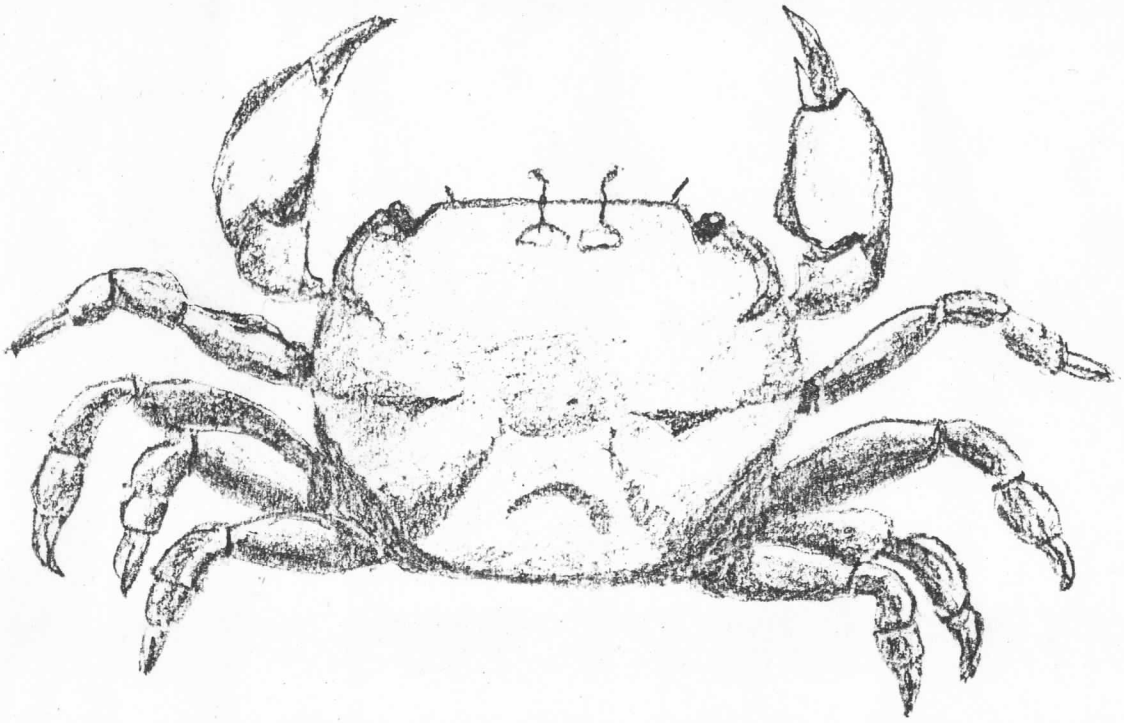
Comprehensive Study of Stretch Island



JUNE 1980

COMPREHENSIVE STUDY OF STRETCH ISLAND

Including Baseline Sampling,
Water Quality Analysis,
History of the Island and
Interviews with Island Residents,
and Effects of Oil Spills on
Tidelands.

Prepared by

Political Ecology Students

Environments: Water Quality, Ecology and Sociology

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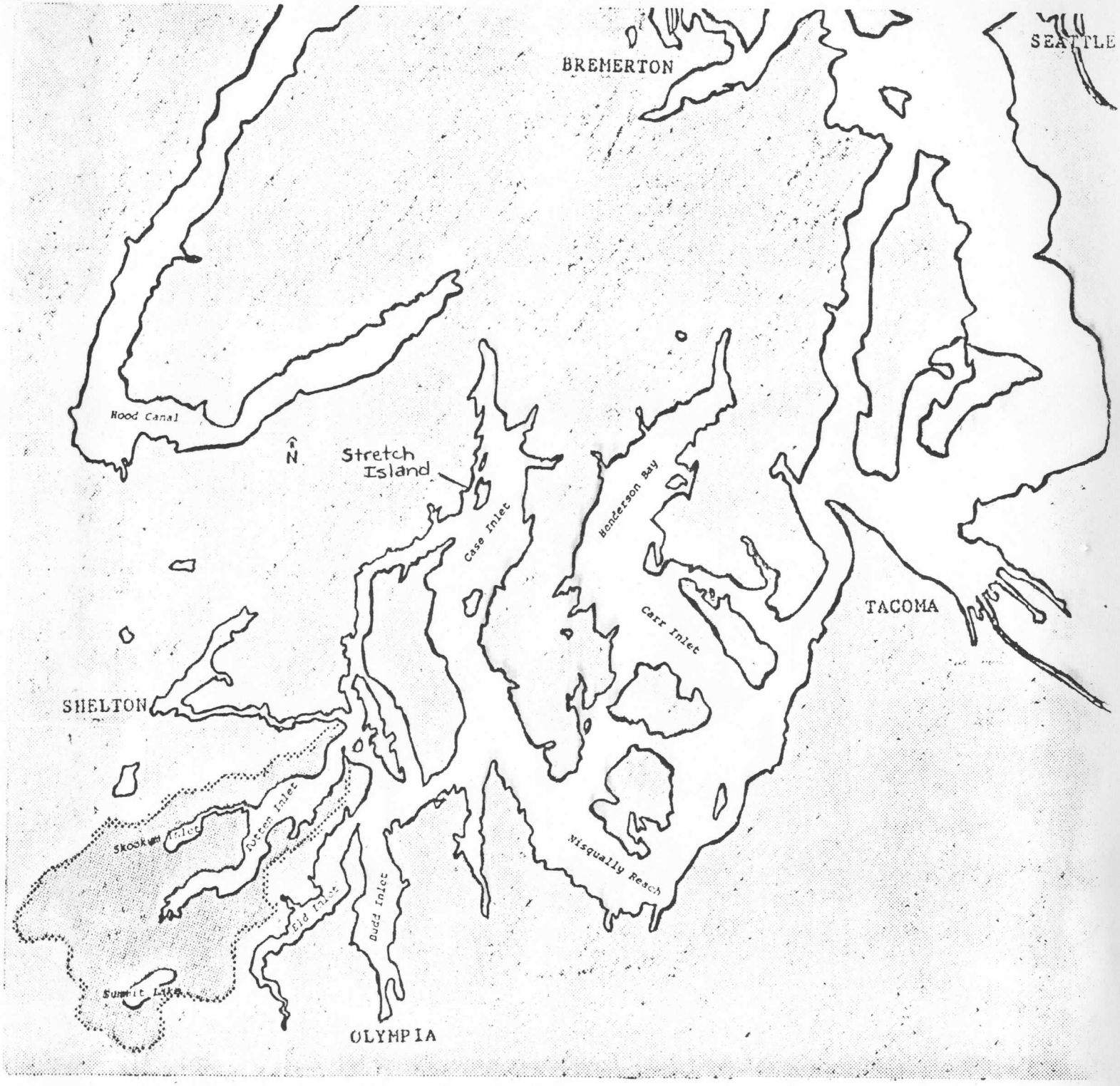
Joan Liberman, Mason County Regional Planners

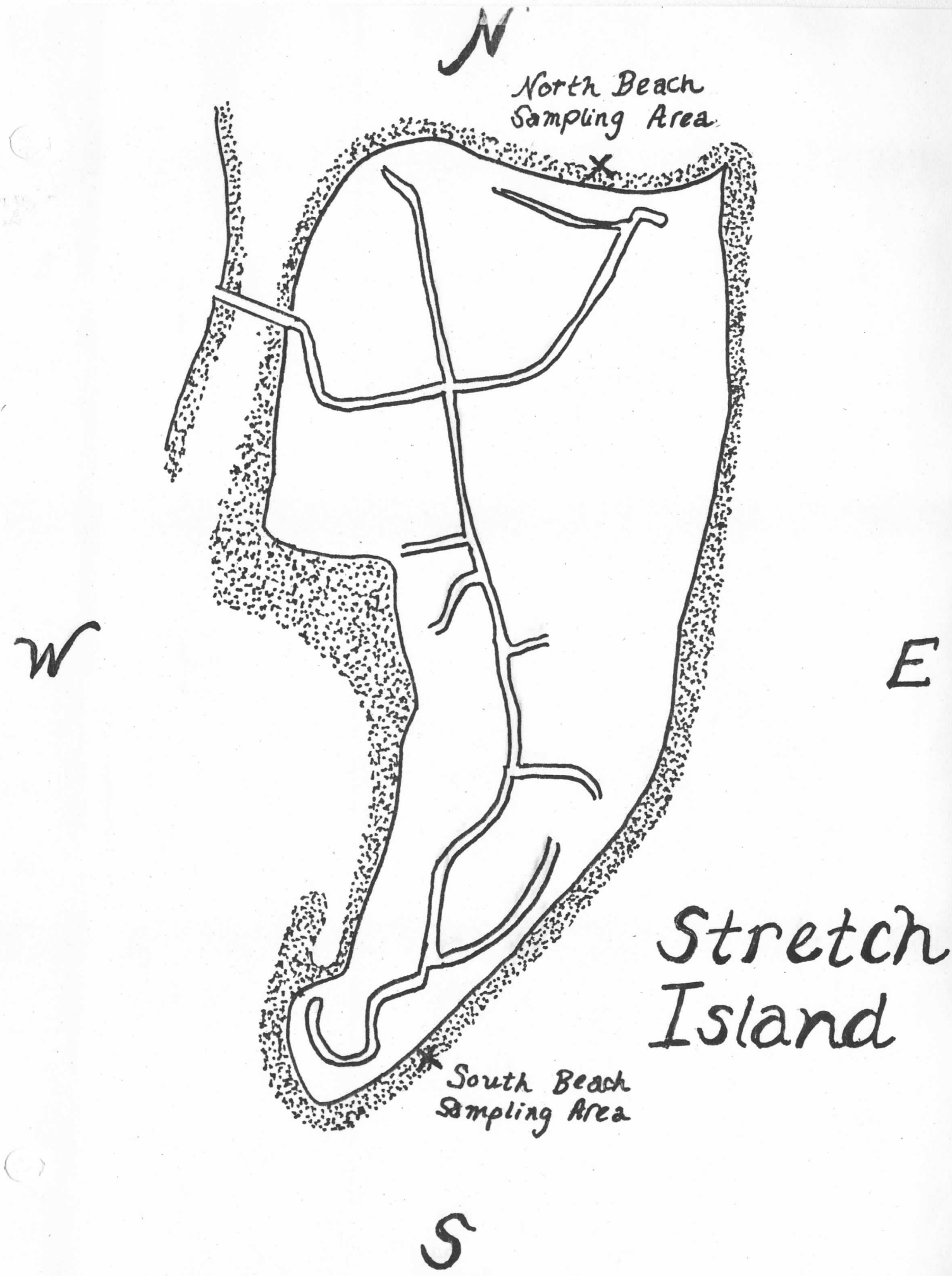
Fred Gardner, The Washington State Department of Ecology

Our instructors Kaye V. Ladd and Bob Sluss, The Evergreen State College

The residents of Stretch Island

LOWER PUGET SOUND AREA

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INTRODUCTION

The Washington State Department of Ecology began field sampling as a part of their Baseline Study Program in order to document the natural changes in the marine environment, and to enable them to separate the natural changes from those caused by people. The main concern was the increased threat of marine oil transport to Puget Sound. Through the use of federal, state and local programs data has been compiled on a yearly basis for the northern Puget Sound region since the program began in 1974. By collecting this information over a long period of time the Department of Ecology would have the ability to assess the total damage caused by an oil spill or other tragedy, not only for the direct mortalities and short term impacts but comparable data would be available for determining the long range impact by doing a baseline study on the affected areas after about a year has elapsed. For this reason it is important to know the normal year to year changes in order to assess the damages to a marine environment.

Sampling sites were chosen in the northern Puget Sound region because of the greater impact it would suffer in the event of an oil spill, but it is also important to inventory the organisms in the southern Puget Sound region as it is continually taking in low levels of pollution. For this reason and the reason of availability our group chose Stretch Island in the northern part of Case Inlet to do a baseline project. Although the area probably won't be studied over a period of years in the near future, as is essential in making the damage assessment of a catastrophe, the data will be available for comparison if the area is inventoried again.

Since one of the main purposes of the baseline study is to eventually be able to assess the damages of a catastrophe such as an oil spill upon the environment we have included a section on the effects of oil and petrochemicals on marine intertidal organisms. Another purpose of the project was to gain experience in using different types of sampling techniques essential to estimating the population of organisms in a given area. We tried several sampling procedures and discuss the validity of each.

Extensive water quality was done on the north beach and the results of our findings are discussed. Despite the low level of nutrients the water is classified as AA water according to the Water Quality Standards of Washington.

Our study also includes the history of the island and the results of interviews with some of the residents. We found their attitudes about the environment and the community important in determining the future development and use of the natural resources available on Stretch Island.

Chapter 1

BIOLOGICAL IMPACTS OF OIL ON THE TIDELANDS

Biological Impact Of Oil on the Tidelands.

Introduction

Puget Sound is one of the most unique marine environments of the entire Pacific coastline. Incorporating a diverse range of aquatic habitats - varying from a multitude of highly productive estuaries to rugged, rocky shorelines - the area is unexcelled in its scenic beauty as well as its commercial and recreational value.

