lands for which the county assessor judges the highest and best use is timber growing[6], rising land values will still make it more profitable to sell this land for development. A spokesman said this Forest Tax Law does compensate timber owners for keeping land in forestry uses[7]; however, the preservation of current forestlands should be further encouraged because of their economic and natural value.

Commercial forestland is valuable to the Totten and Skookum Inlet watershed, both economically and aesthetically, yet can potentially have severe adverse impacts on the natural environment. As the industry feels increasing pressure to produce more on a smaller acreage, practices are being invoked that tend to increase the resulting pollution. Particular caution should be used to prevent erosion, especially in areas shown to have a severe erosion potential (p.26) and near perennial streams. Maintaining buffer zones of vegetation near streams is one way to minimize both erosion and thermal pollution of streams. Herbicides should be applied with extreme care, and additional information should be sought regarding their effects elsewhere in the environment. Additional incentives should be used to encourage the preservation of forestlands, as present tax compensations will most likely not be adequate.

AGRICULTURE

There are approximately ten farms situated within the Totten and Skookum Inlet watershed area (see Existing Land Use section, Figure2-4). These farms are generally small (ranging in size from 25 to about 100 acres) and support hay and pasture lands, as well as some Christmas tree farming. Most of the farmers in this area derive a substantial portion of their income from efforts other than farming. Very little of their net income is obtained through their farms.[8]

This agricultural land is mainly unimproved pastureland on which there is little or no irrigation and fertilization taking place. Some herbicide spraying is presently occurring in an attempt to control the toxic weed, Tansy Ragwort (Senecio jacobaea).[9] Christmas tree farmers utilize fertilizers, herbicides, and pesticides to control aphids and other pests. These are applied once a year in the early spring.[10]

At the present time, because there is so little land in agricultural usage, the affect on water quality is minimal. The livestock pastured on these lands may contribute to the coliform and nutrient levels through runoff, percolation, and infiltration. Pasturelands can also contribute to the amount of erosion occurring due to overgrazing.[11] The use of pesticides and herbicides is limited. However, pesticides and herbicides tend to persist in aquatic environments where they and their degradation products accumulate in food chain organism and may reach levels which are toxic to both humans and other organisms.[12] Also, certain herbicides such as 2, 4, 5,-T are extremely dangerous even in minute amounts.[13] Efforts should be made to limit the type and amount of pesticides and herbicides used.

If agricultural lands were to expand or if more intensive cultivation of crops were to take place, this could create a greater stress on the water quality of the inlets. The erosion and runoff accompanying intensive cultivation can cause siltation, raise nutrient levels (see Water Quality) and introduce pesticides and herbicides into the water system.

Along the inlets farms have already been sold and broken into smaller pieces for residential development. This appears to be a growing trend and is likely to occur more frequently in the future since land prices and demand are increasing.[14] This would mean an increase in septic and other waste treatment systems which would result in greater impact on the inlets' water quality (see page 11).

Attempts should be made to preserve the agricultural lands of the Totten and Skookum Inlet watershed. Many residents of the area (especially along the shorelines) indicated in the citizen survey that they would like to see more agriculture in the

area (see Chapter 4, page 62). The Open Space Taxation Act helps by assessing these lands as agricultural, thereby decreasing their tax burden. However, this is not enough to substantially discourage the turnover of agricultural lands to more intensive development. Further changes in the tax structure and other incentives for farmers to maintain their lands in agricultural use would aid in this.

RESIDENTIAL DEVELOPMENT

Two activities related to residential development affecting water quality are construction of homes and roads and disposal of domestic wastes. Construction related activities, including vegetation removal, excavation, filling, and paving of roads can cause erosion. Paved surfaces also present a problem in that the water draining off the pavement carries with it oil and grease. Presently, erosion problems are minimal in the watershed; however, as more homes and roads are built, associated runoff problems will accelerate.

A greater problem in the study area is adequate waste treatment. Sewage effluent introduces nutrients, such as phosphates, nitrates and ammonia, into the inlets. This raises the Biochemical Oxygen Demand and may lead to over-enrichment problems (see Chapter 1, page 11). Inadequately treated sewage also contains pathogenic bacteria. Filter feeding aquaculture organisms may ingest this bacteria making them unfit for human consumption. The Department of Social and Health Services (DSHS) periodically analyzes water samples from the aquaculture growing areas (see Appendix , page) and certifies these areas to insure the sanitation of the shellfish.

Some residential developments along the shoreline have had problems with sewage disposal. One such subdivision, Olympic View, is served by a sewage lagoon. Waste from the homes goes first to a septic tank, then into the lagoon where natural biological processes break down the wastes. The effluent then flows into the inlet. Unfortunately, this system is not well suited to western Washington's heavy rainfall. In the past it has overflowed and the DSHS has decertifies the nearby oyster beds.

A National Pollutant Discharge Elimination System (NPDES) waste disposal permit issued by the Department of Ecology authorizes the lagoon's outfall. The permit originally expired June 1, 1977, but has been renewed until October 1, 1980. By that time Olympic View must develop another method of treating its sewage. Presently, the subdivision plans to build a community septic tank with a drainfield located on nearby community-owned property. This system will handle 32 homes. It is being funded through a combination of local, state, and federal monies. The County will operate the facility at a cost to the homeowners.

Totten Shores development also has homes located on the waterfront where the soil cannot support septic systems. The effluent from these homes is pumped to a remote drainfield located on the uplands.

In Carlyon Beach Country Club Estates most homes have septic tanks. However, the percolation of the soil in that area is not good and some homeowners must have their septic tanks pumped about twice a week. The sewage is then trucked to a holding tank, chlorinated, and discharged into Squaxin Passage. This outfall is permitted under a NPDES waste disposal permit that expires on June 30, 1978, by which time secondary treatment is to be provided. At present, no changes have been made in the treatment facility, however, the community has hired a consulting engineer to make recommendations.

Another problem affecting aquaculture caused by the influx of people into the area is shellfish poaching. Since oyster growers are unable to fence in their shellfish beds, they are vulnerable to poachers. In recent years, oyster growers in the northern part of the inlet have experienced losses which they attribute to poaching. Although poaching cannot be attributed to the residents of the shorelines, this is a problem which has increased as population in the area has increased. In the future the oyster growers may find it increasingly difficult to protect their beds against poachers.

As discussed in the Land Capability section, most of the soils along the shorelines have severe limitations for buildings, roads, and septic tanks. Special precautions and corrective measures are needed when construction of homes and installation of septic tanks take place. To help ensure proper design, building and septic tank permits should be reviewed. Site plans should address the existing drainage and proposed drainage patterns. Sand filters to filter impurities, such as oil and grease out of street runoff should be incorporated in these plans. Methods to prevent erosion during and after construction and to ensure that no increase in runoff will occur should also be included in the construction plans.

AQUACULTURE

This section discusses the complications arising from the presence of the shellfish industry in Totten and Skookum Inlets.

Presently, about twenty individual aquaculture enterprises operate in the inlets. These operations range in size from small-scale, owner-operated businesses to a corporation employing thirty-five people. (For a more complete description of the local aquaculture industry, see Appendix D)

Since its inception, the aquaculture industry has made significant changes in the character of the inlets. Permanent changes were made when extensive dikes were built in the southern end of Totten Inlet to expand oyster production grounds. These dikes have altered the contours of the inlets, thereby changing the manner in which the tides flow.

The ecology of the area has also been modified by the introduction of the Pacific oyster, the Japanese drill, and a predatory flatworm of the Stylochus genus. Importation of the Pacific oyster began in the 1920's when the Olympia oyster production declined. The Japanese oyster drill and predatory flatworm were accidently imported along with the Pacific oyster. These two species prey on Olympia oysters, preventing the resurgence of Olympia oyster populations.

The extensive cultivation of shellfish enhances the ability of the inlet to act as a nutrient trap. Shellfish filter organic particulate matter, convert it into inorganic nutrients, and secrete the nutrients as pseudo-feces. These accumulate in the sediment where they are slowly released through bacterial action. In this way nutrients are kept within the inlets.

Some aquacultural practices can cause degradation of water quality and environmental aesthetics. For example, organic wastes resulting from the shucking and washing of oysters are discharged from oyster shucking houses into the water. These wastes increase the biochemical oxygen demand.

The cumulative effects of these aquaculture-related changes on the marine environment are unknown. Studies should be conducted to determine the impacts of the shellfish industry on Totten and Skookum Inlets.

SUMMARY AND RECOMMENDATIONS

The primary uses of the watershed of Totten and Skookum Inlets are forestry, agriculture, residential development, and commercial enterprises on the land and aquaculture in the water. There are a few patterns these uses follow which promise to continue in the future. One is that residential development, and the related commercial services, will increase as the population of the area increases. This will have the effect of raising land values, making it more profitable for those involved in activities requiring large tracts of land, such as forestry and agriculture, to sell to development interests. The net result will be more land used for residential purposes and less for agriculture and forestry. This could have a serious impact on the unique aquaculture habitat of Totten and Skookum Inlets by limiting its productivity and making the aquaculture organisms unfit for human consumption. Based on this information, we are presenting the following recommendations aimed at maintaining the present natural, economic, and aesthetic character of the area.

1. The natural characteristics of the land and surrounding water should be considered when planning future residential and commercial development, particularly areas of high density.
   a. Building permits should not be issued on soils incapable of supporting the proposed structures unless corrective measures are included.
   b. Residential development should not significantly disrupt existing natural drainage patterns. Sand filters should be used to remove gross impurities from street runoff.
   c. The density and amount of development on the shoreline should be sharply limited to protect the aquacultural productivity and aesthetics of the area.
2. Attempts should be made to preserve agricultural and forestry lands as they are valuable assets to the economic and natural conditions of the area.
3. Measures should be taken to prevent excessive erosion from forestry, agricultural, and construction activities, particularly in those areas that are most susceptible to erosion or are very near to aquaculture grounds. These measures could include the maintenance of natural barriers and a vegetative cover near streams.
4. The use of herbicides and pesticides should be limited and supervised to pre-

vent unnecessary damage to the terrestrial and aquatic environments. Additional information on their effects should be sought.

REFERENCES FOR CHAPTER 3

1. This information was compiled from interviews with John Vosburgh, U.S. Forest Service, Olympia, Wash.; Cal Poe and Al Petzhold, Simpson Timber Company, Shelton, Wash.; John Colley, Port Blakely Mill Company, Shelton, Wash., 1977.

2. Brian J. Allee and Milton Smith, "Impact of Forest Management Practices on the Aquatic Environment", National Technical Information Service Report (1974): p. 7.

3. U.S. Environmental Protection Agency, Office of Air and Water Programs, Processes, Procedures and Methods to Control Pollution From Silvicultural Activities (Washington, D.C., 1973), p. 25.

4. Washington, Revised Code of Washington, Section 76.09.

5. Washington State Department of Natural Resources, Washington Forest Practices Rules and Regulations

6. Washington, Revised Code of Washington, Section 84.40.

7. Petzhold, 1977.

8. Personal communication with William Petty, U.S. Soil Conservation Service, Shelton, Wash., 1977.

9. Petty, 1977.

10. Personal communication with Donald A. Dahman, Dahman Oyster Company, Shelton, Wash., 1977.

11. U.S. Environmental Protection Agency, Methods for Identifying and Evaluating the Nature and Extent of Non-point Sources of Pollutants, EPA-430/9-73-014 (Washington, D.C., October, 1973), p. 44.

12. U.S. Environmental Protection Agency, Methods for Identifying and Evaluating the Nature and Extent of Non-point Sources of Pollutants, 1973.

13. Personal communication with Dr. Kaye V. Ladd, The Evergreen State College, 1977.

14. Petty, 1977.

Chapter 4

The People & Their Government

INTRODUCTION

An understanding of existing public policy toward water resources and shoreline management is a necessary starting point for developing future policies and plans for these resources. In addition, community attitudes on land and water use should be an integral part of planning for future use.

The following chapter examines the public administration of water quality laws and shoreline management in the study area and analyze results of a citizens survey on land use conducted in the Totten and Skookum Inlet drainage basin.

PUBLIC ADMINISTRATION OF WATER QUALITY

Administration of water quality is a process of controlling sources of pollution that may alter the physical, chemical or biological properties of a waterway. The chemical state of a waterway indicates its gross potential to produce social and economic benefits and reflects the health of the ecosystem. This is why governmental entities are focusing more and more on improving water quality to prevent environmental deterioration. In the study area, sewage waste disposal presents the greatest potential for water quality degradation because residential development is currently the most intensive use of the land. Therefore, we will focus our discussion of administration and regulation for water quality, primarily on the regulations and policies which control sewage waste disposal.

The administration of water quality in the study area can be divided into three basic concerns: environmental quality, public health, and economic value. Every piece of legislation and each agency involved in the issue addresses at least one of these concerns. These concerns generate overlapping responsibilities because they are not exclusive of each other. For example, the Department of Ecology (DOE), Department of Natural Resources (DNR), and the Department of Social and Health Services (DSHS) all regulate sewage waste disposal for various reasons. Overlapping responsibilities can assure protection of water quality as long as one agency does not relax its jurisdiction or let another agency safeguard their concerns. Conflicting agency concerns and financial limitations can lead to compromises in satisfying these concerns in water quality.

This description of water quality administration is divided into legislation and agency jurisdiction. The legislation presents the goals, policies, and responsibilities to the state and federal government. Each piece of legislation then filters down through the agencies involved to reach the point of implementation at the local level.

Federal Legislation

The Federal Water Pollution Control Act Amendments of 1972 (FWPCAA) state a national policy for the restoration and maintenance of the chemical, physical and biological integrity of the nation's waters. The Act also establishes a comprehensive plan for implementing this policy. One objective is to eliminate discharges of pollutants into navigable waters by 1985. The Act specifies that an interim goal of water quality be met by 1983, which provides for the protection and propagation of fish, shellfish and wildlife, and increased public recreation, in and on navigable waters. Presently, Totten Inlet meets this interim goal,

(see DOE section) but the Act is still important because it protects against degradation. The general theme of the Act is to facilitate local solutions to problems. In theory, this will provide the flexibility needed to solve pollution problems which may differ drastically from basin to basin.

Each state is charged with the responsibility of establishing water quality standards for such parameters as Dissolved Oxygen, pH and coliform.[1] They must also set up a planning process, taking inventory and prioritizing needs for waste treatment to meet federal standards. After these plans are drawn, the states administer the National Pollutant Discharge Elimination System (NPDES) permits.[2] These permits are required for all discharging into navigable waters. In the study area there are several discharges currently on this permit system (see DOE section). A NPDES permit requires the establishment of a timetable in order for each discharger to reach secondary treatment and/or Best Management Practices (BMP) by 1977 and to eliminate harmful pollutant discharge by 1985. BMP is defined as the most effective practical means of preventing or reducing the amount of pollution generated by non-points sources.

The Act stresses planning at local levels. It specifies that all waste treatment shall be on an areawide basis and include treatment of all point and non-point sources of pollution.[3] Federal funding is provided for the planning and building of these facilities. The Act also mentions the need to develop new technology to reduce areawide wastes to a harmless state.[4]

The objectives of local planning and areawide waste treatment conflict when applied to the study area. Given the current state of technology, areawide treatment is limited to sewer systems connected to a central treatment plant. The residential density of the study area is too sparse to economically apply areawide treatment. The area of service would have to be expanded to reduce the cost per unit for treatment. The local jurisdictions lack the funds and expertise to establish such a program of waste treatment. Consequently, for implementation of areawide treatment the state and federal governments would have to intervene, an action inconsistent with the objective of planning at the local levels. Also, when sewer systems are installed, the trend of development is along sewer lines. Development in the study area is currently limited somewhat by the physical limitations of septic tank use, however installation of a sewer system in the area would alter development patterns and local planning programs.

State Legislation

The current policy of the State of Washington states that water quality shall be protected to ensure public health and enjoyment, environmental quality, and industrial development of the state's waterways. It specifies the use of "all known, available and reasonable methods" to prevent degradation of the state's water. It defines the waters of the state as "lakes, rivers, ponds, streams, inland waters, underground waters, salt waters and all other surface waters or water courses within the jurisdiction of the state". The state law acknowledges the federal interest in water quality and the need for federal and state cooperation and the need for areawide planning and waste treatment.[5]

The Shorelines Management of 1971 establishes legal significance of state shorelines. This law designates responsibility to DOE and the county governments for management of shoreline areas to protect their water quality and long term benefits. (See Shorelines section, p. 56)

Regulation of sewage treatment is divided into public health, environmental quality and economic uses of the state waters. DSHS and the local health district are concerned with sewage disposal from a public health standpoint.[6] DOE is charged with protecting the quality of state waters.[7] The Department of Natural Resources (DNR) and the Department of Fisheries (DOF) are concerned with the impact of waste disposal on economic values of the watershed area. Each of these agencies is described further under agency jurisdiction.

