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NOAA Data Report ERL PMEL-30

TRACE METAL AND ANCILLARY DATA IN THE WATERSHEDS AND URBAN EMBAYMENTS OF PUGET SOUND

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Pacific Marine Environmental Laboratory
Seattle, Washington

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Trace Metal and Ancillary Data in the Watersheds and Urban Embayments of Puget Sound

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1. INTRODUCTION

This is the first of three data reports encompassing trace metal and ancillary data obtained by the Pacific Marine Environmental Laboratory (PMEL) of NOAA in Puget Sound, Washington, between 1979 and 1986. This report includes the complete data set from two urban embayments (Elliott and Commencement Bays) and the watersheds discharging into Puget Sound. The second report (Paulson *et al.*, 1991b) provides data for the open waters of Puget Sound between 1980 and 1985. The third report (Paulson *et al.*, 1991c) provides data from both the embayments and open waters of Puget Sound and Hood Canal during a single cruise in August 1986.

In 1979, scientists at the Pacific Marine Environmental Laboratory began investigating the sources, transformation, transport and fate of pollutants in Puget Sound and its watershed under Sec. 202 of the Marine Protection, Research and Sanctuaries Act of 1971 (P.L. 92–532) which called in part for "...a comprehensive and continuing program of research with respect to the possible long range effects of pollution, overfishing, and man-induced changes of ocean ecosystems..." The effort was called the Long-Range Effects Research Program (L-RERP) after the language in the Act and was later called the PMEL Marine Environmental Quality Program. Building on research then underway at PMEL on estuarine circulation, laboratory scientists began a coordinated study that began with the description of the distribution of properties (salinity, temperature, trace metals and trace organics) in the water column and underlying sediments. The objectives of the Marine Environmental Quality trace metal program were 1) to quantify the sources and sinks of selected trace metals for Puget Sound, 2) to determine geochemical mechanisms that transform trace metals between the dissolved and particulate phases and 3) to determine to what extent these geochemical mechanisms alter the fate of trace metals entering Puget Sound. Work began in rivers discharging into Puget Sound and process studies were undertaken to understand the role of flocculation in trace metal transport. Subsequently the research centered on the role of suspended sediments in transporting and redistributing trace metals and organics in the main basin of the Sound. Research activities included deployment of long-term current meter moorings, acquisition of a library of sediment cores, deployment of sediment traps and the analysis of dissolved and particulate chemical constituents of the water

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column and sediments. The scientific results of these activities have been reported in over 100 publications (see Section 5).

Because these measurements constitute the most extensive data base of trace metal observations in Puget Sound, many of which have been unavailable to other investigators, we feel that they should be widely available to the local scientific community as well as others interested in estuarine geochemistry. Twenty-eight cruises were undertaken between 1979 and 1986 to accomplish these objectives. Besides the dissolved and particulate trace metals data, salinity, temperature data and concentrations of dissolved oxygen, methane, nutrients, particulate organic carbon and particulate organic nitrogen were sometimes obtained.

The water column data are divided geographically in the following manner: Duwamish River, Duwamish Waterway, Elliott Bay and Commencement Bay and other rivers discharging into Puget Sound. In addition to the water column data, sediment trap, sediment column solid phase and sediment column interstitial phase (pore water) data are presented. The information gained from this data has been interpreted by PMEL scientists and is published in a variety of scientific journals that are listed within each section.

The text of this data report consists of the sampling and analytical methods with the accompanying quality control/quality assurance data. The text of the data sections are a summary of the data and published literature in which the data is interpreted along with a catalogue of the data available on microfiche located in the back pocket of this data report. In most cases, a table consists of one station with the parameters as columns and the depths as rows. The tables on microfiche were produced from hardcopies of files in a grouphome of the data management program RS1 (Version 4.2) on a VAX mainframe computer at PMEL. Those wishing a copy of the RS grouphome on tape should contact the senior author by letter. ASCII text files of each RS1 data file have been produced with fields separated by commas. Those wishing IBM compatible ASCII text files on either high density 3.5" or 5.25" diskettes may contact the senior author by letter. Under no circumstances will hardcopies of the files be available from PMEL.

2. METHODS

2.1 Sampling and Processing

2.1.1 Water Column

Surface samples in the freshwaters of Puget Sound watersheds were collected mid-channel by lowering acid-cleaned, 1-L linear polyethylene bottle (LPE) from bridges or the bow of a small boat with a nylon line or by tossing the LPE bottle attached to the nylon line towards the center of the river channel. Samples from the Duwamish Waterway during the three DEC cruises (Figs. 1 and 2) and the small boat operations of LRERP 80 (Fig. 3) and LRERP 81-4 (Fig. 3) were collected using Go-Flo® bottles attached to a hydrowire and transferred to acid-cleaned, 1-l LPE bottles. Surface samples from the Duwamish River during LRERP 80 and 81-4 and from Elliott Bay and the Duwamish Waterway during LRERP 85-2 (Fig. 4) and LRERP 86-1 (Fig. 5) were collected in acid-cleaned, 1-L LPE bottles from the bow of a small boat. One-liter samples from the DEC cruises and LRERP 86-1 cruises were transported to the laboratory for filtration. During LRERP 80 and 81-4, samples were transported to the *Miller Freeman* and while LRERP 85-2 samples were transported to the *McArthur.*

Elliott (Fig. 1–5) and Commencement Bay (Fig. 3, 6, 8) seawater samples taken for dissolved oxygen, methane and nutrient analyses during L-RERP 80, L-RERP 81-4, L-RERP 82-1 and L-RERP 82-11 were collected in 10-liter standard Niskin bottles attached to a General Oceanics rosette. During L-RERP 84-2, L-RERP 84-9 and L-RERP 85-2, oxygen, methane and nutrient samples were collected from the same 10-L Go-Flo bottles as those used to collect particulate trace metal samples. Once on deck, water for dissolved gas analyses was transferred to clean glass-stoppered bottles in such a way that air bubbles were not trapped. For the methane sampling, 1-liter aliquots were taken from the Niskin samplers and stored until analysis. The oxygen samples were collected in standard 125 milliliter D.O. bottles. Nutrient samples were placed in ice or dry ice onboard and transferred to a low-temperature freezer prior to analysis. Due to the complexity of the project involved, samples had to be stored onboard ship for up to a week before they were transported back to the laboratory. Since storage could result in some complications in the analysis, both the methane and the oxygen samples were placed in wooden containers that were sheltered in a dark, cool place until transportation. Storage tests utilizing multiple samples drawn from the same Niskin bottle were run for both methane and oxygen. The methane storage test samples were treated with approximately 200 mgs of sodium azide as described in Katz (1980). The test results were identical to Katz (1980), which indicated that no significant change in methane concentration occurred if samples were properly stored. The results of the oxygen storage test proved to be somewhat more complicated, and indicated a loss in precision. It was determined that much of this loss was probably due to two factors: 1) under acidic conditions, a gain in iodine by photo-oxidation or oxidation by nitrite, and 2) the introduction of air bubbles during transport. Slight modifications were made to the method which improved the precision of the oxygen procedure to an acceptable level.

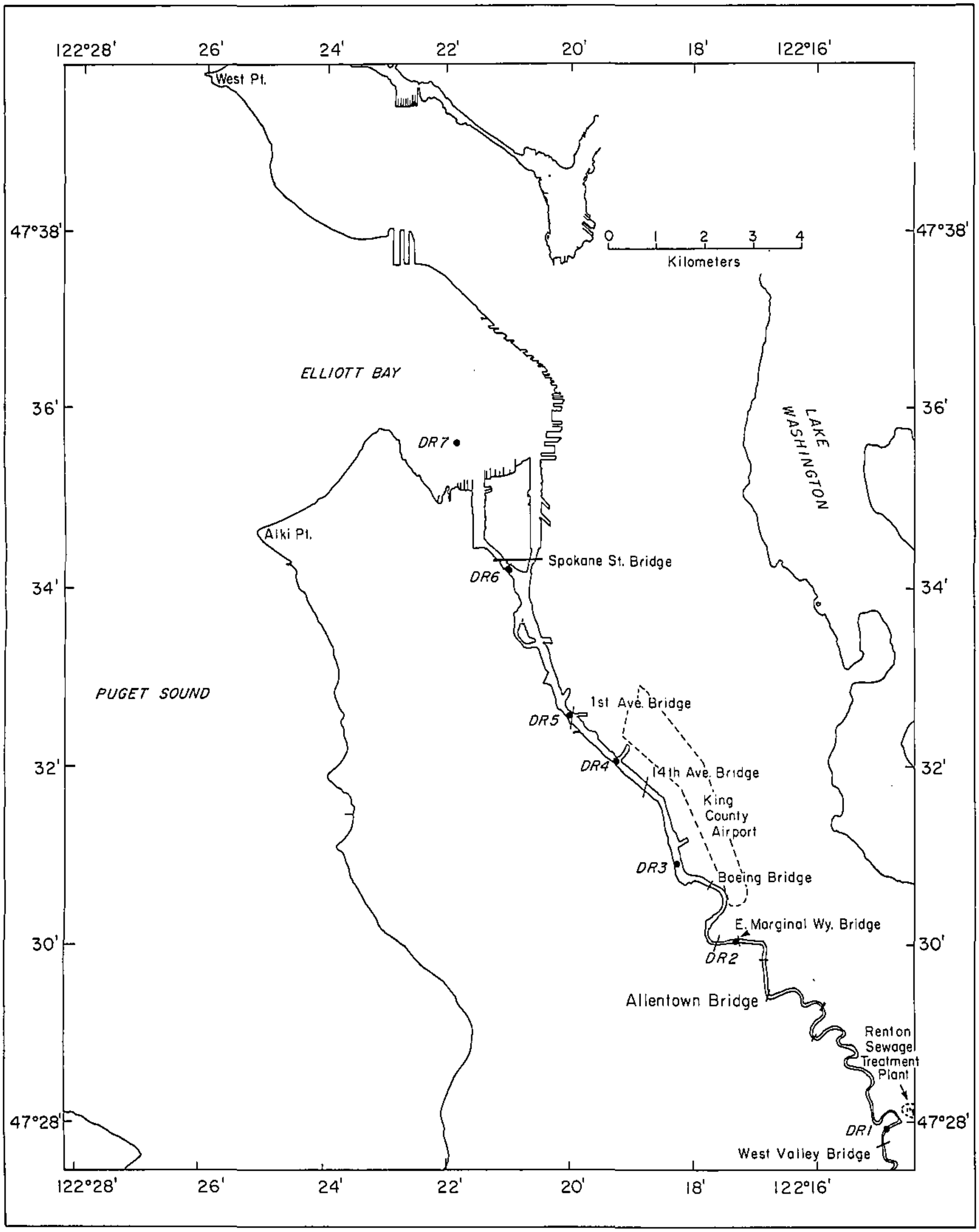

Fig. 1. Sampling locations for DEC-I.

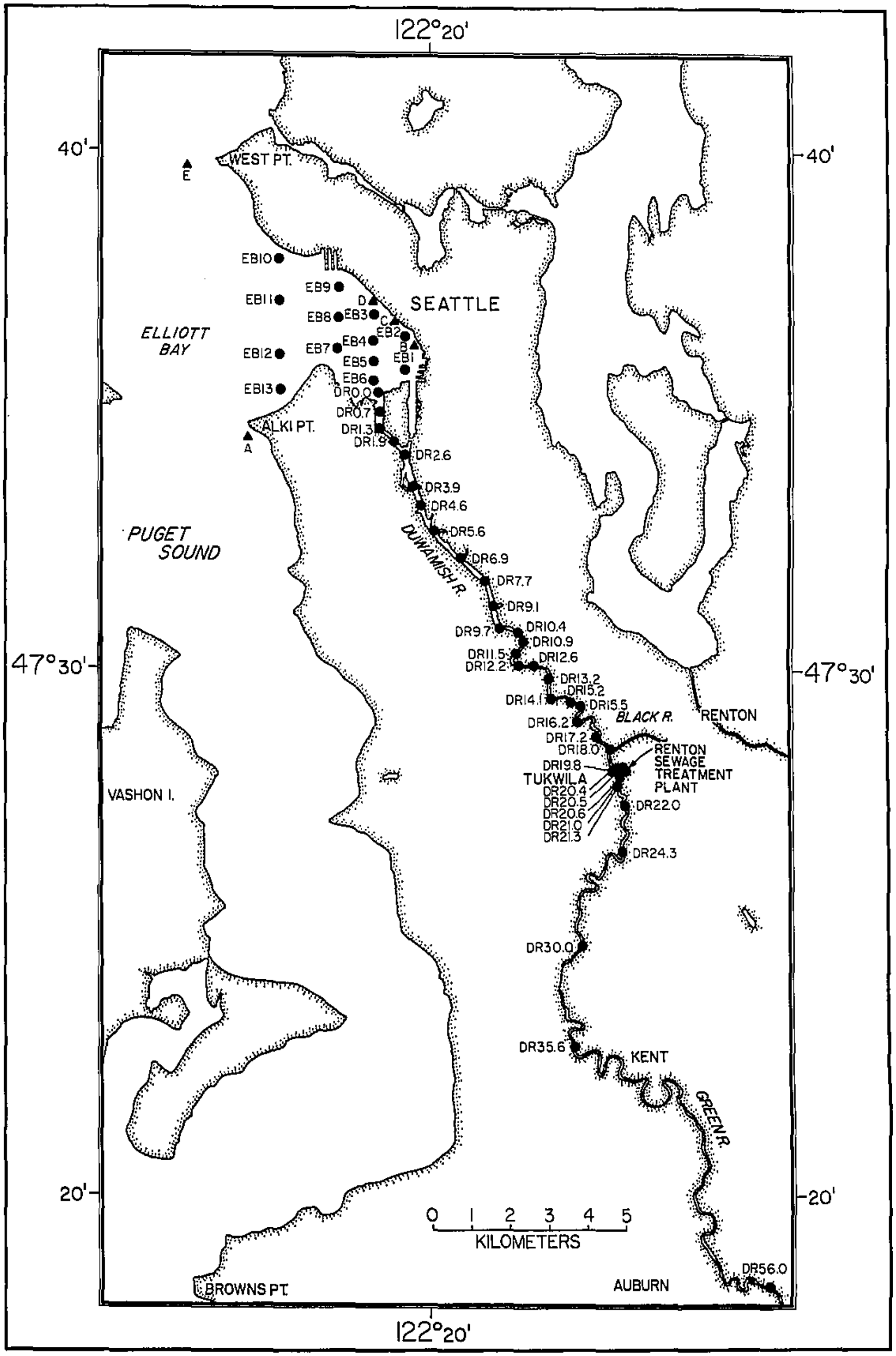

Fig. 2 Sampling locations for DEC-II to DEC-IV.

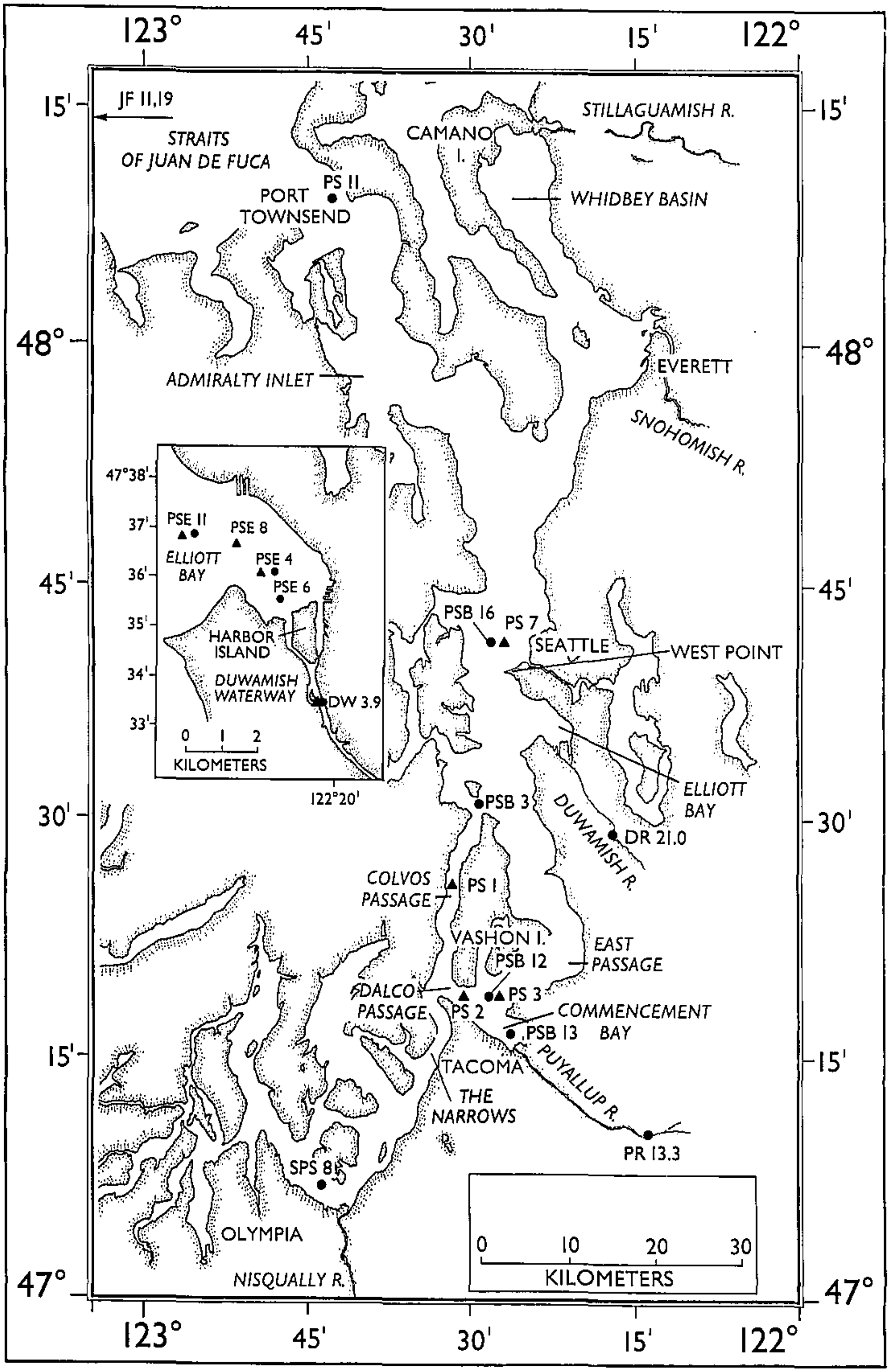

Fig. 3 Sampling locations in Elliott Bay for L-RERP 80 (●) and L-RERP 81-4 (▲) and in Commencement Bay for L-RERP 80 (●) and L-RERP 80-2 thru L-RERP 83-4 (▲).

