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RENTON SEWAGE TREATMENT PLANT PROJECT: SEAHURST BASELINE STUDY

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VOLUME I

Section 1

Executive Summary

Final Report
for the period
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for

The Municipality of Metropolitan Seattle
Seattle, Washington

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1.0 EXECUTIVE SUMMARY

1.1 Introduction

Expansion of the Renton Sewage Treatment Plant to meet the needs of a growing population in the Seattle metropolitan area was begun in 1982. Since its construction in the mid-1960's, the secondary effluent from this plant has been discharged into the Duwamish River near Tukwila, Washington. The increased capacity of this plant from 36 million gallons per day to 72 mgd will not allow continued compliance with required water quality standards in the Duwamish River. A plan was adopted to construct a pipeline, tunnel and marine outfall system to divert effluent directly to a site due west of the plant in the south central Puget Sound basin at Seahurst.

The Seahurst Baseline Study was designed as a part of the plant expansion plan to obtain pre-discharge ecological data in the marine environment in the East and Colvos Passage areas of south central Puget Sound (Figure 1.1). Data from this study were utilized to minimize potential impacts of the design, to aid planning efforts, to evaluate several outfall alignments in Seahurst Bay and to assess changes which could occur once effluent was discharged at the site.

The Seahurst Baseline Study was designed with three broad objectives: (1) to collect, analyze and interpret the significance of physical, chemical and biological data around the proposed sewage treatment plant outfall at Seahurst to determine the properties and characteristics of the receiving environment; (2) to utilize the information obtained to aid in the siting and design of the outfall pipe and diffuser; and (3) to recommend a post discharge monitoring plan that would effectively and efficiently determine if the presence of the new outfall significantly changes the receiving water