Agency Jurisdiction

The U.S. Environment Protection Agency

The Environment Protection Agency (EPA) is designated as the administrator of the FWPCAA policies.[8] The EPA has the responsibility to review and approve each state's planning process for administration of water quality and to insure that the process is at all times consistent with the Act. The EPA published the "Guidelines for State and Areawide Water Quality Management Program Development".[9] DOE must follow this in establishing planning processes for areawide and local administration. Also, under the FWPCAA there is a requirement for each state to provide water quality standards for classifying waterways by chemical parameters, present and potential uses. Each year the DOE sends the EPA data collected on water quality in the state waterways to demonstrate environmental quality.[9]

The EPA's policy on areas of high water quality, such as the study area, is to maintain and protect them unless the state chooses to allow lower water quality as a result of necessary and justifiable economic or social development. In no

event, however, may degradation of water quality interfere with existing water uses, such as aquaculture or recreation. Additionally, no degradation shall be allowed in high quality waters which constitute an outstanding National resource, such as wildlife refuges and aquaculture areas.[10] Consequently, degradation of water quality in the study area could be contrary to the policies set by the FWPCAA and the EPA. However, according to EPA policy in areas certified by the state as having no major pollution problems, such as Totten Inlet, there will be minimum planning and funding available for projects to control degradation.

The EPA may approve funding for areawide planning and treatment of wastes. The amount of funding is proportional to the population of the area requesting the grant. The grants are for special problem areas of the state which are designated by the DOE and the Governor.[11]

The State Department of Ecology (DOE)

DOE is the state regulatory agency concerned with environmental quality of the state's waterways. The department is responsible for carrying out the directives of the EPA in fulfilling the objectives of the FWPCAA. DOE manages water quality by two methods: a planning process and a permit system for waste disposal. Any person who conducts an operation which results in solid or liquid waste disposal into the waters of the state, must procure a permit for DOE.[12] Water disposal of waste requires a NPDES permit which must be approved by the EPA and be consistent with the FWPCAA. Any significant discharge into the ground requires a state permit.[13] An NPDES permit specifies the limiting conditions for effluent discharge and schedule of compliance for upgrading waste treatment to meet federal requirements.[14] The permittee must also provide adequate staff for operation, maintenance and testing activities.

In the watershed there are two permits issued for water discharge of sewage effluent. Carlyon Beach Estates Inc., has a permit to discharge chlorinated waste into Squaxin Passage, and Olympic View subdivisions has a permit which allows overflow from its sewage lagoon to enter into Totten Inlet. Both permits were to expire in June, 1977. Olympic View was scheduled to construct a new treatment facility without discharge. Carlyon Beach was to upgrade their facilities from chlorinated to secondary treatment. Both permits have been extended due to a failure to meet the specified compliance schedule, because a unified agreement of all landowners occurred too late. In fact, landowners at Carlyon Beach have still not reached an agreement on the facilities to be used. They have agreed to improve their facilities and have set up a planning process to do so. The situation at Olympic View, which has fewer residents, is further along, and their new treatment stystem will be constructed in

the summer of 1977. The land owners at Olympic View have received state and federal funds under a 201 facility plan.[15] Thurston County Public Works Department will be responsible for operation and maintenance of the new facility at Olympic View. The county department is directing the plan for treatment improvement at Olympic View and this has facilitated the process. It is usually much easier to handle permit programs with a governmental agency than a home owners association because of the time consumed in acquiring a unified agreement from landowners.[16]

There have been several basin plans conducted on the study area. The water pollution control and abatement plan[17], which identified the waste treatment and pollution problems in the watershed, suggested sewer systems for Olympic View and the Carlyon Beach area.

In 1976, DOE completed the 303 (e) plans for the study area. DOE used the results from one water sampling of Totten Inlet and the Water Pollution Control and Abatement Plans to classify and prioritize the needs in the watershed for water quality management. The study area has been classified as "effluent limiting". This means that present water quality is above, or can be expected to exceed the federal water quality standards with application of Best Practical Treatment and/or secondary treatment of all point sources of pollution. In the 303 (e) plans the DOE states that present data of the study area is insufficient to classify it with certainty. The plans also state non-point sources of pollution are insignificant but potential sources of localized water quality deterioration exist. The 303 (e) plans contain little new information on the study area. It classifies the area by the existing uses rather than on-site evaluation.[18]

The 303 (e) plans were the first step in the planning process to meet the requirements of the FWPCAA. Their purpose was to determine the effluent limitations needed to meet applicable water standards, and at least maintain existing water quality.[19] The next step in the planning process is the development of state and areawide management programs to implement abatement measures for all pollutant sources.[20] These will be the 208 plans, due in November, 1978, and will initiate a water basin plan for sewage treatment to achieve 1985 standards. Currently, there are three areawide programs funded by state and federal governments for solving specific areawide problems: Metro in Seattle is working on urban runoff; the city of Spokane is establishing a program to control contamination of ground water by sewage disposal; and Clark County is working on the problem of drainage from agricultural lands.[21] The problem of sewage leachate in our study area is quite different from the problem in Spokane because of climate and soil conditions, but there is hope the solution may be applied by the DOE to

the western part of the state. Existing controls will have to prevent the water quality in the study area from degrading.

Department of Social and Health Services

The Department of Social and Health Services (DSHS), is concerned with the public health aspects of water quality. There are two branches of this department with administrative responsibility in the study area. The Shellfish Protection Unit, and the Water Supply and Waste Treatment Division.

The Shellfish Unit,[22] tests the water quality in shellfish growing areas and has the authority to de-certify shellfish beds if a public health hazard exists. The Unit performs periodic testing in the study area for coliform bacteria. If a high count is obtained in a specific area the unit will work with the local health district to find the source of pollution and correct it. This provides a mechanism for extensive analysis of the water quality and an interest in maintaining high water quality for the production and collection of shellfish. The Unit has insufficient funds, and the possibility exists for contamination of shellfish beds between water quality surveys. However, this is not likely because of the relatively low density of the study area.

The Water Supply and Waste Treatment Division is responsible for the state's on-site sewage disposal program. On-site sewage disposal has been identified by DOE as a potential source of pollution. Prior to 1974, only the local health districts administered the on-site sewage disposal program in this state. There were many inconsistencies under this administration causing a variety of complaints and problems. DSHS, through the State Board of Health, is responsible for developing guidelines for the formation and operation of on-site waste management systems.[23] In November, 1976, the State Board of Health approved the present guidelines, the objective of which is to establish a framework for the development of effective local regulations. DSHS, DOE and the local health district must jointly approve disposal systems designed to have waste flows between 1,200 gals/acre/day and 14,500 gals/acre/day. Above 14,500 gals/acre/day, DSHS and DOE must reach a joint agreement excluding the local health district.[24] A technical review committee of the DSHS's Water Supply and Waste Treatment Division issues information on unconventional[25] sewage systems such as compost toilets and systems that recycle waste water. Ongoing dispersal of this scientific information will encourage the use of better treatment systems. Such systems can replace the septic tanks and sewage lagoons currently used in the study area. The department is looking into methods to reduce overall water usage in the home. Water conservation would reduce waste water volume

and increase the probability of formulating a functional on-site system (such as septic tanks) on marginal soils.

The new programs and guidelines of the Department provide a more systematic plan for on-site waste disposal. The idea of installing sewer systems in rural areas, such as the study area, is losing appeal, and on-site waste disposal is receiving more attention as an exceptable method for treatment.[26]

The Department of Fisheries (DOF)

DOF is concerned with the water quality of the study area for its' economic value for commercial and sports fisheries. Because of their importance as an economic resource Totten and Skookum Inlets are designated oyster reserves.[27] DOF has the power to inspect oyster packing houses, and oyster spat for disease and pesticides that could affect the productivity of the inlets. The agency can destroy the spat or close an oyster grower's company if there is a threat to the economic value of the study area.[28]

The Department of Natural Resources (DNR)

DNR is responsible for management of state aquatic lands for recreational, economical and industrial benefits. DNR issues leases for growing in the tide lands of the study area. Because of its affects on the productivity of state aquatic lands, DNR is concerned about water quality. DNR issued a moratorium on sewage outfalls on the state aquatic lands of Totten Inlet because of a concern for deteriorating water quality. This moritorium was reviewed in 1975 by DNR, DOE and DSHS, and the policy has not been changed since.[29]

Thurston-Mason Health District

The sanitation division of the Thurston-Mason Health District is responsible for approving and monitoring individual and community on-site waste disposal. The local district works closely with DSHS and is concerned with water quality from a health standpoint. DSHS approved the district guidelines.

The district health officers must perform on-site evaluations of a lot before a permit for sewage disposal and building is granted. The officers also evaluate septic tank failures upon complaint to provide the solution needed to correct faulty systems. In the course of conducting on-site evaluations, they gain an overall understanding of the physical factors affecting sanitary sewage treatment. This information could be used to assess the ability of the land to support residential development and waste treatment. Currently, the information is not in a usable form. However, this problem will be corrected with the implementation

of the uniform reporting system being developed by DSHS.

The Health Department receives little of the federal and State funding used for administration and regulation of water quality and land use. There are currently only two sanitarians who cover all of Mason County, and five are in Thurston. They are responsible for on-site evaluation of all permit applications for septic tanks and investigating reported failures. These officers do not inspect installed systems unless there is a complaint. Additional funding for the local district could reduce the problem of septic tank failure by ensuring adequate maintenance. This would provide greater control over the potential sources of pollution in the study area.

Summary and Recommendations

The responsibilities for the administration of sewage disposal regulations are shared by the Thurston-Mason Health District, DSHS and DOE. DSHS and local health districts are responsible for on-site disposal of sewage effluent. DOE is responsible for all waste disposal affecting the state waters. Since the definition of state waters includes ground waters, DOE is legally concerned with on-site waste disposal. The overlapping responsibilities require interagency agreement and communication.

In the study area, the administration of the waste treatment at Carlyon Beach Estates is an example of these overlapping responsibilities. The local health district is in charge of approving permits for holding tanks and septic tanks in the housing development. DOE regulates a permit for the development's treatment and discharging facility. DSHS must review and approve the other agencies' programs because it is a community system.

While the overlapping responsibility has the benefits of providing a range of expertise, it also involves agencies with different political pressures. This increases the potential for communication gaps and misunderstandings. There is currently an interagency committee composed of representatives of the three different agencies developing a policy for the delegation of responsibilities for sewage disposal, so the process will be less confusing and jurisdictions better defined. This committee will probably lower the upper limit of waste flows which involve the local health district and delegate primary responsibility to DOE and DSHS.[30]

The plans for the study area are comprehensive regarding major sources of pollution such as sewage discharge into the water. The 303 (e) plans and the programs of DSHS effectively control point sources at the present time. When the

facilities at Olympic View and Carlyon Beach are upgraded, there ahould be no significant effects from their waste disposal.

In the Watershed

Control of non-point pollution is not adequately addressed by the state or federal agencies. The 208 plans of DOE will not involve additional information from the study area. If the information collected by the local health district was used by the state agencies, the data available for drawing new plans in the study area would be increased. Information on failure rates or locations of frequent failure would give the DOE and DSHS valuable data for areawide treatment plans.

Communication among agencies involved is crucial for maintenance of high water quality in the study area. Although agencies such as DOF and DNR have no jurisdiction over sewage treatment, their interest in the productivity and economic value of the study area is important to water quality. They must rely on DOE and DSHS to protect their interests and responsibilities. Each agency must be informed of the others' actions, and any major changes in the watershed. If communication breaks down, it's possible that activities of one agency could undermine the interests of another. For instance, the sewage lagoon at Olympic View was built and operating before DNR or DOE learned about the facility. Lack of communication hinders not only governmental agencies but also affects the public as when the oyster beds near Olympic View were decertified because of the sewage outfall.

SHORELINE MANAGEMENT

Introduction

The Shorelines of Puget Sound are subject to increasingly intense pressures for residential, recreational, and industrial development. In order "to prevent the inherent harm in.... uncoordinated and piecemeal development" the Washington legislature enacted the Shoreline Management Act of 1971.[31] The Act applies to all lands within 200 feet of the ordinary high water mark.

The "State Master Program" for shoreline management, written by the Washington Department of Ecology (DOE), sets forth guidelines and policies to aid counties in the development of local shoreline master programs (SMP). The burden of designing and implementing the local SMP is on the county since DOE is primarily concerned with shorelines of state-wide significance. DOE does, however, review and approve local programs. It is ultimately responsible for enforcement.

In Mason and Thurston County, the SMPs were written by local advisory boards made up of citizens, planning commissions, planning staff, and special interest groups. Mason County's program was conditionally approved by DOE contingent upon refinement and clarification, "particularly regarding environment classifications.."[32]. In its approval of Thurston County's program DOE called the program "commendable in its quality and its general consistency with the intent of the Act."[33]

In designing these programs, then, it is important that adjacent counties coordinate plans for bodies of water under multiplex jurisdiction. This situation is addressed in Chapter 90.58.110 of the Act. "Whenever a master program which includes lands and waters located in two or more adjacent local governmental jurisdictions... it shall be the duty of the (local governments) to develop cooperatively an inventory and master program."[34] This is particularly crucial in the case of Totten Inlet. Totten is regarded as the most productive Pacific oyster growing area in Puget Sound.[35] Both Mason and Thurston County have jurisdiction over Totten Inlet. They should, before further shoreline development occurs, design a coordinated shoreline policy for Totten Inlet with the goal of maintaining high water quality.

As a first step in this study, the existing shoreline master programs for both counties will be compared. Recommendations can then be made for rectifying discrepencies and improving protection of water quality. Then, maximum growth, as outlined in the shoreline master programs, will be projected for the shoreline of the two inlets.

Mason and Thurston County Shoreline Programs

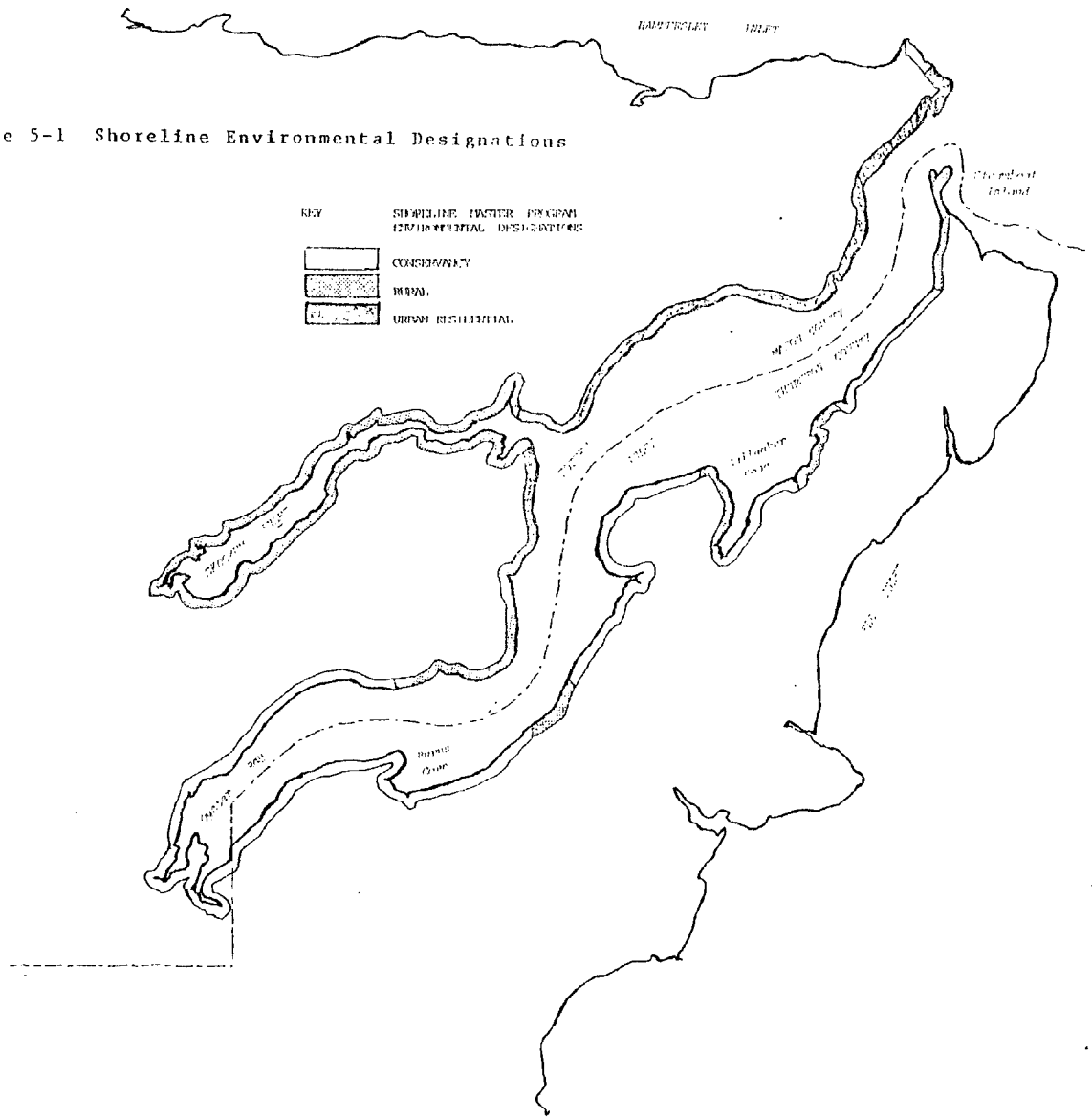
Presently the Mason and Thurston Shorelines Master Programs contain major discrepancies which need to be addressed. The most obvious of these are the different shoreline designations on either side of Totten Inlet (see figure 4-1, page 58). The Thurston County jurisdiction identifies the shorelines as both rural and conservancy environments. The Mason County side of the inlet expands these designations to include a third, urban residential. The urban residential designation in Mason County allows more intensive uses of the shorelines, uses not allowed in either the conservancy or rural environments. These uses include hotels, boatels, restaurants, and allow residential developments densities of four units per acre.

