ECOHAB PNW 2 CRUISE REPORT

R/V Wecoma W0308C
Aug 30 - Sept 19, 2003

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Area of Operations

Coastal Waters off Washington State and Vancouver Island

Itinerary

Depart Seattle, WA, August 30, 2003
Arrive Seattle, WA, September 19, 2003

Participating Organizations

NOAA/Northwest Fisheries Science Center
San Francisco State University
University of Maine
University of Washington
University of Western Ontario

Chief Scientist

Dr. Barbara M. Hickey, School of Oceanography, University of Washington

Personnel

Nicolaus Adams, NOAA/Northwest Fisheries Science Center, Cruise Chief

Principle Investigators

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Dr. Evelyn Lessard, University of Washington
Dr. Vera. Trainer, NOAA/Northwest Fisheries Science Center
Dr. Mark Wells, University of Maine

Staff

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Susan Geier, University of Washington
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Nicolas Ladizinsky, San Francisco State University
Keri Baugh, NOAA/Northwest Fisheries Science Center
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Students

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Amy MacFadyen, University of Washington (Ph. D.)

Brady Olson, University of Washington (Ph. D.)
Liza McClintock, University of Western Ontario (Ms.)
Lisa Pickell, University of Maine (Ph. D.)
Sheri Floge, University of Maine (Ms.)
Jeannie Bush, University of Washington (B.S.)
Megan Bernhardt, University of Washington (B.S.)

Cruise Objectives

The purpose of this cruise was to measure the physical, chemical and physiological conditions under which the algae *Pseudo-nitzschia* produce the toxin domoic acid, and when the toxin is released into the environment. We attempted to observe the conditions under which the released domoic acid moves toward the coast of Washington, where it can be taken up by shellfish. Such occurrences lead to closure of beaches to razor clam collection to avoid outbreaks of amnesiatic shellfish poisoning. Measurements made included continuous surface water properties, temperature, salinity, fluorescence, as well as discrete surface samples for particulate and dissolved domoic acid, chlorophyll concentration, and identification of phytoplankton species. In these surveys profile data taken with the CTD (conductivity, temperature, depth) included extra sensors that measured fluorescence, photosynthetically active radiation (PAR), beam attenuation (light transmission), and oxygen concentration. During CTD casts discrete samples were taken for chlorophyll and nutrient analyses. An iron pump was used to measure iron concentration. On deck incubations of phytoplankton for growth experiments, as well as shipboard laboratory analyses of the plankton were conducted. Satellite tracked drifters were released in the strait, near the Juan de Fuca eddy and off the coast of Washington. The ship followed these drifters for several days each, so that the same parcels of water could be resampled as they aged, and thus measure in situ changes in the physical, chemical and biologic constituents. The ship track and sampling stations are shown in Figure 1.

Operations

ADCP lines: ~4100 km
Flow-Through system track with T,S,FL sensors: ~4100 km
CTD casts: 228
Mooring light repair
Satellite-tracked buoy deployments: 7 (one recovered and redeployed)

Samples Collected

Chlorophyll samples: 167 stations
Nutrient samples: 121 stations
Microzooplankton samples: 15 profiles, 8 dilution experiments
Phytoplankton/Domoic acid samples: 236 stations
Fe samples (pumped): 4 profiles, >60 from 10 m depth
Zooplankton net tows: 21

Cruise Summary

Introduction

The ECOHAB 2 cruise was highly successful. Several of the new technologies that had problems on the first cruise were solved prior to or during the second cruise. For example, the FlowCAM, an imaging cytometer used to rapidly identify and count plankton > 5 μm, was operational after a factory retrofit (Lessard). The custom-made iron pumping system worked flawlessly so that uncontaminated water samples could be obtained throughout the cruise (Wells). Iron measurements were obtained at sea for the first time using was also a newly designed chemiluminescent assay instrument (Wells). The flow injection analysis system was used to analyze dissolved nutrient samples at sea and in near real time (Cochlan).
The study included obtaining multi disciplinary data from a large scale grid (Section 1), sampling water properties while following a drifter (Section 2), deployment of surface drifters (Section 3), satellite imagery (Section 4), and laboratory studies using water collected at selected sites (Section 5).

The setting of cruise sampling events with respect to wind direction (upwelling or downwelling favorable) is shown in Figure 2. The sequence of weather conditions allowed a variety of water and plankton conditions to be sampled. Surveys and sampling were performed under strong, persistent upwelling conditions (the first half of the cruise), downwelling conditions (3.5 days only) and then weak upwelling or downwellling conditions (the last week); overall similar to the sequence on the June ECOHAB PNW cruise. Over 250 data profiles were obtained. Satellite imagery (SST and chlorophyll) was obtained on a number of days due to the generally good weather. Cruise activities were recorded in a sequential “Event” log (Table 1) from which summary tables discussed below were derived.

The cruise was broken September 10 when we came to Neah Bay to exchange staff in Trainer’s group via a small boat. A failed light was repaired on the EH1 buoy at the same time.

On this cruise samples were also taken at three sites in Puget Sound on the return to port. Toxic *Pseudo-nitzschia* (*PN*) blooms had been reported in these areas a few days prior to our sampling. Beaches had been closed to shellfish harvesting due to DA levels above the regulatory limit. These were the first DA related closures in Puget Sound The areas in which the *PN* bloom was found were near Admiralty Inlet.

1. Regional Surveys (ECOHAB PNW team)

The large scale survey grid was designed to include areas influenced by the Strait of Juan de Fuca, the Juan de Fuca eddy region and the coastal upwelling region off the Washington coast (Fig. 3). Data collected on surveys included conductivity (C), temperature (T), light transmission, PAR, oxygen and fluorescence (Fl) profiles, and bottle samples for chlorophyll, sandwich hybridization assays, whole cell fluorescence assays, particulate domoic acid, dissolved domoic acid, samples for scanning electron microscopy of *PN* species, plankton and macronutrients, all at selected depths. Surface net tows for qualitative community assessment were taken at all survey stations. Water samples containing *PN* were placed in medium for isolation and culturing in the laboratory. Underway data included T, S and Fl pumped from a depth of about 4 m near the ship’s bow as well as ADCP current profiles from both a 75 khz Ocean Survey broadband RDI ADCP and a 150 khz narrowband RDI ADCP. An ISUS nitrate sensor was tested for the first time during this cruise and provided some underway data after problems with equipment calibration were resolved. Preliminary water property maps and sections are given in Appendix A (T, S, O2, Chl, Fl maps at selected depths) and Appendix B (T, S, density, Fl transects versus depth for all transects, 0-100 m and 0-500 m scales).

A list of CTD stations organized by sample line and including bottle sample types taken is given in Table 2. Lines were sampled in whichever direction made best use of ship time. Also note that occasional short (1-4 hours) time gaps occurred due to rough weather and also due to the necessity of providing a more stable platform for bio-chemical sampling.
CTD profiles were taken to 500 m where possible. Deeper data were taken on the LP line on Survey 1 (only). Chlorophyll, particulate and dissolved domoic acid and plankton samples were taken near surface, 5 m, 10 m and at the chlorophyll maximum. Macro nutrients were taken generally at the surface, 5 m, 10 m, 15 m, 30 m, 50 m, 100 m, 200 m, 500 m and ~5-10 meters above bottom if the bottom was less than 500 m deep. At canyon stations 5 m and 15 m samples were omitted. In the strait survey, samples were taken also at 150 m. On survey grids, nutrients were taken in most cases at the two stations closest to shore on a line and then every other station on each line. Chlorophyll samples were taken at most stations.
Upper water column iron samples were taken at selected stations (Tables 1 and 2). These samples were obtained by weighting the iron “fish” below the surface (~10 m). Samples typically were taken as the ship left station. Water was pumped for roughly 15 minutes to flush the lines thoroughly before samples were taken. Vertical iron profiles were obtained at several stations by lowering the fish to the target depths (typically 10, 15, 30 and 100 m depth).

The data are organized into four periods: Survey 1 (September 1-6), Survey 2 (September 6-12), Survey 3 (September 12-17) and Survey 4 (September 17-20; strait and Puget Sound samples only) (Fig. 2). Survey grid stations sampled in each period are shown in Figure 4a,b,c,d. The first survey (Fig. 4a), which took place during persistent and strong upwelling favorable winds and warm, sunny weather, was the most complete survey. Drift DD started at the start of Survey period 2 and continued through the downwelling period. The water for drift DD was taken from the southwest edge of the eddy or in the shelf break coastal jet region (ie; we believe, “aged “water). The downwelling period (Survey 2, Fig. 4b) was shorter and also some time was spent following drift DD. Consequently none of the southern lines could be sampled. The biologists took water for on deck experiments at LA2 during this period. This station was in strait/eddy water. The weaker, less intermittent upwelling period (Survey 3, Fig. 4c) was sufficiently long to sample three southern lines; a new line farther south offshore of Grays Harbor (GH) was added to ensure that we were sampling ahead of a toxic “hot spot” that had been discovered (see below). The LP line was sampled twice; once, during the weak upwelling, and a second time after stronger upwelling to see whether the cap of freshwater from the Columbia plume preventing upwelling under weaker wind conditions, had finally moved offshore (it had; see below).

The usefulness of (a) near real time domoic acid analyses and (b) simultaneous physical data were clearly demonstrated on this cruise. A region of high DA was discovered after the Chief Scientist requested immediate analysis of DA samples for a station showing high *PN*. After this discovery the patch was relocated by estimating drift path from our satellite-tracked drifters . A drift station was begun (DE) and indeed the domoic acid levels were extremely high in this patch. The drift was terminated when it became clear that this patch would not likely return to the coast as the plume from the Columbia River was on its shoreward side.
CTD/nutrient transects were made also along the axis and across Juan de Fuca canyon during weak upwelling conditions (Fig, 4d). The same sections were made in June under weak downwelling conditions. Note that on both June and September ECOHAB cruises deeper nutrients were collected on these sections to provide input for modeling studies.

The CTD data were partially edited onboard ship. These data were used to construct the preliminary maps and sections appended to the report. Following the cruise, salinity calibration will be performed and more detailed editing completed (Hickey group). Although water property spatial patterns are likely robust, actual values may change slightly following the final editing which we hope to complete this fall. ADCP and water property data require more extensive processing and will be provided later this year (Foreman group).

Some Preliminary Results (Hickey):

The first survey clearly captured the strong coastal upwelling that was occurring during that period (Appendix A, surface maps). The saltiest water was observed near the coast. Cold water at the surface appeared to emanate from the strait and also from the coastal upwelling region.

The surface chlorophyll during the first survey showed two regions of high values—one offshore of the strait and southeast of Barkley Sound, the other, off the sourthern Washington coast. As in the June ECOHAB cruise, between these two maxima was a region of lower chlorophyll that appeared to emanate from the strait. This low chlorophyll region was observed also in several of the chlorophyll satellite images. Low chlorophyll appears to emanate from the strait. The eddy center—defined as the region of maximum property "doming", varied between depths during the first survey period.

As in the June cruise, during intermittent and weak upwelling (Survey 3) the Columbia River plume occupied the stations nearest the coast at least from La Push south, preventing upwelling on the inner shelf. This was confirmed by a series of inner shelf stations from Grays Harbor to La Push. The La Push line was repeated in Survey 3 to determine whether winds of 20 m s-1 were sufficient to move the plume offshore; they were.

2. Drift Surveys (Amy MacFadyen, Barbara Hickey, drifters; whole team for water samples)

Two drift surveys were performed, following water patches with a GPS-tracked Brightwaters drifter. Drogues were set at 5 m to best accommodate disparate sampling strategies. For example, Wells samples were taken a bit deeper (~ 8-10 m) due to requirements of the iron pumping fish; Lessard sampled at 3-5 m to obtain ideal light levels. Deployment and recovery times and deployment location are listed in Table 3. Note that drifts are being numbered sequentially beginning with drifts on the first ECOHAB cruise. CTD profiles and bottle casts were taken at the start of each drift and water was collected for incubation experiments. CTD profiles and nutrients were taken generally at 12 hour intervals.

The first drift (DD, 3818) was begun on the western edge of the eddy in "aged" water at LA10. The drifter was followed for 2 days and aborted since the water mass had changed. Following the drift, the drifter was left in the water until the cruise end and then recovered. The second drift (DE, 3918) was begun offshore of the coastal upwelling region just south of KB5, halfway to the CB line, after relocating a patch with high *PN*. Although the first drift water had reasonably high levels of particulate DA, the second drift had extremely high levels of particulate DA. Interestingly, the final paths of the two drifts merged (Fig. 6) so that one might speculate that water from the first drift drifted to the site of the second drift.

The deckboard grow-out incubations (Wells/Cochlan/Trick) were typically run for 4-5 days. Water was collected at the time the drifter was deployed. Treatments for the deckboard experiments included both metal (Fe, Cu) and chelator (desferal, domoic acid) manipulations. Incubation bottle and in-situ samples were taken for Chl a, nutrients, cell composition and domoic acid concentrations. Samples for bacterial productivity and Fe uptake measurements were additionally taken for the deckboard experiments.

Deckboard dilution experiments (Lessard) were run for 24 hours with water collected at the beginning, middle and end of each drifter survey. Samples for size-fractionated chlorophyll, picoplankton, nanoplankton and microplankton, macronutrients, dissolved and particulate DA and sandwich hybridization assays were taken in each experiment. Experimental manipulations included the addition of DA, Fe and macronutrients.

3. Drifter Deployments (Amy MacFadyen, Sue Geier, Barbara Hickey, Bill Fredericks)

Two Davis-type Clearwater GPS drifters and one Brightwater drifter were deployed to delineate patterns and speeds of surface flows in the eddy area, as well as to determine the ultimate fate of eddy water. Drifter deployment and recovery times and deployment locations are given in Table 3.

Data were stored at UW and also transmitted to the ship by Bill Fredericks. Deployment times and locations are listed in Table 3. Drifter location and water temperatures are available at 30 minute intervals during deployment. The three remaining drifters will continue to collect data until about the end of October.

Two drifters were deployed at the beginning of the cruise inside the strait. One (3901) was drogued at 20 m, the other had no drogue (3885). The pathways of the two drifters differed radically. The deeper drifter was caught in the nearshore Vancouver Island Coastal Current, staying next to the coast past Barkely Sound, where it was recovered. The surface drifter exited the strait farther from the coast, made one small circuit of the eddy, a second larger circuit and a partial third circuit. It then entered the strait where it became caught in kelp and was subsequently recovered.

Drifters deployed in the north portion of the eddy failed to join the eddy (Fig. 6). Particularly during downwelling (survey 2), the drifters showed little organized motion. However, three drifters did eventually join the coastal front (DD 3818, 3900 and 3943, which was deployed deliberately in the front); these have continued down the coast. 3943 moved somewhat onshore during downwelling later in the cruise, whereas its companion (3900) did not; likely it was impeded by the Columbia plume. The drifters remaining in the water after the cruise period moved onshore and northward in the first large fall storm as expected. These drifters did not turn south again; rather, they both beached on the Vancouver Is. coast where they were recovered through the efforts of the Canadian Coast Guard and Lighthouse keepers. This contrasts with the June period, when drifters remaining after the cruise headed down to Oregon and even California.

