ECOHAB PNW 1 CRUISE REPORT

R/V Wecoma W0306A
June 2-23, 2003

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Area of Operations

Coastal Waters off Washington State and Vancouver Island

Itinerary

Depart Seattle, WA, June 2, 2003
Arrive Seattle, WA, June 23, 2003

Participating Organizations

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

Chief Scientist

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Personnel

Dr. Nancy B. Kachel, University of Washington, Cruise Chief

Principle Investigators

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Dr. Laurie Connell, University of Maine
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Staff

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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 amnesic 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. Several times during the cruise, an iron pump was used to measure vertical profiles of 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 both near the Juan de Fuca eddy, and near 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. Additional drifters were deployed to estimate the ultimate fate of eddy water. The ship track and sampling stations are shown in Figure 1.

Operations

Mooring deployments:1
ADCP lines: ~4200 km
Flow-Through system track with T,S,FL sensors: ~4200 km
CTD casts: 249
Satellite-tracked buoy deployments: 7 (one was picked up and re-deployed)

Samples Collected

Chlorophyll samples: 201 stations
Nutrient samples: 121 stations
Microzooplankton samples: 23 profiles, plus 8 dilution experiments
Phytoplankton/Domoic acid samples: 250 stations
Fe samples (pumped): 6 profiles, 24 from 10 m depth only
Zooplankton net tows: 5

Cruise Summary

Introduction

The ECOHAB 1 cruise was remarkably successful, especially considering the number of new technologies utilized by the investigators. Evelyn Lessard was testing a FlowCAM, an imaging cytometer, to rapidly identify and count plankton > 5 µm. Charlie Trick was using a cell sorting flow cytometer for field studies. Vera Trainer used a 96 well plate format for rapid high-throughput particulate toxin analysis. Laurie Connell used specific molecular probes for *Pseudo-nitzschia* (*PN*) to rapidly determine plankton species. Mark Wells used a custom-made iron pumping system to acquire uncontaminated water samples. He was also using a newly designed chemiluminescent assay instrument for iron and copper determination. Bill Cochlan was using a flow injection analysis system to analyze dissolved nutrient samples at sea and in near real time. Some hardware problems occurred in the first 5 days. However these were all overcome with the help of shoreside support staff and the onboard marine technician, Daryl Swenson. One major problem was the loss of the towed iron fish on the first day of sampling. We believe the fish hit a submerged log. Iron samples were collected the next day using a small boat. Luckily, two of the ship's engineers, Hank Hazen and Chip Milard, constructed a new fish from materials onboard the ship. This fish performed well throughout the remainder of the cruise.

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). Moored arrays were deployed to provide time series of currents and water properties, including total domoic acid, plankton assemblages, and numbers of *PN*, from May to October, bracketing the first two survey cruises (Section 6).

The setting of cruise sampling events within the wind setting (upwelling or downwelling favorable) is shown in Figure 2. The sequence of weather conditions was almost ideal, allowing 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 conditions (the last week). 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.

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. Preliminary water property maps and sections are given in Appendix A (T, S, Fl maps at selected depths, including both underway and CTD data) 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 LP and LC lines on Survey 1, and on the LP and LAB lines on Survey 2. Chlorophyll, particulate and dissolved domoic acid and plankton samples were taken near surface, 5 m, 10 m and at the chlorophyll maximum. On line LAB of Survey 3, however, domoic acid and plankton samples were taken at the surface, 5 m, 10 m, 15 m, 30 m, 50 m to obtain deeper vertical profiles. Macro nutrients were taken generally at the surface, 5 m, 10 m, 15 m, 30 m, 50 m, 100 m, 200 m, 250 m (occasionally), 300 m, 500 m and ~5 meters above bottom if the bottom was less than 500 m deep. At canyon stations, 5 m and 10 m samples were omitted and deeper samples were taken instead to investigate upwelling of nutrients from deeper depths (400 and 450 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 every station except the LA line in Survey 3, where they were taken only at nutrient 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) while towing at a slow speed. 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) while maintaining a slow forward speed.

The data are organized into three periods: Survey 1 (June 3-11), Survey 2 (June 12-16) and Survey 3 (June 17-22) (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 unseasonably warm, sunny weather, was the most complete survey and included two drift studies (DA and DB). Drift DB started at the end of Survey 1 and continued into Survey 2, where most of the drift occurred. The downwelling period (Survey 2, Fig. 4b) was short. Consequently only some of the northern lines could be sampled. While performing a drift survey (DB) CTD transects were made also along the axis and across Juan de Fuca canyon (Fig, 4d). The weak upwelling period (Survey 3, Fig. 4c) was sufficiently long to sample two southern lines and three northern lines, with a drift study in the southern region (DC).

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. 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.

Some Preliminary Results:

The first survey clearly captured the strong coastal upwelling that was occurring during that period (Appendix A, surface maps). The coldest, saltiest water near the coast was observed at the northern end of the grid. This result should be interpreted with caution since the strength and duration of upwelling was likely increasing in the direction of our sampling (south to north). The underway salinity and temperature data maps are very similar to the near surface maps constructed from the CTD data. In the first survey cold water at the surface appeared to emanate from the strait. However, the freshest water was observed in a band running north-northwest offshore of the upwelling zone and was not connected with the strait at the surface. We note that the first survey was performed during a period of neap tides, when surface outflow and hence salinity from the strait would be reduced.

The surface fluorescence during the first survey showed two regions of high values-one offshore of the strait and southeast of Barkley Sound, the other, off the northern Washington coast. Between these two maxima was a region of lower fluorescence that appeared to emanate from the strait. This low fluorescence region was observed also in several of the chlorophyll satellite images. Low chlorophyll appears to emanate from the strait and "wrap around" the higher chlorophyll water. Although it is tempting to think that the two regions of high surface chlorophyll had been bisected by outflowing strait water, a quick look at salinity patterns suggest that this is not the case-the salinity corresponding to most of the high fluorescence region off the Washington coast is much higher than that of the high fluorescence region off Barkley Sound, suggesting that they reside in different water masses. Moreover the fluorescence sections given in Appendix B show subsurface maxima in lines off the Washington coast, but not generally off Barkley Sound. A subsurface chlorophyll maximum is typical of coastal upwelling regions.

The eddy center-defined as the region of maximum property "doming", varied between depths. In general, the eddy center was closer to the strait at shallower depths. Because density is controlled by salinity in this region, salinity is a better indicator of density differences and hence current patterns. At 100 m on Survey 1 the eddy center was at about 48o 20' N 125o 15' W, near the center as defined by multiple eddy tracks deployed in other years and in fall rather than in June. Thus, as we hoped, the mooring E3 appears well placed to monitor currents and water properties slightly away from the center where we expect currents to be less variable.

Significant differences in water property patterns were observed between the first survey period, an upwelling period, and the second survey, a downwelling period. Three lines off northern Washington and Vancouver Island were repeated in Survey 2 (Fig. 4b). Surface temperatures dropped by several degrees, possibly indicative of mixing during the storm.