"The environmental designation system is designed to encourage uses in each environment which enhances the character of that environment."[36] The designations are chosen according to "existing development patterns, biophysical capabilities and limitations, and on the goals and aspirations of the citizens of the region."[37] To interrupt the environment of the shorelines with inconsistent, or conflicting designations contradicts the intent of the Act. The map on page gives a clear illustration of this occuring. The objectives of the rural designation are to "protect agricultural land from urban expansion, restrict intensive development along undeveloped shorelines, function as a buffer between urban areas, and maintain open spaces and opportunities for recreational uses compatable with agricultural activities."[38] But this final intent jeopardizes the agricultural practices in our study area. It is important that the shorelines region be free from the stresses of urban residential development.

Inconsistancies also are found when comparing some of the counties policies of proper shoreline land use. For example, the conservancy environment in Mason County prohibits log rafting and storage practices without a substantial development permit, and if granted, the shorelines "shall then be considered urban industrial."[39] Thurston County allows log rafting and storage with a substantial development permit, but does not allow them "if grounding occurs, especially in areas where aquaculture is practiced and along intertidal beaches."[40] A coordinated policy by the two counties would be appropriate for the current conflicting use of the shorelines. The policy of the Department of Ecology is that there should be no log rafting in Totten Inlet, although it is not enforced. All involved agencies should agree upon, and enforce, a common, coordinated use of the shoreiines.

Figure 4-1 Shoreline Environmental Designations

Figure 5-1 Shoreline Environmental Designations



Another inconsistency is the structure setback guideline of the two counties. This guideline determines how far back a structure must be from the mean high tide. In Thurston County a structure must be set back at least fifty feet from the shoreline, while in Mason County the requirement is only 15 feet. Building a structure closer to the waters edge puts stress on the capability of the land to support it. Since the Mason County Shorelines Master Program has been in effect since 1975, it would be difficult to enforce a new, more stringent requirement. Inconsistent and uncoordinated shoreline use by both counties is the problem.

Inter-agency cooperation must take place at all levels, specifically, more effective communication is in order between the Department of Ecology, Shorelines Advisory Boards, Planning Departments and the County Commissioners. Adjacent environmental designations should not have conflicting objectives and uses. The designations should be cooperatively revised to reflect the intent of the Act, and then enforced. The urban residential designation should be changed to rural. From the results of our questionnaire (see Citizen Survey), the residents in our study area do not want increased development in their neighborhoods. But if development occurs, they favor agriculture. This would further justify the re-classification of the existing shoreline designation.

Projected Growth For the Shorelines

The increased population and income levels in the Puget Sound region have placed great demand on rural recreation lands. This, coupled with citizen resistance to high-density residential development along the shorelines has resulted in a phenomenon called "spread development" in which low-density seasonal and permanent housing is concentrated in a thin ribbon along much of the Puget Sound shoreline.[41]

This trend is evident in the Totten and Skookum Inlet area where the uplands are sparsely populated and primarily used for forestry, while the shorelines bear most of the area population in suburban and recreational housing. The spread development trend, as opposed to high-density, "nucleated" development (e.g., new towns and resort complexes), will likely continue.[42] This section will explore potential growth for the shoreline of Totten and Skookum Inlets.

As previously discussed, use activities are regulated under the Shorelines Management Act by generalized shoreline environment designation. The shoreline designations for Totten and Skookum Inlets are conservancy, rural, and, in Mason County, urban residential. Areas designated conservancy permit one unit per acre, while rural allows two units per acre, and urban residential four units per acre.

Table 4-1 contains growth projections for Totten and Skookum Inlets if the shorelines are developed to the maximum extent permissable under existing shoreline master program restrictions. These estimates are based on units per acre designations, with an acre equaling approximately 217 feet of shoreline. The average family size is 2.9 individuals. These figures are based only on shorelines designations. In some areas, more restrictive local zoning has superseded the shoreline master programs.

Growth Projections for the Shoreline of Totten and Skookum Inlets

County	Current Estimates		Growth Projections	
	Structures	Population	Structures	Population
Thurston	114	331	207	599
Mason	137	391	734	2128
Total	251	722	941	2727

Table 4-1

Table 4-1 shows that population and housing could more than triple along the inlets in the near future. Besides increasing stress on utilities, services, and circulation systems, population growth could alter water quality, making sanitary shellfish production difficult if not impossible.

As Figures 2-1 2-2,and 2-3demonstrate, the shorelines are highly susceptible to erosion and landslide, and present other limitations for building, road construction, and septic use.

The shoreline master programs should be revised to reflect the suitabilities and limitations of the specific shorelines in question. In addition, Mason County urban residential density designations, currently more permissive than state health regulations allow, should be lowered to protect this fragile environment. Then, Mason County's comprehensive plan should, for the Totten and Skookum basin, be coordinated with shoreline master program goals and restrictions in order to present a unified shoreline/uplands policy.

CITIZEN SURVEY

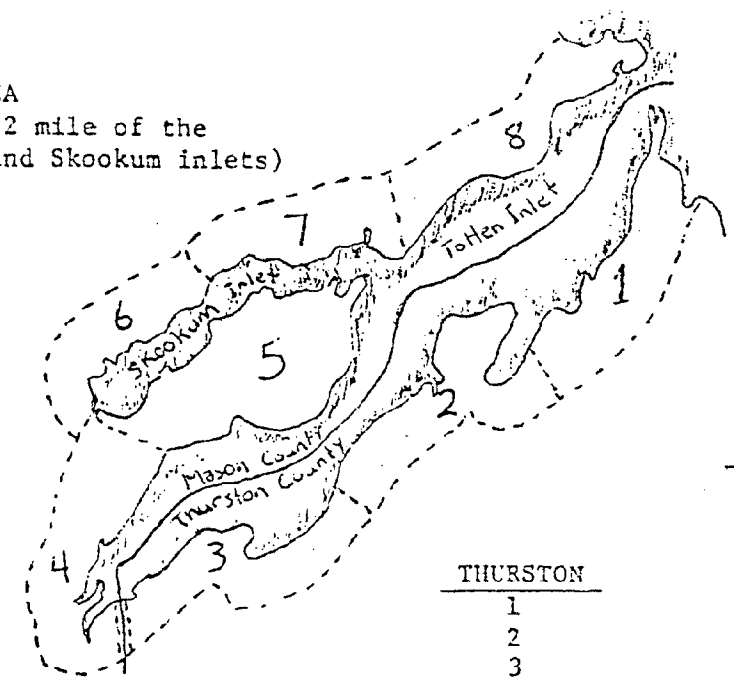
Introduction

Every planning process should include citizen participation, from the onset of a plan to its completion. The preferences of local residents are needed so that they can be incorporated into land use decisions. To obtain such information, a citizen survey was conducted. Our purpose was to obtain views on land use planning and aquaculture from the residents of Mason and Thurston counties. The objective was to offer recommendations for the revision of the Mason County Comprehensive Plan and to establish baseline information for Thurston County. In order to accomplish these objectives and add legitimacy to our study, citizen involvement was necessary.

The questionnaire was divided into three sections--existing land use, attitudes concerning changes in land use and finally, their attitudes on aquaculture. These sections enabled participants to respond to the issues which will affect their futures in and around Totten snd Skookum Inlets.

Three hundred questionnaires were randomly distributed to residents, landowners and seasonal occupants along the shorelines of Totten and Skookum Inlets. The survey area extended one-half mile into the uplands and was divided into eight survey sections for distribution (see Appendix E for complete methods). The following map illustrates the survey area and the eight sections.

SURVEY AREA
(lands within 1/2 mile of the shorelines of Totten and Skookum inlets)



Results

52% of the questionnaires distributed in person and 28% of the mailed surveys were returned as of May 17, 1977. Complete questionnaire results for hand distributed surveys are in the Appendix E, p.E-1. The following results are shown for questionnaires distributed in person.

More than one-third of the residents who responded live in area 8, north of Skookum Inlet. Area 3 in Thurston County and area 4 in Mason County, both which are on the southern end of Totten Inlet received a 5.2% response, the lowest for any area. A majority of the respondents (61.5%) live on the shorelines and are buying their own home (87.5%). More than half (58.1%) have lived in the survey area for more than 10 years. Size of the property residents own or live on runs large--In Mason County 44% own one to five acres and 29% have more than five acres.

Existing Land Use

Twenty-seven percent of the people in the survey area said they have had poor drainage on their property. Twenty percent have had slides. Almost one-quarter, 23%, have had erosion problems on their land. This problem seems to be most prevalent on the shorelines--27% of the shoreline residents said erosion has occured.

As discussed in Land Capability (p.31), the land in the survey area tends to be physically unsuitable for development. Results of the questionnaire reflect the fact that difficulties are encountered when building on land poorly suited for such human use.

Attitudes Concerning Changes in Land Use

A total of 70% of all survey participants favor future development of less than one unit per acre in their neighborhoods. The responses to this question ranged from 62% of those who own more than five acres to 43% of those who own one half to one acre to 62% of the landowners who have more than five acres. Two-thirds of all those surveyed do not favor industrial development, regardless of whether they plan to keep their land in its present use or to change it.

The questionnaire contained two open ended questions which dealt with attitudes of the residents. When asked what they like best about where they live, both Mason and Thurston County residents responded with"privacy", "the view", "peace and quiet" and "the location". Some of the least liked aspects of living along or near Totten and Skookum Inlets include "location away from places of work and shopping" and the prospect of "more development". In Thurston county,

especially in areas 2 and 3, residents are in favor of more agricultural development in their neighborhoods. One half or more of those surveyed do not favor neighborhood services. Mason County results show only two areas, 5 and 7, favoring agricultural development in their neighborhoods. As in Thurston County, most residents who were surveyed in Mason County do not want neighborhood services.

Residents do not favor development which changes the rural atmosphere where they live. A majority prefer a neighborhood with few houses--less than one per acre. Industrial development nad neighborhood services are, apparently, adequate where they are now--away from the homes of residents. Driving fairly lengthy distances to places of employment and to obtain groceries and other household goods seems to be a minor inconvenience for residents. The only development they would like to see in their neighborhoods is more agriculture--and in Mason County, some do not favor even this.

Attitudes on Aquaculture

A small percentage (16.4%) of the residents derive their income from Totten or Skookum Inlets. However, close to one-half (46% in Thurston County and 41% in Mason County) have visited an oyster farm. In Mason County, 23% have been employed by an oyster farm. Twenty percent said aquaculture raised their property values, and another 22% said it has no effect on property values. When asked if maintaining or increasing aquacultural productivity should be important in land use planning, 59% of all those surveyed said yes. Over half said they will agree to limitation on septic tanks (66.4%) and community sewage treatment plants (65.2%) to keep Totten and Skookum Inlets clean for aquaculture. However, residents do not want to limit their recreational use of the inlets. Fifty-seven percent of all participants will not agree to limitations on sport fishing.

Although recreational use of the inlets can have adverse effects on aquaculture, our study has shown that sewage seepage into the inlets has the greatest potential to threaten aquaculture in our study are (see Chapter 1 and Chapter 3). A large number of residents are willing to accept limitations on further development of their own property when it includes sewage treatment. Residents feel that keeping the water clean, and thus maintaining aquacultural productivity in the inlets, is important. This questionnaire shows that they are willing, for the most part, to keep Totten and Skookum Inlets clean for aquaculture presently and in the future.

Conclusions

From our questionnaire we found that some residents have encountered difficulties with their land--these are erosion, slides and flooding. Their response

confirms the findings of the land capability section of this study, where it was determined that land along the shoreline is not well suited for residential development.

Our survey also shows that residents would like to keep the rural character now existing in their neighborhoods. They feel aquaculture is important in Totten and Skookum Inlets, and should be an important concern in future land use decisions.

Recommendations

We recommend that result of this survey be incorporated into the revised Mason County Comprehensive Plan. Further, to insure resident participation on the planning process, their attitudes and opinions should be obtained. We also recommend this participation be ongoing, reflecting changes in land use. To do this, we suggest:

1. A citizen planning group, such as the Griffin Planning Association on the Thurston County side of Totten Inlet, should be formed on the Mason County side.
2. When land use decisions are to be made, public meetings should be held and well publicized.
3. Whenever possible, surveys such as this should be conducted.

The input of local citizens is important because their presence will ultimately affect the water quality of Totten and Skookum Inlets.

SUMMARY AND RECOMMENDATIONS

We can conclude that more coordination is needed at all levels of government in order to provide for effective shoreline and water resource management. Currently, too much money is spent at the federal and state levels for planning, while too few people are available for monitoring and enforcement.

Results of the citizen survey indicate that residents would like to see the rural quality of the area maintained, will accept limitations on septic systems, and believe that aquaculture is an important feature of the area. In relation to land capability, a significant number of respondents have experienced problems with their land (e.g. erosion, flooding, slides), especially along the shorelines. It is also important to note that results differed between counties and survey sections.

These conclusions lead us to make the following recommendations:

1) Implementation of shoreline and water quality regulations should be concentrated at the local level.

2) Mason and Thurston counties should coordinate permitted uses on both sides of the inlet consistent with the Shoreline Management Act.

3) The counties should explore the idea of providing maintenance service for individual septic tank systems.

4) The Shoreline Master Programs should be revised to reflect the suitabilities and limitations of the specific shoreline in questions.

5) If major changes are contemplated in the land or water use of the area, the opinions of local citizens should be obtained again. This could be done with

   -more surveys
   -public meetings
   -the formation of a citizen planning group

6) In future surveys, a larger area should be covered and more citizen input should be sought in the design of the survey.

REFERENCES FOR CHAPTER 4

1. U.S., Congress, Federal Water Pollution Control Act Amendments of 1972, (FWPCAA), Public Law 92-500, 92nd Congress, 1972, section 303.
2. FWPCAA, section 402.
3. Point sources are "any discernible, confined and discrete conveyance of pollutants" such as a pipe, ditch of trench. While non-point source pollution is usually not traceable to a specific location. FWPCAA, section 103.
4. FWPCAA, section 208.
5. Washington, Revised Code of Washington, section 90.48.
6. Washington, Washington Administrative Code, Chapter 248-96.
7. Washington, Revised Code of Washington, section 90.48.
8. FWPCAA, section 102.
9. FWPCAA, section 301.
10. U.S. Environmental Protection Agency, "Policies and Procedures for the State Continuing Planning Process", Federal Register 40, no. 230, (Nov. 8, 1975), p. 55341.
11. FWPCAA, section 208.
12. Washington, Revised Code of Washington, section 90.48.
13. Washington, Revised Code of Washington, section 90.48.
14. FWPCAA, section 402.
15. FWPCAA, section 201.
16. Personal communication with Ron Robinson, Washington State Department of Ecology, Regional Office, Olympia Wash., 1977.
17. R.W. Beck and Associates, Comprehensive Water and Sewer Plan and Water Pollution Control and Abatement Plan (Sewage Drainage Basins 14 and 16), (Mason County, 1971).
18. Washington State Department of Ecology, 303 (e) Water Quality Management Plan-West Sound Basin, (December, 1975).
19. FWPCAA, section 303.
20. FWPCAA, section 208.

21. Personal communication with Myron Saikewicz, Washintion Department of Ecology, Olympia, Wash., 1977.

22. Washington, Revised Code of Washington, section 69.30.050 and 90.30.130.

23. Washington, Washington Administrative Code, Chapter 248-96.

24. Washington, Washington Administrative Code, Chapter 248-96.

25. Personal communication with Gary Plews, Washingtion State Department of Social and Health Services, Water Supply and Waste Treatment Division, Olympia, Wash., 1977.

26. Plews, 1977.

27. Washington, Revised Code of Washington, section 75.24.

28. Washington, Revised Code of Washington, section 75.25.

29. Personal communication with Ralph Beswick, Washington State Department of Natural Resources, Marine Land Management Division, Olympia, Wash., 1977.

30. Plews, 1977.

31. Washington, "Shorelines Management Act of 1971", Revised Code of Washington, Section 90.58.020, 1971.

32. Letter from John A. Biggs, Director, Washington State Department of Ecology, to Martin Auseth, Chairman, Board of County Commissioners, Mason County, Washington, August 6, 1975.