4. Satellite Imagery (Dana Woodruff, Rick Stumpf, Bill Fredericks)

Satellite imagery during the cruise was provided by two groups who sent data to the OSU ftp site—Dana Woodruff from Battelle Northwest Laboratory provided SST imagery and surface chlorophyll imagery was provided by Rick Stumpf at NOAA. Bill Fredericks (Hickey group) assessed data quality for the shipboard group, emailing Dr. Hickey with daily recommendations. The available imagery and an assessment of its quality are listed in Table 4. Both data sets proved to be valuable tools during the cruise. In particular, SST images were useful in locating upwelled water and, more important, in showing changes in surface eddy expression. Images also confirmed that in the weaker, more intermittent upwelling period of Survey 3 upwelled water was not reaching the surface anywhere near the coast. Comparison of SST images at the beginning and end of the cruise showed that the eddy had expanded greatly following a brief downwelling event. The chlorophyll images, which had better spatial coverage, were also very useful, although less frequent on this cruise. These images showed low chlorophyll water exiting the strait and swirling around the eddy. The patterns appeared to have a good relationship to the patterns we were observing shipboard as relative fluorescence. We used some patterns to select in situ sampling sites.

5. Laboratory Analyses

a) Lessard Group (Evelyn Lessard, Brady Olson, Megan Bernhardt)

The main goal of this component of ECOHAB PNW is to determine the role of grazers in *PN* population dynamics and domoic acid (DA) production. We are using three main tools: the dilution experiment, copepod grazing experiments and species-specific rRNA probes. The dilution experiment allows us to experimentally alter grazing pressure and determine grazing effects on net growth rate of the whole and size fractionated phytoplankton community, as well as specific species/groups of phytoplankton, dDA and pDA production. The rRNA probes allow us to identify specific grazers on *PN* (protist and copepod zooplankton) and, with further development, specific grazing rates. We also took FlowCAM and fixed samples to follow the in situ spatial and temporal changes in the protist grazing community in relation to *PN* and hydrography.

On this cruise, we performed the following:

1. Eight dilution growth and grazing experiments and eight macrozooplankton grazing experiments. In these experiments, we followed changes in >5 mm and total chlorophyll, particulate DA, dissolved DA, *PN* species abundance using whole cell and sandwich hybridization assays, and macronutrients. We analyzed the chlorophylls onboard; Cochlan's group analyzed the nutrients. A set of whole cell and sandwich hybridization assays were performed onboard (see below). Experimental manipulations included dissolved DA additions, combined macro/micro nutrient additions, and macronutrient only additions.
2. High frequency abundance estimates of *PN* and other plankton with the FlowCAM. After exhibiting serious problems last cruise, the FlowCAM was repaired by the manufacturer, and performed much better on this cruise. Discrete samples from the Fe pump at every other station along three transect lines were analyzed with the FlowCAM, as well as selected stations in the study grid throughout the surveys. The data files were stored and will be edited and calibrated in the lab to obtain quantitative counts. Replicate fixed samples were taken for microscopic enumerations and calibration of the FlowCAM. During surveys, the FlowCAM proved particular useful for a quick assessment of *PN* abundance and community composition at the surface and at depth.
3. Grazing on *Pseudo-nitzschia australis* measured with rRNA probes. Brady Olson ran both whole cell and sandwich hybridization (SHA) analyses shipboard using *P. australis* probes on a set of samples from a macrozooplankton grazing experiment. A robust signal was detected with the SHA, and the trend in the signal (expected to correlate with

abundance) in treatments with and without copepods and with and without added nutrients indicated that copepods were actively grazing on *P. australis* and that *P.australis* was nutrient limited. The whole cell hybridization on replicate samples worked extremely well; *P. australis* lit up brightly with the probe, and a minimum of background and non-specific staining. Microscopically enumerated probed *P.australis* showed the same trends as the SHA, indicating that the SHA is quantitatively detecting the *P. australis* target. These are very exciting results.

4. Vertical profiles of micro- and nanoplankton and macrozooplankton. We took preserved plankton samples at a number of stations on the large scale survey, and at the beginning and end of drift stations for microscopic determination of autotrophic and heterotrophic nanoplankton, and heterotrophic/mixotrophic dinoflagellates and ciliates. Twenty one vertical net tows with a 200 µm mesh net were also done for enumerating macrozooplankton.

b) Sandwich Hybridization Assay (Vera Trainer, Laurie Connell)

The goal of this aspect of ECOHAB PNW was to initiate field testing of *Pseudo-nitzschia* sandwich hybridization assays (SHA) that will eventually be used to identify and enumerate HAB species in near real-time from environmental samples. In the SHA, extracted nucleic acids from cell lysates are assayed with two oligonucleotide probes, a capture probe and signal probe. The capture probe immobilizes target sequence from the crude cell extract onto a dextran-coated solid support. A “sandwich” hybrid complex is formed when the immobilized target sequence is transferred to a second solution containing a dig-labeled signal probe. SHA products are detected using an anti-dig antibody conjugated to horseradish peroxidase. The horseradish peroxidase reacts with a substrate to generate a blue colorimetric product, the intensity of which is representative of the target cells present in the original sample. When acidified this product turns yellow.

During this cruise, at stations where numerous *Pseudo-nitzschia* were seen, 2 liters of seawater were filtered onto a 5 µm, 25 mm Durapore membrane filters (Millipore). These filters were placed into plastic test tubes and frozen at –80 oC until analyzed in the lab. SHA will be carried out using pre-dispensed reagents in 96-well microtiter plates. Cell lysate is prepared by adding filtered cells to Sample Solution Premix and incubating the cells within Lysis Tube (thin wall tube) at 80ºC for 5 minutes. Cell lysates are then loaded into the Universal Processor (Affirm Corp.) for processing. The optical density (OD) of the colorimetric product is then read using a 96-well plate spectrophotometer.
Two capture probes will be tested on samples collected during this cruise with two primary PN species as targets. AU targets *P. australis* and WA001 targets *P. pseudodelicatissima*.
Cell numbers of either *P. australis* or *P. pseudodelicatissima* will be determined by comparing sample absorbance values with known *Pseudo-nitzschia* cell numbers generated from cultured cells. Standard curves will be generated from serial dilutions of cultured cells that will be isolated from cruise samples.

c) RTC/SFSU Research Activities (Bill Cochlan, Julian Herndon, Nick Ladizinsky)

The primary objective of this component of ECOHAB PNW is to examine the relationship between elevated concentrations of the pennate diatom *PN* and its toxin domoic acid, and ambient concentrations of macro-nutrients and phytoplankton biomass. At each station, phytoplankton biomass levels were estimated from chlorophyll *a* (Chl *a*) concentrations determined using in vitro fluorometry (aboard ship) after extraction for 24 h with 90% acetone.

Chl *a* samples generally were collected at four (4) depths (0, 5, 10, 15 m, and the depth of the chlorophyll maximum). At every second station, dissolved inorganic nutrients were collected at 0, 5, 10, 15, 30, 50, 100, 200 m and near bottom) and analyzed using appropriate colorimetric methods for determination of nitrate, phosphate, and silicate with a Lachat Instruments QuickChem 8000 Series Flow Injection Automated Ion Analyzer. Both Chl *a* and nutrients were determined at the two most-shoreward stations of each sampling line. Vertical profiles of dissolved inorganic nutrients were also determined at the drifter stations (at 12-h intervals), during deep canyon profiles, and at a series of vertical stations (5) in Juan de Fuca Strait on the return transit. Samples from the Juan de Fuca transit were also analyzed for ammonium and urea, in addition to the standard inorganic nutrients. Dissolved nutrients were determined at the beginning (time-zero) and end (time-final) of all of the dilution experiments performed by Lessard's research group. Size-fractionated biomass: total planktonic community, as collected on Whatman GF/F filters (nominal pore-size of 0.7 µm), and cells > 5 µm in size (Poretics silver membranes) were determined for all incubator experiments (described below) and drifter stations.

A series of eleven shipboard incubation experiments (termed 'grow-outs') were designed to access the role of trace metal (Cu and Fe) availability on the growth of *PN* and domoic acid production. During these experiments (conducted in collaboration with Wells and Trick's research group), bacterial heterotrophic productivity (^{3}H-leucine uptake method) was measured daily to evaluate the relationship between micro-nutrient availability and bacterial degradation (or possible stimulation) of domoic acid production by *PN*. Bacterial abundance estimates, to be determined at the UWO using flow cytometry [Becton Dickinson, FACSCalibur] on preserved samples, will be used to calculate specific bacterial productivity. Photosynthetic-irradiance (P-E) curves were generated from short-term (1h) ^{14}C uptake experiments using a photosynthetron during the grow-out experiments; these results will be used to describe the efficiency and capacity of phytoplankton photosynthesis with respect to light intensity. P-E curves were generated for most shipboard incubation experiments at the middle and end of the 3 or 4-day grow-out incubations. Potential new production rates were determined using the ^{15}N-tracer technique using saturated nitrate tracer concentrations (20 µM) to estimate maximal nitrate uptake potential as an indicator of phytoplankton community physiological "health". During selected incubation experiments, the potential uptake rates of both new (nitrate) and regenerated nitrogen substrates (urea and ammonium) were determined to access nitrogenous uptake preference by the size-fractionated plankton communities (total and > 5 µm in size). Size-fractionated phytoplankton biomass estimates (as previously described) were determined for all metal and chelator treatments on all days of the incubation experiments.

Expected Results:

1. *Dissolved Nutrients*: Over 90% of collected samples were analyzed onboard and draft (uncorrected) concentrations made available daily. This enabled working maps of nutrients to be developed that helped guide further sampling strategies. The remainder will be available by Nov 1, 2003 using automated and manual colorimetric methods.
2. *Phytoplankton Biomass*: All initial survey grid samples, drifter profiles and onboard deck experiments were analyzed onboard, and are currently available in draft form.
3. *Bacterial Productivity*: Radio-isotope samples (^{3}H) will be analyzed using liquid scintillation counting at the RTC, rates should be estimated by Dec. 1.
4. *Photosynthetic Efficiency*: Radio-isotope samples (^{14}C) were prepared on board for liquid scintillation counting ashore at RTC; P-E curves should be generated by Dec. 1.

5. *New and Regenerated Production*: Samples must be returned to RTC for mass spectrometric analysis, and may be available prior to Dec 1, depending on the scheduled availability of the RTC mass spectrometer.

d) Trick Research Group (Charlie Trick, Liza McClintock)

Our contribution to the ECOHAB project is two-fold: 1) to provide flow cytometric analysis (FCM) of the communities; and 2) to provide experimental evidence of factors that either increase the competitive ability of *PN* or increase the level of domoic acid per cell. Samples for flow cytometric analysis were preserved by freezing, and will be returned to UWO for quantitative analysis of bacteria, cyanobacteria, picoplankton and nanoplankton communities. FCM samples were collected from all of the survey stations (for depths of 0, 5, 10 m and the depth of maximum chlorophyll layer), at several deep samples, and at the drifter stations (at 12-h intervals).

In addition to the FCM samples, at each of the survey sites (and at each of the indicated depths) we collected cells for pigment analysis. Pigment analysis will be performed using our HPLC isolation-and-characterization methods. This method uses the presence or absence of the taxon-specific pigments (often referred to as the “minor or accessory” pigments) in relation to the ubiquitous photosynthetic pigments (chlorophyll) to describe the phytoplankton community structure. Our analysis by HPLC will establish the composition of the communities before and after the presence of the diatom communities, thus serving as an important oceanographic descriptor. These samples will be analyzed within ~ 1-2 months since they preserve poorly. Maps of reconstructed photosynthetic communities will be available soon thereafter. As part of her Master’s research Liza McClintock collected samples for protein analysis from various areas of the transect survey, upwelling zones, downwelling zones, edges of the eddy and at selected drifter sites. These samples will be analyzed ashore for induced cell wall proteins unique to a hypothesized Fe/Cu reductase protein; this protein is thought to assist in the transport of domoic acid-mediated iron assimilation.

In our second major contribution to the cruise mandate, the personnel from the Cochlan, Wells and Trick labs carried out eleven incubator studies – termed “grow-out” experiments, two of these experiments were designed and conducted primarily by graduate students Liza McClintock (UWO) and Lisa Pickell (UM). All labs offered their expertise to the common goal (biomass formation, nutrient drawdown measurements, DA analysis (particulate and dissolved), community structure changes, bacterial and phytoplankton productivity, nitrogen and iron [^{59}Fe] uptake rates). The overall foundation of these grow-out experiments was aimed at elucidating the factors that influence the initiation, formation and/or maintenance of *PN* blooms or DA levels (either cellular or extracellular). For every cruise we may have different hypotheses to test, but the working hypothesis for this set of experiments was that *PN* benefits from producing DA because DA serves as an iron and/or copper chelator. Thus in the presence of macronutrients (either in upwelling sites or in the areas of high nutrients associated with the Juan de Fuca eddy) DA would act as an iron chelator, ensuring that the cells would have a supply of iron as iron concentrations diminish, either through colloid formation or utilization. Alternatively DA could serve as a copper chelator, reducing the levels of cupric ion to less inhibitory levels, allowing *PN* to fully utilize the macro-nutrients and grow effectively.

e) Trainer Group (Vera Trainer, Nicolaus Adams, Keri Baugh, Jeannie Bush, Jason Ray)

At each survey and drift station, samples were routinely taken at 0, 5, 10 m and chlorophyll maximum for measurement of particulate and dissolved levels of domoic acid. Samples were taken at the surface and chlorophyll maximum for whole cell counts of *PN*, enumeration of *PN* size classes, and scanning electron microscopy for species determination in selected samples. A net tow was taken at every station to rapidly determine the presence or absence of *PN* and their relative abundance. At selected drifter and eddy stations, depth profiles of cells and toxins were done at some of the following depths: 0, 5, 10, 20, 30, 50 m. When large *PN* were numerous, samples were analyzed for whole cell hybridization to *P. australis* species-specific molecular probe. Particulate domoic acid was analyzed by filtering 1 L seawater through a Nucleopore HA filter (0.45 micron pore size). Filters were minced in 5 ml distilled water with a glass pipet and sonicated for 2 h in a bath sonicator to lyse cells. An aliquot of each sample was analyzed using a receptor binding assay in 96-well plate format using a multiwell harvester and Top Count scintillation counter. The receptor binding assay uses the displacement of [^{3}H]kainate by domoic acid in a sample from a cloned glutamate receptor. Each plate of samples is compared to known domoic acid standards analyzed on the same plate. Endogenous glutamate was digested prior to sample analysis using glutamate dehydrogenase.