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

Three drift surveys were performed. Deployment and recovery times and deployment location are listed in Table 3. The goal was to follow patches of water from (a) the eddy and (b) the coastal upwelling region, examining water properties as the patches aged. The first two drifts were attempts to follow water from the eddy-however, in the one case, the drifter was lost before escaping the eddy (DA); in the second case, the drifter stayed in the eddy and went round it (DB). In the third drift (DC) the drifter never left the coastal upwelling zone. Drifter tracks and CTD stations taken during the drifts are shown in Figure 5 a,b,c. The first drift study (DA) took place during strong upwelling (Survey 1). The drift was begun 1-2 miles east of station LAB6. The second drift (DB) took place at the end of the strong persistent upwelling period and

continued through most of the storm (Survey 2). The drift began near LAB4. The third drift (DC) took place during weak upwelling in Survey 3.

CTD profiles and bottle casts were taken at the start of each drift and water was collected for incubation experiments. A Brightwaters GPS-type drifter was deployed, drogued at 5 m for DA and DB, but at 10 m for DC. CTD profiles were taken at 6 hour intervals for roughly a day to accumulate data on tidal changes, then at 12 hour intervals until the end of a drift. In drift DC, CTD profiles were taken at 3 hour intervals for the complete drift. That drift was aborted after 18 hours when the drifter entered water shallower than its drogue.

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.

The first drift, which occurred near the edge of the eddy (Fig. 5a) had much lower near surface nutrients than the second drift, which was more towards the eddy center (Fig. 5b). The first drift was aborted when the drifter transmission failed and the drifter was lost. The DB drift started south of the eddy center but moved northwest and then around the eddy towards the northeast after crossing the mouth of the strait (Fig. 5b). The final drift was begun nearshore near LP1 under weak upwelling conditions (Fig. 5c). In spite of the upwelling, a "lid" of Columbia River plume water remained over the nearshore water throughout the drift (see sections in Appendix B). The origin of this water in the plume was confirmed with underway surveys south towards the Columbia mouth, with CTD transects and with satellite turbidity imagery, graciously provided by R. Stumpf"s group. We speculate that the plume was particularly strong due to the occurrence of spring tides. Also June is the month of maximum seasonal outflow from the Columbia. Isopleths below the shallow plume layer showed clear evidence of upwelling, and nutrients were available at deeper depths but not at the surface. Surprisingly, the drifter remained in shallow water, traveling rapidly down the coast and generally crossing into shallower water (Fig. 5c). This lack of offshore movement was likely a result of the lid of plume water and/or the 10 m drogue depth.

3. Drifter Deployments (MacFadyen, Geier, Hickey, Fredericks)

Three surface Davis-type Clearwater GPS drifters 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. Two drifters were deployed near the eddy center. The third drifter was deployed in the mouth of the strait with the hope of tracking the pathway of water exiting the strait. Data were stored at UW and also transmitted to the ship by Susan Geier. Deployment times and locations are listed in Table 3. Drifter location and water temperatures are available at 30 minute intervals during deployment. These three drifters will continue to collect data until about the end of August.

The two drifters deployed during the strong upwelling event (3819, blue track; 3861, red track) traveled southsoutheast at speeds of 15-20 miles per day (Fig. 6). Although the second drifter was deployed several miles east of the first drifter and a few days later, the second drifter moved rapidly to the same pathway as the first, indicating the existence of a strong front in this region. Both of these tracks were very similar to drifter tracks in two previous years in September, indicating the robust nature of the eddy and the coastal front. The front was confirmed by our CTD surveys and by satellite imagery. During the downwelling event that occurred mid cruise both drifters moved toward shore. The drifter near Kalaloch moved about 10 miles across the shelf to within 7 miles of the beach where it turned northward (see red circular path). It traveled another 20 miles north along the coast until the winds again turned to upwelling favorable. It again moved offshore to almost the identical pathway the second drifter had traveled. The drifter that was close to the Columbia River mouth when the storm occurred moved only slightly onshore, likely being impeded by the strong fronts bounding the Columbia plume. The drifter slowed during the storm but subsequently continued south along the shelf following the isobath direction. All three drifters moed offshore near Haceta/Stonewall banks in Oregon and proceeded south. Two drifters passed in to California before going offline (Fig. 6).

The drifter deployed in the strait (3817, green track) was deployed at maximum ebb during spring tides. It was deployed in the center of the strait in the hopes of avoiding transit in the near coast Vancouver Island Coastal Current. To our surprise, the drifter initially went upstrait, then crossed to the south side of the strait before exiting the strait westward. It then milled about in tidal motions in the region near the mouth of the strait for several days before finally turning south, like its predecessors, following the coastal front (Fig. 6). The drifter tracks illustrate that the location of the coastal front off Washington and northern Oregon was relatively fixed throughout the cruise-this dramatically illustrates that eddy water, and, surprisingly, water exiting the Strait of Juan de Fuca, could impact much of the US west coast.

4. Satellite Imagery (Woodruff, Stumpf, Geier)

Satellite imagery during the cruise was provided by two groups who sent data to the OSU ftp site-Dana Woodruff from Battelle Northwest provided SST imagery and surface chlorophyll was provided by Rick Stumpf at NOAA. Susan Geier (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. For example, the eddy as captured by our survey lines appeared to move nearshore during the first part of our cruise. We subsequently confirmed this with the imagery. The images also confirmed that in the weak upwelling period of Survey 3 upwelled water was not reaching the surface anywhere near the coast. This information helped us change strategy and move back to the eddy before our final shipboard samples. The chlorophyll images, which had better spatial coverage, were the most useful. 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 in relative fluorescence. We used some patterns to select in situ sampling sites.

5. Laboratory Analyses

a) Lessard Group (Evelyn Lessard, Brady Olson, Michael Foy)

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 two main tools: the dilution experiment 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 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/grazing experiments. These were done at KB1, and at the three drift stations. We took samples from the experimental bottles for the following: >5 µm and total chlorophyll, particulate DA, dissolved DA, sandwich hybridization assay (for species-specific *PN* abundance) and macronutrients. We analyzed the chlorophylls onboard; Julian analyzed the nutrients. Experimental manipulations included: dDA additions, macro/micro nutrient suite additions, Fe only addition.
2. Testing of the FlowCAM. Discrete samples from several stations during the initial survey were run and stored. Analyzing continuous flow samples from the iron sampler seems feasible. However, numerous technical problems with the instrument precluded extensive collection of data; the instrument needs repair and attention by the manufacturer before the next cruise.
3. Protist and macrozooplankton grazing measured with rRNA probes. Brady tested his *P. australis* probe using the FISH hybridization technique and found the probe did light up *P. australis* (presumably), but there is a high level of non-specific staining. Further lab testing is needed to optimize probe procedure. He took concentrated ethanol-preserved samples for later lab probing to look for protist ingestion of *PN*. Brady also learned the sandwich hybridization technique (SHA), for species-specific abundance, from Laurie. He applied this technique in some preliminary experiments to examine grazing by macrozooplankton. He obtained macrozooplankton from net tows and did +/- copepod incubations and measured changes in *PN* species abundance by SHA in the different treatments.
4. 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.

b) Sandwich Hybridization Assay (Laurie Connell)

The goal of this aspect of ECOHAB PNW was to initiate field testing of *PN* sandwich hybridization assays used to identify and enumerate HAB species in near real-time from environmental samples. 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.