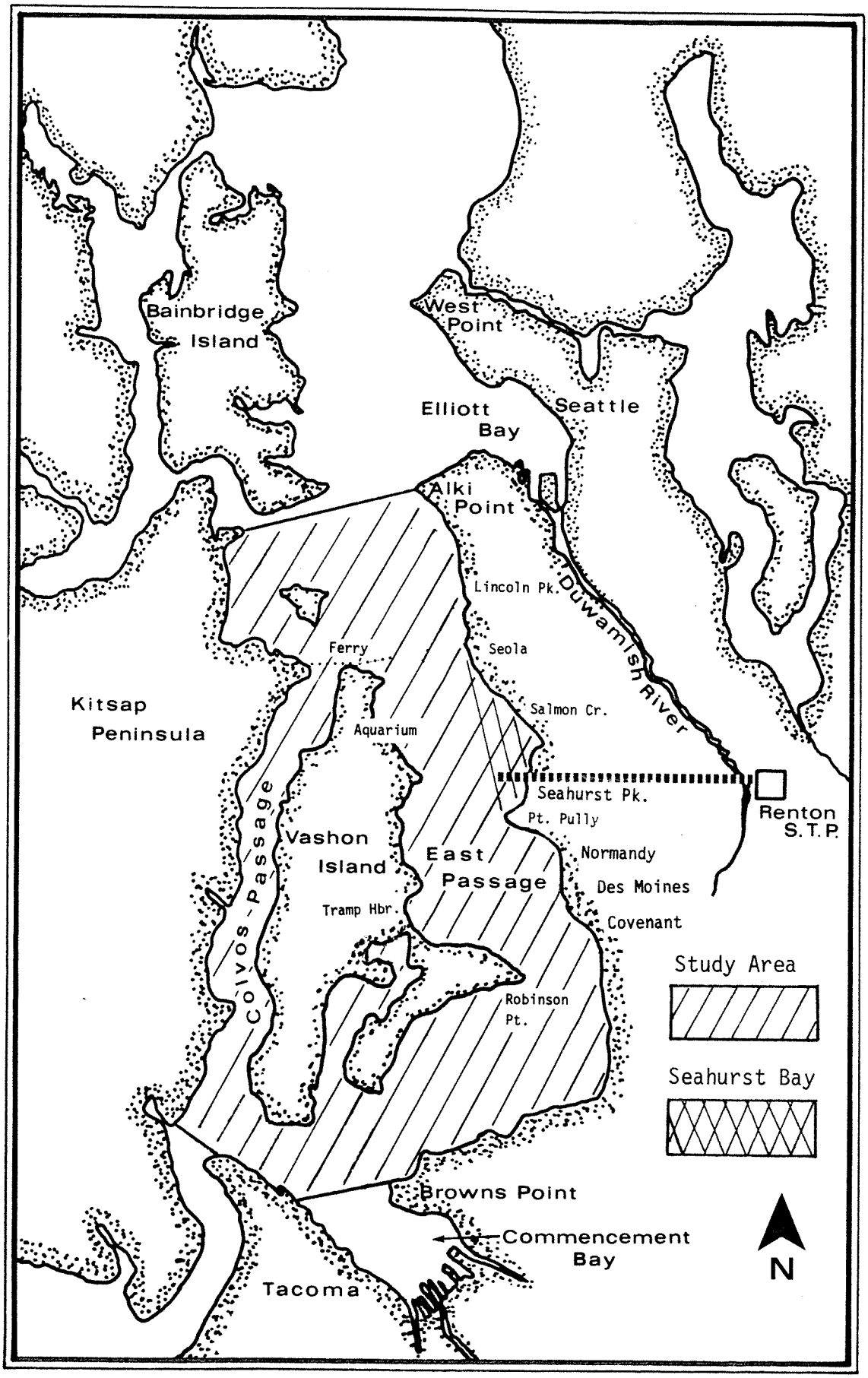

Figure 1.1. The Central Puget Sound basin showing the location of the Renton Sewage Treatment Plant and the Seahurst Baseline study area in the south central basin.

environment (this objective was not fulfilled because Seahurst Bay was dismissed from further outfall siting consideration).

The Seahurst Baseline Study was initiated in April 1982. It was to extend for a three year period with field sampling designed to terminate in March 1984 followed by analysis of the data, a final report and a post-effluent discharge monitoring plan in March 1985. In April 1984, after considerable study of new oceanographic, ecological baseline and cost information, the METRO Council decided to move the Renton Treatment Plant outfall site to Duwamish Head in outer Elliott Bay. This final report was produced on a shortened time schedule to document the ecological data collected in Seahurst Bay and the East and Colvos Passages of Puget Sound.

The technical organization of this study is illustrated in Figure 1.2. The major project divisions which routinely interacted were grouped together under water column, environmental health, sediment investigations and chemistry. The studies of the water column included monitoring of the physical/chemical characteristics of the water and the plankton. Sediment investigations included the ecological studies of the intertidal and subtidal benthos and fishes. Environmental health included the measurement of human pathogens (bacteria and viruses), fish pathology (fish health) and marine toxicology (in the water column, sediments and effluent). The chemical analyses were focused on the presence of trace metals in water, biota and sediment, in addition to a variety of support services to the entire project. The METRO Water Quality Laboratory was responsible for the analysis of trace organic compounds in sediments. The organizational structure of this study facilitated efficiency, fiscal control, interdisciplinary integration within and between tasks and ensured that the study scope and schedules were met in a timely manner. This report is similarly organized by task.