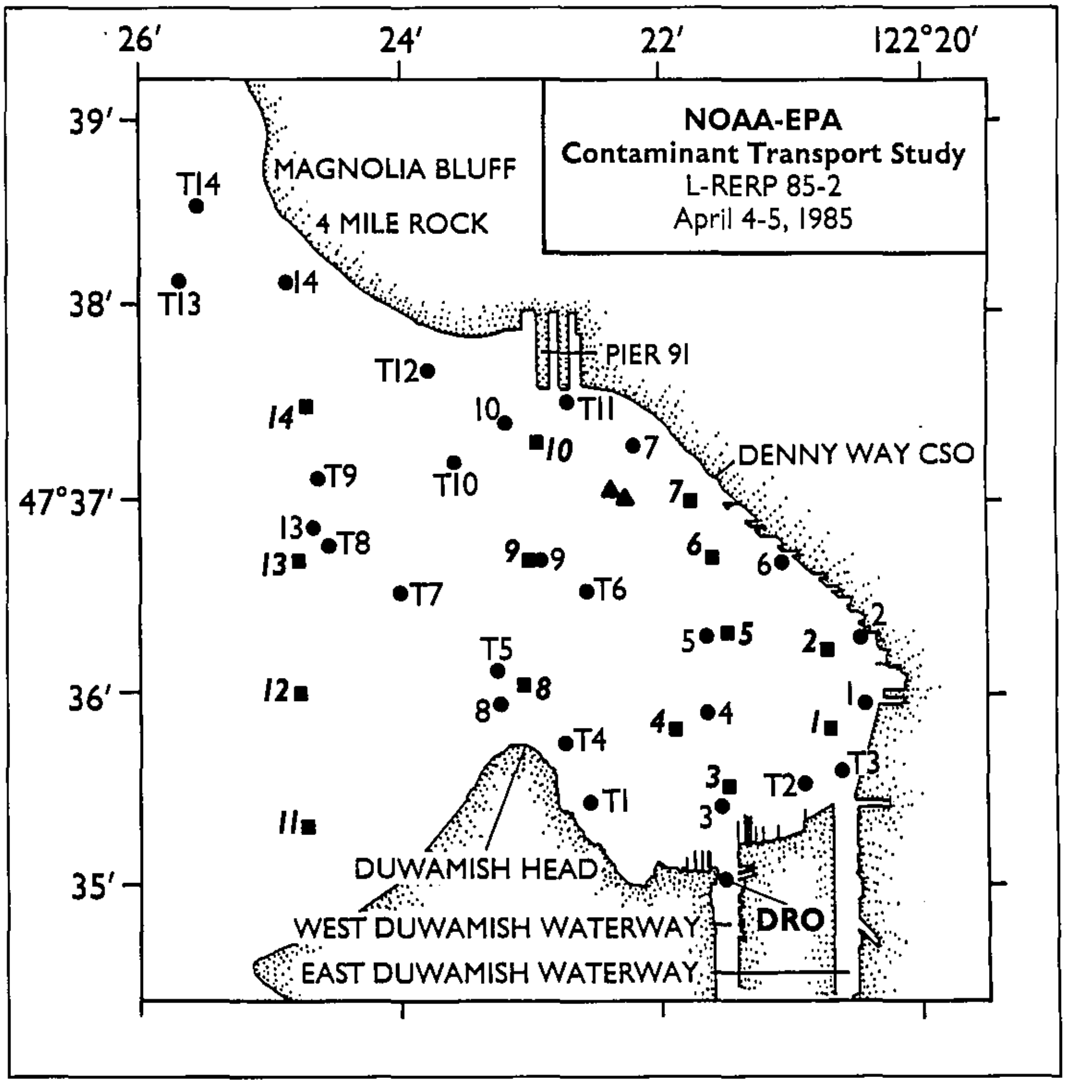

Fig. 4 Sampling locations in Elliott Bay for L-RERP 85-2. Surface samples by small boat stations (●), vertical profiles (■) and sediment trap mooring (▲).

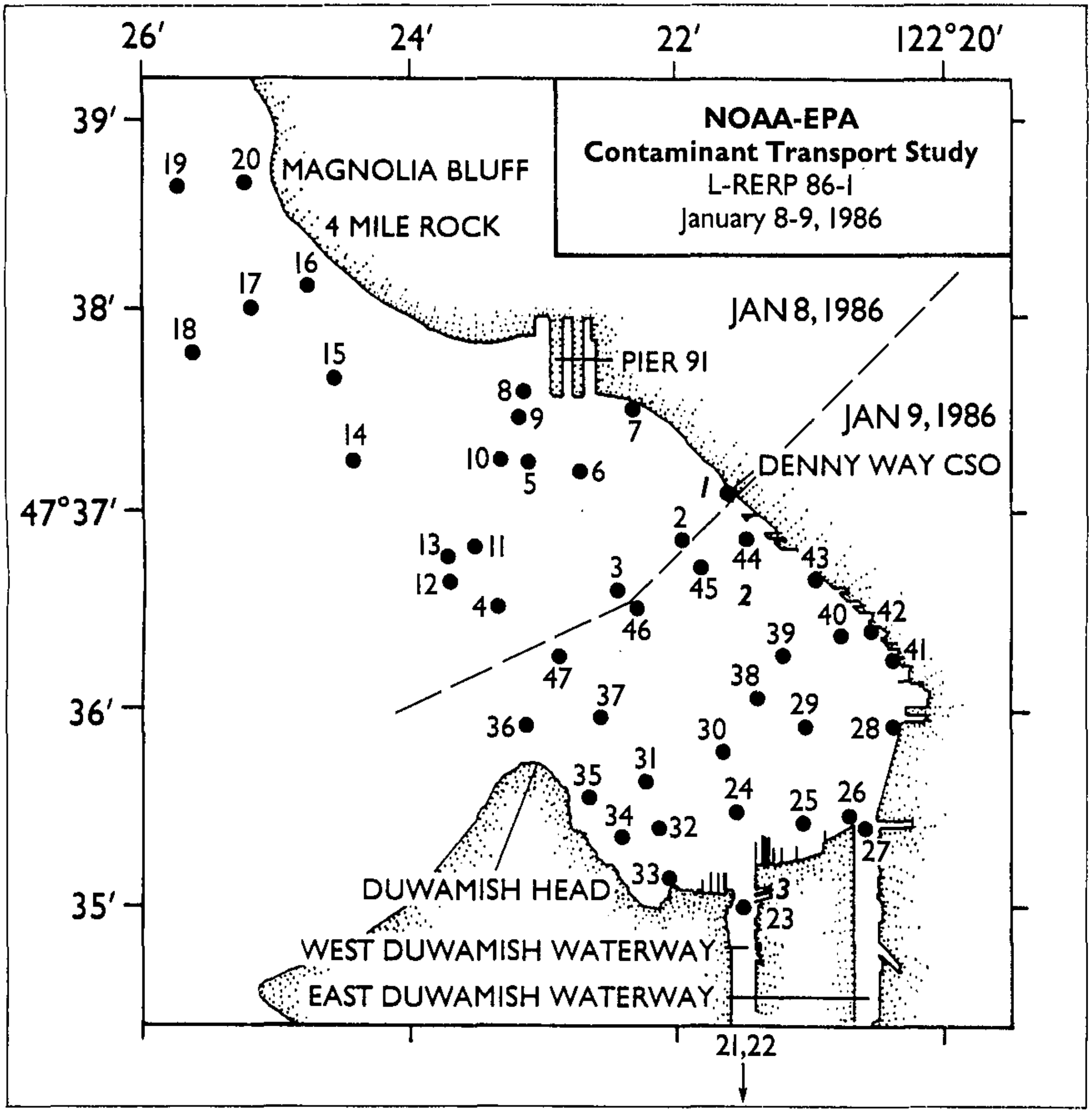

Fig. 5 Sampling locations in Elliott Bay for L-RERP 86-1.

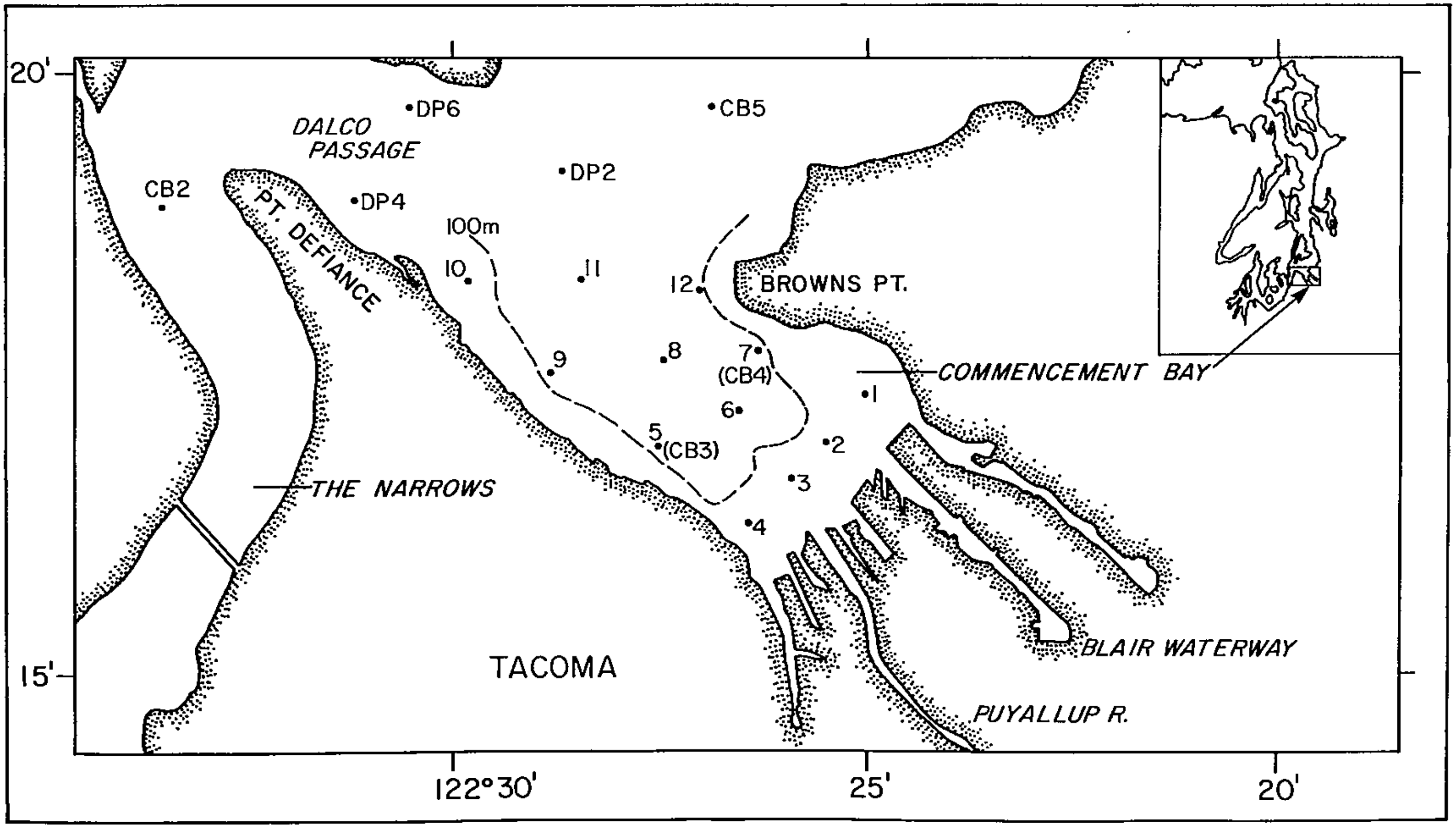

Fig. 6 Sampling locations in Commencement Bay for COMMBAY III. Mooring locations in parentheses.

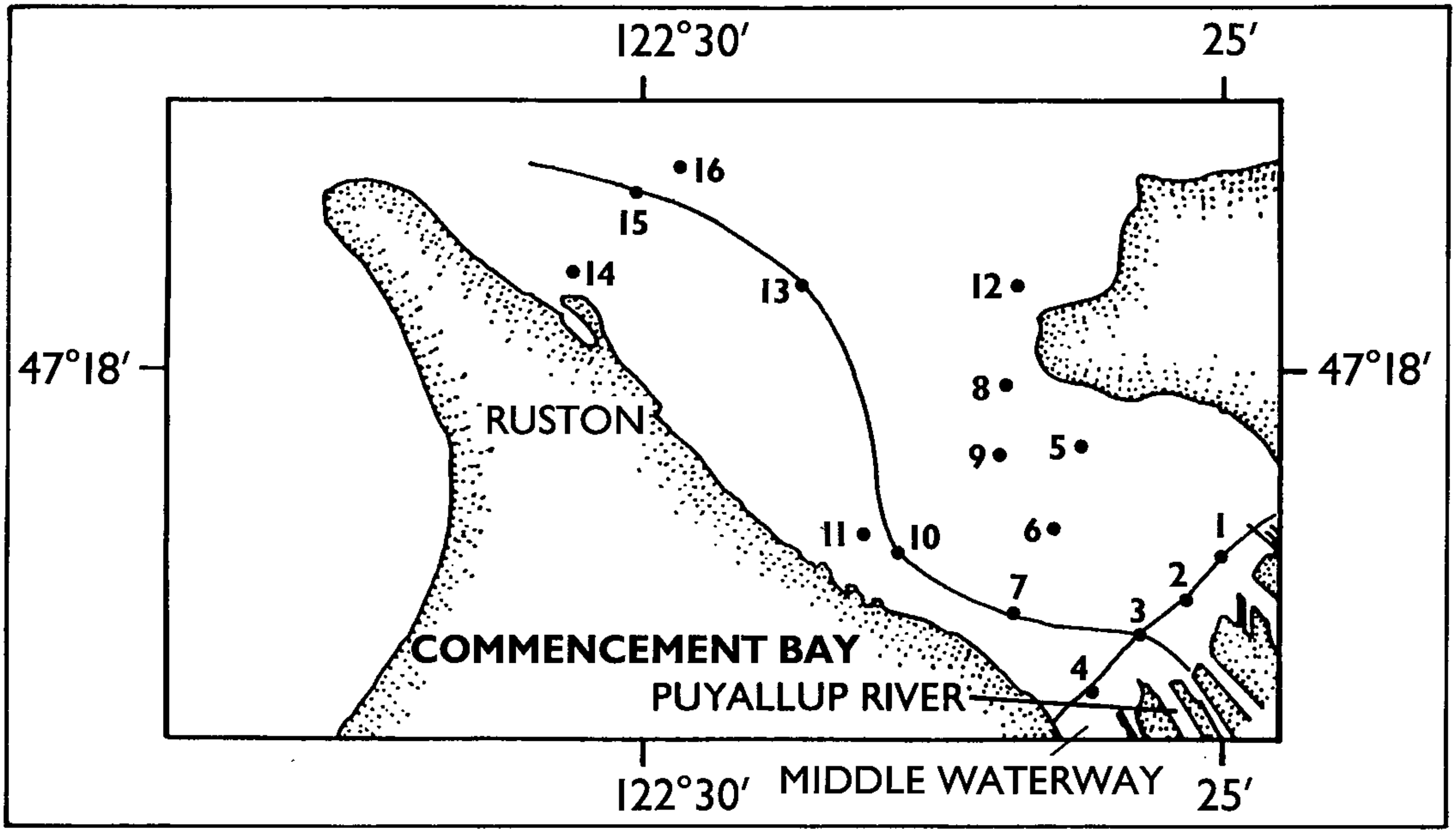

Fig. 7 Sampling locations in Commencement Bay for L-RERP 85-2.

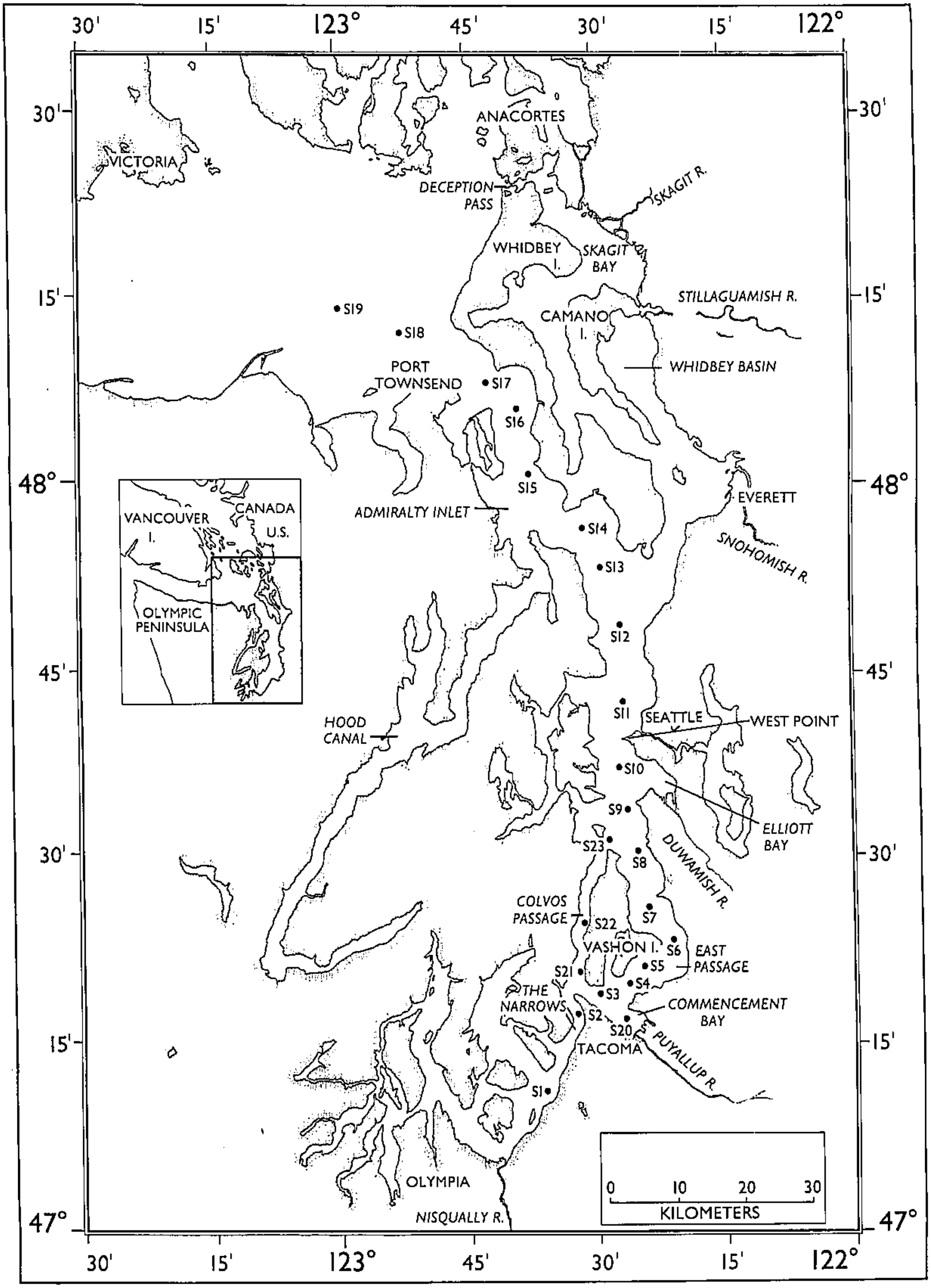

Fig. 8 Sampling locations for L-RERP 84-2 and 84-9.

Elliott and Commencement Bay seawater for nutrients (except L-RERP 80, L-RERP 81-4, L-RERP 82-1 and L-RERP 82-11), total suspended matter (TSM), particulate trace metals and particulate organic carbon and nitrogen (POC & PON) analyses were collected in Teflon®-coated 10-L Go-Flo® bottles attached either to a General Oceanic rossette sampling device or to a hydrowire. Salinity and temperature data were taken from CTD (conductivity-temperature-depth) instrumentation or from discrete samples collected from the Go-Flo® bottles for analyses and from reserving thermometer data, respectively. Analysis of discrete Go-Flo® samples allows comparisons with the CTD data to detect mistripping of Go-Flo® bottles.