SHA was carried out using pre-dispensed reagents in 96-well microtiter plates. Environmental samples were filtered onto a 5 µm, 25 mm Durapore membrane filters (Millipore). Cell lysate were prepared by adding filtered cells to Sample Solution Premix then incubating the cells within Lysis Tube (thin wall tube) at 80ºC for 5 minutes. Cell lysates were then loaded into the Universal Processor (Affirm Corp.) for processing. The optical density (OD) of the colorimetric product was then read using a 96-well plate spectrophotometer.

Four capture probes were field tested during this cruise with four primary *PN* species as targets. AU targets *P. australis*, MuD1 targets *P. multiseries*, 006 targets *P. pseudodelicatisima*, and WA001 targets *P. delicatisima*. After initial tests for general background and basic sensitivity, 1L samples were concentrated from each sample for use with each probe.

Results were encouraging. However cell numbers in samples cannot be determined until isolates of cells collected from this cruise are cultured, tested and standard curves are produced.

Some Preliminary Results:

1. Line LAB (Survey 2) had highest results from probe 006.
2. Drift DB had the best results, most likely due to healthy cells. The relative abundance of cells was highest with probes 006 and AU with good amounts of signal from the other two probes as well.
3. The relative signal strength changed from the start to the end of drift DB among the 4 probes.
4. The total abundance of cells increased from the start to the end of the drift DB.

Bottom line--these probes show promise after cell numbers are ground-truthed using standard microscopy and cell counts.

c) RTC/SFSU Research Activities (William Cochlan, Julian Herndon, Nicholas Ladizinsky)

The primary objective of this componenet 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 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

nutrients were also analyzed at a series of four (4) drifter stations at either 6- or 12-h intervals in addition to determination of 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). 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.

During a series of four shipboard incubation experiments (outlined by Trick and Wells), bacterial heterotrophic productivity (3H-leucine uptake method) was measured daily to evaluate the relationship between micro-nutrient (Fe, Cu) availability and bacterial degradation (or possible stimulation) of domoic acid production by *PN*. Bacterial abundance estimates, determined by Trick using flow cytometry [Becton Dickinson, FACSCalibur], will be used to calculate specific bacterial productivity. Potential new production was determined using the 15N-tracer technique using saturated nitrate tracer concentrations (10 or 20 µM) to estimate maximal nitrate uptake potential as an indicator of phytoplankton community physiological "health". Size-fractionated phytoplankton biomass (as described above) was determined for all metal treatments on all days of the incubation experiments.

Expected Results:

1. *Dissolved Nutrients:* Approximately 60-70% of collected samples were analyzed onboard and draft concentrations made available daily. Due to severe contamination of the ship's purified water (Milli-Q®) supply, many of the first week's samples were necessarily frozen for subsequent analysis ashore at RTC/SFSU; these should be available by August 1.
2. *Phytoplankton Biomass:* All initial survey grid samples, drifter profiles and onboard deck experiments were analyzed onboard and are currently available. Samples collected during the 3rd week of the cruise (other than those described above) have been frozen and will be analyzed within two weeks after cruise termination.
3. *Bacterial Productivity:* Radio-isotope samples will be analyzed using liquid scintillation counting at the University of Washington within 2 days of cruise termination.
4. *New Production:* Samples must be returned to RTC for mass spectrometric analysis, and may be available prior to August 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 of the communities; and 2) to provide experimental evidence of factors that either increase the competitive ability of *PN* or increase the level domoic acid per cell. For flow cytometric (FCM) analysis we brought on-board the flow cytometer with cell sorting capabilities. Initial experiments using our flow cytometer indicated that we were able to assay samples for the presence of bacteria, cyanobacteria (phycoerythrin-containing and phycocyanin-containing prokaryotes), picoeukaryotes and nanoeukaryotes. However we were unable with the setup presently installed in the flow cytometer to quantify these groups of organisms since the large chain-forming diatoms physically impeded the flow of seawater sample into the assay chamber. Without our ability to quantify samples we resorted to the backup procedure of collecting and freezing samples for analysis back in the laboratory. We will be able to solve the problem back in the lab using one of two procedures: modifying the sampling orifice to allow for the sampling and assay of larger cells or using small volume centrifugal filters, remove the largest cells that

cause the blockage, followed by normal FCM analysis. For our analysis we have collected FCM samples from all of the survey points (for depths of 0, 5, 10 m and the depth of maximum chlorophyll). We have supplemented this collection with several deep samples and samples collected at the previously described depths from the drifter sites (samples once-a-day). Overall, we have collected more than 2000 FCM samples for analysis of the indicated cell groups.

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. We recognize that diatom-rich communities (where the presence of *PN* and other diatoms brings great joy to this research group) are the focus of this study (and are easily described using light microscopy.) 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 the next month since they preserve poorly. Maps of reconstructed photosynthetic communities will be available prior to the September cruise.

In our second contribution to the cruise mandate, the personnel from the Cochlan, Wells and Trick lab carried our several incubator studies - termed "grow-out" experiments. All labs offered their expertise to the common goal (biomass formation, nutrient drawdown measurements, DA analysis (particulate and dissolved), community structure changes, bacterial productivity, nitrogen and iron uptakes 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 utilize the nutrients and grow. Four grow-out experiments were performed (two from upwelling areas, two from the Juan de Fuca feature). Samples were collected at a place and time where some *PN* were present in the water column but the levels were still lower than anticipated (allowing "room" for these cells to grow to higher densities - we refer to this as having "bloom potential"). Using a combinatorial experimental design we followed communities in bottles amending with the appropriate nutrients, chelator and/or copper. While analysis will take time, we should be able to evaluate the role of these inducers on DA production and community structure before the September cruise.

e) Trainer Group (Vera Trainer, Nicolaus Adams, Brian Bill)

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. These samples are designated as VT in Table 1.

Particulate domoic acid was analyzed by filtering 1 L seawater through 2-3 Nucleopore HA filters (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 [3H]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.

Dissolved domoic acid

Several control experiments were performed using an enzyme-linked immunosorbent assay for domoic acid using a specific antibody developed in rabbit. Replicate sample variability was high, therefore these samples will be frozen and analyzed upon return to the lab.

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.

f) Wells Group (Mark Wells, Peggy Hughes)

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. Fifty-five 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 six deep (= 100 m) profiles. The original tow-fish and 10 m of Kevlar-reinforced tubing was lost to an underwater obstacle early in the cruise, but a replacement fish was fabricated by the Assistant Engineers and was successfully deployed for the remainder of the cruise.

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. Alternate column techniques were tested but were found to be much less effective than the direct (non-column) method. The analyses show oceanographically consistent patterns in Fe distributions. However, difficulties in accurate determination of the analytical

blanks limited the on-board use of the instrument. The root of this problem was determined, and several approaches were identified for testing on return to the laboratory.