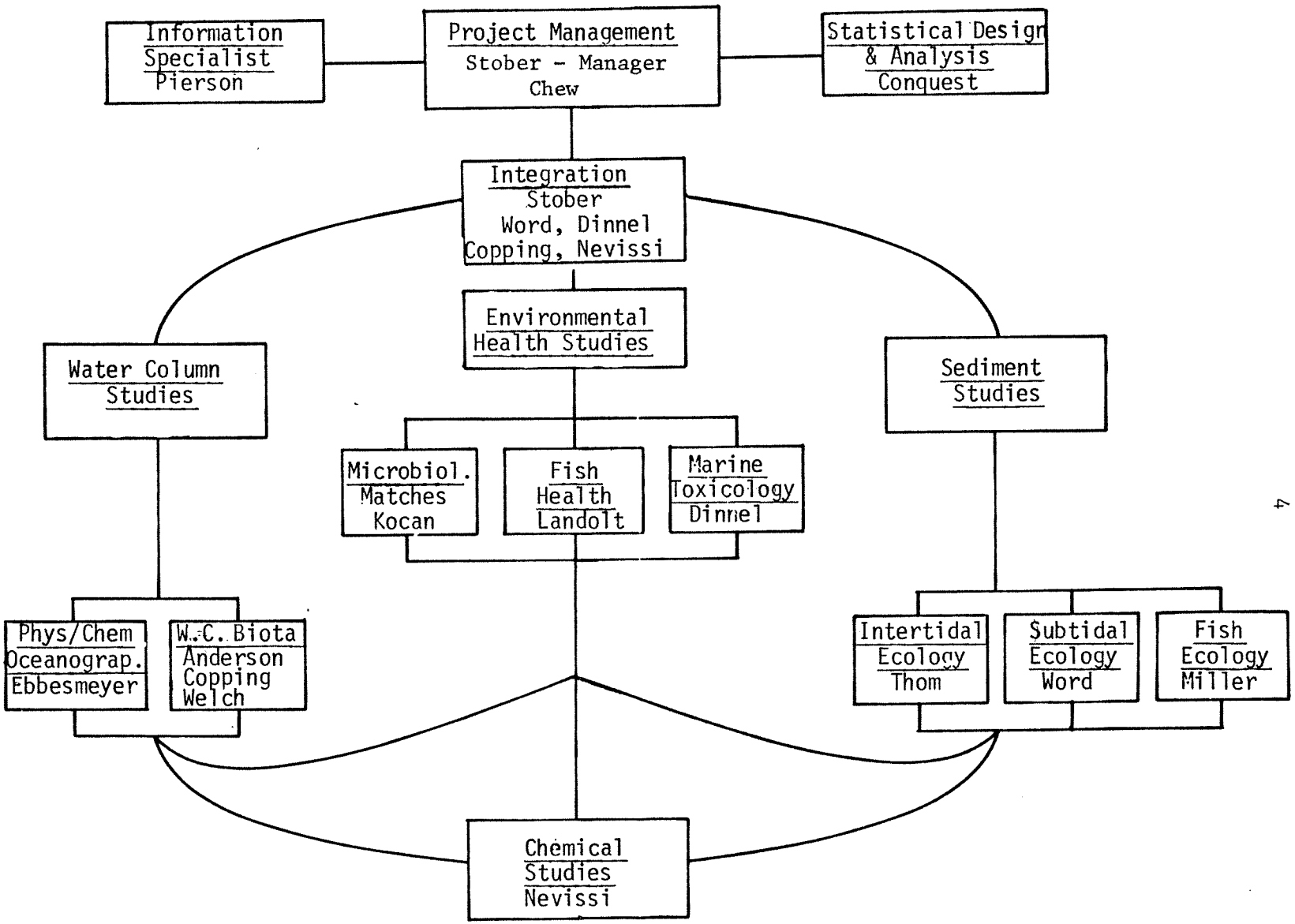

Figure 1.2. Organization of the Renton Sewage Treatment Plant Project, Seahurst baseline study indicating major project divisions, specific tasks, and responsibilities of selected personnel.

The information developed describes the experimental studies conducted and the existing detailed ecological baseline conditions in the south central basin of Puget Sound. These data will have direct applicability in future impact assessments in the area and will provide the basis for long range ecological monitoring of the study area in Puget Sound. The comprehensive and integrated approach used allowed the development of a more complete understanding of the marine ecology and the dispersion of particulates from marine sewage outfalls. The new information gained provides the basis for the design of specific future investigations needed to assess the effects of wastewater management on Puget Sound.

Oceanographic Circulation

Puget Sound is a system of fjord basins connected by constrictions in which there are strong tidal currents. The turbulence of these tidal currents causes water and other substances to be vigorously recycled among the basins before escaping the system after periods lasting as long as several years. The water within Puget Sound is a mixture of approximately 90% Pacific Ocean water and 10% freshwater.

There are substantial variations of physical and biological characteristics at intervals of days, months and years. Some of the processes which control the variability at the shorter intervals have been investigated, but those governing the longer time scales remain unknown.