Whole cell hybridization assay

Up to 25 ml sample was filtered and fixed with saline-ethanol for 2 h. Then a specific *P. australis* probe (auD1) was incubated with samples from several depths and compared to uniC (positive universal species control) and uniR (negative control) probes. Positively labeled cells on each filter were counted using fluorescence microscopy. Slides were kept in the dark for cell counting in our land-based laboratory.

Dissolved domoic acid

These samples were refrigerated and will be analyzed in the land-based laboratory using an enzyme-linked immunosorbent assay in samples where high numbers of *Pseudo-nitzschia* are seen.

Pseudo-nitzschia culturing

At stations throughout the cruise where *PN* cells were present, a drop of sample was placed in f/2 medium for isolation and culturing upon return to the lab. *PN* cells will be allowed to grow in artificial seawater medium and growth and toxin production will be determined for several isolates. This will allow us to understand the relative levels of dissolved and particulate toxin each species is contributing to our cruise samples. Additionally, isolates from the eddy and nearshore regions will be used to assess the genetic diversity among certain *PN* species. This will be used to make a preliminary determination of the relatedness between *PN* populations in the eddy and nearshore regions.

f) Wells Group (Mark Wells, Lisa Pickell)

The primary goals of this ECOHAB PNW component on this cruise were to collect seawater samples for determining the distribution of dissolved Fe concentrations in and around the Juan de Fuca eddy, and to field test a new flow injection analysis instrument for online determinations of dissolved Fe and Cu concentrations in surface and deep waters. Over sixty water samples were collected using a trace metal clean tow-fish deployed from the ships' main boom. These collections included both surface (underway) samples and four deep (= 100 m) profiles.

Flow injection analysis proved to be highly sensitive (detection limits for Fe of < 50 pM). Cross interferences of the dual chemiluminescent methods for Fe and Cu were tested and shown to be insignificant. Problems encountered in determining the analytical blank during the first cruise were solved during this cruise and preliminary results were obtained for more than 40 surface and deepwater samples. While these determinations await verification against more standard analyses of retained samples our shore-based laboratory, the results show oceanographically consistent patterns in Fe distributions.

6. Moored Sensor Arrays: (Barbara Hickey, Rick Thomson)

Three arrays of moored sensors were deployed May 9-11 from the CCGS J. P. Tully and were successfully recovered September 30-October 4 from the CCGS J. P. Tully. Deployment and recovery times and locations are listed in Table 5. The moored arrays were designed to collect time series of winds, above surface and subsurface PAR, currents and water properties throughout the water column, plankton, and domoic acid between June and October, spanning the period of both ECOHAB PNW cruises. Deployments from the CCGS J. P. Tully were made under the supervision of Richard Thomson; the primary marine technicians were Tom Juhasz from the Institute of Ocean Sciences and Jim Johnson from the University of Washington. Sensor set up was primarily done by Susan Geier at the University of Washington. Wind sensors were provided by and set up by the Institute of Ocean Sciences. Nicolaus Adams set up the Aqua Monitors. Bill Fredericks prepared the toroidal buoys, lights, satellite transmitters and towers. Locations of the moorings (EH1, EH2, and EH3) are shown in Figure 3. The moorings (Fig. 7) consist of toroidal surface buoys supporting wind and PAR sensors (above water), a Sea-Bird MicroCAT 37 (C,T) at 1 m, 15 m (C,T) and 7 meters above bottom, a Sea-Bird 16 (C,T) with fluorometry and PAR at 4 m, Sea-Bird 39s (T) at 5, 20 and 40 m, a downward looking 300 khz ADCP at 5 m, an InterOcean S4 current meter at 4 m and an EnviroTech Aqua Monitor at 4 m. The Aqua Monitor was set to acquire samples every 3 days; 1% formalin was added to sample bags prior to deployment. These samples will be analyzed to produce time series of phytoplankton abundance and total domoic acid using enzyme-linked immunosorbent assay (ELISA).

Initial inspection of data suggest close to 100% data collection for in-water sensors. One ADCP only ran for a month when the battery leaked. This battery apparently was part of a bad batch of batteries that have also leaked in the shop. A light went out on the buoy in the strait, a result of water in the battery box due to a poor factory-supplied seal. Batteries were replaced and the light reactivated by Bill Fredericks (Hickey group) and Daryl Swenson (the ship marine technician) on the ECOHAB 2 cruise.

Acknowledgements

We would like to thank the captain and crew of the R/V Wecoma for their support and extra effort that made the September 2003 cruise successful. We thank the crew and officers of CCGS J.P Tully and the IOS/OSAP/UW mooring team of Tom Juhasz, Dave Spears ad Jim Johnson in advance for their help in mooring recovery in October. This research was supported through the Ecology and Oceanography of Harmful Algal Blooms program by National Oceanographic and Atmospheric Administration/Coastal Ocean Program Award No.

NA17OP2789 and National Science Foundation Award No. 0234587. Mooring recovery on the Tully were made possible by Canadian support to Rick Thomson at IOS.

List of Tables and Figures

Table 1. Event Log

Event No.	Date (GMT)	StartTime (GMT)	EndTime (GMT)	Lat-Deg (N)	Lat-Min (N)	Lon-Deg (W)	Lon-min (W)	Grid/Station ID	Event Description	Samples Taken
1	8/31/03	7:14		48	27.8	124	33.9		BW drifter 3901 deployed with 20 m drogue	
2	8/31/03	7:15		48	27.8	124	33.9		CW drifter 3885 deployed	
3	8/31/03	8:03	9:00	48	29.09	124	41.99	EH1	CTD001 + bucket	VT
4	8/31/03	9:35		48	32.7	124	59.1	VB2-01	Bucket sample	VT
5	8/31/03	10:38		48	34.4	125	12.71	VB2-02	Bucket	VT
6	8/31/03	11:32		48	35.81	125	25.96	VB2-03	Bucket	VT
7	8/31/03	12:07		48	31.86	125	31.69	VB2-04	Bucket	VT
8	8/31/03	12:37		48	28.94	125	35.6	VB2-05	Bucket	VT
9	8/31/03	13:13		48	26.05	125	26.92	VB2-06	Bucket	VT
10	8/31/03	13:50		48	24.28	125	19.19	VB2-07	Bucket	VT
11	8/31/03	14:30		48	21.91	125	10.32	VB2-08	Bucket	VT
12	8/31/03	15:10		48	19.49	125	1.72	VB2-09	Bucket	VT
13	8/31/03	15:40		48	17.57	124	54.23	VB2-10	Bucket	VT
14	8/31/03	19:05		48	0	124	49.5	VB2-11	Bucket	VT
15	8/31/03	21:52		47	35.9	124	45.93	EH2	CTD002	Nuts, VT
16	8/31/03	23:35		47	31.67	124	38.56	KB02	Vertical net tow (Brady)	
17	9/1/03	0:23		47	27.76	124	34.14	VB2-12	Bucket	VT, Lessard flow cam sample
18	9/1/03	1:53		47	18.3	124	21.97	CB01	CTD003	Nuts, Chl, VT
19	9/1/03	2:20		47	18.3	124	21.97	CB01	Fe Sample	6m Fe
20	9/1/03	2:56		47	16.07	124	28.22	CB02	CTD004	Nuts, Chl, VT, Lessard, Liza protein sample from flo-thru
21	9/1/03	3:15		47	16.07	124	28.22	CB02	Fe Sample	6m Fe
22	9/1/03	4:01		47	14.4	124	35.48	CB03	CTD005	Chl, VT
23	9/1/03	4:18		47	14.4	124	35.48	CB03	Fe Sample	6m Fe
24	9/1/03	5:05		47	12.16	124	43.32	CB04	CTD006	Nuts, Chl, VT
25	9/1/03	5:21		47	12.16	124	43.32	CB04	Fe Sample	6m Fe
26	9/1/03	6:24		47	10	124	52.95	CB05	CTD007	Chl, VT
27	9/1/03	7:00		47	10	124	52.95	CB05	Fe Sample	6m Fe
28	9/1/03	7:46		47	7.9	125	1.47	CB06	CTD008	Nuts, Chl, VT
29	9/1/03	8:29		47	7.9	125	1.47	CB06	Fe Sample	6m Fe
30	9/1/03	9:45		47	5.75	125	9.95	CB07	CTD009	Chl, VT
31	9/1/03	13:21		47	28.63	124	46.61	KB03	CTD010	Nuts, Chl, VT
32	9/1/03	15:08		47	31.66	124	38.51	KB02	Vertical net tow (Brady)	
33	9/1/03	15:42		47	31.66	124	38.53	KB02	CTD011	Lessard - plankton samples
34	9/1/03	16:07		47	31.67	124	38.53	KB02	CTD012	Nuts, Chl, VT, Lessard plankton
35	9/1/03	17:13		47	31.67	124	38.49	KB02	CTD013	Lessard - dilution expts

36	9/1/03	18:00		47	31.67	124	38.49	KB02	Fe Fish Sample	8m Fe for incubation (Cochlan/Wells GO1)
37	9/2/03	2:58		47	34.7	124	30.05	KB01	CTD014	Nuts, Chl, VT, SALT
38	9/2/03	3:20		47	34.7	124	30.05	KB01	Fe Sample	
39	9/2/03	4:43		47	31.67	124	38.56	KB02	CTD015	Nuts, Chl, VT
40	9/2/03	5:51		47	28.6	124	46.99	KB03	CTD016	Chl, VT
41	9/2/03	6:56		47	25.56	124	55.49	KB04	CTD017	Nuts, Chl, VT, SALT
42	9/2/03	8:18		47	22.59	125	3.96	KB05	CTD018	Chl, VT
43	9/2/03	9:34		47	19.54	125	12.44	KB06	CTD019	Nuts, Chl, VT
44	9/2/03	10:53		47	16.52	125	21.03	KB07	CTD020	Chl, VT, SALT
45	9/2/03	12:47		47	25.69	125	34.01	LP08	CTD021	Nuts, Chl, VT, SALT
46	9/2/03	14:25		47	29.12	125	26.35	LP07	CTD022	Chl, VT
47	9/2/03	15:30		47	29.12	125	26.35	LP07	Fe Sample	6m Fe
48	9/2/03	16:29		47	32.49	125	18.78	LP06	CTD023	Nuts, Chl, VT
49	9/2/03	17:23		47	32.49	125	18.78	LP06	Fe Sample	6m Fe
50	9/2/03	18:19		47	35.88	125	11.16	LP05	CTD024	Chl, VT
51	9/2/03	18:50		47	35.88	125	11.16	LP05	Fe Sample	6m Fe
52	9/2/03	21:26		47	39.29	125	3.56	LP04	CTD025	Nuts, Chl, VT
53	9/2/03	21:50		47	39.29	125	3.56	LP04	Fe Sample	6m Fe
54	9/2/03	22:47		47	42.7	124	55.98	LP03	CTD026	Chl, VT
55	9/2/03	23:06		47	42.7	124	55.98	LP03	Fe Sample	6m Fe
56	9/2/03	0:04		47	46.08	124	48.31	LP02	CTD027	Nuts, Chl, VT
57	9/2/03	0:20		47	46.08	124	48.31	LP02	Fe Sample	6m Fe
58	9/2/03	1:14		47	49.52	124	40.71	LP01	CTD028	Nuts, Chl, VT
59	9/3/03	1:30		47	49.52	124	40.71	LP01	Fe Sample	6m Fe
60	9/3/03	3:31		48	3.79	124	44.04	OZ01	CTD029	Nuts, Chl, VT, SALT
61	9/3/03	4:24		48	0.35	124	51.36	OZ02	CTD030	Nuts, Chl, VT
62	9/3/03	5:17		47	56.92	124	58.75	OZ03	CTD031	Chl, VT
63	9/3/03	6:14		47	53.5	125	6.08	OZ04	CTD032	Nuts, Chl, VT, SALT
64	9/3/03	7:15		47	50	125	13.49	OZ05	CTD033	Chl, VT
65	9/3/03	8:45		47	46.58	125	20.87	OZ06	CTD034	Nuts, chl, VT
66	9/3/03	9:15		47	46.58	125	20.87	OZ06	Vertical net tow (Brady)	
67	9/3/03	9:57		47	43.17	125	28.18	OZ07	CTD035	Chl, VT, SALT
68	9/3/03	11:11		47	39.75	125	35.52	OZ08	CTD036	Nuts, Chl, VT
69	9/3/03	12:26		47	36.34	125	42.99	OZ09	CTD037	Chl, VT
70	9/3/03	14:09		47	44.96	125	47.98	CF09	CTD038	Chl, VT, SALT
71	9/3/03	15:22		47	48.9	125	39.9	CF08	CTD039	Nuts, Chl, VT
72	9/3/03	16:43		47	52.99	125	32.01	CF07	CTD040	Chl, VT
73	9/3/03	17:10		47	52.99	125	32.01	CF07	Vertical net tow (Brady)	
74	9/3/03	17:57		47	52.99	125	32.02	CF07	CTD041	Lessard - dilution expts
75	9/3/03	19:29		47	53	125	27.27	CF06.5	Fe Sample	6m Fe (steamed some distance before collected, hence "6.5")
76	9/3/03	20:57		47	57.21	125	23.45	CF06	CTD042	Nuts, Chl, VT, SALT
77	9/3/03	21:38		47	57.21	125	23.45	CF06	Fe Sample	6m Fe
78	9/3/03	23:11		48	1.53	125	15.43	CF05	CTD043	Chl, VT
79	9/4/03	23:17		48	1.53	125	15.43	CF05	Fe Sample	6m Fe