Elliott and Commencement Bay dissolved trace metal samples were collected in specially-modified Teflon®-coated Go-Flo® bottles attached to a Kevlar line. Standard Go-Flo® bottles were modified by replacing all O-rings with silicone O-rings and replacing the spigot with a Teflon® stopcock. The ends of the bottles were covered with new clean plastic bags whenever they are not on the Kevlar line. Subsurface samples from DEC cruises were collected from Go-Flo® bottles attached to the hydrowire, bagged in plastic and transported to the laboratory for processing. While modified Go-Flo bottles were hanging on the Kevlar line during LRERP cruises 80, 81-2, 81-3, 81-5, 1-L samples were transferred to LPE bottles, bagged in plastic and carried to a laminar flow hood onboard ship. During and after LRERP 82-1, discrete salinity samples from all Go-Flo samples were taken to insure proper collection.

The method of collection of each sampling period is listed in Table 1. Samples for dissolved trace metal analyses were filtered through acid-cleaned 0.2 μm Nuclepore filters, collected in LPE bottles, persevered by adding Ultrex nitric acid to a pH < 2 and refrigerated or frozen until analysis. All sampling and collection LPE bottles were cleaned in hot HCl and cold NNO_3, rinsed with Quartz-distilled water (Q-H_2O) and were stored in plastic bags when not in use. One-liter samples from DEC cruises were filtered using 47 mm filters held in a Sterifil apparatus within the confines of a class 100 laminar flow hood. TIPS I samples were filtered using 47 mm filters held in Sterifil apparatus within a glove bag while TIPS II and III samples were filtered within a portable laminar flow hood powered by a gasoline generator using unleaded gas. L-RERP 80 samples in 1-L LPE bottles were filtered through 47 mm 0.2 μm Nuclepore filters held in a Sterifil apparatus within the confines of a laminar flow hood built into a laboratory van onboard.

Beginning with TIPS 4a in March of 1981, TIPS samples were filtered in-line using 50 mm filters held in the all-Teflon® Savillex® filtering apparatus within a portable laminar flow hood. Prior to each sampling period, all-Teflon® Savillex® filtering apparatus and 50 mm 0.2 μm Nuclepore filters are acid-cleaned, assembled and rinsed by processing 1 L of 0.1 N nitric acid through each apparatus. Quartz-distilled water was then processed through each apparatus. Teflon® Savillex® filtering apparatus were used during LRERP cruises 81-2, 81-3 and 81-5 within a portable laminar flow hood. Surface samples from L-RERP 86-1 in 1-L LPE bottles were filtered using 50 mm filters held by the Teflon® Savillex® apparatus within a laminar flow hood

TABLE 1. Sampling and filtration data.

Cruise	Dates	Location	Type of sampling	Particulate filter diameter (mm)	Maximum elapsed time between collection and filtration (hr)
DEC I	Aug. 11, 1979	Elliott Bay and Duwamish Waterway	Hydrocasts with 5-L Go-Flo's off R.V. ONAR	25	12
	Aug. 11, 1979	Duwamish River	Bridge	25	12
DEC II	Feb. 20, 1979	Elliott Bay and Duwamish Waterway	Hydrocast with 12-L Go-Flo's off R.V. ONAR	25	12
	Feb. 19, 1979	Duwamish River	Small boat	25	12
L-RERP 80	May 22-24, 1980	Elliott Bay	CTD/Rossette cast with 10-L Go-Flo's off NOAA Ship MILLER FREEMAN[1]	25	1
			CTD/Rossette cast with 10-L Niskin off NOAA Ship MILLER FREEMAN[2]		
			Hydrocast with Kevlar Cable[3]	--	1
	May 21, 1980	Duwamish Waterway	Hydrocasts with 5-L Go-Flo's off R.V. ONAR	25	24
	May 24, 1980	Commencement Bay	Same as for Elliott Bay		
DEC III	Sept. 12, 1980	Elliott Bay and Duwamish Waterway	Hydrocast with 5-L Go-Flo's off R.V. ONAR	25	12
	Sept. 11, 1980	Duwamish River	Bridge	25	1
TIPS 1-3	1980-1981	7 rivers	Bridge	25	1
TIPS 4a-7	1981-1984	8 rivers	Bridge	37	1
L-RERP 80-2	Nov. 21, 1980	Commencement Bay	Hydrocast with 10-L Go-Flo's[4] off R.V. ONAR	37	1
L-RERP 81-1	Feb. 6, 1981	Commencement Bay	Same as L-RERP 80-2	37	1
COMBAY III	Mar. 26, 1981	Commencement Bay	Hydrocast with 10-L Niskins off R.V. ONAR	37	1
L-RERP 81-2	Apr. 30, 1981	Commencement Bay	Same as L-RERP 80-2	37	1
L-RERP 81-3	Jul. 16, 1981	Commencement Bay	Same as L-RERP 80-2	37	1
L-RERP 81-4	Aug. 25-26, 1981	Elliott Bay	Same as L-RERP 80	37	1

TABLE 1. (cont.)

Cruise	Dates	Location	Type of sampling	Particulate filter diameter (mm)	Maximum elapsed time between collection and filtration (hr)
	Aug. 27-28, 1981	Commencement Bay	Same as L-RERP 80	37	1
	Aug. 26, 1981	Duwamish Waterway	Hydrocast with 5-L Go-Flo's from small boat	37	24
L-RERP 81-5	Nov. 3, 1981	Commencement Bay	Same as L-RERP 80-2	37	1
L-RERP 82-1	Feb. 22, 1982	Commencement Bay	Same as L-RERP 80 except on NOAA Ship MCARTHUR	37	1
	Mar. 2, 1982	Duwamish Waterway	Hydrocast with 5-L Go-Flo's from small boat	37	2
	Mar. 1-2, 1982	Duwamish River	Bridge	37	1
L-RERP 82-11	Apr. 20, 1982	Commencement Bay	CTD/Rossette cast with 10-L Niskin off NOAA Ship McARTHUR	37	1
L-RERP 83-4	Apr. 20, 1983	Elliott Bay	Same as L-RERP 82-1	37	1
	Apr. 18-19, 1983	Commencement Bay	Same as L-RERP 82-1		
L-RERP 84-2	Dec. 7, 1983	Elliott Bay	CTD/Rossette cast with 10-L Go-Flo's off NOAA Ship McARTHUR Hydrocast with Kevlar line[3]	37	1
	Dec. 5-6, 1983	Commencement Bay	Same as above	37	1
L-RERP 84-9	Aug. 7, 1984	Commencement Bay	Same as L-RERP 84-2[5]		
L-RERP 85-2	Apr. 4-5, 1985	Elliott Bay (profile)	Same as L-RERP 84-2[4]	37	1
		Surface Samples	Small boat	37	4
	Apr. 1-2, 1985	Commencement Bay	Same as L-RERP 84-2	37	1
L-RERP 86-1	Jan. 8-9, 1986	Elliott Bay	Small boat	37	6
	Jan. 9, 1986	Duwamish Waterway	Small boat	37	6

1) TSM, particulate trace metals and POC/PON
2) O_2, methane and nutrients
3) Dissolved trace metals
4) Nutrients, dissolved trace metals, TSM, particulate trace metals and POC/PON
5) Oxygen, methane, nutrients, TSM, particulate trace metals and POC/PON

at PMEL. For kevlar hydrocast samples from the L-RERP 81-4 and from all L-RERP cruises between L-RERP 82-1 and 85-2, the ends of Go-Flo® bottles were covered with plastic bags and carried to a specially-designed laboratory van onboard containing a class 100 laminar flow hood. Water from the Go-Flo® bottles was then filtered in-line in a system containing a 50 mm filter held in a Savillex® filtering apparatus that was closed to the atmosphere and collected in LPE bottles. Beginning with LRERP 82-1, the first 500 ml was discarded before collection of seawater for analysis. All procedures requiring exposure of the sample to the atmosphere were performed in the class 100 laminar flow hood. If the filtering apparatus is reused, a new acid-cleaned filter is placed in the apparatus and the apparatus is then cleaned by rinsing with 1 L of 0.1 M HNO_3.

Suspended matter for TSM and particulate trace metal analyses was collected on pre-tared, acid-cleaned 0.4 μm Nuclepore filters while 0.45 μm Selas® silver filters were used to collect POC & PON samples. All TSM data for TIPS samples were determined from 47 mm filters. TIPS samples were immediately filtered in the field. For DEC cruises and the LRERP 80 cruise, TSM samples were collected on 47 mm filters while particulates for trace metal analyses were collected on 25 mm filters held in Swinnex® filtering apparatus. With L-RERP 80-2 and all LRERP cruises that followed, suspended matter for both the TSM and particulate trace metal analysis was filtered inline using 37 mm Nuclepore filters held in modified, Teflon® Savillex® filtering apparatus. The size of filters used for particulate trace metal analyses and elapsed time between collection and filtration for each sampling period is given in Table 1. Filters for particulate trace metals were loaded and unloaded in a laminar flow hood. All samples were rinsed with Milli-Q water (pH 8), placed in acid-cleaned polycarbonate petri dishes with Teflon® holders and vacuum-desiccated over sodium hydroxide. Reference filters from the same filter lot were stored and desiccated along with the samples to evaluate changes in weight by the filters due to humidity.

By convention, samples collected by hand (small boat, shore, bridge) were assigned a depth of 0 m. Duwamish Waterway samples collected by hydrocast using 5-L Go-Flo bottles were assigned a depth of 0.5 m. The depths of samples collected in 10-L Go-Flo bottles attached at a rossette sampler during a CTD cast were usually recorded as sampling bottles were being tripped. If no depth was recorded, the surface rossette sample was assigned a depth of 1 m. The depths of sub-surface samples taken by hydroccast were calculated by the length of hydrowire or kevlar cable in the water at the time the bottle was tripped. No correction was made for wire angle. With L-RERP 84-2, a non-metallic pinger was installed at the end of the kevlar line to more accurately collect near-bottom samples by Kevlar hydrocast.

2.1.2 Sediments

Surface sediment samples were collected during L-RERP 81-4 in the Duwamish Waterway and River using a Shipek sampler. The top few cm of each sediment sample was scraped into a plastic bag using plastic utensils and frozen until weak acid-soluble (WAS) analyses were undertaken. Sediments used for vertical profiles of solid phase constituents were collected with a Kasten corer or a Benthos Model 2171 gravity corer lined with a plastic core barrel. The cores were stored frozen until sectioned in the laboratory for analysis.

2.1.3 Porewaters

Sediment for porewater analyses were collected with a Benthos Model 2171 gravity corer lined with a plastic barrel or a box corer. When a box corer was used, a vertical sediment core was obtained from the box corer by forcing a plastic barrel through the sediment until the barrel contacted the bottom of the box corer. Sections of sediment were extruded from the top of the corer by mechanically applying upward pressure to the bottom of the sediment core. Sediment sections of measured thickness were then sliced from the sediment corer using thin plastic sheets. The sediment on the sheets was then loaded into acid-cleaned polypropylene centrifuge tubes. The sediment was then centrifuged at 400 g's for 0.5 hours. The supernate was then transferred to acid-cleaned polypropylene syringes and filtered through 0.2 μm Nuclepore filters held in 25 mm Swinnex® filter holders. The filtered porewater was then split into aliquots for salinity, nutrient and trace metal analyses. The aliquot for trace metal analyses was placed in an acid-cleaned polyethylene bottle and acidified to pH <1.6 with nitric acid. All cores were processed in air except the L-RERP 85-2 core, which was processed under a nitrogen gas atmosphere.

2.1.4 Settling Particulates

Sediment trap samples were obtained from moored arrays which have been deployed in Puget Sound for up to 3-month periods. A rotating chamber design permitted individual samples to be collected for 6 days after which a new chamber was positioned under the opening. The lucite collection cylinders were cleaned before deployment in 6 N HCl for 24 hours and then rinsed with deionized water (Milli-Q®). The sample cylinders were filled with a brine solution of about 40 ppt which contained sodium azide to prevent biological oxidation from producing anoxic conditions in the cylinders. Upon recovering the sediment traps, the material was collected on filters as described above.

After the traps were recovered, individual cylinders were mixed by inversion and three 30-ml aliquots of the slurry were removed. The aliquots from the ten cylinders were mixed together for the 1981 sample while aliquots for the 1985 samples were processed individually. The samples were sieved on an acid cleaned Nylon screen (64 μm) and the material passing through the screen was then filtered (0.4 μm, 47 mm Nuclepore). The samples were dried at room temperature over NaOH. If the filter contained more than 2 mg, the dried sediment was removed from the filter and stored in acid cleaned polyethylene vials. The material was then ground with a boron carbide mortar and pestle.

2.2 Analyses

2.2.1 Temperature and Salinity

Salinity data reported for the Duwamish River and Waterway and for porewaters were obtained by coulometric titration. Salinity and temperature data for Elliott Bay and Commencement Bays was obtained from conductivity-temperature-depth (CTD) instrumentation. The Plessey CTD was calibrated in accordance with procedures NOIC-CP-04A. Digitally recorded data from CTD were converted to engineering units by applying the calibration relations determined by the Northwest Regional Calibration Center. The salinity was calculated based on the depth, temperature and conductivity. A temperature and salinity offset was applied to the field CTD data based on the differences between the discrete measurements of salinity and temperature and those calculated from the CTD calibrations. Data converted through calibrations were field checked to provide salinity to ±0.01 and pressure to ±1.0 decibars. The bench salinometers used for the discrete Elliott and Commencement Bay samples provided salinity measurements to 0.003 ppt for discrete samples.

2.2.2 Dissolved Oxygen

Dissolved oxygen concentrations were determined by Winkler titrations (Winkler, 1888) as modified by Carpenter (1965) and reported in Strickland and Parsons (1972) and Parsons *et al.* (1984). The procedure was standardized with oven-dried KIO_3 while blanks were determined by the difference method.

2.2.3 Methane

The methane analyses were performed employing a purge and trap technique adopted and modified from Swinnerton and Linnenbom (1967). This method involved the removal of dissolved gases from a predescribed volume of seawater by purging the sample with ultra-pure helium. Methane, once removed from solution, was passed through Ascarite, Drierite and Tenax G.C. columns in order to remove carbon dioxide, water vapor and other heavy hydrocarbons that compete in the chromatographic eluding times, respectively. The sample then flowed to the activated alumina trap where it was concentrated and held at −196°C for 6 minutes with a puurge rate of 100 mL/min. The trap was then warmed to 100°C and the gases were backflushed into a separation column for a gas chromatography.

The instrumental analyses of methane is described in detail in Katz (1980) and is briefly described below. Separation and detection were carried out on a Hewlett-Packard 5710A gas chromatograph equipped with a flame ionization detector (FID). The voltage changes are reproduced graphically and digitized by a Hewlett-Packard 3380A integrator. The digitized area under each peak is proportional to the moles of methane. The internal G.C. column packing used was a highly Activated Alumina (Applied Science Laboratories, Inc.), 60–80 mesh (1.8 m × 0.48 cm o.d.).

Standards and blanks were analyzed routinely throughout each series of samples. Blank values were determined by restripping samples and analyzing for any residual signal left in solution. In almost all cases, the restripped material was found to be insignificant. Methane values were calculated from the raw integrator signal by comparing the relative detector response of the methane standard with that of the sample. The analyses of a series of standard stainless steel loops carefully calibrated for methane by gravimetric methods determined both the signal-to-noise ratio and the linearity of the detector (ranged from 0 to 0.125 μM methane). The detection limit of this method was approximately 0.0002 μM. The methane standards used throughout the project were prepared by Matheson Gas Products and were intercalibrated by the National Bureau of Standards (NBS). Based on this NBS intercalibration, the accuracy was within 5% while the analytical precision was generally less than 2%.

2.2.4 Nutrients

All nutrient analyses reported in this document were performed under the direction of Ms. Kathy Krogslund of the Marine Chemistry Laboratory of the Department of Oceanography, University of Washington. Between 1979 and 1984, nutrient analyses were performed using a Technicon Autoanalyzer 1 according to the procedures of Harrison and Pavlou (1975). During 1985 and 1986, nutrient analyses were performed using the procedures of Whitledge *et al.* (1981) using a Technicon Autoanalyzer 2.

2.2.5 Dissolved Trace Metal Analyses

The trace metal analyses were performed by graphite furnace atomic absorption spectrometry (GFAAS) using a Perkin-Elmer Zeeman 500 spectrometer or a Perkin-Elmer 603 spectrometer equipped with a HGA-500 graphite furnace and an AS-40 automatic sampler using standard conditions (Perkin-Elmer, 1977) with slight modifications when necessary. A modification of the Chelex-100®, ion-exchange, pre-concentration procedure following the method of Kingston *et al.* (1978) was used as described in Paulson (1986). All apparatus were made of polyethylene or Teflon® and were acid-cleaned. Reagents were made by diluting Ultrex® acid (HNO_3), base (NH_4OH) or salt mixtures (NH_4OH and acetic acid) with Q-H_2O to the appropriate molarity.

Ion-exchange columns were prepared by soaking 5.0 g of 200–400 mesh Chelex-100® in 2.5 M HNO_3 for two hours, and then decanting and soaking in clean 2.5 M HNO_3 for another two hours. This slurry mixture was poured into a fritted polyethylene Isolab column, allowed to drain, washed with 30 mL of 2.5 M HNO_3, rinsed with 30 mL of Q-H_20, and then converted to the ammonium form by eluting with 10 mL of 2 M NH_4OH. Excess NH_4OH was removed by rinsing with 30 mL of Q-H_2O. The prepared columns were placed in a plexiglass rack and the effluent end of the column was attached to a peristaltic pump (Manostat®) with silicon tubing. The weighed samples were neutralized to pH 2 with concentrated NH_4OH, buffered with 10 mL of 1 M NH_4Ac, adjusted to pH 5.4 with concentrated NH_4OH and transferred to 1000-ml Teflon separatory funnels (Nalgene). Five mL of the sample was placed in the prepared column and an air-tight seal was formed between the column and the funnel by placing the tip of the separatory funnel through a hole in a #5 hollow stopper (Nalgene) and firmly inserting the stopper into the top of the column. The stopcock was opened and the flow rate of the pump is adjusted to 0.15 mL/minute. When no solution remains above the column, the column was rinsed with 10 mL of Q-H_2O, rinsed with 30 mL of 10 M NH_4Ac in order to remove excess sea salts and eluted with 20 mL of 2 M HNO_3 into a pre-weighed 30-mL (LPE) bottle. The eluate was analyzed by GFAAS using calibration against standards prepared in a similar HNO_3 matrix.

Quality control was based on measurements of procedural blanks (Table 2), extraction efficiencies (Table 3), and analytical precisions. The field filtering blanks suggest that the analyses of these metals reported in this report were not jeopardized by field or laboratory contamination. Extraction efficiencies have been determined by spiking a low concentration seawater sample with a known amount of trace metal and extracting the spiked sample. The extraction efficiency for all metals was greater than 90%. The analytical imprecision was generally less than 10% (Paulson, 1986). The open ocean standard NASS-1 was analyzed and all elements except Fe were within the range of the reported values (Table 4). The nearshore CASS-1 standard was analyzed and our results were within the range of certified values except for Fe, which was 4% lower than the lower limit of the certified value. Variations in the extraction efficiency, natural variability and random contamination by sampling, filtration or analytical procedures can combine to limit our ability to define the concentration of a trace metal at a particular depth at an exact station location. In 1980, ten samples from 100 m were collected during four casts at a single station in the main basin of Puget Sound using four different Go-Flo® bottles in order to determine the overall precision of our measurements. The sampling and processing precisions for dissolved Mn, Cu, Ni and Cd were 4%, 3%, 8% and 1%, respectively.