The influence of man on Puget Sound has become evident as elevated metal concentrations in the sediments, increased incidence of tumors in flatfish in urban embayments and elevated bacteria concentrations on the beaches. Because man's individual discharges are recycled throughout the Puget Sound system, it is important that, the impact of these input activities be managed from a system point of view rather than by following the present practice of

considering individual discharges.

Resolution and understanding of the nearshore circulation of water in Seahurst Bay in relation to that in East and Colvos Passages was the focus of the physical and chemical oceanographic studies. Vertical profiles of temperature, salinity, density and dissolved oxygen were collected at two week intervals at 13 locations in the study area (Figure 1.1). These data along with results from current meters, drogues, drift cards and circulation tests in the University of Washington Puget Sound hydraulic model were utilized to describe the nearshore and offshore circulation under various tidal, weather and runoff conditions.

During much of the observational period of this study air temperature and river runoff was above normal. A comparison with historical hydrographic data showed that the departures from normal were highly correlated with water temperature and salinity. In fourteen one year intervals (1932-1983) for which monthly hydrographic data were available the annual average density in the water column during these observations was the lowest on record.

The circulation in Seahurst Bay was found to differ significantly between the northern and southern halves. A closed gyre circulating counter clockwise was found in the northern half of the bay. Within the gyre the mean speeds and tidal energetics were weak. The current in the southern half of the bay was found to sweep swiftly along shore to Point Pully. Contrary to the northern half the mean speeds and tidal energetics in the southern half of the bay were strong and comparable to those observed at mid-channel. These findings indicated the southern half of Seahurst Bay would be a better discharge site than the northern half which was dropped from any further consideration. Ultimately the METRO Council decided to eliminate the entire Seahurst Bay as the outfall site.

Water Column Ecology

Studies of the water column ecology were designed to focus on determination of seasonal patterns and the interrelationship between various study components. Phytoplankton (chlorophyll) and nutrient levels in the photic zone were related to the seasonal light cycle. The zooplankton cycle followed the phytoplankton cycle in time. The cycles were coupled in terms of the rates of change of each of the parameters. Phytoplankton increased in the spring and decreased in the autumn with respective minimum and maximum concentrations near the winter and summer solstice. A larger increase in zooplankton in the spring followed chlorophyll with a decrease in autumn. Maximum zooplankton abundance was observed about the summer solstice and minimum abundance about the winter solstice. The rates of change of nutrients were inverse to that for chlorophyll.

Phytoplankton, zooplankton and nutrient levels exhibited a large variability about the seasonal pattern. The spatial variation between stations on a given day was about 15% for nutrients, 30% for plankton biomass, and 40% to 50% for plankton species abundance. The temporal variation was about 2 to 3 times larger. Thus, the total variability about the seasonal smoothed averages was about 15 to 30% for nutrients, 100% for plankton biomass, and 150 to 200% for plankton species.

During the summer of 1983 chlorophyll levels in the photic zone were about twice that observed in 1982 or any year observed over the last decade. A major El Nino affected the waters of the Northeast Pacific Ocean in 1983 and resulted in an average water column temperature increase of about $1^{o}C$ in Puget Sound. This may have had a positive effect on phytoplankton growth in Puget Sound, however, the cause of the doubling in chlorophyll from 1982 to 1983 was not fully understood.

The dominant phytoplankton species were diatoms, which had maximum rates of growth in the spring. Dinoflagellates were second with maximum numbers in midsummer. Microflagellates were the third most abundant group with maximum numbers in midsummer. Toxic dinoflagellates were infrequently observed in small numbers. The dominant zooplankton observed in the main basin and Seahurst Bay were Paracalanus sp. and Corycaeus angilicus. Calanus pacificus was not numerically abundant but because of its size contributed a large biomass.

Intertidal and Shallow Subtidal Benthic Ecology

The intertidal and shallow subtidal benthic ecology of 30 south central Puget Sound beaches indicated that the major ecologically important habitats were sand flats, eelgrass meadows and cobble fields. Seasonal sampling was conducted in these habitats at six beaches [Seahurst Park, Seola, Normandy, Covenant (Des Moines), Tramp Harbor (Vashon Island) and Aquarium (Vashon Island)] located on the east and west shores of East Passage.