The introduction of oil and other petrochemicals through accidental spillage presents numerous environmental problems. The foremost problem with oil spills in Puget Sound are the water circulation patterns and the strong, highly localized winds. If, for example, an oil spill were to occur in the Straits of Juan de Fuca, where the winds and tidal currents are strong, the danger of the oil spreading to the inland waters of the Sound, as well as the Straits of Georgia, would be extreme. The vigorous mixing action through the Straits would also complicate cleanup procedures, and consequently increase the degree of environmental damage.

Geographically, Puget Sound is particularly susceptible to oil spills. The rugged, heavily indented coastline and numerous islands opens up hundreds of miles of beaches to damage from oil pollution. The region is also a major resting area on the Pacific flyway. Estuaries and marshland areas would be particularly vulnerable to oil pollution during times

of peak migratory activity. Commercial and recreational fishing would also be seriously affected if a major spill occurred in the Straits of Juan de Fuca between June and September.

There have been numerous studies done on the specific effects of very localized forms of oil or petrochecal pollution. Very little is known, though, on how a major oil spill would affect, on a broader scale, an ecosystem as complex and diverse as that of Puget Sound. This may be attributed to the fact that there has never been a major spill, and only a smallhandful of lesser incidents on which to base any hypothesis. Much information, then, on the toxicity of oil in the tidelands must be ascertained from spills in other regions, with similar organismic community structure and comparable habitat types.

There are many factors that influence the severity of oil or petrochemical pollution of the tidelands. Factors such as the differences in life and the habitat type, the type of oil or petrochemical, the residual effects of previously spilled oil, and oceanographic and meterological conditions at the time of the spill, all have a strong impact on the extent of damage caused by a spill.

To illustrate this, after a major oil spill in Santa Barbara, California, scientists concluded that after one year they could detect little or no biological damage as a result of the spill. In contrast to this, another

major crude oil spill in Baja, California, had devastating results. The biological damage persisted for years, and after four years it recovered only 90% of its original community structure in terms of population.

In this chapter I will examine first the chemical properties of oils and petrochemicals, and how they affect the degree of environmental damage resulting from a spill. Secondly I will assay various environmental factors and how they influence the dispersal rate of an oil or petrochemical. Finally I will examine specifically how an oil spill would affect the various organisms unique to the north and south beaches of our baseline study.

Chemical Properties and Toxicities of Oils and Petrochemicals.

The environmental damage of an oil spill is hard to predict. The beach type and organismic community, and the combination of other external elements (e.g. weather, hydrological energy, etc.), makes the estimation of damage from a hypothetical oil spill an extremely involved and complicated task. Certain general characteristics, though, of oils and petrochemicals have been identified that apply to all habitats and all organism groups.

Because the number of compounds found in oils and petrochemicals is so large, four broad catagories have been established to group those compounds with similar structural properties. Paraffins are stable compounds

saturated with hydrogen atoms, and having a straight or branched chain which contains no double bonds between carbon atoms. Napthenes, or cycloparafins, are also saturated with hydrogen atoms, but the ends of the carbon chain are joined to form a ring structure. Olefins are straight or branched carbon chains which are not completely saturated with hydrogen atoms, and therefore have some double bonds between carbon atoms. Olefins are usually more characteristic of petrochimical products rather than crude oils. Aromatics contain rings of carbon atoms where the bonding in the rings is characteristic of that in benzene.

There are several factors that influence the length of time that oils are present in the environment after a spill, as well as the pollutants degree of toxicity and impact upon the marine community. Some of these factors include the carbon number of the oil or petrochemical involved, the degree of unsaturation, and the extent of aromaticity.

Oils or petrochemicas with a low evaporation rate, or those which tend to stick to or interact with the substrate, generally are more persistant in the environment. Oil substances with large molecules (i.e. those with high carbon numbers) tend to evaporate slower, especially if they tend to interact with each other or the substrate.

The toxicity of an oil pollutant is directly correlated to its reactivity; the more reactive a compound (i.e. the easier it will react with

other substances to change its chemical structure) the more likely it is to be biologically harmful. Large aliphatic compounds, most notably the paraffins, do not mix easily with saltwater, and tend not to react biologically. Therefore the toxicity of these compounds is almost always low[1]. The toxicity of olefins tend to be notably more harmful due to the presence of carbon-carbon double bonds, which increases the tendancy of reactivity. Aromatic compounds are very reactive, and consequently are extremely harmful to biological systems. Naphthenic, or cycloparaffinic, compounds are aromatic in character but contain double rings which tend to stabilize each other chemically. The toxicity of these compounds is generally low since they do not react easily, nor are they highly soluble.

Compounds with smaller molecules, especially those that are more reactive, are considerably more damaging since they can easily penetrate tissue matter, hence being highly toxic. The smaller molecules though, due to their low carbon numbers, tend to evaporate much more quickly than compounds with larger moecules, and therefore are not as persistent after the spill.

1. They do, however, cause other problems which are not of a biological nature, e.g. coating organisms with oil to the extent that gas exchange becomes imposible, and suffocation takes place.

Environmental Factors Effecting the Dispersal Rate of Oils and Petrochemicals.

After a spill the rate of solubilization, evaporation, emulsification, and natural dispersion depends upon several environmental factors. For example,high air temperatures and moderate wind conditions speed the process of evaporation of light, toxic compounds. If the conditions are too windy, though, it is likely that the pollutant will spread out more quickly and encompass a greater area, therefore contaminating more shoreline.

High water temperatures hasten the rate of solubilization (dissolving of the oil) of aromatic compounds. It also increases the rate of biological degradation and incoporation into the water column and tends to reduce the viscosity of the oil allowing it to disperse more readily.

The hydrological conditions of the shorelines affected by the spill influences the impact of oil on the intertidal communities. High energy conditions (heavy wave action) tend to increase the rate of solubilization and emusification. If the pollutant is a toxic aromatic compound, rapid incorporation into the water column would increase the severity of ecological damage. However, if the pollutant is an aliphatic compound (a paraffin, or to a lesser extent an olefin), hydrological conditions favorable to the dissipation of these relatively non-toxic compounds would significantly reduce the degree of damage. Under low energy conditions, the

heavier aliphatic compounds tend to remain in the environment for a considerably longer period of time. Low energy systems, however, do favor the evaporation of toxic compounds, and therefore minimize their incorporation into the water column.

The benefits or disadvantages of these environmental influences are all relative to the local of the spill, in open water or close to shore, and to the clean up action that is chosen. If a spill is far enough from shore where the danger of shoreline contamination is minimal, calm seas and low winds facilitate clean up procedures considerably. Cooler air and water temperatures also tend to impede further spread of the slick. If the spill were closer to shore, the relative merit of these influences would depend largely upon the method of clean up employed to contain or remove the oil or petrochemical. If a shoreline is heavily contaminated, heavy wave action will help to flush the substrate and dissipate the highly toxic residual compounds. A condition such as this, though, would tend to exist only after the spilled oil has been exposed to the weathering processes for a longer period of time, and therefore would not be characteristic of freshly spilled oil.

In hot weather or when freshly spilled, oils are thinner and have a tendency to seep into sand[2] and crevices between the rocks. On a beach of

2. Oil contaminants do not readily penetrate wet sand, but incoming waves (particularly in a high energy system) may throw fresh sand over stranded oil, burying it like geological strata (Smith-Nelson, 1970).

course peebles or cobbles, oil may penetrate up to one half or one metre between the stones, from which it is particularly hard to remove. A saturated substrate under these conditions may be purged by heavy storms, which are apt to remove suface layers. In a beach with larger rocks and cobbles (which tend to be more stable and unaffected by heavy wave action), the only way that the contaminant could be dissipated would be through biological degradation.

Impact of Oil Upon the Organisms Unique to the North and South Beaches of Stretch Island.

The beach types of the north and south sampling sites can be broadly classified into two catagories: mixed-fine for the north beach, and mixed-coarse for the south. The primary criteria for the classification of beach types are the physical characteristics of the shoreline (i.e. size of the rocks, type and composition of the substrate, exposure to wave action, etc.), and the type of habitats which are created. First the phyisical features that are characteristic of our two beach types will be described, and then the habitats which they typically provide.

Mixed-Fine: North Beach

This habitat consists of a mixture of mud, sand, and gravel. Since this beach type is found primarily in low energy areas, it is extremely common in the southern Puget Sound, due to the mixed glacial sediments and the protected nature of its waters. Very often the mixed-fine habitat

of oil on the mixed-fine and mixed-coarse habitats of the north and south beach sites. Secondly, the discussion will examine the specific impact on the most prominent organisms unique to the two beach types.

General Impact: Mixed-Fine

The hydrological energy of a given shoreline is crucial in determining the impact of an oil spill. High energy systems are flushed most rapidly of residual compounds, while low energy systems (as in the case of the mixed-fine habitat) take considerably longer to be rid of these highly toxic remains. The wave action of the mixed-fine beach type is usually strong enough to cause some shifting of the substrate, but generally not strong enough to flush the system rapidly. Oil deposits can therefore be mixed into the substrate by moderate wave action and be retained there for long periods of time. Oil is also typically absorbed onto clay, and can be further mixed into the surface sediments by burrowing organisms, such as clams. The quantity and toxicity of the pollutant will also be a deciding factor in the severity of a spill. The relatively poor flushing of the system suggests that the probability of both immediate mortalities (suffocation, impaired mobility, or loss of function), and chronic effects (unsuccessful development, or incorporation of oil into tissue matter), are all very likely.

Crustaceans

Five of the crustaceans on the Department of Ecology's list of Significant Biological Resources of Washington[3] occur on mixed-fine beach types; only

one (Balanus spp.) showed up in our sampling quadrats. Sand fleas were abundant in the upper reaches of the tide zone, but these were too small to show up in the sampling screen. The other species common to the mixed-fine habitat are Dungeness crab (Cancer magister), red rock crab (Cancer productus), and ocean pink shrimp (Pandalus jordani).

Barnacles appear to be fairly resistant to oil pollution as far as toxicity is concerned, but may be susceptible to smothering by a heavy direct coating of oil. Judging from evidence gained from previous spills, the smaller crustaceans seem particularly susceptable to oil pollution. Sand fleas have been shown to suffer severe mortalities after two hours exposure to No. 2 diesel oil (Cardwell, 1973). This may be a result of the greater surface/volume ratio of the smaller organisms. The larger crustaceans probably will not suffer significantly high mortalities, but commercially important shell fish may become tainted for many seasons.

Molluscs

Of the thirty-one molluscs on the Biological Resources List, ten of these

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3. Significant Biological Resources of Washington is a list of 336 species of marine oriented plants or animals which the Dept. of Ecology feels are "significant". These species have been placed on the list on the basis of one or more of the following criteria: (1) Commercially obtained for food or for industrial products. (2) A known important food item of a commercial or recreational species. (3) Recreationally important. (4) A known important predator or competitor on a commercial or recreational species or on a food item of a commercial or recreational species.

are fairly common in the mixed-fine habitat. Not all of these were found in our sampling quadrats. Those species recorded in our sampling data were the cockle (Clinocardium nuttalli), the mussel (Mytilus spp.), and the moon snail (Polinices lewisii).

The effects of oil and petrochemicals on the intertidal molluscs will vary a great deal. The 1969 Santa Barbra crude spill had no apparent effect on the intertidal mollusc communities. A spill of No. 2 diesel oil near Anacortes in 1971, though, caused 100 percent mortality of the clam Vernerupsis. The severity of the spill tends to be proportional to the water temperature; higher temperatures increase the mortality rate. Another factor determining the impact of oil in this habitat type is the type of oil involved. Molluscs do not appear to be very susceptible to low aromatic crudes (as in the Santa Barbra spill), but tend to be very sensitive to refined products and petrochemicals (as in the Anacortes spill). Oil that is mixed with the substrate can lead to persistant tainting and can lead to the possibility of recurring mortalities if the sediments are mixed.

Echinoderms

Echinoderms are found to some extent on a mixed fine beach type, but this habitat does not constitute a preferred habitat. Most of those that do inhabit this area are subtidal and escape the heavy oil coating that can occur in the intertidal region. The only echinoderm that showed up in our sampling quadrats was the sand dollar (Echinarachnius excen-

tricus).

Echinoderms in general are severely affected by oil. These creatures maintain an equilibrium between their internal salinity and the external water and do not have adequate defense mechanisms to protect themselves from an oily substance. Exposure to oil or petrochemicals usually causes narcotization with loss of gripping ability, which thereby exposes the animals to wave damage and increased predation. Repopulation tends to be slow, due to the tendancy of oil sludge and residual compounds to be buried in the substrate, and subsequently reexposed by further wave action.

