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WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Marine Water Column Ambient Monitoring Plan

Final Report

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Marine Water Column Ambient Monitoring Plan

Final Report

by
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Washington State Department of Ecology
Environmental Investigations and Laboratory Services Program
Ambient Monitoring Section
Olympia, Washington 98504-7710

April 1992

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ABSTRACT

The Washington State Department of Ecology (Ecology) conducts several statewide monitoring programs including marine water, marine sediment, and freshwater monitoring. The marine water program, which encompasses Puget Sound and two coastal estuaries, was initiated in 1967. Since then, long-term monthly water quality data have been collected at over 55 stations. Recent development of a comprehensive environmental protection program for the Puget Sound Region has directed Ecology to conduct additional monitoring tasks, seasonal and solstice monitoring. The design of the additional monitoring components is intended to improve the understanding of water quality conditions in areas where water quality problems are episodic in nature, and to help define nutrient and phytoplankton dynamics throughout Puget Sound. The Ambient Marine Water Column Monitoring Plan details Ecology's marine water monitoring program, and includes a full description of the program's goals and objectives, monitoring strategies, field and laboratory procedures, data management, quality assurance and quality control, and safety guidelines.

ACKNOWLEDGEMENTS

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INTRODUCTION

The Washington State Department of Ecology (Ecology) initiated its statewide Marine Ambient Monitoring Program in 1967. The purpose of the program was to examine marine water quality on a regular basis with the objectives of determining existing conditions, and identifying spatial and temporal trends. Many of the sampling sites were located near municipal and industrial discharges in order to measure effectiveness of agency regulatory programs.

During the program's twenty year history, minor changes were made that modified the original monitoring program to meet growing information needs. For example, due to agency regulatory action, municipal and industrial discharges of oxygen-consuming wastes have markedly declined. Thus, Ecology has shifted its emphasis to non-point source pollution. This shift in agency focus motivated a change in monitoring strategy, resulting in the relocation of many monitoring stations.

Recently, State and Federal agencies have embarked on a comprehensive Puget Sound environmental protection campaign, the Puget Sound Water Quality Management Plan (Puget Sound Water Quality Authority, 1988). As a result of this plan, a monitoring program was established to expand existing Puget Sound monitoring efforts, and to coordinate the collection of information on parts of the Sound ecosystem that might be affected by pollution. In 1987-88, the Puget Sound Ambient Monitoring Program (PSAMP) was developed by a regional group of professional environmental scientists from the Pacific Northwest, known as the Monitoring Management Committee (MMC). A plan was designed to guide comprehensive long-term monitoring in Puget Sound (MMC, 1988a), and to measure ambient (background) conditions in Puget Sound, as well as to measure the cumulative effects of contamination and habitat degradation from human activities. To encourage cooperation with existing programs, the MMC recommended that monitoring tasks be assigned to appropriate state agencies. Ecology's Ambient Monitoring Section (AMS) was assigned the marine water column monitoring task of PSAMP, as well as the marine sediment and freshwater monitoring tasks.

The Ambient Marine Water Column Monitoring Plan that follows describes a program designed to accomplish a set of defined goals for monitoring waters in Puget Sound and two coastal estuaries. It describes, in detail, how Ecology will carry out the marine water column task of PSAMP.

The plan contains a description of a sampling strategy that includes:

- long-term core (fixed) station monitoring;
- long-term rotating station monitoring;
- floating station monitoring;
- seasonal monitoring (intensive surveys); and
- solstice monitoring of biological parameters by citizen volunteer monitors (Puget Sound only).

Also included in the plan are descriptions of:

- field and laboratory procedures;
- data management;
- quality assurance/quality control (QA/QC); and
- safety.

Follow-up intensive surveys that may be recommended by findings in the Ambient Marine Water Column Monitoring Program are not discussed in this plan.

Current funding does not allow for full implementation of this plan. As funding becomes available, additional monitoring activities will be implemented. The portions of this plan that will be implemented each year with the existing funding level are outlined in Appendix A. Appendix A will be updated annually to reflect changing priorities and funding levels.

GOALS AND OBJECTIVES

Goals

The goals of the Puget Sound and coastal marine ambient monitoring programs are as follows:

1. Characterize spatial and temporal patterns of ambient water quality conditions in the marine waters of Puget Sound and the coastal estuaries of Washington.

2. Identify significant changes in key environmental indicators throughout the marine waters of Puget Sound and the Washington Coast.

3. Provide water quality information to support specific programs of Ecology, other agencies, and those programs identified in the Puget Sound Water Quality Management Plan.

4. Determine the effectiveness of regulatory agencies in improving marine water quality through regulatory activities.

5. Support environmental research activities through the availability of consistent, scientifically and statistically valid data.

6. Provide baseline water quality data to the public, managers, private institutions, and other data users.

Objectives

The specific objectives required to meet the listed goals are as follows:

1. Document long-term spatial and temporal conditions and trends occurring in open basins, embayments and waterways statewide. These conditions may be affected by natural and anthropogenic factors (e.g., sluggish circulation and development, respectively).

2. Provide data to:

   - help interpret conditions and trends in other monitoring tasks (sediment, shellfish, and fish tasks of PSAMP);
   - support needs of water quality protection programs and research (Urban Bay Action Programs, Watershed Action Programs, Puget Sound Estuary Program, Environment 2010); and
   - assist in public education and involvement.

3. Identify water quality sensitive areas and possible emerging problems in bays. This will help regulatory agencies monitor pollution and set water quality priorities (e.g., permitting), and will trigger intensive studies to identify cause and effect relationships in order to recommend corrective action.

4. Identify areas where point and non-point source pollution may be affecting water quality (e.g., unpermitted discharges, septic systems, and recreational boating areas).

5. Provide data to help assess compliance with State and Federal water quality regulations such as Clean Water Act requirements (accomplished during 305(b) reporting efforts).

6. Provide information needed to understand functional processes and pathways for transport of contaminants (dilution modeling). This information will be used to assist management in setting discharge standards, and supply baseline information from the state's marine waters.

7. Document water quality changes in areas where water quality regulatory actions have been implemented to assess effectiveness of such actions (e.g., best management practices).

8. Provide water quality information to the public by responding to data requests and preparing annual reports.

PUGET SOUND AMBIENT MONITORING

Study Area

The study area covered by the Puget Sound portion of the Ambient Marine Water Column Monitoring Program extends from Semiahmoo Bay and the Straits of Georgia in northern Puget Sound, to Port Angeles in the Strait of Juan de Fuca, through Hood Canal, the main basin, and South Puget Sound.

General Design

To meet the marine water column monitoring program goals and objectives, the monitoring strategy is three faceted. The first facet consists of long-term, monthly monitoring at a fixed set of stations. The second entails more frequent monitoring of areas where water quality conditions may be episodic, and thus are not adequately characterized with monthly sampling efforts. The third is a proposed citizen monitoring effort that entails semi-annual sampling of biological parameters conducted only during the solstice periods (June 21 and December 21).

The parameter and information list for this program are designed to measure:

- factors that endanger human health (fecal coliform bacteria);
- biological communities (chlorophyll and phytoplankton);
- factors affecting general water quality and biological populations (nutrients, salinity, temperature, dissolved oxygen, pH, and water clarity); and
- factors that affect aesthetic conditions (floating debris, odors).

Much of the analyses will be completed in the field, but some samples are collected for laboratory analysis. A conductivity-temperature with depth profiler (CTD) with three additional sensors, measures six of the ten parameters throughout the water column at each station (temperature, conductivity, salinity, pH, dissolved oxygen, and light transmissivity). Secchi disk depth measurements for water clarity are taken at each station as well. The remaining tests are conducted on water samples, collected with a Niskin™ sampling bottle, and analyzed at the Ecology/EPA shared laboratory in Manchester, Washington, or the Environmental Investigations laboratory in Olympia.

Long-term Monitoring

During preparation of this plan, questions related to long-term sampling frequency and number of stations necessary to conduct a statistically valid long-term monitoring component have been brought up at PSAMP Steering Committee meetings. One suggestion was made that would result in a sweeping change to Ecology's existing program. The suggestion also deviates significantly from the guidance given in the PSAMP Plan. Stations would be reduced by 30 percent, and the sampling frequency tripled. There are no clear references in the existing

literature that suggest this change would result in a significant statistical improvement to the existing program, except with respect to biological parameters such as phytoplankton.

To address the biological sampling issue, two additional monitoring components described in this plan and in the PSAMP Plan were developed, and are designed to improve biological monitoring by increasing sampling frequency and increasing spatial coverage in given study areas. To solve the questions surrounding the validity of sampling monthly for physical and chemical parameters in the water column, a statistical analysis of Ecology's existing database will be conducted. During this analysis, a comparison between monthly and weekly data statistics will be done using Ecology's historical and current monthly database, as well as the Seahurst Baseline Study (Stober and Chew, 1984) weekly and daily database. Each parameter will be analyzed and compared statistically between monthly and weekly data sets, and any recommendations to improve the existing program will be made based on technical findings following the analysis.

Once the determination of the best statistical approach for long-term monitoring in Puget Sound is established, the section of this plan describing long-term monitoring will be revised if necessary. Until then, the plan as stated below will be followed, as directed by the PSAMP Plan. Appendix A contains the current implementation status of the entire monitoring program, including long-term monitoring station numbers and locations.

Strategy

Ideally, long-term trends should be assessed for each body of water. This is requested by the federal government as part of a nationwide monitoring program and by the Clean Water Act. To locate a station in each waterbody, however, would result in an exhaustive and expensive station network. In order to accomplish long-term monitoring efficiently and effectively, three sampling approaches are employed:

1. core station monitoring;
2. rotating station monitoring; and
3. floating station monitoring.

Core Station Monitoring -- Core station monitoring is intended to provide a base of continuous, widespread, long-term water quality data at selected points throughout the Puget Sound system. Measurements provide a basis for determining the following:

- temporal changes and spatial differences in water quality between waterbodies in the deep open basins and in select embayments;
- annual variability of marine water quality;
- changing water quality conditions and emerging problems; and
- relationships with spatial patterns and temporal trends in other monitoring components.

Stations are located in each deep basin as well as in major urban areas and some rural embayments.

Rotating Station Monitoring -- The rotating station component of the water column sampling program is intended to augment the data collected during the core station monitoring. The additional stations allow both a more extensive look at specific regions, and a general increase in the geographic coverage of the station network. These stations, generally located offshore but focused more in semi-enclosed embayments, have an interrupted data record, being sampled for twelve months every third year.

Floating Station Monitoring -- Floating stations are specially focused stations and are established to meet short-term and very limited objectives. These stations are usually operated for twelve months at a time. They might not be visited on a set schedule, like the rotating stations, and individual stations may never be reactivated after initial sampling. These stations may be located offshore and nearshore, depending on the data needs.

Station Location

Station locations were determined by incorporating the existing station network used by Ecology (Appendix B), the rationale, and criteria set forth by the MMC in their final report (MMC, 1988a), and from recommendations by the program's clients. Where possible, station locations from the historical station list were incorporated to facilitate determining long-term trends.

Tables 1 and 2 list the core and rotating stations for the Puget Sound portion of this program. Figures 1 and 2 show respectively these proposed stations. Floating stations will be selected on an annual basis, thus are not shown in these figures.

Core Stations -- Core stations are located in the center of deep basins and in urban/industrialized as well as rural embayments. These stations will provide a long-term record of offshore ambient water column conditions. Currently, Ecology has active and inactive stations at 173 locations (Appendix B). Sixteen stations are designated for core monitoring in Puget Sound.

Rotating Stations -- Rotating stations in Puget Sound are located in distinct hydrographic regions, separated mainly by major sills, and will correspond, when possible, to other PSAMP task sampling rotating stations. This will ensure a cooperative sampling effort amongst PSAMP tasks. Three sets of ten rotating stations will be visited on a three-year rotation cycle in Puget Sound.

Floating Stations -- Floating stations will be selected annually based on recommendations and data needs, and may be moved to fill or improve data records for other sections of the monitoring program. Final stations will be selected by Ecology Ambient Monitoring staff. These locations may be visited for one sampling period or may be revisited when necessary. The number of floating stations monitored each year may vary, depending on the need and the resources available. At least two to three floating stations will be available each year for monitoring.

Table 1. Long-term PSAMP and Ecology core monitoring stations for Puget Sound.

STATION	LOCATION	BASIN
PSAMP Stations		
GRG002	Georgia Strait	San Juan Island/Georgia St.
ADM001	Admiralty Inlet	Admiralty Inlet
ADM002	Outer Admiralty Inlet	Strait of Juan de Fuca
SAR003	Saratoga Passage	Whidbey Basin
PSB003	West Pt.- Main Basin	PS Main Basin
DNA001	Dana Passage	Southern Basin
HCB006	North Hood Canal	Hood Canal Basin
Ecology Stations		
BLL009	Bellingham Bay	San Juan Island/Georgia St.
PTH005	Port Townsend	Admiralty Inlet
PSS019	Outer Possession Sound	Whidbey Basin
ELB015	Elliot Bay	PS Main Basin
SIN001	Sinclair Inlet	PS Main Basin
CMB003	Commencement Bay	PS Main Basin
BUD005	Budd Inlet	Southern Basin
OAK004	Oakland Bay	Southern Basin
HCB004	South Hood Canal	Hood Canal Basin

Table 2. Long-term rotating monitoring stations in Puget Sound.

STATION	LOCATION	BASIN
GRG003	Whitehorn	San Juan Is./Georgia St.
EAS001	East Sound	San Juan Is./Georgia St.
LOP001	Lopez Sound	San Juan Is./Georgia St.
FID001	Fidalgo Bay	San Juan Island Basin
PAH008	Outer Port Angeles	Strait of Juan de Fuca
JDF005	Sequim Bay	Strait of Juan de Fuca
DIS001	Inner Discovery Bay	Strait of Juan de Fuca
SKG001	Deception Pass	Whidbey Basin
SKG003	Skagit Bay	Whidbey Basin
PNN001	Penn Cove	Whidbey Basin
HLM001	Holmes Harbor	Whidbey Basin
SUZ001	Port Susan	Whidbey Basin
PSS008	Mukilteo	Whidbey Basin
PMA001	Port Madison	PS Main Basin
POD006	Liberty Bay	PS Main Basin
DYE004	Dyes Inlet	PS Main Basin
EAP001	East Passage	PS Main Basin
QMH001	Quartermaster H.	PS Main Basin
CMB006	Inner Comm. Bay	PS Main Basin
BML001	Burley-Mintor Lag.	Southern Basin
CRR001	Carr Inlet	Southern Basin
CSE001	Case Inlet	Southern Basin
BUD002	Inner Budd Inlet	Southern Basin
ELD001	Eld Inlet	Southern Basin
TOT001	Totten Inlet	Southern Basin
HND001	Henderson Inlet	Southern Basin
PGA001	Port Gamble	Hood Canal Basin
HCB007	Lynch Cove	Hood Canal Basin
HCB002	Dabob Bay	Hood Canal Basin
HCB003	Central Hood Canal	Hood Canal Basin

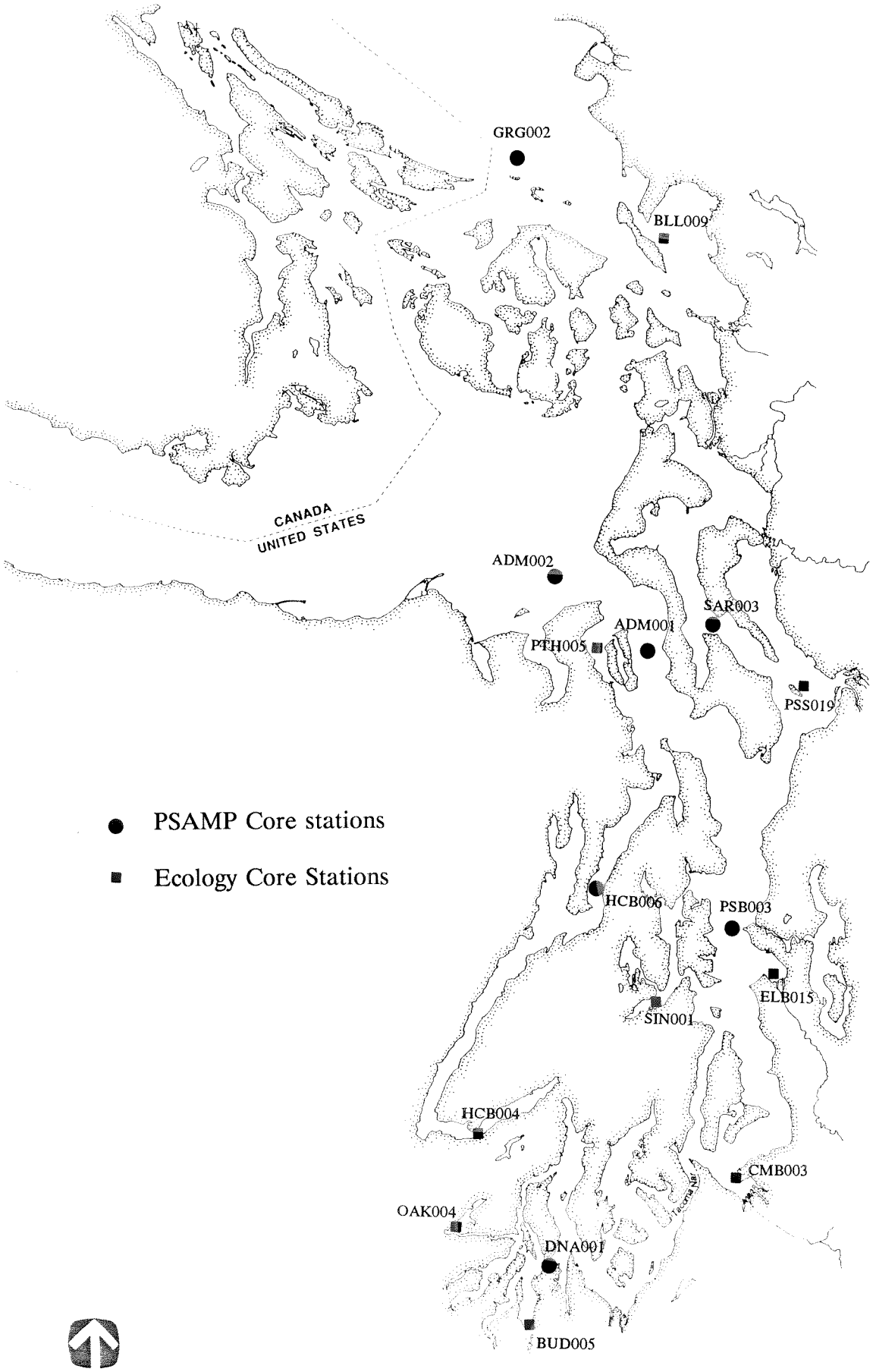

Figure 1. Long-term core monitoring stations -- Puget Sound.

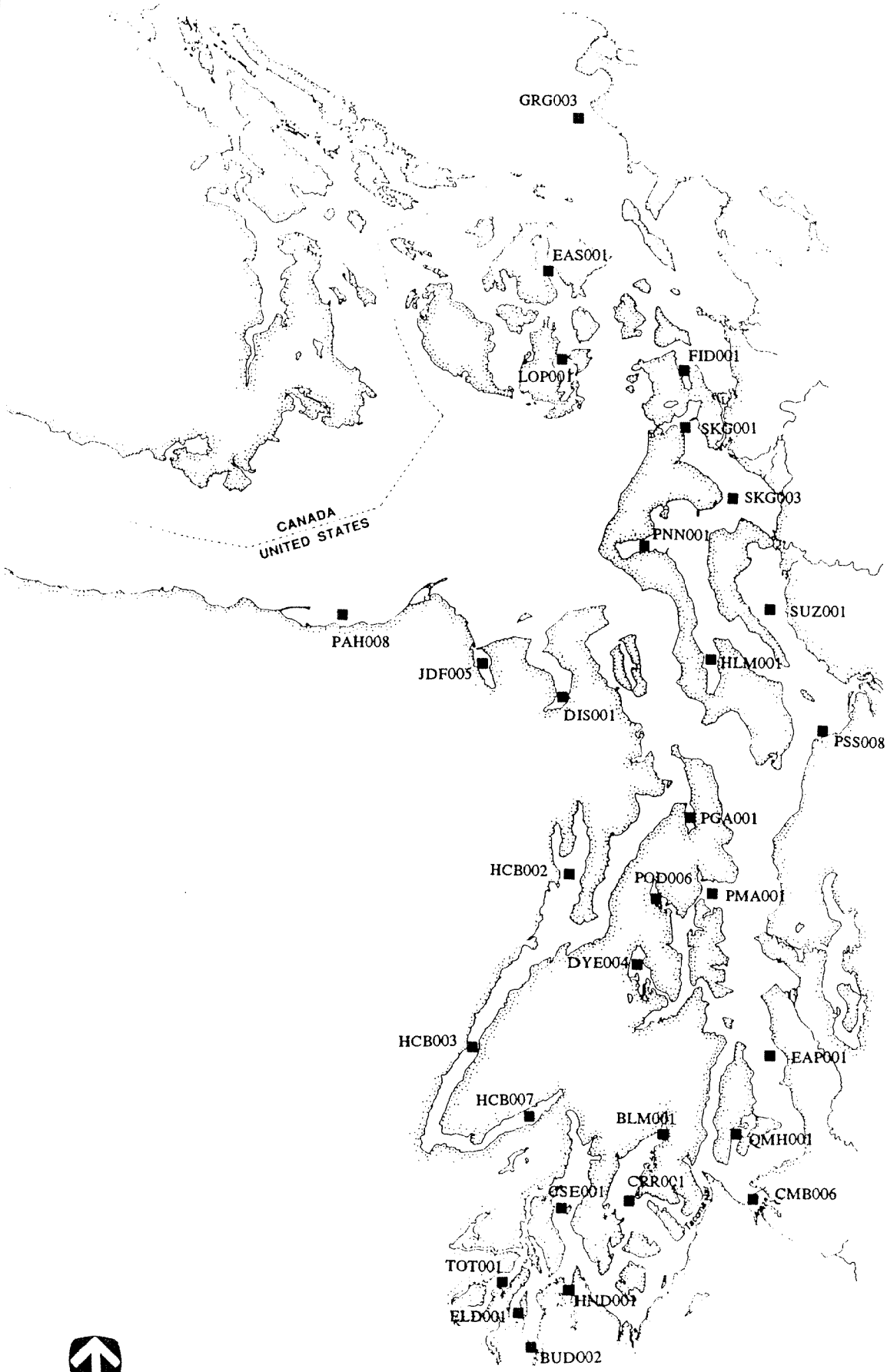

Figure 2. Long-term rotating monitoring stations -- Puget Sound.