2.2.6 Total Suspended Matter (TSM)

The filters with collected suspended matter were re-weighed after desiccation on Cahn electrobalance models 26, 29 or 4700. The weight of suspended matter on the filters was corrected for changes in weight of the filters determined from re weighing the reference filters. Given the corrected net weight of suspended matter and the volume of water filtered, the total suspended matter concentrations were calculated. The accuracy and precision of the Cahn balances are ±0.0012% and ±0.001 mg, respectively. The precision of total suspended matter measurements is nominally 0.01%. The shipboard sampling precision for total suspended matter is highly dependent on location, depth and elapsed time. Sampling precisions for total suspended matter reported for the main basin of Puget Sound have ranged between 1.0% and 17%.

TABLE 2. Dissolved trace metal fields filtering blanks.

Cruise	Cd	Mn	Fe	Ni	Cu	Zn	Pb	n
L-RERP 80	0.008 ±0.003	0.006 ±0.003		0.14 ±0.06	0.047 ±0.027			8
TIPS I		<0.5	<4					
Dec III	0.02	0.2	1.0		0.10			
TIP II		<0.5			0.12			
TIPS III		0.10		0.30	0.20			
L-RERP 81-2,3,5	0.014 ±0.003	0.05 ±0.03		0.19 ±0.05	0.033 ±0.011			4
TIPS IV N	0.016	<0.2	<6	0.54	0.03	0.12	0.03	
M	0.022	<0.2	<6	0.65	0.04	0.12	0.04	
S	0.002	<0.2	<6	0.20	0.03	0.20	0.03	
L-RERP 81-4	0.003 ±0.001	0.07 ±0.06		0.11 ±0.01	0.035 ±0.005	0.14 ±0.07	0.01 ±0.01	2
TIPS V		2.5	<5		0.16			
TIPS VI	0.009	<1	<1		0.02	0.3	0.02	
LRERP 82-1	0.005 ±0.001	0.023 ±0.009		0.09 ±0.04	0.04 ±0.01	0.22 ±0.06	0.010 ±0.005	2
TIP VII	0.01	<1	<1	<0.03	0.01	0.1	0.01	
L-RERP 83-4	0.001 ±0.001	0.001 ±0.001	0.058 ±0.012	0.011 ±0.006	0.003 ±0.001	0.059 ±0.014	0.002 ±0.001	3
L-RERP 84-2	0.002 ±0.001	<0.008	0.064 ±0.038	<0.010	<0.006	0.085 ±0.025	0.004 ±0.003	2
L-RERP 85-2	<0.001	<0.03	0.13 ±0.03	<0.03	<0.01	0.076 ±0.006	<0.006	3
L-RERP 86-1	0.0019 ±0.0002	<0.03	0.048 ±0.052	<0.03	<0.01	0.042 ±0.018	<0.006	3

Detection limits for sets with one blank are the value of the blanks. Therefore, blank-corrected values reported will be greater than twice the blank.

Detection limits for set with more than one blank are three times the variance of the blank value.

TABLE 3. Extraction efficiencies of dissolved trace metal analysis.

Cruise		Cd	Mn	Fe	Ni	Cu	Zn	Pb
L-RERP 80	Extraction Eff. (%)	97	106		101	97		
		±6	±7		±4	±9		
	Conc. (µg/l)	0.12	10.0		0.60	0.60		
TIP III	Extraction Eff. (%)	95			100	93		
	Conc. (µg/l)	0.3			1.4	1.4		
L-RERP 81-2,3,5	Extraction Eff. (%)	120	104		103	91		
		±3			±9	±9		
	Conc. (µg/l)	0.24	4		0.52	0.61		
TIP IV	Extraction Eff. (%)				89	108		78
	Conc. (µg/l)				1.7	1.7		0.24
L-RERP 81-4	Extraction Eff. (%)	96	115		92	95	105	90
		±9	±14		±12	±10	±15	±13
	Conc. (µg/l)	0.24	9.0		1.3	0.61	1.4	0.12
L-RERP 83-4	Extraction Eff. (%)		98	89	99	95	94	97
			±4	±8	±5	±5	±3	±12

TABLE 4. Analysis of standard reference material for dissolved trace metals.

Cruise	STD	Cd	Mn	Fe	Ni	Cu	Zn	Pb	n
L-RERP 81-4	NASS-1	0.027	0.026		0.233	0.093	0.146	0.032	1
L-RERP 83-4	NASS-1	0.032	0.024	0.252	0.254	0.097	0.164	0.035	2
		±0.022	±0.006		±0.008	±0.003	±0.025	±0.002	
L-RERP 84-2	CASS-1	0.030	2.38	0.77	0.300	0.264	1.07	0.252	3
		±0.001	±0.15	±0.06	±0.008	±0.027	±0.03	±0.008	
L-RERP 85-2	CASS-1	0.030	2.44	0.75	0.303	0.268	1.00	0.225	4
L-RERP 86-1		±0.001	±0.18	±0.08	±0.009	±0.023	±0.03	±0.020	
Certified	NASS-1	0.029	0.022	0.192	0.257	0.99	0.159	0.039	
		±0.004	±0.007	±0.036	±0.027	±0.01	±0.028	±0.006	
Certified	CASS-1	0.026	2.27	0.873	0.290	0.291	0.98	0.251	
		±0.005	±0.17	±0.076	±0.031	±0.027	±0.09	±0.027	

2.2.7 Particulate Trace Metal

Total elemental compositions (Al, Si, Fe, Mn, Ni, Cu, Zn, and Pb) in suspended particulate matter were determined by X-ray primary- and secondary-emission spectrometry using the thin-film technique (Baker and Piper, 1976; Feely *et al.*, 1981, 1986; Holmes, 1981). A Kevex Model 7077-0700 X-ray energy spectrometer with a rhodium X-ray tube was used in the direct and secondary-emission (Ge and Zr targets) modes to obtain maximum efficiency for excitation of individual elements in the sample. Thin-film standards were prepared from suspensions of finely ground U.S. Geological Survey Standard Rocks (W-1, AGV-1, GSP-1, G-2, BCR-1, BHVO-1, MAG-1, GXR-1, GXR-3, and GXR-5; 90 percent by volume less than 15 µm in diameter), NBS Standard Reference Materials (SRMs) (#1571, Orchard Leaves; #1577, Bovine Liver; #1648, Urban Particulates; and #1645, River Sediment), National Research Council of Canada Standard Reference Materials (MESS-1 and BCSS-1), and National Institute of Environmental Studies of Japan Standard Reference Materials (Pond Sediment and Pepperbush Powder). Calibration was effected using standard regression techniques.

The reported values for trace metals in suspended particulates were calculated in the following manner:

$$\text{conc (sample)} = \frac{C * A}{WT * S}$$

where: conc (sample) is concentration of sample in ppm,
C is net counts/(sec cm^2)
Wt is weight of particulates on filter in mg,
A is effective area of filter, and
S is slope of net counts/sec cm^2 vs. ng/cm^2

The sources of the reference values for the thin-film standards used in accuracy tests were: USGS Rock Standard W-1 for Al, Si, Mn, Fe, Ni, Cu, and Zn; and NBS SRM 1645 (River Sediment) for Pb (Table 5). For Al, Si, Mn, Fe, Ni, Cu, and Zn the measured value was obtained from a standard that was prepared by passing a suspension of the finely ground rock through a 37-µm nylon mesh followed by collection of the suspensate (353 µm) on a Nuclepore filter identical to those used for sample acquisition. Replicate XRF analyses of this standard were then randomly chosen from 53 sequential days of analyses during which this filter served as a stability monitor. Single analyses of the respective standard filters for P, S, Cl, As and Pb were performed.

The precision is given in terms of the units of measurements (Wt.% and ppm) and as a coefficient of variation ($\text{C.V.} = \frac{1\sigma \text{ error}}{\text{mean value}} \cdot 100$). For particulate Al, Si, Mn, Fe, Ni, Cu, and Zn the mean and 1 error values were determined from 10 replicate measurements, each of which was obtained on a different analysis day. For particulate Pb and dissolved Mn, and Fe the

TABLE 5. X-ray fluorescence spectrometry: standards and values used in recent calibration wherever elemental values are given.

Standard Source	Designation	WT.% Al	Si	Fe	PPM Mn	Ni	Cu	Zn	Pb
U.S. Geological	W-1	7.95	24.64	7.77	1278	76	110	86	
Survey	G-2	8.15	32.31	1.85	230	4	10	84	30
	AGV-1	9.10	27.86	4.76	775	15	59	86	33
"Standard Rocks"	BCR-1	7.26	25.49	9.39	1390	10	16	125	14
	GSP-1	8.09	31.47	3.00	310	9	33	105	54
	BHVO-1	7.25	23.32	8.46	1320	140	137	100	
	MAG-1	8.68	23.79	4.76	775	52	33	140	25
	GXR-1	3.55	23.00	24.69	310	42	1300	740	670
	GXR-3		6.08	18.60	22460	55		220	15
	GXR-5	20.80	19.68	3.22		63	360	50	
National #1571	Orchard Leaves			0.03			12	25	45
Bureau of #1577	Bovine Liver			0.027			193	130	
Standards #1648	Urban Part.	3.5		3.91	790	82	609	4760	6555
"SRM" #1645	River Sed.			11.3	785	46	109	1720	714
National Research Council of Canada Marine Sediments	MESS-1	5.84	30.80	3.05	513	30	25	191	34
	BCSS-1	6.26	30.20	3.29	229	55	19	119	23
National Inst. of Environ. Studies of Japan	Pond Sediment	10.6	21.00	6.53	770	40	210	343	105
	Peperbush Powd.		0.193	0.021	2030	9	12	340	

precision data represents the standard estimate of error ($Sy.x = \sqrt{\frac{\Sigma yi^2 - a_0\Sigma yi - a_1\Sigma xiyi}{n-2}}$ where a_0 and a_1 are the calibration regression line intercept and slope, respectively) resultant from calibration regressions.

The determination limits are based on counting statistics and are defined as:

$$\text{Determination Limit} = 3 \times \text{Minimum Detection Limit}$$
$$= 3\left(2 \cdot K \cdot \frac{1}{\sqrt{T}} \frac{\sqrt{I_B}}{I_p}\right)$$

where: K = standard concentration in desired units (Wt.% or ppm),
T = counting or analysis time in seconds,
I_B = background intensity in counts-per-second, and
I_p = net peak intensity in counts-per-second.

The precision and determination limits are given in Table 6.

2.2.8 Particulate Organic Carbon and Nitrogen

Analyses of total particulate carbon and nitrogen in the suspended matter for DEC I, L-RERP 80 and parts of DEC III were performed with a Hewlett Packard 185B CHN analyzer. In this procedure, particulate carbon and nitrogen compounds were combusted to CO_2 and N_2 (micro Pregl-Dumas method) chromatographed on Poropak Q, detected sequentially with a thermal conductivity detector following a modification of the procedure outlined by Sharp (1974). NBS acetanilide was used for standardization. Given the total amount of organic carbon and nitrogen combusted, the volume of water filtered and the TSM from the 47 mm filters, the POC and PON in weight percent (Wt.%) was calculated. Analysis of replicate field sampling yield relative standard deviations ranging from 2% to 10% for carbon and 7% to 14% for nitrogen.

Analysis of particulate carbon and nitrogen in suspended matter for DEC II, parts of DEC III and all L-RERP cruises after L-RERP 80 were performed with a Perkin-Elmer Model 240B CHN analyzer. Particulate carbon and nitrogen compounds were combusted to CO_2 and N_2 and detected with a thermal conductivity detector (Baker *et al.*, 1985). The calculations of weight percent POC and PON were similar to those used for the HP 185B analyzer and yield relative standard deviations that are typically less than 10% for the regions reported in this report.

2.2.9 Trace Metal Analyses of Sediments

Analyses of trace metals in Elliott and Commencement Bay sediment columns presented in this data report were performed by Dr. E.A. Crecelius and Nick Bloom of Battelle Northwest. The methods for the analyses of the 1981 cores are reported in Crecelius *et al.* (1985). Methods

TABLE 6. X-ray fluorescence spectrometry of particulate: accuracy precision and determination limits.

TEST	WT.% Al	Si	Fe	PPM Mn	Ni	Cu	Zn	Pb
Accuracy:								
Ref.	7.95	24.64	7.77	1278	76	110	86	714
Meas.	8.20	25.33	7.80	1299	79	129	71	753
Precision:								
Wt/Wt	0.25	0.41	0.09	23	2	12	2	30
C.V.*	3.1	1.6	1.2	1.7	2.4	9.3	2.8	4.2
Determination Limits:								
25 mm filter (DEC I only)	0.03	0.20	0.10	48	33	75	12	
37 mm filter	0.09	0.06	0.02	7	14	14	12	14

* C.V. = coefficient of variation = $\frac{1\sigma \text{ error}}{\text{mean}} \cdot 100$

for the chemical and radiochemical analyses for the 1982 core are reported in Bloom and Crecelius (1987) and Lavelle *et al.* (1985).

2.2.10 Eh Measurements

The reduction-oxidation (redox) potential of sediments was measured by inserting a platinum electrode at mid-depth of each sediment section and allowing the measured potential to stabilize. The potential of the platinum electrode was standardized to Zobell's solution (Zobell, 1946) in the following manner:

$$Eh = E_{meas} + (0.430 - E_{Zob})$$

where E_{meas} is the measured potential of the sediment, E_{Zob} is the measured potential of Zobell's solution and 0.430 v is the standard potential of Zobell's solution.

2.2.11 Trace Metal Analyses of Porewaters

Between 1980 and 1982, dissolved Fe and Mn analyses of porewaters were performed by X-ray fluorescence spectrometry using atomic absorption standards diluted in Standard Seawater (I.A.P.S.O.) for calibration. The determinations limits for porewater Fe and Mn were 0.57 and 0.63 ppm, respectively. Relative standard deviations of multiple analyses were 2% for both elements. The L-RERP 85-2 Fe and Mn porewater analyses were performed employing direct injection GFAAS methods following 100 to 200-fold dilutions. The detection limit of the GFAAS method was less than 0.01 ppm for both Fe and Mn.

Porewater analyses of Cd, Ni, Cu and Pb were performed using a modification of the Chelex ion-exchange method of Paulson (1986). Porewater was acidified to pH 0 with nitric acid, placed in Teflon bombs, which were heated to boiling for one hour. The solution was then cooled, neutralized with NH_4OH, buffered to pH 5.5 with NH_4Ac and passed through a one-gram Chelex column at a flow rate of 0.1 ml/min. The column was then rinsed with NH_4Ac and eluted with 5 ml of 2 M nitric acid. The nitric acid solution was then analyzed by GFAAS. All apparatus were made of plastic or Teflon and acid-cleaned and rinsed with Q-H_2O. All reagents were diluted with Q-H_2O. The processing blanks for the 1980 and 1985 sampling periods are listed in Table 7 with the extraction efficiencies of this method as measured by porewater samples spiked with known amounts of trace metals.

2.2.12 Trace Metal Analyses of Settling Trap Particulates

Composite sediment trap samples collected in 1981 from Commencement Bay were analyzed by E.A. Crecelius of Battelle Northwest employing dispersive X-ray fluorescence using the method of Nielson (1977).

Elliott Bay and Commencement Bay sediment trap material recovered from the cylinders deployed in 1985 during the time of the water column survey were dissolved using the method of Eggimann and Betzer (1976) and analyzed by graphite furnace atomic absorption spectrometry

TABLE 7. Quality control data for trace metal analyses of porewater using ion-exchange.

	Cd	Ni	Cu	Pb
L-RERP 80 Processing Blanks (µg/l)	0.28	1.2	0.55	1.3
L-RERP 80 Extraction Efficiency (%)	103 ±3	100 ±20	91 ±14	95 ±5
L-RERP 85-2 Processing Blank (µg/l)	0.02	0.3	0.2	0.3

Detection limits are the blank values. Therefore, blank-corrected values reported will be more than twice the blank.

(GFAAS) using a Perkin-Elmer Zeeman 5000 spectrometer equipped with a HGA-500 graphite furnace and an AS-40 automatic sampler. The dissolution of the sediment trap particulates was accomplished by placing 2 mg of sediment trap particulates into a teflon digestion bomb (Bombco, Inc.), adding 0.75 mL of concentrated Ultrex® HCl, placing the bomb in boiling water for 30 min., cooling the bomb, adding 0.25 mL of Ultrex® HNO_3, placing the bomb in boiling water for 30 min., cooling the bomb, adding 0.05 mL of Ultrex® HF and placing the bomb in boiling water for 90 min. After cooling, the solution was transferred to an acid cleaned 1-oz. LPE bottle. The bomb was rinsed three times with quartz-distilled water (Q-H_2O) into the 1-oz. LPE bottle and the weight of the eluate was increased to 20 gm with Q-H_2O. Procedural blanks were obtained by performing the dissolution step in an empty bomb. In the event that less than 2 mg was recovered from a single trap cylinder, the particulates were left on the filter and the filter itself was placed into the bomb. The procedural blank for this operation consisted of performing the dissolution step on a reference filter from the same lot as that used for the sediment trap particulates.

The reported value for trace metals in sediment trap particulates were calculated in the following manner:

$$\text{Conc (sample)} = \frac{\text{conc (eluate)} * \text{Wt (eluate)}}{\text{Wt (sample)}}$$

where: Conc (sample) is the concentration of the sample in ppm (parts per million)
Wt (eluate) is the weight of eluate in gms
Wt (sample) is the weight of sample in mg, and
Conc (eluate) is weight of the eluate in µg/Kg and is detemrined by the following:

$$\text{Conc (eluate)} = \frac{\text{ABS (eluate)} - \text{ABS (Blank)}}{\text{S}}$$

where: ABS (eluate) is the absorbance of the eluate
ABS (Blank) is the absorbance of the procedural blank, and
S is the slope of a linear calibration curve of absorbance vs. concentration of standards.

The results of the standard reference material, the detection limit and the analytical variability are listed in Table 8.

2.2.13 Weak Acid Analyses of Particulates and Sediments

Suspended matter used for weak-acid soluble (WAS) analyses were collected on acid-cleaned 47-mm filters as noted in the water column sampling methods. Surface sediments were collected during L-RERP 81-4 using a Shipex grab sampler at the mid-channel.

TABLE 8. Quality control data for trace metals in sediment trap particulates.

Standard		Cu ppm	Mn ppm	Cd ppm	Pb ppm	Fe wt%	Zn
BCSS	Mean	18±1	227±13	0.35±.07	24±2	3.63±0.36	135±1
	Established	18±3	229±15	0.25±.04	23±3	3.2 9±0.097	119±12
MAG	Mean	28±1	651±15	0.33±.06	29±3	4.25±0.38	139±9
	Established	27	650	N/A	24	4.69	135
MESS	Mean	32±5	472±78	0.60±.01	32±1		
	Established	25±4	513±25	0.59±.1	34±6		
	Sample Prec. (% CV)	9	4	19	1		
MDL		2	12	0.15	2		

MDL = Minimum Detection Limit

The weak-acid-soluble (WAS) trace metal concentrations of suspended matter and sediments were determined using the method of Bolger *et al.* (1978). About 2 mg of sediments or filters containing 0.5 to 2 mg of suspended matter were placed in individual teflon tubes and extracted with 5 mLs of 25% (V/V) Ultrex® acetic acid for 2 hours and the extract from each tube was filtered. This solution was placed in a pre-weighed LPE bottle, acidified with 0.1 mLs of Ultrex® HCl and analyzed by GFAAS using standard methods (Perkin-Elmer, 1977) with the exception that ammonium phosphate addition was used for the Cd determination.