When compared to geographic location and elevation, substrate type was the primary factor accounting for differences in floral and faunal assemblage structure over the entire region. Cobble fields contained the greatest standing stocks of seaweeds, bivalves and smaller infauna while sand flats were lowest. Trace metal concentrations in sediments were generally at or below "background" Puget Sound concentrations, except at sites at the southern end of Vashon Island. There were no strong correlations between trace metal concentrations and biological parameters. Small infauna abundance and species richness correlated significantly with sediment biochemical oxygen demand (BOD), volatile solids, organic carbon, sulfide, percent silt and percent clay.

The major benthic plant life on these beaches consisted of eelgrass

(Zostera marina), sediment associated microflora, and seaweeds. Eelgrass generally occurred at depths between +1 and -10 ft (MLLW), and reached greatest density in embayments. Sediment microflora and seaweeds were distributed throughout the intertidal zone and down to a depth of at least -20 ft. The greatest standing stocks of seaweeds, microalgae and eelgrass occurred during summer (July-August), with minimum values recorded in winter (January-February). Species richness in seaweed assemblages was greatest in spring (April-May). Experiments with secondary sewage effluent indicated the production of bladed green algae was stimulated by concentrations of 0.1 and 1.0% and inhibited by concentrations of 5 and 10%. Drift vegetation along the shore reached greatest biomass in August.

All sediment parameters varied with season, with largest variations generally in cobble and eelgrass habitats. Parameters reflecting organic content of the sediment (i.e., BOD, volatile solids, organic carbon, nitrogen) showed maximum values during warmer months when algal detritus was in greatest abundance. It appeared that cobble and eelgrass habitats were more effective sinks of organic matter than were the sand habitats studied.

Small infauna (i.e., animals retained on a 1 mm mesh screen) abundance showed no consistent seasonal patterns. However species richness and biomass did exhibit seasonal variations, with peaks in spring and summer. Analysis indicated that habitat type was more important than geographic location or season in explaining among sample differences in species composition and abundance. Significant changes in infaunal assemblages occurred over a time period of 1 month or less. Changes included shifts in the feeding structure of the assemblage over this time period, and were most likely due to increased food supply from benthic algae.

Bivalves in the cobble habitat showed minimum abundance, species richness

and biomass in winter and a maxmimum in summer 1983. Changes in abundance and biomass were due primarily to changes in two species: littleneck clam (Protothaca staminea) and sand clam (Macoma spp.). Littleneck clams were most abundant during spring and summer, while the sand clam was most abundant during autumn and winter. Seasonal changes were due to both the growth of the bivalves and recruitment. Gravimetrically, littleneck and butter clams (Saxidomus giganteus) were the dominants throughout the year. Bivalves in the cobble habitat at Seahurst Park represent a recreationally important resource.

Epibenthic zooplankton were abundant in all intertidal habitats, with greatest densities occurring in sand habitats. The shallow subtidal eelgrass habitat appeared to sustain greater densities over time perhaps due to reduced predation and/or increased food trapping ability. Seasonal fluctuations in epibenthic zooplankton standing stocks were great, and reached maximum values in spring and summer. Fish stomach content analysis indicated that two (shiner perch and tube-snout) of the three epibenthic-feeding fish that were sampled had fed predominantly upon epibenthic zooplankters found specifically associated with subtidal sand and eelgrass. The third fish species (juvenile chinook salmon) had fed mostly on neustonic and planktonic prey. The data indicate that there may be a direct relationship between the standing stock of eelgrass-associated epibenthic zooplankton and the production of epibenthic-feeding fishes on the basis of the amount of substrate available for these forms.

The nearshore system in the Seahurst Bight is well integrated with regard to physical-chemical-biological linkages. Atmospheric and water chemistry conditions caused changes in the benthos. Further, primary production was relatively high as compared to other temperate marine geographic regions. Coupling of primary producers with benthic secondary producers is close, and

the dependence upon benthic prey by epibenthic fish populations appears to be specific.