Sampling Schedule

All long-term monitoring stations are visited once a month, year-round, to ensure that all major seasonal hydrographic conditions are observed.

Sample Types and Depths

Parameters measured at core and rotating stations, and the depths measured are listed in Table 3. At six of the core stations located in the major Puget Sound basins, nutrients will be sampled near the bottom, in addition to the three upper 30-meter depths. Fecal coliform bacteria will be collected at all core stations and at the rotating and floating stations closer to shore where bacteria densities are expected to be higher.

Floating station parameters will be tailored to the specific station objectives. Parameters will likely be those listed in Table 3, and may include other parameters that are normally associated with intensive monitoring (e.g., phytoplankton).

Justification for use of the listed parameters is briefly described in Appendix C and in the PSAMP Plan (MMC, 1988a).

Replicate Samples

Replicate samples will be collected during each long-term monitoring survey to help determine field and sampling variability. One station will be selected for each survey in order to conduct a quantitative determination of homogeneity of conditions. Parameters to be replicated include nutrients and chlorophyll *a* (and phaeopigments). Three bottle casts will be required at each replicate site. Fecal coliform bacteria samples will be duplicated at these stations. Laboratory variability and replication are discussed under Laboratory Analytical Methods.

CTD Comparison Samples

A Sea-bird Electronics Seacat profiling CTD is used for measuring hydrographic conditions at each monitoring station (Figure 3). The base unit measures conductivity and temperature with depth. The CTD has also been interfaced with sensors that measure dissolved oxygen, pH, and light transmissivity.

Samples for conductivity and dissolved oxygen will be collected during each long-term monitoring survey to compare with sensor values and verify CTD sensor performance.

Dissolved oxygen samples will be collected at stations where there is little to no vessel drift due to the rapid changing nature of this parameter. Samples will be collected from the one, ten, and 30-meter depths. Conductivity samples will be collected at various locations throughout the day to cover the range of expected salinities.

Table 3. Sample types and depths for long-term monitoring.

Sample Type	Depth in Meters
Secchi Depth	*
CTD Parameter: +	
Temperature	0-Bottom
Conductivity (Salinity)	0-Bottom
pH	0-Bottom
Dissolved Oxygen	0-Bottom
Light Transmissivity	0-Bottom
Dissolved Nutrients	0, 10, 30, Near bottom‡
Total Nutrients (N and P)	0, 10, 30, Near bottom‡
Chlorophyll a and Phaeopigments	0, 10, 30
Fecal Coliform Bacteria	Surface only
Phytoplankton++	1

* Depth at which the Secchi Disk disappears.

\+ Only selected depths will be in the database. Entire CTD profile data will be available from AMS.

++ Phytoplankton may be collected at rotating or floating stations in some areas, depending on the objectives of the study. Select core stations will be sampled for phytoplankton should funding allow.

‡ Near bottom sampling of nutrients will occur at the six major basin stations.

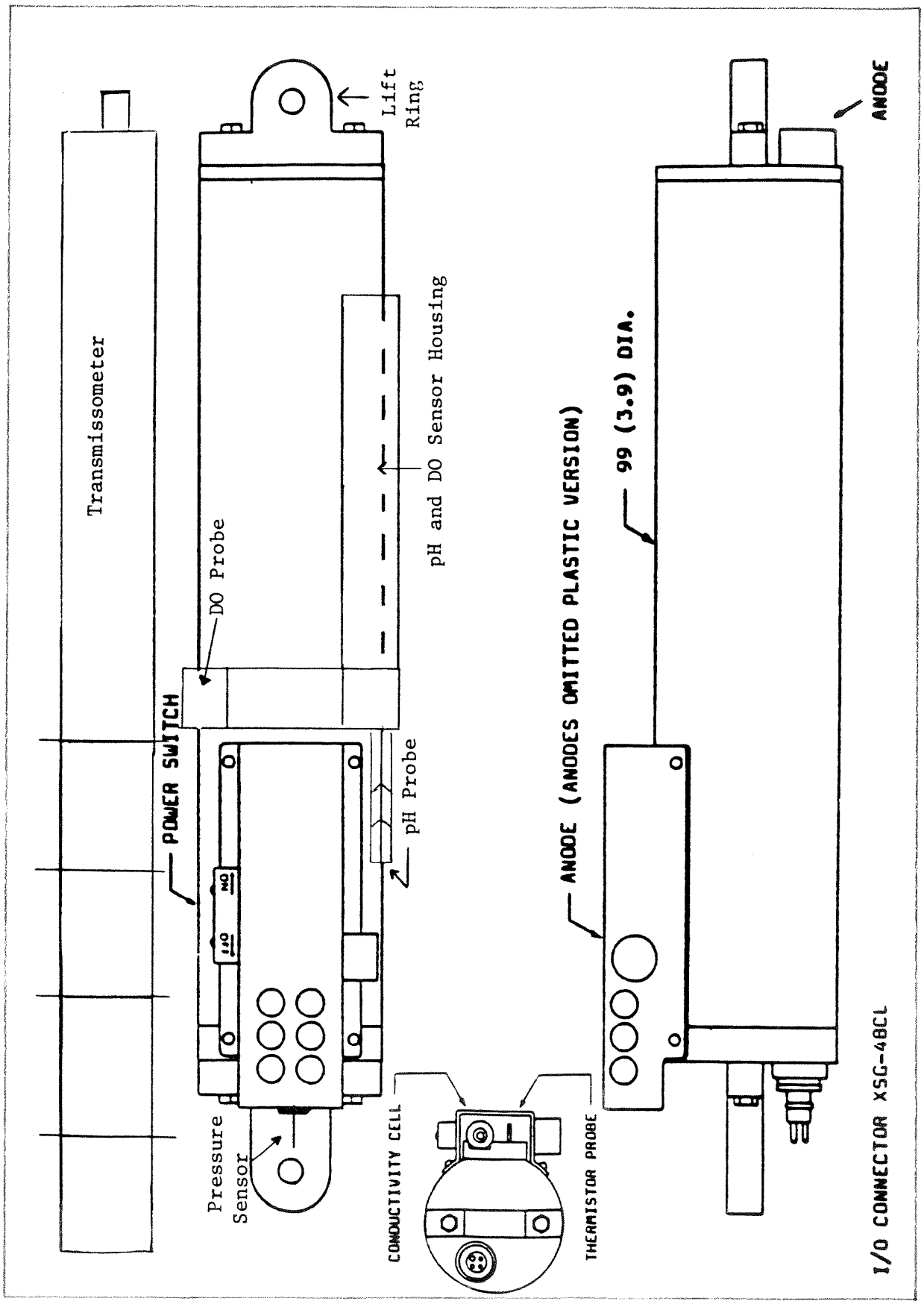

Figure 3. CTD Profiler used for marine water column monitoring.

Should the CTD values differ substantially from the analyzed water samples, CTD data will be "flagged" until the problem is resolved. Pressure sensor tests will be conducted at the beginning and end of each survey to determine the daily pressure offset. Pressure offsets are determined by recording pressure values before lowering the CTD into the water. The remaining sensors are checked against standard solutions during laboratory calibrations as recommended by the manufacturer. CTD duplicate casts that measure CTD field variability are discussed in the CTD Data Collection section.

Sampling Vessel

Long-term station monitoring will be conducted by floatplane. The floatplane allows sampling of a large geographic area in a short period of time. Surveys are conducted from a Dehaviland Beaver seaplane, which can accommodate the sampling gear, pilot, technician and a helper/observer. Samples are collected using a portable winch through a floor mounted observation hatch in the rear of the passenger compartment. These surveys are referred to as marine flight surveys.

Scientific Party

A crew of two (the pilot and a principal investigator (PI)) are required to conduct a marine flight survey. The PI will be responsible for following pre- and post-survey procedures (Appendices D and E), processing CTD data, checking data, transferring field data to the AMS database, and complying with safety procedures.

Equipment and Supplies

The required field equipment for marine flight surveys is listed in Table 4. This list will serve as a checklist prior to the surveys.

Field Logs and Notebooks

Most of the parameters measured for the water column task are either recorded with the CTD, or are collected as water samples and analyzed at the laboratory. Secchi depth, time, weather conditions, tide stage, and CTD cast information are recorded on field logs (Figures 4 and 5). A copy of the Field Data Report Form (Figure 4) will be sent to the laboratory with the samples. CTD comparison sample information for the CTD will be noted on the CTD Field Log (Figure 5) along with needed CTD processing information such as start and stop times and station numbers. A field log book will be taken on each survey to record ancillary information such as launching locations, start and stop times for the survey, tidal activity, and other information not recorded on the field logs. Copies of the CTD field log book entries will be filed for future reference.

Table 4. List of required field equipment for long-term and seasonal monitoring.

SAMPLING GEAR	SPECIALIZED GEAR
Conductivity-temperature with depth profiler (CTD)	Tide Gauges
Line for CTD	Current Meters
Secchi disk	Loran C
Niskin water sampler with line and messenger	Radios
Winch	
Winch frame apparatus	
Charged gel-celled batteries	TRANSPORTATION+
Sample cooler	Boats
Equipment cooler	Gasoline
Tool kit	Batteries
Fecal coliform bottle holder	
Dissolved oxygen kit	
OTHER	**PERSONAL GEAR**
Water bottles and jars--(brown nutrient, brown chl. *a*, glass jars with 1% formalin).	Gloves
Ice	Camera
Sample labels	Lunch
Sample logs	Sunglasses
CTD field log notebook	Life Vests
Pencils	Boats
Maps	
Procedures Manual	
Deionized water	
Ear protection	
Carry cart	
Towels/rags	
Lap-top computer *	
Diskettes *	
CTD adapter cable *	

* Bring in field only if planning on downloading data from the CTD during the survey.
\+ Seasonal Monitoring only.

State of Washington
Department of Ecology

FIELD DATA REPORT FORM

SURVEY ..... SAMPLER ..... PAGE..... OF.....

Y M M D D

S C , 8
1 3 10 16

STATION NO.	TIME		DEPTH METERS DM	TEMP °C P10,	DO PPM ( ) M.R. ( ) P300,	DO #	DO % SATURATION P301,	pH P400,	COND. uMHOS/CM P95,	TRANSP. SECCHI M P78,	BAROMETRIC PRESSURE In. Hg P25,	BAROMETRIC PRESSURE mm Hg P25,		*	STAGE HEIGHT	CHK BAR OR WT LNGTH ADDITION	STATION NAME OR COMMENTS
4	17	21															
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WEATHER:
ADDITIONAL COMMENTS:

ECY 040-2-41
Rev. 4-84 834 3

* 1=WWG 2=STAFF 3=GH 4=TAPE DOWN 5=OTHER (SPECIFY ABOVE)

Figure 4. Field data report form.

Survey _____

Date _____

Station _____
Cast # _____
Turn on _____
Start Down _____
Turn Off _____
Observations _____

Station _____
Cast # _____
Turn on _____
Start Down _____
Turn Off _____
Observations _____

Station _____
Cast # _____
Turn on _____
Start Down _____
Turn Off _____
Observations _____

Calibration Cast

Station _____
Cast # _____
Turn on _____
Start Down _____
Turn Off _____

Operators _____
Program _____
Checked _____

Station _____
Cast # _____
Turn on _____
Start Down _____
Turn Off _____
Observations _____

Station _____
Cast # _____
Turn on _____
Start Down _____
Turn Off _____
Observations _____

Station _____
Cast # _____
Turn on _____
Start Down _____
Turn Off _____
Observations _____

	Sal	Temp	pH
Surface			
10 Meters			
30 Meters			
Bottle #s			

Figure 5. CTD field log.

Navigation

Positioning of the aircraft is accomplished by line of sight (triangulation) and use of permanent landmarks (buoys). This has historically enabled stations to be re-occupied to within approximately ± 20 meters. This will be the preferred method of navigation for the long-term monitoring component.

Field Sample Collection Methods

The Puget Sound Estuary Program (PSEP) recommends protocols for measuring conventional water column variables in Puget Sound (PSEP, 1990). These protocols will be followed during all Puget Sound water column sampling efforts. This will ensure consistency with other programs in Puget Sound. If deviations from the protocols occur, a brief explanation will be given in the annual plan (Appendix A). Field sample collection methods are outlined in Table 5.

Secchi Disk Depth Measurement - Secchi depth measurements will be conducted at each long-term monitoring station. The disk is lowered into the water to the depth at which it disappears. The disk is then raised until it can be seen again. This depth is recorded on the Field Data Report Form (Figure 4).

CTD Data Collection - A CTD cast is conducted at each monitoring station. Each time the CTD is turned on, data will be recorded internally at two scans per second and will be assigned a header (e.g., cast number, time). For each cast, the station number, cast number, turn-on time, start cast time, and the turn-off time will be recorded on the CTD Field Log Sheet (Figure 5). This information is needed for CTD data processing. Additional comments can be written on the log sheets to detail the purpose of the station or cast (e.g., duplicate cast) or to note any problems or peculiarities.

The sensors on the CTD will be equilibrated with the sample water. The CTD is turned on, lowered into the water until the entire unit is submerged, and held stationary for two minutes. A two minute equilibration is needed for the dissolved oxygen sensor to polarize. The CTD is then lowered to the bottom.

The CTD used during this program has a pump attached to give the conductivity and dissolved oxygen sensors a continuous flush of sample water. The lowering rate will be between 25 and 50 centimeters per second. The advantages to lowering the CTD at this rate rather than faster are:

- The dissolved oxygen sensor, with a relatively slow response time of four seconds, has time to respond to changes in the water column more accurately.

- The resultant water column hydrographic structure will have higher resolution, especially in the upper layers where steep gradients may exist.

Table 5. Field sample collection methods for ambient water column monitoring.

Sample Parameter	Collection Method	Sample Container	Preservation Method
Fecal Coliform Bacteria	Fecal bottle Sampler	250 mL sterile glass bottles with sterile caps	Store sample on ice for lab delivery. Analyzed within 24 hours.
Dissolved Nutrients	1.2 litre Niskin bottle cast	125 mL Brown Polyethylene bottles--pre-cleaned	Store on ice--filtered immediately upon arrival at lab (if within 24 hours) or filtered in the field--filtrate frozen
Total Nutrients	Niskin bottle cast	125 mL Brown Polyethylene bottles--pre-cleaned	Preservative added to bottle prior to survey--0.3mL H_2So_4. Stored on ice.
Chlorophyll a (Phaeophytin)	Niskin bottle cast	125 mL Brown Polyethylene bottles--pre-cleaned	Store on ice--filtered immediately upon arrival at lab (if within 24 hours) or filtered in field. Analyzed immediately; or desiccate and freeze.
Conductivity/Salinity	Niskin bottle cast	500 mL Clear Polyethylene bottles--pre-cleaned	Keep in a well sealed container.
Dissolved Oxygen (check samples)	Niskin bottle cast (1st sample drawn)	300 mL BOD glass stoppered bottles--pre-cleaned	Fix with manganous sulfate and alkaline azide. Stopper, shake, and cap. Store in dark. Upon arrival at lab, set with sulfuric acid--stopper and shake. (modified Winkler)
Secchi Disk Depth	Lower into water until disk disappears then bring up until it reappears--record reading	NA	NA
CTD Parameters:			
Conductivity	CTD--	Internally Recorded	At each station, the CTD must be allowed to equilibrate in the water for 2 minutes prior to conducting the cast.
Salinity	CTD--	Internally Recorded	
Temperature	CTD--	Internally Recorded	
pH	CTD--	Internally Recorded	
Dissolved Oxygen	CTD--	Internally Recorded	
Light Transmissivity	CTD--	Internally Recorded	
Pressure	CTD--	Internally Recorded	

- Measurement errors due to rapid sampling and steep parameter gradients will be reduced (e.g., rapid changes in temperature).

CTD duplicate casts are additional casts to measure CTD sensor variability in the field, and will be done at least once per survey. CTD duplicate casts will be conducted for every 12 stations. Water samples for analysis to compare with the CTD sensor values are collected at the duplicate station (dissolved oxygen). Samples will be collected at other stations for conductivity to represent the range of salinities sampled in a given survey.

CTD probe principles are described in the Seacat SBE 19 CTD Recorder Operating Manual (Sea-Bird Electronics, 1990). More details on optimum CTD data collection are outlined in this manual.

Water Sample Collection -- At each station, water samples will be collected for nutrients and chlorophyll *a*. Fecal coliform bacteria samples will be collected at all core and a select number of offshore and nearshore rotating and floating stations. At CTD duplicate stations, water samples will also be collected for dissolved oxygen analysis. Nutrient, chlorophyll *a*, conductivity (for salinity computations), and dissolved oxygen water samples will be collected using a 1.2 liter Niskin™ water bottle. Fecal coliform bacteria samples will be collected with a sampler that will allow the samples to be drawn without contamination. The samples will be labeled with station, depth, and sample identification numbers (Figure 6). The samples will be stored on ice for delivery to the laboratory. Sample collection methods are further outlined in Appendix F, and in the recommended PSEP protocols (PSEP, 1990).

Laboratory Analytical Methods

Fecal coliform bacteria, nutrient, chlorophyll *a*, and conductivity water samples are analyzed at Ecology's lab in Manchester, Washington, using the recommended PSEP protocols (PSEP, 1990). Phytoplankton samples will be analyzed by the University of Washington. Table 6 lists each parameter, the method used for analysis, and holding times for the samples. Analytical procedures including QA/QC are briefly described in Appendix G. More details on laboratory procedures are described in the Manchester Laboratory User's Manual (Ecology, 1986), the recommended PSEP protocols (PSEP, 1990), and the Quality Assurance Manual (Ecology, 1988b). Program QA/QC objectives and procedures are briefly described in the QA section of this report.

Seasonal Monitoring

Strategy

Water quality problems may occur in areas where wastewater discharges exist, or in bays where water circulation is limited. Some areas do not currently suffer from severe water quality problems, but may be showing signs of sensitivity such as increased algal blooms and consequential low dissolved oxygen concentrations in the water column (Tetra Tech, 1988).

Surface Sample

ADM002 01 Marine 2

Date_____Collected by_____

[] F.C. [] GenChem
[] Nut(prev) [] Nut(unprev)
[] CHL.a

Marine 2 1988 __6263

10 Meter Sample

ADM002 10 Marine 2

Date_____Collected by_____

[] GenChem
[] Nut(prev) [] Nut(unprev)

Marine 2 1988 __6264

30 Meter Sample

ADM002 30 Marine 2

Date_____Collected by_____

[] GenChem
[] Nut(prev) [] Nut(unprev)
[] CHL.a

Marine 2 1988 __6265

Figure 6. Example of labels used on marine water column samples.

Table 6. Laboratory analytical methods and holding times for the Marine Water Column Monitoring Program.