80	9/4/03	0:34		48	4.75	125	7.92	CF04	CTD044	Nuts, Chl, VT
81	9/4/03	0:40		48	4.75	125	7.92	CF04	Fe Sample	6m Fe
82	9/4/03	0:00		48	9.02	124	59.99	CF03	CTD045	Chl, VT
83	9/4/03	2:01		48	9.02	124	59.99	CF03	Fe Sample	6m Fe
84	9/4/03	3:24		48	13	124	52.45	CF02	CTD046	Nuts, Chl, VT
85	9/4/03	3:24		48	13	124	52.45	CF02	Fe Sample	6m Fe
86	9/4/03	4:44		48	16.81	124	44.33	CF01	CTD047	Nuts, Chl, VT
87	9/4/03	5:30		48	16.81	124	44.33	CF01	Fe Sample	6m Fe
88	9/4/03	7:29		48	29.26	124	43.67	LA01	CTD048	Nuts, Chl, VT, SALT
89	9/4/03	7:36		48	29.26	124	43.67	LA01	Fe Sample	6m Fe
90	9/4/03	8:57		48	26.24	124	51.34	LA02	CTD049	Nuts, Chl, VT
91	9/4/03	9:28		48	26.24	124	51.34	LA02	Fe Sample	6m Fe
92	9/4/03	10:17		48	22.87	124	57.78	LA03	CTD050	CHL, VT
93	9/4/03	11:18		48	19.36	125	4.16	LA04	CTD051	Nuts, Chl, VT
94	9/4/03	12:20		48	16.13	125	10.58	LA05	CTD052	Chl, VT
95	9/4/03	13:44		48	12.66	125	17.15	LA06	CTD053	Nuts, Chl, VT
96	9/4/03	11:41		48	9.22	125	23.87	LA07	CTD054	Chl, VT
97	9/4/03	15:40		48	5.8	125	30.39	LA08	CTD055	Nuts, Chl, VT, SALT
98	9/4/03	16:03		48	5.8	125	30.39	LA08	Fe Sample	6m Fe
99	9/4/03	16:53		48	2.36	125	36.94	LA09	CTD056	Chl, VT
100	9/4/03	17:56		47	59.02	125	43.39	LA10	CTD057	Nuts, Chl, VT, Fe
101	9/4/03	20:05		47	53.8	125	53.49	LA11	CTD058	Chl, VT
102	9/4/03	21:00		47	53.8	125	53.49	LA11	Sampling from Fe fish	Student experiment (Liza and Lisa) for Fe and Cu availability (GO2)
103	9/4/03	23:07		47	59.95	125	58.41	LAB10	CTD059	Nuts, Chl, VT, SALT
104	9/5/03	0:41		48	3.9	125	50.81	LAB09	CTD060	Chl, VT, Lessard Plankton
105	9/5/03	1:57		48	7.87	125	43.2	LAB08	CTD061	Nuts, Chl, VT
106	9/5/03	3:08		48	11.8	125	35.61	LAB07	CTD062	Chl, VT
107	9/5/03	4:33		48	15.74	125	27.97	LAB06	CTD063	Nuts, Chl, VT, SALT
108	9/5/03			48	17.805	125	27.201	EH03	Mooring Check	
109	9/5/03	5:58		48	19.71	125	20.4	LAB05	CTD064	Chl, VT
110	9/5/03	7:04		48	23.66	125	12.7	LAB04	CTD065	Nuts, Chl, VT
111	9/5/03	8:41		48	27.64	125	5.23	LAB03	CTD066	Chl, VT
112	9/5/03	9:52		48	31.57	124	57.62	LAB02	CTD067	Nuts, Chl, VT, SALT
113	9/5/03	10:56		48	35.52	124	50.08	LAB01	CTD068	Nuts, Chl, VT
114	9/5/03	12:30		48	29.38	124	42.25	EH01	Check mooring light	None
115	9/5/03	16:02		48	50.45	125	27.73	LC01	CTD069	Nuts, Chl, VT
116	9/5/03	16:30		48	50.45	125	27.73	LC01	Deployed Fe fish	
117	9/5/03	16:35		48	50.45	125	27.73	LC01	Fe Sample	6m Fe
118	9/5/03	17:29		48	46.94	125	34.22	LC03	CTD070	Nuts, Chl, VT
119	9/5/03	18:34		48	43.43	125	40.8	LC04	CTD071	Chl, VT
120	9/5/03	18:55		48	43.43	125	40.8	LC04	CW drifter 3943 deployed	
121	9/5/03	19:00		48	43.43	125	40.8	LC04	Fe Sample	6m Fe

122	9/5/03	19:51		48	39.39	125	47.4	LC05	CTD072	Nuts, Chl, VT, SALT
123	9/5/03	20:51		48	36.46	125	54.02	LC06	CTD073	Chl, VT
124	9/5/03	21:06		48	36.46	125	54.02	LC06	Fe Sample	6m Fe
125	9/5/03	21:58		48	32.97	126	0.47	LC07	CTD074	Nuts, Chl, VT, Lessard flow cam sample
126	9/5/03	22:59		48	29.42	126	7.17	LC08	CTD075	Chl, VT
127	9/5/03	23:20		48	29.42	126	7.17	LC08	Fe Sample	6m Fe
128	9/6/03	0:06		48	25.94	126	13.72	LC09	CTD076	Nuts, Chl, VT
129	9/6/03	1:22		48	22.43	126	20.18	LC10	CTD077	Chl, VT, Lessard flow cam sample
130	9/6/03	1:52		48	22.43	126	20.18	LC10	Fe Sample	6m Fe
131	9/6/03	2:21		48	20.79	126	19.66	LC10	Fe fish recovered	
132	9/6/03	3:09		48	13.44	126	15.16	LBC09	CTD078	Nuts, Chl, VT
133	9/6/03	4:56		48	21.02	126	0.59	LBC07	CTD079	Chl, VT, SALT
134	9/6/03	6:47		48	28.58	125	45.37	LBC05	CTD080	Nuts, Chl, VT
135	9/6/03	7:49		48	32.41	125	37.75	LBC04	CTD081	Nuts, Chl, VT
136	9/6/03	10:23		48	7.85	125	43.2	LAB08	CTD082	Chl, VT, looking for spot to start Drift D
137	9/6/03	11:44		48	3.89	125	50.81	LAB09	CTD083	Looking for spot to start Drift D
138	9/6/03	12:51		47	59.03	125	43.37	LA10	CTD084	Nuts, Chl, VT
139	9/6/03	13:31		47	59.03	125	43.37	LA10	Vertical net tow (Brady)	
140	9/6/03	13:47		47	59.03	125	43.37	LA10	Fe fish deployed	
141	9/6/03	13:55	15:45	47	59.03	125	43.37	LA10	Fe Sample	Start of GO3 - Cochlan/Wells
142	9/6/03	16:07		47	59.03	125	43.39	LA10/DD01	CTD085	Lessard - dilution expts
143	9/6/03	16:20		47	59.03	125	43.39	LA10/DD01	BW drifter 3818 deployed with 5 m drogue, start of Drift D	
144	9/6/03	16:50		47	59.03	125	43.4	LA10/DD01	CTD086	Nuts, Chl, VT, first CTD for Drift D (at spot drifter was deployed ~30 min prior)
145	9/6/03	17:30		47	58.71	125	43.48	DD01	Sampling from Fe fish	Start of GO4 - Cochlan/Wells
146	9/6/03	19:10		47	58.97	125	43	DD01	Vertical net tow (Brady)	Olsen/zooplankton
147	9/6/03	19:15		47	58.97	125	43	DD01	Vertical net tow (Brady)	Olsen/zooplankton
148	9/6/03	23:08		47	59.93	125	40.99	DD02	CTD087	no samples
149	9/7/03	0:03		47	59.82	125	40.27	DD02	CTD088	VT
150	9/7/03	5:03		47	59.5	125	39.6	DD03	CTD089	Nuts, Chl, VT
151	9/7/03	5:03		47	59.5	125	39.6	DD03	Fe samples	6m Fe
152	9/7/03	11:04		47	59.51	125	38.18	DD04	CTD090	VT
153	9/7/03	16:54		48	1.88	125	36.58	DD05	CTD091	Nuts, Chl, VT
154	9/7/03	17:20		48	1.88	125	36.58	DD05	Fe Sample	6m Fe
155	9/7/03	17:30		48	2.46	125	36.69		Fe fish recover	

156	9/7/03	22:43		48	48	125	42.8		BW drifter 3901 recovered	
157	9/7/03	23:22		48	50.568	125	44.342		CW drifter 3943 recovered	
158	9/8/03	0:16		48	28.459	125	45.248		CW drifter 3943 re-deployed	
159	9/8/03	4:04		47	59.02	125	43.38	LA10	CTD092	Nuts, Chl, VT
160	9/8/03	5:33		48	4.93	125	35.06	DD06	CTD093	Nuts, Chl, VT
161	9/8/03	6:32		48	5.79	125	30.42	LA08	CTD094	Nuts, Chl, VT
162	9/8/03	7:34		48	9.24	125	23.83	LA07	CTD095	Chl, VT, 2m bottle for Lessard
163	9/8/03	8:31		48	12.62	125	17.12	LA06	CTD096	Nuts, Chl, VT
164	9/8/03	9:33		48	16.08	125	10.66	LA05	CTD097	Chl, VT
165	9/8/03	10:28		48	19.36	125	4.09	LA04	CTD098	Nuts, Chl, VT
166	9/8/03	13:40		48	5.78	125	30.34	LA08	CTD099	Nuts, Chl, VT, SALT
167	9/8/03	14:55		48	2.34	125	36.93	LA09	CTD100	
168	9/8/03	17:07		48	8.04	125	37.18	DD07	CTD101	Nuts, Chl, VT, Lessard flow cam sample
169	9/8/03	18:19		48	8.16	125	37.06	DD07E	CTD102	Small scale survey - VT, Lessard flow cam sample
170	9/8/03	19:10		48	8.18	125	38.11	DD07W	CTD103	Small scale survey - VT, Lessard flow cam sample
171	9/8/03	19:52		48	8.47	125	37.5	DD07N	CTD104	Small scale survey - VT, Lessard flow cam sample
172	9/8/03	20:36		48	7.82	125	37.41	DD07S	CTD105	Small scale survey - VT, Lessard flow cam sample
173	9/8/03	23:09		48	10.4	125	39.06	DD08	CTD106	Small scale survey - VT, Lessard flow cam sample
174	9/8/03	23:45		48	10.65	125	39.29	DD08W	CTD107	Small scale survey - Surface net tow, Lessard flow cam sample
175	9/9/03	0:15		48	11.04	125	38.76	DD08N	CTD108	Small scale survey - Surface net tow, Lessard flow cam sample
176	9/9/03	0:44		48	10.7	125	38.15	DD08E	CTD109	Small scale survey - Surface net tow, Lessard flow cam sample
177	9/9/03	1:09		48	10.5	125	38.65	DD08S	CTD110	Small scale survey - Surface net tow, Lessard flow cam sample
178	9/9/03	2:10		48	10.97	125	38.55	DD08	Vertical net tow (Brady)	
179	9/9/03	2:42		48	7.85	125	43.23	LAB08	CTD111	Nuts, Chl, VT
180	9/9/03	4:12		48	11.82	125	35.58	LAB07	CTD112	Chl, VT
181	9/9/03	5:16		48	15.76	125	27.95	LAB06	CTD113	Nuts, Chl, VT, SALT

182	9/9/03	6:18		48	19.68	125	20.37	LAB05	CTD114	Chl, VT
183	9/9/03	7:18		48	23.66	125	12.79	LAB04	CTD115	Nuts, Chl, VT
184	9/9/03	8:22		48	27.62	125	5.22	LAB03	CTD116	Chl, VT, SALT
185	9/9/03	9:22		48	31.6	124	57.59	LAB02	CTD117	Nuts, Chl, VT
186	9/9/03	10:16		48	35.5	124	50.03	LAB01	CTD118	Nuts, Chl, VT
187	9/9/03	15:45		48	15.28	125	40.22	DD09	CTD119	Nuts, Chl, VT
188	9/9/03	1647		48	15.7	125	40.04	DD09	CTD120	Lessard dilution experiment
189	9/9/03	2343		48	13.39	126	15.65	LBC09	CTD121	Chl, VT
190	9/10/03	0058		48	17.15	126	8	LBC08	CTD122	Nuts, Chl, VT, SALT
191	9/10/03	0213		48	21	126	0.46	LBC07	CTD123	Chl, VT
192	9/10/03	0325		48	24.8	125	52.83	LBC06	CTD124	Nuts, Chl, VT
193	9/10/03	0430		48	28.59	125	45.33	LBC05	CTD125	Chl, VT, Lessard sample
194	9/10/03	0447		48	28.59	125	45.33	LBC05		Lisa & Liza samples off fantail
195	9/10/03	0534		48	32.41	125	37.76	LBC04	CTD126	
196	9/10/03	0633		48	36.19	125	30.18	LBC03	CTD127	Chl, VT
197	9/10/03	0739		48	39.98	125	22.61	LBC02	CTD128	Nuts, Chl, VT
198	9/10/03	0837		48	43.83	125	15.23	LBC01	CTD129	no water samples taken
199	9/10/03	0945		48	43.8	125	14.95	LBC01	CTD130	Nuts, Chl, VT
200	9/10/03	18:05		48	29.19	124	42.02	EH01	CTD131	Nuts, Chl, VT
201	9/10/03	?		48	29.19	124	42.02	EH01	Brady Vertical net tow	
202	9/10/03	18:37		48	29.19	124	42.02	EH01	Fe sample	8m
203	9/11/03	0:24		48	16.82	124	44.31	CF01	CTD132	Nuts, Chl, VT, Sherie
204	9/11/03	1:21		48	12.95	124	52.37	CF02	CTD133	Nuts, Chl, VT
205	9/11/03	2:22		48	9.06	124	59.93	CF03	CTD134	Chl, VT
206	9/11/03	3:43		48	4.66	125	8	CF04	CTD135	Nuts, Chl, VT
207	9/11/03	4:44		48	1.5	125	15.49	CF05	CTD136	Chl, VT
208	9/11/03	5:44		47	57.17	125	23.48	CF06	CTD137	Nuts, Chl, VT, SALT
209	9/11/03	7:02		47	52.98	125	31.98	CF07	CTD138	Chl, VT, salt
210	9/11/03	8:15		47	48.9	125	40	CF08	CTD139	Nuts, Chl, VT
211	9/11/03	9:35		47	44.88	125	48.08	CF09	CTD140	Chl, salt
212	9/11/03	12:17		48	4.44	126	8.44	LB15	CTD141	Nuts, Chl, VT
213	9/11/03	13:43		48	8.39	125	59.99	LB14	CTD142	Chl, VT
214	9/11/03	14:53		48	11.99	125	52.96	LB13	CTD143	Nuts, Chl, VT
215	9/11/03	15:30		48	11.99	125	52.96	LB13	Fe fish deployed	
216	9/11/03	15:45 est		48	11.99	125	52.96	LB13	Fe sample	
217	9/11/03	16:28		48	15.21	125	47.72	LB11	CTD144	Chl, VT
218	9/11/03	17:41		48	18.56	125	41.35	LB10	CTD145	Nuts, Chl, VT, SALT
219	9/11/03	18:02		48	18.56	125	41.35	LB10	Fe sample	6m Fe sample
220	9/11/03	18:55		48	21.98	125	34.76	LB09	CTD146	Chl, VT
221	9/11/03	19:56		48	25.28	125	28.58	LB08	CTD147	Nuts, Chl, Fe, Sheri
222	9/11/03	20:18		48	25.28	125	28.58	LB08	Fe sample	6m Fe
223	9/11/03	21:25		48	28.73	125	22.13	LB07	CTD148	Chl, VT
224	9/11/03	22:29		48	32.23	125	15.5	LB06	CTD149	Nuts, Chl, VT, Flow