General Impact: Mixed-Coarse

The mixed-coarse beach type is generally associated with high energy wave or current conditions. Again, the biological impact of an oil spill in this habitat is dependent on the type of oil or petrochemical involved. Cleanup procedures are hampered by stronger wave action, which tends to disperse the slick and contaminate a greater expanse of shoreline. The heavier wave action can also emulsify oil in the intertidal zone, incorporating the contaminant into the substrate and causing an initially heavy coat of oil. Light toxic compounds, which might otherwise evaporate on the surface, tend to be dispersed into the water column with the potential of initially high toxicity. Flushing of the system is generally rapid due to the high energy conditions, but heavy coatings

may remain in the high intertidal zone for long periods of time. The immediate impact upon the mixed-coarse habitat would be narcotization of snails and purple shore crabs, as well as damage to numerous small fish and their eggs.

Crustaceans

Sampling of the south beach was focoused exclusivly on barnacles (Chthamalus dali and Balanus glandulus), and purple shore crabs (Hemigrapsus nudus and H. oregonensis). Since these were the dominant species of the sampling site and are classed under the same phylum (crustacea), the discussion will dwell primarily with the effects of oil on this catagory of species.

Data pertaining directly to the Hemigrapsis spp. was not available, but data on the red rock crab, which has roughly the same feeding habits but occupies a slightly lower zone, was used instead. The red rock crab is quite resistant to oil and its toxic compounds, but tainting of its tissue is quite likely. Tainting would probably be more severe of the purple shore crabs since their exposure to oil and other contaminants is more prolonged, and flushing of their prefered habitat is not as strong. This tainting condition has been found to persist for more than two years in other Cancer species (Scavratt, 1972).

Barnacles have shown locally high mortality rates in intertidal spills. The barnacles appear to suffer more from the mechanical effects of contamination (i.e. suffocation by a thick layer of oil), rather than being poisoned by the toxic compounds (Chan, 1972). This evidence would sug

gest then that barnacles would be more susceptable to heavy crudes, and more tolerant to the lighter, toxic compounds.

Chapter 2

THE BASELINE

Methodology for the South Beach Baseline: The Mark and Recapture Method for Determining Crab Population

A thirty foot baseline was set up along the foot tide mark, which we had marked with stakes at high tide the night before. Two transect lines at right angles with this baseline were extended 165 feet down the beach by the same process used in setting up the North Beach baseline. We divided this area into sampling quadrats according to apparent zonation of barnacles and rock size. The first sampling quadrat, which we called Zone 1, consisted of small rocks mostly under 2" in diameter. Scattered here and there on some of the larger rocks was Balanus glandula and Chthamalus dalli, though this occurred very infrequently in this zone. The second quadrat, Zone 2, consisted of larger rocks with a much larger barnacle population; again Balanus glandula and Chthamalus dalli. The third quadrat was very heavily populated with these two species of barnacles, and this quadrat we called Zone 3.

The population of Hemigraphsus nudus found on this beach was determined by the mark and recapture method,(introduced by Pielow, 1974.)

After we set up the baseline three of us walked down the beach from the top of the baseline to the water line turning over random rocks. We caught as many as we could and put a dab of pink fingernail polish on their carapace, being careful not to paint the eyes. We set them down under the rocks we found them under and recorded the quantities of crabs marked. We continued this until we had marked 150 crabs.

The next day,two low tides later (which gave ample time for the marked crabs to mix freely), we walked up the beach turning over random rocks and counted the total number of crabs we saw and recorded any marked ones. We recaptured 800.

Methodology for the South Beach Baseline: Determining the Barnacle Population

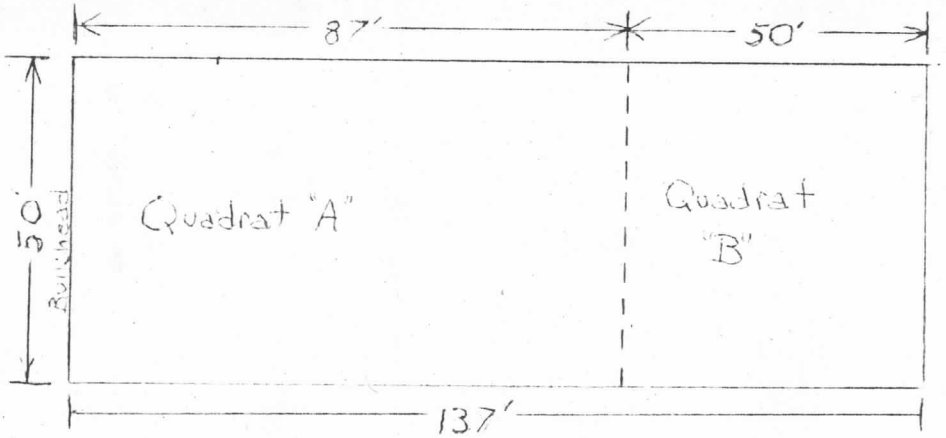
In order to determine the number of barnacles on the South Beach we picked sampling sites randomly by the same process we followed on the North Beach. We randomly picked ten sets of coordinates in Zone 1, five sets of coordinates in Zone 2, and 15 sets of coordinates in Zone 3. (we attempted to coordinate the size of the sampling zone with the amount of sample sites we sampled, thus the varied numbers of sets of coordinates.) The points were plotted and we counted the barnacles within a square yard, the point being the center of this square. This worked pretty well for Zone 1 but once we entered Zone 2 there were too many barnacles in one square yard to count so we reduced the sampling area to six square inches, and later compensated for this reduction in our calculations. The quantities of barnacles within this ½ foot square were recorded. The same was done in Zone 3.

In order to determine the amounts of each species of barnacle in each zone, we later went back and in each zone picked random, barnacled rocks and counted the amounts of each species and recorded it.

Methodology for the North Beach Baseline: The Screening Method

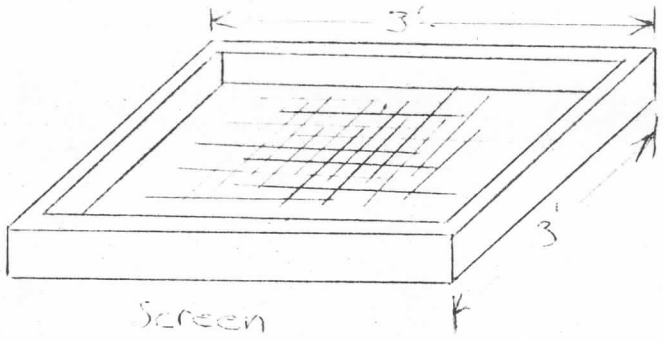
A fifty foot baseline was set parallel to a twelve foot tide mark along the bulkhead in front of the Uhlman's property. A compass bearing was taken from one end of the baseline to the other. Ninety degrees was added to this bearing in order to determine the two transect lines at each end of the baseline.

We divided the whole sampling area into two quadrats. The upper quadrat extended eighty-three feet along the transect lines down to the zero tide level. This will be referred to as sampling quadrat A. The second quadrat below the zero foot tide level will be referred to as sampling quadrat B. The water level, at lowest tide, was the endline itself for sampling quadrat B.



We next chose fifteen sets of coordinates for sampling quadrat A and fifteen sets of coordinates for sampling area B by random selection(picked numbers out of a hat). In order to plot these coordinates we treated the baseline as the x axis and the left transect line as the y axis. Using the graphing technique we measured, with a 100 ft. tape measure, over and down using the sets of randomly selected coordinates and followed compass bearings to keep our lines straight.

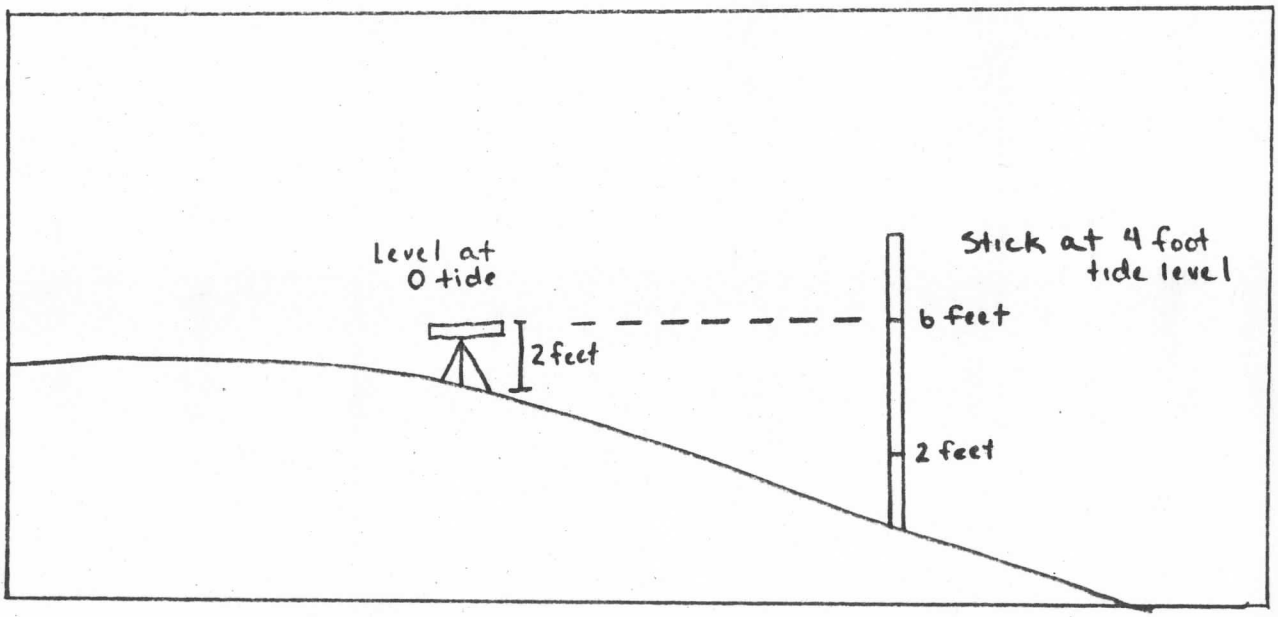
Once the point from a set of coordinates in the sampling quadrat wa plotted and located, we measured 1½ feet on four sides of it to create a square yard. With shovels we dug down 10 cm. into the substrate and dumped the extracted material into a ½" mesh screen with a wooden frame around it.(see illustration)



This sieve we took down to the water and swished it around until all particles of anything smaller than ½" had fallen through. We were careful to do this sieving outside of the quadrat as we did not want to dump excess substrate into an area that might be sampled later when the tide was out further.

After excess material washed out we counted all organisms left in the screen with the exception of worms and pieces of seaweed.

We recorded the tide level at each sample site using a basic surveying method. The level was determined by sighting across a level two feet off the ground to a stick eight feet in length. The hieght of the sighting level was subtracted from the hieght sighted on the stick. (illustration below)



Discussion of South Beach

After the sampling was done, we tabulated the results of the crab and barnacle counts. After doing this, we noticed a definite zonation of barnacles. Zone 1 had very few barnacles. Zone 2 had a very dense population of barnacles. Zone 3 was about one half as populated with barnacles as Zone 2.

The two species of barnacles varied in density in the three zones. Chthamalus dalli was about 60% of the whole barnacle population in zone 1, and Balanus glandula made up the other 40%. In zone two it was about half C. dalli and half B. glandula. In Zone 3 there was a larger population of B. glandula.

This zonation we believe is due to C. dalli's ability to withstand longer periods of dryness associated with the higher tide zone. In zones 2 and 3 however, B. glandula took up more rock space and seemed to occupy choice positions on the rocks. This coice position we saw as being around the vertical sides of the rocks. This way when the water turns the rocks over they are not buried in the mud.

Crabs

The crabs found were Hemographsis nudus and two Hemographsis oregoninsis, (which we did not include in the sampling). Since we found so few H. nudus in the recapturing procedure we feel that the marking procedure may not have met some basic assumptions for the mark and recapture method. These assumptions are:

1. The population is closed.
2. The probability of getting caught is equal for all crabs.
3. An animal caught first must not be more or less likely to get caught again.
4. Marking does not increase or decrease chance of death before recapture.
5. Released animals must mix freely.

The method of Mark and Recapture for the crabs on this beach may not have been appropriate because the crab population may drift with the currents. Therefore we would have had a whole new population of crabs on our beach. Our method of marking may have increased their chance of death by predation though this is very unlikely since we recaptured so soon (one day) after we marked.

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To increase the validity of our results, this method should be tested again.

Discussion of North Beach

This beach is charactaristic of a mixed-fine beach (see "Effects of Oil and Petrochemicals on Marine Intertidal Organisms" on page 3), ranging from pebbles down to sand and mud.

After sampling we found that there was apparent zonation according to barnacle mussel, limpet, and sanddollar populations. In Zone 1, we found no organisms. In Zone 2, there were a few barnacles and mussels. In Zone 3 the majority of the organisms were found. We got a wide range of population per square of each organism found because of the uneven distribution of organisms. In Zone 4, there was an abundance of marine worms but we did not count them. This zone also had a few barnacles and sanddollars, and although this habitat is excellent for shellfish, we only dug down 6" into the substrate which wasn't deep enough to find more than one of two.