Parameter	Method	Holding Time
Fecal Coliform	MF; Standard Methods 17th Ed. No. 9222D (APHA *et al.*, 1989)	30 Hours
Dissolved Nutrients - Ammonia	Parson *et al.*, (1984) (see PSEP Protocols, U.S. EPA 1990*) Auto Analyzer	Immediately if not frozen. If frozen, 7 days (filter before freezing)
- Nitrate/Nitrite - Nitrate - Orthophosphorus		Immediately if not frozen If frozen, 28 days (filter before freezing)
Total Nutrients - Phosphorus	EPA Method 365.3 (Colorimetric, Automated, Ascorbic Acid)(U.S. EPA 1982)	28 Days
- Nitrogen (Total Persulfate)	D'elia, C.F. *et al.*, 1977 Smart, M.M. *et al.*, 1981	28 Days
Chlorophyll *a*	Parsons *et al.* (1984) (See PSEP Protocols, U.S. EPA 1990) Fluorometry	Filter immediately (within 24 hours) 28 days holding time for frozen filters
Phytoplankton	Sournia, A. 1978 (species level)	Fixated w/formaldehyde or lugols solution in special cases, stored in a cool, dark place for several years.

* Puget Sound Estuary Program (PSEP)

Water quality problems are often episodic and may occur over short periods of time, in which case monthly sampling may not adequately characterize the prevailing and changing water quality conditions. Seasonal monitoring, defined here as a higher resolution temporal sampling component, will be used to:

- more accurately identify water quality conditions and possible problems;
- help define the spatial extent and severity of the water quality conditions;
- help define the functional processes occurring in the study areas;
- observe improvements as a result of regulatory actions;
- identify areas where regulatory actions may be needed; and
- establish useful baseline data for discharge permitting activities and follow-up intensive surveys.

Seasonal monitoring surveys will be tailored to fit study area objectives. Specific monitoring plans will be incorporated and appended to the fiscal year plans in Appendix A as site studies are selected and monitoring efforts initiated[1].

Study and Station Locations

Monitoring study sites will consider:

- monitoring requests by program participants (e.g., PSAMP Steering Committee, Ecology regional offices);
- locations where source controls may be needed or have been implemented;
- areas where few data exist; and
- areas where monthly sampling is not yielding enough information on water quality conditions.

The number of stations per monitoring area will depend on the objectives of the monitoring survey. Specific monitoring plans will be written designating station locations. Ecology's regional offices and Water Quality Program, the PSAMP Steering Committee, and other data users will be consulted for input to the specific monitoring plans.

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[1]Ecology relies on other sections within their programs to conduct follow-up intensive surveys (Watershed Assessments; Toxics, Compliance, and Ground Water Investigations). These sections are responsible for conducting intensive, environmental studies to address cause and effect relationships in areas suffering from degradation. They focus on point and nonpoint sources of pollution, and serve as an inside consultant to Ecology staff who require technical assistance in support of their water pollution control activities. Follow-up studies based on recommendations from AMS findings will need to have an identified source of funds. Once funds are secured, the intensive survey task will be assigned to appropriate staff and the work scheduled.

Sampling Schedule

Sampling frequency may, as an example, be conducted on an hourly, daily, weekly, or bi-monthly schedule during various seasons (Table 7). To characterize the seasonal water quality conditions and their annual variations, monitoring may occur for more than one year.

Sample Types and Depths

Parameters and the depths measured will depend on the objectives of the individual monitoring efforts and are specific to the area being sampled, but may include some or all of the following:

- nutrients;
- fecal coliform bacteria/klebsiella;
- chlorophyll *a* and phaeopigments;
- hydrographic data collected with a profiling CTD meter;
- dissolved oxygen;
- pH;
- Secchi depth;
- phytoplankton;
- metals; and
- organics.

Monitoring efforts may also include continuous time series data collection (e.g., from current meters). Time series data of temperature, salinity, dissolved oxygen, tide height, and current speeds and directions yield useful information on water quality in relationship to tidal fluctuations, seasonal, as well as diurnal changes in indicator parameters, such as dissolved oxygen, circulation, and mixing regimes. Time series data can also be correlated to monthly sampling data by determining parameter value ranges and comparing them to see where in the range the monthly values lie. Time series data will be collected at varying depths, and will depend on the location of the station and data needs.

Replicate Samples

Replicate samples will be collected during seasonal monitoring efforts. The number of stations selected for replication will depend on the survey.

Sampling Vessels

Small boats, such as whalers, will be used to conduct most seasonal monitoring. A floatplane, described under the long-term monitoring section, may also be used (e.g., for bi-monthly sampling).

Table 7. Seasonal monitoring sampling scheme prototypes.

PROTOTYPE SAMPLING PLANS PER SURVEY

SCHEMES I and IV

3 stations sampled for	nutrients (4) chlorophyll *a* fecal coliform bacteria phytoplankton
12 CTD stations 1 replicate station 1 calibration station (salinity)	

SCHEMES II and III

1 station sampled for	nutrients (4) chlorophyll *a* fecal coliform phytoplankton
5 CTD stations 1 replicate station 1 calibration station	

SCHEME I

Weekly sampling for one month, four times a year, once per season (spring, summer, fall, and winter).
Total sampling days = 16 days

SCHEME II

Daily sampling for two weeks during distinct water quality periods. Assume critical periods encompassing two to three months.
Total sampling days = 49 days maximum

SCHEME III

Bi-monthly sampling during critical periods (i.e., May through October). Will be done in conjunction with long-term monitoring.
Total sampling days = 12 days (half of which will be done during long-term monitoring.

SCHEME IV

Continuous tidal cycle sampling (at least 50 hours, every four hours), during each season. Sampling should encompass both spring and neap tide events.
Total sampling days = 16 days maximum

Scientific Party

An Ecology certified boat operator and one to three crew members will conduct surveys. The boat operator must be trained in boat operation, maintenance, and safety procedures prior to conducting surveys. The crew members and principal investigators responsibilities are the same as listed in the long-term monitoring section of this document.

Equipment and Supplies

In most cases, equipment needs will be the same as those used in the long-term monitoring component (Table 2). Additional specialized equipment, such as tide gauges and current meters, may also be deployed during the seasonal monitoring surveys.

Field Logs and Notebooks

The field logs and notebooks used for seasonal monitoring surveys will be the same as for long-term monitoring. On occasion, new forms may be used to meet special survey and equipment needs. New logs will be included in the survey plans as they are written.

Navigation

A LORAN C will be used during seasonal monitoring. Landmarks will be noted when available. LORAN C repositioning is accurate within a circular diameter of approximately 20 meters (Striplin, 1988).

Field Sample Collection Methods

The field sample collection methods used during seasonal monitoring surveys are the same as those used for long-term monitoring. Phytoplankton samples and time series data from moored instruments may also be collected during seasonal monitoring. The field sampling procedure for phytoplankton is described in Appendix F. Moored instrumentation data collection methods will follow the manufacturer's operation manuals.

Laboratory Analytical Methods

The laboratory analytical methods used to analyze seasonal monitoring survey samples are the same as those used to analyze the long-term monitoring samples. The phytoplankton analysis method is described in Appendix G, and the UNESCO Technical Papers in Marine Science, Phytoplankton Manual (Sournia, A. (ed.), 1978).

Solstice Monitoring

Strategy

Concentrations of dissolved nutrients and phytoplankton (chlorophyll) in Puget Sound change cyclically throughout the year and have been related to the phytoplankton's reaction to the seasonal light cycle (Stober and Chew, 1984). In winter months, phytoplankton are growing at a slow rate, surface waters are well mixed, and light is limited. Growth is slow under these conditions, which results in high nutrient and low chlorophyll concentrations. During summer months, the upper water column is stratified in many areas and the daylight hours are longer, thus increased phytoplankton growth can occur, resulting in a depletion of nutrient concentrations and increased phytoplankton abundance. The summer phytoplankton maxima and nutrient minima, and the winter phytoplankton minima and nutrient maxima have been found to occur around the summer and winter solstices respectively, at least in the main basin of Puget Sound (South Whidbey Island to Seahurst; Stober and Chew, 1984). The concept behind solstice monitoring incorporates these findings into intensive biological sampling in other areas of Puget Sound.

Solstice monitoring entails intensive sampling for several years during the summer and winter solstices. PSAMP envisions utilizing citizen volunteers for solstice monitoring data collection. The results will be useful for characterizing nutrient/plankton patterns throughout Puget Sound. Also, the data will aid in interpreting impacts of nutrient inputs (e.g., food availability to higher trophic levels).

Sampling Site Locations

Solstice sampling will be conducted in embayments where circulation and flushing are limited, and are thus most sensitive to nutrient inputs. Under full funding and implementation, solstice sampling will occur at eight stations in two to three embayments in Puget Sound (Figure 7 - this figure shows all candidate sampling sites). Study sites will be selected annually, and the monitoring details will be described in the annual update plans (Appendix A). During the first year or two of this monitoring component, only one embayment will be monitored in order to see how the program is functioning using citizen volunteers.

Sampling Schedule

The sampling effort will entail sampling once a day during slack tide, preferably during consistent tidal conditions (Mean Low Water or Mean High Water) and during daylight hours. Sampling will occur for 28 days surrounding the summer and winter solstices (June 21 and December 21), for a total of 56 days per year.

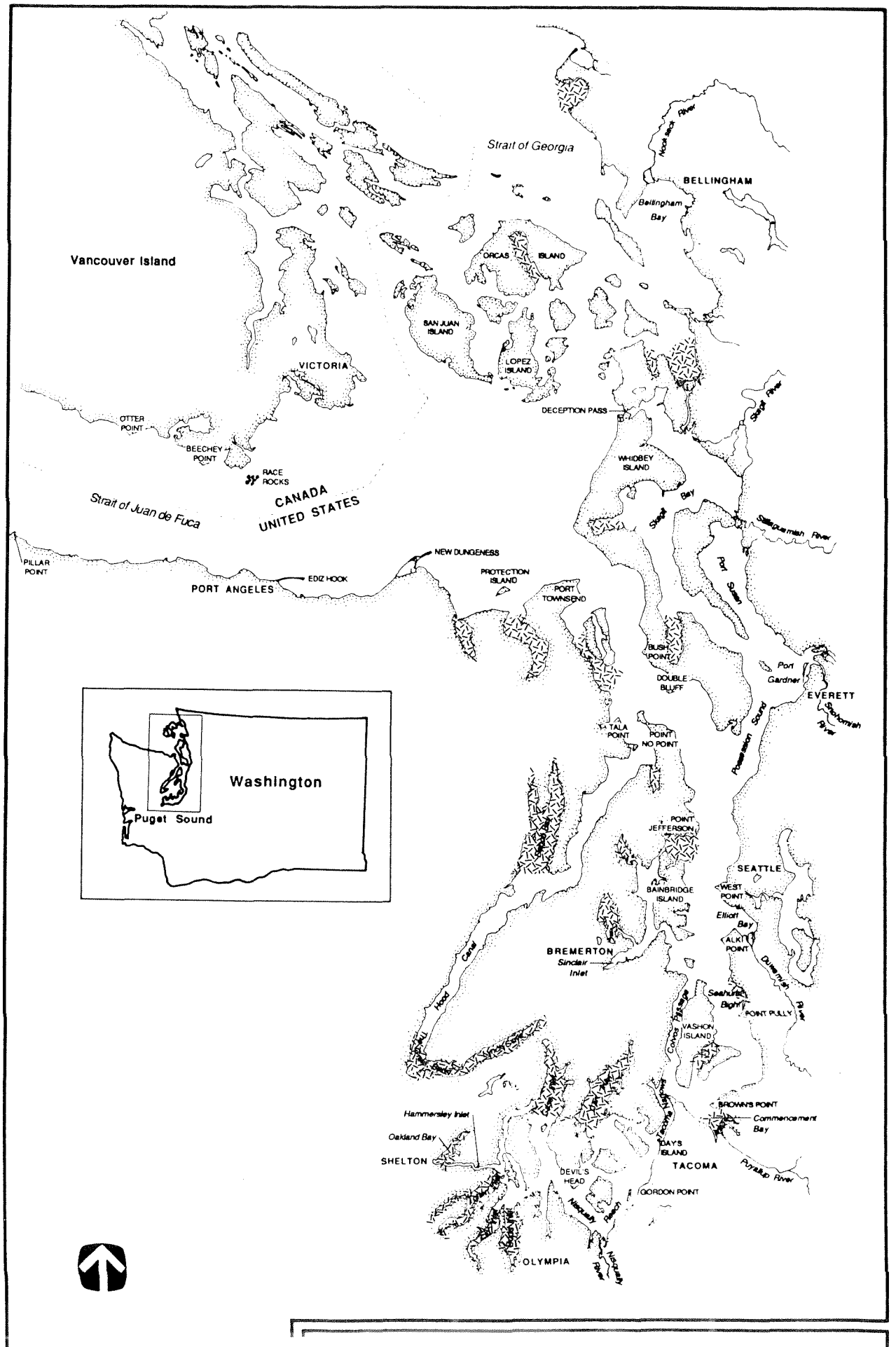

Figure 7. Candidate solstice sampling locations in Puget Sound.

Sample Types and Depths

Dissolved nutrients, chlorophyll *a* with phaeopigments, and phytoplankton specimen samples will be collected daily in the upper surface of the water column (one-half to one meter). Surface temperature, Secchi depth, and incident light measurements will also be conducted daily. Surface samples collected nearshore will not be much different than surface samples collected offshore. If samples are collected at depths greater than one meter, however, the species may differ (James Postel, personal communication, 1990).

Replicate Samples

Replicate samples (two additional samples at the routine station) will be collected four times during each solstice sampling effort (once per week). Parameters to be replicated include nutrients and chlorophyll *a* with phaeopigments. These samples will provide an estimate of overall precision of the sampling methods.

Sampling Vessel

Ideally, samples will be collected using a boat, or from a pier/dock that extends offshore (30 meters or more). If a boat is used, it should be anchored (in shallow waters) and the motor turned off prior to sampling.

If the volunteers do not have a boat or dock available to them, they will collect the samples by wading into the water. The sampler will go offshore until the water is approximately thigh deep. Once the water column has stabilized, the samples will be collected.

Scientific Party and Citizen Volunteers

The Solstice Program Coordinator (PI) will be responsible for coordinating the citizen volunteer monitoring efforts. Duties include training of the volunteers, distribution of sampling equipment, installment and maintenance of the moored light meters, laboratory coordination, quality assurance of the field activities and the data, and compilation of final results in a data report.

Citizen volunteers must be trained to collect the solstice monitoring samples. The volunteer groups must also be self-insured and willing to sample daily at specified times throughout the sampling periods. Group interviews and contract agreements will be drawn to ensure successful completion of the solstice projects.

Equipment and Supplies

Each citizen volunteer will be given sampling packages which include collection equipment, bottles, logs, and other necessary equipment (Table 8).

Table 8. List of field equipment for solstice sampling.

SAMPLING GEAR
Water Sampler
Incremented Line (10 meters)
Secchi Disk with Line
Thermometer
Small Cooler for Samples
Sample Logs
Pencils
Sampling Procedures Notebook

WATER BOTTLES*
(All bottles will be pre-labeled and cleaned)
Chlorophyll *a* - brown 125 mL
Nutrients - brown 125 mL
Phytoplankton - glass jar with 1% formalin
Wide Mouth Bottle (for temperature and salinity values)

PERSONAL GEAR
Life Preserver
Gloves
Boots
Jacket

* One of each bottle per day. On replication station days, will need three of each bottle type.

Field Logs and Notebooks

The citizen volunteers will be responsible for filling out the Solstice Sample Log (Figure 8), and preparing the samples for shipment to the laboratory. The logs will be completed daily, and a copy submitted to the lab with the samples (weekly). The originals will be sent to the AMS PI for checking and archival.

Navigation

The solstice stations should be easily revisited and the location known. If landmarks or features do not exist, a buoy or flag marker will be used to designate the sampling location.

Field Sample Collection Methods

The methods used for collecting the samples during the solstice monitoring are the same as those described in the long-term and seasonal monitoring sections. Water samples will be collected using a Niskin™ type water sampler, leased or purchased on the program. Temperature will be collected using a hand held thermometer. Secchi depth measurements will be collected using the method described in the long-term monitoring section. Incident light measurements will be collected using a moored light meter, such as a photometer, and measurements will be recorded on an internally recording data logger over averaged periods of time.

Laboratory Analytical Methods

The methods used for analyzing the samples collected during the solstice sampling are the same as those described under the long-term and seasonal monitoring sections.

If samples are to be held for any length of time prior to lab shipment, the volunteers will filter the samples using 0.45μm and 0.7 μm (chlorophyll *a*) filters and manual pump apparatus. Filtering will be conducted in dim light, especially if the pigment is in a solvent. The filtrate then should be frozen (standard freezer is adequate), and the chlorophyll filters sealed in an air-tight container and stored in the freezer. Samples should be analyzed immediately upon sample thawing, or within 28 days of collection if kept frozen. Phytoplankton samples need to be preserved with one-percent formaldehyde (or lugols) solution, and stored in a dark, cool place prior to lab shipment. Samples will be shipped to the laboratory in a cooler with ice.

Data Management

The AMS data management plan for marine water column sampling includes:

1. a document management system (filesystem);
2. a computerized database of monitoring data (AMS Database);
3. a procedure for data transfer to the Puget Sound Database; and
4. a data analysis and reporting procedure.

SOLSTICE SAMPLE LOG

NAME _____ LOCATION _____

DATE _____ BUOY (Y/N) _____

START TIME _____ END TIME _____

BOTTOM DEPTH _____

WATER SAMPLES:

	COMPLETED	BOTTLE NUMBER
NUTRIENT BOTTLE	_____	_____
CHLOROPHYLL BOTTLE	_____	_____
PHYTOPLANKTON BOTTLE	_____	_____

Surface Temperature: _____
(take 2 readings)

_____

Secchi Depth: _____
(take 2 readings)

_____

OBSERVATIONS:

Weather:

Water condition:

Other:

Checked By: _____
Date: _____

Figure 8. Solstice Sample Log.

The data management plan is intended to track and control data collection as well as data quality.

Document Management System

Field Data

The marine water column program collects observational data as well as water quality data. The observational data include:

- sampling party;
- date of survey;
- station name;
- location;
- sampling time;
- sampling depths; and
- water or weather conditions.

Additional observations may include:

- tidal activity;
- water color;
- odors;
- floatables;
- sightings of fronts; and
- recent past weather conditions.

Pertinent information are recorded on the Field Data Record Forms (Figure 4) and the CTD Field Log Sheets (Figure 5), both described in previous sections of this document. All logs and relative information are maintained in a filesystem designed for this program (Table 9). The filesystem will be updated annually and included in Appendix A. All forms will be checked for completeness by a staff person other than the sampler. Field data recorded on the field log sheets will be entered into the AMS database after being checked. Copies of these log sheets are then filed with the appropriate survey file.

CTD data are loaded onto a computer, processed with applied calibration coefficients, and printed. Hard copies of CTD calibration coefficients, CTD processing steps and data printouts are kept in the filesystem. Discrete CTD data values from 0, 10, 30-meters, and near the bottom are entered into the AMS database (described later). The CTD records are kept in individual survey files. CTD profile data are kept on two floppies; one floppy is kept in each survey file and the backup floppy is kept in a diskette archival notebook, which is kept off-site.

Table 9. Water column data management file system.

File numbering system: Ambient Monitoring Section (AMS)
YY = year file established
= file number
Format: AMS-YY-###

AMS-89-100	Marine Water Column Implementation Plan
-89-101	PSAMP Marine Sediment Implementation Plan
-90-102	Bi-State lower Columbia River Water Quality Program - 4-year Plan
-90-103	Navy Homeport Monitoring Plan - Everett
-90-104	EPA - Coastal Segmentation Program 1990 - *
-89-108	PSAMP Fish Monitoring Task Implementation Plan
-89-110	Seabird Electronics CTD Operator's Manual
-89-111	CTD Sensor Maintenance and Calibration Procedures
-89-112	CTD Acquisition Software Manual Vers. 3.3, April 1989
-89-113	Toshiba Lap-top Computer Manual
-89-114	Turner Fluorometer Model 112 - Operator's Manual
-90-115	Analytical Methods - Water Quality (i.e., phytoplankton)
-90-116	Data analysis Methodologies and Ideas
-90-117	Ambient Monitoring Recommendations
-90-118	Marine Water Column Monitoring History - Washington State
-90-119	Methods for tidal analysis (Software)
-89-120	Marine Monitoring Maps
-89-121	Historical Program Maps
-89-130	Puget Sound Marine Water Column Recommended Protocols
-89-140	PC STORET Parameter Codes
-89-150	Memos/Letters Dealing with the Marine Water Column Program
-89-151	Salinity/Conductivity Notes - EILS
-89-152	Manchester/AMS Nutrient Study
-91-153	1991 PSAMP Update
-89-160	Tide Tables for Washington State
AMS-89-200	Quality Assurance/Quality Control Files
-89-210	Marine Water Column QA/QC Objectives/Notes
-89-220	Training Record Forms - Water Column
-89-230	CTD Maintenance Log/Schedule
-89-231	CTD Calibration Logs
-89-231a	Temperature Sensor
-89-231b	Conductivity Sensor
-89-231c	Pressure Sensor
-89-231d	pH Sensor
-89-231e	Dissolved Oxygen Sensor
-89-231f	Light Transmissometer

Table 9. Continued.