Subtidal Benthic Ecology

The ecology of subtidal benthic invertebrate communities between Alki Point and Brown's Point at water depths of 50, 75, 200, 400, and 600 feet and the deepest points on cross Sound transect lines was examined at quarterly intervals from June 1982 to December 1983. Biological, physical, and chemical data were obtained at 93-132 stations during each of these sampling periods. The relationship of benthic communities to physical and chemical aspects of the sediments and the water column were examined through various statistical and graphical techniques.

Examination of conventional sediment chemical parameters (BOD, TVS, TOC and Dry/Wet weight ratio) revealed seven depositional areas which were associated with eddy circulation patterns and quiet water areas observed in the circulation studies. These areas had greater levels of conventional organic materials than generally observed at comparable depths within the study area. Other areas with increased conventional organic levels were located near sewage discharges (Salmon Creek, West Point, Zenith, etc.), combined sewer overflows (Denny Way in Elliott Bay), and near areas of river runoff (e.g., Duwamish River).

In the areas with greater quantities of conventional organic materials, greater abundance and fewer species of benthic infauna were observed. Near points or headlands, greater numbers of species were observed. The regions with the lowest abundance and species numbers were located at the greatest depths in the study area. It was also discovered that the eastern sides of the south central basin showed signs of organic enrichment with fewer species and greater abundance of indicator species at comparable depths.

Temporal patterns of subtidal benthic invertebrates were examined quarterly and compared to data previously collected in 1969-70. Polychaetes and arthropods were the most abundant groups taken in the samples in the spring and early summer while molluscs were most abundant in the summer and early fall. Individual species were found to behave differently than these group patterns. Longer temporal periods showed a switch from numerical dominance by polychaetes to dominance by a pelecypod. More species and more individuals are present in the system now than were there fifteen years ago. These differences are not due to variance in sampling or sorting techniques and do not seem to show a clear change in those species that are more tolerant to natural disturbance or man-made perturbations.

Adequate replication was examined as were various statistical clustering techniques and the effect of transforming data. These examinations will permit planning of monitoring programs that may eventually be developed for the East Passage area. The observations are sufficient to permit the prediction of effects of discharging effluents at various depths over different sediment types.

In general, increased organic loading to sediments will result in fewer taxa and more individuals. The species most likely to show enhancements as a result of organic loading are two pelecypods, Psephidia lordi in shallow water sands and Axinopsida serricata in deeper silty sediments. Species which will decrease in abundance are echinoderms and certain arthropods.

Fish Ecology and Health

The ecology of fishes in East Passage was determined quarterly at three sites at depths ranging from the surface intertidal zone to 600 ft. A total of 102 species of fish was caught during the sampling period. Fish abundance, groupings and species diversity showed that all of the sites were similar as a

result of physical and environmental similarities. A comparison of nearshore and offshore catches showed that species diversity was highest at 165 ft. and 328 ft. depths while species richness was highest in the nearshore area. Numerical analysis of species at all sample sites combined revealed that nearshore fish assemblages differed with season and offshore fish assemblages differed primarily with depth and secondarily with season. Presence of fin rot, skin tumors, and a parasitic bloodworm (Philometra) were used to monitor general external fish health. Incidences were very low and similar to previous studies indicating good fish health in a relatively unpolluted area of Puget Sound.

The presence of internal pathological defects was examined in 1,468 fish collected from demersal and pelagic populations. A variety of pathological conditions were noted; however, the general health of the populations was excellent. Most of the lesions observed posed minor risk to the fish and consisted primarily of parasitic infestations, traumatic injuries or inflammation. With the exception of a benign fibroma, no obvious neoplasms were found.

Microbiology/Virology

Intertidal samples of shellfish, water, and sediment were collected on a monthly basis from Lincoln Park, Seahurst Park, Normandy Park, Des Moines, Vashon Ferry, NE Vashon Park, Tramp Harbor, and Robinson Point for microbiological analyses. Water column samples were collected on a monthly basis from five offshore sampling stations. Shellfish and water samples from all beaches except Tramp Harbor and Robinson Point on Vashon Island were found to exceed U.S. Food and Drug Administration (FDA) fecal coliform standards for commercial shellfish harvesting and also to exceed EPA and Washington State Department of Ecology (DOE) water quality standards. A U.S. Environmental

Protection Agency health effects criterion was used to estimate between 10 and 23 cases of gastrointestinal (enterococci) illness per 1,000 individuals swimming in nearshore waters of East Passage. Tramp Harbor and Robinson Point were the only beaches sampled for which swimmers were not predicted to assume an increased risk of gastrointestinal illness above that of nonswimmers.