South Beach Determination of Crab Population

Mark and Recapture method (Pielow, 1974)

N is population (this is to be estimated)

M= 150 population members caught, marked and released

n = 800 the number caught the second time

m = 8 the number of those caught which were marked

The formula used to estimate N was the following: $\hat{N} = \frac{(M+1)(n+1)}{(m+1)} - 1 = 13,438$

and the variance $(\hat{N}) = \frac{(M+1)(n+1)(M-m)(n-m)}{(m+1)^2(m+2)} = 16,793,374$.

The 95% confidence interval was determined by the following formula:

$\hat{N} \pm 2\ \mathrm{Var}(\hat{N})$, which gave a range of 5,242 to 21,634 crabs in 4,950 square feet.

South Beach Barnacle Population

Zone 1	0-87 (5/10)*
Zone 2	7,417 to 15,032 (5/ 5)
Zone 3	4,245 to 8,263 (15/15)

*The number of sampling sites with the organism over the total number of sampling sites within the zone.

North Beach Zonal Population

Zones	2	3	4
Organism			
Barnacles *Balanus glandula*	1 to 8(4/6)*	45 to 68(7/7)	3 to 8(7/8)
Mussels *Mytilus spp.*	0 to 3(4/6)	0 to 34(3/7)	0
Limpets	0	0 to 17(5/7)	0
Sanddollars *Echinarachnius excentricus*	0	2 to 21(5/7)	5 to 7(7/8)
Cockles *Clinocardium nuttalli*	0	0	1

Table These numbers represent the 95% confidence interval for the mean per square yard.

* The number of sampling sites with the organism over the total number of sampling sites within the zone.

SEAWEED

On the north side of the island three species of seaweed were found. These were Ulva lactuca, Enteromorpha intestinalism and Fucus distichus. These three species were also found on the south side of the island along with another species, Bonnemaisonia nootkana. Refer to Appendix III for more information about seaweeds.

Chapter 3

WATER QUALITY

INTRODUCTION TO WATER QUALITY

Water quality is the measurement of those chemical factors which indicate the suitability of the water for sustaining life. Many organisms can exist only under certain chemical/biological conditions and therefore any disruption in the ecological balance of the water column can have catastrophic results. Organisms unique to a given aquatic environment have adapted to a specific range of chemical conditions so that the relative "health" of the system can be assessed by measuring these characteristics.

The water quality of the waters surrounding Stretch Island were assessed using the following perameters: temperature and salinity, pH and alkalinity, nitrite and nitrate, phosphate, dissolved oxygen and chlorophyll, and coliform. The sampling was done on three different occasions: April 14, 23, and May 7, 1980. On the first sampling, surface and bottom samples were taken at the north and south beach sites. After analyzing the results, the data in comparison between the north and south beach sites were seen to be nearly identical. For this reason the second and third samples were taken from the north beach site only. See Appendix I.

PHYSICAL CHARACTERISTICS

The temperature and salinity very often determine the types of organisms that can exist in an aquatic environment. Some organisms are very sensitive to even the slightest change of these perameters.

The measurement of temperature and salinity, as well as being the very basic test for any water quality study, are also important in determining the saturation value for dissolved oxygen. Both of these measurements were quite normal for water in the Puget Sound.

pH AND ALKALINITY

The pH scale is used to define degrees of acidity. The pH of pure water is 7.0 and is considered 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. The normal pH level of seawater is around 8.0 . The level of acidity is an important measurement of water quality because aquatic organisms can exist only within a narrow pH range. Alkalinity is a measurement of the systems ability to resist acididty, or change the acidic level of the water column.

The pH for the waters around Stretch Island was very near the normal level for seawater and within the range of the State of Washington's Water Quality Standards for Class AA water .*

*See Water Quality Standards below.

NITROGEN

Nitrogen makes up 78% of our atmosphere, and indeed the air is the chief reserve supply of this nutrient. Most living things, however, cannot use elemental atmospheric nitrogen, but instead must depend on the nitrogen contained in soil minerals. Despite the abundance of nitrogen in the atmosphere there is often a shortage of nitrogen in the soil. The process by which this limited amount of nitrogen is circulated through the food web is known as the nitrogen cycle. The first step of this cycle is the ammonification stage, in which nitrogen compounds bound with other organic materials (proteins, amino and nucleic acids), are consumed by certain soil bacteria and fungi and released in the form of ammonia (NH_3) or ammonium (NH_4). The second step is the nitrification cycle, whereby common soil bacteria consumes ammonia or ammonium and releases nitrites (NO_2^-). The final step of this cycle is the assimilation stage, entailing members of another genus of bacteria oxidizing the nitrite back to nitrate again. Although plants can utilize ammonium directly, nitrate is the form in which most nitrogen moves from the soil into the roots. Once the nitrate is within the cell, it is reduced back to ammonium thereby completing the cycle.

Nitrogen in the water column can originate from several sources. One of the primary supplies is that which is leached away by runoff or by percolation. Agricultural runoff and sewage effluents are also major sources. Blue-green algae are able to fix gaseous nitrogen from the air into organic nitrogen containing compounds and thereby adding fresh nitrogen to the cycle.

The concentrations of nitrate and nitrite in all the sample was below average, and generally indicates a very low availability of nutrients in the system. When comparing the total phosphate and nitrogen concentration, the ratio between the two nutrients was extremely low (average of the four samples was 1:5). We were then able to conclude that since there was an overbalance of phosphorous the productivity of the system is controlled by the availability of nitrogen, i.e. a nitrogen controlled system. And since the overbalance is so acute, we would not foretell the algae bloom to be very prolific this spring.

PHOSPHOROUS

Phosphorous is directly involved in the transfer of energy in biological systems and is also a component of nucleic acids, both RNA and DNA. For these reasons it is required by every living system. Many kinds of rocks contain phosphorous and when such rocks are eroded by water, minute amounts of phosphate dissolve and become available. Detergents are also a source of phosphorous in the water column, but the dumping has to be fairly direct or the phosphorous compounds fix with other minerals or nutrients and do not readily dissolve.

Ortho is the form of phosphorous in a system that is readily available and metabolically useful. Phosphate on the other hand is the total amount of phosphorous available but not necessarily in a form that is metabolically useful to plants and animals. Commonly they are bound up with other minerals

(iron for example) in a form that cannot be readily utilized.

The results from the ortho/total phosphate experiments showed, with one exception a nearly equal ratio between the ortho and the total phosphates. This equal ratio means that the total amount of phosphorous present in the system was in the form of ortho and was readily available for metabolic purposes. The one exception was a bottom sample taken for the second water quality test. In this sample, approximately 15% of the total phosphate was in the form of ortho. Some of the discrepancy between this sample and the others (which were approximately 80-100%) may be attributed to a comparatively large sampling error but the error alone would not account for all the deviation.

DISSOLVED OXYGEN

The amount of oxygen present in water is a very important factor in determining the type of biological matter able to survive. Oxygen is produced in two ways; by plants through the photosynthetic process and by the exchange with the oxygen in the atmosphere. Oxygen is consumed by the respiration of organic matter; therefore, the more organic matter in the water the greater the oxygen consumption.

Using temperature and salinity, the oxygen concumption can be determined by comparison of the saturation value to the obtained sample value. Stretch Island water is above the 8.5 mg/l saturation value determined for that water. A higher value of dissolved oxygen in the sample water evidences an

increased amount of oxygen in the system. The fact that the sampling was done in early spring when the production levels of organic matter may still be low could account for the higher value of dissolved oxygen. Another factor involved may have been the wave action on the water during sampling since the water was slightly choppy on the days of the sampling. By comparing the results to other data obtained near northern Stretch Island in the months of April and May, 1958-60 (Collias, McGary, and Barnes,1974) the amount of dissolved oxygen in the water can be seen to be higher than the saturation value.

A measurement of the productivity of oxygen in the water over time is gained by incubating the samples either in the light or the dark for 24 hours. The net productivity that was calculated on the difference between the amount of dissolved oxygen in the light sample and the dark sample was less than .5 mg O_2/ liter/day. Since the productivity in the sample water kept in the dark increased there must have been light leaking in and that factor would create a smaller difference determining the net productivity.

Since chlorophyll is essential for photosynthesis the amount of chlorophyll present in the system is another way to measure the productivity of the water. The chlorophyll was extremely low at Stretch Island, reaffirming the low level of plant productivity.

The Biochemical Oxygen Demand (BOD) which measures the amount of oxygen consumed by respiration over time was calculated but came out to be a negative number which is of no value.

COLIFORM

Coliform are a diverse group of bacteria which are found in soils, plants, and animals. One type of coliform, called fecal coliform, is normally found only in the intestines of warm blooded animals. The measurement of the total coliform in water is an indicator of the level of pollution such as sewage contamination, agricultural runoff and livestock.

All coliform readings for Stretch Island were low with the exception of the surface sample from the second testing. The water currents at the time of this sampling were running parallel to the shoreline, i.e. southeast to northwest. The tidal currents during the other samplings were transecting the shoreline at roughly a 90 degree angle bringing in fresh seawater from the bay. The currents that were running parallel to the shoreline were probably picking up coliform bacteria which were seeping from the bank. Since coliform bacteria have very short lives in salt water, those colonies (organisms) originating from points other than the immediate area would most likely have expired by the time the water sample was taken.

WATER QUALITY STANDARDS

The state of Washington has established a set of criteria for the classification of water quality of fresh and salt water bodies. Four categories have been established: AA-extraordinary, A-excellent, B-good, and C-fair. Minimum standards have been identified for each class using the following perameters: fecal coliform, dissolved oxygen, and pH. In all accounts, the waters tested off the north sampling site of Stretch Island fit the criteria of Class AA water. Characteristic uses of Class AA water include the following: (1) water supply (domestic, industrial, agricultural), (2) wildlife, stock watering, (3) general recreation and aesthetic enjoyment, (4) general marine recreation and navigation, and (5) fish and shellfish reproduction, rearing, and harvesting.

Chapter 4

HISTORY OF STRETCH ISLAND

HISTORY OF STRETCH ISLAND

History: Lambert Evans

In 1872 a man named Lambert Evans, after fighting in the civil war, headed west to California. He wasn't satisfied with the country so he headed north ending up in Olympia. He rented a row boat and explored the southern half of Puget Sound. Lambert ended up on Stretch Island and set up a homestead claim for 160 acres, which became the home of the first grapevines on the island.

Lambert was a hard working young man, and almost totally self-sufficient. He had no horse to pull his plow, only himself to rely on, to clear his land for the small cabin that he built on the west side of the island. In clearing the land for the grapes he cut all the trees, and burnt all the stumps, a difficult job to say the least. Lambert planted fruit trees and, grew his own tobacco. He used to make trips to Olympia in a 16ft flatbottom skiff to sell his grapes. Often times Indians came to trade fish for the fruit that Evans had. Many years before Evans came, there had been an old Indian burial ground on the north side of the island.

Lambert was a bachelor for most of his life, but at the age of 72 Lambert married a 55 year old mail order bride that had been rejected from a friend on Harstene. Lambert sold chunks of his property to different people over the years. In 1917 Lambert died and his wife sold the rest of their land, and moved to Tacoma to live out her last years.

History: The Eckerts

In 1889 Adam Eckert left Albany New York and came to Stretch Island with his wife and five children. Adam had grown grapes in New York and was looking for a place out west. Eckert bought 40 acres from Evans on the north side of the island. The old grape juice plant that stands on the north end of the the island was built as the first home of the Eckert family. Many of Mrs. Eckert's prize possessions were sent out from New York by ship in 1893, when the main house was finally built. When the family first arrived Adam didn't realize that there wasn't a school near by for the children to attend, so little 12½ year old Walter and his ten year old brother had to row to Vaughn every morning. "Walter's mother was never quite sure whether she would ever see her boys again after they left each morning.[1]"

In the early years all trade and travel was done from a dock in front of the Eckert's home. In many places where grapes are today, there used to be fruit trees. The fruit was sold to the old sternwheelers that came to the island three times a week.

In 1904 Walter Eckert, the oldest of the boys, married a girl from Tacoma, who had been a friend of the family for years. The white house that Walter built for his wife, still stands on the north beach today. In 1911 the second generation of Eckerts gave birth to their first and only child, Ann. Ann attended the first Grapeview School, still having to row, because there was no bridge. After the eighth grade Ann moved to Tacoma to live with her mother's family, and to finish school.

Up to 1920 the area had been known as Detroit, but was then changed to Grapeview after people got tired of having there mail sent to Detroit, Michigan. During this time the Eckerts had the post office in the back of there home. The bridge was built around 1920; "When the bridge came, every thing changed ... The cars came.[2]" Walter Eckert had a grapejuice plant where his father first built. The plant still has some of the original equipment in it. Walter lived on to the ripe old age of 97. His daughter Ann now lives with her husband in a beautiful home on the beach right where her grandparents first landed.

Ann Eckret

Land Ethic

We asked Ann about her feelings concerning the proposed shoreline plan. This plan would designate certain areas as rural or suburban on the island. Suburban areas could be subdivided so that there would be four houses per acre. Rural areas could not be divided into lots smaller than 2½ acres.