-89-232	Seabird Electronics/Northwest Regional Calibration Center CTD Calibration Records
-89-233	Certified Thermometer Lab Test Certificate
AMS-89-300	Water Column Field Procedures
-89-310	Field Equipment Checklist
-92-330	Seasonal Sampling Proposals
-89-320	Bottle Needs for Marine Water Column Sampling
AMS-89-420	CTD Setup and Download Log
-89-440	Copies of Field Notes from the CTD Field Notebook
AMS-89-500	Individual Survey Files 1989: Survey date, Marine Flight Number (Field logsheets, CTD Calibration Coefficients, CTD Printouts, Processing Sheets) - Marine Flights - November-December 1989
AMS-90-Sed	CTD Data from the Sediment Survey -- March 1990
-90-500	Individual Survey Files 1990 - Marine Flights - January-December 1990
-90-501	CTD Data Diskette Notebooks (data starts November 1989 through present)
-91-500	Individual Survey Files 1991 - Marine Flights - January-December 1991
-92-500	Individual Survey Files 1992 - Marine Flights - January-December 1992
-91-600	Reports
-91-601	1991 Oceans '91 Conference
AMS-Other	
-90-Sed	CTD Data from Sediment Survey - March 1990
-90-CMB-Sed	CTD Data from 1990-92 Commencement Bay Sediment Trap Project (Dale Norton)

Laboratory Data

Laboratory results of marine water quality analysis are sent directly to the AMS database via modem. Hard copies of laboratory data are kept with copies of the Field Data Record Forms in notebooks containing data for individual water years (October through September). These records are maintained by the AMS at Ecology.

Databases

Hardware

CTD data processing and storage will take place on a Compaq™ 386-S Model 40 computer with a two megabyte (MB) RAM (Random Access Memory). There are two disk drives available for data accessing and downloading; a disk drive for 5-1/4 inch floppy disks, and a 3-1/2 inch micro-floppy drive. CTD data are downloaded in the field and laboratory using a Toshiba 1200 lap-top dual floppy computer. All data are downloaded on 3-1/2 inch floppies. These floppies are archived as backup copies, as described in the Document Management section above.

The AMS database is maintained on a Compaq 386-20. The AMS system is on a Local Area Network (LAN) which allows multiple users to access the data at any given time.

Software

CTD data are processed using modified Seasoft™ software, specifically designed for the Seacat profiling CTD. The CTD data acquisition information is outlined in CTD Data Acquisition Software, SEASOFT Version 3.3 (Sea-Bird Electronics, 1989).

Discrete water column data for all parameters will be stored and retrieved on the AMS database. The AMS database is written in DBASE IV™ and is capable of running quality control checks and performing basic statistical analysis.

Additional commercial software will be used for more extensive data analysis. The following is a list of the available software for marine water column data manipulation and analyses:

- WordPerfect 5.1™ -- word processing;
- Lotus 1-2-3™ -- spreadsheet presentations and data manipulations;
- Systat and Sygraph™ -- statistical analysis;
- Surfer and Freelance™ -- graphical presentation;
- PC Arcinfo™ -- geographical information system; and
- WQHydro -- trend analysis and statistics.

Description of Databases

Several databases exist for ambient data collected by Ecology. Data are routinely (monthly) entered into the AMS Database. The data are checked at this point. Data are transferred into EPA's national and regional databases quarterly, STORET and PCSTORET respectively. Other databases that receive ambient data include the Puget Sound Central Database (PSAMP database) and the Waterbody Tracking System (WBTS). These two systems are described in detail in the PSAMP Plan (MMC, 1988a) and the Water Body System Manual, respectively. General data flow is shown in Figure 9. Transfer of data to STORET and the PSAMP databases is briefly discussed later in this section.

AMS Database -- Ambient water column data (discrete values) are entered into the AMS database. Station data and discrete values of CTD data are entered into the system each month. These data include:

- date;
- station names;
- locations (fixed in the system for long-term monitoring);
- sampling times;
- sampling depths;
- Secchi depths;
- salinity;
- temperature;
- pH;
- dissolved oxygen;
- light transmissivity; and
- observational information that may be useful in data analysis.

Data are entered into the AMS database after preliminary QA/QC checks have been conducted. Software within the database will further flag anomalous values and suspect data after data entry. All data entered into the AMS database will be verified quarterly. One-hundred percent data checks, conducted by AMS staff, will be completed using printouts. Verification will include checking of codes and station identification information. Corrections are made to the AMS database and the database updated prior to data transfer to the STORET and PSAMP databases.

A hardcopy of the laboratory data is sent to the AMS office for data verification and checks. These data include:

- parameter method used;
- name of analyst who performed the analysis;
- date of sampling;
- date of analysis;
- station name and sample numbers;

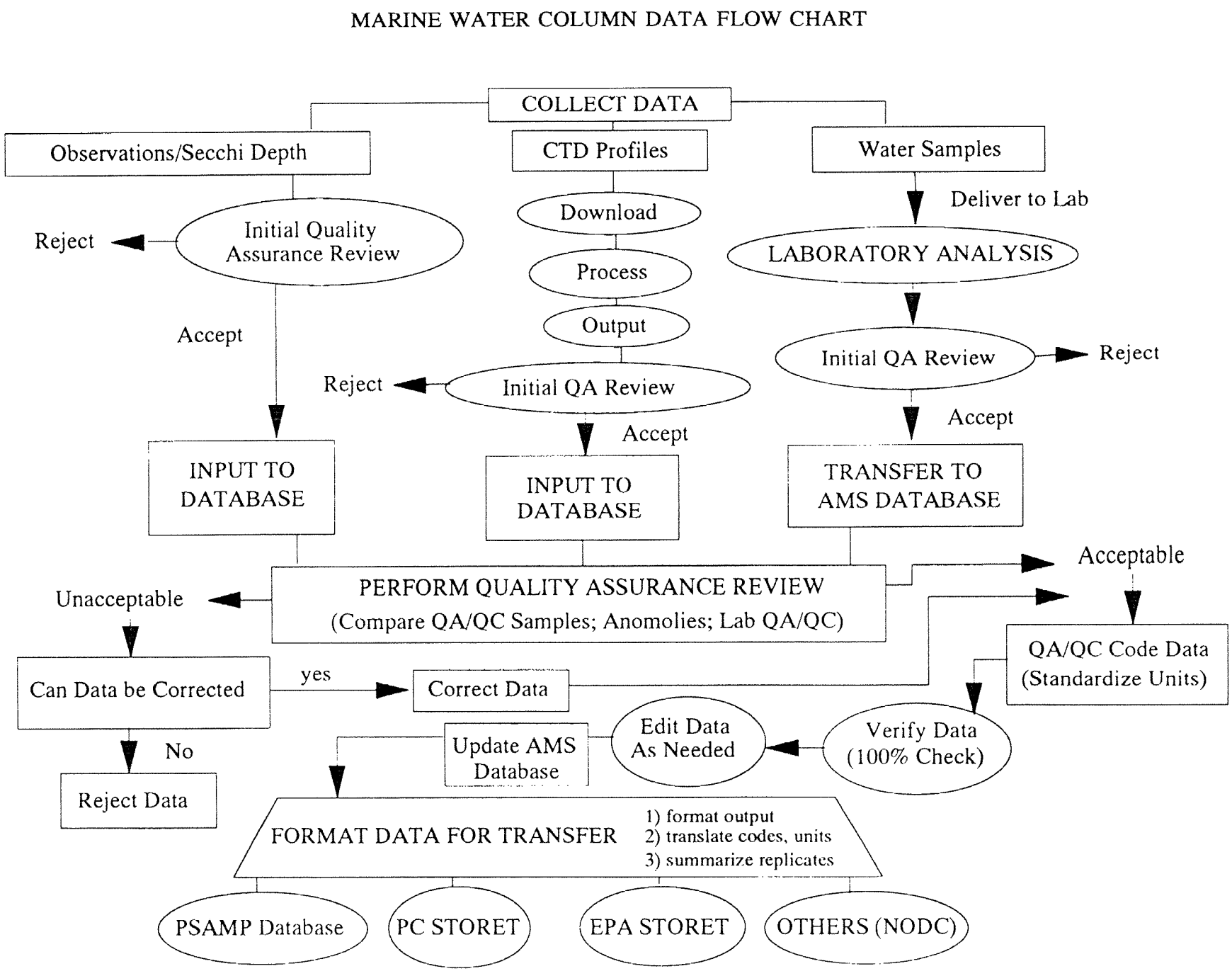

Figure 9. Data flow chart.

- nutrient concentrations;
- chlorophyll *a* and phaeopigment concentrations;
- fecal coliform bacteria counts;
- conductivity values from CTD comparison stations; and
- field duplicate/replicate data for nutrients, chlorophyll *a*, phaeopigments, and fecal coliform bacteria from QA stations.

The AMS database software allows the user to:

- conduct basic data manipulations;
- conduct internal data QA/QC checks;
- create pre-determined data reports that flag violations in water quality standards and other conditions;
- apply QC codes to the data; and
- create spreadsheets for use in other programs.

The QC codes are assigned to each result (Appendix H). Data formats and codes used in the AMS database are the same as those used in the EPA STORET database.

The internal QC checks include identification of:

- anomalous values (2.5 times the standard deviation of the means (of a three month period) for the particular station for the past six years);
- samples held over holding times;
- coefficients of variance between duplicate samples;
- mean coefficients of variance against all duplicates (batch checks); and
- summation of chemical fractions to check for incorrect values (e.g., total phosphorus values less than orthophosphorus values).

Statistical analyses can be conducted in the AMS database as well, such as seasonally normalized temporal data plots. Additional documentation for the AMS database, including data formats and codes, is available in the AMS Database Manual (in preparation).

EPA STORET -- Part of Ecologys' existing monitoring program is funded by EPA to meet Clean Water Act requirements. Ecology, therefore, submits all of its ambient data to EPA STORET, a nationally computerized information system residing on EPA's mainframe computer at Research Triangle Park, North Carolina. The STORET database contains several software modules allowing users to store and retrieve data, and has a package of analytical programs that can be used to access and analyze the data. The user can also pass data to user written software or to a statistical package. EPA STORET contains information for over 590,000 sampling sites throughout the United States with over 90 million parametric observations. Approximately 400 groups use EPA STORET, supplying information and retrieving information from the database. The data in EPA STORET is used to:

- detect changes in pollution levels nationwide;
- demonstrate effects of pollution abatement programs;

- meet reporting requirements;
- check water quality against established criteria; and
- conduct a variety of other environmental management processes.

Since the AMS database format is the same as that used in EPA STORET, the AMS data are input quarterly to STORET via modem. For more explicit guidance to EPA STORET, consult the Water Quality Control Information System STORET Handbook (U.S. EPA, 1986).

PC STORET -- PC STORET is generally the same as the national EPA STORET system, but contains data specifically from EPA Region X.

Puget Sound Central Database (PSAMP database) -- The PSAMP database, maintained by the PSAMP central staff at the Puget Sound Water Quality Authority, is designed to:

- improve the availability of information at appropriate decision-making levels;
- enable a soundwide approach to information analysis;
- enable data to be used in a variety of forms (graphs, tables);
- present geographic data in a usable format (Puget Sound Environmental Atlas);
- ensure data quality; and
- encourage data sharing among agencies and programs.

The PSAMP database is written in Dbase IV™ and kept on a microcomputer at the Puget Sound Water Quality Authority. The database stores PSAMP data from all PSAMP tasks as well as historical data from Puget Sound that meet the quality assurance requirements. Integrated analysis is conducted using this comprehensive management system. QA/QC codes for PSAMP are listed in the PSAMP data transfer specifications (MMC, 1988b).

Ambient marine water column data will be transferred to the PSAMP database annually. The data will be converted to PSAMP format using an interactive program at Ecology's AMS office. Once the data are in PSAMP format, the data will be delivered to PSAMP managers via modem, or by floppy disk.

Data Security and Backup

To ensure data security, AMS staff and the Computer Information Consultant (CIC) for the section are the only persons who have direct access to the AMS database. The LAN allows AMS staff to conduct specific tasks according to their accessibility to the system. Passwords will control future user accessibility to the database.

Regular backups are made weekly and monthly of the LAN directories, which include the AMS and STORET databases. These will enable recovery of information lost by accident or equipment failure. Hardcopy printouts of all data entered into the database are retained until data validation and backup procedures are completed. The document management section of this report discusses the archival of CTD profile data.

Data Transfer to PSAMP Database

Water column data to be transferred into the PSAMP database will follow the data format outlined in the PSAMP data transfer specifications (MMC, 1988b). A software module will be written by a contractor for translating STORET codes into PSAMP, ODES, and NODC codes. ASCII files in PSAMP format will be copied onto diskettes and delivered to PSAMP managers annually. Documentation of these transfers (Figure 10) will be kept in the filesystem.

Data Analyses and Reporting

Data Summaries

Data summaries of periodical data (monthly) will be produced to check for initial QA/QC such as:

- anomalous data points;
- coefficients of variance between duplicate/replicate samples; and
- mean coefficients of variance against all duplicates/replicates (batch checks).

Also, data points that show exceeding values with respect to water quality standards will be flagged in the summaries. The summaries are sent monthly to the regional offices of Ecology to assist in their regulatory activities. These reports will be maintained in the filesystem for use in preliminary analysis and program planning.

Statistical Analyses

Initial statistical tests will be conducted on ambient water column data as mentioned in previous sections. For analyses, a variety of statistical tests can be conducted on the water column data.

Current analyses include use of the Water Quality Index (WQI), a statistical package developed by EPA, which allows for determination of meeting water quality standards for beneficial uses, such as swimming and fishing. Use of the WQI is limiting and sometimes can produce misleading results when determining if an area is water quality limited (not meeting standards). To characterize water quality conditions more accurately, additional analytical procedures need to be conducted. More information about how the WQI system is used can be found in Ecology's 1988 and 1990 305(b) Reports (Ecology, 1988a; Ecology, 1990).

Methods for determining trends in water quality parameters can vary from simple qualitative observations, to testing for changes in a mathematical index, to powerful statistical tests on water quality data. Obvious trends can frequently be observed as a graph, once the seasonal influences, such as flow, have been removed.

DATA TRANSFER LOG

DATE	OPERATOR	DATA TYPE	DATE RANGE	COMPLETED

Figure 10. Data Transfer Log to PSAMP; Marine Water Column Ambient Monitoring.

Detection of small but significant changes in water quality will require mathematical analysis of the data. Though not preferred, parametric tests such as linear regression techniques, analysis of variance, and multivariate analysis can be conducted if the data are normally distributed. However, in most cases, water quality parameters collected at random do no display a normal frequency distribution. The data set may include some of the following attributes which must be considered when conducting statistical analysis:

- missing data;
- values that exceed laboratory detection limits (data at or below detection limits);
- storm events that cause anomalous values;
- laboratory method changes;
- field data collection method changes;
- personnel changes; and
- equipment malfunctions.

In order to deal with these attributes in a data set, non-parametric tests, such as the seasonal Kendall's tau, applied by Hirsch, (Hirsch, *et al.*, 1982) will be used. The seasonal Kendall's tau test is a modification of the Kendall's test for correlation to test for randomness against trend, and is distribution free. More information regarding the Hirsch methodology used for a similar monitoring program is in Maryland 1988 305(B) Report (MDOE, 1988a; MDOE, 1988b). As data analyses continues, additional statistical approaches will be explored.

Tidal influence on the long-term water quality data will need to be addressed during data analysis. The long-term monitoring program samples randomly with respect to tides, and the tidal excursions may affect the water quality parameter values (Janzen, *et al.*, 1991). Methods for assessing the effects of tides on the water quality data have not been systematically documented, thus methodology for this type of analysis will be explained in detail in the annual reports.

Annual Report

An annual report will be prepared for the water column task. Draft reports will be completed about six months after the end of each water year (March 15). Introductory information and data listings will be included, as well as an update of the water column task implementation. Detailed analysis and interpretation will be completed during this time. Recommendations for additional stations or program changes will be summarized at the end of each report.

The first annual report will detail the methodologies used for sampling, laboratory analyses, and data analyses. Following reports will reference the first report with respect to these topics. Detailed program component descriptions will not be repeated.

The annual reports will be submitted to PSWQA for use in their annual Puget Sound Update Report. Here, integration of water quality results with other PSAMP tasks such as sediment and shellfish monitoring, is conducted.

Quality Assurance/Quality Control

Much of the quality control of the marine water column data has been discussed in the previous data management section. The remaining quality assurance/quality control (QA/QC) measures to be taken include:

- training of personnel;
- calibrating equipment;
- meeting QA/QC objectives for water quality parameters;
- conducting laboratory QA/QC procedures;
- performing proper sample custody; and
- conducting audits.

Training of Personnel

All personnel who will perform any field activities will receive training on CTD usage and calibration, sample handling, program QA/QC, and safety. Each trainee will be required to be familiar with this Water Column Implementation Plan and the field procedures. All involved program staff will be given demonstrations of field procedures prior to performing field activities. The trainee will be accompanied by the instructor on his/her first few field trips to verify that the procedures are understood and followed. Upon completion of the training, a Training Record Form will be completed (Figure 11). The forms will be kept in the filesystem for future reference of personnel training. Revisions in procedures will require updating the training of personnel and training records to assure compliance with program procedures.

Periodic field checks will be conducted by the program principal investigator to ensure consistent sampling performance amongst staff. Results from these checks will be reported in writing to each person involved, and will be archived in the ambient marine water column filesystem.

Equipment Calibration

The main piece of equipment used on the Ambient Marine Water Column Monitoring Program is the CTD. The CTD is a specialized system that will give accurate and precise results when properly calibrated and maintained. Maintenance and calibration procedures are fully described in the Seacat SBE 19 CTD Operating Manual (Sea-Bird Electronics, 1990).

The CTD unit should be calibrated according to the schedule in Table 10. All calibration check data will be recorded on separate sensor forms (Figure 12 a-f) and archived in the filesystem. Controlled, professional calibrations will be done at the factory and the Northwest Regional Calibration Center in Seattle for the temperature and conductivity sensors yearly, and the pressure, dissolved oxygen, and pH sensors every two years. The results will be archived in the filesystem. Calibration coefficients are generated using the most recent calibration results, and applied to the data prior to processing and entry into the AMS database.

TRAINING RECORD FORM

DATE _____

NAME _____

has been trained for the following procedures in accordance with the Marine Ambient Monitoring Plan:

_____

_____

_____

_____

_____

_____

Comments:

_____

_____

_____

_____

Instructions were read and discussed and a practical demonstration of required techniques was presented. The trainee was monitored for correct technique. As procedures are updated, the trainee will be notified and proper procedure literature and training (when required) will be administered to the trainee.

I have received the above described training, read the pertinent procedures and plans, and understand the instructions presented to me.

Trainee _____ Instructor _____

Date _____ Date _____

Figure 11. Training Record Form

Table 10. CTD Calibration and maintenance schedule.

Sensor	Monthly Calibrations	Monthly Checks	Annual Factory Calibrations	Factory Ca Every Two Years
Conductivity[1]		X	X	
Temperature		X	X	
Pressure		X		X
Dissolved Oxygen[2]	X			X
pH[3]	X			X
Light Transmissometer[4]	X			

[1] Conductivity cell is re-platinized bienially prior to factory calibration.

[2] During factory calibrations, dissolved oxygen sensor will be checked for: membrane, module, internal electrolyte, and electrical connections. Probe will probably need to be replaced every two years.

[3] During factory calibration, pH sensor will be checked for internal electrolyte and electrical connections. Probe will probably need to be replaced every two years.

[4] Light transmissometer will be sent to factory only when the light omitting diode (LED) and/or synchronous detector needs to be replaced.

Figure 12. CTD sensor calibration forms

a. pH

Sensor _____

S/N _____

Date _____

CTD Calibration Log – pH

Prepared By _____

Buffer pH	Ref Temp	Vout from Meter	CTD Temp Readout	Change Coeff? (Y/N)	If Y, List Vref	M	
							New
							Old

	pH Vref	M
Factory:	0.3927	4.5545
Date	16 Aug 89	

Assume B = 2.4902 volts for pH 7 buffer

pHfit will ask for S/N, B, Temp, Vout @ pH7, pH for other solutions. The program will determine Vref and M. Compare with factory calibrations and see if they should be updated.