Water samples will be returned to U. Maine for dual determination of Fe and Cu by both FIA and Inductively-Coupled Plasma Mass Spectrometry methods. Work also was done in testing Vera's new antibodies for the detection of dissolved domoic acid with cELISA. These tests found the method to lack precision and accuracy at sea, in contrast to runs on-shore.

More than 80 dissolved and particulate fractions have been collected from the incubation experiments for analysis of domoic acid on our return. In addition, a 2 day experiment was conducted to determine the photodegradation kinetics of domoic acid in the deckboard incubation bottles.

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

Three arrays of moored sensors were deployed May 9-11 from the R/V Tully. Deployment 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).

Acknowledgements

We would like to thank the captain and crew of the R/V Wecoma for their support and extra effort that made the June 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 for their help in mooring deployments. 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 deployments 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)	Start Time (GMT)	End Time (GMT)	Lat. Deg (N)	Lat Min (N)	Lon Deg (W)	Lon Min (W)	Grid/ Station ID	Event Description	Samples Taken
1	6/2/03			47	49.97	122	25.11	TEST01	CTD001	None: Test in Puget Sound
2	6/2/03	5:50	6:00	48	17.97	124	0.00	VB01	BUCKET #1	VT (Surface Only)
3	6/3/03	7:05	7:15	48	23.72	124	20.33	VB02	BUCKET #2	VT (Surface Only)
4	6/3/03	8:30	8:40	48	29.29	124	40.68	VB03	BUCKET #3	VT (Surface Only)
5	6/3/03	8:47		48	29.38	124	41.09	EH01	CTD002	None: Mouth of Str. of Juan de Fuca, mooring calib.
6	6/3/03	10:20	10:30	48	27.78	124	58.40	VB04	BUCKET #4	VT (Surface Only)
7	6/3/03	11:15	11:25	48	26.68	125	10.64	VB05	BUCKET #5	VT (Surface Only)
8	6/3/03	12:10	12:20	48	25.65	125	22.95	VB06	BUCKET #6	VT (Surface Only)
9	6/3/03	12:45	12:55	48	25.94	125	29.85	VB07	BUCKET #7	VT (Surface Only)
10	6/3/03	13:20	13:30	48	20.09	125	30.10	VB08	BUCKET #8	VT (Surface Only)
11	6/3/03	14:10	14:20	48	15.08	125	30.00	VB09	BUCKET #9	VT (Surface Only)
12	6/3/03	14:27	20:26	48	14.96	125	30.17		Fe Sampler	Surface Fe
13	6/3/03	14:48	14:48	48	15.15	125	30.49	DR01	Clearwater Drifter Deployment of #3819	Lat, Lon position to ARGOS
14	6/3/03	15:35	15:45	48	9.16	125	25.49	VB10	BUCKET #10	VT (Surface Only)
15	6/3/03	16:35	16:45	48	1.99	125	19.93	VB11	BUCKET #11	VT (Surface Only)
16	6/3/03	17:30	17:40	47	55.58	125	13.10	VB12	BUCKET #12	VT (Surface Only)
17	6/3/03	18:45	18:55	47	50.06	125	5.36	VB13	BUCKET #13	VT (Surface Only)
18	6/3/03	19:12	19:22	47	44.36	124	57.69	VB14	BUCKET #14	VT (Surface Only)
19	6/3/03	20:05	20:15	47	38.87	124	50.39	VB15	BUCKET #15	VT (Surface Only), SHA
20	6/3/03	22:17		47	35.83	124	45.95	EH2A	Mooring Deployed	Aqua Monitor
21	6/3/03	21:29		47	35.99	124	46.60	VB16	BUCKET #16	VT (Surface Only), SHA
22	6/3/03	22:47		47	35.60	124	46.41		Fe Sampler Deployed	Surface Fe
23	6/3/03	1:33		47	18.30	124	22.01	CB01	CTD003	Nutrients, VT, CHL
24	6/3/03	2:28		47	16.10	124	28.19	CB02	CTD004	Nutrients, VT, CHL, Fe at 10m
25	6/3/03	3:30		47	14.38	124	35.50	CB03	CTD005	CHL, VT
26	6/3/03	4:41		47	12.18	124	43.24	CB04	CTD006	Nutrients, VT, CHL, Fe at 10m
27	6/3/03	5:57		47	10.00	124	53.04	CB05	CTD007	CHL, VT, Fe at 10m
28	6/4/03	7:15		47	7.91	125	1.65	CB06	CTD008	Nutrients, VT, CHL
29	6/4/03	8:45		47	5.84	125	10.07	CB07	CTD009	CHL, VT
30	6/4/03	11:09		47	16.48	125	21.00	KB07	CTD010	CHL, VT
31	6/4/03	12:15		47	19.54	125	12.50	KB06	CTD011	Nutrients, VT, CHL
32	6/4/03	13:16		47	22.58	125	3.99	KB05	CTD012	CHL, VT
33	6/4/03	14:31		47	25.58	124	55.47	KB04	CTD013	Nutrients, VT, CHL
34	6/4/03	16:01		47	28.61	124	46.96	KB03	CTD014	CHL, VT, Fe at 10m
35	6/4/03	17:10		47	31.65	124	38.53	KB02	CTD015	Nutrients, VT, CHL
36	6/4/03	18:10		47	34.70	124	29.96	KB01	CTD016	Nutrients, VT, CHL, SHA (5m-chl max), Fe at 8, 13, 15, and 22m
37	6/4/03	18:59		47	34.68	124	29.98	KB01	CTD017	CHL, VT, Water Grab for Microzooplankton dilution expt.
38	6/4/03	20:42		47	34.69	124	29.99	KB01	CTD018	CHL, VT, Water Grab for Microzooplankton dilution expt.
39	6/5/03	0:30		47	49.45	124	40.68	LP01	CTD019	Nutrients, VT, CHL