										cam
225	9/11/03	22:48		48	32.23	125	15.5	LB06	Fe sample	6m Fe
226	9/11/03	23:31		48	34.54	125	9.93	LB05	CTD150	Chl, VT
227	9/12/03	0:17		48	37.29	125	5.6	LB03	CTD151	Nuts, Chl, VT
228	9/12/03	0:40		48	37.29	125	5.6	LB03	Fe sample	6m Fe
229	9/12/03	1:25		48	40.4	124	59.52	LB01	CTD152	Nuts, Chl, VT
230	9/12/03	1:40		48	40.4	124	59.52	LB01	Fe sample	6m Fe
231	9/12/03	2:06		48	38.28	124	58.51	LB01	Fe fish recovery	
232	9/12/03	3:31		48	26.23	124	51.38	LA02	CTD153	CDOM Mark, 0,5,10 Ev, VT
233	9/12/03	5:20 est		48	12.67	124	52.96	CF02	Bucket & surface net tow	
234	9/12/03	6:21		48	8.97	125	0.03	CF03	Bucket & surface net tow	
235	9/12/03	7:17		48	4.65	125	7.91	CF04	Bucket & surface net tow	
236	9/12/03	8:15		48	1.5	125	15.45	CF05	Bucket & surface net tow	
237	9/12/03	8:17		48	1.5	125	15.45	CF05	BW drifter 3900 deployed	
238	9/12/03	9:23		47	53.43	125	6.21	OZ04	Bucket & surface net tow	
239	9/12/03	10:07		47	56.82	124	58.69	OZ03	Bucket & surface net tow	
240	9/12/03	10:56		48	0.44	124	51.43	OZ02	Bucket & surface net tow	
241	9/12/03	11:47		48	3.81	124	44.01	OZ01	Bucket & surface net tow	
242	9/12/03	14:19		48	26.2	124	51.38	LA02	Brady Vertical net tow	
243	9/12/03	14:45		48	26.2	124	51.38	LA02	Surface net tow	
244	9/12/03	14:55		48	26.25	124	51.36	LA02	CTD154	Chl, VT, Lessard, Sherie
245	9/12/03	16:00		48	26.25	124	51.36	LA02	Fe fish deployed	
246	9/12/03	16:35		48	26.25	124	51.36	LA02	CTD155	Lessard dilution experiment
247	9/12/03	17:00		48	26.29	124	51.32	LA02	Vertical net tow (Brady) x 2	Brady
248	9/12/03	17:35		48	26.28	124	51.66	LA02	water collection from Fe fish	GO 6/7
249	9/12/03	21:16		48	26.29	124	51.32	LA02	CTD156	Nuts, Chl, VT, Lessard flow cam sample (0,5,10,30)
250	9/13/03	4:44		47	35.9	124	45.94	EH02	CTD157	calibration cast at mooring
251	9/13/03	6:03		47	34.71	124	29.98	KB01	CTD158	Nuts, Chl, VT
252	9/13/03	6:56		47	31.65	124	38.56	KB02	CTD159	Nuts, Chl, VT, SALT
253	9/13/03	7:50		47	28.61	124	46.99	KB03	CTD160	Chl, VT
254	9/13/03	8:52		47	25.54	124	55.55	KB04	CTD161	Nuts, Chl, VT, SALT
255	9/13/03	10:04		47	22.52	125	4.00	KB05	CTD162	Chl, VT
256	9/13/03	11:15		47	19.56	125	12.51	KB06	CTD163	Nuts, Chl, VT

257	9/13/03	12:34		47	16.54	125	20.97	KB07	CTD164	Chl, VT, salt
258	9/13/03	19:51		47	3.99	124	15.00	GH01	CTD165	Columbia Plume Survey VT, Lessard
259	9/13/03	20:58		47	11.72	124	18.71	CRT1	Bucket	(Columbia River Transit) Plume Survey VT
260	9/13/03	21:41		47	18.31	124	21.97	CB01	CTD166	Columbia Plume Survey VT, Lessard
261	9/13/03	22:47		47	26.503	124	27.17	CRT2	Bucket	CRT- VT
262	9/13/03	23:38		47	34.72	124	30.01	KB01	CTD167	CRT- VT, Lessard
263	9/14/03	0:29		47	33.18	124	34.3	CRT3	Bucket	CRT- VT
264	9/14/03	0:50		47	31.66	124	38.58	KB02	CTD168	CRT VT
265	9/14/03	1:06		47	31.66	124	38.58	KB02	Fe fish deployed	
266	9/14/03	1:15		47	31.66	124	38.58	KB02	Fe profiling	
267	9/14/03	2:53		47	31.71	124	38.47	KB02	Fe fish recovered	
268	9/14/03	4:08		47	43.49	124	33.49	CRT4	Bucket	Columbia Plume
269	9/14/03	5:02		47	49.52	124	40.74	LP01	CTD169	Nuts, Chl, VT
270	9/14/03	5:57		47	46.09	124	48.33	LP02	CTD170	Nuts, Chl, VT
271	9/14/03	6:50		47	42.71	124	55.88	LP03	CTD171	Chl, VT
272	9/14/03	7:51		47	39.33	125	3.45	LP04	CTD172	Nuts, Chl, VT, SALT
273	9/14/03	8:53		47	35.9	125	11.15	LP05	CTD173	Chl, VT
274	9/14/03	10:10		47	32.52	125	18.73	LP06	CTD174	Nuts, Chl, VT
275	9/14/03	12:12		47	22.55	125	4.03	KB05	CTD175	no water samples taken
276	9/14/03	13:45 est		47	16.59	125	3.99	PS03A	surface net tow	
277	9/14/03	13:50		47	16.59	125	3.99	PS03B	Brady Vertical net tow	
278	9/14/03	14:11		47	16.61	125	3.95	PS03C	Surface net tow	
279	9/14/03	14:19		47	16.58	125	4.02	DE01	CTD176	Nuts, Chl, VT
280	9/14/03	14:38		47	16.6	125	4.00	DE01	BW drifter 3918 deployed with 5m drogue, start of Drift E	
281	9/14/03	15:23		47	15.92	125	3.73	DE01	Brady surface net tow	
282	9/14/03	15:42		47	15.62	125	3.70	DE02	CTD177	Lessard dilution experiments
283	9/14/03	16:20		47	14.93	125	3.74	DE02	vertical net x 2	Olsen
284	9/14/03	17:00 est		47	14.93	125	3.74	DE02	Fe fish deployed	
285	9/14/03			47	14.93	125	3.74	DE02	Fe profiling 2-3 hours	
286	9/14/03	21:00 est		47	14.93	125	3.74	DE02	Fe fish recovery	
287	9/14/03	22:19		47	11.36	125	7.16	DE03	CTD178	VT
288	9/15/03	4:04		47	9.83	125	8.04	DE04	CTD179	Nuts, Chl, VT
289	9/15/03	6:03		46	52.96	125	3.74	GH07	CTD180	Chl, VT
290	9/15/03	7:23		46	54.66	124	55.45	GH06	CTD181	Nuts, Chl, VT
291	9/15/03	8:46		46	56.89	124	46.9	GH05	CTD182	Chl, VT, salt
292	9/15/03	9:59		46	58.78	124	37.49	GH04	CTD183	Nuts, Chl, VT

293	9/15/03	11:11		47	1.04	124	28.98	GH03	CTD184	Chl, VT
294	9/15/03	12:30		47	2.5	124	21.7	GH02	CTD185	Nuts, Chl, VT
295	9/15/03	13:28		47	4.01	124	14.58	GH01	CTD186	Nuts, Chl, VT, SALT
296	9/15/03	17:34		47	3.92	125	12.94	DE05	CTD187	Nuts, Chl, VT, Lessard
297	9/15/03	18:10		47	3.92	125	12.94	DE05	Fe fish deployed	
298	9/15/03	18:30		47	3.92	125	12.94	DE05	Fe sampling	
299	9/15/03	21:00		47	3.88	125	13.0	DE05	Fe fish recovered	
300	9/15/03	21:00		47	3.38	125	13.5	DE06	BW drifter 3918 recovered, end of Drift E	
301	9/16/03	1:51		47	49.51	124	40.69	LP01	CTD188	Nuts, Chl, VT
302	9/16/03	2:59		47	46.11	124	48.32	LP02	CTD189	Nuts, Chl, VT
303	9/16/03	3:59		47	42.68	124	55.94	LP03	CTD190	Chl, VT
304	9/16/03	4:54		47	39.29	125	3.55	LP04	CTD191	Nuts, Chl, VT
305	9/16/03	5:55		47	35.91	125	11.16	LP05	CTD192	Chl, VT
306	9/16/03	7:07		47	32.49	125	18.8	LP06	CTD193	Nuts, Chl, VT
307	9/16/03	8:24		47	29.09	125	26.36	LP07	CTD194	Chl, VT, salt
308	9/16/03	12:43		48	9.04	124	59.98	CF03	Bucket & surface net tow	VT
309	9/16/03	13:55		48	17.66	124	55.49	CF03A	Bucket & surface net tow	VT (note CF3A is half way between CF3 & LA2)
310	9/16/03	15:00		48	26.26	124	51.31	LA02	Bucket & surface net tow	VT
311	9/16/03	15:44		48	22.84	124	57.71	LA03	Bucket & surface net tow	VT
312	9/16/03	15:50		48	22.84	124	57.71	LA03	Brady vertical net tow	
313	9/16/03	16:46		48	19.36	125	4.13	LA04	Bucket & surface net tow	VT
314	9/16/03	17:05		48	19.36	125	4.11	LA04	CTD195	Lessard-dilution expts.
315	9/16/03	17:30		48	19.36	125	4.11	LA04	Brady vertical net tow x 2	
316	9/16/03	18:08		48	19.36	125	4.13	LA04	CTD196	Nuts, Chl, VT
317	9/16/03	19:00		48	19.36	125	4.13	LA04	Fe fish deployed	
318	9/16/03	21:00		48	19.36	125	4.13	LA04	Sampling from Fe fish	water for Lessard grazing, Fe sample
319	9/16/03	23:26		48	29.37	124	57.85	C15	Sampling from Fe fish	M Fe (on way to C15)
320	9/16/03	23:41		48	30.34	124	57.42	C15	CTD197	No samples
321	9/17/03	0:15		48	28.86	124	55.64	C14	CTD198	Nuts, VT
322	9/17/03	0:48		48	28.15	124	54.65	C13	CTD199	No samples
323	9/17/03	1:08		48	27.4	124	53.87	C12	Fe sample	6m Fe
324	9/17/03	1:11		48	27.4	124	53.87	C12	CTD200	Nuts, VT
325	9/17/03	1:55		48	26.15	124	51.29	C11	CTD201	Nuts, VT
326	9/17/03	2:22		48	26.15	124	51.29	C11	Fe sample	Fe 6m
327	9/17/03	2:50 est.		48	23.59	124	49.62	C10	Fe sample	
328	9/17/03	2:52		48	23.59	124	49.62	C10	CTD202	Nuts, Chl, VT

329	9/17/03	3:39		48	22.72	124	48.76	C09	CTD203	
330	9/17/03	4:07		48	21.8	124	48.32		Fe sample started 10min before C008	
331	9/17/03	4:23		48	21.6	124	47.43	C08	CTD204	Nuts, Chl, VT
332	9/17/03	5:03		48	20.19	124	45.99	C07X	CTD205	
333	9/17/03	5:35 est		48	18.87	124	44.22		Fe sample	
334	9/17/03	5:46		48	18.87	124	44.19	C06X	CTD206	Nuts, VT, SALT, Sherie
335	9/17/03	6:58		48	26.19	124	51.34	C11	Fe fish deployed	Start Fe sampling fish in 30m
336	9/17/03	7:38		48	26.19	124	54.41	C11	change Fe fish depth	drop Fe fish to 50m
337	9/17/03	8:03		48	26.19	124	54.41	C11	change Fe fish depth	drop Fe fish to 10m
338	9/17/03	8:27		48	26.22	124	51.37	C11	Fe fish recovered	
339	9/17/03	9:25		48	30.00	124	47.61	C07	CTD207	Nuts, VT, salt
340	9/17/03	10:37		48	24.14	124	51.77	C06	CTD208	Nuts, VT
341	9/17/03	11:50		48	18.95	124	56.91	C05	CTD209	Nuts, VT
342	9/17/03	13:01		48	13.6	125	1.78	C04	CTD210	salt
343	9/17/03	14:03		48	8.47	125	0.01	C03.5	CTD211	VT
344	9/17/03	14:59		48	7.41	125	5.59	C03	CTD212	Nuts, VT
345	9/17/03			48	6.46	125	14.97	C02	CTD213	VT
346	9/17/03	17:45		48	2.9	125	20.68	C01	CTD214	Nuts, VT, SALT
347	9/17/03	19:00		47	59.93	125	15.71	DD10	BW drifter 3818 recovered, end of Drift D	
348	9/17/03	21:00		48	8.38	125	15.07	BS01	Net tow looking for PN	(++)
349	9/17/03	21:23		48	8.82	125	14.93	BS01	Fe fish deployed	BS=Bill station
350	9/17/03	22:00		48	9.58	125	14.83		water collection from Fe fish	
351	9/17/03	22:00		48	9.58	125	14.83		water collection from Fe fish	
352	9/17/03	22:39		48	8.85	125	14.86	BS02	CTD215	Nitrate 13.0 (ISUS), VT (++), Lessard
353	9/17/03	23:51		48	7.87	125	13.11	BS03	Net tow	Examing PN abundance in rel'n to temp front (++), nitrate 9.1-stn at front
354	9/18/03	0:35		48	6.58	125	10.71	BS04	Net tow	Nitrate 3.8 (ISUS), (+)
355	9/18/03	1:24		48	7.62	125	14.02	BS05	Net tow	Nitrate 9.4 (++)
356	9/18/03	1:41		48	7.87	125	15.47	BS06	Net tow	Nitrate 12.6 (++) same as last
357	9/18/03	1:56		48	7.99	125	15.35	BS06	CTD216	VT, Lessard
358	9/18/03	2:33		48	8.22	125	17.25	BS07	remove Fe sampler	
359	9/18/03	2:33		48	8.22	125	17.25	BS07	Net tow	Nitrate 13.0, (+++)
360	9/18/03	3:01		48	8.37	125	17.3	BS07	CTD217	VT, Lessard
361	9/18/03	6:52		48	29.11	124	41.98	EH01	CTD218	Nuts, VT, salt, ammonia

362	9/18/03	8:17		48	26.04	124	32.55	JDFA	CTD219	Nuts, VT
363	9/18/03	9:36		48	23.13	124	22.84	JDFB	CTD220	Nuts, VT, ammonia
364	9/18/03	11:40		48	17.24	124	2.93	JDFC	CTD221	Nuts, VT, salt
365	9/18/03	13:29		48	14.00	123	43.01	JDFD	CTD222	Nuts, VT, ammonia
366	9/18/03	13:49		48	14.14	123	43.1	JDFD	Fe fish deployed	deployed to 100m
367	9/18/03	14:20		48	14.18	123	42.69	JDFD	raise fish to 60m	60m samples
368	9/18/03	14:49		48	14.24	123	41.82	JDFD	raise fish to 40m	40m samples
369	9/18/03	15:13		48	14.27	123	41.69	JDFD	raise fish to 10m	10m samples
370	9/18/03	15:40		48	14.33	123	41.29	JDFD	Fe fish recovered	
371	9/18/03	16:44		48	13.67	123	24.78	JDFE	CTD223	Nuts, VT, Lessard
372	9/18/03	18:30		48	14.7	123	4.99	JDFF	CTD224	Nuts, VT
373	9/18/03	20:01		48	12.99	122	50.03	JDFG	CTD225	Nuts, VT, Sheri
374	9/18/03	21:28		48	8.02	122	44.78	PGS01	CTD226	Puget Sound Bloom, Nuts, VT
375	9/19/03	0:21		47	59.78	122	42.18	PGS02	CTD227	VT
376	9/19/03	1:15		47	57.51	122	39.67	PGS03	CTD228	VT