Most recent calibration casts:	CTD Values (pH)	Ref Values	CTD Values (pH)	Ref Values
Date _____				

Comments: _____

Figure 12. continued.
b. Dissolved Oxygen

Sensor _____
S/N _____
Date _____

CTD Calibration Log – Dissolved Oxygen
(Weather: 943–4310)

Prepared By _____

Enter current m and b values in SEACON.

m = _____
b = _____
k = _____
c = _____
Date _____

After equilibration:

local atm pressure _____ millibars
Water Temp (sensor) _____ deg C
Water Temp (ref) _____ deg C
DO Sensor Temp _____ deg C
Oxygen sensor current _____ microamps
Zero oxygen current (zoc) (in sodium–sulfite) _____ microamps

Run OXFIT:
computes 1) Oxygen current bias (Boc) _____
2) Oxygen current slope (Soc) _____

Verify: tcor = −0.033 _____
pcor = 2.38 e−4 _____
tau = 2.0 _____
ut = 0.67 _____

Run SEACON and enter values of Boc and Soc _____

atm to millibars: ____Hg x 0.03342 atm/Hg x Bar/0.9869 atm x millibar/10(−3) Bar = _____millibars

Most recent calibration casts:	CTD Values (DO)	Ref Values	CTD Values (DO)	Ref Values
Date _____	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____

Comments: _____

Figure 12. continued.
c. Light Transmissometer

Sensor _____

S/N _____

Date _____

CTD Calibration Log – Light Transmissometer

Prepared By _____

Cleand and Dry lenses _____

Air calibration from cal. sheet: A = 4.750

Blocked path voltage from cal. sheet: Y = 0.002

Record data in air		Record data with light path blocked	
Start time	Stop time	Start time	Stop Time
_____	_____	_____	_____

Run SEASAVE (plot) to display data in voltages:

b (current air voltage) = _____ volts

Z (current blocked path voltage) = _____ volts

Compute: M = 20(A−Y)/(b−Z)

B = −MZ

Enter these values of M and B into SEACON

M = _____

B = _____

Comments: _____

Figure 12. continued.
d. Temperature

Sensor _____ CTD Calibration Log – Temperature

S/N _____

Date _____ Prepared By _____

CTD Temp	Ref Temp	Difference (Ref–CTD)	Check Okay (Y/N)	Change Coeff? (Y/N)	If Y, List

Most recent calibration casts:	CTD Values (T)	Ref Values	CTD Values (T)	Ref Values
Date _____				

Comments: _____

Sensor _____
S/N _____
Date _____

CTD Calibration Log – Conductivity

Prepared By _____

Worksheet

Bath Temp (Ref T)	Bath Sal ppt (Ref Val)	CTD Temp deg C	CTD Sal ppt	CTD Cond mmhos	Diff Sal ppt
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Most recent calibration casts:	CTD Values	Ref Values	CTD Values	Ref Values
Date _____	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____

Change Calibration Coefficients? _____

_____

_____

Comments: _____

_____

_____

Figure 12. continued.
e. Conductivity

Figure 12. continued.
f. Pressure

Sensor _____

S/N _____

Date _____

CTD Calibration Log – Pressure

Prepared By _____

Cast # Date	CTD Pressure decibars	Fathometer Depth (meters)	CTD Depth (meters)	Difference (Fathom–CTD)	Correction?

Cast # Date	CTD Pressure decibars	Fathometer Depth (meters)	CTD Depth (meters)	Difference (Fathom–CTD)	Correction?

Comments: _____

Duplicate CTD casts are done in the field every 10-12 stations to measure CTD precision. CTD comparison samples are collected in the field as well, and will namely be used to indicate possible sensor malfunction or drift. If a sensor is malfunctioning, the date the problem is recognized will be recorded, and the sensor repaired or replaced. The maintenance schedule will help track age of sensors and calibration data will track sensor behavior.

QA/QC Objectives

Table 11 lists the water column parameters data quality objectives. These objectives may change with study design or with advancing technology in laboratory methods. Any changes will be noted in the annual updates of Appendix A.

Laboratory QA/QC Procedures

To ensure proper laboratory procedures and QA/QC, Manchester Laboratory participates in the federal Environmental Monitoring Systems/Support Laboratories inter-laboratory performance tests, and is also a participant in the Washington Lab Accreditation Program.

Analytical methods and QA/QC tests conducted in the laboratory are described in Appendix G. Table 12 outlines the QA/QC procedures for water column sample analysis. The Manchester Laboratory Quality Assurance Manual further details procedures for sample analyses (Ecology, 1988b).

Sample Custody

After sample collection, samples will be labeled and stored on ice in a cooler. Copies of field sample logs are delivered to the lab with the corresponding samples. Once the samples are delivered, lab personnel will log in each sample and assign a lab number to each, using the sample label number and a date extension. Each laboratory sample number corresponds to a particular date, station, and depth.

Audits

QA/QC files containing raw data field sheets, calibration records, laboratory QA/QC, and other program related materials will be periodically checked by the program section head. All guidelines described in this document will be checked for compliance. Field sampling audits are discussed under Training of Personnel.

The principal investigator (PI) will submit audit reports to the AMS section head and Environmental Investigations and Laboratory Services (EILS) Program Manager, detailing the findings and the performance of the system audit, significant QA problems, and recommended solutions.

Table 11. Marine water column quality assurance/quality control objectives.

Analytical Parameters	Reporting Units		Reporting Limit		Relative Standard Deviation (RSD)	Significant figures 0-9	10-99	>100
Laboratory Sample Parameters:								
Ammonia	mg/L*	μg-at/L†	0.01*	0.71†	±10%	nearest 0.01	nearest 0.01	3
Nitrite	mg/L	μg-at/L	0.01	0.71	±10%	"	"	"
Nitrate-Nitrite	mg/L	μg-at/L	0.01	0.71	±10%	"	"	"
Orthophosphate	mg/L	μg-at/L	0.01	0.32	±10%	"	"	"
T-Phosphate	mg/L	μg-at/L	0.01	0.32	±10%	"	"	"
T-Persulfate Nitrogen	mg/L	μg-at/L	0.05	3.57	±10%	"	"	"
Chlorophyll & phaeopigments	μg/L		0.05		±20%	nearest 0.01	nearest 0.01	3
Fecal Coliform	#/100ml		1		±20%	1	2	2
Conductivity	μmhos/cm @ 25°C		1		±3%	2	3	3
Salinity	ppt		2		±5%	2	3	N/A
CTD Parameters:								
Conductivity/ Salinity	parts per thousand		0.01		±8%	3	4	N/A
Temperature	degrees Celsius		0.1		±5%	2	3	N/A
pH	pH units		0.1		±0.1 pH unit	2	3	N/A
Dissolved Oxygen	mg/L		0.05		±8%	2	3	N/A
Light Transmissivity	% Light		0.01		±5%	2	3	N/A

* STORET units

† PSAMP units ((mg/L X 1000) ÷ 14.01) for Nitrogen; ((mg/L X 1000) ÷ 30.97)) for Phosphorus.

Table 12. Quality assurance/quality control procedures for water column parameter analysis in the laboratory.

Analytical Parameters	Calibration and Standardization	Check (control)* Standard (20 or less samples)	Replicates+ (20 or less samples)	Blanks per batch	Spiked Samples per batch
Laboratory					
Ammonia	3 point Calibration (per batch)	2	1	2	1
Nitrite	3 point Calibration (per batch)	2	1	2	1
Nitrate-Nitrite	3 point Calibration (per batch)	2	1	2	1
Orthophosphate	3 point Calibration (per batch)	2	1	2	1
T-Phosphate	3 point Calibration (per batch)	2	1	2	1
T-Persulfate Nitrogen	3 point Calibration (per batch)	2	1	2	1
Chlorophyll & phaeopigments	1 per year	1 per year	1	2	N/A**
Fecal Coliform	N/A	N/A	1	Controls	N/A
Conductivity	1 (batch)	1	1	N/A	N/A
Salinity	1 (batch)	1	1	N/A	N/A

* 1 high, 1 low standard

\+ Nutrients and chlorophyll *a* are replicated in the field. Fecal Coliform bacteria samples are duplicated in the field.

** Not applicable

Periodic assessment reports of data accuracy, precision and bias, completeness, and compliance to these procedures will be submitted to the AMS section head for review. Regular QC reports will be sent from the lab to the PI for review. If corrective action is needed, the PI will write a recommended action report to the AMS section head and appropriate laboratory staff.

Safety Plan

The safety plan for the water column task details the potential hazards and safety considerations that may be encountered during program implementation. Personnel responsibilities, safety equipment, emergency procedures, and emergency contacts are also discussed.

Hazards and Safety Considerations

Marine Flights -- Physical hazards that may be encountered during a marine flight survey include:

- gear and sample handling;
- fatigue; and
- adverse flying conditions.

All equipment will be secured prior to take-off at each station. Two corrosive chemicals are used during the water column task. These two chemicals are alkaline azide and manganous sulfate, both used for dissolved oxygen sample fixing. Liquid corrosive chemicals are prohibited on the airplanes, thus powder pillows containing the appropriate measures of each chemical for one sample will be used. All samples fixed with these reagents will be stored in a secured cooler.

The pilot and the field staff will communicate before initiating a marine flight. Weather conditions, personal health, and other considerations will be taken into account. For instance, on windy days when there may be considerable vessel drift, a survey may be postponed. These factors must be considered prior to sampling. As a general rule, if it is expected that out of ten stations, more than three will be missed, the survey will be postponed until the following day.

Marine flights will last about eight hours. One break will be taken mid-day, unless it is unfeasible due to time or location constraints. Marine flights will not be conducted under adverse flying conditions (fog, storms), and must abide by all visible flight regulations (VFR).

Boat Surveys -- Physical hazards that may be encountered during boat surveys include gear and sample handling, exposure, and fatigue. Gear and sample handling are discussed above. To reduce danger from exposure, extra dry clothing should be brought on the survey or kept in the vehicle (for day trips). Foul weather gear should always be available, in case conditions change. Each crew member is responsible for their own clothing and gear. First aid kits will be available on all vessels.

Personnel Responsibilities

The PI or crew leader for each survey conducted during this program is the designated safety officer for that survey. The safety officer will have the following responsibilities:

- sample handling and processing;
- canceling surveys should conditions warrant;
- compliance to field and safety procedures;
- knowledge of how to use the radio;
- knowledge of use and location of the safety equipment; and
- emergency procedures.

The pilot during marine flight surveys, and boat operators during cruises are authorized to cancel a survey, should conditions warrant.

Safety Equipment and Emergency Procedure

Safety equipment includes:

- inflatable life preservers (for marine flights);
- standard Coast Guard approved life preservers and survival suits (for cruises);
- ship-to-shore radio;
- first aid kit;
- fire extinguisher; and
- list of emergency frequencies and phone numbers.

Emergency procedures require the field staff to have current CPR training and knowledge of agency procedures for emergencies (Ecology, 1989).

Emergency Contacts

All personnel will be familiar with the emergency contact list, which will also be carried in the field during every survey. Appendix I lists the radio frequencies for offshore emergencies, and a list of on-shore facilities. This list will serve as the field emergency contact list.

COASTAL ESTUARY AMBIENT MONITORING

Study Area

The study area covered by the coastal portion of the Ambient Marine Water Column Monitoring Program includes the lower portion of the Chehalis River at Aberdeen out to the mouth of Grays Harbor, and from the lower part of the Willapa River at Raymond to the southern reaches of Willapa Bay near Long Island and out to the mouth of the bay. Currently, Ecology does not

monitor the state's nearshore and offshore waters along the Pacific coast due to resource constraints and difficulties encountered in sampling in the nearshore/coastal environment.

General Design

The general design for coastal monitoring is virtually the same as that described by the Puget Sound monitoring program, except that solstice sampling will not be implemented in the coastal estuaries. The coastal monitoring program consists of long-term monitoring and seasonal monitoring. All aspects of the Puget Sound monitoring, excluding solstice monitoring, apply to the coastal estuaries.

Appendix A describes the coastal ambient monitoring program that will be implemented with existing funds. Currently, only long-term monitoring has been conducted. Below is a brief description of the long-term monitoring component in the coastal estuaries. The remaining details and plan directives for long-term and the seasonal monitoring can be found in the Puget Sound section of this plan.

Long-term Monitoring

Strategy

As in Puget Sound, the long-term monitoring in the coastal estuaries will include:

1. core station monitoring;
2. rotating station monitoring; and
3. floating station monitoring.

The basis for this monitoring strategy is fully explained under the Puget Sound section of this plan.

Station Location

Table 13 lists the core and rotating stations for the coastal estuaries. Figure 13 shows these proposed stations.

Core Stations -- A total of six stations are designated for core station monitoring in the coastal estuaries; three in Grays Harbor, and three in Willapa Bay.

Rotating Stations -- Two sets of two rotating stations will be visited on a two year rotation cycle in the coastal estuaries. As with the Puget Sound hydrographic division of the rotating stations, the coastal rotations will occur in one of the two estuaries every other year.

Table 13. Long-term core and rotating stations for Grays Harbor and Willapa Bay.

STATION	LOCATION	BASIN
Core Stations		
GYS004	Chehalis River	Grays Harbor
GYS008	Inner South Channel	Grays Harbor
GYS016	Outer Harbor	Grays Harbor
WPA004	Toke Point	Willapa Bay
WPA006	Nahcotta Channel	Willapa Bay
WPA001	Willapa River	Willapa Bay
Rotating Stations		
GYS009	Outer North Channel	Grays Harbor
GYS015	Whitecomb Flats	Grays Harbor
WPA003	Johnson Slough	Willapa Bay
WPA007	S. Jensen Point	Willapa Bay

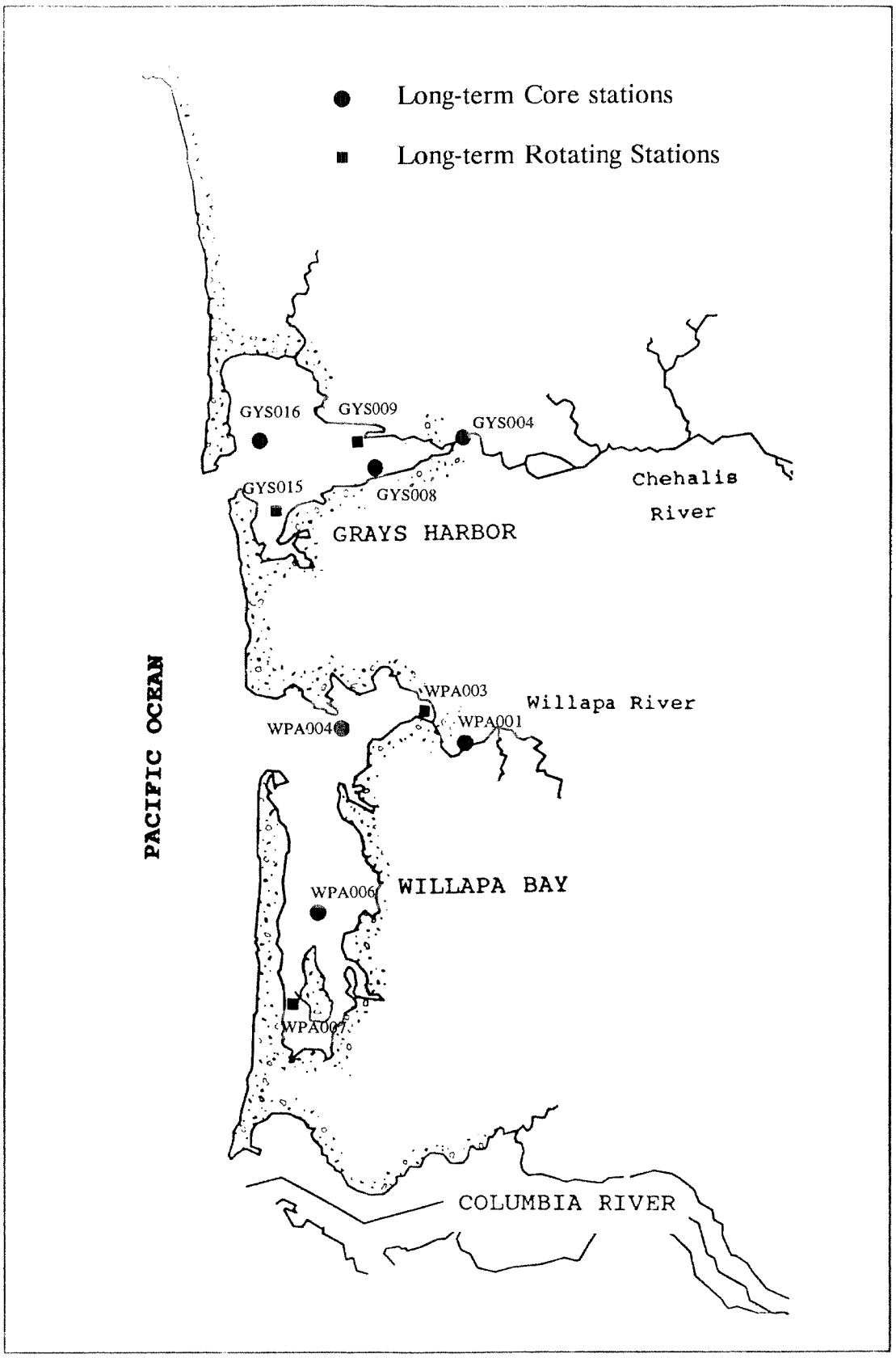

Figure 13. Long-term core and rotating stations -- Grays Harbor and Willapa Bay.

Floating Stations -- As in Puget Sound, floating stations will be selected annually based on recommendations and data needs. The number of floating stations monitored each year may vary, depending on the needs and the resources available.

Sampling Schedule

All coastal long-term monitoring stations are visited once a month, year-round, to ensure that all major seasonal hydrographic conditions are observed.

Sample Types and Depths

Parameters measured at core and rotating stations, and the depths measured, are the same as those for Puget Sound and are listed in Table 3. Fecal coliform bacteria will be collected at all core stations and at the rotating and floating stations closer to shore where bacteria densities are expected to be higher.

Floating station parameters will be tailored to the specific station objectives. Parameters will likely be those listed in Table 3, and may include other parameters that are normally associated with intensive monitoring (e.g., phytoplankton).

Seasonal Monitoring

Strategy

Seasonal monitoring surveys in the coastal estuaries will serve the same purposes as they do in Puget Sound. The surveys will be tailored to fit study area objectives. Specific monitoring plans will be incorporated and appended to fiscal year plans in Appendix A as the program is funded and studies are initiated.

See the Puget Sound Section of this plan for remaining plan directives and procedures.

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APPENDIX B

APPENDIX B

Ambient marine water column long-term monitoring station list. The stations listed are those with data in the Ambient Database and in EPA Storet. Wateryears begin in October and end in September of the following year. Some wateryears have an incomplete record of data due to missed surveys and lack of winter sampling through 1987.