Ann said, "I don't like the idea of people telling me what I can do with my land." She says these regulations might be fine for people in newer developing areas, but feels that if she, in extreme old age, could not keep up her house, should be able to rent it out and put up a trailer on her property to live in. She feels that if this proposed plan is put into effect she will not be able to do this. "Besides," she says commenting on the required 2½ acres designated for rural areas," who could afford to pay that much on waterfront?"

She does believe that people should be aware of where they build their homes. Erosion is a very important factor in deciding where to put a house. We talked for a while about the house being built on a feeder bluff on a nearby hill. "I would no more have built there than the man in the moon," Says Ann.

Sense of Community

Ann has always felt that Stretch Island was her home. She lived here as a child but had to move to Tacoma to live with her grandparents in order to go to school when she finished eighth grade. Ann went to Bellingham to go to college, then moved to Shelton where she met her husband, Francis who had a business there. Her parents lived on the island during this time, however, and it was still "home" for her.

We asked her about the changes she had seen in the community during the time she has lived here...,"Now there are so many people here...we don't even know them..." Mr. Eckret commented on the sense of community they experienced in the past when farmers would pitch in and help neighbors during harvest time. "People were really close then..,I think it's more individual now..."

Harvest time was a very important time to get together and help each other. "It wasn't until World War II that people began to have a comfortable living... until the navy yard..." "Then it became a bedroom community" Even before the navy yard took away workers from the island, the Eckrets saw a big change when the bridge was built. "Then when the bridge came, everything changed...the cars came...people came from the city."

In the last ten years they have noticed change because of robbery occurring and the feeling that it wasn't safe to leave the house unlocked. Before that it wasn't neccessary to lock doors.

Clams, Geoducks, Crabs

Both the Eckrets have noticed a huge decline in the geoduck,mud shrimp, and clam populations. The noticable decline came with the heavy population of the north end of the island.

Earlier in the century when Ann's dad owned waterfront property she, her husband, and friends would dig geoducks; "There were lots of them."

Steamer clams on the south side of the island were plentiful then, along with the huge rock crabs. "Clams and crabs like you wouldn't believe!" There also were a lot of mud shrimp and there still are some in the mud near the bridge and in the state park.

History: Howard, Rosch, Hillman

In 1909 A.E. Howard bought a large chunk of land on the north east end of the island, and built a large gray house that still stands today. "At the time this family was the center of the cultural life.[3]" One of the Eckert daughters married a Howard son, so there also was romance in the little farming community. A man by the name of Rosch bought the house from Howard. He intended it as a retirement home when he bought it. His wife was a city woman, however, and was not used to the rural life of a remote island. When she came to the island, which wasn't often, she brought her maid, and her chauffeur to take her to Bremerton to get her hair done. Peggy Hillman and her husband were the caretakers for the Rosch's. The Hillman, eventually obtained the land. This was sold off in later years. Today Peggy lives on the beach down by the state park.

History: The Summers

In 1918 Charles Summers bought the last of the Evans property from Lamberts widow. The Summers family came out in the early years, only during the summer. In 1932 Charles and his son Bill started the St. Charles Winery, which for many years was the number one winery in the state. In 1965 Bill sold out to a company on the east side of the mountains. Today the Summers again enjoy their home on Stretch Island as a summer place. The old winery is used as a museum today.

Bill Summers

Land Ethic

Bill Summers owns a house and an old winery with cultivated grapes nearby on the western shore of Stretch Island. His winery has been made into a museum. He says he gives quite a few tours..."senior citizens, boy scouts, etc..." Bill also has on his property the oldest vine on the island.

His land ethic includes a strong feeling for saving the grapes on his property so that they will be preserved for future generations. His museum serves the same purpose as well as giving him and enjoyable pasttime.

Bill said that "So far, Stretch Island isn't bad" when we asked him about growth and development. "Stretch Island has always been agriculteral," he continues. Bill expressed the feeling that there will continue to be agriclu-ture on the island, though not on such a large scale as it has been in the past. "I kinda hope the island stays kind of like it is now."

We asked Bill about the proposed land use plan that had been explained to us by the Shelton Regional Planners. About the 2½ rural plan he says, "The trouble with that is that the government agencies aren't getting together to work things out and taxes are too high. He says he "might have to sell off the land" in the case that taxes are raised because of the plan being put into effect.

Sense of Community

Bill commented a lot on the strong sense of community he experienced in the "old days." "In the old days you used to know every car that went by...now you don't know anybody. Farmers used to help each other during harvest and also when someone's roof needed fixing or someone was sick.

He still has many positive feelings about the community spirit, as he calls it. He mentioned the local grange and the volunteer fire department, of which he was a member for 32 years. The Grapeview school he also sees as a good object for binding the community together..."It's a real good country school-good teachers."

Bill estimated that there are at least 40 permanent families on the island and the rest are summer residents. As did all other respondants, Bill saw the bridge as being responsible for much of the change on the island. The summer people began to make up more and more of the population once they were able to bring their cars on the island.

Clams, Geoducks

When we asked Bill about clam and geoduck populations and how they have changed, he said, "Used to be in the old days there was lots of fish and lots of shrimp.. could buy a bag of shrimp for 25¢." Clam and geoduck populations are not the only ones which have declined since the earlier part of the century, we found. "I hate to see these mechanical harvesters come in", he continued. He feels that this ruthless type of harvesting really destroys populations of the mollusks which used to be so plentiful on the island.

The Tobeys

History

The first person we talked to at the Tobey household was Mr. Tobey. He was only with us shortly as it was his luch break but he gave us a little bit of a feeling for how the island was twenty or thirty years ago. "I remember when this whole island was vineyard...we took our horse from one end of this island to the other." "Nobody locked their houses." He mentioned that all the lumber for the house came off the property. Much more timber was taken off so that grapes could be cultivated.

Mrs. Tobey (Dorothy) spoke to us next about the history of her house and the surrounding area. A Charlie Anderson who was one of the earlier settlers, before the Eckerts, owned the south end of the island. Doroty's father, William Sŭnd, came here in 1909 and bought property from this Charlie Anderson in 1917. Mr. Sund then sold some of his land in ten acre plots and a different Charlie Anderson bought one of those plots.

In 1924 William Sund went back to his homeland, Finland, and married a Finnish woman. He brought her and her two brothers back to Stretch Island in 1925. Mrs. Sund couln't speak English when she came here and used to communicate with her neighbors with the aid of a Sears Roebuck catologue. Mr. Sund at the time was a logger but then got into the grape growing business and also raised chickens. The grapes were sold to the St. Charles Winery on the island.

Doroty went to school at Grapeview and her daughter also went there for a few years. In 1959 the family moved to Ketchikan and did not come back until 1969. She mentioned that changes on the island were becoming noticable just before the family moved to Alaska. When they came back big development in what is known as Vineyard Cove had begun. Most of the land had been subdivided.

Land Ethic and Growth

We asked Dorothy why she and most of her family stayed here. She replied, "We just like it here." She also added, "I don't think this island will get too much more developed." The shorelines land use plan is undersirable, she feels. "Taxes are getting so high that people have to sell. 2½ acres is a lot... that's a lot of taxes." Dorothy believes that Stretch Island will never develop as much as Treasure Island has.

As for Dorothy's feelings about the community, she says, "I think people are friendly out here now. I visit with my neighbors all the time."

History: The Buckinghams

Ethel and Orin Buckingham arrived in 1925, and bought a ten acre tract in the center of the north end of the island, for $100 an acre. They built a small log cabin with two rooms, and a stove in the center. For the first 5 years in there new home they had no electricity. They used kerosene lamps because they couldn't afford the $100 to hook up to the power lines that went right by their home. Later Orin and Ethel bought an additional 10 acres. " Those were the happiest day's of our lives.[4]" Things started changing on the island when the navy yards in Bremerton opened up, people moved into the area, and the men went to work in the yards. About this time the Buckinghams log house burnt down. For many months things were really tight. Finally the Buckinghams were able to build the big white house on the hill that can be seen from the main road coming on to the island.

The Buckinghams always worked in the area. Orin drove the Grapeview school bus for many years. Ethel and Orin both worked in the wineries and grape juice plants around the island. In 1962 Ethel retired form the St. Charles winery. In 1967 the Buckinghams sold their large home and moved to the north beach. Today Ethel lives in a mobil home on the north side, she keeps busy with charities, the grange, and the senior citizens group.

Ethel Buckingham

The Buckinghams were pretty much self sufficient in the earlier part of the century. They ate a lot of clams..."We could go anywhere and help ourselves." The islanders made enough money off grapes to live and sold wood that had been cut to make way for the cultivation of grapes to supplement their incomes.

Adam Ekert, Walter's father, had grapes sent from New York and found that "Island Belle" grew well here. After the forest was cleared, people went through and blasted stumps out with dynamite. The dynamite blasted through the hardpan layer of soil and caused permanent water-retentive holes, unfortunately. The grapes in those wet areas still do not grow as well. Grapes planted on the hill on the northwest side of the island with eastern exposure always did the best. "The grapes in the valley were never first grade grapes-the hardpan was too close to the surface."

In the 40's and 50's the wine business was at its peak. "Pretty good payroll at the wineries when they were all running." There were about 10 employees at one plant at one time. Many grapes were shipped in from eastern Washington.

On the island, the grapes were mostly picked by women. The Summers had over ten types of wine and a few types had to be fortified (alcohol added). Ethel retired from the St. Charles Winery in 1964. The winery closed down two years after she left, in 1966.

Ethel said she believes the grapes began to go downhill when power tractors began to do the cultivation. Before that they were cultivated with horses. The tractors broke off roots and grapes began to die..."Mechanical things started to come."

There were also two grape juice plants on the island and fruit leather made by Hany Branch. They bought fruit pulp from Eastern Wa, added sweetener and nuts and dried it.

Ethels Ethic

Ethel believes that stringent regulation for septic tanks and subdivision are good - "absolutely". Laurie mentioned the house recently built on the feeder bluff above Ethel's house... "I don't know about these people..." she replied. She said that she has noticed the erosion - bluffs wearing away - very much. She also said that ivy planted on the bluffs is not a "good holder"; it is too shallowrooted. The "Big chestnut tree will go over sometime" she said, speaking of the chestnut next to Laurie's house.

Community

"If you are friendly, the people are friendly".

The people on the island are "high class - no hippies". She stressed that most everyone was retired and well off. There are a lot of teachers, writers, and doctors.

She feels that there will be no development in the area she lives because the owners have bought the land to keep it from being developed.

History: The Grapes

Grapes first came to Stretch Island in 1872 with the first settler, Lambert Evans. The first grapevine still stands today on Bill Summers property. During these early years the land was cleared for the grapes by cutting the trees down and burning the stumps. Stretch Island was an excellent place to grow grapes. Being near the water, the grapes were not affected by the spring frosts. The hard pan was so close to the surface they never had to worry about irrigation on most parts of the island. As more grapes were started the process of removing the stumps was changed from burning, to blasting them out with dynamite. The turning of the soil each year was done by horse and plow. Each winter the grapes are pruned and tied. In June a white flower blooms, them in the fall the grapes are cultivated and harvested.

Before the grapes became plentiful, fruit trees were on many parts of the island. The main business was selling fresh fruit to the boats that came to the island to trade. As the grapes started to boom these also were sold to boats that were going to market.

Some bootlegging was done during prohibition, but in 1934 after the repeal of prohibition the winery business went into full force. Over the years there have been three wineries on the island, The St Charles winery, The Davis winery, and The Stretch Island winery. There are approximatly 300 acres on the island, and at one time 200 of these acres had been in grapes. Before the heavy duty machinery came in, the grapes had to be "stomped by the pretty girls.[5]" During the heaviest times of wine making in the 40's and 50's many of the grapes were brought in from Eastern Washington to fill the demands of the sought after wines from Stretch Island. Grape juice plants were also open during these busy times. In 1965 the last of the wineries, St. Charles, finally closed down. For the last 15 years about half of the grape arbors have been neglected and overgrown. A lot of this is due to old time farmers retiring and selling off their places, while summer people move in and are not interested in farming. The grapes that are left today, are sold as "you pick" in the fall.

Footnotes

1. Ann Eckert, Ethel Buckingham. 2.Ethel Buckingham. 3.Ann Eckert.
4. Ethel Buckingham. 5. Bill Summers

Discussion and Conclusion

The overall view about sense of community on the island was that people were much closer when the population was on a smaller scale and farming was a neccessity for life. They see the community today as a positive environment on this larger scale as in comparison with suburban or urban areas. However, people lead a more individual existances now because interdependence is not as neccessary as it was in the farming days.

The edible seafood population was very abundant in the past on Stretch Island but because of exploitation of this resource over the years the population has dwindled substantially. Unless there are restrictions put on the consumption of this food source, we see no other end to these once plentiful organisms than even a more drastic lowering of the populations.

We found overall that the four people we interviewed who had been associated with Stretch Island for at least 55 years had a very strong attachment to the Island in years past. They were very aware of changes that have taken place over the years but feel that Stretch Island will never be subdivided and developed as Treasure Island has. All four respondents want very much to retain the land they live on. However with the increase in taxes over the past few years the four residents have questions as to whether or not they will be able to hold on to there land in future years. Feelings about Erosion is another factor we considered as part of each persons land ethic. Each has observed substantial erosion on the shores over the last half a century. They could not understand how new residents developing on the feeder bluffs could have such indifferent attitudes towards erosion just for the sake of a better view.