It was not possible to draw conclusions as to the extent of viral contamination of Puget Sound shellfish in the Seahurst area. The analysis of samples lagged the collection to the extent that procedural corrections were not possible and little data became available in this cooperative effort. Due to the lack of new data from this study, a review of the literature developed the following information. The presence of human enteric viruses in shellfish in the marine environment can not be statistically correlated with the presence of coliform bacteria in the shellfish or in the surrounding water using current microbiological standards. The majority of enteric human viruses found in marine shellfish are found in the vicinity of known sewage outfalls or in areas known to be contaminated by human sewage. Areas declared to be free of contamination by human enteric bacteria may not necessarily be free of contamination by human enteroviruses. The majority of human enteric viruses found in contaminated marine shellfish are the polio type 1 (vaccine) strain. The extent of viral contamination in Puget Sound shellfish has potential human health implications and remains an important area for future investigation.

Marine Chemistry

The chemical analyses conducted in this study constitute a first step in the evaluation of baseline trace metals in water, biota, and sediments in the Seahurst area. The level of trace metals in clam samples from the Seahurst area were generally lower than reported values for other areas of Puget Sound.

The concentration of most metals in fish muscle from the study area were comparable to values reported for Commencement Bay and Elliott Bay with the exception of As and Cr, which were lower in fish tissues from the study area. Plankton samples collected close to Seahurst beach showed high concentrations of trace metals, probably due to runoff and local input sources.

The concentration of trace metals in intertidal sediments was generally lower than in the subtidal sediments, due to a lower clay content in the intertidal sediments. Trace metal contents of subtidal sediments were comparable with those reported for central basin sediments but lower than the corresponding values for Elliott Bay and Commencement Bay.

Marine Toxicology

Baseline levels of water column toxicity were measured at eleven stations near Seahurst in East Passage and at one historical station off West Point. Water samples were collected several times per month during summer and fall of 1982 and 1983 at two or three depths per station. The assessment of toxicity was based on the results of standard 48-hour oyster embryo survival and abnormal development and sand dollar egg fertilization bioassays.

Measurable background water toxicity was detected at all stations and depths sampled. A high degree of variance dependent on date, location, year and assay type was evident at most stations. Oyster embryo mortality was highest in surface waters and within the Seahurst area of East Passage. Comparison of these results with historical Washington Department of Fisheries data from 1962-76 showed no substantial changes in oyster embryo responses either in magnitude or degree of variability for four similar stations.

Bioassays of five treatment stages of Renton sewage were conducted using a variety of gamete, embryo, and larval stages of common marine animals. The relative sensitivity of the bioassay indices ranked highest for: sand dollar

and sea urchin sperm (egg fertilization) followed by oyster and sea urchin embryo abnormality, oyster and sea urchin embryo mortality, and crab zoea mortality. The toxicity of sewage was ranked by type in the following order with chlorinated secondary effluent being most toxic followed by influent (raw sewage), primary effluent, dechlorinated secondary effluent, and unchlorinated secondary effluent. Primary treatment afforded only a slight reduction in acute toxicity over that observed for the influent sewage. Secondary treatment (without chlorination) effected a marked reduction in acute toxicity over that observed for primary treated sewage. Unchlorinated and chlorinated-dechlorinated secondary sewage were essentially equal and the least toxic. Chlorinated secondary sewage was more acutely toxic than influent or primary sewage. However, the rapidity of chlorine decay in seawater may "dilute out" the toxic effects of chlorine a short distance from the discharge point. Primary or influent sewage was less toxic than chlorinated secondary sewage. However, the toxicity of these stages may be due to the interaction of a wide variety of pollutants (i.e., metals, xenobiotic organics, petroleum hydrocarbons, pesticides, detergents, etc.) which are probably more persistant than chlorine in receiving waters.