Station	Description	Sample Periods (month/year)	Wateryears
Admiralty Inlet			
ADM001	Adm Inlet	10/75 - 11/87	1976 - 1987
ADM002	N. Adm Inlet	06/88 - Present	1988 - 1992
ADM003	S. Adm Inlet	06/88 - 09/91	1988 - 1991
Bellingham Bay			
BLL002	Whatcom WW	08/73 - 09/77	1974 - 1977
BLL003	Std Oil Dock	08/73 - 09/75	1974 - 1975
BLL004	S. Whatcom WW	08/73 - 09/75	1974 - 1975
BLL006	Nun Buoy 4	10/75 - 11/87	1976 - 1987
BLL007	Cannery Shipyd	10/75 - 09/77	1976 - 1977
BLL008	Post Point	08/73 - 11/87	1974 - 1987
BLL009	Pt. Frances	10/77 - Present	1978 - 1992
BLL010	Eliza Is.	10/76 - 06/80	1977 - 1980
Burley Mintor-Lagoon			
BML001	Burley Min. L.	06/88 - 10/90	1988 - 1990
Budd Inlet			
BUD001	Yacht Basin	08/73 - 09/75	1974 - 1975
BUD002	S. End Oly Port	10/76 - 10/90	1977 - 1990
BUD003	Spar Buoy 10	08/73 - 08/77	1974 - 1977
BUD004	Light Buoy 6	10/76 - 08/77	1977 - 1977
BUD005	Oly Shoal at Horn	08/73 - Present	1974 - 1992
Commencement Bay			
CMB003	Off Brown Pt	10/76 - Present	1977 - 1992
CMB006	Mouth of City WW	08/73 - 11/87	1974 - 1987
CMB010	Puyallup R Mouth	08/73 - 11/87	1974 - 1987
CMB012	Puyallup R I-5	08/73 - 08/75	1974 - 1975
CMB013	Blair WW mouth	08/73 - 08/77	1974 - 1977
CMB016	Hylebos WW 11th St	08/73 - 08/77	1974 - 1977
Carr Inlet			
CRR001	Off Green Pt.	10/76 - 09/91	1977 - 1991

Case Inlet			
CSE001	S. Heron Is.	10/77 - 09/91	1978 - 1991
CSE002	Off Rocky Pt.	11/90 - 09/91	1991 - 1991
Discovery Bay			
DIS001	Near Mill Pt.	11/90 - 09/91	1991 - 1991
Dana Passage			
DNA001	Near Brisco Pt.	10/84 - 09/85	1984 - 1984
		06/88 - Present	1988 - 1992
Drayton Harbor			
DRA001	Entrance Channel	08/73 - 11/87	1974 - 1987
Dyes Inlet			
DYE002	Windy Point	10/75 - 09/76	1976 - 1976
DYE003	Wash. Narrows	08/73 - 11/87	1974 - 1987
DYE004	NE Chico Bay	10/91 - Present	1992 - 1992
East Passage			
EAP001	S. Three Tree Pt	06/88 - 09/91	1988 - 1991
East Sound - Orcas Island			
EAS001	Rosario Pt.	11/90 - Present	1991 - 1992
Elliott Bay			
ELB001	Pier 91	08/73 - 09/75	1974 - 1975
ELB002	Pier 66	08/73 - 09/75	1974 - 1975
ELB003	Pier 51	08/73 - 09/75	1974 - 1975
ELB004	East WW Mouth	08/73 - 09/75	1974 - 1975
ELB005	Nr Harbor Is	07/80 - 11/87	1981 - 1987
ELB006	West WW Mouth	08/73 - 09/75	1974 - 1975
ELB008	Duwamish Head	08/73 - 09/75	1974 - 1975
ELB009	Duw. WW Spok. St.	08/73 - 09/75	1974 - 1975
ELB010	Duw. WW 16th St.	08/73 - 11/87	1974 - 1987
ELB012	Duw. R. Marg. Way	08/73 - 09/75	1974 - 1975
ELB015	E. Duwamish Head	10/91 - Present	1992 - 1992
Eld Inlet			
ELD001	Flapjack Pt.	10/76 - 10/90	1977 - 1990
ELD002	S. Flapjack Pt.	06/88 - 10/90	1988 - 1990
Georgia Strait			
GRG001	At Birch Bay	08/73 - 09/74	1974 - 1974
		10/76 - 09/77	1977 - 1976
GRG002	N. of Patos Is.	06/88 - Present	1988 - 1992

Grays Harbor			
GYS004	Chehalis R.	10/74 - Present	1975 - 1992
GYS006	E. Rennie Is.	11/76 - 11/81	1977 - 1981
GYS007	N. Ch. Rayonier	11/76 - 10/87	1977 - 1987
GYS008	Mid-S. Channel	10/74 - 09/76	1975 - 1976
		04/82 - Present	1982 - 1992
GYS009	Moon Is. Reach	10/74 - Present	1975 - 1992
GYS014	At the Bar	08/73 - 09/76	1974 - 1976
GYS015	N. Whitcomb Flats	04/82 - 06/88	1982 - 1988
GYS016	Nr Damon Pt	04/82 - 10/87	1982 - 1987
		01/91 - Present	1991 - 1992
Hood Canal			
HCB002	Dabob Bay Pulali Pt	10/75 - 11/87	1976 - 1987
HCB003	Eldon/Hamma Hamma	10/76 - 09/91	1977 - 1991
HCB004	Gt. Bend/Sis. Pt.	10/75 - 11/87	1976 - 1987
		12/90 - Present	1991 - 1992
HCB006	King Spit/Bangor	10/75 - Present	1976 - 1992
HCB007	Lynch Cove	12/90 - Present	1991 - 1992
Holmes Harbor			
HLM001	Honeymoon Bay	08/73 - 10/87	1974 - 1987
Henderson Inlet			
HND001		No data	New station
Haro Strait			
HRO001	Skipjack Is.	10/74 - 11/87	1975 - 1987
Straits of Juan de Fuca			
JDF005	Sequim Bay	10/76 - 11/87	1977 - 1987
		11/90 - 09/91	1991 - 1991
JDF007	Seq. @ Goose Pt.	11/90 - 09/91	1991 - 1991
Lopez Sound - Lopez Island			
LOP001	Off Decatur	11/90 - Present	1991 - 1992
Tacoma Narrows			
NRR001	Nr Pt. Defiance	04/77 - 09/91	1977 - 1991
Nisqually Reach			
NSQ001	Nisq. R. Delta	04/77 - 09/91	1977 - 1991
NSQ002	Devils Head	10/84 - 09/85	1985 - 1985
Oakland Bay			
OAK001	At Eagle Pt.	07/83 - 07/83	
OAK004	Near Eagle Pt.	10/74 - Present	1975 - 1992

Padilla Bay			
PAD001	Near Hat Island	08/73 - 09/75	1974 - 1975
PAD002	Fid. Bay/Caps.Is	08/73 - 05/76	1974 - 1975
PAD003	E. Guemes Channel	10/75 - 05/76	1976 - 1976
Port Angeles			
PAH003	Ediz Hook Head	08/73 - 11/87	1974 - 1987
PAH006	Rayonier Mill	08/73 - 09/75	1974 - 1975
PAH007	Rayonier Pier	08/73 - 09/77	1974 - 1977
PAH008	Morse Creek	08/73 - 09/91	1974 - 1991
Pickering Passage			
PCK001	Harstene Island	10/76 - 10/87	1977 - 1987
		10/91 - Present	1992 - 1992
Penn Cove			
PNN001	Penn Cove Park	08/73 - 11/87	1974 - 1987
Port Orchard			
POD004	Lib. Bay/Port	10/75 - 09/76	1976 - 1976
POD005	Brownsville	10/75 - 11/87	1976 - 1987
POD006	Lib. Bay/Virg.Pt	10/77 - 11/87	1978 - 1987
		10/91 - Present	1992 - 1992
Puget Sound Main Basin			
PSB002	Alki Point	08/73 - 09/75	1974 - 1975
PSB003	West Point	10/76 - Present	1977 - 1992
PSB005	L. Wa. Ship Can.	08/73	
PSB006	Ballard Br.	08/73 - 05/76	1974 - 1976
PSB007	L. Union/Gas W.	08/73 - 09/76	1974 - 1976
PSB008	L Wa Fremont Br	09/73 - 09/76	1974 - 1976
Possession Sound - Port Gardner			
PSS002	Tulallip Bay	08/73 - 06/76	1974 - 1976
PSS005	PG Bay Weyerhaus.	08/73 - 06/76	1974 - 1976
PSS008	PG Bay Pier 3	07/80 - 11/87	1981 - 1987
PSS009	PG Bay @ Scott	08/73 - 09/77	1974 - 1977
PSS015	Snoh. R. HWY 99	08/73 - 11/87	1974 - 1987
PSS016	Snoh. R. Smith Is	08/73 - 09/75	1974 - 1975
PSS018	Snoh. R. Lowell	08/73 - 09/77	1974 - 1977
PSS019	Poss. S. Ged. Is	07/80 - Present	1981 - 1992
PSS020	Ebey Slough	08/73 - 11/87	1974 - 1987
Port Townsend Harbor			
PTH002	Crown Zeller	10/74 - 09/75	1975 - 1975
PTH003	Yacht Basin	10/74 - 09/75	1975 - 1975

PTH005	Walan Point	10/77 - 11/87	1978 - 1987
Samish Bay			
SAM001	Williams Point	10/75 - 05/76	1976 - 1976
Saratoga Passage			
SAR002	Crescent Harbor	08/73 - 05/76	1974 - 1976
SAR003	Sar. P. East Pt	10/77 - Present	1978 - 1992
Sinclair Inlet			
SIN001	Naval Shipyds	08/73 - 11/87	1974 - 1987
		10/91 - Present	1992 - 1992
San Juan Islands			
SJI001	SJ Chan. Reid Rk.	10/74 - 11/87	1975 - 1987
Skagit Bay			
SKG001	Hope Island	08/73 - 11/87	1974 - 1987
SKG002	Strawberry Pt	10/75 - 09/77	1976 - 1977
SKG003	Str. Pt Red Buoy	12/90 - 09/91	1991 - 1991
Port Susan			
SUZ001	Kayak Point	08/73 - 11/87	1974 - 1987
Totten Inlet			
TOT001	Windy Point	10/77 - 10/90	1978 - 1990
Willapa Bay			
WPA001	Will. R. Raymond	08/73 - Present	1974 - 1992
WPA002	Will. R. South B.	08/73 - 09/77	1974 - 1977
WPA003	Will. R. John. Sl	08/73 - Present	1974 - 1992
WPA004	Toke Point	08/73 - Present	1974 - 1992
WPA005	Oysterville	08/73 - 09/75	1974 - 1975
WPA006	Nahcotta Ch.	10/90 - Present	1991 - 1992
WPA007	S. Jenson Pt LI	10/90 - Present	1991 - 1992

APPENDIX C

APPENDIX C

Secchi Depth -- A measure of the transparency of the water column. A decrease in transparency (Secchi depth) indicates a decrease in light penetration, which results in the reduction of depth to which phytoplankton can grow. Overall productivity of biological resources could ultimately be affected.

Hydrographic Profiles (CTD) -- CTD profiles measure temperature, salinity (thus density), with depth. This information aids in understanding water movement, seasonal cycles in temperature and salinity (important for biological growth cycles), and monitoring unusual changes in these parameters under episodic climatic events (e.g., flooding).

pH -- A measure of the hydrogen ion concentration. In the open sea, the carbon dioxide equilibrium controls the hydrogen ion concentrations, resulting in a narrow pH range (8.0-8.3). In inland waterways and estuaries, pH values vary to a greater degree since photosynthesis raises pH, and respiration lowers it. Furthermore, in and around outfall areas and river mouths, pH values may be affected, especially around pulp and paper dischargers.

Dissolved Oxygen -- A measure of the concentration of oxygen available for marine organisms and natural processes. Adequate dissolved oxygen (D.O.) is required for fish, as well as for decomposition processes. Photosynthesis increases D.O. concentrations. Other naturally occurring events in seasons, climate and circulation cause D.O. changes as well. D.O. levels are sensitive to anthropogenic inputs in response to nutrient and biochemical oxygen demand (BOD) loadings.

Light Transmissivity -- An estimated measure of the suspended matter concentration. Same rationale as for Secchi depth, but transmission meter values are continuous throughout the water column, whereas, Secchi depth measures from the surface to the depth that the light intensity is extinguished.

Nutrients -- Nutrients are food for many primary biological organisms. Excess nutrient concentrations can stimulate excessive marine plant growth that, during the decaying process, depletes oxygen concentrations in the water. Changes in nutrient concentrations may also cause a shift in plant communities and may encourage opportunistic noxious species to flourish. Anthropogenic pressures require the continuous and intensive sampling of nutrients.

Chlorophyll *a* and phaeopigments -- A qualitative measure of phytoplankton standing stock. Phytoplankton are critical to the normal functioning of an ecosystem. Nutrient enrichment may cause excessive algal production, thus consequential D.O. depletion. Circulation, flushing, and hydrographic conditions also affect phytoplankton production.

Fecal Coliform Bacteria -- An organism used to indicate fecal pollution caused by human sewage and animal wastes. Bacterial counts are quite variable and often are affected by seasonal changes (e.g., increased precipitation causing sewers to overflow).

APPENDIX D

PRE-FIELD PROCEDURES -- OVERVIEW

Water Bottle, Field Log, and Sample Label Preparation

The field equipment checklist should be used in preparation for a field survey. Before entering the field, all bottles need to be ordered from the lab, and field logs and labels prepared. Bottles should be ordered five days before a scheduled survey. The field logs are to be copied onto water proof paper (Rite in the Rain™). The labels for sample custody are run off a D-BASE III program. This procedure is detailed in this appendix.

Lab Top Computer

The lap top computer is used for CTD setup and downloading. The lap top can run off a charged battery and be taken in the field. The battery yields about three hours of operating time. To check the battery charge, type the Fn and SysReq buttons simultaneously. A bar graph in the lower right hand corner will indicate the battery charge. Hit ESC to remove the display. When charging the battery, use a surge protector. The charge indicator light near the on/off switch of the lap top will glow green when fully charged, and red when not. Be sure to charge the computer battery prior to field application. Note that the battery charge will decline during off time. When operating a printer or downloading data from the CTD, more power is used than with normal operation. The battery should periodically be discharged to maintain ability to hold a full charge. To charge the battery, simply plug the AC adapter into the computer and a surge protector, and allow to charge six to eight hours. More lap top information can be obtained in the users manual, kept at the PI's office.

The lap top will not be necessary for all field applications. The CTD is capable of storing data from a complete marine flight survey for instance. On some occasions, the lap top will be used to download data in the field (seasonal monitoring).

CTD

Check the CTD status using the program PROTERM. Things to check is battery charge (8.3 volts when battery is new--change batteries when voltage reaches around 7 volts). CTD software is described in the Seasoft Data Acquisition Manual, kept in the PI's office. CTD initialization procedures are described in this appendix.

Printing Sample Labels

1) From the main menu, type number that corresponds to "labels"

2) List will appear asking what to do. Select number that corresponds with "Get Label File"

3) Under list of label files, choose one of the following: NEWMARI, NEWMARII, NEWMARIII (changes annually).

4) The system will return to the previous menu again. This time, select "Print Labels"

5) Be sure the printer has label paper, line up starter just above the top of the 1st label to be printed; turn on the printer after lining up (turn on-off if necessary) and switch the box set to A.

6) Screen will ask how many labels to print. Depending on samples per station, print four labels for fecals, preserved and unpreserved nutrients, chlorophyll, and calibration samples. The other parameters are already set on the labels, so press F10 to continue and F10 again to start printing.

8) Be sure labels are printing completely on each label immediately after printing starts. If the printing is off, hit ESC two times on the keyboard and wait for the printer to quit printing. Adjust printer accordingly and try again.

9) When labels are done printing, staple a rubber band (2 times) to each label on the left hand side (opposite the sample #) on the back.

10) Group stations and depths together as usual (i.e., 0 meters grouped for station X, same for 10m and 30m).

CTD INITIALIZATION

1) Boot lap top computer with SEASOFT program disk 1 in the A drive. (This disk should have the correct version of command.com for the MS DOS version used by the Toshiba. If the SEASOFT disk doesn't boot the computer, use the MSDOS System disk, then load SEASOFT after the system is up).

2) Check to see that the CTD is turned off (Figure 3 is a diagram of the SeaBird-19 and its components).

3) Mate the 4-pin test cable to the computers serial port (these cables and ports are labeled). Type PROTERM to get into communication with the SEACAT. Hit return < > several times until the S> prompt is displayed on the screen. (If setting up on a hard disk system, just run PROTERM to communicate with the SEACAT). SEACAT PROFILER is now in command mode and can be initialized. NOTE: After two minutes of keyboard inactivity, the SEACAT will go into time out and be in quiescent state. To regain communication, press return repeatedly until the S> prompt appears. To save battery wear, after completing a session with SEACAT PROFILER, enter QS < > (< > = return) (QS = quiescent status) which returns the PROFILER to quiescent mode immediately, otherwise the profiler will wait two minutes before it enters quiescent mode.

4) See if there is any existing data still in the CTD memory by typing DS < >, (display status). The display on the CRT will give SEACAT information: a) battery charge; b) pressure range (500 psi); c) clock time frequency (clk) (set time on CTD to that on your watch with ST< > command), date is MMDDYY< > and time is HHMMSS< >); d) operating current (iop in milliamps); e) main battery voltage (vmain); f) lithium battery voltage (vlith); g) number of casts (ncasts should = 0); h) stored samples; i) number of samples free in memory; and j) time in milliseconds to wait after sending a carriage return line feed (for slow computers). If data exists in the CTD, check CTD Setup/Download Log (check disks) to see that it has been downloaded and backed up before initializing the memory. Also, check that the battery charge reads at least 7.0 volts. If it seems low (below 7.0 volts) check maintenance log to see when batteries were last changed. Six D-cell batteries will give 24 hours of continuous use.

5) To initialize logging, type IL < >. The profiler will ask if you wish to start logging, reply yes by typing Y. You will be asked "are you sure," reply with CTRL Y (*Y). The first time the magnetic switch is turned on after receipt of the IL command, the data recording will start at the beginning of memory and any previously recorded data will be written over whether the memory has been initialized or not. After the IL command has been sent, send the QS < > command to put the profiler into quiescent mode. ONE MUST WAIT AT LEAST 3 SECONDS BEFORE DATA RECORDING CAN START AFTER THE QS COMMAND IS SENT, (this is critical only if instrument is initialized in the field).

ADDENDUM, SEACAT PROFILER S/N 191843-165

Your SEACAT PROFILER has been customized to support a submersible pump for flushing the conductivity cell and dissolved oxygen sensor.

PUMP OPERATION

In order for the pump to run, the conductivity cell must be in seawater. After the cell enters the water, there is also a delay provided before turn-on so that all the air in the pump tubing can escape. If the pump motor turns on when there is air in the pump's impeller housing, priming will be uncertain and a proper flow rate cannot be ensured.

Pump turn-on occurs when the 'raw frequency' from the conductivity interface circuit exceeds the value programed into the Profiler using the 'SP' (set pump) command entered at the S> when running PROTERM. Find the conductivity 'raw frequency' value on the instrument configuration sheet (typically about 3000 Hz). If you will be working in oceanic water in the 35 ppt range, the set point for pump turn-on can be entered as 3500 Hz since actual in-water frequencies will always be higher than this. If you will be working in fresh or nearly fresh water, the set-point frequency must be only slightly higher (e.g., 5 Hz) than the listed 'raw frequency' value. Keep in mind that if the set point is made too close to the 'raw frequency', the pump may inadvertently turn on as a result of small drifts in the electronics. Some experimentation may be required. If for some reason you want the pump to run contiuously, set a frequency lower than the 'raw frequency' value.

The second entry made via the 'SP' command sets the time delay. The necessary delay can be judged by immersing the Profiler (not running) just below the air-bleed hole at the top of the *tygon tubing. Measure the time needed to completely fill the tubing (30 seconds is typical) and* set the delay to about 1.5 times longer. When actually using the Profiler, be sure to 'soak' the instrument just under the surface for at least the time required for pump turn on.

The entries made using the 'SP' command will be permanently stored in the Profiler and will remain in effect until you change them (by running 'SP' again). The only exception is in the event of *complete* initialization (not by running the 'IL' command) of the Profiler. This will occur only with disassembly of the electronics from the housing (along with disconnection of the battery connector to the electronics card set) or if the toggle switch at the bottom of the battery compartment (newer units only) is placed in the 'reset' position.

The tubing extending above the air-bleed hole will contain a small reserve of water which will maintain the pump prime for quite some time (up to one minute depending on the length of tubing above the air-bleed) even though the Profiler is lifted up so that the cell inlet and pump outlet are just below the water surface. This allows beginning the actual profile very near the top of the water column. Remember that the cell inlet and pump outlet must not come above the water surface or the prime will be lost.

APPENDIX E

APPENDIX E

Post-Field Procedures -- Overview

CTD Downloading and Maintenance

Downloading the CTD survey data is the first order of business upon returning from the field. By immediately downloading the data, danger of loss or over writing the data can be reduced. To download the CTD data, refer to the Seasoft Data Acquisition Manual, and the cheat sheet in this appendix.

Follow CTD maintenance procedures after each survey to help preserve the CTD unit and sensors. If the batteries need to be replaced, inform the PI or the technician in Environmental Investigations, and they will be sure it gets done before the next survey. These are the only individuals who should change batteries, so please notify them. The CTD housing should never be opened in the field. If neither of these people are available and the situation is urgent, refer to the Operator's Manual.

The entire CTD unit and probes should be rinsed with fresh water following every field effort. Prior to storage, the conductivity and dissolved oxygen probes should be soaked in a 1% Triton-X (tm) solution for 15 to 30 minutes, then rinsed with freshwater. Replace the tygon tubing on the conductivity and dissolved oxygen probes and fill with distilled water. Avoid contact with the probes and always store in distilled water.

The pH probe should also be rinsed with distilled water prior to storage. The pH probe is not stored in distilled water however. The probe needs to be stored in a storage bottle containing a saturated potassium chloride solution; the internal probe solution will break down, resulting in erroneous data readings if this in not done. Refill solution will be made a the EILS wetlab and kept in the CTD cooler. If solution is not available, store in a pH 4 buffer.

The light transmissometer windows should be rinsed. Allow to air dry.

During cold weather periods, store the CTD unit in warm storage, otherwise freezing could occur and cause probe damage and other complications. THIS UNIT SHOULD NEVER BE LEFT IN A VAN OVERNIGHT.

All completed field logs, data printouts, logbook, and disks are to be put in the CTD In-Box at the AMS for data checking, processing, and filing. All logsheets and data disks will be checked for compliance to procedures, and filed in accordance with the QA/QC Filelist. Be sure to recharge the computer's battery by plugging the AC adapter into the computer and plugging into a surge protector. Allow six to eight hours if full recharge is required.

CTD Cheat Sheet

Pre-Field Check and Preparation

Attach line to eye piece on top of the CTD cage using a BOWLINE knot. Tape the tail of the knot to the line to help prevent loosening. Tie the other end of the line to some permanent fixture on the plane or boat.

Unscrew protective cage over the pH probe. Remove the pH storage solution bottle and either discard solution, or cap to save. Stow bottle. REPLACE the protective cage prior to sampling. **Remove** carefully the tygon tubing with distilled water from the base of the conductivity probe - pull straight down.

Sampling Procedure

Loop line over the capstan winch (or block). Turn CTD on with switch by the conductivity probe cage. Record the turn on time on the CTD Field Log Sheet.