33. Letter from John A. Biggs to Thurston County Commissioners, May 21, 1976.

34. Washington, Revised Code of Washington, section 90.58.020.

35. Thurston County Comprehensive Plan, July ,1975, P. III-16.

36. Thurston County, Shoreline Master Program, 1975, p.7.

37. Thurston County, Shoreline Master Program, 1975,p.7

38. Mason County, Shoreline Master Plan for Mason County, 1975, p. 8.

39. Mason County, Shoreline Master Plan for Mason County, p. 8.

40. Thurston County, Shoreline Master Program, 1975, p. 68.

41. Peter Harrison,"Spatial Aspects of the Pressure for Shoreline Development: The Example of Puget Sound", Coastal Zone Management Journal, Vol. 2 no. 2, 1975, p. 134

42. Harrison, P. 134-135.

Summary & Recommendations

SUMMARY AND RECOMMENDATIONS

In our study of the Totten and Skookum Inlet watershed, we have attempted to illustrate the importance of the interrelationship existing between the land and water. In order to accomplish this, we have described the existing conditions of the area, evaluated the effects of upland uses on the water quality and aquacultural productivity of the inlets, and developed recommendations aimed at coordinating the uses of the land and water.

We found that Totten Inlet is a clean, well mixed, productive estuary. This makes it an ideal habitat for certain forms of aquaculture, notably Pacific and Olympia oysters, and the Japanese and native Littleneck clams. Such productivity manifests itself in the fact that the oysters of these waters grow faster than in other nearby waters or on the coast, making it possible to harvest them two to three years earlier.

Most residents of the area are acquainted in some manner with various aspects of the local aquaculture industry. They also favor maintaining its present status rather than having it deteriorate because of excessive development. They are even willing to limit the use of septic tanks.

This positive attitude towards aquaculture is due to many factors. The aquaculture industry provides numerous jobs for the community, not to mention tasty dinners. Although some shellfish is exported to other states and countries, much of the seafood is distributed locally. In addition, the oyster growers are residents, and profits from their business keeps revenue in the region--a plus for the economy.

This farming of the sea provides another service to the area: oyster growers, largely dependent on the quality of water in the inlets, maintain a watchful eye on the changing conditions of the water and often attract the attention of government officials to these changes, individually or as a lobbying effort. This serves an important purpose for the whole community, for at times those departments charged with the responsibility of monitoring and maintaining the water quality of Totten and Skookum Inlets do not do so because of a lack of time, funding, personnel, or interest. Many times public agencies such as the Department of Natural Resources, Department of Ecology, and the Department of Social Health Service have overlapping jurisdiction, but fail to communicate with each other, or sometimes even within themselves.

It may be that too much money is tied up at federal and state levels. The planning which occurs is not always implemented in the local arena, for all-encompassing federal plans cannot adequately deal with local variations. This is not to say that nationwide guidelines are useless, but that the local governments are usually short on funding and personnel to collect baseline data, plan, and monitor the natural and human activities of the area.

The need for local attention was shown in the study of the land's capability and existing land use. The soils of the Totten watershed are not well suited for development, especially along waterways, yet it is here that most people live posing problems not only for themselves but to the environment as well.

The water and the land are interrelated, and therefore, their uses should be coordinated. Though this is not always a simple straight forward matter, neither is it impossible. From the studies we conducted, we have come up with numerous recommendations on how to proceed in such a manner. In some areas further studies need to be done, while in others the studies and plans already developed need to be implemented.

Our water quality study covered only one season during a year in which the rainfall was far below normal. In order to obtain a complete picture of the inlets' water quality, a year long study, including monthly water sampling, is needed. The plankton study also dealt with only one season of the year and the successional communities associated with that season. It is, therefore, advisable that a study encompassing a full year and using more sampling stations be carried out in order to better pinpoint the most productive areas of the inlets. Ecological studies dealing with the other species of marine organisms in the inlets should be conducted, with special attention given to the effects of oyster dikes on the marine habitat.

The maps included in this report illustrating the limitations of soils in the study area may be used to guide the planning process and as an aid to private citizens but do not pre-empt the need for on-site evaluation. Since most of the soils within the Totten watershed have severe limitations for buildings, roads, and septic tanks, percautionary measures are necessary for construction.

Wider dispersal of information on alternative methods of waste disposal is needed so that residents will be aware of the choices available to them. Most septic tank failures are due to a lack of maintenance. If the county were to provide a septic tank maintenance service, at a cost to the users, this would help to

prevent failures and their corresponding adverse affects on the water quality of the area.

The valuable agricultural and timber lands of this area should be preserved, while the farming and forestry practices used should be compatible with the water resources they affect. The type and amount of pesticides and herbicides used should be strictly regulated, and the state Forest Practices Act should be followed scrupulously to reduce erosion and resultant destruction of fish spawning grounds.

Citizen input is an important part of the planning process. Before any decisions regarding major changes in land use take place, the area residents should be consulted. Various means such as questionnaires and public meetings should be used to solicit the opinions and recommendations of residents. Formation of a citizen group similar to the Griffin Planning Association in Thurston County would help facilitate community involvement in the planning process.

More attention should be given to the implementation of the existing water quality standards and policies on a local level. This would include allowing a greater portion of the federal and state funding for these programs to filter down to the local governments. Increased communication between the various agencies responsible for maintenacce of water quality standards is also needed.

Future development should attempt to coordinate the human uses with the physical features of the land and to ensure that the various uses are compatible with each other. Various plans could be used to accomplish this and should be investigated. For example, cluster development is one method which provides both residential housing and the maintenance of low density areas ideal as wildlife habitat. Establishing park areas is another way to ensure lower density in certain areas while still enabling their recreational use.

The maintenance of high water quality is important for the aquaculture industry, for the marine life of the inlets, and in order to provide an enjoyable, healthful environment for the human inhabitants. It is hoped that the use of this study in the planning process will aid both Mason and Thurston Counties in the important decisions which they must make regarding land use in the future.

Appendices

APPENDIX A

METHODOLIGIES FOR CHEMICAL PARAMETERS

The methods prescribed in A Practical Handbook of Seawater Analysis were used for our analysis of the chemical parameters except where mentioned otherwise.[1] All glassware and plasticware was rinsed with 6 M HCl and then with water before use. The water used was treated by reverse osmosis system (Culligan Aqua Clear Co.). All chemicals were either Baker Analyzed Reagent grade (J.T. Baker Chemical Co.) or Analytical Reagent grade (Mallinckrodt Chemical Works).

Absorbance of samples for nitrite, nitrate, chlorophyll, ortho and total phosphate were measured on a Varian UV/Vis spectrophotometer (Model 635, Varian Techtron) using a cell with a 1 cm pathlength. A Jones reductor was used for reducing nitrate to nitrite for sample analysis.[2] Zinc was substituted for cadmium in the reductor[3], and a peristaltic pump (Model 375A, Sage Instruments, a division of Orion Research Incorporated) was used rather than gravity to drive samples through the reductor column.

Ammonia in the samples was measured with an ammonia electrode (Model 95-10, Orion Reserach Incorporated). Chlorophyll was analyzed by filtering 500 ml of sample and soaking the filter in 7.5 ml of 90% acetone, and then following the method prescribed.[4] The result of the Strickland and Parson's formula was multiplied by 7.5 to compensate for differences in volume of acetone and the cell pathlength.

BOD was measured by the Winkler technique[5] using a Gilmont pipet (Gilmont ultramicro buret, Manostat Corporation). The BOD samples were stored for 40 hours on the 4/12/77 samples, and 75 hours on the 4/22/77 samples. Samples were kept in an environmental chamber (CEL 255-5178-01-37, Kysor Industrial Corporation) at 10°C.

DO, temperature, salinity and pH were measured in the field using a Hydrolab (Hydrolab Incorporated, Houston, Texas). The Hydrolab was calibrated immediately prior to each use as per Hydrolab instruction book. The DO probe was calibrated by the Winkler technique.

The dissolved oxygen saturation percentile formula came from The Biology of Estuaries and Coastal Waters.[6]

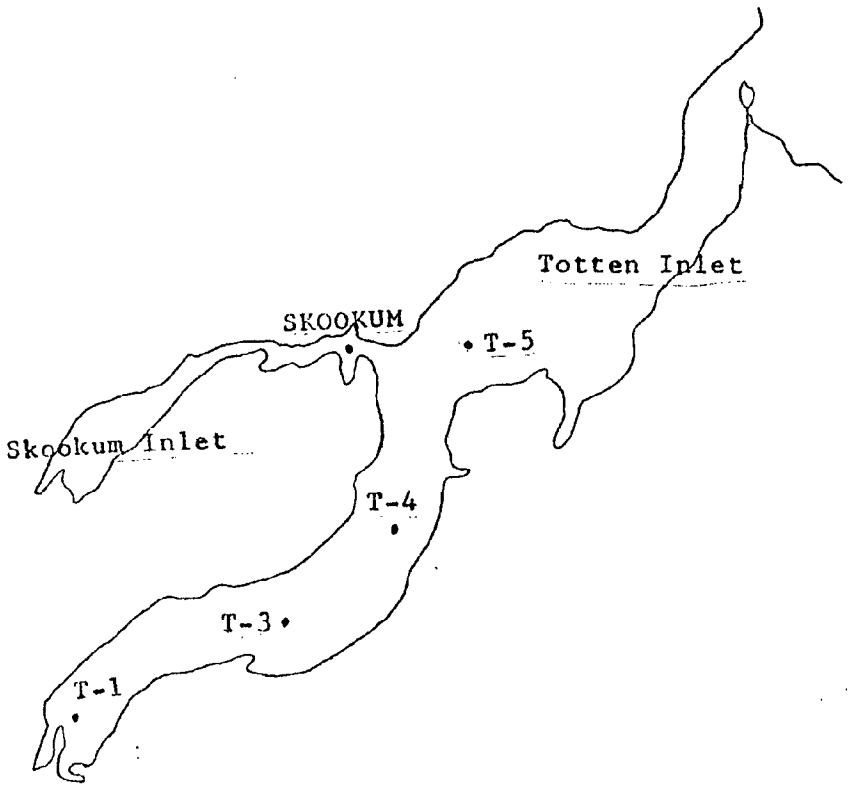
Site	Depth (m)	Temperature (C)	Salinity (°/oo)	pH	Dissolved Oxygen (ppm)	Dissolved Oxygen % Saturation	Dissolved Oxygen L&D (ppm)	Dissolved Oxygen Dark (ppm)	BOD (ppm)	Ortho PO_4 (uM)	Organic PO_4 (uM)	NH_3 (uM)	NO_2 (uM)	NO_3 (uM)	Chlorophy (ug/l)
T_1	0.0	14.7	21.0	8.5	15.6	179	ND	11.2	.110	1.75	.92±.05	ND	.659	ND	13.0
	1.8	11.6	27.7	8.7	14.6	164	16.0	10.9	.093	2.80	1.57±.07	23	.402	ND	09.8
T_3	0.0	12.0	28.3	8.7	14.6	166	14.2	12.0	.065	1.33	1.17±.04	ND	.560	ND	19.0
	2.0	11.4	28.4	8.7	15.4	173	14.4	12.0	.085	1.12	1.09±.03	33	.521	ND	14.0
	3.5	10.5	28.4	8.7	15.0	165	14.7	11.6	.085	4.10	0.0± .07	27	.323	ND	30.0
T_4	0.0	12.5	27.7	8.6	13.2	152	11.7	10.5	.068	1.02	.74±.03	ND	.560	ND	06.4
	4.5	10.4	29.1	8.6	14.4	160	13.1	12.1	.058	.76	.43±.02	21	.501	ND	08.2
	6.0	10.0	29.1	8.5	12.4	136	15.8	9.9	.063	1.54	1.58±.05	26	.659	ND	61.0
	0.0	11.0	28.4	8.7	14.2	158	12.3	11.6	.065	.81	.21±.02	ND	0.0	ND	05.2
T_5	6.0	10.8	29.1	8.7	14.2	158	13.2	11.7	.063	.76	.54±.02	ND	.580	ND	18.0
	12.2	9.7	29.3	8.4	11.4	124	14.1	9.1	.058	1.54	.84±.04	ND	.204	ND	36.0
ookum	0.0	11.8	27.7	8.5	11.0	124	10.3	ND	ND	1.59	.28±.04	ND	.560	ND	3.4
	2.0	11.3	27.7	8.5	11.6	130	11.0	9.8	.045	1.75	.35±.04	ND	.600	ND	3.4
Error on Measurement		±.1	±.02	±.03	±3	±.2	±.2	±.02	±.02	±1%		±2%	±4%	ND	±2%

Table A-1 Water Quality Data From the 4/12/77 Sampling

Site	Depth (m)	Temperature (°C)	Salinity (°/oo)	pH	Dissolved Oxygen (ppm)	Dissolved Oxygen % Saturation	Dissolved Oxygen Light&Dark (ppm)	Dissolved Oxygen Dark (ppm)	BOD (ppm)	Ortho PO_4 (uM)	Organic PO_4 (uM)	NH_3 (uM)	NO_2 (uM)	NO_3 (uM)	Chlorop (ug/l
T_1	0	11.2	26.6	8.23	10.6	117	8.7	9.3	0.017	1.1	1.1±0.1	24	0.30	.95±.02	ND
	2.5	10.8	27.3	8.30	11.6	128	9.4	9.1	0.033	0.9	0.7±0.1	22	0.0	.25±.05	3.6
	5	10.5	27.4	8.27	11.6	127	10.2	8.8	0.037	1.3	1.0±0.3	19	0.28	7.6±.8	5.4
T_2	0	10.9	26.6	8.22	10.6	117	8.5	8.6	0.027	1.6	0.5±0.4	27	0.23	0.0	1.7
	3.5	10.5	27.1	8.24	11.6	127	9.6	9.1	0.033	1.2	1.2±0.2	17	0.23	ND	6.3
	7.5	10.3	27.3	8.20	11.2	122	10.1	8.8	0.032	1.4	0.6±0.2	22	0.48	.31±.06	ND
T_3	0	11.2	27.5	8.23	11.2	125	9.1	9.3	0.025	.009	1.8±0.1	23	0.21	1.1±.2	1.7
	10	10.0	27.8	8.18	11.0	120	9.5	9.4	0.021	1.0	0.2±0.2	18	0.35	4.3±.9	ND
	20	10.0	28.1	8.15	10.8	118	9.6	8.6	0.029	1.3	0.4±0.2	18	0.43	4.0±.4	13.0
T_4	0	10.8	27.1	8.23	11.2	123	8.8	8.9	0.031	1.1	0.7±0.2	15	0.24	1.6±.3	1.7
	13.5	9.8	27.5	8.18	10.8	117	9.4	8.5	0.031	1.2	0.7±0.2	18	0.45	3.8±.4	5.8
	27	9.5	27.7	8.13	11.0	118	9.4	8.9	0.028	1.3	0.8±0.2	14	0.33	5.6±.6	14.0
Skookum Creek					8.9		9.0	8.4	0.007	.43	0.5±0.2	14	0.49	35±3	ND
Schneider Creek					8.7		8.9	9.0	0.0	.77	0.7±0.2	22	4.6	12±1	ND
Kennedy Creek					8.7		8.8	8.3	0.005	.58	5.4±0.2	12	0.05	35.4±.3	ND
Error on Measurement		±0.1	±0.1	±.02	±0.03	±3	±0.2	±0.2	±0.02	±2%		±2%	±20%		±2%

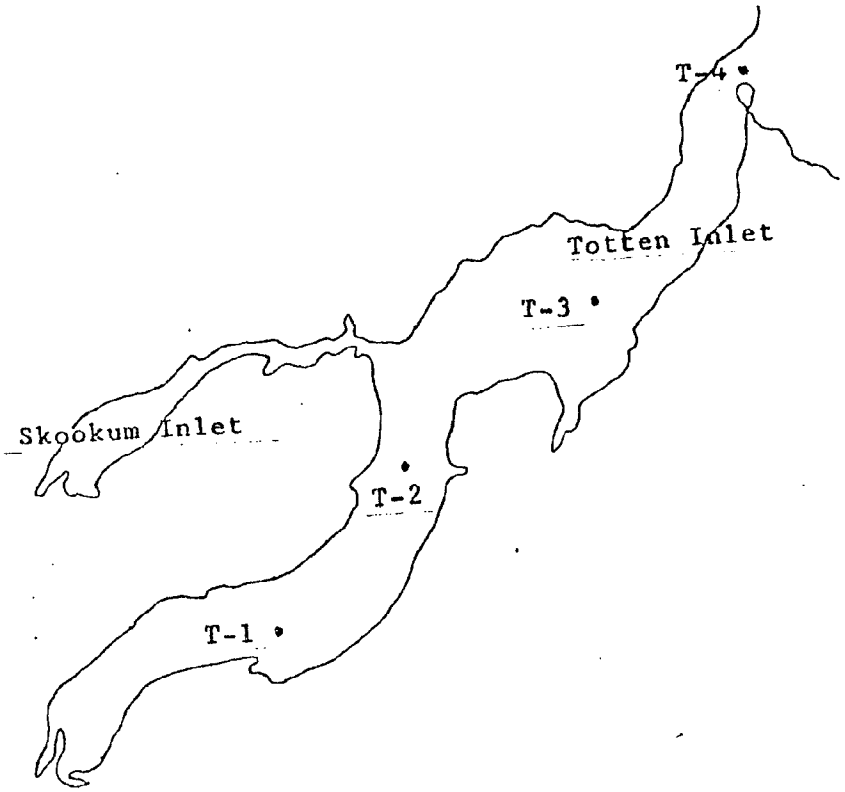
Table A-2 Water Quality Data from the April 22, 1977, Sampling.