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3. RESULTS

3.1 Water Column

The water column data is listed in 34 columns grouped in the following manner:

Column	Data
0–1	Sample identification
2–3	Temperature and Salinity Data
4–5	Methane and Oxygen Data
6–10	Nutrient Data
11	Temperature, Salinity, Methane, Oxygen, Nutrient Comments
12–13	Depth and Salinity for Dissolved Trace Metal Samples
14–20	Dissolved Trace Metal Data
21	Dissolved Trace Metal Comments
22	Depth for Particulate Samples
23	Total Suspended Matter (TSM) Data
24–31	Particulate Trace Metal Data
32	Particulate Trace Metal Comments
33–34	Particulate Organic Carbon and Nitrogen (POC/PON) Data
35	Availability of Coulter Counter Data

In a few sampling programs that did not include temperature data such as the L-RERP 82-1 Duwamish Waterway sampling, col 2 was used for sample identification. Samples for the Duwamish River and Waterway were taken at mid-channel at standard station locations that were identified by local geographical features (Table 9). The Duwamish River and Waterway salinity data were obtained by analyses of discrete samples. Separate samples for the different analyses were taken from bridges and small boat sampling in the Duwamish River and Waterway. Samples for different analyses were usually taken from the same Go-Flo® bottle during hydrocast operations in the Duwamish Waterway. The temperature and salinity data for Elliott Bay and Commencement Bay were usually taken from CTD output. When temperature data from reserving thermometers mounted on sampling bottles associated with chemistry samples is listed in column 2, column 11 is labeled "temp." When salinity data from discrete salinity samples that were collected from the sampling bottle used to collect other chemistry samples is listed in column 3, column 11 is marked "sal." During L-RERP 80, L-RERP 81-4, L-RERP 82-1 and L-RERP 82-11, methane, oxygen and nutrient samples were taken from standard Niskin sampling bottles during one cast while TSM and particulate trace metal samples were taken from Go-Flo® bottles during a second cast. Oxygen, methane, nutrient and particulate samples on other cruises were taken from the same sampling bottle. Dissolved trace metal samples from Elliott Bay and Commencement Bay were always taken from casts with a special winch that was mounted on

TABLE 9. Locations of Duwamish River and Waterway stations.

Station Name	Station Location
DW0.0	Head of Waterway
DW1.9	Spokane Street Bridge
DW2.6	Confluence of East and West Waterway
DW3.9	Pier 107
DW5.6	1st Avenue Bridge
DW6.9	Slip 4
DW7.7	6th Avenue South Bridge
DW 9.1	Slip 7
DW 9.7	Middle of Turning Basin
DR10.4	Boeing Parking Lot Bridge
DR10.9	Tower
DR12.2	Pacific Highway South Bridge
DR12.6	East Marginal Way Bridge
DR13.2	119th Street Foot Bridge
DR14.1	Allentown Bridge
DR15.5	I-5 Bridge
DR16.2	56th Avenue South Bridge
DR17.2	Foster Links Foot Bridge
DR19.8	Fort Dent Bridge
DR20.5	Metro Outfall
DR21.0	Interurban Avenue Bridge
DR21.3	I-405 Bridge
DR22.0	Strander Avenue Bridge
DR24.3	Orilla
DR30.0	212th Street Bridge
DR35.6	Kent-Des Moines Road Bridge
DR56.0	Black Diamond Road Boat Launch

the bows of ships and was distinct from the CTD casts. Prior to L-RERP 82-1, the salinity data for dissolved trace metal samples from Elliott and Commencement Bays reported in column 13 were taken from CTD data. During L-RERP 82-1 and all following cruises, discrete salinity samples were taken in conjunction with every dissolved trace metal sample. Inferences about the possibility of mistripping of sampling bottles can be made from examination of discrete salinity, oxygen and nutrient data. Such inferences about mistripping can be applied to dissolved and particulate trace metal data if the trace metal samples were taken on the same cast.

3.1.1 Duwamish River

Transects of the Duwamish River were undertaken as part of the Duwamish Estuarine Chemistry (DEC) program in Aug. 1979 (DEC I), Feb. 1980 (DEC II) and Sept. 1980 (DEC III) and as part of the Long-Range Effects Research Program (L-RERP) in May 1980 (L-RERP 80) and Sept. 1981 (L-RERP 81-4) (Table 10). Stations DR 12.2 or 12.6 were originally sampled as part of the Trace Inventory of Puget Sound (TIPS) study in order to quantify the fluxes of particulate and dissolved trace metals from the Duwamish River. With the realization that the Duwamish River at stations DR 12.2 or 12.6 contained a variable amount of Renton Sewage Treatment Plant (STP) effluent, the TIPS IV sampling site was changed to DR 21.0. This change allowed the quantification of the separate contributions from the Renton STP and the Green River at DR 21.0, which is upstream of the Renton STP. Samples of the Renton STP effluent (Table 11) were collected to determine the partitioning of trace metals between the dissolved and particulate phases, which could be applied to annual mass loading data provided by METRO. A time series at stations DR 10.4 was undertaken during L-RERP 82-1 (Feb. 1982).

Duwamish River results are presented in Appendix A. In conjunction with additional laboratory experiments, the field particulate trace metal data from DEC I was interpreted by Feely *et al.* (1983a). The DEC II particulate trace metal data was examined by Massoth *et al.* (1982) and Feely *et al.* (1983b). Paulson *et al.* (1984) provided an interpretation of the DEC III dissolved trace metal and nutrient data. Trace metal concentrations in Duwamish River suspended matter were compared to main basin suspended matter in Feely *et al.* (1986). TIPS data at DR 21.0 and Renton STP data were used to quantify the contributions of dissolved and particulate trace metals from the Renton (STP) and the Green River to Puget Sound (Paulson *et al.*, 1988b; 1988c; 1989b). Weak-acid soluble data was used in the interpretation of DEC II data (Feely *et al.*, 1983b) and DEC III data (Paulson *et al.*, 1984) and is listed in page A-20. Other publications containing chemical data for the Duwamish River include Bates *et al.* (1983), Hamilton and Cline (1981) and Hamilton *et al.* (1984).

Table 10. Sampling Locations and Sampling Data for the Duwamish River

0 Cruise Name	1 Sta. Name	2 Station Location	3 Date	4 Cast Type	5 Time Loc.	6 Nut.	7 Dis. TM	8 Part. TM	9 POC/ PON	10 Page
DEC I	1	DR 56.0	11 Aug 79	Bridge	10:05	x		x	x	A-3
DEC I	2	DR 22.0	11 Aug 79	Bridge	12:15	x		x	x	A-3
DEC I	4	DR 19.8	11 Aug 79	Bridge	11:20	x		x	x	A-3
DEC I	5	DR 17.2	11 Aug 79	Bridge	14:20	x		x	x	A-3
DEC I	6	DR 12.6	11 Aug 79	Bridge	13:10	x		x	x	A-3
DEC II	DR 10.4	DR 10.4	19 Feb 80	Small Boat	09:17	x		x	x	A-4
DEC II	DR 10.9	DR 10.9	19 Feb 80	Small Boat	09:20	x		x	x	A-4
DEC II	DR 11.5	DR 11.5	19 Feb 80	Small Boat	09:24	x		x	x	A-4
DEC II	DR 12.2	DR 12.2	19 Feb 80	Small Boat	09:27	x		x	x	A-4
DEC II	DR 12.6	DR 12.6	19 Feb 80	Small Boat	09:34	x		x	x	A-4
DEC II	DR 13.2	DR 13.2	19 Feb 80	Small Boat	09:41	x		x	x	A-4
DEC II	DR 14.1	DR 14.1	19 Feb 80	Small Boat	09:43	x		x	x	A-4
DEC II	DR 15.2	DR 15.2	19 Feb 80	Small Boat	09:52	x		x	x	A-4
DEC II	DR 15.5	DR 15.5	19 Feb 80	Small Boat	09:55	x		x	x	A-4
DEC II	DR 16.2	DR 16.2	19 Feb 80	Small Boat	10:00	x		x	x	A-4
DEC II	DR 17.2	DR 17.2	19 Feb 80	Small Boat	10:11	x	x	x	x	A-4
DEC II	DR 18.0	DR 18.0	19 Feb 80	Small Boat	10:16	x		x	x	A-4
DEC II	DR 19.8	DR 19.8	19 Feb 80	Small Boat	10:20	x		x	x	A-4
DEC II	DR 20.4	DR 20.4	19 Feb 80	Small Boat	11:08	x		x	x	A-4
DEC II	DR 20.5	DR 20.5	19 Feb 80	Small Boat	11:09	x		x	x	A-4
DEC II	DR 20.6	DR 20.6	19 Feb 80	Small Boat	11:15	x		x	x	A-4
DEC II	DR 21.0	DR 21.0	19 Feb 80	Small Boat	11:19	x		x	x	A-4
DEC II	DR 22.0	DR 22.0	19 Feb 80	Small Boat	11:32	x	x	x	x	A-4
DEC II	DR 24.3	DR 24.3	19 Feb 80	Small Boat	11:51	x		x	x	A-4
DEC II	DR 30.0	DR 30.0	19 Feb 80	Small Boat	12:17	x		x	x	A-4
DEC II	DR 35.6	DR 35.6	19 Feb 80	Small Boat	12:35	x		x	x	A-4
DEC II	DR 56.0	DR 56.0	19 Feb 80	Bridge	14:47	x		x		A-4
L-RERP 80	DR 10.4	DR 10.4	21 May 80	Bridge		x				A-8
L-RERP 80	DR 12.2	DR 12.2	21 May 80	Bridge		x				A-8
L-RERP 80	DR 12.6	DR 12.6	21 May 80	Bridge		x				A-8
L-RERP 80	DR 13.2	DR 13.2	21 May 80	Bridge	10:40	x				A-8
L-RERP 80	DR 14.1	DR 14.1	21 May 80	Bridge		x				A-8
L-RERP 80	DR 17.2	DR 17.2	21 May 80	Bridge		x				A-8
L-RERP 80	DR 19.8	DR 19.8	21 May 80	Bridge	11:30	x				A-8
L-RERP 80	DR 21.0	DR 21.0	21 May 80	Bridge	11:40	x				A-8
L-RERP 80	DR 22.0	DR 22.0	21 May 80	Bridge	14:15	x				A-8
L-RERP 80	DR 56.0	DR 56.0	21 May 80	Bridge		x				A-8
TIPS I	DR 12.6	DR 12.6	23 Jun 80	Bridge	09:50		x	x		A-10
TIPS II	DR 12.6	DR 12.6	23 Sep 80	Bridge		x	x	x		A-10
DEC III	DR 10.4	DR 10.4	11 Sep 80	Bridge	08:00	x	x	x	x	A-14
DEC III	DR 12.2	DR 12.2	11 Sep 80	Bridge	10:00	x	x	x	x	A-14
DEC III	DR 13.2	DR 13.2	11 Sep 80	Bridge	11:00	x	x	x	x	A-14
DEC III	DR 17.2	DR 17.2	11 Sep 80	Bridge	12:45	x	x	x	x	A-14
DEC III	DR 19.8	DR 19.8	11 Sep 80	Bridge	13:15	x	x	x	x	A-14
DEC III	DR 21.0	DR 21.0	11 Sep 80	Bridge	15:40	x	x	x	x	A-14
DEC III	DR 22.0	DR 22.0	11 Sep 80	Bridge	16:15	x	x	x	x	A-14
DEC III	DR 35.6	DR 35.6	11 Sep 80	Bridge	18:20	x	x	x	x	A-14
DEC III	DR 56.0	DR 56.0	11 Sep 80	Bridge	19:40	x	x	x	x	A-14
TIPS III	DR 12.6	DR 12.6	7 Jan 81	Bridge			x	x	x	A-10
TIPS IV	DR 12.6	DR 12.6	28 May 81	Bridge	14:00	x	x	x	x	A-10

Dis. Ox. at DECII Stations DR10.4, 16.2, 20.5, 21.0, 22.0, 24.3, 30.0, 35.6.
Methane at L-RERP 81-4 Stations DR10.9, 13.2 and 19.8.

Table 10. Sampling Locations and Sampling Data for the Duwamish River

0 Cruise Name	1 Sta. Name	2 Station Location	3 Date	4 Cast Type	5 Time Loc.	6 Nut.	7 Dis. TM	8 Part. TM	9 POC/ PON	10 Page
TIPS IV	DR 19.8	DR 19.8	28 May 81	Bridge	12:28	x	x	x	x	A-10
TIPS IV	DR 21.0	DR 21.0	28 May 81	Bridge	10:30	x	x	x	x	A-10
L-RERP 81-4	DR 10.4	DR 10.4	26 Aug 81	Small Boat	18:15				x	A-16
L-RERP 81-4	DR 10.9	DR 10.9	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 12.2	DR 12.2	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 12.6	DR 12.6	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 13.2	DR 13.2	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 14.1	DR 14.1	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 15.2	DR 15.2	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 15.5	DR 15.5	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 16.2	DR 16.2	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 17.2	DR 17.2	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 18.0	DR 18.0	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 19.8	DR 19.8	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 20.4	DR 20.4	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 20.5	DR 20.5	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 20.6	DR 20.6	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 21.0	DR 21.0	26 Aug 81	Small Boat		x			x	A-16
L-RERP 81-4	DR 21.3	DR 21.3	26 Aug 81	Small Boat		x			x	A-16
TIPS V	DR 12.2	DR 12.2	7 Oct 81	Bridge	09:45	x	x	x	x	A-10
TIPS V	DR 19.8	DR 19.8	7 Oct 81	Bridge	13:30	x	x	x	x	A-10
TIPS V	DR 21.0	DR 21.0	7 Oct 81	Bridge		x	x	x	x	A-10
TIPS VI	DR 19.8	DR 19.8	26 Jan 82	Bridge	15:25	x	x	x		A-10
TIPS VI	DR 21.0	DR 21.0	26 Jan 82	Bridge	13:50	x	x	x		A-10
L-RERP 82-1	DR 10.4	DR 10.4	1 Mar 82	Bridge	01:30	x	x	x		A-18
L-RERP 82-1	DR 10.4	DR 10.4	1 Mar 82	Bridge	05:30	x	x	x		A-18
L-RERP 82-1	DR 10.4	DR 10.4	1 Mar 82	Bridge	09:00	x	x	x		A-18
L-RERP 82-1	DR 10.4	DR 10.4	1 Mar 82	Bridge	12:30	x	x	x		A-18
L-RERP 82-1	DR 10.4	DR 10.4	1 Mar 82	Bridge	16:40	x	x	x		A-18
L-RERP 82-1	DR 10.4	DR 10.4	1 Mar 82	Bridge	19:30	x	x	x		A-18
L-RERP 82-1	DR 19.8	DR 19.8	1 Mar 82	Bridge	22:30	x	x	x		A-18
L-RERP 82-1	DR 21.0	DR 21.0	1 Mar 82	Bridge	22:00	x	x	x		A-18
TIPS VII	DR 21.0	DR 21.0	5 Oct 84	Bridge	09:55		x			A-10
DECIII	WAS Data									A-20
	Rent. Eff.									A-21

Dis. Ox. at DECII Stations DR10.4, 16.2, 20.5, 21.0, 22.0, 24.3, 30.0, 35.6.
Methane at L-RERP 81-4 Stations DR10.9, 13.2 and 19.8.

Table 11. Renton Effluent Sampling Data

0 Cruise	1 Date	2 Type	3 Nutri-ents	4 Dis. TM	5 Part. TM	6 POC/ PON	7 Page
DEC I	11 AUG 79	24 HR COMP	X		X		A-21
DEC II	02 FEB 80	24 HR COMP	X	X	X		A-21
L-RERP 80	21 MAY 80	24 HR COMP		X	X		A-21
DEC III	11 SEP 80	24 HR COMP	X	X	X	X	A-21
TIPS IV	28 May 81	GRAB	X	X	X	X	A-21
TIPS V	7 OCT 81	GRAB	X	X	X	X	A-21
TIPS VI	26 JAN 82	GRAB/14:05	X	X	X		A-21
L-RERP 82-1	1 MAR 82	GRAB/22:00	X	X	X		A-21
L-RERP 82-1	2 MAR 82	GRAB/07:30	X	X	X		A-21
L-RERP 82-1	2 MAR 82	GRAB/11:30	X	X	X		A-21
L-RERP 82-1	2 MAR 82	GRAB/19:30	X	X	X		A-21
L-RERP 82-1	2 MAR 82	24 HR COMP	X	X	X		A-21

3.1.2 Duwamish Waterway

Transects of the Duwamish Waterway were undertaken as part of the Duwamish Estuarine Chemistry (DEC) program in Aug. 1979 (DEC I), Feb. 1980 (DEC II) and Sept. 1980 (DEC III) and as part of the Long-Range Effects Research Program (L-RERP) in May 1980 (L-RERP 80) and Sept. 1981 (L-RERP 81-4) (Table 12). A time series at stations DW 9.7 and 7.7 was undertaken during L-RERP 82-1 (Feb. 1982). A limited number of Duwamish Waterway samples were collected during L-RERP 85-2 (April 1985) and L-RERP 86-1 (Jan. 1986).

The Duwamish Waterway results are listed in Appendix B. In conjunction with additional laboratory experiments, the field data from DEC I was interpreted by Feely *et al.* (1983a). DEC II data were examined by Massoth *et al.* (1982) and Feely *et al.* (1983b). Paulson and Feely (1985) compared dissolved trace metal concentrations from the Duwamish Waterway during L-RERP 80 and L-RERP 81-4 with those in other regions in Puget Sound. The L-RERP 85-2 and L-RERP 86-1 data are presented in Feely *et al.* (1988) and Paulson *et al.* (1989c; 1989a).