Lower the unit into the water, submerged to the top of the cage (or lower during rough seas). HOLD AT THIS DEPTH FOR 2 MINUTES.

After two minutes, raise unit just so the DO sensor is just beneath the water's surface. Hold there for 5 seconds, then begin to lower the CTD. Tell the assistant the time of the start of the cast.

Lower the CTD at a consistent rate of about 25-30 cm per second. Guide the line with your hand to keep the feed smooth. In rough seas, speed the lowering rate to avoid spiking the data with heaving vessel motion.

Feel for the touch down of the CTD on the bottom (when the line slackens) and stop feeding out line. Hold the CTD at bottom for 5 seconds, then start to raise using the winch.

As the CTD nears the surface, be careful not to bang the CTD on the base of the plane. Guide the unit into the plane (or boat), turn off winch, and set CTD down inside.

Turn CTD unit off -- record the turn off time.

For in flight or when underway, secure the CTD with line or a bungee cord. If more than 1-2 hours will pass before using the CTD, replace the pH storage solution bottle until needed again. AVOID LEAVING THE CTD STANDING IN THE DIRECT SUNLIGHT.

Post Field Procedure

At the end of the survey day, Rinse the CTD with freshwater (all probes, the pumping system, the line, and the cage). Replace the pH storage solution and the tygon tubing filled with distilled water to the conductivity sensor. Make sure distilled water fills up past the DO sensor. Secure tygon for storage. Place CTD unit in its proper cubby in the Electronics Shop of the boatshed.

NISKIN WATER SAMPLER CHEAT SHEET

PRE-FIELD CHECKS

Be sure the line is attached with the messenger above the trip mechanism, and a weight about 1-2 feet below the base of the bottle.

Check all knots before sample at the beginning of the day. (Bowline knots are the best)

Do not trip bottles in the air if it can be avoided. The bottles are made of PVC and will break, especially the lids.

Check the inner tubing of the bottle to see if there are any tears or cracks, or if the knot is loose. Replace if there are any problems with the tubing.

Check the O-rings on the top and bottom of the bottle.

To rig the bottle open:

Pull top cap up and gently pull over the side of the bottle (opposite of the lowering line attachments). Push the tripper button and hook the line into the hook and release the trip button.

Pull bottom cap down and gently pull over the side of the bottle and place the metal hook over the TOP of the top cap loop (already latched).

Lower bottle into the water and allow water column to equilibrate (5-10 seconds) prior to collecting the sample.

To trip bottle:

"Throw" the messenger down the line and feel the tug. Sometimes, if there is considerable angle in the line, the bottle will not trip. Try adjusting the open rig configuration if all else fails (power the vessel to remove the angle for instance).

Raise the bottle. Attach the line to the clam cleat on the frame (left side) and bungee cord the bottle to the left window slot. This will keep the bottle still for sample collection.

Sampling: Remember that you only have 1.2 liters of water!

Rinse the bottle THREE TIMES prior to filling. Just put a squirt of water into the bottle, cap, shake, empty and repeat two more times.

Nutrients: 125 mL brown bottles. Fill the bottles to the neck, cap, label, and stow in the cooler. Be sure to label the bottles as you go as to not confuse samples from different depths in similar bottles.

Conductivity: 500 mL clear poly bottles. Rinse bottles three times (same as above), and fill half full. Cap, label (note that this is a conductivity sample), and stow.

Dissolved Oxygen: 300 mL glass BOD bottles with glass stoppers. Draw the DO sample first before other samples. Do not plan to take DO samples with conductivity samples due to limited water. Take DO samples at stations with little to no drift. Get the powder pillows out and ready for fixing.

Place the tygon tubing on the Niskin all the way into the bottle, tip upside down, flush, and tip right side up, still flowing and with tubing all the way to the bottom. Fill, allowing the water to cycle through a bit. Keep water flowing while removing tubing.

Tap the top sides of the bottle with the stopper to jar loose air bubbles. When satisfied that most bubbles are loosened, at the managanous sulfate powder (PINK) first, than add the alkaline azide powder (WHITE) second. Place stopper into bottle neck, pour off residual water through hatch, and shake vigorously. Label and read the bottle number to the pilot.

Prior to stowing, squirt water into bottle neck, place plastic cover cap on top, shake one more time, and stow.

Phytoplankton: In pre-measured preservative (1% formalin after sample added), fill jar to neck. Label and stow.

CTD Data Dumping Procedures

* Be sure the CTD is TURNED OFF. Connect the lap top to the SEACAT as was done during intialization.

* Boot computer with disk in drive A, type PROTERM, hit <> several times until S> prompt appears.

* Type DH to see how many casts the CTD has in memory. Verify this with the CTD field log sheet.

* To retrieve header data and save to a floppy, put a formatted floppy in the B drive, and type the F3 function key. The profiler will respond "capture data to disk without conversion, data not echoed to CRT, output file = _____". Enter b: filename <> (b:DDMYY#.hdr),(see below for convention). Type DH<> to dump headers to the CRT and floppy. When no more dots are being printed on CRT screen, press F4 to close the file.

* Press <> several times until S> appears.

* Next, type the F9 key which dumps profile data by cast to a seasoft compatible file. The computer will prompt you to assign a filename to each cast before it will dump the data. The filename convention for raw data will be as follows:

Symbols used for month designation in filenames:

J = Jan	Y = May	S = Sept
F = Feb	U = June	O = Oct
M = Mar	L = July	N = Nov
A = Apr	G = Aug	D = Dec

DDMYY## D=day, M=month, Y=year, #=cast number.

i.e. 26J8900 (Jan. 26, 1989, cast number 0)

26J89 (Jan. 26, 1989, cast number 1)
03A8915 (April 03, 1989, cast number 15)

This will create a data file with extension .DAT (automatic extension is assigned). If formatted disk in drive B is ready, push F10 button to continue. Computer will prompt you for cast number; start the cast numbers with 0, then 1 thru *. The first CTD cast number is always 0. Type in the cast number (should agree with # on filename) and hit <>. The data will dump from the SEACAT. After dump is complete (when no more dots are printing), hit F9 to dump consecutive cast and repeat steps. When all casts have been dumped, type F10 key to return to DOS. Run a Directory to verify successful data dump. Label backup disk as Disk A DDMMMYY, time, your initials, and put in a safe place. Record dump with number of casts and first and last filename on the CTD field log sheet.

* When all is acceptable, check the memory of the CTD and estimate if there is enough room for the remaining survey data to be collected. Our CTD can hold 43,302 samples (memory bytes - scratch pad bytes/bytes per scan). In PROTERM, type DS for CTD status and check number of samples. The expanded memory should allow us to take all of our stations without re-initializing in the field, but should it run out of room or looks like it will before the end of the day, type the IL <> command which will reset the memory at cast 0 and any previously recorded data will be written over. If this step is required, backup the data dump onto another formatted floppy before reinitializng. Make a note of this on the field log.

CTD Final Downloading Procedures

* Unplug dummy plug and hook up serial port to lap top or computer. Be sure CTD is turned off.

* Load SEASOFT software or fire up PROTERM. Press <> until S> appears. Now you are in communication with the CTD.

* Display Status by typing DS <> command. Print out status by typing - CTRL PrSc*. Initial and date the printout.

* Display Headers by typing DH <> command. Print out headers. Print headers from first data dump by commanding print from floppy, "PRINT *.hdr".

* To download header and data files (*.hdr, and *.dat), follow procedures listed under Field Data Dumps. Backup the second dump on the same disks as were used in the field, and assign continuation of casts in consecutive order (CTD will call first cast 0 if unit was re-initialized in the field). The software will warn you if the same filename has already been assigned. Once data has been downloaded and backed up, sign out on the CTD setup/download log and record any difficulties.

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APPLICATION NOTE NO. 2D Revised April 1990

INSTRUCTIONS FOR CARE AND CLEANING OF CONDUCTIVITY CELLS

Since any conductivity sensor's output reading is proportional to its dimensions, it is important to keep the cell clean of internal coatings. Also, cell electrodes contaminated with oil, biological growths, or other foreign material, will cause low conductivity readings.

If the cell is allowed to dry out between usage, salt crystals may form on (and in) the platinized electrode surfaces. When the instrument is next used, there will be a delay before these crystals are dissolved -- in the meantime, sensor accuracy may be affected. Therefore, we recommend that the cell be kept filled with distilled or de-ionized water between uses. A length of 7/16" ID Tygon tubing is provided for this purpose, to be connected in such a way that any air entrapped will be in the Tygon tube rather than in the cell.

An additional important benefit of keeping the cell ends closed with Tygon is to keep air-borne contaminants (of which there are an abundance on most research vessels) from entering the cell.

If it is not practical to keep the cell filled with distilled water between use (for example, in Arctic environments where freezing is a hazard), flush the cell with clean fresh water (preferably distilled or de-ionized) and close the cell with Tygon. Also, remember to keep the Tygon in a clean place (so that it does not pick up contaminants) while the instrument is in use.

Experience indicates that in normal intermittent use (such as in CTD profiling operations), drift rates of 0.0003 S/m (0.003 mmho/cm) or less per month can be expected **without any cleaning** if the procedures described above are followed.

PRECAUTIONS!!!!!!

The conductivity cell is primarily made of glass, and therefore is subject to breakage if mishandled. It is especially important to use the right size Tygon tubing, since if you use tubing with a too small ID, it will be difficult to remove the tubing, and the cell end may be broken if excessive force is used. **The correct size tubing for all instruments produced since 1980 is 7/16" ID, 9/16" OD (1/16" wall).** Instruments shipped prior to 1980 had smaller retaining ridges at the ends of the cell, and 3/8" ID Tygon is the right size for these older instruments. It is better to use Tygon than other plastic tubing, since it tends to remain flexible over a wide temperature range and with age.

Do not probe the interior of the cell with a Q-tip or other object, since if the platinized electrode surface is touched it will be necessary to replatinize the cell.

If your instrument is filled with distilled water, do not subject it to low temperatures which will freeze the water and break the cell. **Remove the water before shipment during the winter, or to Arctic regions at any season.** No adverse affects have been observed as a result of temporary "dry" storage, particularly if the cell is rinsed with fresh water before storage.

The anti-foulant used is a biological poison. Unnecessary handling of treated surfaces should be avoided, and your hands thoroughly washed after contact.

CELL CLEANING

Routine Cleaning (inside of cell not visibly dirty)

Fill the cell with a 1% solution of Triton X-100* and let soak for 30 minutes. This is most easily done by using a length of 7/16" ID Tygon tubing to form a closed loop including the cell. After the soak, drain and flush with warm (not hot) fresh water for 1 minute. Refill the cell with distilled water until the next usage.

Cleaning Severely Fouled Cells (visible deposits or marine growths on the inside of the cell)

Clamp the instrument so that the cell is vertical, and attach a length of 7/16" Tygon tubing to the lower end of the cell. Use masking or other tape to secure the open end of the Tygon about even with the top end of the cell. Pour Muriatic Acid (37% HCl) into the open end of the Tygon until the cell is filled to near the top and let soak for 1 to 2 minutes only. **Avoid breathing the acid fumes!!** Drain the acid from the cell and flush for 5 minutes with warm (not hot) fresh water. Also rinse the exterior of the instrument to remove any spilled acid from the surface. Then fill the cell with 1% Triton* solution, let stand for 5 minutes, and flush with warm fresh water for 1 minute. Refill with distilled water until the next usage.

If this process does not remove the visible deposits, it will be necessary to mechanically clean the cell with a small (0.275" diameter) soft-bristled nylon bottle brush and 1% Triton solution. **However, extreme care must be exercised, since the electrodes could be damaged if too large or too stiff a brush is used. Also, it is absolutely essential that the electrodes be replatinized after "brush" cleaning.** Our service department will clean and replatinize your cell for a nominal fee.

ANTI-FOULANT ATTACHMENTS

SBE 4-05 anti-foulant attachments are optional, and are recommended for moored applications where biological activity is anticipated. These small porous cylinders are impregnated with a toxic material, and are attached to each end of the conductivity cell, so that any water which enters the cell is treated. The SBE 4-05 attachments are effective for 6 months to 1 year, depending upon biological activity and upon water flow velocity past the instrument.

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*Triton X-100 (a trade name of J. T. Baker, Inc) is a concentrated liquid non-ionic detergent available at most chemical or scientific supply stores. Other liquid detergents can probably also be used, but scientific grades are preferable because of their known composition. It is better to use a non-ionic detergent since conductivity readings taken immediately after use are less likely to be affected by any residual detergent left in the cell.

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APPLICATION NOTE NO. 18-2 July 1988

pH SENSOR STORAGE, MAINTENANCE, AND CALIBRATION

When the pH sensor is not in use, replace the 'soaker' bottle over the plastic pH electrode. The procedure for doing this is to first remove the soaker bottle cap, slide it along the plastic pH electrode as far as it will go, then thread the bottle up into the cap. Remove the bottle by reversing the sequence. There should be enough fluid in the bottle to cover at least the glass electrode and teflon reference junction.

The 'soaker' fluid is pH 4 buffer solution saturated with KCL. Additional solution, if required, may be made using commercially available buffer capsules, KCL crystals, and distilled water.

The sensor will tolerate the periodic absence of the soaker bottle and can be returned to initial performance by soaking for a few hours. However, exposure of the bare sensor to temperature extremes (e.g., strong direct sunlight on a hot day) can cause a loss of internal electrolyte. Subsequent cooling will draw air into the sensor, which will lead to pressure-related problems.

The sensor contains a non-organic electrolyte and antibacterial inhibitors designed to optimize its use in marine environments.

Sea-Bird pH sensors are calibrated with commercial buffer solutions (+/- 0.02 pH). The user is advised to make periodic corrections by comparison to buffers near the anticipated in situ pH, typically in the 7 - 8 pH range. Best calibration of the sensor is obtained by soaking the sensor in deionized water for 30 minutes prior to standardization with buffers.

To calibrate the pH sensor, run SEACON and select voltage V2 for display. Then run SEASAVE selecting real-time data. Disassemble the DO/pH probe from its mounting cradle for easier access to the pH probe. Connect a small-gauge wire to the one of the screws at the connector end of the DO/pH housing and put the other end into the buffer solution bottle. Put the pH probe in the buffer solution and wait 1 minute for complete stabilization. Note the resulting voltage on the computer display. Repeat this process for at least 2 other values of pH, preferably 'bracketing' the range of interest.

See Application Note 18-1 for information about use of the PHFIT program (on SEASOFT disk 3) for calculation of pH calibration coefficients. The coefficients generated by PHFIT must be entered using SEACON.

OXYGEN SENSOR CLEANING AND STORAGE

Care must be taken to avoid fouling the oxygen membrane will oil or grease, and it is recommended that the oxygen sensor be rinsed with a 1% water-solution of Triton X-100 and flushed with distilled water after each use. With pumped instruments having a clear plastic manifold, loop tubing from inlet to outlet and partly fill with distilled water between deployments (if there is freezing danger, use only a few drops of water). With unpumped instruments, put a few drops of water in the DO sensor's red protective cap and thread the cap on securely. As an added benefit, the sensor will be kept free of airborne particulates that could otherwise coat the membrane and reduce the sensitivity.

For routine cleaning, soak the sensor in a 1% solution of Triton X-100 for 30 minutes. After the soak, drain and flush with warm (not hot) fresh water for 1 minute.

OXYGEN SENSOR DEPLOYMENT

Connect the pump tubing to the sensor manifold (pumped designs) or remove the red protective cap (unpumped designs) before deployment. **NOTE: Failure to remove the red cover will result in the crushing of the cover at depth and will cause destruction of the oxygen sensor.**

A large drop of undiluted Triton X-100 gently placed directly on the sensor membrane will protect the sensor from oil on the seawater surface. The Triton will quickly rinse away leaving behind a clean and fully functional sensor membrane.

To allow time for the oxygen sensor to polarize, the instrument to which it is connected must be powered for at least 2 minutes before beginning the water-column profile. Failure to wait will result in erroneously high oxygen readings. When taking water samples using a General Oceanics rosette, wait at least one minute after the bottle has been tripped (less time is required when the sensor has been recently energized) before resuming the CTD profile.

When using an unpumped oxygen sensor, a water flow speed of at least 0.5 meter / second (horizontal motion, current, or vertical profiling rate) must be maintained to avoid local oxygen depletion and erroneously low readings.

APPENDIX A CORRECTION FACTOR FOR NON-STANDARD ATMOSPHERE

$$nsa(T,bp) = (bp/pO) * (1 - (pH_2O/bp) / (1 - pH_2O/pO)$$

bp	=	barometric pressure in kilopascals
pO	=	101.325 kilopascals
pH_2O	=	water vapor pressure in kilopascals
T	=	water temperature in °C

$$pH_2O = \exp[(-216961 * X - 3840.7) * X + 16.4754]$$

$$X = 1/(T+273.15)$$

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APPLICATION NOTE NO. 13-4 2 March 1990

SBE 13/22/23 DISSOLVED OXYGEN SENSOR LIFE EXPECTANCY

This application note summarizes the material on sensor performance tests and other life-expectancy-determining criteria found in the Beckman 'MINOS DOM' (Dissolved Oxygen Monitor) manual published in 1971. MINOS DOM was a complete DO profiling instrument including pressure, temperature, and DO sensors as well as a single-conductor cable telemetering system and surface readout. Although this instrument is no longer available, the DO sensor (now manufactured by SensoMedics Corporation) upon which it was based continues to be used on modern CTD equipment. The original Beckman descriptions are therefore applicable. Some additional material based on Sea-Bird's experience is included in this note.

SENSOR MODULE LIFE EXPECTANCY BASED ON ELAPSED AND DEPLOYMENT TIME

Storage Life. Beckman gives a 'storage life' of 12 months for sensors stored in their sealed pouches (these sensors are typically received at Sea-Bird within one month of their manufacture and are in our inventory for less than 2 months). The meaning of 'storage life' as used by Beckman seems to be that the sensor can be considered 'new, unused' during the storage period. We believe that the 12 month storage life is a very conservative figure and that the sensor can be considered 'like new' for 2 years or more if properly stored.

Dryout Time. Failure can be caused by drying out of the sensor electrolyte, however the sensor will not dry out if maintained in a 100% relative humidity environment. This environment can be achieved with Sea-Bird sensors by either 1) installing the red protective cap after placing a few drops of fresh water inside (unpumped sensors); or 2) connecting plastic tubing partially filled with fresh water from the inlet to the outlet port (pumped sensors with clear plastic manifolds).

If the sensor is not kept in a 100% relative humidity environment, the dryout time can be calculated as:

minimum dryout time = 180 days X 100%/(100% - relative humidity)

For example, dryout time will be at least 360 days at 50% relative humidity.

Electrolyte Depletion. A final cause of sensor failure occurs as a result of electrochemical depletion of the sensor electrolyte as follows:

sensor life = 2160 hours/(PO_2)

Where PO_2 is the partial pressure of oxygen (in units of absolute atmospheres, i.e., 0.2095 or 159/760 mm Hg for dry air) in the environment being monitored. This gives a sensor life *in terms of actual powered operation* of 10,324 hours (well over one year at 100% air saturation).

SENSOR MODULE REPLACEMENT BASED ON SENSITIVITY

Beckman states that '...when continuously exposed to air or water, the sensor output gradually decreases to a point at which the (sensor) cannot be properly calibrated' and suggests that a 'rate of span loss of 2% per day' indicates that the sensor's electrolyte is nearly depleted and that the sensor should be replaced. In Sea-Bird's experience, use of the 2%/day criteria gives poor results because the sensor is failing so quickly; it is better to make an end-of-life judgment based on absolute sensor sensivitivity. A good rule-of-thumb is to replace the sensor when the Soc value obtained with air-saturated-water calibration reaches 4.0.

An oil film on the membrane will cause a reduction in output indistinguishable from sensor aging, so it is important that the sensor be kept clean.

SENSOR MODULE REPLACEMENT BASED ON SPEED OF RESPONSE

Typical response time is cited by Beckman as 'less than 6 seconds for 95% of the total response to a step change in oxygen concentration at 70 °F (21.1 °C)'. Since 95% of total response is the level reach in 3 'time constants', the 'time constant' for the sensor may be said to be 2 seconds. Beckman specifies the 95% response time at 32 °F (0 °C) as 18 seconds, so the time constant at this temperature will be 6 seconds.

Beckman states that a sensor whose 95% time response has decreased to 8 seconds at 70 °F should be replaced. They recommend using ambient air and an oxygen-free inert gas (usually nitrogen) to judge the time response. While the *increase* in response time is probably a valid indicator of the sensor's approaching end-of-life, most users will find it awkward to perform the necessary measurements.

SUMMARY OF RECOMMENDATIONS

1. Keep the sensor in a moist (100%) environment when not deployed. Air exposure for a few hours between casts will cause no significant shortening of life, however.