Figure A-1



Water Quality Sampling Sites 4/12/77

Figure A-2



Water Quality Sampling Sites 4/22/77

Date	Salinity	Temperature
4/12/77	27.9 ± 2.3	11.3 ± 1.4
4/12/77	27.3 ± 0.4	10.5 ± 0.6

Table A-3 Salinity and Temperature Means and Standard Deviations for the Dates that Water Quality Sampling Occurred.

Date of Sampling	Depth (Feet)	Dissolved Oxygen mg/l at Each Site				
		Budd 1	Budd 2	Budd 3	Budd 4	Budd 5
8/1/67	1	10.9	9.5	11.0	11.2	14.6
	20	3.6	3.0	4.8	3.8	7.9
1/15/68	1	9.5	9.1	9.2	8.8	8.6
	20	7.6	7.5	7.8	7.9	8.2
4/1/68	1	12.9	11.3	9.4	10.0	9.6
	20	7.5	8.5	8.9	9.0	10.7
1/28/69	1	9.7	10.1	10.2	10.2	9.7
	20	8.1	9.3	8.6	8.9	8.6
4/22/69	1	9.6	10.0	10.2	9.7	10.9
	20	9.6	9.3	10.0	10.2	10.9
7/23/69	1	5.4	7.1	6.1	6.8	8.2
	20	7.2	5.1	6.6	7.6	10.0
10/22/69	1	7.0	6.6	6.5	6.1	6.2
	20	6.4	5.5	5.8	5.8	6.4
1/19/70	1	11.2	10.8	9.8	14.5	14.9
	20	8.3	7.9	8.2	14.7	14.2
4/20/70	1	10.7	9.8	9.6	10.0	10.5
	20	8.4	8.7	8.9	8.9	11.5
7/28/70	1	6.6	5.7	5.9	8.5	6.5
	20	5.1	5.0	5.4	5.7	6.7

le A-4 Dissolved Oxygen Data for Budd Inlet Collected by the Department of Ecology[7]

References for Appendix A

1. J.D.H Strickland and T.R. Parsons, A Practical Handbook of Seawater Analysis, (Ottawa, Canada, Fisheries Research Board of Canada, 1972).
2. I.M. Kolthoff, Quantitative Chemical Analysis, (N.Y., N.Y., MacMillan Company, 1969) p. 830.
3. Personal communication with Dr. Kaye V. Ladd, The Evergreen State College, 1977.
4. Strictland and Parsons, p. 195.
5. Strictland and Parsons, p. 21.
6. E.J. Perkings, The Biology of Estuaries and Coastal Waters, (London, 1974).
7. Washington State Department of Ecology, Computer Storet Retrieval System, (Olympia, Wash.).

APPENDIX B

INTRODUCTION

Many shellfish, such as oysters, are herbivorous and their abundance is related to the abundance of food available to them. Phytoplankton are an important component of such food. In viewing the abundance of food available to oysters, an understanding of the population dynamics of phytoplankton is important.

The increase of phytoplankton in spring is called the spring bloom. This bloom is characterized by three phytoplankton communities which succeed each other through the season. The first community is replaced by the second, which, in turn, is replaced by the third. The relative abundance and productivity of the phytoplankton community is largely dependent on its secessional stage. The greatest productivity is associated with the first community.[1]

The first community consists of algae and small diatoms, having a high surface area to volume ratio, a factor important to buoyancy. These plankton have a preference for high concentrations of nutrients and are capable of rapid reproduction. They are easily grown in culture.[2]

The third community is composed of a mixture of forms, many of which are motile. Dinoflagellates, the organisms responsible for red tides and paralytic shellfish poisoning, are a characteristic member of this community. This community has a patchy occurrence in the marine environment and is extremely difficult to culture.[4]

To study the phytoplankton communities, we used a method for determining the diversity of the various communities. Diversity, as used in our study, is the ratio between the total numbers of phytoplankton in a community, and the total number of species in the community.

METHODOLOGY

On April 12 and 22, surface plankton tows were made at the sites noted for the water quality sampling (see Figures A-1 and A-2). Taken during ebbing tides on both days, we used a Nitex net with 0.25 meter opening, and 73 micron mesh. The tows lasted for 30 seconds, with the boat travelling at 2 knots. Once aboard, the specimens were stored in a cooler for the duration of the trip. They were refrigerated in the laboratory and fixed with formalin.

To count the plankton, Neubauer cell counting chambers (Hemacytometer) were used under Nikon compound microscopes. Bottles containing the samples were first shaken to insure a random distribution, and then one drop was placed on each of the counting grids (see FigureB-1). The hemacytometer was then covered with a glass cover slip. Numbers were tabulated for the different species and total organisms in each of the counting grids, which was repeated for each sample for

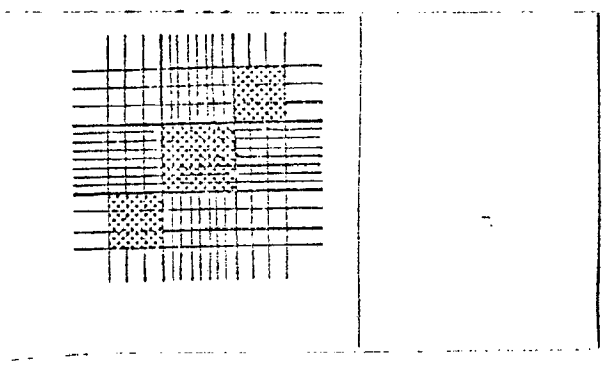


Figure B-1 Counting Grid

The numbers tabulated were then used in the formula,[1]

$$D = \frac{S-1}{\log_e N}$$

where D = the diversity index, or value of diversity.

S = total number of species.

N = total number of organisms.

It should be noted that the above formula is actually simplified and derived from the larger formula,

$$D = 1/N \left(\log_2 \frac{N!}{N_a!N_b!\ldots N_s!}\right)$$

where a, b.....s = types of species

$N_a, N_b, \ldots, N_s$ = the numbers of e each specie.

N = total number of organisms.

Both formulas evolved out of the field of information theory, from which Margalef and others developed the techniques for computing species diversity.[2]

A brief computer program was written for ease of calculation of all the D values obtained. The Evergreen State College computer system (Hewlett-Packard BASIC) was readily available for this, as well as for computing the mean and standard deviation for the D values.

DATA

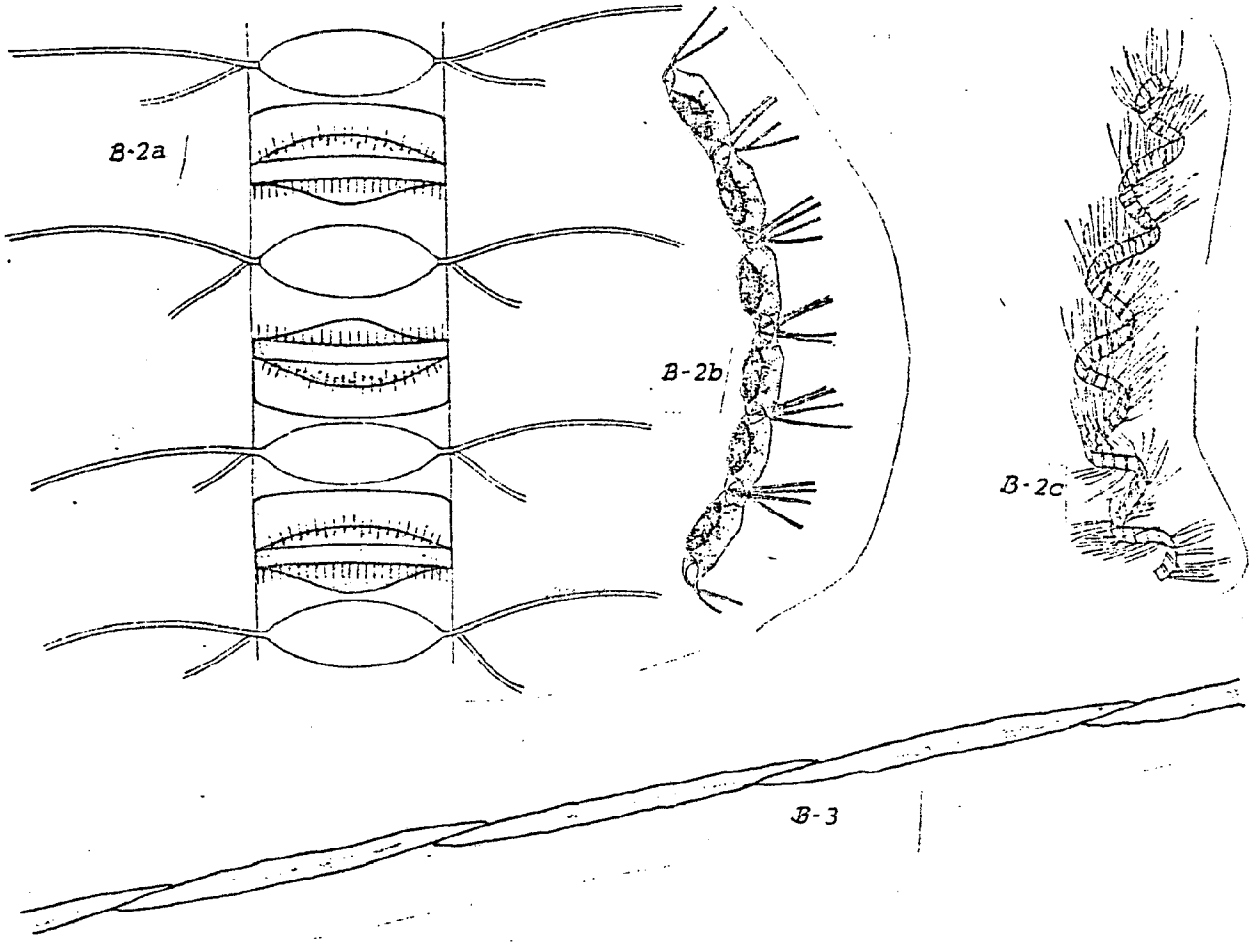
Sixteen countings were made for each of the samples. The mean and standard deviation for the diversity indeces were then computed. The results are shown in Table B-1.

	5/12/77		5/22/77	
Sites	D mean	Standard Deviation	D mean	Standard Deviation
Skookum Inlet	1.70358	.794607	ND	ND
T_1	2.29973	.708485	.97876	.418322
T_2	ND	ND	.70443	.525631
T_3	2.10171	.491126	1.14617	.687523
T_4	1.50536	.449618	.72386	.688584
T_5	1.45998	.423444	ND	ND

Table B-1 Diversity (D) Indices for Sampling Sites

The predominant species of diatoms in our samples were keyed,[3] and those species are illustrated on pages B-4and B-5.

Predominant Species of Phytoplankton



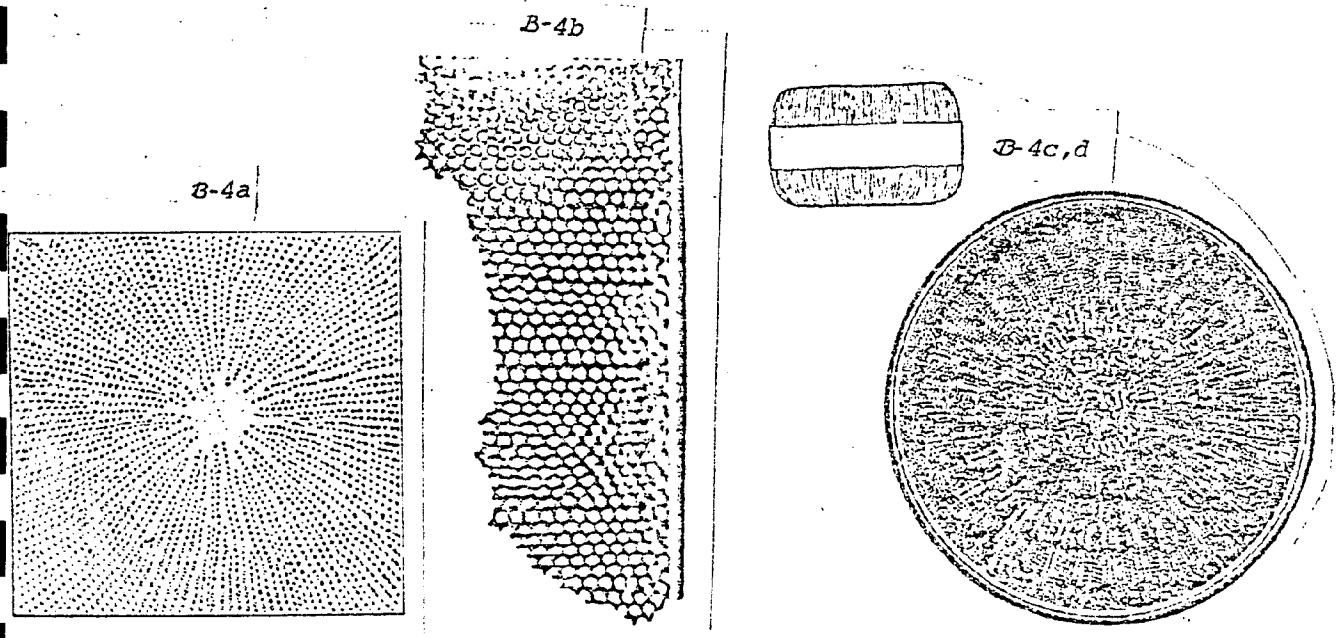


Fig. B-2. *Chaetoceros secundus: a, broad girdle view, spikes as a rule not present; b, narrow girdle view; c, habit sketch*

Fig. B-3. *Nitzschia seriata*

Fig. B-4. *Coscinodiscus vailesii: a, photomicrograph of central region of valve; b, photomicrograph of marginal areolae; c,d, Actinocyclus ehrenbergii, to give an example of general disk diatom appearance, girdle and valve views.*

All sketches are from Gran and Angst, Plankton Diatoms of Puget Sound, 1931.

Additional Species of Phytoplankton*

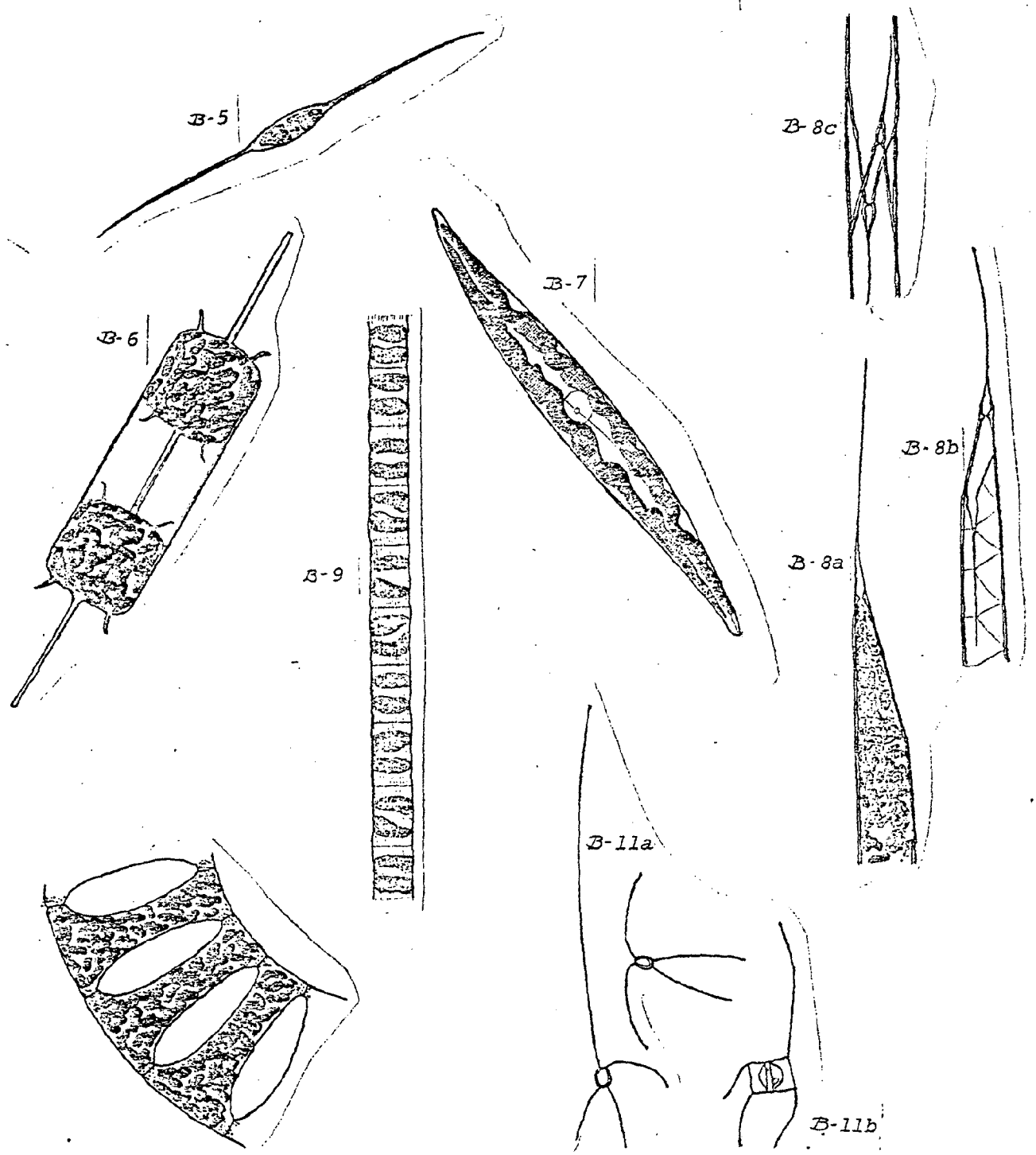


Fig. B-5. Nitzschia closterium
Fig. B-6. Ditylum brightwelli
Fig. B-7. Pleurosigma formosum
Fig. B-8. Rhizosolenia semispania: a, tip of cell; b, showing imprint of sister cell; c, division
Fig. B-9. Skeletonema costatum
Fig. B-10. Eucampia zoodiacus
Fig. B-11. Chaetoceros socialis; a, valve views; b, resting spore

All sketches are from Gran and Angst, Plankton Diatoms of Puget Sound, 1931.