We have come to the conclusion that from these peoples views about the land and the taxes that Stretch Island will continue to be developed unless the proposed 2½ acre rural act is put into action.

APPENDICES

APPENDIX I

WATER QUALITY - METHODS AND PROCESSED DATA

There were 3 testings run for the water quality. The dates were: Test #1 on 16 April 1980, Test #2 on 23 April 1980, and Test #3 on 07 May 1980.

S A M P L E C O L L E C T I O N

TEST #1 - METHODS

On 16 April 1980 at 0830 on the south side of Stretch Island from a row-boat, a van buran bottle was dropped over the side and a bottom sample was taken at a depth of 25 ft. Three BOD bottles were filled without blurping and fixed (see methods for dissolved oxygen). Two sterile 1 liter bottles and two HCL rinsed bottles were also filled. The same was done for the surface sample taken at the same location.

On the north side of the island at 0930 from a rowboat the vanburan bottle was dropped over the side at a depth of 30 ft. A top and bottom sample were taken following the same procedures mentioned above.

The water conditions, tide level and the water temperature were noted. The salinity was measured back at the lab.

RESULTS

The weather conditions were as follows on 16 April 1980 at 0830 and 0930. It was a clear calm morning and the current was running north to south, the tide was approximately a 9 ft. tide on the south side, and a 7 ft. tide on the north side. The temperature of the water was 12^{o}C and the salinity was measured at 27 ppt - top, 29 ppt - bottom on the south side and 28 ppt - top, 26 ppt - bottom on the north side.

TEST #2 - METHODS

On 23 April 1980 at 0830 on the north side of Stretch Island from a row-boat, a vanburan bottle was dropped over the side and a bottom sample was taken at a depth of 40 ft. The same procedures used in Test # 1 were used.

The water conditions, tide level, and the water temperature were noted. The salinity wasn't measured for this test.

No sample was taken on the south side of the island.

RESULTS

The weather conditions on 23 April 1980 at 0830 were over cast and warm with no breeze. The current was running to the north west. The water temperature was 11.5^{o}C and the tide was approximately a 4 ft. tide.

TEST #3 - METHODS

On 07 May 1980 at 0900 on the north side of Stretch Island from a row-boat, a vanburan bottle was dropped over the side and a bottom sample was taken at a depth of 30 ft. This was done using the same procedures as in Test #1 and Test #2.

The water conditions, tide level and water temperature were noted. The salinity was taken back at the lab.

No sample was taken on the south side of the island.

RESULTS

The weather conditions on 07 May 1980 at 0900 were over cast with a slight breeze. The current was running north to south. The water

temperature was 12°C and the tide was approximately a 5 ft. tide. The salinity was 28 ppt for both the top and the bottom.

METHODOLOGIES AND PROCESSED DATA

NITRATE AND NITRITE

Preparation of Solutions

A 10^{-4}M nitrate stock solution was made from a 10^{-2}M nitrate solution in a 1 liter volumetric flask. A set of 5 calibration solutions were made up with concentrations of 0, 2.5, 5, 7.5, and 10 uM/1 using 0, 5, 10, 15, and 20 ml. respectively of 10^{-4}M nitrate stock solution and diluting to 200 ml. in a volumetric flask.

A 5 x 10^{-3}M nitrite stock solution was made from a 50 umol/1 nitrite solution in a 1 liter volumetric flask. Another set of calibration solutions were made with concentrations of 0, 1, 2, 3, and 5 uM/1 using 0, 1, 2, 3, and 5 ml. respectively of 50 uM stock solution and diluting to 50 ml. in a graduated cylinder.

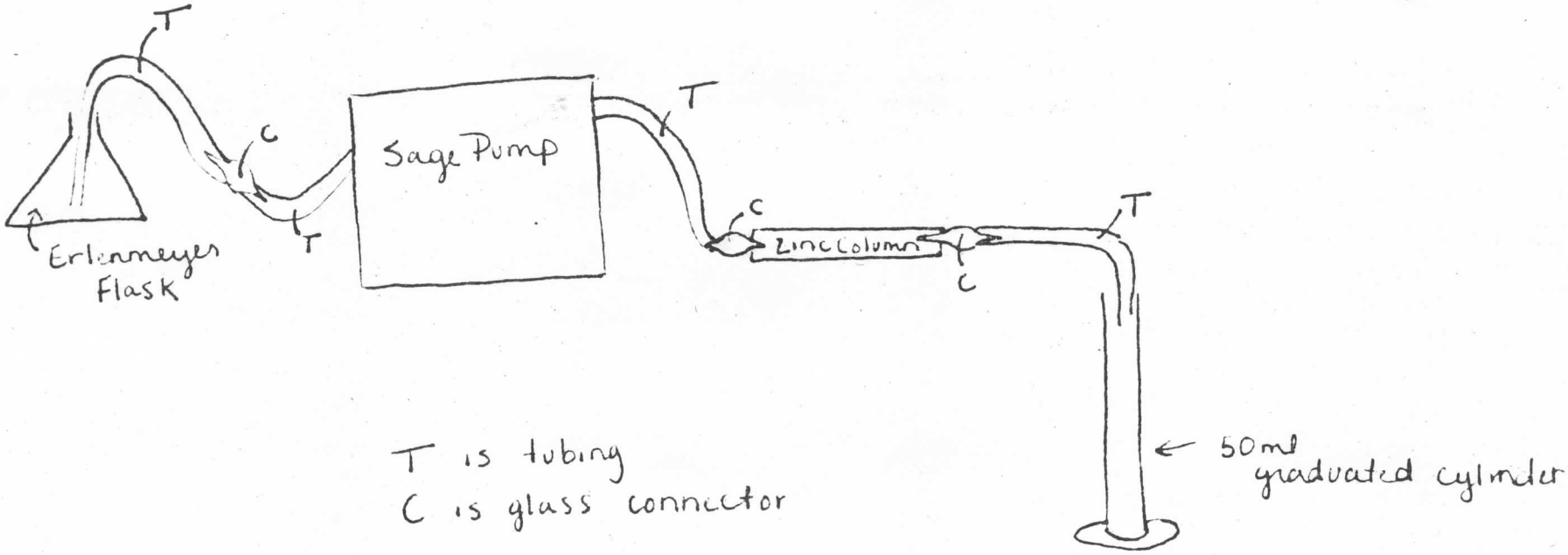
Reduction of Nitrate to Nitrite

200 ml. of sample water for the nitrate experiment and 50 ml. of sample water for the nitrite and calibration solutions were measured into a 250 ml. Erlenmeyer flask. 1 ml. of 4M NH_4Cl was added to each flask. The solution was pumped through an amalgomated zinc column (a Jones Reductor) using a sage pump (Orion model 375A) set at 10 ml/min (see Figure 1). The initial 50 ml. of sample were discarded and the subsequent 50 ml. were collected and analyzed as below for nitrite.

Analysis for Nitrite

1 ml. of sulphanilimide (1% sulphanilimide, 10% HCl) was added to 50 ml. of the solution to be analyzed. After 2 - 8 minutes elapsed 1 ml. ethylene diamine (1% naphthyl ethylene diamine dihydrochloride) was added. After

Figure 1
Nitrate Reduction System



10 minutes but less than 2 hours each solution was analyzed spectrophotometrically using a Bausch and Lombe Spectronic 88 set at a wavelength of 540 nm in 1 cm. cuvettes against deionized water.

Results

TEST #1 - NITRATE

CALIBRATION CURVE

Solution #	Concentration	Absorbance
1	0	0
2	2.5	.048
3	5.0	.098
4	7.5	.140
5	10.0	.189

Slope and Standard Deviation - .0188 ± .0002
Intercept and Standard Deviation - .001 ± .0013
Correlation Coefficient - .9997

North Surface
Absorbance - .002
Sample Concentration - .0532 ± .0532
Absolute Error in Sample Concentration - 1.3073

North Bottom
Absorbance - .04
Sample Concentration - 2.0745
Absolute Error in Sample Concentration - .0445

South Surface
Absorbance - 0
Sample Concentration - .0532 ± .0532
Absolute Error in Sample Concentration - 1.2848

South Bottom
Absorbance - .058
Sample Concentration - 3.0319
Absolute Error in Sample Concentration - .0339

TEST #2 - NITRATE

CALIBRATION CURVE

Solution #	Concentration	Absorbance
1	0	.008
2	2.5	.025
3	5.0	.051
4	7.5	.073
5	10.0	.100

Slope and Standard Deviation - .0093 ± .0003
Intercept and Standard Deviation - .0050 ± .0017
Correlation Coefficient - .9975

North Surface
Absorbance - .001
Sample Concentration - .4310
Absolute Error in Sample Concentration - .4157

North Bottom
Absorbance - 0
Sample Concentration - .5388
Absolute Error in Sample Concentration - .3262

TEST #3 - NITRATE

CALIBRATION CURVE

Solution #	Concentration	Absorbance
1	0	.006
2	2.5	.028
3	5.0	.046
4	7.5	.057
5	---	---

Slope and Standard Deviation - .0068 ± .0005
Intercept and Standard Deviation - .0086 ± .0023
Correlation Coefficient - .9897

North Surface
Absorbance - .011
Sample Concentration - .3509
Absolute Error in Sample Concentration - 1.028

North Bottom
Absorbance - .01
Sample Concentration - 1.8129
Absolute Error in Sample Concentration - 1.710

TEST #1 - NITRITE

CALIBRATION CURVE

Solution #	Concentration	Absorbance
1	0	.01
2	1	.012
3	2	.02
4	3	.025
5	5	.039

Slope and Standard Deviation - .006 ± .0004
Intercept and Standard Deviation - .0079
Correlation Coefficient - .9907

North Surface
Absorbance - .009
Sample Concentration - .1667
Absolute Error in Sample Concentration - 1.078

North Bottom
Absorbance - .015
Sample Concentration - 1.1667
Absolute Error in Sample Concentration - .2060

South Surface
Absorbance - .009
Sample Concentration - .1667
Absolute Error in Sample Concentration - 1.078

South Bottom
Absorbance - .015
Sample Concentration - 1.6667
Absolute Error in Sample Concentration - .2060

TEST #2 - NITRITE

CALIBRATION CURVE

Solution #	Concentration	Absorbance
1	0	.000
2	1	.003
3	2	.01
4	3	.018
5	5	.029

Slope and Standard Deviation - .0061 ± .0003
Intercept and Standard Deviation - .0014 ± .0008
Correlation Coefficient - .9939

North Surface
Absorbance - .005
Sample Concentration - 1.0489
Absolute Error in Sample Concentration - .1802

North Bottom
Absorbance - .002
Sample Concentration - .5555
Absolute Error in Sample Concentration - .2965

TEST #3 - NITRITE

CALIBRATION CURVE

Solution #	Concentration	Absorbance
1	0	.006
2	1	.012
3	2	.018
4	3	.021
5	5	.031

Slope and Standard Deviation - .0049 ± .0002
Intercept and Standard Deviation - .0068 ± .0006
Correlation Coefficient - .9958

North Surface
Absorbance - .01
Sample Concentration - .6464
Absolute Error in Sample Concentration - .2190

North Bottom
Absorbance - .01
Sample Concentration - .6464
Absolute Error in Sample Concentration - .2190

ORTHO AND TOTAL PHOSPHATE

Treatment of glass and plastic ware

All glassware was rinsed with deionized water, rinsed with 6M HCl, and then rinsed again with deionized water. This cleaning method was used to clean all glassware everytime it was used.

Conversion of Total Phosphate to Ortho Phosphate

50 ml. of sample was first measured into an Erlenmeyer flask. 1 ml. of each of 20% H_2SO_4 and 1 M ammonium per sulfate solution was added to this sample. The flask was then placed on a hot plate in a hood and heated, reducing the volume of the sample to less than 15 ml. but not to dryness.

The flask was removed from the hot plate and cooled. 2 drops of 1% phenolphtalin indicator were added. 6 M NaOh was added dropwise until the first permanent pink was observed. Then 1 M H_2SO_4 was added until the pink color just dissappeared. The sample was then transfered to a graduated cylinder, diluted to 50 ml. with deionized water, returned to the same Erlenmeyer flask, and analyzed for ortho phosphate as described below.

Analysis for Ortho Phosphate

50 ml. of sample water was transfered to a dry Erlenmeyer flask. 10 ml. of the coloring reagent (see below) was then pipeted into this solution. A reaction time of 5 minutes was allowed after mixing. The absorbance of this solution was determined against deionized water at 885 nm using a Bausch and Lombe Spectronic 88.

Preparation of Coloring Reagents

These solutions were used to make up the coloring reagents.

Reagent A - To 150 ml. of distilled water add:

2.64 g Ascorbic acid
50 mg of Disodium EDTA
1 ml Formic Acid
250 ml 2.5 M H_2SO_4

Reagent B - 0.274 g/100 ml of Antimony potassium tartrate

Reagent C - 4 g/100 ml of Ammonium molybdate

The coloring reagents were prepared just prior to use. First, 240 ml. of Reagent A was transfered into a dry beaker. To this, 15.6 ml. of Reagent B, and 47.7 ml. of Reagent C were added. This was mixed by swirling.