Table 12. Sampling Locations and Sampling Data for the Duwamish Waterway

0 Cruise Name	1 Sta. Name	2 Station Location	3 Date	4 Cast Type	5 Time Loc.	6 Nut.	7 Dis. TM	8 Part. TM	9 POC/ PON	10 Page
DEC I	7	DW 9.1	11 Aug 79	HYDROCAST	10:58	x		x	x	B-3
DEC I	8	DW 7.7	11 Aug 79	HYDROCAST	11:26	x		x	x	B-4
DEC I	9	DW 6.9	11 Aug 79	HYDROCAST	11:50	x		x	x	B-5
DEC I	10	DW 5.6	11 Aug 79	HYDROCAST	12:21	x		x	x	B-6
DEC I	11	DW 3.9	11 Aug 79	HYDROCAST	12:47	x		x	x	B-7
DEC I	12	DW 1.9	11 Aug 79	HYDROCAST	13:34	x		x	x	B-8
DEC II	EW-1	EW 0.0	19 Feb 80	HYDROCAST	10:05	x		x	x	B-9
DEC II	DW 0.0	DW 0.0	19 Feb 80	HYDROCAST	11:45	x		x	x	B-10
DEC II	DW 0.7	DW 0.7	19 Feb 80	HYDROCAST	12:33	x		x	x	B-11
DEC II	DW 1.3	DW 1.3	19 Feb 80	HYDROCAST	12:55	x		x	x	B-12
DEC II	DW 1.9	DW 1.9	19 Feb 80	HYDROCAST	13:38	x		x	x	B-13
DEC II	DW 2.6	DW 2.6	19 Feb 80	HYDROCAST	13:17	x		x	x	B-14
DEC II	DW 3.9	DW 3.9	19 Feb 80	HYDROCAST	14:07	x		x	x	B-15
DEC II	DW 4.6	DW 4.6	19 Feb 80	HYDROCAST	14:21	x		x	x	B-16
DEC II	DW 5.6	DW 5.6	19 Feb 80	HYDROCAST	14:55	x	x	x	x	B-17
DEC II	DW 6.9	DW 6.9	19 Feb 80	HYDROCAST	15:12	x		x	x	B-18
DEC II	DW 7.7	DW 7.7	19 Feb 80	HYDROCAST	15:33	x		x	x	B-19
DEC II	DW 9.1	DW 9.1	19 Feb 80	HYDROCAST	15:48	x		x	x	B-20
DEC II	DW 9.7	DW 9.7	19 Feb 80	HYDROCAST	16:00	x		x	x	B-21
L-RERP 80	EW-1	EW 0.0	21 May 80	HYDROCAST	10:41	x				B-22
L-RERP 80	DW 0.0	DW 0.0	21 May 80	HYDROCAST		x		x		B-23
L-RERP 80	DW 0.7	DW 0.7	21 May 80	HYDROCAST	14:10	x				B-24
L-RERP 80	DW 1.3	DW 1.3	21 May 80	HYDROCAST		x				B-25
L-RERP 80	DW 1.9	DW 1.9	21 May 80	HYDROCAST		x				B-26
L-RERP 80	DW 2.6	DW 2.6	21 May 80	HYDROCAST		x				B-27
L-RERP 80	DW 3.9	DW 3.9	21 May 80	HYDROCAST	16:04	x		x		B-28
L-RERP 80	DW 4.6	DW 4.6	21 May 80	HYDROCAST	16:35	x				B-29
L-RERP 80	DW 5.6	DW 5.6	21 May 80	HYDROCAST		x				B-30
L-RERP 80	DW 6.9	DW 6.9	21 May 80	HYDROCAST		x				B-31
L-RERP 80	DW 7.7	DW 7.7	21 May 80	HYDROCAST	17:39	x				B-32
L-RERP 80	DW 9.7	DW 9.7	21 May 80	HYDROCAST		x				B-33
DEC III	EW-0	EW 0.0	12 Sep 80	HYDROCAST	09:30	x	x		x	B-34
DEC III	DW 0.0	DW 0.0	12 Sep 80	HYDROCAST	11:32	x	x	x	x	B-35
DEC III	DW 0.7	DW 0.7	12 Sep 80	HYDROCAST	12:05	x		x	x	B-36
DEC III	DW 1.3	DW 1.3	12 Sep 80	HYDROCAST	12:23	x		x	x	B-37
DEC III	DW 1.9	DW 1.9	12 Sep 80	HYDROCAST	12:40	x		x	x	B-38
DEC III	DW 2.6	DW 2.6	12 Sep 80	HYDROCAST	12:58	x		x	x	B-39
DEC III	DW 3.9	DW 3.9	12 Sep 80	HYDROCAST	13:18	x	x	x	x	B-40
DEC III	DW 4.6	DW 4.6	12 Sep 80	HYDROCAST	13:37	x		x	x	B-41
DEC III	DW 5.6	DW 5.6	12 Sep 80	HYDROCAST	13:52	x		x	x	B-42
DEC III	DW 6.9	DW 6.9	12 Sep 80	HYDROCAST	14:15	x		x	x	B-43
DEC III	DW 7.7	DW 7.7	12 Sep 80	HYDROCAST	14:32	x		x	x	B-44
DEC III	DW 9.1	DW 9.1	12 Sep 80	HYDROCAST	14:53	x		x	x	B-45
DEC III	DW 9.7	DW 9.7	12 Sep 80	HYDROCAST	15:08	x	x	x	x	B-46
L-RERP 81-4	DW 0.0	DW 0.0	26 Aug 81	HYDROCAST		x		x	x	B-47
L-RERP 81-4	DW 0.7	DW 0.7	26 Aug 81	HYDROCAST		x			x	B-47
L-RERP 81-4	DW 1.9	DW 1.9	26 Aug 81	HYDROCAST		x			x	B-47
L-RERP 81-4	DW 2.6	DW 2.6	26 Aug 81	HYDROCAST		x			x	B-47
L-RERP 81-4	DW 3.9	DW 3.9	26 Aug 81	HYDROCAST	08:00	x	x	x	x	B-47
L-RERP 81-4	DW 4.6	DW 4.6	26 Aug 81	HYDROCAST		x			x	B-47
L-RERP 81-4	DW 5.6	DW 5.6	26 Aug 81	HYDROCAST		x			x	B-47
L-RERP 81-4	DW 6.9	DW 6.9	26 Aug 81	HYDROCAST		x			x	B-47
L-RERP 81-4	DW 7.7	DW 7.7	26 Aug 81	HYDROCAST		x			x	B-47

Table 12. Sampling Locations and Sampling Data for the Duwamish Waterway

0 Cruise Name	1 Sta. Name	2 Station Location	3 Date	4 Cast Type	5 Time Loc.	6 Nut.	7 Dis. TM	8 Part. TM	9 POC/ PON	10 Page
L-RERP 81-4	DW 9.1	DW 9.1	26 Aug 81	HYDROCAST		x			x	B-47
L-RERP 81-4	DW 9.7	DW 9.7	26 Aug 81	HYDROCAST		x			x	B-47
L-RERP 82-1	DW 7.7	DW 7.7	2 Mar 82	HYDROCAST	09:00	x	x	x		B-49
L-RERP 82-1	DW 7.7	DW 7.7	2 Mar 82	HYDROCAST	19:30	x	x	x		B-49
L-RERP 82-1	DW 9.7	DW 9.7	2 Mar 82	HYDROCAST	09:00	x	x	x		B-50
L-RERP 82-1	DW 9.7	DW 9.7	2 Mar 82	HYDROCAST	12:30	x	x	x		B-50
L-RERP 82-1	DW 9.7	DW 9.7	2 Mar 82	HYDROCAST	16:40	x	x	x		B-50
L-RERP 82-1	DW 9.7	DW 9.7	2 Mar 82	HYDROCAST	21:30	x	x	x		B-50
L-RERP 85-2	EB85-SBDRO	DW 0.0	4 Apr 85	Small Boat	09:18		x	x		B-52
L-RERP 86-1	21	DW 2.6	9 Jan 86	Small Boat	08:42	x	x	x		B-53
L-RERP 86-1	22	DW 1.9	9 Jan 86	Small Boat	08:55	x	x	x		B-53
L-RERP 86-1	23	DW 0.5	9 Jan 86	Small Boat	09:04	x	x	x		B-53
L-RERP 86-1	27	EW 0.0	9 Jan 86	Small Boat	09:43	x	x	x		B-53
L-RERP 86-1	49	DW 1.9	9 Jan 86	Small Boat	16:00		x	x		B-53
DECII	WAS Data									B-54

3.1.3 Elliott Bay

A limited number of stations were occupied in Elliott Bay (Table 13) during Aug. 1979 (station 13; DEC I) and Sept. 1980 (EB4 & 6; DEC III). More extensive surveys of Elliott Bay surface and subsurface waters were conducted in Feb. 1980 (DEC II), May 1980 (L-RERP 1980), Aug. 1981 (L-RERP 81-4) and Apr. 1985 (L-RERP 85-2). During May 1980 (L-RERP 80), a time series was conducted at three Elliott Bay stations (PSE4, 6 & 11) for methane measurements. A single shallow cast (20 m) was taken in Elliott Bay during Apr. 1985 (PS6b; L-RERP 83-4) and Dec. 1985 (S25, L-RERP 84-2). An extensive survey of the surface waters of Elliott Bay was conducted in Jan. 1986 (L-RERP 86-1).

Elliott Bay results are presented in Appendix C. Particulate trace metal data from DEC I were used in the interpretation presented by Feely *et al.* (1983a). Massoth *et al.* (1982) examined particulate trace metal data from DEC II. An interpretation of the particulate trace metal data from DEC II, weak acid-soluble data from DEC II and III and dissolved trace metal data from DEC III has been offered by Feely *et al.* (1983b). Paulson and Feely (1985) compared the dissolved trace metal concentrations in Elliott Bay found during L-RERP 80 and L-RERP 81-4 with those found in other regions of Puget Sound. The particulate and dissolved trace metal data from L-RERP 85-2 were examined in Feely *et al.* (1988) and Paulson *et al.* (1989c). Feely *et al.* (1988) and Paulson *et al.* (1989a) examined the dissolved trace metal data from L-RERP 86-1. The temporal trends in the dissolved trace metal concentrations in Elliott Bay were examined by Paulson *et al.* (1989d). Other chemical data for Elliott Bay were also presented in Curl *et al.* (1988). The circulation of Elliott Bay was described by Sillcox *et al.* (1981) while processes affecting suspended matter distribution in Elliott Bay were described by Baker (1982) and Baker *et al.* (1983).

Table 13. Sampling Locations and Sampling Data for Elliott Bay

0 Cruise Name	1 Sta. Name	2 Lat. N	3 Long W	4 Date	5 Cast Type	6 Time Loc.	7 O2	8 CH4	9 Nut	10 Dis TM	11 Part TM	12 POC PON	13 Page
DEC I	EB-13	47 34.35	122 21.43	11 Aug 79	HYDRO	08:09			x		x	x	C-4
DEC II	EB-1	47 35.65	122 20.73	19 Feb 80	HYDRO	15:30	x		x		x	x	C-5
DEC II	EB-2	47 36.38	122 20.72	20 Feb 80	HYDRO	15:55	x		x		x	x	C-6
DEC II	EB-3	47 36.85	122 21.63	20 Feb 80	HYDRO	13:03	x		x		x	x	C-7
DEC II	EB-4	47 36.38	122 21.62	20 Feb 80	HYDRO	13:35	x		x		x	x	C-8
DEC II	EB-5	47 35.93	122 21.63	20 Feb 80	HYDRO	14:25			x		x	x	C-9
DEC II	EB-6	47 35.53	122 21.63	19 Feb 80	HYDRO	11:55	x		x	x	x		C-10
DEC II	EB-6	47 35.53	122 21.63	20 Feb 80	HYDRO	15:00					x		C-12
DEC II	EB-7	47 36.23	122 22.60	20 Feb 80	HYDRO	11:05	x		x		x	x	C-13
DEC II	EB-8	47 36.75	122 22.55	20 Feb 80	HYDRO	11:48	x		x		x	x	C-14
DEC II	EB-9	47 37.27	122 22.58	20 Feb 80	HYDRO	12:41	x		x		x	x	C-15
DEC II	EB-10	47 37.75	122 24.12	20 Feb 80	HYDRO	08:00	x		x		x	x	C-16
DEC II	EB-11	47 36.98	122 24.12	20 Feb 80	HYDRO	09:00	x		x		x	x	C-17
DEC II	EB-12	47 36.12	122 24.17	20 Feb 80	HYDRO	09:48	x		x		x	x	C-18
DEC II	EB-13	47 35.45	122 24.15	20 Feb 80	HYDRO	10:32	x		x		x	x	C-19
DEC II	OF-A	47 34.28	122 25.20	20 Feb 80	HYDRO	09:35	x		x		x	x	C-20
DEC II	OF-B	47 36.15	122 20.47	20 Feb 80	HYDRO	16:10	x		x		x	x	C-20
DEC II	OF-C	47 36.65	122 21.07	20 Feb 80	HYDRO	16:16	x		x		x	x	C-20
DEC II	OF-D	47 37.05	122 21.72	20 Feb 80	HYDRO	16:30	x		x		x	x	C-20
DEC II	OF-E	47 39.85	122 26.85	20 Feb 80	HYDRO	17:45	x		x		x	x	C-20
L-RERP 80	EBH-1	47 35.65	122 20.73	22 May 80	HYDRO				x		x		C-21
L-RERP 80	EBH-6	47 35.55	122 21.60	22 May 80	HYDRO				x		x		C-22
L-RERP 80	PSE-6	47 35.50	122 21.70	22 May 80	CTD	14:39		x					C-23
L-RERP 80	PSE-4	47 36.60	122 21.50	22 May 80	CTD	16:31		x					C-24
L-RERP 80	PSE-11	47 37.80	122 23.90	22 May 80	CTD	18:18		x					C-25
L-RERP 80	PSE-6	47 35.50	122 21.70	22 May 80	CTD	20:07		x					C-26
L-RERP 80	PSE-4	47 36.40	122 21.70	22 May 80	CTD	22:18		x					C-27
L-RERP 80	PSE-11	47 37.20	122 23.70	23 May 80	CTD	00:56		x					C-28
L-RERP 80	PSE-6	47 35.50	122 21.70	23 May 80	CTD	02:22		x					C-29
L-RERP 80	PSE-4	47 36.40	122 21.40	23 May 80	CTD	04:14		x					C-30
L-RERP 80	PSE-11	47 37.30	122 22.40	23 May 80	CTD	06:17		x					C-31
L-RERP 80	PSE-6	47 35.50	122 21.70	23 May 80	CTD	08:09		x					C-32
L-RERP 80	PSE-4	47 36.30	122 21.90	23 May 80	CTD	03:00		x	x		x	x	C-33
L-RERP 80	PSE-6	47 35.55	122 21.60	23 May 80	TM					x			C-34
L-RERP 80	PSE-6	47 35.50	122 21.70	23 May 80	CTD	12:50	x	x	x		x	x	C-34
L-RERP 80	PSE-4	47 36.40	122 21.60	23 May 80	TM					x			C-35
L-RERP 80	PSE-4	47 35.30	122 21.70	23 May 80	CTD	16:37	x	x					C-35
L-RERP 80	PSE-8	47 36.70	122 22.70	23 May 80	CTD	20:00	x	x	x		x		C-36
L-RERP 80	PSE-11	47 37.00	122 24.10	24 May 80	TM					x			C-37
L-RERP 80	PSE-11	47 36.80	122 24.30	24 May 80	CTD	00:09	x	x	x		x	x	C-37
L-RERP 80	PSE-10	47 37.80	122 24.30	24 May 80	CTD	05:20	x	x	x		x		C-39
L-RERP 80	PSE-13	47 35.40	122 24.10	24 May 80	CTD	08:20	x	x	x				C-40
L-RERP 80	PSE-12	47 36.10	122 24.10	24 May 80	CTD	10:34		x			x		C-41
DEC III	EB-4	47 36.38	122 21.62	12 Sep 80	HYDRO	17:09			x	x	x	x	C-42
DEC III	EB-6	47 35.53	122 21.63	12 Sep 80	HYDRO	10:45			x		x	x	C-43
L-RERP 81-4	EB-4	47 36.3	122 21.6	25 Aug 81	TM					x			C-44
L-RERP 81-4	EB-4	47 36.3	122 21.6	25 Aug 81	CTD	13:05							C-44
L-RERP 81-4	EB-1	47 35.6	122 20.8	25 Aug 81	CTD	16:12	x	x	x				C-45
L-RERP 81-4	EB-2	47 36.4	122 20.7	25 Aug 81	CTD	17:28		x					C-46
L-RERP 81-4	EB-3	47 36.8	122 21.7	25 Aug 81	CTD	18:16	x	x	x				C-47
L-RERP 81-4	EB-5	47 36.0	122 21.9	25 Aug 81	CTD	20:14	x	x	x		x	x	C-48
L-RERP 81-4	EB-4	47 36.6	122 21.6	25 Aug 81	CTD	23:43		x			x	x	C-44
L-RERP 81-4	EB-6	47 35.5	122 21.7	26 Aug 81	CTD	01:26		x			x	x	C-49

Table 13. Sampling Locations and Sampling Data for Elliott Bay

0 Cruise Name	1 Sta. Name	2 Lat. N	3 Long W	4 Date	5 Cast Type	6 Time Loc.	7 O2	8 CH4	9 Nut	10 Dis TM	11 Part TM	12 POC PON	13 Page
L-RERP 81-4	EB-7	47 36.0	122 22.5	26 Aug 81	CTD	04:02		x					C-50
L-RERP 81-4	EB-8	47 36.7	122 22.5	26 Aug 81	CTD	05:42		x					C-51
L-RERP 81-4	EB-8A	47 36.9	122 23.2	26 Aug 81	TM					x			C-52
L-RERP 81-4	EB-8A	47 36.9	122 23.2	26 Aug 81	CTD	08:37	x	x	x		x	x	C-52
L-RERP 81-4	EB-9	47 37.3	122 22.5	26 Aug 81	CTD	06:55		x					C-54
L-RERP 81-4	EB-11A	47 37.2	122 25.8	26 Aug 81	TM	19:00				x			C-55
L-RERP 81-4	EB-11A	47 32.2	122 25.8	26 Aug 81	CTD	20:11	x	x	x		x	x	C-55
L-RERP 83-4	PS6b	47 36.5	122 21.5	20 Apr 83	CTD	12:43			x		x	x	C-56
L-RERP 83-4	PS6b	47 36.6	122 21.5	20 Apr 83	TM	12:29				x			C-56
L-RERP 84-2	S25	47 36.5	122 21.5	7 Dec 83	CTD	07:40	x	x	x		x	x	C-57
L-RERP 84-2	S25	47 36.4	122 21.5	7 Dec 83	TM	07:22				x			C-57
L-RERP 85-2	EB85-1	47 35.8	122 20.6	4 Apr 85	CTD	15:06			x	x	x		C-58
L-RERP 85-2	EB85-SB1	47 36.0	122 20.4	4 Apr 85	SB	10:38				x	x		C-58
L-RERP 85-2	EB85-2	47 36.2	122 20.6	4 Apr 85	CTD	15:36			x		x		C-59
L-RERP 85-2	EB85-SB2	47 36.3	122 20.7	4 Apr 85	SB	12:46				x	x		C-59
L-RERP 85-2	EB85-3	47 35.6	122 21.5	4 Apr 85	TM	08:45				x			C-60
L-RERP 85-2	EB85-3	47 35.6	122 21.6	4 Apr 85	CTD	09:09			x		x		C-60
L-RERP 85-2	EB85-SB3	47 35.4	122 21.5	4 Apr 85	SB	10:19				x	x		C-60
L-RERP 85-2	EB85-4	47 35.8	122 21.5	4 Apr 85	TM	10:10				x			C-61
L-RERP 85-2	EB85-4	47 35.8	122 21.9	4 Apr 85	CTD	10:37			x		x		C-61
L-RERP 85-2	EB85-SB4	47 35.9	122 21.6	4 Apr 85	SB	10:47				x	x		C-61
L-RERP 85-2	EB85-5	47 36.3	122 21.4	4 Apr 85	TM	12:42				x			C-62
L-RERP 85-2	EB85-5	47 36.3	122 21.3	4 Apr 85	CTD	11:43			x		x		C-62
L-RERP 85-2	EB85-SB5	47 36.3	122 21.7	4 Apr 85	SB	12:32				x	x		C-62
L-RERP 85-2	EB85-6	47 36.7	122 21.6	4 Apr 85	CTD	16:08	x		x		x		C-63
L-RERP 85-2	EB85-SB6	47 36.7	122 21.1	4 Apr 85	SB	12:57				x	x		C-63
L-RERP 85-2	EB85-7	47 37.0	122 21.7	5 Apr 85	CTD	14:53			x		x		C-64
L-RERP 85-2	EB85-SB7	47 37.3	122 22.2	4 Apr 85	SB	14:08				x	x		C-64
L-RERP 85-2	EB85-8	47 36.1	122 23.1	4 Apr 85	CTD	17:44			x		x		C-65
L-RERP 85-2	EB85-SB8			4 Apr 85	SB						x		C-65
L-RERP 85-2	EB85-9	47 36.8	122 22.7	4 Apr 85	TM	14:26				x			C-66
L-RERP 85-2	EB85-9	47 36.8	122 22.8	4 Apr 85	CTD	13:01			x		x		C-66
L-RERP 85-2	EB85-SB9	47 36.7	122 23.0	4 Apr 85	SB	13:16				x	x		C-66
L-RERP 85-2	EB85-10	47 37.2	122 22.9	4 Apr 85	CTD	12:01			x		x		C-67
L-RERP 85-2	EB85-11	47 35.3	122 24.7	4 Apr 85	CTD	21:02			x		x		C-68
L-RERP 85-2	EB85-12	47 36.0	122 24.8	4 Apr 85	CTD	18:10			x		x		C-69
L-RERP 85-2	EB85-13	47 36.8	122 24.8	4 Apr 85	TM	16:43				x			C-70
L-RERP 85-2	EB85-13	47 36.7	122 24.7	4 Apr 85	CTD	17:07			x		x		C-70
L-RERP 85-2	EB-SB13			4 Apr 85	SB						x		C-70
L-RERP 85-2	EB85-14	47 37.6	122 24.7	4 Apr 85	TM	15:21				x			C-71
L-RERP 85-2	EB85-14	47 37.5	122 21.7	4 Apr 85	CTD	14:22			x		x		C-71
L-RERP 85-2	EB-SB14	47 38.2	122 24.9	4 Apr 85	SB	14:39					x		C-71
L-RERP 85-2	EB-SBT1	47 35.4	122 22.5	4 Apr 85	SB	10:08					x		C-72
L-RERP 85-2	EB-SBT8	47 36.5	122 24.4	4 Apr 85	SB	13:43					x		C-72
L-RERP 85-2	EB-SBT9	47 37.1	122 24.4	4 Apr 85	SB	13:49					x		C-72
L-RERP 85-2	EB-SBT13	47 38.1	122 25.3	4 Apr 85	SB	14:49					x		C-72
L-RERP 85-2	EB-SBT14	47 38.3	122 25.3	4 Apr 85	SB	15:01					x		C-72
L-RERP 86-1	1	47 37.1	122 21.6	8 Jan 86	SB	08:40			x	x	x		C-73
L-RERP 86-1	2	47 36.9	122 22.0	8 Jan 86	SB	08:55			x	x	x		C-73
L-RERP 86-1	3	47 36.6	122 22.4	8 Jan 86	SB	09:24			x	x	x		C-73
L-RERP 86-1	4	47 36.5	122 23.3	8 Jan 86	SB	09:50			x	x	x		C-73
L-RERP 86-1	5	47 37.2	122 23.1	8 Jan 86	SB	10:23			x	x	x		C-73
L-RERP 86-1	6	47 37.2	122 22.7	8 Jan 86	SB	10:45			x	x	x		C-73