2. Keep the sensor membrane clean by rinsing it with Triton X-100 (liquid detergent).

3. Perform monthly or pre-deployment calibration checks using air-saturated water and sodium sulfite (see AN 13-1 for a description of this procedure). When Soc (as determined using the Sea-Bird OXFIT routine) reaches 4, replace the sensor. In our experience, this replacement will usually be required between one and two years after first deployment.

4. Routinely replace the sensor module (the brown-colored part containing the membrane) after two years service. The remainder of the sensor assembly (receptacle) has an unlimited operating life.

APPENDIX F

APPENDIX F

Dissolved Oxygen -- A pre-cleaned 300 mL BOD glass stoppered bottle is used for dissolved oxygen samples. Powder pillows containing manganous sulfate, and alkaline azide in powder form, are the reagents used for fixing the oxygen in the samples. Dissolved oxygen is the first sample collected from a given cast. After the samples have been fixated, they are stored in the dark. Sulfuric acid is added to each sample at the AMS lab after each survey, and the samples are analyzed within three days of collection.

This method of analyzing for dissolved oxygen is the proven modified Winkler method, described in Standard Methods (APHA *et al.*, 1989). Currently, the Department of Ecology is not set up to conduct oxygens by the Carpenter Method as recommended in the PSEP Protocol procedure (PSEP, 1990). For the purposes of these samples (general calibration checks), the existing method used by Ecology is adequate. Since liquid chemicals are not allowed on the seaplane for safety reasons, powdered versions of the reagents are used. Sulfuric acid cannot be taken out on the plane either, therefore, the samples are acidified immediately following the survey, usually within six hours.

Nutrients -- Nutrient concentrations derived from the water samples include dissolved nutrients (ammonia, nitrate-nitrite, nitrite, orthophosphorus), and total nutrients (total nitrogen and total phosphorus). For dissolved nutrient samples, pre-cleaned 125 mL brown polyethylene bottles are used. Bottles and caps are rinsed with sample water three times before filling. The bottles are then filled 3/4 full. The samples to be filtered are done so upon arrival at the lab or filtered in the field. Total nutrient samples are collected in clear 125 mL polyethylene bottles and are preserved in the field with 0.3 mL of sulfuric acid (TP and TPN). The sample is labeled and put on ice prior to lab delivery.

NOTE: This procedure deviates slightly from the recommended PSEP Protocol procedure (PSEP, 1990). Filtering in the field would be difficult to accomplish due to time limitations. Therefore, the samples are filtered at the laboratory (within 24 hours). There is no protocol for total nitrogen nor total phosphorus.

Chlorophyll *a* -- Only a small sample volume is necessary for chlorophyll *a* analysis using the fluorometric method. A pre-cleaned 125 mL brown polyethylene bottle is used. The sample is stored on ice prior to lab delivery. The sample is filtered with a 0.70 μm filter. Filters should be stored in the dark in a desiccant and frozen, or analyzed immediately.

NOTE: This procedure deviates slightly from the recommended protocols for the same reasons as the nutrient sampling procedure.

Fecal coliform bacteria -- Sterile 250 mL glass bottles with sterile caps are used. Bottles are placed in a sample holder, lowered to just below the surface, and allowed to fill. The sample is retrieved, and 1/4 of the sample poured out. The cap is replaced, the bottle labeled, and the sample is put on ice.

Conductivity -- A pre-cleaned 500 mL clear polyethylene bottle is used for conductivity samples. The bottle and cap are rinsed with sample water three times prior to filling. The bottle is filled half way, capped, labeled, and stored in the cooler prior to lab delivery.

Polyethylene bottles are not the recommended bottles stated in the PSEP Protocols. Over long periods of time (two plus months), salinity samples stored in polyethylene bottles will suffer a salinity change, as much as one-tenth a part per thousand (Kathy Krogslund, Personal Communication, 1989). The PSEP Protocols (PSEP, 1990) recommend using glass borosilicate bottles for salinity samples to help avoid this change. These bottles are expensive, and can break much easier. For the purposes of the conductivity/salinity samples collected during this program (general calibration checks), and because the samples are analyzed usually within two weeks of collection, polyethylene bottles will be used.

Phytoplankton -- Two techniques are available for plankton analysis (Sournia, 1978). The usual method examines a concentrated preserved sample in one or more counting slides having chambers appropriate to the dimensions and abundances of the algae in the sample. In the second method, a preserved sample is concentrated by sedimentation in the combined plankton chamber designed for use with an inverted microscope. Using the second method, the whole bottom, or known fraction, of the chamber is first scanned using the low power objective of a standard microscope, then the central portion of the chamber is examined for abundant small species using a higher magnification lens. The advantage to the first test is the excellent optical resolution permitted without use of the inverted microscope. Plankton will be identified to the lowest known taxon. In some cases the plankton will only be identified into groups based on size and shape. Quantities of each species will be reported.

APPENDIX G

APPENDIX G

Fecal Coliform Bacteria -- The membrane filter method described in Standard Methods for the Examination of Water and Wastewater, 17th Ed., No. 9222 D., "Fecal Coliform Membrane Filter Procedure" (APHA *et al.*, 1989) is used for fecal coliform bacteria analysis. The samples are cultured within 24 hours.

QA/QC -- If sample bottles are overfilled, the results will be flagged with the appropriate QC code. Sample results with large numbers of background organisms are also coded. One duplicate is filtered and analyzed separately per sample batch, and blanks are run.

NOTE: This holding time differs from the recommended six hour holding time in the PSEP Protocols (PSEP, 1990). Ecology samples cannot be analyzed within six hours, thus are cultured within 24 hours and analyzed after an incubation period of 24 hours.

Nutrients -- Methods for the analysis of all nutrients follows the recommendations in the PSEP Protocols (PSEP, 1990). Each nutrient to be analyzed is briefly discussed. Holding time for all the dissolved nutrients (except ammonia) is 28 days if the filtrate is frozen at -20°C, preferably on dry ice. Ammonia should be analyzed within seven days of collection and freezing is not recommended if it is possible to analyze the sample immediately. If samples are not frozen after being filtered, they should be analyzed immediately.

QA/QC -- A three point calibration is conducted per sample batch. Two check (control) standards and one duplicate are analyzed per twenty (or per batch if less than 20) samples. Two blanks and one spike are analyzed per sample batch. Samples will be re-run if the batch has failed to pass QA/QC criteria. These include:

a. qualitative interpretation of the peak shapes;
b. baseline drifting;
c. carry-over problems;
d. pH effects; and
e. QC factors, such as:
   1. high blanks;
   2. poor recovery of check standards (>10%);
   3. poor ability to reproduce values with replicates (>10%); and
   4. poor spike recovery (lower than 70% or higher than 130%).

None of the factors alone warrant a repeat of a batch of samples, but a combination of the above does. The analyst looks at the results and prioritizes them in the order "a" through "e" and within "e", 1 through 4, with "a" and 1 being the highest priorities.

Nitrogen (Ammonia) -- The recommended analytical method for ammonia is described by Parsons *et al.*, (1984). Ammonia is analyzed using an autoanalyzer. Ammonia is determined

colorimetrically by observing the formation of indophenol blue at 630 nm by using the appropriate wavelength filters. The color is intensified by the addition of sodium nitroprusside to the reaction mixture. Values are reported in terms of nitrogen. Detection limits for Ecology samples are 0.01 mg N/L. (This detection limit is in the process of being lowered.)

Nitrogen (Nitrate-Nitrite) -- The recommended analytical method for nitrate-nitrite is described by Parson *et al.*, (1984). Nitrate-nitrite is determined using an autoanalyzer. The sample determination utilizes a procedure where nitrate is reduced to nitrite by a copper-cadmium reductor column. The nitrite ion then reacts with sulfanilamide under acidic conditions to form a diazo compound. This compound then couples with N-1-Napthylethylendediamine dihydrochloride to form a reddish-purple azo dye. Analysis is performed colorimetrically by observing the formation of the reddish-purple azo dye at 550 nm. Detection limits for Ecology are 0.01 mg N/L.

Nitrogen (Nitrite) -- Same as nitrate-nitrite, but nitrite is determined by observing the formation of the soluble dye at 540 nm. Detection limits for Ecology are 0.01 mg N/L.

Nitrogen (Nitrate) -- The difference between nitrate-nitrite and nitrite is the concentration of nitrate, reported to detection limits of 0.01 mg N/L.

Orthophosphorus -- The recommended method for orthophosphorus analysis is described in Parsons *et al.*, (1984). Orthophosphorus is determined using an autoanalyzer. Orthophosphorus reacts with ammonium molybdate in an acid medium to form molybdophosphoric acid which is reduced to the molybdenum blue complex with ascorbic acid. Orthophosphorus is determined colorimetrically by observing the formation of the molybdenum blue complex at 880 nm by using the appropriate wavelength filters. Detection limits for Ecology are 0.01 mg N/L.

Total Nitrogen (Total Persulfate (TPN)) -- The method used by Ecology for analyzing total nitrogen uses a persulfate digestion as described in Koroleff, 1972 and D'Elia *et al.*, 1977. Total Kjeldahl procedures yield total Kjeldahl nitrogen (TKN) which includes most organic-N compounds and ammonia, but neither nitrate nor nitrite. With the persulfate method, alkaline persulfate oxidation of water samples yields NO3-N as the sole product and conversion of all species to NO3-N is complete. The reporting limits for Ecology are estimated at 0.05 mg N/L.

Total Phosphorus -- Total phosphorus is determined by using the EPA Method 365.1 (U.S. EPA, 1982). Phosphorus is converted to dissolved orthophosphorus by ammonium persulfate/ sulfuric acid digestion. The resulting dissolved orthophosphorus reacts in acidic solution to form molybdophosphoric acid which is then reduced to the molybdenum blue complex by reaction with ascorbic acid. The digestion is completed by heating on a hot plate until about 10 mL of solution remains. The dissolved orthophosphorus of this digestate is determined colorimetrically by observing the formation of molybdenum blue complex at 880 nm. Detection limits are reported to 0.01 mg P/L.

Chlorophyll *a* (and Phaeopigments) -- Chlorophyll *a* determinations using the fluorometric method are described in Parsons *et al.* (1984). The sample is filtered and the filter containing the planktonic concentrate is preserved with magnesium carbonate and either analyzed immediately, or desiccated and frozen for storage. The chlorophyll pigments are extracted from the plankton concentrate with aqueous acetone, and the red fluorescence of the extract (excited by blue light) is determined with the fluorometer. The positive influence of pheophytin is removed by acidification of chlorophyll *a* to pheophytin *a*. (Phaeopigments are a collection of several pigments.)

QA/QC -- Chlorophyll samples cannot be re-analyzed, thus care should be taken in the determination of chlorophyll *a* and pheophytin. One standardization per year and one check control standard per year are conducted. Duplicates are run with a batch of 20 samples or less. Two blanks are run per batch of samples.

Conductivity/Salinity -- The method for measuring conductivity in the laboratory is described in Standard Methods for the Examination of Water and Wastewater, 17th Ed., No. 2520 B., "Electrical Conductivity Method" (APHA *et al.*, 1989). A Wheatstone bridge with null indicator is used to measure the ration of applied alternating current through the conductivity cell to the voltage across the cell. Values are expressed in μmho/cm at 25°C. These values are then converted to salinity concentrations in parts per thousand for comparison to the CTD salinity values. Detection limits are 0.1 parts per thousand.

QA/QC -- Both the above methods are tested using blanks and Copenhagen Standard Seawater (approx. 34.32 to 34.99 ppt). KCL standards have posed problems with respect to accurate instrument reading as well as titrations, therefore, real seawater will be used to create standards. Splits of the standards collected will be sent to the University of Washington Marine Chemistry Lab for analysis. Conductivity equipment is maintained on a regular basis including cell cleaning, electronic checks, cell platinization when needed (annually), and cell constant determination.

Dissolved Oxygen -- The dissolved oxygen content is determined using the azide modification of the Winkler titration as described in the Standard Methods (APHA *et al.*, 1989). The samples are fixated in the field with manganous sulfate and alkaline azide. Sulfuric acid is then added to the sample. The sample is titrated with a thiosulfate solution to a clear end point. The volume of thiosulfate used to reach this endpoint is equivalent to the concentration of oxygen in the water in mg/L.

QA/QC -- Thiosulfate used for winkler titrations is standardized against a known normality of bio-iodate. Ten milliliters of bio-iodate with the same molarity of the thiosulfate is titrated. The endpoint value of thiosulfate used if other than 10 mL, is used to compute a correction factor to the dissolved oxygen values, simply by dividing the volume of bio-iodate (10 mL) used by the volume of thiosulfate used. This correction factor should be determined for each batch of dissolved oxygen samples processed.

Phytoplankton -- Two techniques are available for plankton analysis (Sournia, 1978). The usual method examines a concentrated preserved sample in one or more counting slides having chambers appropriate to the dimensions and abundances of the algae in the sample. In the second method, a preserved sample is concentrated by sedimentation in the combined plankton chamber designed for use with an inverted microscope. Using the second method, the whole bottom, or known fraction, of the chamber is first scanned using the low power objective of a standard microscope, then the central portion of the chamber is examined for abundant small species using a higher magnification lens. The advantage to the first test is the excellent optical resolution permitted without use of the inverted microscope. Plankton will be identified to the lowest know taxon. In some cases, the plankton will only be identified into groups based on size and shape. Quantities of each species will be reported.

APPENDIX H

DATA REPORT RESULT QUALIFIERS

Data reports from the laboratory will use the following reporting qualifiers. These qualifiers indicate the reason the analyses did not produce a numeric result or when a numeric result is reported, a remark code is used to qualify the data value.

These are provided to help the user interpret the data reports issued from the laboratory.

List of Qualifiers for Non-numeric Results

Qualifier	Full Name	Definition
FPS	Failed Preliminary Screening	A preliminary screening of the sample for the subject parameter was conducted with negative results.
NSQ	Not Sufficient Quantity	There was not a sufficient quantity of the sample to conduct an analysis to determine the concentration of the target parameter.
LAC	Laboratory Accident	There was an accident in the laboratory that either destroyed the sample or rendered it not suitable for analysis.
FAC	Field Accident	There was an accident in the field that either destroyed the sample or rendered it not suitable for analysis.
ISP	Improper Sample Preservation	Due to improper preservation of the sample, it was rendered not suitable for analysis.
NAI	Not Analyzed Due to Interference	Because of uncontrolled interference the analysis for the subject parameter was not conducted.
NAR	No Analysis Result	There is no analysis result. Reason is unspecified.
PNQ	Present But Not Quantified	The subject parameter was present in the sample but no quantifiable result could be determined.
CAN	Cancelled	The analysis of this parameter was cancelled and not performed.
FQC	Failed Quality Control	The analysis result is unusable because quality control limits were exceeded when the analysis was conducted.

Qualifier	Full Name	Definition
NA	Does Not Apply	
CON	Confluent Growth	
OHT	Over Holding Time	No analysis.
OHTX	Over Holding Time	Due to equipment failure.
TNC	Too Numerous to Count	
BDL	Below Detectable Limits	There was not a sufficient concentration of the parameter in the sample to exceed the lower detection limit in force at the time the analysis was performed.
E	Exponent	Used to report results with large values. The value is equal to the number before E times 10 to the power of the number after E.

List of Qualifiers for Numeric Results

Remark Code	Definition
B	Analyte is found in the blank as well as the sample, indicated possible/probable blank contamination.
J	Estimated value; value not accurate.
M	Presence of material verified but not quanitifed.
U or K	Compound was analyzed for but not detected. The number is the minimum detection limit.
UJ	Compound was analyzed for but not detected. The number is the estimated minimum detection limit.
C	The value is one of, or the sum of both, Benzo (b) Fluoranthene and Benzo (k) Fluoranthene.
X	Many background organisms.
S	Spreader.
H	Over holding time. Analysis run.
G	Improper container.
L	Total plate count greater than 200.
Z	Sample low due to interfering substance.
D	Sample high due to interfering substance.
IS	Interfering substance.
P	Greater than. (>)

APPENDIX I

APPENDIX I

Emergency Contact List

I. THE FOLLOWING ARE FOR EMERGENCY USE ONLY AND NOT FOR GENERAL INFORMATION

Emergency air lift ambulance services

Air-Evac International	1-800-854-2569
Airlift Northwest	1-800-542-1646
EMS Helicopter	1-206-733-3096
Dial	911

II. VHF Radio Frequencies

Emergency	16
Seattle Traffic (VTS)	22
Fishers channel	67
Marine Operator	
Seattle	25,26
Tacoma	28
Olympia	85
Port Angeles	25
Bellingham	28,85

III. Regional Emergency Telephone Numbers

REGION 1

Bellingham Bay/Whatcom County
St.Luke's General Hospital; 809 E. Chestnut Street; Bellingham; 1-206-734-8300
St. Joseph's Hospital; 2901 Squalicum Pkwy; Bellingham; 1-206-734-5400

Emergency Services and Transportation

Whatcom County Sheriff	1-206-676-6650
Bellingham Police Dept.	911
Bellingham Fire Dept.	911

Hubbard Ambulance	1-206-676-9555
United States Coast Guard	1-800-592-9911

Anacortes/Skagit County
Island Hospital; 24th and M Avenue; Anacortes; 1-206-293-3181

Emergency Services and Transportation

Skagit County Sheriff	1-206-336-3146
Island Hospital Ambulance Service	1-206-293-3181
Anacortes Fire Department	911
Anacortes Ambulance Service	911

REGION 2

Olympic Memorial Hospital; 939 Caroline; Port Angeles; 1-206-457-8513

Emergency Services and Transportation

Clallam County Sheriff	911
Port Angeles Police Dept.	911
Port Angeles Fire Dept.	911
Olympic Ambulance Service	1-206-683-3347
Port Angeles Ambulance Service	1-206-452-2366
United States Coast Guard	1-206-457-4401

Port Townsend
Jefferson General Hospital; 834 Sheridan Avenue; Port Townsend; 1-206-385-4622

Emergency Services and Transportation

Jefferson County Sheriff	1-800-552-0750
Port Townsend Police Dept.	911
Port Townsend Fire Dept.	911
United States Coast Guard	385-3070

REGION 3

In North Hood Canal, use emergency services from Port Townsend.

Bremerton
Harrison Memorial Hospital; 2520 Cherry Avenue; Bremerton; 1-206-377-3911

Emergency Services and Transportation

Kitsap County Sheriff	911
Bremerton Police Dept.	911
Bremerton Fire Dept.	911
Olympic Ambulance Service	1-206-377-7777

Shelton
Mason General Hospital; 2100 Sherwood Lane; Shelton; 1-206-426-2611

Emergency Services and Transportation

Mason County Sheriff	911
Shelton Police Department	911
Shelton Fire Department	911

REGION 4

Everett
Everett General Hospital; (Trauma Center); 14th and Whitmore; Everett; 1-206-258-6301
Providence Hospital; 916 Pacific Avenue; Everett; 1-206-258-7555

Emergency Services and Transportation

Everett Police Dept.	911
Everett Fire Dept.	911
Everett Ambulance	1-206-252-1234
Shepard Ambulance	1-206-258-1825
United States Coast Guard	1-206-252-5281

REGION 5

Seattle
Haborview Medical Center; (Trauma Center), 325 9th; Seattle; 1-206-223-3074
Virginia Mason Hospital; 925 Seneca; Seattle; 1-206-624-1144
University Hospital; 1959 NE Pacific Avenue; Seattle; 1-206-548-4000

Emergency Services and Transportation

King County Sheriff	911
Seattle Police Dept.	911
Seattle Fire Dept.	911
Shepard Ambulance Service	1-206-322-0330
United States Coast Guard	1-206-422-7070

South King County
Renton
Valley Medical Center; 400 South 43rd; Renton; 1-206-251-5185
St. Francis Community Hospital; 34515 - 9th Avenue South; Renton; 1-206-927-9700

Tacoma
St. Joseph's Hospital; (Trauma Center); 1718 South I Street; Tacoma; 1-206-591-6660
Tacoma General Hospital; 315 South K. Street; Tacoma; 1-206-594-1050

Emergency Services and Transportation

Pierce County Sheriff Dept.	911
	1-800-562-9800
City of Tacoma Emergency Servs.	1-206-591-5747
Pierce County Emergency Servs.	1-206-593-4797
Tacoma Police Dept.	1-206-593-4911
Washington State Patrol	1-206-593-2424
Tacoma Fire Dept.	1-206-627-0151
Shepard Ambulance Services	1-206-383-5416
Oliver Ambulance Service	1-206-572-3111
United States Coast Guard	1-206-858-9998

REGION 6

Gig Harbor
Pennisula Ambulance and Paramedic Service; 1-206-851-2383

Olympia
St. Peter's Hospital; 413 North Lilly Road; Olympia; 1-206-456-7289
Capital Medical Center; 3900 Capital Mall Drive SW; Olympia; 1-206-754-5858

Emergency Services and Transportation

Thurston County Sheriff	911
Olympia Police Dept.	911
Olympia Fire Dept.	911
Olympic Ambulance and Cabulance	1-206-491-3200
United States Coast Guard	1-800-592-9114