Table 2. CTD stations organized by sample line and date, showing types of bottle samples taken as well as associated surface iron samples

Date (GMT)	Line ID	Direction	CTD Cast Nos. W-E	Sta Ids	Nutrient sites	Fe Sampling Sites	Lessard Sites
8/31/2003	EH01-Mooring		1	EH01			
8/31/2003	EH02-Mooring		2	EH02	EH02		
9/1/2003	Copalis Beach	E-W	9-3	CB01-07	CB01,02,04,06	CB01-06	CB02
9/1-9/2/2003	Kalaloch Beach	W-E	10-14	KB03-01	KB01,02,03	KB02	KB02
9/2/2003	Kalaloch Beach	E-W	20-15	KB02-07	KB02,04,06		
9/2/2003	La Push	W-E	21-28	LP08-01	LP01,02,04,06,08	LP01-07	
9/3/2003	Ozette	E-W	37-29	OZ01-09	OZ01,02,04,06,08		
9/3-9/4/2003	Cape Flattery	W-E	38-47	CF09-01	CF01,02,04,06,08	CF01-06,6.5	CF07
9/4/2003	La Perouse A	E-W	58-48	LA01-11	LA01,02,04,06,08,10	LA01,02,08,10	
9/4-9/5/2003	La Perouse B	W-E	59-68	LAB10-01	LAB01,02,04,06,08,10		LAB09
9/5-9/6/2003	La Perouse C	E-W	77-69	LC01-10	LC01,03,05,07,09	LC01,04,06,08,10	
9/6/2003	La Perouse BC	W-E	78-81	LBC09,07,05,04	LBC04,05,09		
9/6/2003	La Perouse B	E-W	83-82	LAB08-09			
9/6/2003	La Perouse A		84	LA10	LA10		
9/6-9/7/2003	Drift D		85-91	LA10/DD01-05	DD01,03,05	LA10/DD01,03,05	DD01
9/8/2003	La Perouse A		92	LA10	LA10		
9/8/2003	Drift D		93	DD06	DD06		
9/8/2003	La Perouse A	W-E	94-98	LA08-04	LA04,06,08		
9/8/2003	La Perouse A	E-W	100-99	LA08-09	LA08		
9/8-9/9/2003	Drift D		101-110	DD07-08 (E,W,N,S)	DD07		
9/9/2003	La Perouse AB	W-E	111-118	LAB08-01	LAB01,02,04,06,08		
9/9/2003	Drift D		119-120	DD09	DD09	DD09	
9/9-9/10/2003	La Perouse BC	W-E	121-130	LBC09-01	LBC01,02,06,08		
9/10/2003	EH01-Mooring		131	EH01	EH01	EH01	
9/11/2003	Cape	E-W	140-132	CF01-09	CF01,02,04,06,08		

	Flattery						
9/11-9/12/2003	La Perouse B	W-E	141-152	LB15-01	LB01,03,06,08,10,13,15	LB01,03,06,08,10,13	
9/12/2003	La Perouse A		153-156	LA02	LA02	LA02	LA02
9/13/2003	EH02-Mooring		157	EH02			
9/13/2003	Kalaloch Beach	E-W	164-158	KB01-07	KB01,02,04,06		
9/13/2003	Grays Harbor		165	GH01			
9/13/2003	Copalis Beach		166	CB01			
9/13/2003	Kalaloch Beach	E-W	167-168	KB01-02		KB02	
9/14/2003	La Push	E-W	174-169	LP01-06	LP01,02,04,06		
9/14/2003	Kalaloch Beach		175	KB05			
9/14-9/15/2003	Drift E		176-179	DE01-04	DE01,04	DE02	DE02
9/15/2003	Grays Harbor	W-E	180-186	GH07-01	GH01,02,04,06		
9/15/2003	Drift E		187	DE05	DE05	DE05	
9/16/2003	La Push	E-W	194-188	LP01-07	LP01,02,04,06		
9/16/2003	La Perouse A		195-196	LA04	LA04	LA04	LA04
9/16-9/17/2003	JDF Canyon	E-W	197-206	C15-C06x	C14,12,11,10,08	C15,12,11,08	
9/17/2003	JDF Canyon	N-S	207-214	C07-01	C07,06,05,03,01		
9/17-9/18/2003	PN Scouting		215-217	BS02,06,07			
9/18/2003	EH01-Mooring		218	EH01	EH01		
9/18-9/19/2003	JDF Strait	W-E	219-225	JDFA-JDFG	JDFA-JDFG	JDFD	
9/19/2003	Puget Sound	N-S	226-228	PGS01-03	PGS01		

Table 3. Drifter deployment locations and times

Drifter ID	Model	Deployed (GMT)	Lat deg	Lat min	Lon deg	Lon min	Recovered/Last Transmit	Drift	Comments
3901	Brightwater 115	8/31/03 7:14	48	27.80	124	33.90	9/7/03	-	Recovered
3885	Clearwater	8/31/03 7:15	48	27.80	124	33.90	9/19/03	-	Beached
3943	Clearwater	9/5/03 18:55	48	43.43	125	40.80	9/7/03	-	Recovered
3818	Brightwater 104a	9/6/03 16:20	47	59.03	125	43.39	9/17/03	D	Recovered
3943	Clearwater	9/8/03 0:16	48	28.46	125	45.25	10/18/03	-	Beached
3900	Brightwater 115	9/12/03 8:17	48	1.50	125	15.45	10/18/03	-	Beached
3918	Brightwater 104a	9/14/03 14:38	47	16.60	125	4.00	9/15/03	E	Recovered

Table 4. Dates and file name of available satellite imagery

Sea Surface Temperature
2003_0902_0417_sst
2003_0902_0417_sst1
2003_0902_0417_sstBU
2003_0902_2311_sst
2003_0902_2311_sstBU
2003_0903_1129_sst
2003_0904_0355_sst
2003_0905_0343_sst
2003_0907_2258_sst
2003_0908_0309_sst
2003_0909_1235_sst
2003_0909_1423_sst
2003_0909_1423_sst-blowup
2003_0911_2307_sst
2003_0912_2245_sst
Ocean Colour
01_sept_2003
02_sep_2003
03_sep_2003
07_sep_2003
09_sept_2003_a
09_sept_2003_b
11_sept_2003

Table 5. Mooring locations, bottom depths, deployment times and satellite PTT ID

Mooring	Location	Lat deg	Lat min	Lon deg	Lon min	Deployed (GMT)	Depth (m)	PTT ID
E1	Juan de Fuca Strait	48	29.303	124	41.987	5/11/03 18:32	255	3944
E2	Washington coast	47	36.020	124	46.051	5/10/03 20:41	89	3973
E2-subsurface	Washington coast	47	35.826	124	45.955	6/3/03 22:17	91.5	9128
E3	Juan de Fuca eddy	48	17.807	125	27.530	5/10/03 0:58	127	3939

Figure 1. Cruise track with sampling stations

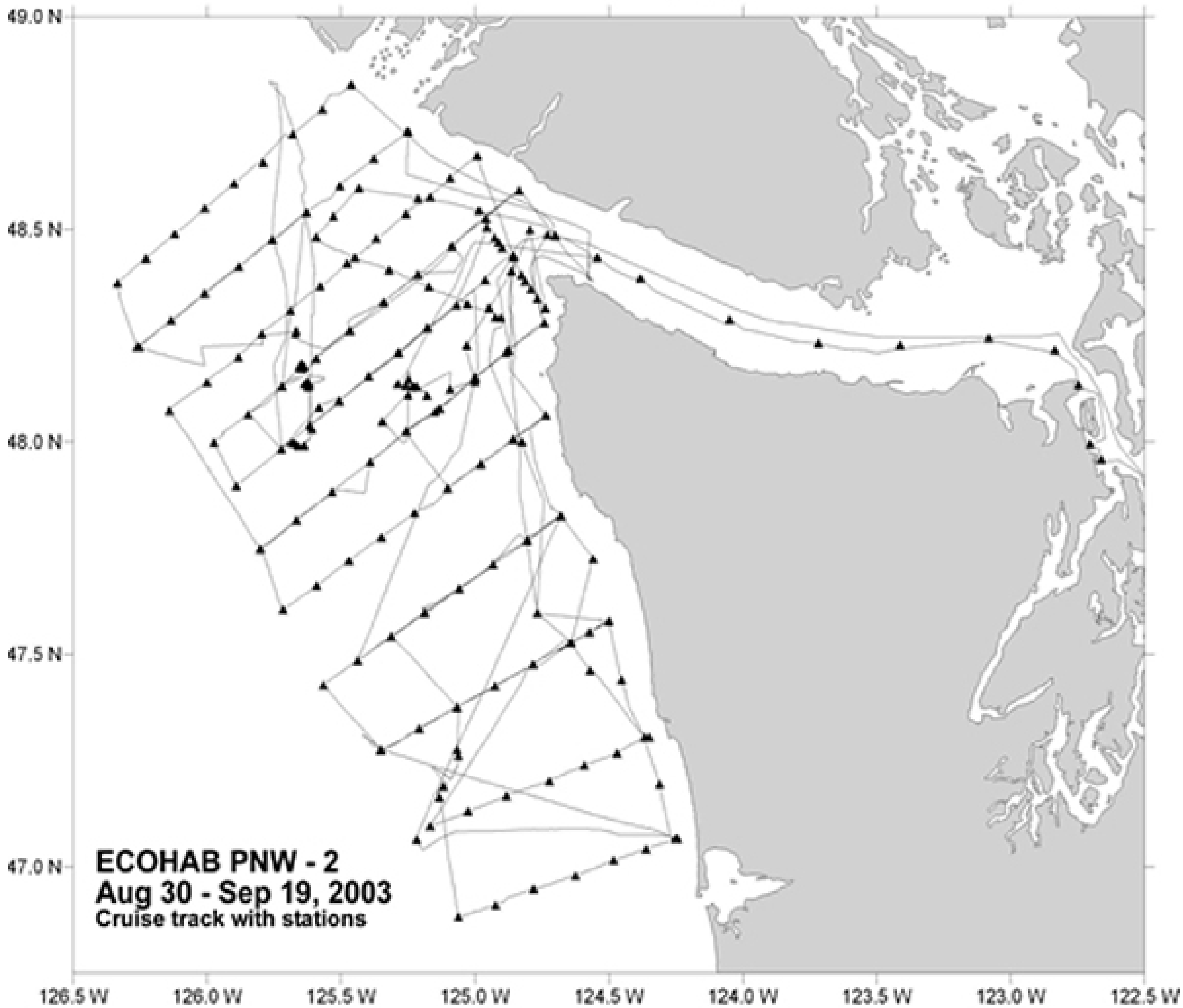
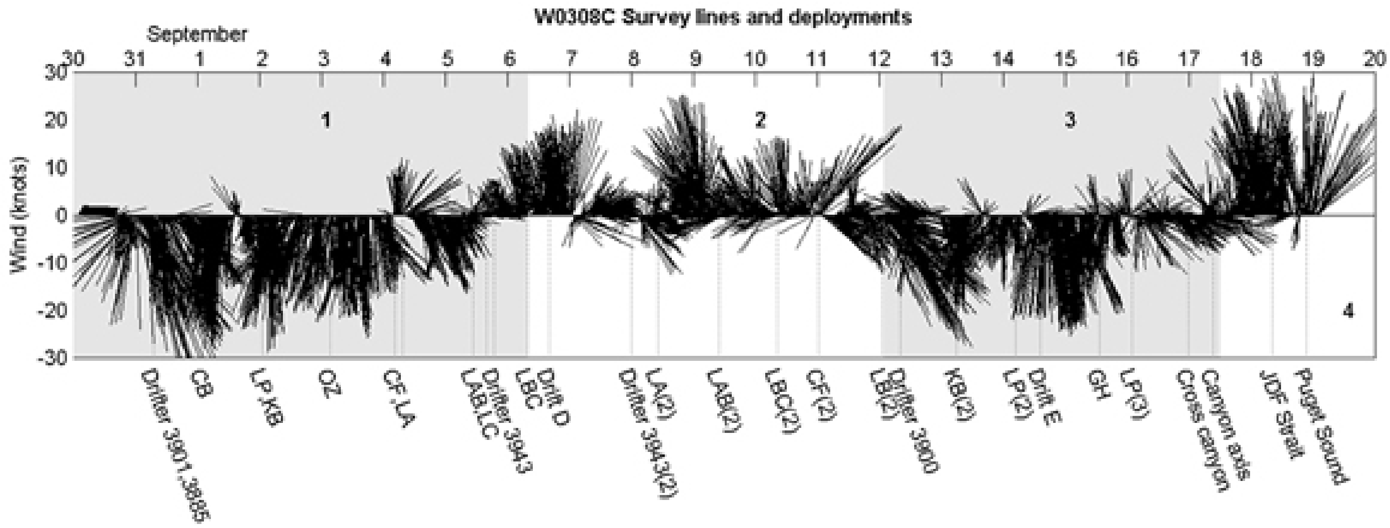


Figure 2. Time series of shipboard vector winds during cruise



Sampling events are shown below the x-axis. Vectors show the direction to which the wind is directed; thus, upwelling favorable below the zero line and downwelling favorable above it. The four survey periods are also shown.