Table 13. Sampling Locations and Sampling Data for Elliott Bay

0 Cruise Name	1 Sta. Name	2 Lat. N	3 Long W	4 Date	5 Cast Type	6 Time Loc.	7 O2	8 CH4	9 Nut	10 Dis TM	11 Part TM	12 POC PON	13 Page
L-RERP 86-1	7	47 37.6	122 22.7	8 Jan 86	SB	11:05			x	x	x		C-73
L-RERP 86-1	8	47 37.6	122 22.1	8 Jan 86	SB	11:16			x	x	x		C-73
L-RERP 86-1	9	47 37.5	122 23.2	8 Jan 86	SB	12:56			x	x	x		C-73
L-RERP 86-1	10	47 37.2	122 23.3	8 Jan 86	SB	13:07			x	x	x		C-73
L-RERP 86-1	11	47 36.9	122 23.5	8 Jan 86	SB	12:20			x	x	x		C-73
L-RERP 86-1	12	47 36.7	122 23.3	8 Jan 86	SB	13:31			x	x	x		C-73
L-RERP 86-1	13	47 36.8	122 23.7	8 Jan 86	SB	14:00			x	x	x		C-73
L-RERP 86-1	14	47 38.3	122 24.4	8 Jan 86	SB	14:11			x	x	x		C-73
L-RERP 86-1	15	47 37.7	122 24.6	8 Jan 86	SB	15:20			x	x	x		C-73
L-RERP 86-1	16	47 38.2	122 24.7	8 Jan 86	SB	15:28			x	x	x		C-73
L-RERP 86-1	17	47 38.1	122 25.1	8 Jan 86	SB	15:41			x	x	x		C-73
L-RERP 86-1	18	47 37.8	122 25.6	8 Jan 86	SB	15:55			x	x	x		C-73
L-RERP 86-1	19	47 38.7	122 25.6	8 Jan 86	SB	16:22			x	x	x		C-73
L-RERP 86-1	24	47 35.5	122 21.6	9 Jan 86	SB	09:14			x	x	x		C-73
L-RERP 86-1	25	47 35.4	122 21.1	9 Jan 86	SB	09:25			x	x	x		C-73
L-RERP 86-1	26	47 35.5	122 20.7	9 Jan 86	SB	09:33			x	x	x		C-73
L-RERP 86-1	28	47 36.0	122 20.4	9 Jan 86	SB	09:52			x	x	x		C-73
L-RERP 86-1	29	47 35.9	122 21.0	9 Jan 86	SB	10:14			x	x	x		C-73
L-RERP 86-1	30	47 35.9	122 21.6	9 Jan 86	SB	10:26			x	x	x		C-73
L-RERP 86-1	31	47 35.6	122 22.3	9 Jan 86	SB	10:35			x	x	x		C-73
L-RERP 86-1	32	47 35.4	122 22.1	9 Jan 86	SB	10:43			x	x	x		C-73
L-RERP 86-1	33	47 35.1	122 22.1	9 Jan 86	SB	10:51			x	x	x		C-73
L-RERP 86-1	34	47 35.4	122 22.4	9 Jan 86	SB	11:46			x	x	x		C-73
L-RERP 86-1	35	47 35.5	122 22.7	9 Jan 86	SB	11:54			x	x	x		C-73
L-RERP 86-1	36	47 35.9	122 23.1	9 Jan 86	SB	12:02			x	x	x		C-73
L-RERP 86-1	37	47 36.0	122 22.6	9 Jan 86	SB	12:15			x	x	x		C-73
L-RERP 86-1	38	47 36.1	122 21.5	9 Jan 86	SB	12:35			x	x	x		C-73
L-RERP 86-1	39	47 36.3	122 21.3	9 Jan 86	SB	13:10			x	x	x		C-73
L-RERP 86-1	40	47 36.4	122 20.8	9 Jan 86	SB	13:19			x	x	x		C-73
L-RERP 86-1	41	47 36.3	122 20.4	9 Jan 86	SB	13:27			x	x	x		C-73
L-RERP 86-1	42	47 36.4	122 20.5	9 Jan 86	SB	13:33			x	x	x		C-73
L-RERP 86-1	43	47 36.3	122 21.0	9 Jan 86	SB	13:40			x	x	x		C-73
L-RERP 86-1	44	47 36.9	122 21.5	9 Jan 86	SB	13:48			x	x	x		C-73
L-RERP 86-1	45	47 36.7	122 21.9	9 Jan 86	SB	14:00			x	x	x		C-73
L-RERP 86-1	46	47 36.5	122 22.3	9 Jan 86	SB	14:07			x	x	x		C-73
L-RERP 86-1	47	47 36.3	122 22.9	9 Jan 86	SB	14:21			x	x	x		C-73
DECII	WAS Data												C-77
DECIII	WAS Data												C-77

3.1.4 Commencement Bay

Single stations in inner Commencement Bay were occupied during May 1980 (PSB-13; L-RERP 80), Apr. 1983 (PS2b; L-RERP 83-4) and Dec. 1983 (S20; L-RERP 84-2) (Table 14). More extensive surveys of Commencement Bay were conducted in Apr. 1981 (COMMBAY III) and in Apr. 1985 (L-RERP 85-2). In Aug. 1981 (L-RERP 81-4), a time series was conducted at one station in Dalco Passage (PS3CTS) for TSM and particulate trace metals measurements and at three stations (PS3TS, PS3BTS and PS3CTS) for methane measurements. Single stations in Dalco Passage were occupied in Apr. 1983 (PS3b; L-RERP 83-4), Dec. 1983 (S3; L-RERP 84-2) and Aug. 1984 (S3; L-RERP 84-2) while three stations were occupied in Dalco Passage during Apr. 1985 (CB85-14 to 16; L-RERP 85-2). A station off Browns Point (usually labeled PS3) was occupied during May 1980 (PSB-12, L-RERP 80), Nov. 1980 (L-RERP 80-2), Feb. 1981 (L-RERP 81-1), Apr. 1981 (L-RERP 81-1), July 1981 (L-RERP 81-3), Aug. 1981 (L-RERP 81-4), Nov. 1981 (L-RERP 81-5), Feb. 1982 (L-RERP 82-1), Apr. 1982 (L-RERP 82-11), Apr. 1983 (L-RERP 83-4), Dec. 1983 (S4; L-RERP 84-2), Aug. 1984 (S4; L-RERP 84-9), Apr. 1985 (MB85-2; L-RERP 85-2).

Commencement and Dalco Passage results are presented in Appendix D. Dissolved trace metal concentrations of Commencement Bay and Dalco Passage samples collected during L-RERP 80 and L-RERP 81-4 were compared to those in other regions of Puget Sound by Paulson and Feely (1985). Chemical data from L-RERP 85-2 was presented by Curl *et al.* (1988). The circulation of Commencement Bay was studied by Cannon and Grigsby (1982) while suspended matter distributions were described by Baker and Walker (1982).

Table 14. Sampling Loactions and Sampling Data for Commencement Bay

0 Cruise Name	1 Sta. Name	2 Lat. N	3 Long. W	4 Date	5 Cast Type	6 Time Loc.	7 O2	8 CH4	9 Nut	10 Dis TM	11 Part TM	12 POC PON	13 Page
L-RERP 80	PSB-13	47 17.2	122 26.8	24 May 80	TM	13:25				x			D-3
L-RERP 80	PSB-13	47 17.2	122 26.8	24 May 80	CTD	13:57	x	x	x			x	D-3
L-RERP 80	PSB-12	47 18.9	122 29.5	24 May 80	TM	15:18				x			D-4
L-RERP 80	PSB-12	47 18.9	122 29.5	24 May 80	CTD	15:57	x	x	x			x	D-4
L-RERP 80-2	PS3	47 19.9	122 26.4	21 Nov 80	TM						x		D-6
L-RERP 80-2	PS3	47 19.9	122 26.7	21 Nov 80	CTD	17:20							D-6
L-RERP 81-1	PS3	47 19.9	122 26.4	6 Feb 81	TM	02:13			x		x	x	D-7
L-RERP 81-1	PS3	47 19.9	122 26.4	6 Feb 81	CTD	02:21							D-7
COMMBAY III	City W			26 Mar 81	HYDRO						x		D-8
COMMBAY III	Sitc W			26 Mar 81	HYDRO						x		D-8
COMMBAY III	Blr W			26 Mar 81	HYDRO						x		D-8
COMMBAY III	1	47 17.2	122 24.8	26 Mar 81	HYDRO						x		D-8
COMMBAY III	2	47 16.8	122 25.2	26 Mar 81	HYDRO						x		D-8
COMMBAY III	3	47 16.5	122 25.7	26 Mar 81	HYDRO						x		D-8
COMMBAY III	4	47 16.2	122 26.2	26 Mar 81	HYDRO						x		D-8
COMMBAY III	5	47 16.7	122 27.2	26 Mar 81	HYDRO						x		D-8
COMMBAY III	6	47 17.0	122 26.3	26 Mar 81	HYDRO						x		D-8
COMMBAY III	7	47 17.4	122 26.1	26 Mar 81	HYDRO						x		D-8
COMMBAY III	8	47 17.5	122 27.1	26 Mar 81	HYDRO						x		D-8
COMMBAY III	9	47 17.5	122 28.6	26 Mar 81	HYDRO						x		D-8
COMMBAY III	10	47 18.3	122 30.0	26 Mar 81	HYDRO						x		D-8
COMMBAY III	11	47 18.3	122 28.3	26 Mar 81	HYDRO						x		D-8
COMMBAY III	12	47 18.1	122 27.0	26 Mar 81	HYDRO						x		D-8
L-RERP 81-2	PS3	47 19.9	122 26.4	30 Apr 81	TM				x	x	x	x	D-12
L-RERP 81-2	PS3	47 19.9	122 26.4	30 Apr 81	CTD	15:18							D-12
L-RERP 81-3	PS3	47 19.9	122 26.4	16 Jul 81	TM				x	x	x	x	D-13
L-RERP 81-3	PS3	47 19.9	122 26.4	16 Jul 81	CTD	16:14							D-13
L-RERP 81-4	PS3BTS	47 18.9	122 29.1	27 Aug 81	CTD	01:06		x					D-14
L-RERP 81-4	PS3TS	47 19.5	122 31.1	27 Aug 81	CTD	01:50		x					D-15
L-RERP 81-4	PS3CTS	47 19.7	122 33.2	27 Aug 81	CTD	02:55		x			x	x	D-16
L-RERP 81-4	PS3BTS	47 19.1	122 29.1	27 Aug 81	CTD	03:48		x					D-17
L-RERP 81-4	PS3TS	47 19.4	122 31.1	27 Aug 81	CTD	04:49		x					D-18
L-RERP 81-4	PS3CTS	47 19.8	122 33.1	27 Aug 81	CTD	05:47		x			x	x	D-19
L-RERP 81-4	PS3BTS	47 19.1	122 28.9	27 Aug 81	CTD	06:33		x					D-20
L-RERP 81-4	PS3TS	47 19.5	122 31.0	27 Aug 81	CTD	07:33		x					D-21
L-RERP 81-4	PS3CTS	47 19.5	122 33.3	27 Aug 81	CTD	09:34		x			x	x	D-22
L-RERP 81-4	PS3BTS	47 18.8	122 28.8	27 Aug 81	CTD	10:32		x					D-23
L-RERP 81-4	PS3TS	47 19.4	122 31.3	27 Aug 81	CTD	11:32		x					D-24
L-RERP 81-4	PS3CTS	47 19 4	122 33.4	27 Aug 81	CTD	12:17		x			x	x	D-25
L-RERP 81-4	PS3BTS	47 19.1	122 29.2	27 Aug 81	CTD	13:12		x					D-26
L-RERP 81-4	PS3TS	47 19.5	122 31.6	27 Aug 81	CTD	14:10		x					D-27
L-RERP 81-4	PS3CTS	47 19.5	122 33.4	27 Aug 81	CTD	15:16		x			x	x	D-28
L-RERP 81-4	PS3BTS	47 19.0	122 29.0	27 Aug 81	CTD	16:32		x					D-29
L-RERP 81-4	PS3TS	47 19.3	122 30.9	27 Aug 81	TM	17:05				x			D-30
L-RERP 81-4	PS3TS	47 19.3	122 30.9	27 Aug 81	CTD	17:32		x					D-30
L-RERP 81-4	PS3CTS	47 19.6	122 33.4	27 Aug 81	CTD	18:18		x			x	x	D-31
L-RERP 81-4	PS3	47 19.9	122 26.5	28 Aug 81	TM	02:30				x			D-32
L-RERP 81-4	PS3	47 19.9	122 26.5	28 Aug 81	CTD	03:57	x	x	x		x	x	D-32
L-RERP 81-5	PS3	47 19.9	122 26.4	3 Nov 81	TM	17:47			x	x	x	x	D-34
L-RERP 81-5	PS3	47 19.9	122 26.4	3 Nov 81	CTD	17:47							D-34
L-RERP 82-1	PS3	47 19.9	122 26.4	22 Feb 82	TM	19:43				x			D-35
L-RERP 82-1	PS3	47 19.9	122 26.4	22 Feb 82	CTD	16:30	x	x	x		x	x	D-35
L-RERP 82-11	PS3	47 20.0	122 26.7	20 Apr 82	CTD	16:00	x	x	x				D-36

Table 14. Sampling Loactions and Sampling Data for Commencement Bay

0 Cruise Name	1 Sta. Name	2 Lat. N	3 Long. W	4 Date	5 Cast Type	6 Time Loc.	7 O2	8 CH4	9 Nut	10 Dis TM	11 Part TM	12 POC PON	13 Page
L-RERP 83-4	PS2b	47 17.0	122 26.4	19 Apr 83	CTD	07:45			x		x		D-37
L-RERP 83-4	PS2b	47 17.1	122 26.7	19 Apr 83	TM	07:21				x			D-37
L-RERP 83-4	PS3	47 19.1	122 27.3	19 Apr 83	CTD	09:49			x		x	x	D-38
L-RERP 83-4	PS3	47 19.2	122 27.3	19 Apr 83	TM	09:20				x			D-38
L-RERP 83-4	PS3a	47 21.3	122 24.3	19 Apr 83	CTD	12:10			x		x	x	D-39
L-RERP 83-4	PS3a	47 21.3	122 24.3	19 Apr 83	TM	11:35				x			D-39
L-RERP 83-4	PS3b	47 19.1	122 30.0	18 Apr 83	CTD	21:06			x		x	x	D-40
L-RERP 84-2	S3	47 19.0	122 30.0	6 Dec 83	CTD	08:23	x	x	x		x	x	D-41
L-RERP 84-2	S3	47 19.0	122 30.1	6 Dec 83	TM	08:00				x			D-41
L-RERP 84-2	S4	47 19.8	122 26.7	6 Dec 83	CTD	10:41	x	x	x		x	x	D-42
L-RERP 84-2	S4	47 19.1	122 26.6	6 Dec 83	TM	10:16				x			D-42
L-RERP 84-2	S20	47 17.2	122 27.1	5 Dec 83	CTD	22:20	x	x	x		x	x	D-43
L-RERP 84-2	S20	47 17.1	122 26.8	5 Dec 83	TM	22:11				x			D-43
L-RERP 84-9	S3	47 18.9	122 30.0	7 Aug 84	CTD	15:14	x	x			x		D-44
L-RERP 84-9	S4	47 19.5	122 27.0	7 Aug 84	CTD	14:00	x	x			x	x	D-45
L-RERP 85-2	CB85-1	47 16.9	121 24.9	1 Apr 85	TM	11:38				x			D-47
L-RERP 85-2	CB85-1	47 16.9	122 25.0	1 Apr 85	CTD	11:46			x		x		D-47
L-RERP 85-2	CB85-2	47 16.7	121 25.5	1 Apr 85	TM	12:10				x			D-48
L-RERP 85-2	CB85-2	47 16.6	122 25.3	1 Apr 85	CTD	12:26			x		x		D-48
L-RERP 85-2	CB85-3	47 16.6	121 25.7	1 Apr 85	TM	13:11				x			D-49
L-RERP 85-2	CB85-3	47 16.5	122 25.7	1 Apr 85	CTD	12:51			x		x		D-49
L-RERP 85-2	CB85-4	47 16.1	121 26.2	1 Apr 85	TM	14:31				x			D-50
L-RERP 85-2	CB85-4	47 16.1	122 26.1	1 Apr 85	CTD	13:41			x		x		D-50
L-RERP 85-2	CB85-5	47 17.6	122 26.2	1 Apr 85	CTD	16:37			x		x		D-51
L-RERP 85-2	CB85-6	47 17.1	122 26.4	1 Apr 85	CTD	19:18			x		x		D-52
L-RERP 85-2	CB85-7	47 16.7	122 26.8	1 Apr 85	TM	19:57				x			D-53
L-RERP 85-2	CB85-7	47 16.6	122 26.8	1 Apr 85	CTD	20:25			x		x		D-53
L-RERP 85-2	CB85-8	47 17.9	122 26.9	1 Apr 85	CTD	20:53			x		x		D-54
L-RERP 85-2	CB85-9	47 17.5	122 26.9	1 Apr 85	CTD	21:27			x		x		D-55
L-RERP 85-2	CB85-10	47 17.2	122 27.6	1 Apr 85	TM	21:54				x			D-56
L-RERP 85-2	CB85-10	47 17.0	122 27.8	1 Apr 85	CTD	22:26			x		x		D-56
L-RERP 85-2	CB85-11	47 17.0	122 28.1	1 Apr 85	CTD	22:53			x		x		D-57
L-RERP 85-2	CB85-12	47 18.5	122 26.8	2 Apr 85	CTD	10:21			x		x		D-58
L-RERP 85-2	CB85-13	47 18.7	122 28.7	2 Apr 85	TM	10:56				x			D-59
L-RERP 85-2	CB85-13	47 18.6	122 28.7	2 Apr 85	CTD	11:25	x	x	x		x		D-59
L-RERP 85-2	CB85-14	47 18.6	122 29.7	2 Apr 85	TM	13:11				x			D-60
L-RERP 85-2	CB85-14	47 18.6	122 30.6	2 Apr 85	CTD	13:31			x		x		D-60
L-RERP 85-2	CB85-15	47 19.1	122 29.9	2 Apr 85	TM	15:50				x			D-61
L-RERP 85-2	CB85-15	47 19.1	122 30.1	2 Apr 85	CTD	15:24			x		x		D-61
L-RERP 85-2	CB85-16	47 19.2	122 29.7	2 Apr 85	CTD	14:59			x		x		D-62
L-RERP 85-2	MB85-1	47 20.4	122 27.1	2 Apr 85	CTD	16:32			x				D-63
L-RERP 85-2	MB85-2	47 19.8	122 26.4	2 Apr 85	CTD	17:05			x	x			D-64
L-RERP 85-2	MB85-3	47 19.3	122 26.0	2 Apr 85	CTD	18:24			x				D-65

3.1.5 Freshwaters other than the Duwamish River (TIPS)

The Trace Inventory of Puget Sound (TIPS) program was initiated in order to quantify the fluxes of dissolved and particulate trace metals contributed to Puget Sound by freshwaters (Table 15). The Skagit (North and South Forks), Stilliquamish, Snohomish, Puyallup, Nisqually and Skokomish Rivers and the Lake Washington Ship Canal (LWSC) were sampled during Jun. 1980 (TIPS I), Sept. 1980 (TIPS II), Jan. 1981 (TIPS III), Jun. 1981 (TIPS IV), Oct. 1981 (TIPS V) and Oct. 1984 (TIPS VII). The Puyallup River was also sampled in Mar. 1981 (TIPS IVa). The effluent from the West Point Sewage Treatment Plant (STP) was sampled in Oct. 1981 (TIPS V), Aug. 1984 (L-RERP 84-9) and Oct. 1984 (TIPS VII) in order to determine the partitioning of trace metals between the dissolved and particulate phases, which could be applied to the mass loadings of total trace metals provided by METRO.