*Other species were also present, notably of the genera *Chaetoceros* and *Coscindiscus*, but were not positively identified.

ANALYSIS AND CONCLUSIONS

"Species diversity is a measurable biological characteristic unique to the community level of ecologial organization. Furthermore, it is a characteristic that reflects organizational features important in the functioning of the community."[8]

Our analysis of the succession of plankton communities, using the mean and standard deviation of the samples' D values, shows a clear transition of one plankton community into another. That is, the D values are significantly different and therefore indicate an alteration of organization within one community that is evolving into another.

Our observations confirmed that, at least for the spring bloom, the inlet's plankton ecology is in a normal state, and has the characteristics that Margalef ascribes to spring successions.[9] Also, our visual observations support the different D values in that there was an obvious visual difference in the communities of the sample sites between one sample day and the next. This corresponds with the D values differing between the sampling days.

The data indicates that we saw the climax of one community, just before the next community began. Community succession goes on throughout the entire year, and our samples give only a small picture of the yearly community structure in Totten Inlet. A full year's survey is necessary for a complete analysis.

REFERENCES FOR APPENDIX B

1. Ramon Margalef, "Temporal Succession and Spatial Heterogeneity in Phytoplankton", Perspectives in Marine Biology, ed. A.A. Buzzati Traverso, Los Angeles, Calif; University of California Press, 1958 p. 330-331.
2. Margalef, p. 330-331.
3. Margalef, p. 330-331.
4. Margalef, p. 330-331.
5. Ramon Margalef, Perspective in Ecological Theory, Chicago, 1968, p. 55.
6. George W. Cox, Laboratory Manual of General Ecology, Wm. C. Brown Co., 1976, p. 163.
7. H.H. Gran and E.C. Angst, Plankton Diatoms of Puget Sound, reprinted from Publications of Puget Sound Biological Station, Vol. 7, March, 1931.
8. Cox, p. 162.
9. Margalef, "Temporal Succession and Spatial Heterogeneity in Phytoplankton".

APPENDIX C

INTRODUCTION

Coliform are a group of closely related, non-pathogenic bacteria. They can be found in soils, plants, and animals.[1] One type of coliform, called fecal coliform, is normally found only in the intestines of warm blooded animals.[2] Their presence in natural waters indicates the recent discharge of sewage, and their numbers are an index of the extent of the pollution.[3]

The degree of sewage contamination which exists in natural waters is important to know because most diseases transmitted through water are due to bacteria and viruses contained in the feces of infected persons.[4] This makes sewage contamination potentially the most dangerous kind of water pollution.

This is especially true of waters containing shellfish. Shellfish filter bacteria out of surrounding waters in the process of feeding. If pathogenic (disease producing) bacteria and viruses are present in sufficient numbers, humans eating raw or inadequately cooked, contaminated shellfish can contract diseases. In order to protect the public from this, shellfish beds are regularly inspected by state health officials for sewage contamination. If total and fecal coliform concentrations exceed established standards, the shellfish are not allowed to harvested and sold.

We conducted a study of total and fecal coliform concentrations to indicate the degree of sewage contamination in Totten and Skookum Inlets. Our study was not designed to indicate individual sources of pollution.

METHODOLOGY

Samples were collected by boat and foot from numerous sites around Totten and Skookum Inlets on April 6th, 19th, and 26th. Sampling sites were selected to indicate how coliform concentrations vary with different levels of development along the shorelines. Where possible, surfacewater runoff samples were taken at the shoreline.

Samples were collected and processed by the method described in Standard Methods.[5] The membrane filtering technique was used, utilizing type HA Millipore filters for the fecal coliform determination, and type HC Millipore filters for the total coliform tests.[6] BBL MF Endo Medium[7] jelled by adding Difco Bacto Agar[8] was used for the fecal coliform tests, while Difco Bacto Endo Agar was used for the total coliform tests.[9] A phosphate buffer was used and prepared according to Champ and Benzer.[10]

RESULTS

The results of the coliform samplings are listed in Tables C-1 through C-3 with Figures C-1 through C-3 showing the location of the sampling sites for the respective days. The salinities listed in the tables indicate the relative amounts of freshwater and saltwater contained in the samples, and, thereby, indicating the sample source. For example, a low salinity measurement indicates the sample is mostly freshwater derived from land drainage, while a high salinity sample indicates that the water is mainly seawater.

DISCUSSION

Generally, the coliform concentrations measured on the 26th were higher than those measured on either the 6th or 19th. This is probably due to extended dry weather proceeding the sampling on the 6th and 19th while the sampling on the 26th was proceeded by 1 to 2 days of light rainfall. The rain apparently washed coliforms into the inlets from surface and subsurface land sources.

The coliform concentrations obtained were compared with the U.S. Public Health Service recommended standards for shellfish growing waters.[11] These standards state that approved shellfish growing waters cannot exceed 70 coliform per 100 milliliters of water.

The only coliform concentrations measured which exceeded this standard were from the sampling on the 26th. The low salinities of those samples which exceeded 70 coliform per 100 milliliters indicate the samples were taken from direct land drainage. Since these samples were not diluted by seawater, they are not a true indication of the general condition of adjacent marine waters. They simply indicate an area where significant numbers of coliforms enter the inlet waters. The effects of these sources were not observable in adjacent sampling sites.

No correlation could be made between density of human development along the shoreline and coliform concentrations in adjacent waters.

Figure C-1: Map of Totten and Skookum Inlets showing the sites where coliform were sampled on 6 April 1977.

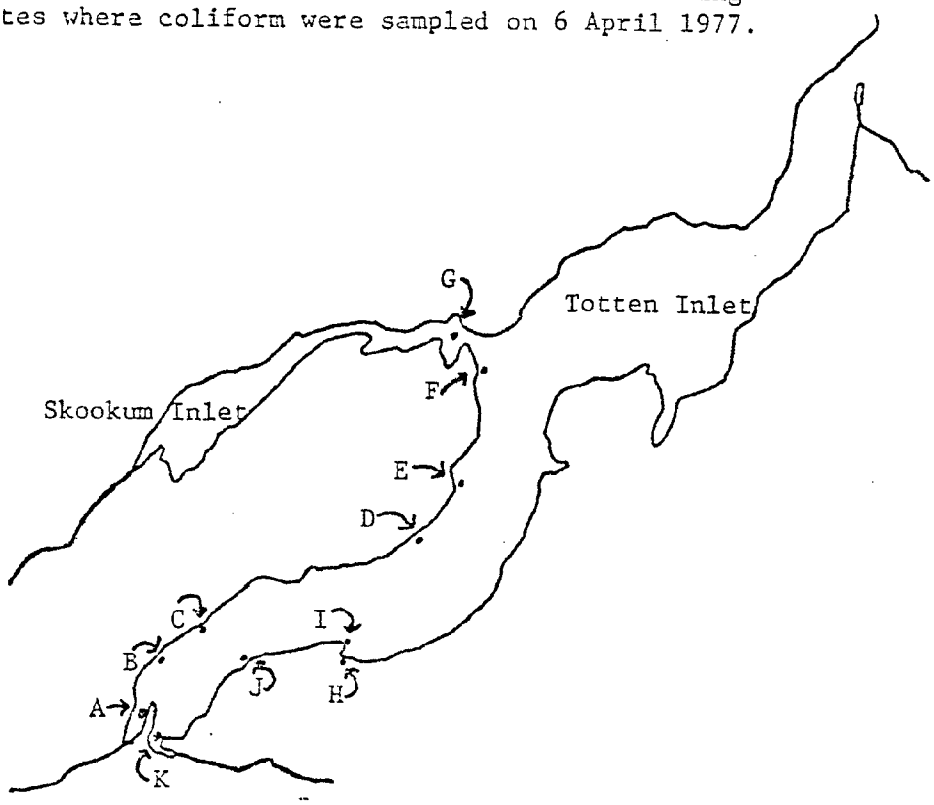


Table C-1: Results of coliform sampling on 6 April 1977.

Site	# of Total Coliform per 100 ml.	# of Fecal Coliform per 100 ml.	Site	# of Total Coliform per 100 ml.	# of Fecal Coliform per 100 ml.
A	*	1	G	*	*
B	*	*	H	ND	9
C	*	*	I	*	*
D	1	*	J	*	2
E	*	*	K	9	2
F	*	*			

ND=No Data

*=Coliform levels are less than one coliform per 100 ml.

Figure C-2: Map of Totten and Skookum Inlets showing the sites where coliform were sampled on 19 April 1977.

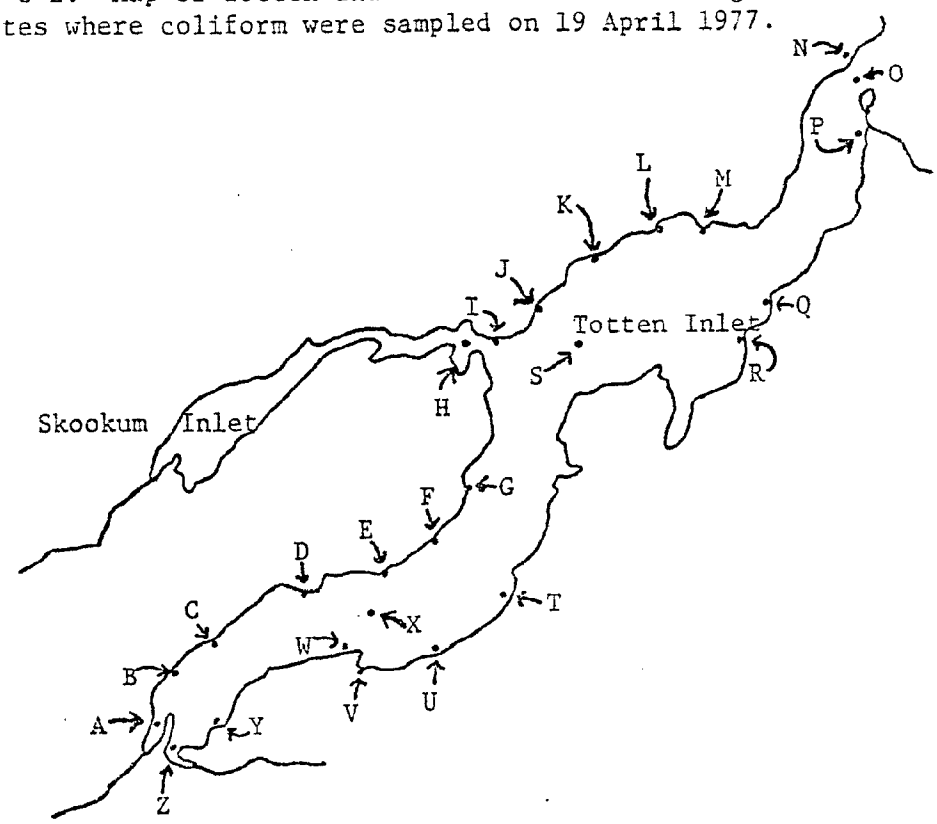


Table C-2: Results of coliform sampling on 19 April 1977.

Site and Salinity (ppt)	# of Total Coliform per 100 ml.	# of Fecal Coliform per 100 ml.	Site and Salinity (ppt)	# of Total Coliform per 100 ml.	# of Fecal Coliform per 100 ml.
A - 16	3	4	N - 29	*	*
B - 28	12	2	O - 26	*	*
C - 30	*	*	P - 0	*	*
D - 4	*	*	Q - 28	*	*
E - 28	*	*	R - 27	ND	16
F - 29	*	*	S - 26	*	*
G - 30	9	4	T - 23	*	*
H - 0	*	*	U - 28	3	3
I - 18	3	4	V - 0	*	*
J - 28	2	*	W - 20	*	*
K - 28	*	*	X - 27	2	*
L - 28	1	*	Y - 26	1	*
M - 28	1	2	Z - 14	1	*

ND=No Data *=Coliform levels are less than one coliform per 100 ml.

Figure C-3: Map of Totten and Skookum Inlets showing the sites where coliform were sampled on 26 April 1977.

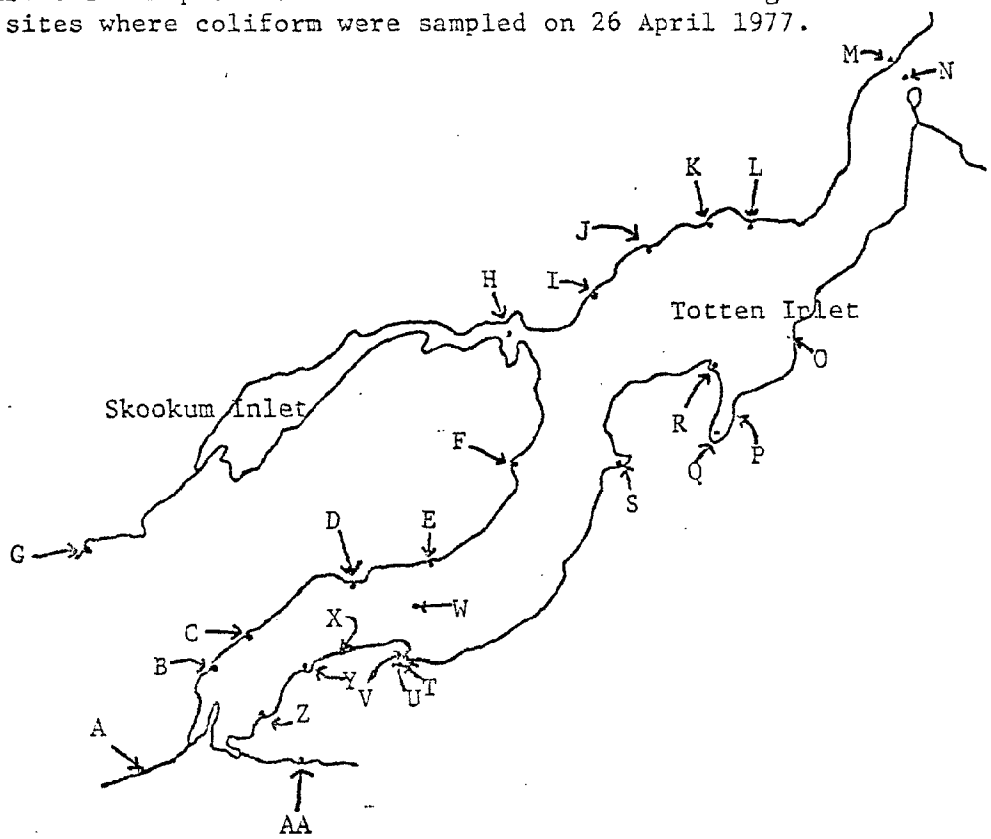


Table C-3: Results of coliform sampling on 26 April 1977.

Site and Salinity (ppt)	# of Total Coliform per 100 ml.	# of Fecal Coliform per 100 ml.	Site and Salinity (ppt)	# of Total Coliform per 100 ml.	# of Fecal Coliform per 100 ml.
A - 0	34	3	N - 30	*	*
B - 27	ND	10	O - 20	ND	2
C - 27	1	1	P - 4	*	1
D - 27	4	1	Q - 30	*	1
E - 27	6	1	R - 8	ND	145
F - 0	*	1	S - 25	ND	20
G - 0	ND	28	T - 13	ND	10
H - 30	*	*	U - 0	ND	>300
I - 30	ND	7	V - 26	23	9
J - 1	13	11	W - 29	*	*
K - 0	3	*	X - 0	>150	168
L - 1	ND	3	Y - 2	ND	2
M - 17	4	3	Z - 26	ND	1
			AA - 0	21	22

ND=No Data *=Coliform levels are less than one coliform per 100 ml. >=Coliform levels are greater than the number indicated

CONCLUSIONS

Our study indicates that there was no major contamination of Totten and Skookum Inlets by sewage during the periods we sampled. Since there was not a significant amount of rainfall proceeding our samplings, there was less chance of sewage effluent from septic drainfields and other systems would be washed into the inlets. Our study did demonstrate to some degree that an increase in rainfall will increase coliform levels in the inlets, but this is not conclusive.