Preparation of Calibration Solutions

The phosphate stock solution (50 umol/L), was prepared by transfering 10 ml. of a prepared solution (5×10^{-3} umol/L), into a 1 L. volumetric flask and diluting to the mark with deionized water. 0 umol/L was achieved by transfering 50 ml. of deionized water to an Erlenmeyer flask. Into a graduated cylinder, 1 ml. of PO_4 was pipeted and diluted with deionized water to the mark, and transfered to another flask, forming a concentration of 1 umol/L. This same method was repeated with 2 ml., 3 ml., and 4 ml. to form concentrations of 2 umol/L., 3 umol/L. and 4 umol/L. Each solution was analyzed for ortho phosphate.

Data Reduction

The absorbance as concentration were plotted and the best straight line through the points was determined by linear regression analysis. The line obtained was used to determine the contration of each sample.

Results

TEST #1 - ORTHO AND TOTAL PHOSPHATE

Results were unacceptable.

TEST #2 - ORHTO AND TOTAL PHOSPHATE

CALIBRATION CURVE

Solution #	Concentration	Absorbance
1	0	.008
2	1	.021
3	2	.031
4	3	.047
5	4	.062

Slope and Standard Deviation - .0135 ± .0005
Intercept and Standard Deviation - .0067 ± .0011
Correlation Coefficient - .9972

TOTAL PHOSPHATE

North Surface
Absorbance - .003
Sample Concentration - -.2741
Absolute Error in Sample Concentration - -.2661

North Bottom
Absorbance - .025
Sample Concentration - 1.3556
Absolute Error in Sample Concentration - .0941

ORTHO

North Surface
Absorbance - .0125
Sample Concentration - .4296
Absolute Error in Sample Concentration - .2247

North Bottom
Absorbance - .01
Sample Concentration - .4296
Absolute Error in Sample Concentration - .3694

TEST #3 - ORTHO AND TOTAL PHOSPHATE

CALIBRATION CURVE

Solution #	Concentration	Absorbance
1	0	.051
2	1	.07
3	2	.09
4	3	.104
5	4	.12

Slope and Standard Deviation - .0172 ± .0005
Intercept and Standard Deviation - .0526 ± .001

TOTAL PHOSPHATE

North Surface
Absorbance - .07
Sample Concentration - 1.0116
Absolute Error in Sample Concentration - .1035

North Bottom
Absorbance - .076
Sample Concentration - 1.3605
Absolute Error in Sample Concentration - .0847

ORTHO

North Surface
Absorbance - .07
Sample Concentration - 1.0116
Absolute Error in Sample Concentration - .1035

North Bottom
Absorbance - .07
Sample Concentration - 1.0116
Absolute Error in Sample Concentration - .1035

DISSOLVED OXYGEN

Field Methods

Three BOD bottles were filled at each site. One was fixed immediately (see below) to determine the amount of dissolved oxygen in the field. All three bottles were placed in a light tight box and transported to the lab. The two unfixed bottles were placed in an incubator for 24 hours at 11°C., one in the light and the other in the dark.

Fixing

To determine the dissolved oxygen of a given sample the following chemicals were added using a Pasture pipet that was callibrated to 2 mls.: Manganese chloride (MnCl) and Iodide hydroxide (KOH-KI).

Analysis

Dissolved oxygen was determined using a modified Winkler technique. Before testing each BOD had 1 ml. of concentrated sulfuric acid (H_2SO_4) added to it. Then 20 mls. of sample were pipeted into a beaker. The sample with thiosulfate concentration ($Na_2S_2O_3$) was titrated using a Gilmont Buret (2 ml capacity) until the color of the solution turned yellow. Then three drops of starch solution were added to the sample, turning the color blue. The titration was continued until the color was clear. The

volume of the thiosulfate used was recorded. The concentration of oxygen was determined from this data.

Results

See page xiii.

RESULTS OF DISSOLVED OXYGEN

Sample Site	T.	Saturation Level-D.O.	Volume Thiosulfate Used			DO-(mg O_2/L)			BOD mg/L	NOP mg/L	Productivity (mg O_2/L/day)
			Sample	Light	Dark	Sample	Light	Dark			
TEST #1											
North Surface	11.5	8.5 mg/L	1.357±.001	1.756±.004	1.569±.001	13.57±.01	17.56±.04	15.69±.01	-.088	.166	.254
North Bottom	"	"	1.247±.001	2.014±.006	1.505±.001	12.47±.01	20.14±.06	15.05±.01	-.107	.319	.426
South Surface	"	"	1.330±.005	1.712±.006	1.505±.004	13.30±.05	17.12±.06	15.05±.04	-.07	.159	.166
South Bottom	"	"	1.106±.005	1.898±.008	1.378±.008	11.06±.05	18.98±.08	13.78±.08	-.113	.330	.443
TEST #2											
North Surface	"	"	1.427±.006	1.559±.008	1.318±.010	14.27±.06	15.59±.08	13.18±.10	.045	.055	.010
North Bottom	"	"	1.479±.007	1.845±.004	1.549±.004	14.79±.07	18.45±.04	13.18±.10	-.029	.152	.181
TEST #3											
North Surface	"	"	1.212±.004	1.258±.005	1.168±.004	12.12±.04	12.58±.05	11.68±.04	.018	.019	.001
North Bottom	"	"	1.247±.001	1.232±.000	1.264±.001	12.47±.01	12.32±.00	12.64±.01	-.007	.006	.001

CHLOROPHYLL

For this experiment, 10 dram vials were filled with 10 ml. of 90% acetone, which acted as the solvent of the chlorophyll in the tissue, that was suspended in the water sample.

A known volume of water was filterd through a 1 u glass fiber filter (Millipore), using the aspirator filtering system. Each filter was rolled and placed into a vial, capped and shaken vigorously. All vials were then stored in the dark, at about $1^{o}C$ for 24 hours.

The supernatent in each vial was pipeted into a centrifuge tube and centrifuged at medium high speed for approximately 1 minute. The supernatent was then pipeted into a optical cubicle and tested for its optical density (absorbance value) at both 663 and 750 nm. A 90% acetone blank was used to calibrate the Bausch and Lombe Spectronic 88 spectrophotometer in which the samples were tested.

The density of each sample was computed by using the equation below.

$$\frac{\text{mg of chlorophyll}}{\text{1 liter } H_2O} = \frac{(A^{*}\ 663\text{-}A\ 750)(\text{vol. acetone})}{\text{volume of sample in ml}}$$

A^{*} - absorbance value

Results

Sample Site	ml of sample	Absorbance value at 663nm	750nm	mg of chlorophyll/L
TEST #1 -				
N. Surface	960	.028	.001	.00028
N. Bottom	960	.217	.008	.0022
S. Surface	915	.038	.014	.00026
S. Bottom	820	.175	.021	.0018
TEST #2-				
N. Surface	1000	.03	-.0	.0003
N. Bottom	1000	.188	-.0	.00188
TEST #3-				
N. Surface	1000	.050	.011	.00039
N. Bottom	1000	.051	.003	.00048

PH, ALKALINITY AND SALINITY

To measure the salinity a Bausch and Lombe temperature compensated salinometer was used.

The pH was measured with the Orion 407 A Specific Ion Meter with hydrogen electrode using 2 buffer solutions (pH=6+8).

The alkalinity of the samples was measured as follows. 3 drops of Bromcresol green indicator was added to the sample, a magnetic stir bar was placed in the sample, the sample (in container) was put on a magnetic stirrer and the stirrer was turned on. The titration was done using a 2.0 ml. Gilmont Micro-Buret filled with 0.12 M HCl. The sample was titrated to the end point. The sample boiled for 5 minutes and again the sample was titrated to the end point. The amount of acid used was noted and from this results were obtained.

Note: For fresh water samples 100 ml of water was used.
For salt water samples 50 ml of water was used.

Results

Sample Site	Salinity	pH	ml HCl	Alkalinity ($mgCaCO_2/L$)	Milli-equiv/L
TEST #1-					
N. Surface	28 ppt	8.09	.886	53.16	1.0632
N. Bottom	26 ppt	8.19	.9538	57.23	1.1446
S. Surface	27 ppt	8.19	.9015	54.09	1.0818
S. Bottom	29 ppt	7.86	.9478	56.87	1.1374
TEST #2-					
N. Surface	------	----	-----	-----	------
N. Bottom	------	----	-----	-----	------
TEST #3-					
N. Surface	28 ppt	8.2	.571	68.52	1.3704
N. Bottom	28 ppt	8.02	.574	68.88	1.3776

COLIFORM

All 1 liter plastic sample bottles were sterilized by placing them in boiling water for 10 minutes. All millipore plates were sterilized by dipping them in 95% ethenol. All 10 ml. pipets were sterilized in a 300^{o} oven for 3 hours. The MF Endo medium was made 24 hours in advance. The medium ingredients were: 4.8 g DIFCO mEndo Broth, 2.6 g agar (Bacto), 175 ml. deionized water, and 3.5 ml. 95% ethenol.

Each sample was first inverted to stir up sediment which had settled on the bottom. The filtering apparatus was boiled in water for 3 minutes for sterilization and cooled to room temperature with deionized water. Using flame sterilized forceps, a sterile millipore type HAWG filter was placed in the sterile apparatus. The funnel was then removed and after sterilizing the forceps again, the filter was transfered from the apparatus onto the medium in one of the plates. The plate was placed upside down in a 37^{o}C incubator for 24 hours.

The same procedure was repeated when filtering 10 ml. of the sample water, except that a sterile 10 ml. pipet was used. For the 1 ml. filtering, a sterile 10 ml. pipet was used to pipet 1 ml. of the sample water into the funnel and another sterile 10 ml. pipet was used to add 9 ml. of sterile water.

Results

On 16 April 1980 two plates were made for each sample brought in: a 100 ml. sample and a 10 ml. sample. On 23 April 1980 two plates were also made for each, but because of the high colony count on South Prairie's plates on 17 April 1980 10 ml. and 1 ml. plates were made for fresh water and 100 ml. and 10 ml. plates were made for salt water. On 07 May 1980 the same procedure as in Test #2 was used.

After the 24 hour incubation period, the colonies (only those with a green shiny surface) were counted and their number recorded.

OF COLONIES COUNTED

Sample Site	Colonies/100 ml.	Colonies/10 ml.
TEST #1-		
N. Surface	3	0
N. Bottom	0	0
S. Surface	1	0
S. Bottom	0	0
TEST #2-		
N. Surface	20	2
N. Bottom	0	0
TEST #3-		
N. Surface	0	0
N. Bottom	0	0

APPENDIX II

Results Data - Baseline

Zone 2 North Side (50ft baseline and 28ft to 72ft on the transect line)

Sampling Sites/Tide Level/Barnacles/Mussels/Hermit Crabs
across x down

23 x 30	8ft 6in	0	1	0
33 x 29	8ft 9in	11	0	1
21 x 44	7ft	3	1	0
27 x 54	6ft	0	4	0
21 x 58	5ft 6in	9	0	0
10 x 67	4ft 9in	5	3	0
		28	9	1

Barnacles

N=733 sq yds

n=6 sampling sites

y=28 orgainisms per sampling area

$\bar{y}$= sampling sites divided into number of orgainsisms in sampling area=$\frac{28}{6}$

$\bar{y}$=4.67 number per sampling unit.

To find out the 95% conf. interval you:

$\text{var}(y) = \frac{N^2}{n(n-1)} \left(\Sigma y^2 - \frac{(\Sigma y)^2}{n} \right) = 1{,}870{,}056$

Then you divide the var(y) by $N^2 = \frac{1870056}{537289} = 3.48 = \text{Var } \bar{y}$

$\bar{y} \pm 2x\sqrt{\text{var } \bar{y}}$

$4.67 \pm 2x\sqrt{3.48}$

$4.67 \pm 2x\ 1.86$

4.67 ± 3.7 is the est of barnacles in one sq yd in zone 2

95% of the time you will find between .97 and 8.37 barnacles in a sq yd in this location.

Mussels

N=733 sq yds

n=6 sampling sites

y=9 organisms per sampling area

$\bar{y}$=1.5 number per sampling unit

1.5 ± 1.3 is the est of mussels in one sq yd in zone 2

95% of the time you will find between .2 and 2.8 mussels in a sq yd in this location.

Results Data cont.

Zone 3 North Side (50ft baseline and 72ft to 104ft on the transect line)

Sampling Sites across x down	Tide Level	Barnacles	Mussels	Limpets	Sanddollars	Cockels	Clams
21 x 78	3ft 8in	64	53	11	0	0	0
14 x 82	3ft 6in	118	0	2	23	1	0
42 x 83	3ft 3in	146	50	31	1	0	1
15 x 93	2ft 3in	17	4	1	33	2	0
13 x 100	1ft 6in	7	0	0	13	0	0
50 x 101	1ft 4in	9	0	0	0	0	0
28 x 102	1ft 6in	35	0	16	11	1	0
	TOTAL	396	107	61	81	4	1

Barnacles

N=533 sq yds

n=7 sampling sites

y=396 organisms per sampling area

$\bar{y}$=56.57 number per sampling unit

56.57± 11.91 is the est of barnacles per sq yd in zone 3

95% of the time you will find between 44.66 and 68.48 barnacles in a sq yd in this location.