40	6/5/03	1:28		47	46.11	124	48.29	LP02	CTD020	Nutrients, VT, CHL, SHA (5m)
41	6/5/03	2:10		47	42.75	124	55.81	LP03	CTD021	CHL, VT
42	6/5/03	3:12		47	39.31	125	3.55	LP04	CTD022	Nutrients, VT, CHL
43	6/5/03	4:25		47	35.87	125	11.19	LP05	CTD023	VT, CHL
44	6/5/03	5:50		47	32.52	125	18.80	LP06	CTD024	CHL, VT
45	6/5/03	7:20		47	29.10	125	26.39	LP07	CTD025	Nutrients, VT, CHL
46	6/5/03	8:33		47	25.68	125	33.99	LP08	CTD026	CHL, VT
47	6/5/03	11:10		47	36.31	125	42.98	OZ09	CTD027	CHL, VT
48	6/5/03	12:00		47	39.75	125	35.70	OZ08	CTD028	CHL, VT
49	6/5/03	13:05		47	43.20	125	28.18	OZ07	CTD029	Nutrients, VT, CHL, microzooplankton
50	6/5/03	14:20		47	46.63	125	20.82	OZ06	CTD030	CHL, VT
51	6/5/03	15:45		47	50.04	125	13.50	OZ05	CTD031	CHL, VT
52	6/5/03	16:38		47	53.48	125	6.12	OZ04	CTD032	Nutrients, VT, CHL, microzooplankton
53	6/5/03	17:45		47	56.88	124	58.77	OZ03	CTD033	VT, CHL, SHA (5m-chl max)
54	6/5/03	18:45		48	0.33	124	51.40	OZ02	CTD034	Nutrients, VT, CHL, SHA @5m-chl max
55	6/5/03	19:44		48	3.80	124	44.02	OZ01	CTD035	Nutrients, VT, CHL, microzooplankton
56	6/5/03	21:31		48	16.92	124	44.20	CF01	CTD036	Nutrients, VT, CHL, SHA @3m chl max
57	6/5/03	22:29		48	12.95	124	52.49	CF02	CTD037	Nutrients, VT, CHL, SHA @ chl max
58	6/5/03	23:47		48	9.00	124	59.98	CF03	CTD038	CHL, VT
59	6/6/03	0:50		48	4.68	125	7.94	CF04	CTD040	Nutrients, VT, CHL, microzooplankton
60	6/6/03	2:18		48	1.51	125	15.55	CF05	CTD041	CHL, VT
61	6/6/03	3:26		47	57.19	125	23.49	CF06	CTD042	Nutrients, VT, CHL, microzooplankton
62	6/6/03	4:36		47	53.00	125	31.99	CF07	CTD043	CHL, VT
63	6/6/03	5;45		47	48.89	125	40.05	CF08	CTD044	Nutrients, VT, CHL
64	6/6/03	7:40		47	44.89	125	48.02	CF09	CTD045	CHL, VT
65	6/6/03	8:01		47	53.86	125	53.31	LA11	CTD046	Nutrients, VT, CHL
66	6/6/03	9:33		47	59.03	125	43.44	LA10	CTD047	CHL, VT
67	6/6/03	10:44		48	2.34	125	36.95	LA09	CTD048	CHL, VT
68	6/6/03	11:25		48	5.78	125	30.43	LA08	CTD049	Nutrients, VT, CHL
69	6/6/03	12:20		48	9.18	125	23.90	LA07	CTD050	CHL, VT
70	6/6/03	13:19		48	12.62	125	17.27	LA06	CTD051	Nutrients, VT, CHL, microzooplankton
71	6/6/03	14:12		48	16.10	125	10.57	LA05	CTD052	CHL, VT
72	6/6/03	8:06		48	19.36	125	4.10	LA04	CTD053	Nutrients, VT, CHL, microzooplankton
73	6/6/03	16:01		48	22.83	124	57.77	LA03	CTD054	CHL, VT
74	6/6/03	10:07		48	26.25	124	51.37	LA02	CTD055	Nutrients, VT, CHL
75	6/6/03	18:12		48	29.24	124	43.65	LA01	CTD056	Nutrients, VT, CHL
76	6/7/03	0:53		48	35.51	124	50.02	LAB01	CTD057	Nutrients, VT, CHL
77	6/7/03	1:40		48	31.54	124	58.00	LAB02	CTD058	Nutrients, VT, CHL
78	6/7/03	3:05		48	27.56	125	5.17	LAB03	CTD059	Nutrients, VT, CHL, microzooplankton

79	6/7/03	4:13		48	23.64	125	12.75	LAB04	CTD060	Nutrients, VT, CHL
80	6/7/03	5:15		48	19.68	125	20.22	LAB05	CTD061	Nutrients, VT, CHL, microzooplankton
81	6/7/03	5:30		48	19.71	125	20.38	LAB05	Clearwater Drifter Deployment (3861)	Lat, Lon position to ARGOS
82	6/7/03			48	19.68	125	20.22	LAB05	Zooplankton Vertical Net Haul	
83	6/7/03	6:20		48	15.71	125	28.15	LAB06	CTD062	Nutrients, VT, CHL
84	6/7/03	7:21		48	11.74	125	35.56	LAB07	CTD063	Nutrients, VT, CHL, microzooplankton
85	6/7/03	8:22		48	7.86	125	43.15	LAB08	CTD064	CHL, VT
86	6/7/03	9:26		48	3.86	125	50.79	LAB09	CTD065	Nutrients, VT, CHL
87	6/7/03	10:45		48	0.00	125	58.34	LAB10	CTD066	CHL, VT
88	6/7/03	12:12		48	4.37	126	8.53	LB15	CTD067	CHL, VT
89	6/7/03	13:41		48	8.48	125	59.98	LB14	CTD068	Nutrients, VT, CHL
90	6/7/03	15:08		48	11.99	125	53.02	LB13	CTD069	CHL, VT
91	6/7/03	16:15		48	15.21	125	47.71	LB11	CTD070	Nutrients, VT, CHL
92	6/7/03	18:08		48	18.87	125	41.34	LB10	CTD071	CHL, VT,microzooplankton
93	6/7/03	19:26		48	22.03	125	34.94	LB09	CTD072	Nutrients, VT, CHL
94	6/7/03	20:32		48	25.31	125	28.66	LB08	CTD073	CHL, VT,microzooplankton
95	6/7/03	20:25		48	25.33	125	28.59	LB08	Fe Water Sampling (small boat)	Fe at 10m
96	6/7/03			48	25.33	125	28.59	LB08	Zooplankton Vertical Net Haul A	
97	6/7/03			48	25.33	125	28.59	LB08	Zooplankton Vertical Net Haul B	
98	6/7/03	23:06		48	28.67	125	22.07	LB07	CTD074	Nutrients, VT, CHL
99	6/8/03	0:06		48	32.17	125	15.56	LB06	CTD075	CHL, VT
100	6/8/03	1:06		48	34.55	125	9.96	LB05	CTD076	Nutrients, VT, CHL
101	6/8/03	01;57		48	37.33	125	5.55	LB03	CTD077	Nutrients, VT, CHL
102	6/8/03	2:20		48	37.33	125	5.41	LB03	Fe Water Sampling (small boat)	Fe at surface and 10m
103	6/8/03	3:27		48	40.40	124	59.47	LB01	CTD078	Nutrients, VT, CHL
104	6/8/03	4:52		48	43.80	125	15.06	LBC01	CTD079	Nutrients, VT, CHL
105	6/8/03	5:52		48	40.06	125	22.56	LBC02	CTD080	Nutrients, VT, CHL
106	6/8/03	7:05		48	36.18	125	30.24	LBC03	CTD081	CHL, VT
107	6/8/03	8:00		48	32.38	125	37.74	LBC04	CTD082	Nutrients, VT, CHL, microzooplankton
108	6/8/03	8:55		48	28.49	125	45.49	LBC05	CTD083	CHL, VT
109	6/8/03	3:10		48	24.86	125	52.82	LBC06	CTD084	Nutrients, VT, CHL
110	6/8/03	12:24		48	21.11	126	0.30	LBC07	CTD085	CHL, VT
111	6/8/03	10:33		48	50.48	125	27.68	LCO1	CTD086	Nutrients, VT, CHL, SHA @ chl max
112	6/8/03	1:17	3:40	48	50.48	125	27.68	LCO1	Deployed Fe Fish	FE at 20,40,90m
113	6/9/03	3:23		48	46.92	125	34.20	LC03	CTD087	Nutrients, VT, CHL
114	6/9/03	4:35		48	43.35	125	40.86	LC04	CTD088	CHL, VT
115	6/9/03	5:30		48	39.93	125	47.33	LC05	CTD089	Nutrients, VT, CHL, SHA @ chl max
	6/9/03	5:35		48	36.41	125	53.97	LC06	CTD090	CHL, VT
116	6/9/03	7:52		48	32.95	126	0.00	LC07	CTD091	Nutrients, VT, CHL