The discharge of either unchlorinated or dechlorinated secondary effluent to Puget Sound should not cause any discernable acute toxicity to sensitive marine life stages assuming initial dilution of 100:1 or greater. The discharge of either chlorinated secondary or primary (especially chlorinated primary) effluent could cause acute toxicity on some occasions at initial dilutions less than 200:1.

Ten day amphipod bioassays of sediments from 27 Seahurst area stations were conducted twice each year for two years. Reduced amphipod survival and increased sublethal stress occurred in sediments from the northern East

Passage area and were correlated with grain size (threshold response in survival was observed between 20-63 um) and toxicant concentration. Seasonal trends in survival were generally not evident and within station variability was not consistently different between seasons and may be associated with differences in toxicant bioavailability. Results suggest that future addition of toxicants to the Seahurst area sediments may result in lower amphipod survival, however, additional types of sediment bioassays should be conducted to refine estimates of sediment toxicity.

Floatable Particulate Dispersion

The dispersion of secondary sewage effluent particulates and bacteria in seawater was studied under both laboratory and field conditions. The fate of 10 to 15% of primary effluent materials (which settle rapidly to the sea floor) discharged in wastewater outfalls can be predicted. The remaining portion is carried by a buoyant plume that is theoretically dispersed and then prevented from reaching the surface of the water by density stratification of the water column. A hypothesis is presented that suggests that vertical transport occurs and a significant percentage of buoyant materials penetrate density layers, may reconcentrate in surface layers and be available to horizontal transport and stranding on shorelines.

Experimental studies investigated the nature and behavior of some buoyant materials contained in secondary effluent. Previous research studies of these materials were rudimentary requiring development of particulate collection and analytical techniques to examine particle behavior after discharge into a closed system. Experiments were carried out in a water chamber 2.2 m high with a cross-section of 0.5 m^2. The water column was maintained with realistic density stratifications (both thermocline and halocline conditions). Secondary effluent was discharged through a model diffuser at the bottom of

the chamber. At selected times after discharge, the surface film and various depths within the water column were sampled and analyzed for these materials.

Results show a rapid increase in surface concentrations of Freon extractable and non-Freon extractable materials, as well as bacteria, after discharge of effluent into the chamber. Thirteen experiments yielded an average value of 1.7 mg of Freon extractable and 3.3 mg of non-freon extractable material per gallon effluent (normalized) from surface aspirations taken 60 to 80 minutes after discharge. For bacteria, the average of two experiments yielded 369 fecal coliform bacteria and 12 enterococci bacteria. An unexpected result of non-extractable analyses showed an actual doubling of the mass (the amount filterable on 1.2 μm paper) throughout the water column and at the surface. This may have been due in part to a complex process of coagulation where colloidal particles expand and absorb additional matter.

Results did not vary significantly under thermocline or halocline conditions. Physical measurements indicated that the vertical transport was not due to advection or mixing of water masses within the chamber. Therefore, the materials studied were more buoyant than the freshwater plume and behaved independently once the freshwater plume reached equilibrium.

In general, surface concentrations increased most dramatically within the first 20 minutes, and continued to increase more slowly between 20 and 80 minutes after discharge. From these data, an average rate of rise was formulated ($\sim$2 m/h). Extrapolations were made to hypothetical outfalls located at 60 and 180 m depths in Puget Sound. Materials discharged at these depths would require 12 and 48 hours, respectively, to reach the water surface. For a discharge of 100 million gallons per day, at experimental rates and concentrations shown, an estimated 500 kg or 192 gallons of buoyant materials would reach the sea surface on a daily basis. It is suggested that

efforts should be aimed at maximizing horizonal dispersion of this sizeable quantity of material before these particulates reach the surface waters.

Field studies of the Salmon Creek outfall which discharges into northern Seahurst Bay served as a field model for testing the concept of transport mechanisms and probable impact. Analytical studies documented several concentrating mechanisms including lateral transport predominately in surface slicks, stranding on shorelines and bio-accumulation processes. Two proposed outfall options were examined. Good correlations were found between predicted values of shoreline accumulations and direct observations.