Mussels

N=533 sq yds

n=7 sampling sites

y=107 organisms per sampling area

$\bar{y}$=15.29 munber per sampling unit

15.29± 18.6 is the est of mussels per sq yd in zone 3

95% of the time you will find between 0 and 33. 89 mussels in a sq yd in this location.

Limpets

N=533 sq yds

n=7 sampling sites

y=61 organisms per sampling area

$\bar{y}$=8.714 number per sampling unit

8.714± 8.733 is the est of limpets per sq yd in zone 3

95%of the time you will find between 0 and 17.45 limpets in a sq yd in this location.

Results Data Cont.

Zone 3 North Side Cont.

Sanddollars

N=533 sq yds

n=7 sampling sites

y=81 organisms per sampling area

$\bar{y}$=11.57 number per sampling unit

11.57$\pm$ 9.56 is the est of sanddollars per sq yd in Zone 3

95% of the time you will find between 2.01 and 21.03 sanddollars in a sq yd in this location.

Zone 4 North Side (104ft to 130ft on the transect line and 50ft baseline)

Sampling Sites/Tide Level/Barnacles/Sanddollars/Cockles/Mussels

across x down					
5 x 108	9in	2	12	1	0
20 x 108	9in	18	7	0	0
22 x 110	8in	30	7	0	0
35 x 113	3in	2	5	0	0
9 x 117	0	1	0	0	0
7 x 121	-9in	0	3	1	0
18 x 124	-1ft	2	8	0	1
48 x 130	-1ft 5in	1	8	1	0
	TOTAL	56	50	3	2

Barnacles

N=433 sq yds

n=8 sampling sites

y=56 organisms in sampling area

$\bar{y}$=7 numbers per sampling unit

7$\pm$ 3.85 is the est of barnacles per sq yd in zone 4

95% of the time you will find between 3.15 and 10.85 barnacles in a sq yd in this location.

Results Data Cont.

Zone 4 North Side Cont.

Sanddollars

N=433 sq yds

n=8 sampling sites

y=50 organisms in sampling area

$\bar{y}$=6.25 numbers per sampling unit

6.25± .87 is the est of sanddollars per sq yd in zone 4

95% of the time you will find between 5.38 and 7.12 sanddollars in a sq yd in this location.

Results Data cont.

Zone 1 South Side (30ft baseline and 1ft and 40ft on the transect line)

Sampling Sites/Tide Level/Barnacles across x down		
24 x 5	13ft 5in	0
22 x 11	12ft 10in	11
24 x 17	12ft 3in	0
2 x 19	12ft 1in	0
17 x 23	11ft 9in	0
7 x 29	11ft 2in	2
28 x 32	10ft 11in	44
13 x 33	10ft 9in	37
28 x 38	10ft 6in	0
15 x 38	10ft 6in	265
	TOTAL	359

Barnacles

N=400 sq yds

n=10 sampling sites

y=359 number of organism per sampling area

$\bar{y}$=35.9 number per sampling unit

35.9$\pm$ 51.3 is the est of barnacles per sq yd in zone 1

95% of the time you will find between 0 and 87.2 barnacles in a sq yd in this location.

Results Data cont.

Zone 2 South Side (30ft baseline and 40ft to 65 ft on the transect line)

Sampling Sites/Tide Level/Barnacles across x down		
21 x 45	10ft	504
26 x 47	9ft 11in	10,620
14 x 51	9ft 6in	13,536
11 x 53	9ft 4in	18,396
23 x 59	8ft 11in	13,068
	TOTAL	56,124

Barnacles

N=250 sq yds

n=5 sampling sites

y=56,124 number of organisms per sampling area

$\bar{y}$=11,224.8 number per sampling unit

11,224.8$\pm$ 3807.4 s the est of barnacles per sq yd in zone 2

95% of the time you will find between 7417 and 15,032 barnacles in a sq yd in this location.

Results Data cont.

Zone 3 South Side (30ft baseline and 65ft and 165ft on the transect line)

Sampling Sites/Tide Level/Barnacles across x down		
22 x 67	8ft 2in	11,484
20 x 74	7ft 6in	900
19 x 80	7ft 2in	13,860
14 x 80	7ft 2in	12,060
7 x 87	6ft 6in	3,240
5 x 92	6ft	9,720
9 x 99	5ft 7in	4,680
26 x 103	5ft 3in	7,200
6 x 113	4ft 5in	6,480
30 x 119	3ft 11in	4,680
20 x 121	3ft 8in	3,672
29 x 122	3ft 8in	6,660
7 x 125	3ft 5in	3,600
24 x 132	2ft 10in	1,620
27 x 144	1ft 8in	3,960
TOTAL		93,816

Barnacles

N=1000 sq yds

n=15 sampling sites

y=93,816 number of organisms per sampling area

$\bar{y}$=6254.4 number per sampling unit

6254.4$\pm$ 2009.33 is the est of barnacles per sq yd in zone 3

95% of the time you will find between 4245 and 8263 barnacles in a sq yd in this location.

APPENDIX III

SEAWEED - FOOD FOR HUMANS

Any plant that grows in the sea can be called a seaweed. In this paper the word seaweed will refer to the larger brown and red plants. Presently in poorer areas of the world where food is scarce or where long tradition exists, seaweeds form a part of the human diet. Of all the countries of the world Japan is the only one making full use of these resources. Further research is being done with seaweeds which may result in more extensive cultivation around the entire world. However, seaweeds aren't the answer to our world's food problem. There are two reasons for this. The first is that seaweed resources are already on the road to exploitation and the second is that it's value as a food source is questionable. Both of these issues will be covered below.

Seaweed is known to contain: carbohydrates; fats; proteins; vitamins A, B-complex and C; sodium; iodine and iron[1]; trace elements and potassium. Despite the presence of these properties seaweed is relatively unpalatable and unnutritious. "The algae that have so far been analysed lack certain essential amino acids and thus do not provide for a complete diet. Rich though they may be in minerals and vitamins, the latter would probably be lost in processing".[2] Moreover, seaweeds are not easily digestible unless their cell walls have been broken down.

Seaweeds are used by humans as a source of chemicals and as a condiment. The specific species and their uses are discussed below.

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1 "Some species have 300x more iodine and iron than whole wheat". From C. P. Idyll, "The Harvest of Seaweed" Sea Frontiers, Nov. - Dec., 1971. Pg. 345.

2 John E. Bardach, Harvest of the Sea (New York: Harper and Row, Publishers, 1968) Pg. 204.

The use of seaweeds is increasing somewhat over the world, but not so much for food as for the production of chemicals and other substances. The most widely used substances are from the brown algae which are called phycocolloids and those from the red algae which are called polysaccharides. Both groups have properties that make them excellent gels and are thus used in a variety of food processes.

Three main classes of these organic extractives are: agar, carrageenans, and algins. Each of these will be discussed in terms of what seaweed it is extracted from and it's purposes.

The first extractive, agar, was the first seaweed product to become an important item of commerce (see Table I). It produces a firm, jellylike substance. Agar is derived from the red seaweed genera Gelidium, Ahnfeltia, Pteroeladia, Gelidiella and Acanthopeltis: the genus Gracilaria is also generally included in this group. This product is used as an additive in foods, such as canned meats, fish and other perishables, ice creams, chiffon pies, meringues, icings and as a clarifier in wines and beer.

The second extractive, carrageenan, is also a gel, however it is chemically different from agar. Carrageenan is derived from the red algae Chondrus crispus and Gigartina stellata; these two species represent the true carrageenans but generally Eucheuma, Phyllophora, Iridea, and other species of Gigartina are also included. It is used in jellied desserts, various beverages, bakery products, meat and fish canning, milk products, salad dressings, sauces, as a coating for frozen food products and as a batter ingredient.

The third extractive, algin, is used as a thickener, stabilizer, and gelling and emulsifying agent. It is derived from the major brown seaweeds, Macrocystis, Nereocystis, Sargassum, Fucus, Ascophyllum, Laminaria, Ecklonia, etc. Algin is used in jams, soups, mayonnaise, sauces, sausage casings, ice cream, pudding, salad dressings and syrups.

Table I *

Principal Seaweeds in Present Commercial Use and Their Geographical Distribution 1/

Classification and Genus	Known Concentrations
Red Algae	
Gelidium	Japan, Spain, Portugal, Morocco, Algeria, Senegal, U.S.A., Mexico, Ireland, Chile, India, Philippines, Madagascar
Gracilaria	South Africa, Japan, Philippines, coastal areas of South China Sea, India, Sri Lanka, Australia, Chile, Peru, Brazil, Argentina, Adriatic, U.S.A. (Florida), Canada (British Columbia)
Pterocladia	Japan, New Zealand, Algeria, Senegal
Phyllophora	U.S.S.R. (Black Sea)
Ahnfeltia	U.S.S.R. (White Sea, Okhotsk Sea)
Chondrus	Canada (Nova Scotia, Newfoundland), Portugal, France (Brittany), U.K. (Scotland), Republic of Korea, Japan
Gigartina	South Africa, New Zealand, Portugal
Hypnea	U.S.A. (Florida), north Brazil, South Africa, Gulf of Oman
Eucheuma	Indonesia, Philippines, Malaysia, East Africa
Iridea	U.S.A. (California), Japan, Chile, South Africa
Furcellaria	Denmark, Baltic, Canada
Brown Algae	
Macrocystis	Northeast Pacific, California, Mexico, Peru, Chile, Argentina, South Africa, New Zealand, Tasmania
Alaria	Alaska, Japan
Laminaria	Northwest Atlantic, Greenland, Iceland, Norway, Ireland, Scotland, France, Spain, Morocco, Japan, U.S.S.R. (White Sea, Murmansk, Kamchatka, Okhotsk Sea)
Nereocystis	Northeast Pacific
Ecklonia	South Africa, Japan, Australia, New Zealand
Eisenia	Japan
Fucales order 2/	Northeast and Northwest Pacific, Northeast and Northwest Atlantic, Chile, Murmansk, White Sea, New Zealand, Australia, Gulf of Oman

1/ After Chapman (1970), Whistler (1973), Firth (1969), Dawson (1966) and Kim (1970)

2/ Of which the main genera are Fucus, Ascophyllum and Sargassum

* J. Naylor, Production, Trade & Utilization of Seaweeds and Seaweed Products, (Rome: Food & Agriculture Organ. of the U.N., 1976). Pg. 3.

There are quite a few algal species that are eaten by man (see Table II). A few of them and how they are eaten will be discussed below.

One species, Eucheuma, can be eaten raw and is consumed by thousands daily as a salad vegetable or dessert pudding. The Filipinos prefer it boiled slightly and seasoned with hot pepper, soy sauce and lime. Another species, Chondrus crispus or Irish Moss, is used in the making of Blancmange, a pudding. One type of seaweed, Gelidium, is sometimes boiled down to make jelly. Nori or Laver looks very much like sea lettuce. It can be eaten raw, chewed as a gum, used as a relish, mixed with salads, soups and meats, spread like jam on crackers or coated with sugar and eaten as a candy.

As yet algae has a relatively small part in the process and consumption of our food. "It is to be expected that the harvest of red and brown algae will be large in future years, until eventually - many years from now - the seaweed forests will be fully exploited. But it is apparent that they will not solve the world's food problem. Unless much progress is made during the next several decades, seaweeds can be ignored as one of those resources of the sea that will make a strong contribution in the fight against hunger."[3]

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[3] C. P. Idyll, "The Harvest of Seaweed" Sea Frontiers, Nov. - Dec., 1971. Pg. 348.

TABLE II*

TABLE 27

Algal species eaten by man (after Johnston, 1966)

	W. Europe	England & Wales	Scotland	Ireland	Mediterranean	Iceland	W. Indies	Eastern Canada	Eastern U.S.A.	Alaska	Western U.S.A.	Chile
Ulva lactuca	×		×				×					×
Ulva latissima												
Alaria esculenta	×		×	×		×				×		
Durvillea antarctica												×
,, *utilis*												×
Fucus vesiculosus	×		×	×								
Laminaria digitata	×	×	×									
,, *saccharina*	×		×									
,, *bongardiana*										×		
Nereocystis luetkeana										?	×	
Porphyra columbina												×
,, *laciniata*	×	×								×		
,, *perforata*	×										×	
,, *umbilicalis*		×		•								
Chondrus crispus	×			×				×	×			
Gigartina stellata				×								
Gracilaria compressa		×										
Iridaea edulis			×			×						
Laurencia pinnatifida	×		×									
Rhodymenia palmata	×		×	×	×	×		×	×			

* Valentine Jackson Chapman, Seaweeds and Their Uses, (Great Britain: Camelot Press Ltd., 1970). Pg. 87.

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