117	6/9/03	9:12		48	29.38	126	7.10	LC08	CTD092	CHL, VT
118	6/9/03	11:06		48	25.91	126	13.23	LC09	CTD093	CHL, VT
119	6/9/03	12:22		48	22.48	126	20.15	LC10	CTD094	CHL, VT
120	6/9/03	17:12		48	15.05	125	29.97	DA1	Fe Profiler deployed	FE at 10,20,40,90
121	6/9/03	18:43		48	15.97	125	27.68	DA1	Net tow to confirm presence of Pseudo-nitzschia	
122	6/9/03	18:43		48	15.97	125	27.68	DA1	CTD095	Collected water for dilution/grazing experiments
123	6/9/03	18:55		48	15.97	125	28.68	DA1	Brightwater drifter deployed 3860 DA	Lat, Lon, SST, SSSal
124	6/9/03	19:32		48	15.96	125	27.72	DA1	CTD096	Nutrients, CHL, VT, SHA @ 0m & chl max
125	6/9/03	19:32		48	15.96	125	27.72	DA1	Sampling from Fe Profiler	Size Fractionated CHL, NO3 uptake, Bacterial productivity, Plankton sample, microzooplankton
126	6/9/03	20:00		48	21.38	125	16.95	DA1	Fe Profiler recovered	see above (estimated recovery time)
127	6/10/03	1:08		48	16.23	125	26.02	DA2	CTD097	Nutrients, VT, CHL, SHA @ 0m & chl max
128	6/10/03	1:52		48	17.76	125	27.32	EH3	CTD098	VT (@5m for Aqua Monitor calibration), CHL, Fe Profile, 10,40,60 and 100m
129	6/10/03	3:39		48	19.70	125	20.37	LAB05	CTD099	Nutrients, VT
130	6/10/03	5:26		48	21.38	125	16.95	LAB04	CTD100	Nutrients, VT, CHL
131	6/10/03	7:15		48	15.00	125	22.96	DA3	CTD101	Nutrients, VT, CHL, SHA, SHA @ 0m & chl max
132	6/10/03	13:08		48	13.57	125	24.01	DA4	CTD102	VT, SHA, SHA @ 0m & chl max
133	6/10/03	15:42		48	17.75	125	27.36	EH3	CTD103	None
134	6/10/03	15:53		48	17.73	125	27.20	EH3	Fe Profile	Fe Profile
135	6/10/00	19:25		48	12.92	125	22.45	DA5	CTD104	VT, SHA @ 0m & chl max
136	6/10/03	20:04		48	12.32	125	22.46	DA5	Fe Surface	Fe at 10m
137	6/11/03	1:06		48	12.32	125	22.00	DA6	CTD105	VT, CHL
138	6/11/03	1:20		48	12.34	125	21.99	DA6	Fe Surface	Fe at 10m
139	6/11/03	7:18		48	11.37	125	15.36	DA7	CTD106	Nutrients, VT, CHL, SHA @ 0m & chl max
140	6/11/03	13:08		48	10.14	125	16.85	DA8	CTD107	VT, SHA
141	6/11/03	13:54		48	10.30	125	16.74	DA9	CTD108	Water grab for microzooplankton dilution experiments
142	6/11/03	15:31		48	10.79	125	15.80	DA10	Fe Surface deployment	Fe
143	6/11/03	19:20		48	10.89	125	12.30	DA10	CTD109	Nutrients, VT, CHL
144	6/11/03	19:40		48	10.89	125	12.28	DA10	Fe Surface	FE at 10m
145	6/11/03	23:07		48	19.75	125	20.50	LAB05	CTD110	Nutrients, VT, CHL
146	6/12/03	0:46		48	19.72	125	20.21	LAB05 / DB01	CTD111	Water grab for microzooplankton dilution experiments
147	6/12/03	1:25		48	19.70	125	20.39	DB01	CTD112	Nutrients, VT, CHL,SHA @ 0,5,10,30 m
148	6/12/03	2:34		48	19.74	125	20.42	DB01	Deployed drifter DB	Lat, Lon, SST, SSSal

									3818	
149	6/12/03	2:45		48	19.70	125	20.39	DB01	Fe Fish Sampling	Size frac. Chl, NO3 Uptake, bacterial productivity, plankton (10m)
150	6/12/03	7:10		48	10.32	125	5.19	DA11	CTD113	Nutrients, VT, CHL
151	6/12/03	13:08		48	18.55	125	20.56	DB02	CTD114	Nutrients, VT, CHL, SHA @ 5m
152	6/12/03	13:46		48	18.51	125	21.09	DB02	Fe Fish Sampling	Fe Profile at 10, 20, 60 and 90m
153	6/13/03		0:19	48	7.53	125	4.87	DA12	Fe Sampler Recovered	Fe at 10m
154	6/12/03	22:12		48	7.64	125	5.70	DA12	CTD115	Nutrients, VT, CHL, microzooplankton (last known position of Drifter A)
155	6/13/03	1:22		48	20.91	125	16.70	DB03	CTD116	Nutrients, VT, CHL, SHA @ 0 & 30 m, microzooplankton
156	6/13/03	13:59		48	19.34	125	6.44	DB04	CTD117	Nutrients, VT, CHL, SHA @ 0, chl max, 30 m
157	6/13/03	14:46		48	18.90	125	6.97	DB04	CTD118	Water grab for microzooplankton dilution experiments
158	6/13/03	18:02		48	29.91	124	47.48	C07	CTD119	CS, Nutrients, VT, SHA @ 5m
159	6/13/03	18:28	4:28	48	24.04	124	54.90	C06	Fe Surface	Fe at 5m
160	6/13/03	19:34		48	24.04	124	54.90	C06	CTD120	CS, Nutrients, VT, SHA @ 5m
161	6/13/03	20:05	20:23	48	24.20	124	51.46		Vertical net tow	Zooplankton
162	6/13/03	21:41		48	18.93	124	56.98	C05	CTD121	VT, SHA @ 5m
163	6/13/03			48	18.93	124	56.98	C05	Fe Surface	Fe at 10m
164	6/14/03	23:49		48	22.26	125	4.97	DB05	CTD122	Nutrients, VT, CHL
165	6/14/03	1:43		48	13.00	124	59.97	C04	CTD123	Nutrients, Fe at 10m
166	6/14/03	2:08	2:23	48	12.95	125	0.02	C04	Vertical net tow	Zooplankton
167	6/14/03	3:40		48	8.44	125	5.54	C03	CTD124	VT, CHL, Fe at 10m
168	6/14/03	5:32		48	6.64	125	14.99	C02	CTD125	VT
169	6/14/03	6:54		48	2.83	125	20.68	C01	CTD126	Nutrients, VT, CHL
170	6/14/03	13:06		48	23.78	124	58.14	DB06	CTD127	Nutrients, VT, CHL
171	6/14/03	14:56		48	29.24	124	43.69	LA01	CTD128	VT, SHA @ 0 & 10m (chl max), P.Hughes
172	6/14/03	16:13		48	26.24	124	51.34	LA02	CTD129	Nutrients, VT, Fe Surface, SHA @ 0 & 15m (chl max)
173	6/14/03	16:40	4:02	48	27.09	124	52.44	DB07	Fe SamplerDeployed	Fe
	6/14/03	17:47		48	22.85	124	57.76	LA03	CTD130	VT, CHL
174	6/14/03	19:04		48	19.41	125	4.08	LA04	CTD131	Nutrients, VT, CHL, SHA @ 0 & 20m (chl max)
175	6/14/03	23:16		48	12.63	125	17.19	LA06	CTD133	Nutrients, VT, CHL, SHA @ 0 & chl max
176	6/15/03	3:17		48	27.25	124	52.60	DB07	CTD134	Nutrients, VT, CHL, SHA @ 0 & chl max
177	6/15/03	3:34		48	27.25	124	52.60	DB07	Drifter B (3818) Recovery/re-deploy	
178	6/15/03	6:36		48	27.48	124	53.58	DB08	CTD135	None
179	6/15/03	4:56		48	27.66	124	53.85	DB09	CTD136	None
180	6/15/03	6:53		48	21.60	124	47.40	C08	CTD137	Nutrients, VT, CHL
181	6/15/03	8:39		48	22.63	124	48.76	C09	CTD138	VT
182	6/15/03	9:10		48	23.55	124	49.70	C10	CTD139	Nutrients, VT, CHL