A survey of the files at the State Department of Social and Health Services revealed that significant levels of sewage have periodically entered the inlets from faulty septic systems. A study done in 1974 by Ted Wilkens indicated that 8% of the permanent and 16% of the recreational residences along Totten Inlet[12] have experienced some operational difficulty leading to raw sewage discharge.

A close survey of coliform levels in Totten and Skookum Inlets should be regularly maintained in order to insure that coliform levels do not exceed safe limits and endanger the public.

REFERENCES FOR APPENDIX C

1. Harold W. Wolf, "The Coliform Count as a Measure of Water Quality", Water Pollution Microbiology, edited by Ralph Mitchell, John Wiley and Sons, Inc., 1972, p. 338.
2. Wolf, "The Coliform Count as a Measure of Water Quality", p. 336.
3. Wolf, "The Coliform Count as a Measure of Water Quality", p. 336 and 339.
4. Wolf, "The Coliform Count as a Measure of Water Quality", p. 336.
5. Standard Methods for the Examination of Water and Wastewater, 12th edition (American Public Health Association: New York, 1971), p. 635-385.
6. Millipore; Bedford, Mass., 01730.
7. BBL M-Coliform Broth no. 11119, BBL, Cockeysville, Maryland.
8. Difco Laboratories, Detroit, Michigan.
9. Difco Laboratories, Detroit, Michigan.
10. S. Champ and S. Benzer, Proceedings of the National Academy of Sciences, vol. 48, 1962, p. 533-546.
11. U.S. Department of Health, Education and Welfare, National Shellfish Sanitation Program Manual of Operation, Part I - Sanitation of Shellfish Growing Areas, Public Health Service Publication No. 33 (Washington D.C., 1965).
12. Ted Wilkens, Sanitary Survey of Totten Inlet - Thurston-Mason Counties, Washington Department of Social and Health Services, Shellfish Division, 1974, p. 1.

APPENDIX D

INTRODUCTION

Shellfish culture is one of the few forms of mariculture (the culture of marine organisms) practiced in the United States. It has a distinct advantage over other types of mariculture because the shellfish exploit natural food sources, freeing the culturist from the costs of food. In Totten Inlet the major species cultured are the Pacific oyster, the Olympia oyster, and Manilla clam. Some economic aspects of the culture of each of these species shall be discussed in the subsequent sections of this appendix.

AQUACULTURE IN TOTTEN AND SKOOKUM INLETS

In Totten Inlet the Pacific oyster, Crassostrea gigas, is the mainstay of the shellfish industry. The type of culture used in this region is called bottom culture.[1] There is a great variability in size and method of operation used by different companies. The smaller companies, where the owner does a large portion of the work, tend to use more labor-intensive methods than the large companies. Types of equipment used by the various companies are shown in Figure D-1.

The Pacific oyster is not native to the area and due to the low water temperature cannot reproduce in Totten and Skookum Inlets. These oysters are obtained as seed from various sources.[2] About 20 cases of seed are required for each acre of oyster bed.[3] Seed from Japan, the source preferred by most oyster growers, costs about $32.00 per case.[4] The treatment of the seed varies depending upon the size of the oyster company. Large companies deposit the seed in special areas, favorable to the growth of the relatively fragile seed. After the oysters have developed to a hardier size, they are transplanted to the regular oyster beds where they remain until harvested. Small companies spread the seed directly on the beds where it remains until harvested. This reduces the amount of labor required but increases the mortality of young oysters.

Most oyster growers sell oysters to the wholesale market as raw oyster meat. The price depends upon the method of marketing: five gallon institutional cans bring $8.00 a gallon, pint jars can bring $14.00 a gallon. Ten dollars a gallon is an approximate value for the price of oyster meat which has been used here to estimate the gross revenues for oyster culture in all of Totten Inlet (see Figure D-2).

The costs of production vary with different oyster companies. Smaller companies appear to have lower production costs than the large oyster companies which include the costs of management as part of their production costs. The small oyster companies are owner-managed, and their production costs do not include the costs of management. The larger companies use highly efficient culture techniques and utilize machinery, so their costs of production, excluding cost of management, are actually lower than the smaller companies.

The native Olympia oyster, Ostrea lurida, is the species on which the oyster industry in southern Puget Sound was founded.[5] At present, the Olympia oyster constitues only a small fraction of the total shellfish production in the area.

There are several reasons for this.

From 1927 to 1957 the total production of all types of aquaculture in Totten and Skookum Inlets was disrupted, apparently by the discharge of a pulp mill in Shelton.[6] During this time the Pacific oyster, which proved to be more resistant to pollution, was imported to bolster the production of oysters in the area. After the pulp mill closed, the total production of shellfish increased rapidly. The production of Olympia oysters has increased but does not approach the former levels of production. Three of the oyster companies listed in Figure -1 presently produce Olympia oysters. These oyster growers give various reason for this ability.

The most simple explanation was given by an oyster grower who said that his beds are naturally suited for Olympia oyster production. Another grower believes his oyster dikes built in the 1950's (the most recently constructed in Totten Inlet) create river-like currents which favor the Olympia oyster.

A more detailed explanation was given by another grower. When the Pacific oyster was imported, two oyster predators, the Japanese oyster drill, Ocenia japonica, and a predatory flatworm, Stylochus spp., were accidently introduced into the area as well. They are now established in Totten Inlet. These predators prefer to feed on juvenile Olympia oysters. As a result, total mortality in the Olympia oyster seed can occur, however, in some areas the Olympia oyster seed does survive. In these areas the environmental conditions are not favorable to the predators. This oyster grower was actively experimenting to determine what environmental conditions exist in such areas.

Olympia oysters, as with Pacific oysters, are sold as raw oyster meat. The price per gallon received is the highest for any oyster in the Northwest.[7] Two prices given by oyster growers were $55.00 a gallon and $88.00 a gallon.

The Olympia oyster reproduce in the area, so there is a natural setting of seed in Totten Inlet. The labor required consists of cultivation of the beds, harvesting, and shucking. However, due to the small size of the Olympia oyster, a large number are required to make a gallon. One oyster grower paid his Olympia oyster shuckers by the pint. The resulting high labor costs are another reason why Olympia oysters are such a small portion of total oyster production.

Figure D-1

Year	Total Production Totten Inlet *		Gross income from Aquaculture in Totten**
1973	Clams	532,351 lbs.	$266,175
	Olympia Oyster	1,987 gals.	119,220
	Pacific Oyster	73,890 gals.	738,900
			1,124,295 total
1974	Clams -	759,666lbs.	379,833
	Olympia Oyster	2,152 gals.	129,120
	Pacific Oyster	61,473 gals.	614,730
			1,123,683
1975	Clams	819,076 lbs.	409,538
	Olympia Oyster	2,488 gals.	149,280
	Pacific Oyster	91,958 gals.	919,500
			1,478,398
1976 ***	Clams	254,723 lbs.	127,361
	Olympia Oyster	3,470 gals,	208,200
	Pacific Oyster	118,629 gals.	1,186,290
			1,521,851

* State Department Fisheries

** Gross income estimated From DOF and average values for products; Clams 50¢/lb., Olympia Oysters $60/gal., Pacific Oyster $10/gal..

*** Preliminary figures subject to revision.

Figure D-2 Comparison of ten aquaculture enterprises located on Totten and Skookum Inlets. Figures are yearly averages obtained through interviews with business managers.

Oyster grower	Type of product	Total acreage	Productive acreage	Cost of equipment replacement	# of People employed	Annual expenditures	Annual gross	Annual production	~~Annual net~~ Annual net
I	PO	-	-	-	4-6	-	25,000	3,000 PO	-
II	PO C	7	-	20,000	2	-	8,500p 21,000C	1,500P	-
III	P	8	6	-	2	-	14,000	2,000P	-
IV	P Y	8	4	10,000	1-9	14,000	7,000 16,800	5,000P 2,500Y	8,050
V	P C	20	5	7,000	1	-	17,000	1,300P 6,000C	-
VI	P C Y	35	15-20	20,000	8-15	20,000	-	4,137P 540Y 103,915C	- -
VII	P	38	-	40,000	4-5	-	59,500	7,000	20,000-25,000
VIII	P Y	83	13	-	5	50,000	100000	3,000P 1,000Y	50,000 -
IX	P	220	90	58,000	17-18	133000	188000	23,500	55,000
X	P Y C	395	237	500,000	35-40	624804	703616	46,600P 100000C	8,812

P - Pacific Oyster
Y - Olympia Oyster
C - Clam

Oyster production listed in gallons
Clam production in pounds

REFERENCES FOR APPENDIX D

1. J.E. Bardach, W.O. McLarney and and J.S Ryther, Aquaculture, The Farming and Husbandry of Freshwater Organisms. New York, N.Y., John Wiley and Sons, Inc., Wiley-Interscience 1972, p. 692.

2. State of Washington, Department of Fisheries, "Oyster Culture in the State of Washington" by Cedric Lindsay, Olympia, 1970.

3. Personal communication with Chris Jones, Washington State Shellfish Lab, Brinnon, Washington, April, 1977.

4. Personal communication with Richard Murakami, Coast Oyster Co. South Bend, Washington, May, 1977.

5. Aquaculture and Water Quality, Totten Inlet, The Evergreen State College, 1975.

6. Aquaculture and Water Quality, p. 6

7. Bardach, et. al. p. 677.

APPENDIX E

Dear Participant,

This survey is being conducted by students from The Evergreen State College under the supervision of the Mason and Thurston Regional Planning Councils. Three hundred questionaires will be distributed in the areas adjacent to Totten and Skookum Inlets (see map on following page) on April 26, 27 and 28. The questionnaires will be picked up on . The purpose is to collect information for the Mason County Comprehensive Land Use Plan and to provide information for Thurston Regional Planning Council.

Throughout the questionnaire the word "aquaculture" is used. Aquaculture, as it is referred to in this questionnaire, is the growing and maintaining of marine organisms,such as oysters, clams and salmon, for food. Totten and Skookum Inlets are major areas of aquaculture, and the uses of the inlets are affected by the uses of the surrounding land. We are, therefore asking your opinion of the local aquaculture industry as well as other uses in the area. The questionnaire is divided into several topic headings, each of which refers to the theme of the questionnaire. If you own more than one piece of property in the survey area, choose that which you consider to be the principal one for purposes of the questionnaire.

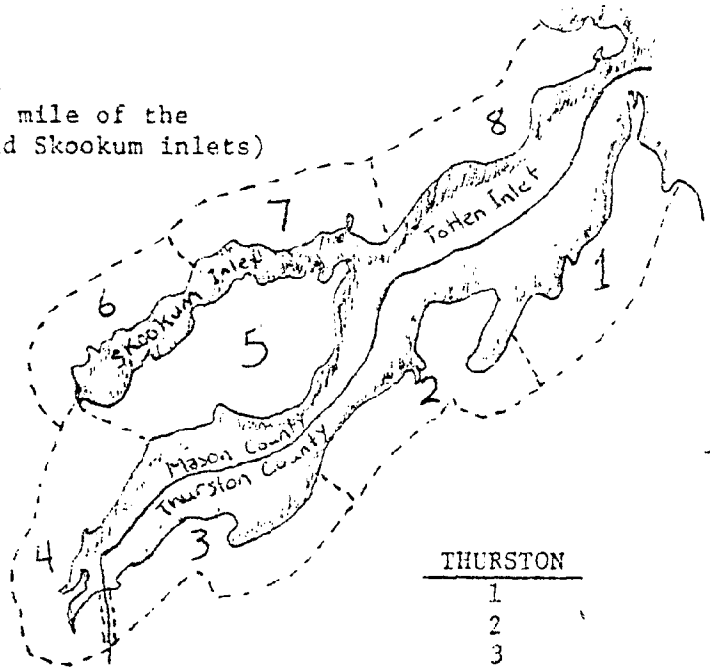
Individual responses will be kept confidential and all answers will be kept strictly in the context of the questions asked. Please answer the questions as candidly and completely as possible. Each question should have only <u>one</u> answer unless otherwise specified, and all questions are provided with a "no response" box.

Mason County will soon be revising its comprehensive land use plan, consisting of policies for the types and amount of land use in your growing community. More than ever, your planning department needs citizen input and help to make their planning compatible with your needs and desires. In Thurston County, the information will also be used in land use planning decisions. Be on the lookout for future notices in the local newspapers for additional ways that you can contribute to the planning process.

If you would like the results of the survey or have any questions, call faculty member Carolyn Dobbs at 866-6342. Thank you very much for your time and help.

The Coordinated Uses of Land and Water Project
The Evergreen State College

SURVEY AREA
(lands within 1/2 mile of the
shorelines of Totten and Skookum inlets)



MASON
4
5
6
7
8

THURSTON
1
2
3

QUESTIONNAIRE

MAILED % HAND DISTRIBUTED % (AVERAGES)

General Information

1) After referring to the map above, which area do you live or own property in?

8	14	1
8	7	2
23	6	3
	5	4
31	13	5
	5	6
	14	7
31	36	8
	3	No response* - ACTUAL NUMBER

2) Where is your property or residence located?

23	38	Uplands
77	61	Shorelines (property adjacent to water)
	3	No response*

3) Which of the following pertains to you?

Year-round resident

33	88	Own/buying dwelling
	7	Rent/lease dwelling
	2	Occupy dwelling provided by someone else

Seasonal resident

8	2	Own/buying dwelling
	.7	Rent/lease dwelling
		Occupy dwelling provided by someone else
58		Absentee landowner
	2	No response*

4) How long have you lived in Mason or Thurston Counties?

36	15	Less than 3 years
18	27	3 to 10 years
46	58	More than 10 years
	2	No response*

MAILED%	HAND DISTRIBUTED%	

5) What is the approximate size of the primary property that you live on, vacation on, or own?

	7	Less than 10,500 sq. feet
15	9	10,500 sq. feet to ½ acre
8	18	½ acre to 1 acre
23	36	1 acre to 5 acres
54	30	More than 5 acres
	8	No response*

6) How long do you plan to live on your property or stay at your present residence?

	2	Up to 5 more years
8	9	5 to 10 more years
17	64	Through retirement
75	26	Don't know
	9	No response*

7) At present, what is your primary use of the following?

	Residential		Business		Recreational		Industrial		Agricultural		Forestry		Aquaculture		Other		No response*
Your primary property	44	88	7	7	22	2		.9	11	3	11	.9	11	4		.9	22
Totten and Skookum inlets	11	83		3	67	2			11	1	11	1		16		8	46

8) What percent of your total annual income is derived from:

	None		<25%		26%-50%		51%-75%		76%-100%		No response*
The use of your land	85	88	8	7		2		2	8	2	21
The use of the inlets	82	83	9	3		2		3	9	9	35

9) If you own other land, in which county is it located? (refer to map)

Mason

	5	4
33	9	5
	14	6
33	14	7
	14	8

Thurston

	14	1
33	14	2
	18	3
	116	No response*

What is the approximate size of this other property? (largest tract)

39	Less than 1 acre
23	1 to 5 acres
39	More than 5 acres
112	No response*

Existing Conditions

What do you like best about where you live or own land in the survey area?

_____

_____

* ACTUAL NUMBER

MAILED% | HAND DISTRIBUTED%

What do you like least about where you live or own land in the survey area?

_____

10) How often do you use Totten or Skookum inlets for the following recreational purposes

	Often		Sometimes		Never		Season of the year
Swimming	10	16	40	51	50	33	
Boating	30	34	30	45	40	21	
Water skiing		13	11	23	89	64	
Sport fishing	20	26	30	48	50	25	

11) What type of sewage disposal do you have?

40	95	Septic tank
10	3	Community sewage treatment
10		Out house
40	2	Other (please specify) _____
	3	No response*

12) Have you experienced the following with your property?

	Yes		No		Don't know		No response*	
Poor drainage	17	27	67	73	17			17
Structure settlement		17	73	87	27			27
Erosion	9	23	73	77	18			26
Slides	17	20	67	80	17			23
Flooding		8	83	91	17	.9		25
Saltwater intrusion	8	9	75	91	17	1		28
Inadequate water supply	9	7	73	93	18	1		28
Other (please specify)		21	75	74	25	5		119

Does your land have any outstanding natural features?

_____

Changes In Land Use

13) What is the likelihood of your building new structures or enlarging present structures on your primary property in the next 5 years?

39	19	Most likely
15	8	Likely
15	33	Not likely
15	28	None
15	12	Don't know
	4	No response*

14) Do you plan to change the primary use of your land in the next 5 years?

	3	Yes, I plan to subdivide
8	3	Yes, I plan to change to agricultural use
		Yes, I plan to change to commercial use
62	81	No
15	2	Other (please specify) _____
15	10	I don't know
	4	No response*

* ACTUAL NUMBER

MAILED %	HAND DISTRIBUTED %

What do you think will be the major changes in land use that will occur in the next 10 years?

_____

15) What types of land use would you favor in your neighborhood?