Figure 3. Theoretical survey grid and locations of moored arrays

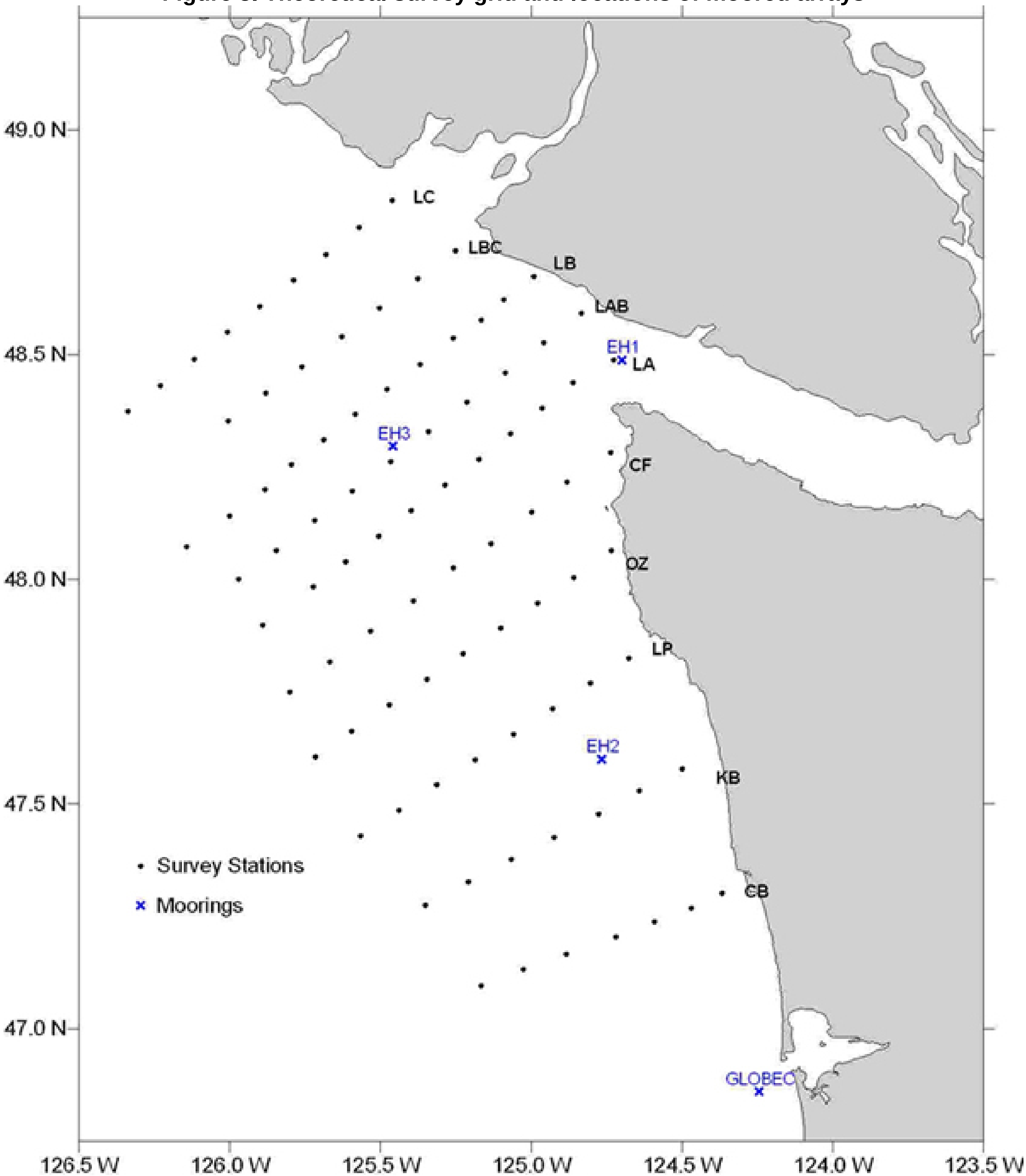


Figure 4a. CTD station numbers for Survey 1

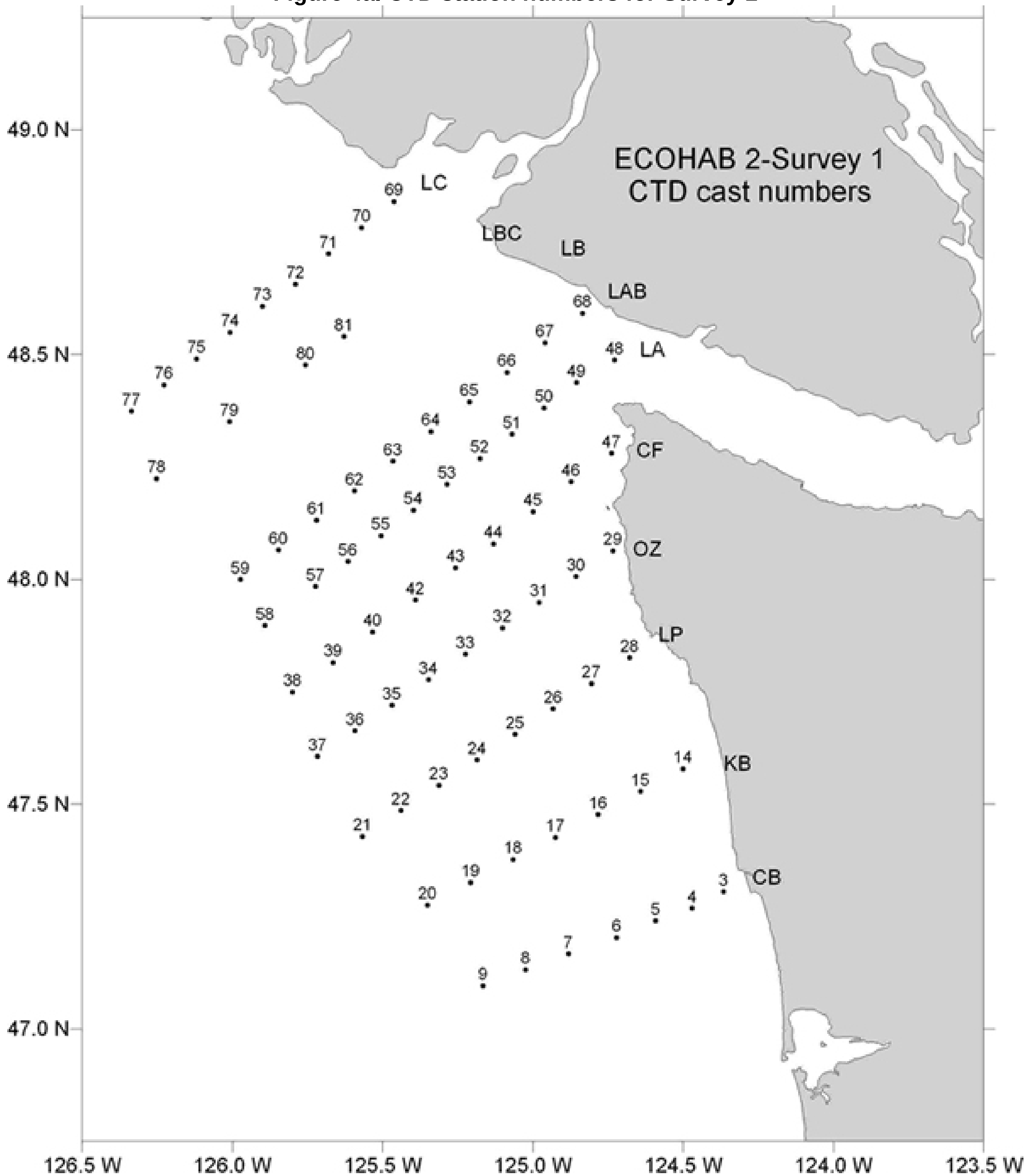


Figure 4b. CTD station numbers for Survey 2

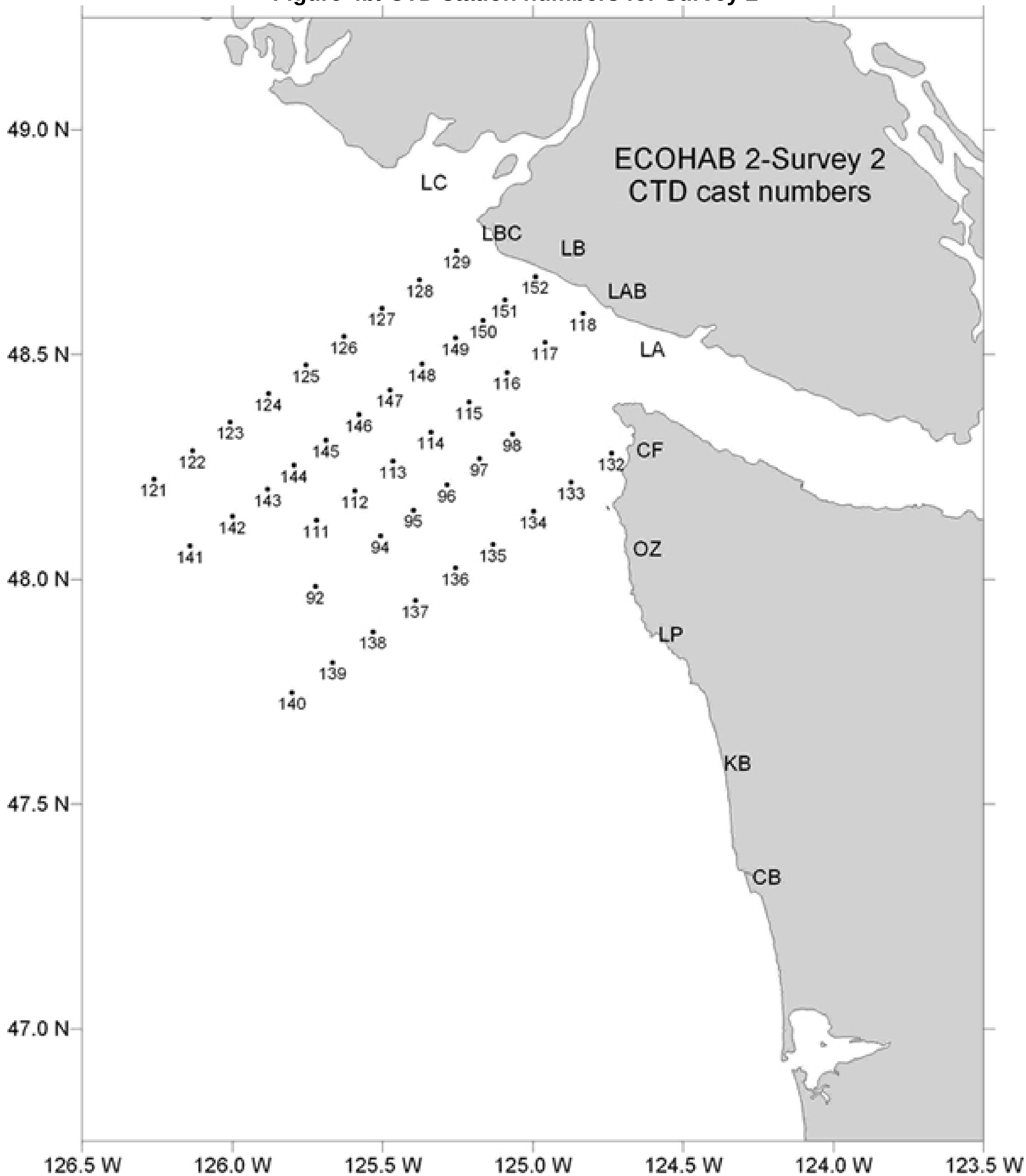


Figure 4c. CTD station numbers for Survey 3

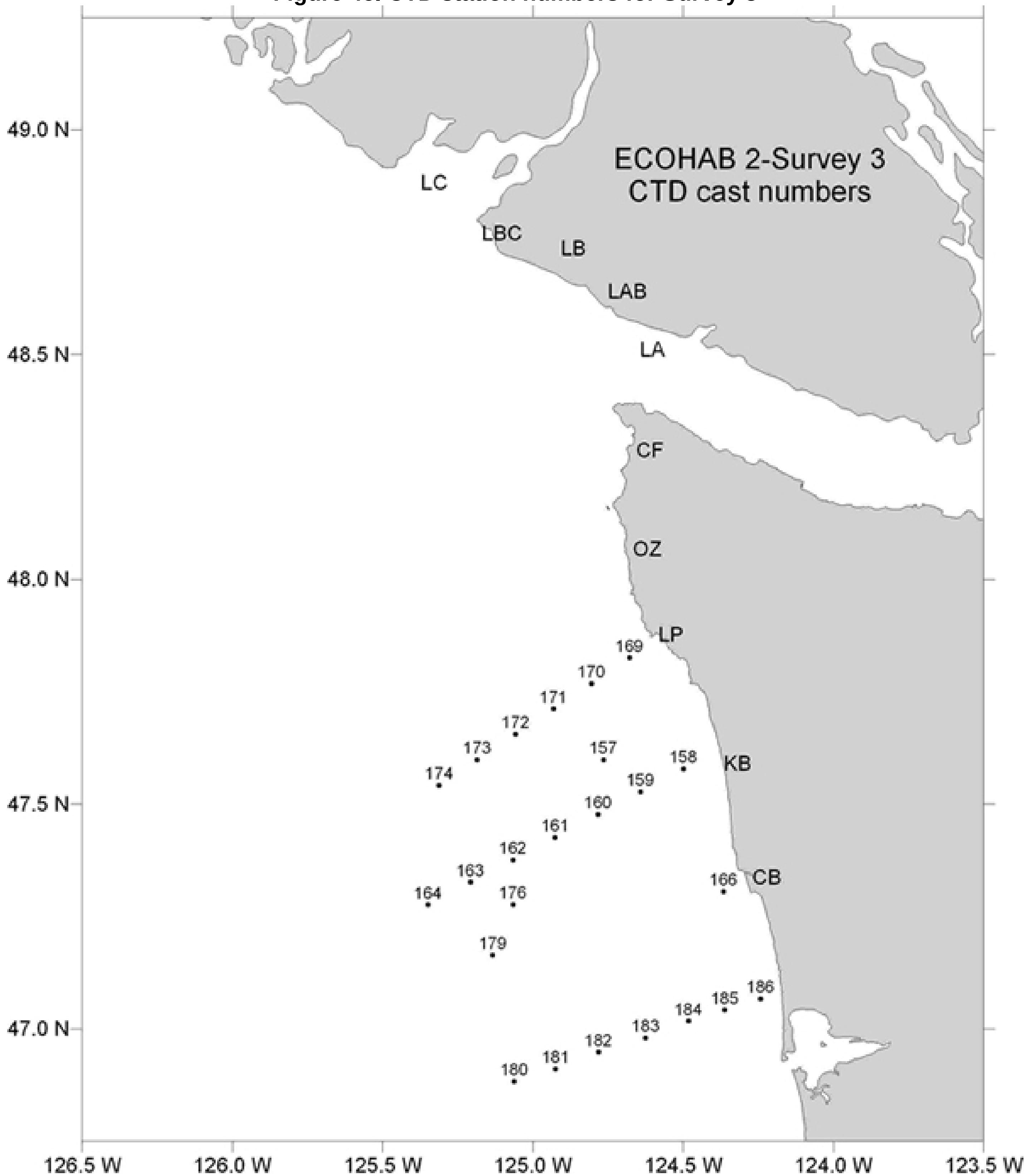


Figure 4d. CTD station numbers for the final survey lines – LP, Juan de Fuca Canyon and Strait of Juan de Fuca