183	6/15/03	9:58		48	26.09	124	51.24	C11	CTD140	VT
184	6/15/03	10:41		48	27.39	124	53.85	C12	CTD141	Nutrients, VT, CHL
185	6/15/03	11:37		48	28.16	124	54.66	C13	CTD142	VT
186	6/15/03	12:05		48	28.86	124	55.68	C14	CTD143	Nutrients, VT, CHL
187	6/15/03	14:35		48	31.41	124	57.91	DB10	CTD144	Nutrients, VT, CHL
188	6/15/03	15:08		48	31.99	124	59.49	DB10	CTD145	Water grab for microzooplankton dilution experiments
190	6/15/03	16:33	0:46	48	35.52	124	50.02	LAB01	Fe Sampler	
189	6/15/03	17:07		48	35.52	124	50.02	LAB01	CTD146	Nutrients, VT, CHL, Fe Surface, Protein
191	6/15/03	18:36		48	31.56	124	57.58	LAB02	CTD147	Nutrients, VT, CHL, Fe Surface, Protein
192	6/15/03	20:06		48	27.63	125	5.10	LAB03	CTD148	CHL, VT, protein
193	6/15/03	21:19		48	23.68	125	12.78	LAB04	CTD149	Nutrients, VT, CHL, Fe Surface, Protein
194	6/15/03	22:42		48	19.72	125	20.38	LAB05	CTD150	CHL, VT, protein
195	6/16/03	0:09		48	15.74	125	27.95	LAB06	CTD151	Nutrients, VT, CHL, Fe Surface, Protein
196	6/16/03	3:17		48	33.68	124	59.56	DB11	CTD152	Nutrients, VT, CHL, Protein
197	6/16/03	4:21		48	40.40	124	59.45	LB01	CTD153	Nutrients, VT, CHL, Protein
198	6/16/03	5:15		48	37.32	125	5.57	LB03	CTD154	Nutrients, VT, CHL, Protein
199	6/16/03	6:05		48	34.53	125	10.01	LB05	CTD155	Chl, VT
200	6/16/03	6:51		48	32.16	125	15.57	LB06	CTD156	Nutrients, VT, CHL
201	6/16/03	8:00		48	28.70	125	22.10	LB07	CTD157	Chl, VT
202	6/16/03	9:01		48	25.29	125	28.55	LB08	CTD158	Nutrients, VT, CHL
203	6/16/03	9:57		48	22.02	125	34.84	LB09	CTD159	Chl, VT
204	6/16/03	13:02		48	37.76	125	8.29	DB12	CTD160	Nutrients, VT, CHL, microzooplankton
205	6/16/03	13:30		48	37.76	125	8.29	DB12	Recover Drifter B (3818)	Lat, Lon, SST, SSSal
206	6/16/03	18:36		48	29.38	124	42.05	EH01	Clearwater Drifter deployed	Lat, Lon position to ARGOS
207	6/16/03	19:12	22:37	48	29.37	124	42.00	EH01	Fe Profiler deployed	Fe at 10, 30, 50 and 70m
208	6/16/03	18:50		48	29.38	124	42.04	EH01	CTD161	Nutrients, VT, CHL,protein
209	6/16/03	21:39		48	23.17	124	22.75	JDF01	CTD162	Nutrients, VT, CHL,protein, Fe at 10m
210	6/17/03	1:46		48	16.80	124	44.30	CF01	CTD163	Nutrients, VT, CHL,protein
211	6/17/03	3:25		48	3.77	124	44.02	OZ01	CTD164	Nutrients, VT, CHL,protein
212	6/17/03	4:59		47	49.49	124	40.73	LP01	CTD165	Nutrients, VT, CHL,protein
213	6/17/03	6:46		47	34.69	124	30.04	KB01	CTD166	Nutrients, VT, CHL
214	6/17/03	8:40		47	18.24	124	21.99	CB01	CTD167	Nutrients, VT, CHL
215	6/17/03	10:45		47	28.62	124	47.01	KB03	CTD168	Chl, VT
216	6/17/03	11:52		47	31.68	124	38.45	KB02	CTD169	Nutrients, VT, CHL
217	6/17/03	12:52		47	34.20	124	29.95	KB01	CTD170	Nutrients, VT
218	6/17/03	16:07		47	34.71	124	29.99	KB01	CTD171	Nutrients
219	6/17/03	17:44		47	31.64	124	38.42	KB02	CTD172	VT, CHL
220	6/17/03	18:55		47	32.08	124	34.96	KB1.5	CTD173	VT, CHL
221	6/17/03	19:35		47	34.70	124	30.03	KB01	CTD174	Chl, VT
222	6/17/03	0:41		47	18.23	124	21.97	CB01	CTD175	Nutrients, VT, CHL