	Yes		No		Don't know		No response*	
Residential Development								
Less than 1 unit/acre	80	70	10	26	10	4		40
1 unit/acre	33	41	67	55		4		64
2 units/acre		20	100	75		5		73
4 units/acre		14	100	81		5		75
Commercial Development								
Shopping centers		2	89	98	11			40
Neighborhood services	13	19	88	78		3		36
Agricultural Development	60	52	40	42		6		39
Industrial Development		1	100	96		3		42

16) When land use changes, should its future use be compatible with existing surrounding uses of the land?

92	87	Yes
	3	No
8	10	Don't know
	14	No response*

17) Which, if any, of the following recreational facilities would you like to see more of in and around Totten and Skookum inlets?

	Yes		No		Don't know		No response*	
Public beaches	30	23	60	70	10	6		7
Parks along the shoreline	40	27	60	65		8		26
Marinas	10	11	90	80		9		32
Boat launches	36	26	63	64		10		23
Other (please specify)		27	100	61		12		105

Point Of View On Aquaculture

18) What experience have you had with aquaculture?

	2	Did not know that it exists
8	27	Know that it exists
42	43	Have visited an oyster farm
25	19	Have been employed by an oyster farm
25	10	Other (please specify) _____
	10	No response*

19) Do you own or lease an oyster or clam bed?

31	26	Yes, in front of my property
8	3	Yes, in another part of Totten or Skookum inlets
62	72	No
	6	No response*

If, yes, how many beds do you own? _____

20) How much seafood do you eat from Totten or Skookum inlets?

17	9	None
17	25	1 to 2 meals/year
50	52	1 to 2 meals/month
	8	1 to 2 meals/week
17	6	Don't know
	10	No response*

* ACTUAL NUMBER

MAILED% | HAND DISTRIBUTED%

21) How do you feel aquaculture affects:

	Raises		Reduces		No impact		Don't know		No response*	
Your recreational use of the inlets		10	42	24	50	53	8	13		15
Your property values	25	28	25	17	42	32	33	24		12
The visual appearance of the inlets	17	15	42	27	33	42	8	16		15

22) How important a factor do you think maintaining or increasing aquacultural productivity should be in future land use planning?

59	Very important
16	Important
12	Not important
13	Don't know
9	No response *

23) To keep the waters of Totten and Skookum inlets clean for aquaculture, what limitations would you agree to on the following types of development?

	Yes		No		Don't know		No response*	
Residential Development								
Limit density to less than 1 unit/acre on the shoreline	80	65	10	19	10	16		46
Limit density to 1 unit/acre on the shoreline	80	55	20	27		18		72
Limit density to 2 units/acre on the shoreline	60	37	40	44		19		84
Limit density to 4 units/acre on the shoreline	50	17	50	63		21		90
Limit density to less than 1 unit/acre on the uplands	50	52	50	30		18		72
Limit density to 1 unit/acre on the uplands	50	46	50	33		21		77
Limit density to 2 units/acreon the uplands	50	32	50	45		23		85
Limit density to 4 units/acre on the uplands	33	19	67	58		23		86
Commercial Development								
Limit shopping centers on the shoreline	91	86	9	9		5		31
Limit neighborhood services on the shoreline	83	79	17	15		7		35
Limit shopping centers on the uplands	75	71	25	21		9		36
Limit neighborhood services on the uplands	75	58	25	30		12		40
Industrial Development	83	45	17	45		10		45

24) To keep the waters of Totten and Skookum inlets clean for aquaculture, would you agree to limitations on:

	Yes		No		Don't know		No response*	
Septic tanks	62	66	31	14	8	19		19
Community sewage treatment plants	64	65	27	12	9	23		26

25) To keep the waters of the inlets clean for aquaculture, would you agree to limitations on the following types of recreation?

	Yes		No		Don't know		No response*	
The use of the water for:								
Swimming	33	27	67	68		5		17
Boating	42	35	58	59		6		21
Water skiing	58	47	42	47		6		17
Sport fishing	33	27	67	67		6		22
The use of the shorelines for:								
Marinas	91	83	9	15		3		18
Boat launches	67	72	33	25		3		17
Parks	42	71	58	24		5		19

Do you have any comments on this questionnaire, or about aquaculture in general?

*ACTUAL NUMBER

CITIZEN SURVEY RESULTS

What is the approximate size of the primary property that you live on, vacation on, or own?	% of total participants	% in Thurston County	% in Mason County
Less than 10,500 sq. ft.	7%	16%	3%
10,500 sq. ft. to 1/2 acre	9%	14%	4%
1/2 acre to 1 acre	18%	22%	16%
1 acre to 5 acres	36%	19%	44%
More than 5 acres	30%	30%	29%

Table 1: Cross tabulation of the size of respondents' primary property with the county in which it is located (99% confidence limits).

Have you experienced erosion on your property?	% of total participants	Uplands	Shorelines
Yes	19%	6%	27%
No	62%	69%	59%
Don't Know	0	0	0
No response	19%	25%	15%

Table 2: Cross tabulation of whether respondents have had erosion on their property with the location of the property (95% confidence limits).

Do you favor less than one unit per acre?	% of total participants	Less than 10,500 sq. ft.	10,500 sq. ft. to 1/2 acre	1/2-1 acre	1-5 acres	More than 5 acres
Yes	70%	67%	42%	43%	49%	62%
No	26%	0	8%	13%	28%	18%
Don't know	4%	11%	17%	0	2%	0
	0	22%	33%	43%	21%	21%

Table 3: Cross tabulation of whether the respondents favor limiting residential development to less than one unit per acre with the size of their property (99% confidence limits).

Do you favor Industrial development in your neighborhood?	% of total participants	Yes, I plan to subdivide	Yes, I plan to change to agricultural use	Yes, I plan to change to commercial use	No	Other	Don't know
Yes	1%	0	0	0	1%	0	0
No	67%	75%	50%	0	68%	33%	71%
Don't Know	2%	25%	25%	0	0	33%	0
No response	30%	0	25%	0	31%	33%	29%

Table 4: Cross tabulation of whether respondents favor industrial development in their neighborhood with whether they plan to change the primary use of their land (99% confidence limits).

What do you like best about where you live or own land in the survey area?

Area #	Peace and quiet	The view	Privacy	Recreation facilities	Clean air, clean water	The location	
1	9	11	11	2	7	4	
2	7	6	3	0	1	2	Thurston County
3	4	2	3	0	1	2	
4	1	1	5	0	0	0	
5	1	1	4	0	0	0	
6	2	1	4	0	0	4	Mason County
7	2	6	7	2	1	9	
8	17	20	21	10	6	14	

Number of people responding

Table 5: Cross tabulation of open-ended question asking respondents what they like best about where they live or own property with area in which they live.

What do you like least about where you live or own property in the survey area?

Area #	Problems with natural features of the land	More development	Problems with location	Taxes	Other	
1	0	5	6	4	2	Thurston County
2	1	1	4	2	0	
3	1	0	0	1	0	
4	2	0	2	0	0	
5	0	2	1	2	0	Mason County
6	1	0	0	0	0	
7	2	3	6	0	0	
8	6	4	5	1	3	

Table 6: Cross tabulation of open-ended question asking respondents what they least like about where they live or own property in the survey area with the area in which they live.

Do you favor neighborhood service in your neighborhood?	% of total participants	1	2	3	4	5	6	7	8
Yes	14%	21%	40%	0	14%	0	0	5%	19%
No	58%	58%	50%	63%	43%	71%	29%	63%	58%
Don't know	2%	0	0	13%	0	0	14%	0	2%
No response	26%	21%	10%	24%	43%	29%	57%	32%	21%

Table 7: Cross tabulation of whether respondents favor neighborhood services with the area in which they live (95% confidence limits).

What experience have you had with aquaculture?	% of total participants	% in Thurston County	% in Mason County
Did not know it exists	2%	0	2%
Know that it exists	27%	38%	23%
Have visited an oyster farm	43%	46%	41%
Have been employed by an oyster farm	19%	8%	23%
Other	10%	8%	11%

Table 8: Cross tabulation of experience respondents have had with aquaculture vs. County in which their property is located (99% confidence limits).

Would you agree to limitations on sport fishing?	% of total participants	Often	Sometimes	Never
Yes	22%	17%	26%	33%
No	57%	81%	54%	53%
Don't know	0.05%	0	0.07%	0.07%
No response	16%	1%	12%	0.07%

Table 9: Cross tabulation of use of the inlets for sport fishing with whether respondents would agree to limitations on sport fishing (90% confidence limits).

APPENDIX F

URBAN RESIDENTIAL ENVIRONMENT-MASON COUNTY

Agriculture

Not a compatible use in the urban residential environment

Must comply with practices enumerated under Rural environeent

Prohibited: largescale animal feedlots, corrals, stockyards, facilities for the retention or storage of their waste

Buffer of permanent vegetation required to retard surface runoff

Pesticides: Regulated by (RCW 15.58) Wa Pesticide control act (RCW 17.21) Wa Pesticide Application Act

High nitrogen fertilizers prohibited

Aquaculture

Shoreline development adjacent to unique areas especially suitable for aquaculture shall practice strict pollution control procedures

Aquaculture activities include land based structure

Aquaculture enterprises located where navigation of commercial traffic won't be significantly restricted

No permit required

Floating aquaculture located where protected from extreme currents, winds, waves, etc.

Allowed outright:

A. Totten Inlets
   1. Section 28 T.20N Range 2West to section 32 T.20N Range 2W
   2. Section 1 T.19N Range 3West to Section 11 T.19N Range 3W
   3. Section 11 T.19N Range 3West to Section 14 T.19N Range 3W

B. All of Skookum Inlet

Floating aquaculture permitted in other areas subject to review by Administrator and/or Shorelines Advisory Board

Protect aesthetics

Private interests used for commercial purposes require permit from the Washington State Dept. of Fisheries

Forest Practices	Notices of logging operations which don't require Shorelines Substantial Development Permits shall be made to the Administrator Herbicides, Insecticides, according to Wa. Pesticide Application Act (RCW 17.21) and Wa. Pesticide Act (RCW 15.47) No logs yarded through streams or rivers. Accidentally injected slash shall be removed Trees within 50 feet of the water shall be felled away from the water Keep terrain in shape Slash cleaned and burned where it won't get into water Shorelines of state wide significance shall follow the Act When practical roads should be outside shoreline area Selective removal of timber adjacent to waterways when practical Revegetation accomplished as quickly as feasible Accumulation of slash in water not permitted under the Act
Commercial Development	Redevelopment in mixed areas promoted Priorities to private developers who serve public needs Variences should be favored by involved agenices New construction not permitted in unmixed areas on water side of road Comply with all state and county health regulations Water oriented development on the shorelines shall be discouraged Priorities to water dependent developments Conditional uses encouraged to locate on upland side of the road Uses permitted outright: 1. Water Dependent a. Marinas b. Marine fueling facilities c. Ferry and boat terminals d. Waterfront parks 2. Water Oriented a. Seafood stores b. Boating and Fishing Supplies c. Eating/Drinking Establishments d. Import shops e. Parks and Recreation facilities

Uses permitted conditionally:

1. Hotels and Motels
2. Boatels
3. Restaurants
4. Other

If conditional uses comply with requirements they convert to water dependent use

Encourage marine development for public use

Other uses require Varience

Landfills and Dredging

Shoreline areas not considered for sanitary landfill or disposal of solid wastes

Wood product materials should be prohibited for landfills

Priority to landfills for water dependent uses

Dreding permitted:

To deepen or widen navigation channels

To deepen or widen commercial moorage

To create settling lagoons

To remove roots, logs, brush, etc. to create access to navigable water

For certain shellfish farming, harvesting, and protection operations

In conjunction with flood control

To obtain peat and peat moss

To facilitate channel clearance and improvement

Dredging restrictions:

All urban industrial dredging restrictions shall apply in the environment

Marinas

Must be aesthetically compatible; spillages <u>should be</u> manageable; shallow embayments with poor flushing <u>should not</u> be used for overnight or long term moorage

Marinas must comply with state and federal regulations

A buffer zone of vegetation is required

Marinas <u>should be</u> located near high use areas

Residential Development	Shall be aesthetically compatible with environment Setbacks: minimum of 15' from ordinary high water line (can't reduce view of neighboring structures) Cluster development, small single-family residences (close together), condominiums, and apartment houses discouraged Total number of dwellings in PUDs shall not exceed number permitted in regular subdivision in this environment Must comply with county regulations No addition or modification shall substantially reduce view of water
Recreation	Recreation is encouraged All proposed recreation developments analyzed (what does that mean?) Designed to protect scenic and environmental quality Development of fishing piers encouraged
Solid Waste	Local and state health regulations must be complied with Sanitary landfills restricted within water course and floodplains

RURAL ENVIRONMENTS

	MASON	THURSTON
Agriculture	-Discourage tillage patterns causing runoff into water -Erosion control: SCS/USDA -Feedlots prohibited in floodways -Buffer of permanent veg. required -Barns, feedlots, corrals, stockyards, etc. located to retain wastes; no runoff; must comply w/EPA -Floodplain const. conform to appropriate legislative regulations -Existing watering grounds (creeks, rivers, lakes) preserved. Development discouraged -Dumping of fertilizers and chemicals in water prohibited if harmful -Federal, state and local codes apply -Feedlots, animal wastes located away from shorelines and wetlands	-Permitted -Operations affecting water quality causing erosion, or involving pesticide application are subject to state and federal regulations.
Aquaculture	-Same as Urban (Mason)	-Same as Conservancy (Thurston)

	MASON	THURSTON
Forest Practices	-Same as Urban (Mason), except: -Vegetation along shoreline must be left intact except for bridges and culverts -Reforestation within 18 months. Density: 350 trees/acre of commercial species	-Same as Conservancy (Thurston)
Commercial Development	-Preservation of good agricultural land; creation and expansion of recreation facilities for public use -Emphasis on aesthetics -Commercial development prohibited from encroachment on agricultural land	-Limited to public, water-oriented or neighborhood services -Parking between shoreline and facility is prohibited -Developments impairing upstream and downstream land use, wildlife, and stream hydrology are prohibited
Landfill & Dredging	-Same as Urban (Mason)	-Same as Conservancy (Thurston), except: -Fill on 50 year floodplains is permitted, but restricted.
Marinas	-Same as Urban (Mason)	-Prohibited (along with boat launches) in shallow embayments and spit bars -Parking permitted beyond 50' with certain restrictions

	MASON	THURSTON
Residential Development	-Same as Urban (Mason) (no exceptions for structural setbacks)	-Same as Conservancy (Thurston), except: -2 units/acre minimum lot size; adjusted with increasing slopes -Setbacks: 50' or height of building, whichever is greater
Recreation	-Same as Urban (Mason)	-Low to medium intensity; emphasizes control of recreation facilities and intensity -Development should not reduce "seriously" prime agricultural and forest land -Other provisions same as Conservancy (Thurston)
Solid Waste	-Same as Urban (Mason)	-Same as Conservancy (Thurston)

CONSERVANCY ENVIRONMENTS

	MASON	THURSTON
Agriculture	-Same as Rural (Mason), except: -Feedlots and stockyards prohibited	-Same as Rural (Thurston), except: -Permitted only if not substantially altering character of shoreline
Aquaculture	-Same as Urban (Mason)	-Permitted if not substantially altering shoreline character or degrading water quality -Permit required for uses materially affecting shoreline and normal public use of water (except recreation) -Practices not requiring permits are listed
Forest Practices	-Same as Rural (Mason)	-Adopted from Forest Practices Act, 1974
Commercial Development	-Human intrusion only; to have minimal impact on natural characteristics -Commercial development on shorelines limited to waterdependent uses for public rec. -Water-oriented conditional uses prohibited	-Low-intensity only (i.e., rec. in conformity with conservancy uses)
	-Landfill prohibited -Dredging: same as Urban (Mason)	-Landfill for creation of new land area, extension of septic tank drainfields prohibited -Prohibited in 100 year floodplains -Dredging of toxic sediments is regulated -Bulkheads must conform to State Fisheries standards

	MASON	THURSTON
Marinas	-Prohibited	-Prohibited (except where upland designation permits) -Landfills prohibited -Specific conditions for boat launch siting and parking facilities (prohibited within 200' (in other words: prohibited)
Residential Development	-Same as Urban (Mason)	-Developers must indicate plans for dealing with vegetation, erosion, sewage disposal, ground water, storm-water runoff, & resident access to shore-shorelines -Building over water prohibited -Multi-family residences prohibited -Single-family regulations deal with geographical hazards, suitability, and and aesthetics -1 unit/acre minimum lot size (adjusted for slope increas)
Recreation	-Same as Urban (Mason)	-Low-intensity; facilities development and pesticide use subject to state and federal regulations, and to stipulations of assoc. uses in a conservancy environment -Motor boats prohibited on lakes smaller than 75 acres -1 parking space for every 10 acres of surface water maximum -Artificial habitats must not pollute or interfere with surface navigation

	MASON	THURSTON
Solid Waste	-Prohibited	-Disposal of inert substances subject to permit and limited to materials found shoreline area -Disposal subject to regulations of Thurston solid waste plan

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