The results of the TIPS sampling program are presented in Appendix E. The TIPS results from the Puyallup River, the Lake Washington Ship Canal and the West Point STP were used to quantify dissolved and particulate trace metals fluxes to the main basin of Puget Sound (Paulson *et al.*, 1988b, 1988c and 1989b). Trace metal concentrations on suspended matter from the Skagit, Snohomish, Stilliquamish, and Puyallup Rivers were compared to those in the main basin of Puget Sound by Feely *et al.* (1986).

Table 15. Sampling Locations and Sampling Data for Freshwaters other than the Duwamish River (TIPS)

0 Cruise Name	1 Sta. Name	2 Sta. Loc.	3 Date	4 Cast Type	5 Time Loc.	6 Nut.	7 Dis. TM	8 TSM	9 Part. TM	10 POC/ PON	11 Pg.
TIPS I	N. Skagit	6.8	23 Jun 80	Bridge	15:18		x	x	x		E-2
TIPS I	S. Skagit	7.1	23 Jun 80	Bridge	15:01		x	x	x		E-2
TIPS I	Stillaguamish	3.1	23 Jun 80	Bridge	14:09		x				E-4
TIPS I	Snohomish	4.2	23 Jun 80	Shore	12:35		x	x	x		E-6
TIPS I	Puyallup	13.3	23 Jun 80	Bridge	20:45		x	x	x		E-8
TIPS I	Nisqually	6.1	23 Jun 80	Shore	19:11		x	x	x		E-10
TIPS II	N. Skagit	6.8	23 Sep 80	Bridge		x	x	x	x		E-2
TIPS II	S. Skagit	7.1	23 Sep 80	Bridge		x	x	x	x		E-2
TIPS II	Stillaguamish	3.1	23 Sep 80	Bridge		x	x	x	x		E-4
TIPS II	Snohomish	4.2	2 Oct 80	Shore		x	x	x	x		E-6
TIPS II	Lk. WA. Boat Canal	5.2	23 Sep 80	Shore		x	x	x	x		E-12
TIPS II	Puyallup	13.3	23 Sep 80	Bridge			x	x	x		E-8
TIPS II	Nisqually	5.5	23 Sep 80	Bridge		x	x	x	x		E-10
TIPS III	N. Skagit	6.8	2 Jan 81	Bridge			x	x	x	x	E-2
TIPS III	S. Skagit	7.1	2 Jan 81	Bridge			x	x	x	x	E-2
TIPS III	Stillaguamish	12.1	2 Jan 81	Bridge			x	x	x	x	E-4
TIPS III	Snohomish	7.6	2 Jan 81	Bridge			x	x	x	x	E-6
TIPS III	Lk. WA. Boat Canal	5.2	5 Jan 81	Shore			x	x	x		E-12
TIPS III	Puyallup	13.3	7 Jan 81	Bridge			x	x	x	x	E-8
TIPS III	Nisqually	6.1	7 Jan 81	Shore			x	x	x		E-10
TIPS III	Skokomish	Rt. 101	7 Jan 81	Bridge			x	x	x		E-14
TIPS IVA	Puyallup	13.3	25 Mar 81	Bridge	11:15		x	x			E-8
TIPS IV	N. Skagit	6.8	1 Jun 81	Bridge	14:45	x	x	x	x	x	E-2
TIPS IV	S. Skagit	7.1	1 Jun 81	Bridge	13:42	x	x	x	x	x	E-2
TIPS IV	Stillaguamish	3.1	1 Jun 81	Bridge	12:22	x	x	x	x	x	E-4
TIPS IV	Snohohmish	4.2	1 Jun 81	Shore	10:06		x	x	x	x	E-6
TIPS IV	Lk. WA. Boat Canal	5.2	3 Jun 81	Shore		x	x	x	x		E-12
TIPS IV	Puyallup	13.3	3 Jun 81	Bridge	11:00	x	x	x	x	x	E-8
TIPS IV	Nisqually	6.1	3 Jun 81	Shore	13:00	x	x	x	x		E-10
TIPS IV	Skokomish	Rt. 101	3 Jun 81	Bridge	16:30	x	x	x	x		E-14
TIPS V	N. Skagit	6.8	9 Oct 81	Bridge		x	x	x	x	x	E-2
TIPS V	S. Skagit	7.1	9 Oct 81	Bridge		x	x	x	x	x	E-2
TIPS V	Stillaguamish	3.1	9 Oct 81	Bridge		x	x	x	x	x	E-4
TIPS V	Snohomish	4.2	9 Oct 81	Shore		x	x	x	x	x	E-6
TIPS V	Lk. WA. Boat Canal	5.2	13 Oct 81	Shore		x	x	x	x		E-12
TIPS V	Puyallup	13.3	8 Oct 81	Bridge		x	x	x	x	x	E-8
TIPS V	Nisqually	6.1	8 Oct 81	Bridge		x	x	x	x		E-10
TIPS V	West Point		13 Oct 81	Grab		x	x	x	x		E-15
L-RERP 84-9	West Point		13 Aug 84	Grab			x	x	x		E-15
TIPS VII	N. Skagit	6.8	3 Oct 84	Bridge	12:20		x	x			E-2
TIPS VII	S. Skagit	7.1	3 Oct 84	Bridge	14:20			x			E-2
TIPS VII	Stillaguamish	3.1	3 Oct 84	Bridge	15:35		x	x			E-4
TIPS VII	Snohomish	4.2	5 Oct 84	Shore	14:00		x	x			E-6
TIPS VII	Lk. WA. Boat Canal	5.2	5 Oct 84	Shore	11:15		x	x			E-12
TIPS VII	Puyallup	13.3	4 Oct 84	Bridge	16:15		x	x			E-8
TIPS VII	Nisqually	6.1	4 Oct 84	Shore	14:30	x	x	x	x	x	E-10
TIPS VII	Skokomish	Rt. 101	4 Oct 84	Bridge	12:15		x	x			E-14
TIPS VII	West Point		7 Oct 84	Grab			x	x	x		E-15

3.2 Sediments

Sediments were collected for the characterization of the solid phase chemistry (3.2.1) and the interstitial porewater chemistry (3.2.2).

3.2.1 Solid Phase Chemistry

Surface sediments in the Duwamish Waterway and River were collected by a Shipek grab sampler in Aug. 1981 (L-RERP 81-4) for weak acid-soluble analyses (Table 16). The results of those analyses are presented in Appendix F along with their particle size distribution.

All sediments for total trace metal analyses and radiochemical determinations listed in Table 16 were collected by PMEL scientists in cooperation with E.A. Crecelius of Battelle Northwest's Sequim Marine Laboratory and analyzed by Battelle Northwest. During Aug. 1981 (L-RERP 81-4), surface samples from three Elliott Bay stations were analyzed for trace metals while one vertical profile of trace metal and ^{210}Pb concentrations were obtained at station EB5. Vertical profiles of trace metal concentrations and radiochemical measurements for the 4 cores in Commencement Bay (CB1 to CB4) were presented in Crecelius *et al.* (1985). The analyses of trace metal concentrations for the BPS-15 core were supported in part by METRO and were presented in Romberg *et al.* (1984) while the radiochemical results were interpreted by Lavelle *et al.* (1986). Results of trace organic analyses are presented in Bates *et al.* (1987).

Table 16. Sediment Collection Data for Solid Phase Analyses

0 Cruise Name	1 Sta. Name	2 Latitude	3 Longitude	4 Date	5 Core type	6 Total TM	7 WAS TM	8 Radio chem.	9 Page/ Ref.
L-RERP 81-4	DW0.0			25 Aug 81	Shipek		X		F-2,F-3
L-RERP 81-4	DW1.3			25 Aug 81	Shipek		X		F-2,F-3
L-RERP 81-4	DW2.6			25 Aug 81	Shipek		X		F-2,F-3
L-RERP 81-4	DW3.9			26 Aug 81	Shipek		X		F-2,F-3
L-RERP 81-4	DW5.6			25 Aug 81	Shipek		X		F-2,F-3
L-RERP 81-4	DW7.7			25 Aug 81	Shipek		X		F-2,F-3
L-RERP 81-4	DW9.7			25 Aug 81	Shipek		X		F-2,F-3
L-RERP 81-4	DR12.2			25 Aug 81	Shipek		X		F-2,F-3
L-RERP 81-4	DR15.2			25 Aug 81	Shipek		X		F-2,F-3
L-RERP 81-4	DR18.0			25 Aug 81	Shipek		X		F-2,F-3
L-RERP 81-4	DR19.8			25 Aug 81	Shipek		X		F-2,F-3
L-RERP 81-4	DR21.0			25 Aug 81	Shipek		X		F-2,F-3
L-RERP 81-4	DR21.3			25 Aug 81	Shipek		X		F-2,F-3
L-RERP 81-4	EB4-1	47 36.5 N	122 21.6 W	25 Aug 81	Gravity	X			F-4
L-RERP 81-4	EB5	47 36.2 N	122 21.3 W	25 Aug 81	Gravity	X		X	F-5
L-RERP 81-4	EB8A	47 36.9 N	122 23.6 W	25 Aug 81	Gravity	X			F-4
L-RERP 81-4	EB11A-3	47 37.3 N	122 25.4 W	25 Aug 81	Gravity	X			F-4
L-RERP 81-4	CB1	47 16.4 N	122 26.2 W	27 Aug 81	Gravity	X		X	Ref. 1
L-RERP 81-4	CB2	47 16.7 N	122 27.5 W	27 Aug 81	Gravity	X		X	Ref. 1
L-RERP 81-4	CB3	47 17.7 N	122 27.5 w	27 Aug 81	Gravity	X		X	Ref. 1
L-RERP 81-4	CB4	47 17.6 N	122 25.5 W	27 Aug 81	Gravity	X		X	Ref. 1
L-RERP 83-1	BPS-15	47 18.6 N	122 27.9 W	24 Aug 82	Kasten	X			Ref. 2
		47 18.7 N	122 27.7 W	24 Aug 82	Kasten			X	Ref. 3

See Table 9 for DR & DW station location.
References:
1) Crecelius et al. (1985).
2) Romberg et al. (1984)
3) Lavelle et al. (1985), Core-17.

3.2.2 Porewater Chemistry

The format of col 2, 6 to 21 of the tables listing porewater data is the same as the format of the water column tables. Column 4 of porewater tables lists the Eh measurements while col 5 lists the porosity data.

Sediments for porewater Fe, Mn and nutrient analyses were collected in the Duwamish Waterway during May 1980 (L-RERP 80), Aug. 1981 (L-RERP 81-4) and Feb. 1982 (L-RERP 82-1) (Table 17). Fe, Mn and nutrient analyses were performed on porewater extracted from Elliott Bay cores collected during Feb. 1980 (DEC II), May 1980 (L-RERP 80), Sept. 1980 (DEC III), Aug. 1981 (L-RERP 81-4) and Apr. 1985 (L-RERP 85-2) and from cores collected off Brown's Point during Aug. 1981 (PS3; L-RERP 81-4) and Mar. 82 (L-RERP 82-1). Porewater for analyses of other trace metals was collected from one Duwamish Waterway core (DW 3.9) and from two Elliott Bay cores (PSE4 & 6) during May 1980 (L-RERP 80) and one Elliott Bay core during Apr. 1985 (EB14; L-RERP 85-2).

Porewater results are reported in Appendix G. Porewater Mn data for the EB4 cores from DEC II and III were presented by Feely *et al.* (1983b). Porewater Cu and Pb concentrations for the EB14 box core (L-RERP 85-2) were reported by Paulson *et al.* (1988a) and cited by Paulson *et al.* (1988b; 1988c; 1989b; 1989a).

Tabel 17. Sediment Collection Data for Porewater Analyses

0 Cruise Name	1 Sta. Name	2 Latitude	3 Longitude	4 Date	5 Core type	6 PW Nut.	7 PW Fe&Mn	8 Other PW TM	9 Page
DECII	EB4	47 36.38 N	122 21.62 W	19 Feb 80	Gravity	X	X		G-2
L-RERP 80	DW3.9			21 May 80	Gravity	X	X	X	G-3
L-RERP 80	PSE4	47 36.5 N	122 21.5 W	22 May 80	Gravity	X		X	G-4
L-RERP 80	PSE6	47 35.5 N	122 38.0 W	22 May 80	Gravity	X	X	X	G-5
L-RERP 80	PSE11	47 36.9 N	122 24.0 W	22 May 80	Gravity	X	X	X	G-6
DECIII	EB4	47 36.28 N	122 21.62 W	12 Sep 80	Gravity	X	X		G-7
L-RERP 81-4	DW3.9			26 Aug 81	Gravity	X	X		G-9
L-RERP 81-4	DW9.7			26 Aug 81	Gravity	X	X		G-10
L-RERP 81-4	EB4-4	47 36.5 N	122 21.6 W	25 Aug 81	Gravity	X	X		G-11
L-RERP 81-4	EB4-5	47 36.6 N	122 21.5 W	26 Aug 81	Box	X	X		G-12
L-RERP 81-4	EB11A-4	47 37.3 N	122 25.4 W	25 Aug 81	Box	X	X		G-13
L-RERP 81-4	PS3	47 19.8 N	122 26.5 W	28 Aug 81	Box	X	X		G-14
L-RERP 81-5	EB4	47 36.45 N	122 21.55 W	4 Nov 81	Gravity		X		G-15
L-RERP 82-1	DW3.9			1 Mar 82	Gravity	X	X		G-16
L-RERP 82-1	DW7.7			1 Mar 82	Gravity	X	X		G-17
L-RERP 82-1	DW9.7			1 Mar 82	Gravity	X	X		G-18
L-RERP 82-1	BX1	47 18.85 N	122 28.8 W	2 Mar 82	Box	X	X		G-19
L-RERP 85-2	EB14	47 38.2 N	122 24.9 W	8 Apr 85	Box		X	X	G-21

See Table 9 for DR & DW station locations.
See Sec. 2.2.11 and Table 8 for QA/QC data.

3.3 Settling Particulates

Settling particulate material was collected by sediment traps in Elliott Bay during Apr. 1985 and in Commencement Bay during 1981 and Apr. 1985 (Table 18). The accumulation rates for 1981 Commencement Bay moorings are given in Table 19.

The results of the sediment trap analyses are presented in Table 20. Feely *et al.* (1988) and Paulson *et al.* (1989c) presented data from the near-surface sediment trap deployed in Elliott Bay and estimated the vertical flux of particulate trace metals settling from the very thin fresh water surface plume that was evident in Elliott Bay during Apr. 1985.

TABLE 18. Location of moored equipment.

Mooring	Location	Depth	Duration
CB-3	47°16′24″N 122°27′12″W	25	3/25/81–5/4/81
CB-4	47°17′37″N 122°26′48″W	123 123	3/25/81–5/4/81
CB-5B	47°19′48″M 122°26′48″W	73	3/25/81–5/4/81
PS85-01	47°37′02″N 122°22′42″W	6 50	3/29/85–4/6/85 3/29/85–4/6/85
PS85-02	47°37′06″N 122°22′42″W	95 98 101	3/29/85–4/6/85 3/27/85–7/9/85 3/22/85–7/9/85
PS85-04	47°17′44″N 122°27′31″W	6	3/26/85–4/15/85 4/1/85–4/2/85
PS85-05	47°17′39″N 122°27′15″W	150	3/26/85–4/15/85 4/1/85–4/12/85

TABLE 19. 1981 Commencement Bay accumulation rates (gram/m^2/day).

Cyl./ Mooring	CB-3 25 m Trap 11	CB-4 23 m Trap 8	CB-4 123 m Trap 7	CB-5B 73 m Trap 9	CB-5B 123 m Trap 10	CB-5B 168 m Trap 13
1	7.73	10.51	64.12	1.99	5.51	21.48
2	6.38	11.04	66.69	4.44	6.32	26.95
3	7.14	13.19	108.10	1.37	6.21	27.52
4	2.81	13.54	109.43	5.18	7.38	30.03
5	0.58	5.31	87.70	1.21	5.93	18.68
6	0.35	0.89	98.52	0.20	3.82	13.08
7	0.02	0.54	72.18	0.19	4.22	15.14
8	1.11	1.39	66.90	0.35	4.08	14.94
9	24.06	0.48	58.64	0.35	4.36	16.92
10	0.48	2.16	86.98	0.20	2.87	37.13

TABLE 20. Trace metals in sediment trap samples (in units of wt./wt. sample).

Mooring	Bay	Depth ppm	Vertical mass flux (g/m^{-2}day^{-1})	Cu ppm	Mn ppm	Cd ppm	Pb ppm	Fe wt%	Zn ppm	As	Cr
CB-4	Commencement	23	5.91	102	610		55	3.99	435	35	67
		123	81.93	73	910		39	4.14	115	24	67
85-1	Elliott	6	0.09 (0.16±0.07)	52	553	*	100	4.25	480†		
		52	0.11 (0.16±0.05)	76	1113	3.60	229	4.64	287†		
85-2	Elliott	95	7.3 (7.7±1.9)	61	1725	0.17	76	4.49	156		
85-4	Commencement	6	0.22 (0.22±0.07)	52	625	0.16	68	3.82	159		
85-5	Commencement	150	31.7 (29.3±8.7)	57	1436	0.21	48	4.59	123		

* Below detection limit
† Contamination from mooring 85-1 suspected

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