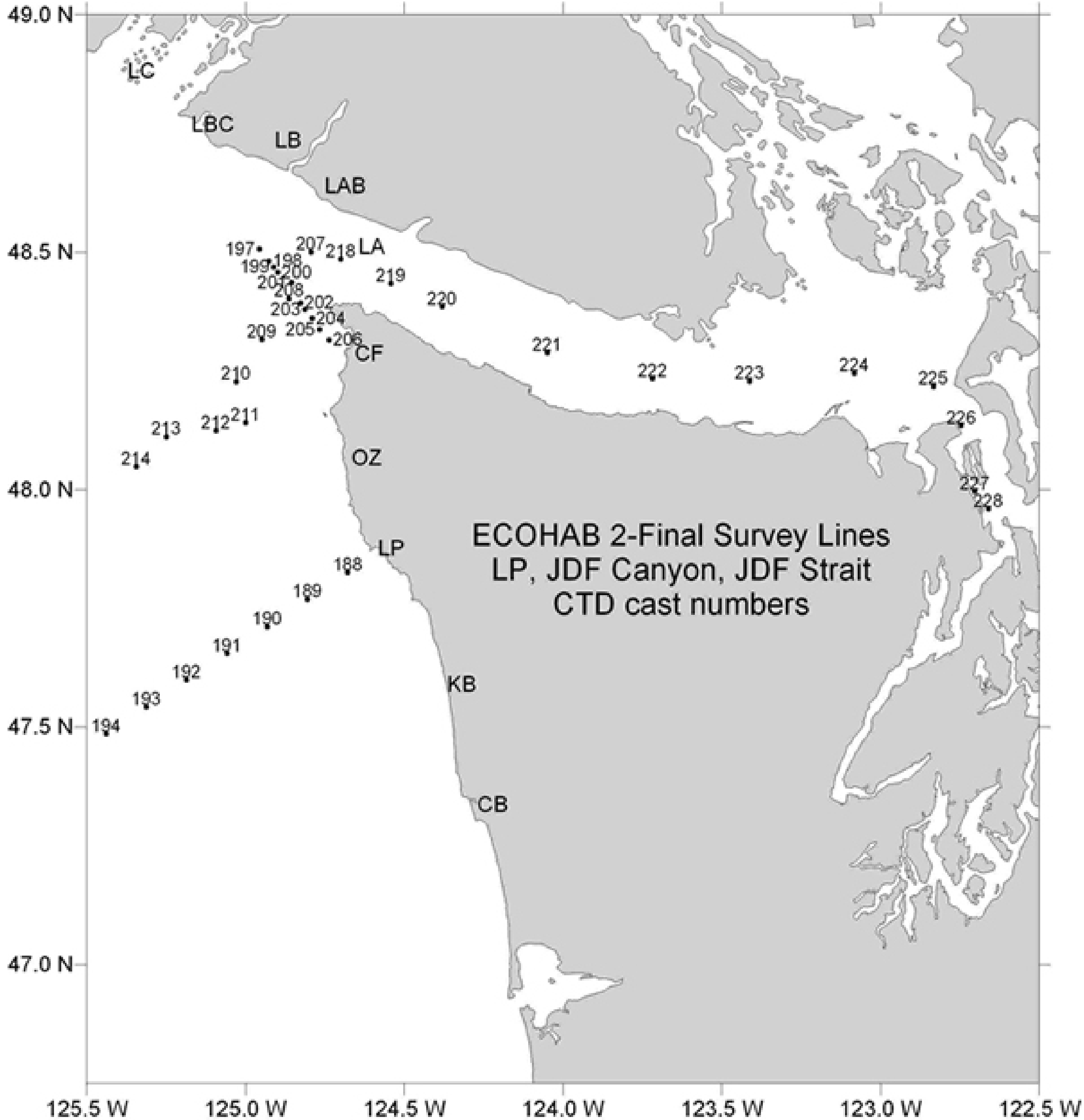


Figure 5a. Drifter track during Drift D (3818) with CTD cast numbers

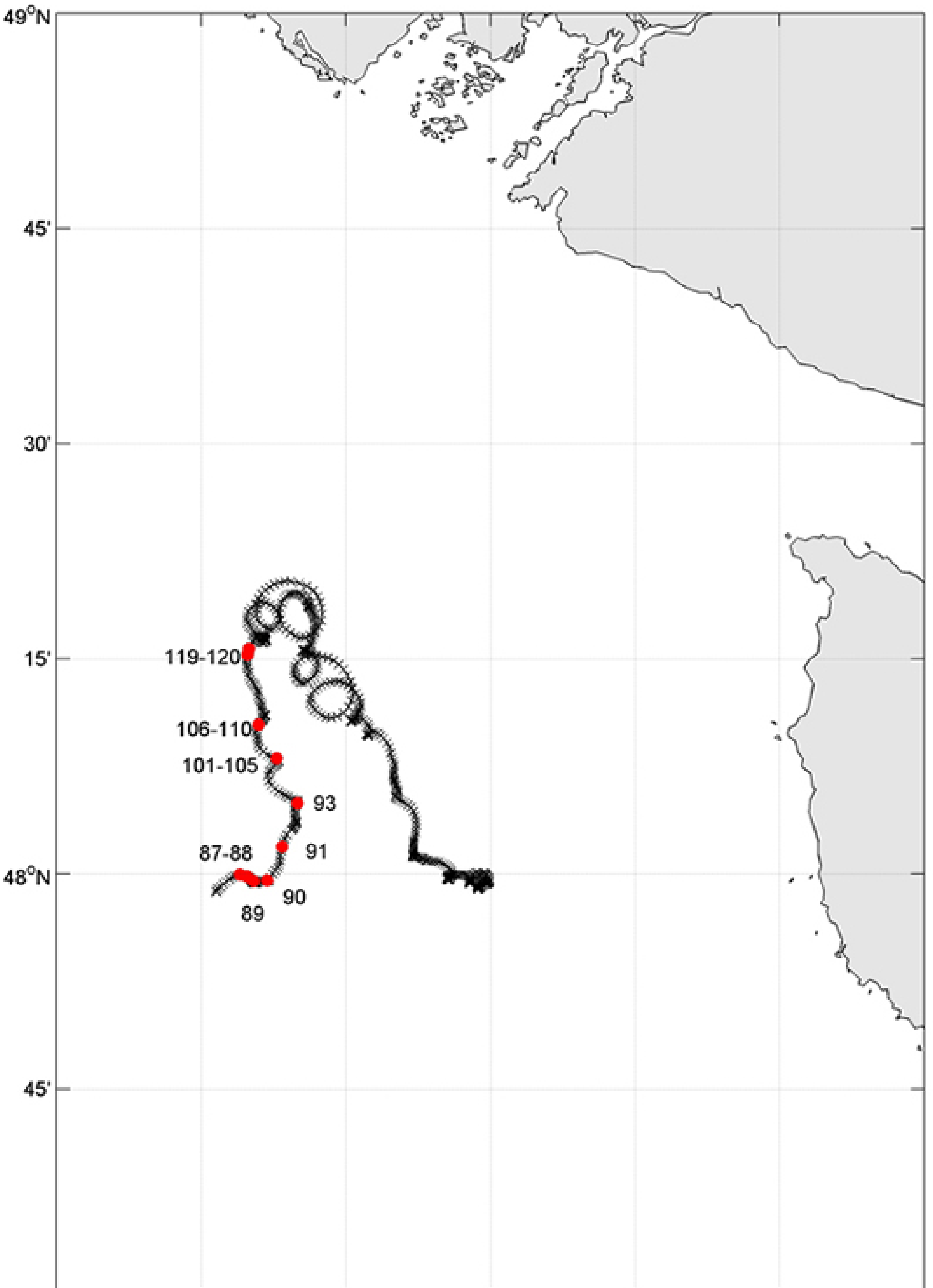


Figure 5b. Drifter track during Drift E (3918) with CTD cast numbers

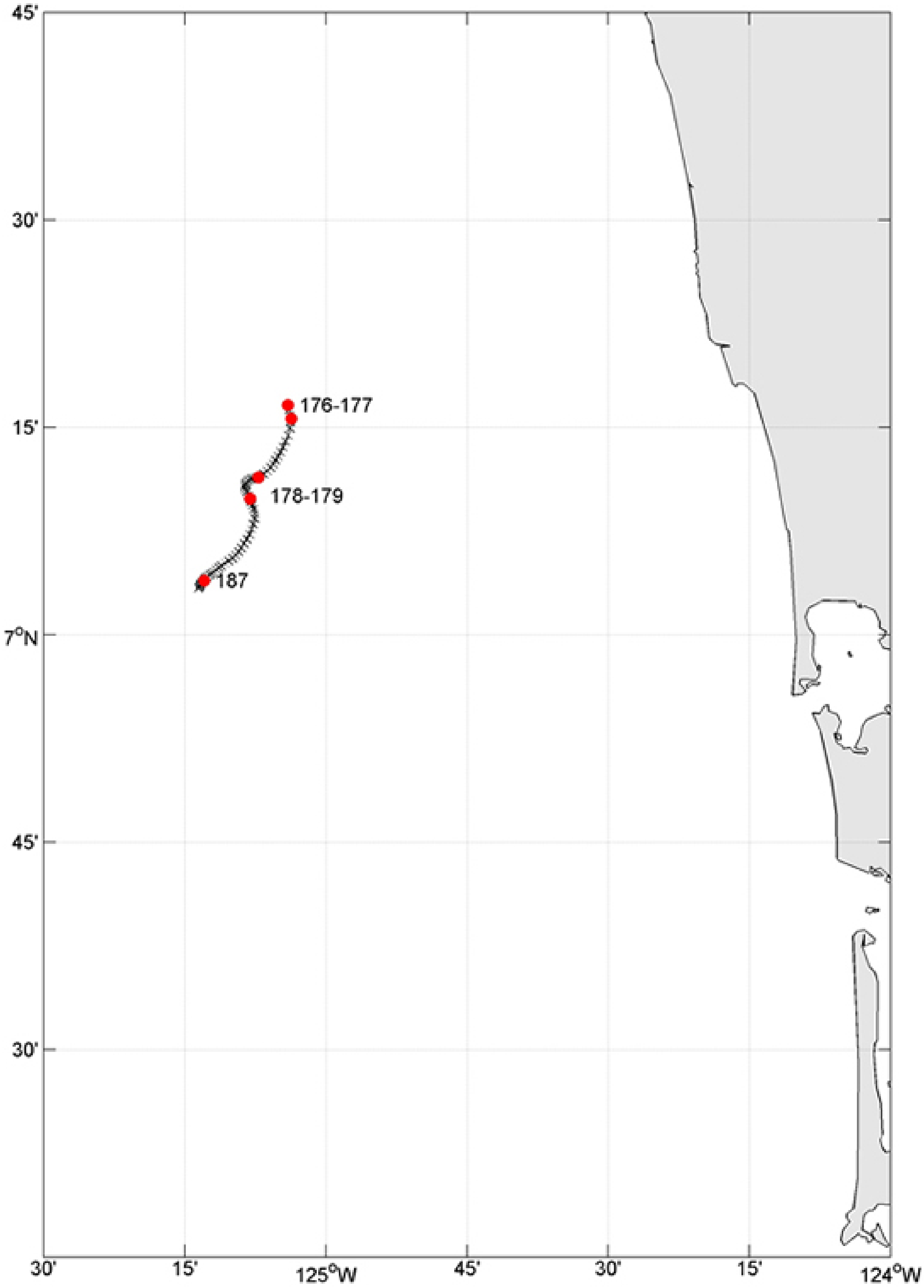
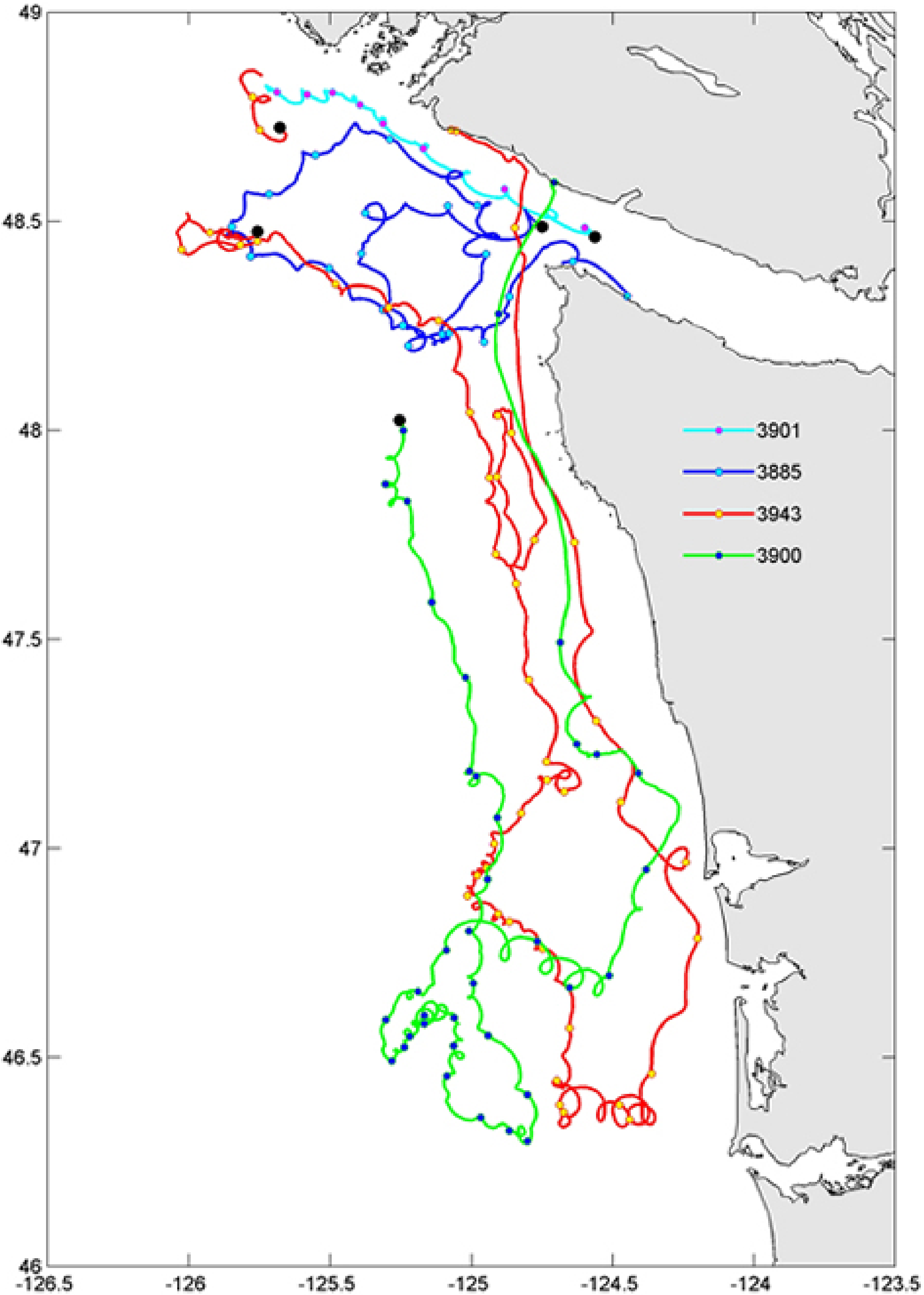


Figure 6. Trajectories of expendable drifters deployed during the cruise



Drifters were deployed off northern Washington and in the mouth of the Juan de Fuca Strait - shown by black circles. Drifter 3943 was recovered and re-deployed after 2 days. Colored dots represent 1 day.

Figure 7. Mooring schematic