223	6/17/03	22:20		47	16.13	124	28.19	CB02	CTD176	Nutrients, VT, CHL, microzooplankton
224	6/17/03	23:16		47	14.42	124	35.43	CB03	CTD177	Chl, VT
225	6/17/03	23:52		47	12.19	124	43.32	CB04	CTD178	Nutrients, VT, CHL, microzooplankton
226	6/18/03	0:50		47	10.00	124	52.99	CB05	CTD179	Chl, VT
227	6/18/03	1:40		47	7.90	125	1.49	CB06	CTD180	Nutrients, VT, CHL, microzooplankton
228	6/18/03	2:48		47	5.80	125	9.97	CB07	CTD181	Chl, VT
229	6/18/03	6:39		47	29.10	125	26.38	LP07	CTD182	Chl, VT
230	6/18/03	7:03		47	32.51	125	18.85	LP06	CTD183	Nutrients, VT, CHL
231	6/18/03	8:26		47	35.96	125	11.10	LP05	CTD184	Chl, VT
232	6/18/03	9:38		47	39.32	125	3.53	LP04	CTD185	Nutrients, VT, CHL
233	6/18/03	10:39		47	42.69	124	55.94	LP03	CTD186	Chl, VT
234	6/18/03	11:45		47	46.09	124	48.32	LP02	CTD187	Nutrients, VT, CHL
235	6/18/03	12:46		47	49.50	124	40.63	LP01	CTD188	Nutrients, VT, CHL, microzooplankton
236	6/18/03	15:04		47	49.51	124	40.70	DC01	CTD189	Water grab for microzooplankton dilution experiments
237	6/18/03	15:40		47	49.50	124	40.69	DC01	CTD190	Chl, VT
238	6/18/03	16:03		47	49.50	124	40.70	DC01	Deploy Drifter C (3818)	Lat, Lon, SST, SSSal
239	6/18/03	16:09	21:34	47	49.50	124	40.30	DC01	Fe Sampler	Fe Sample at 13m
240	6/18/03	22:09		47	45.32	124	37.68	DC02	CTD191	VT
241	6/18/03	22:36		47	45.22	124	37.57	DC02E	CTD192	None
242	6/19/03	1:01		47	44.06	124	36.74	DC03	CTD193	VT
243	6/19/03	4:04		47	42.51	124	35.32	DC04	CTD194	Nutrients, VT, CHL
244	6/19/03	7:05		47	40.78	124	33.73	DC05	CTD195	VT
245	6/19/03	10:04		47	38.68	124	31.88	DC06	CTD196	VT
246	6/19/03	13:12		47	36.48	124	30.00	DC07	CTD197	VT
242	6/19/03	16:12		47	34.32	124	29.40	DC08	CTD198	VT
247	6/19/03	19:02		47	32.55	124	28.50	DC09	CTD199	VT
248	6/19/03	22:03		47	31.10	124	27.76	DC10	CTD200	VT
249	6/20/03	1:02		47	29.89	124	26.81	DC11	CTD201	VT
250	6/20/03	2:16		47	29.40	124	26.48	DC12	CTD202	Nutrients, VT, CHL, microzooplankton
251	6/20/03	2:24		47	29.40	124	26.48	DC12	Recover Drifter C (3818)	T,Sal, Lat, Lon T-series
252	6/20/03	4:29		47	35.90	124	46.12	EH2	CTD203	CHL, VT-Mooring Calibration
253	6/20/03	9:22		48	16.78	124	44.37	CF01	CTD204	VT
254	6/20/03	10:44		48	17.11	124	59.11	FL01	CTD205	VT
255	6/20/03	12:03		48	16.43	125	13.47	FL02	CTD206	VT,Microzooplankton
256	6/20/03	12:57		48	16.08	125	20.77	FL03	CTD207	VT
257	6/20/03	13:44		48	15.75	125	27.88	LAB06	CTD208	VT profile
258	6/20/03	14:17		48	15.78	125	28.02	LAB06	CTD209	Nutrients, VT, CHL, microzooplankton
259	6/20/03	14:55		48	15.74	125	28.00	LAB06	CTD210	Evelyn's Water grab for microzooplankton dilution experiments

260	6/20/03	15:33		48	15.75	125	28.00	LAB06	CTD211	protein analysis samples
261	6/20/03	21:55		48	0.01	125	58.02	LAB10	CTD212	
262	6/20/03	22:23	1:22	48	0.07	125	58.08	LAB10	Fe Profiler deployed	Fe at 100,20,30,50 and 100m
263	6/21/03	1:32		47	59.92	125	58.30	LAB10	CTD213	Nutrients, VT, CHL
264	6/21/03	3:14		48	3.91	125	50.78	LAB09	CTD214	VT, CHL
265	6/21/03	4:48		48	7.82	125	43.16	LAB08	CTD215	Nutrients, VT, CHL,protein
266	6/21/03	6:09		48	11.79	125	35.54	LAB07	CTD216	VT, CHL,protein
267	6/21/03	7:30		48	15.72	125	28.02	LAB06	CTD217	Nutrients, VT, CHL,protein
268	6/21/03	8.49		48	19.70	125	20.40	LAB05	CTD218	VT, CHL,protein
269	6/21/03	10:03		48	23.68	125	13.00	LAB04	CTD219	Nutrients, VT, CHL,protein
270	6/21/03	11:29		48	27.59	125	4.91	LAB03	CTD220	VT, CHL,protein
271	6/21/03	12:38		48	31.59	124	57.43	LAB02	CTD221	Nutrients, VT, CHL,protein
272	6/21/03	13:44		48	35.48	124	50.01	LAB01	CTD222	Nutrients, VT, CHL,protein
273	6/21/03	14:54		48	40.41	124	59.48	LB01	CTD223	Nutrients, VT, CHL
274	6/21/03	15:51		48	37.30	125	5.57	LB03	CTD224	Nutrients, VT, CHL
275	6/21/03	16:42		48	34.50	125	10.01	LB05	CTD225	VT, CHL
276	6/21/03	18:25		48	32.19	125	15.51	LB06	CTD226	Nutrients, VT, CHL
277	6/21/03	21:14		48	28.71	125	22.03	LB07	CTD227	VT, CHL,protein
278	6/21/03	22:11		48	25.33	125	28.59	LB08	CTD228	Nutrients, VT, CHL
279	6/21/03	23:08		48	22.01	125	34.76	LB09	CTD229	VT, CHL
280	6/22/03	0:01		48	18.64	125	41.30	LB10	CTD230	Nutrients, VT, CHL
281	6/22/03	0:55		48	15.27	125	47.69	LB11	CTD231	VT, CHL
282	6/22/03	1:47		48	12.00	125	53.00	LB13	CTD232	Nutrients, VT, CHL
283	6/22/03	2:56		48	8.49	126	0.01	LB14	CTD233	VT, CHL
284	6/22/03	4:10		48	4.36	126	8.42	LB15	CTD234	VT, CHL
285	6/22/03	6:18		47	59.04	125	43.31	LA10	CTD235	VT
286	6/22/03	7:24		48	2.35	125	36.92	LA09	CTD236	VT profile
287	6/22/03	8:24		48	5.75	125	30.40	LA08	CTD237	VT profile
288	6/22/03	9:16		48	9.13	125	23.84	LA07	CTD238	VT profile
289	6/22/03	10:10		48	12.60	125	17.24	LA06	CTD239	Nutrients, VT
290	6/22/03	11:04		48	16.10	125	10.57	LA05	CTD240	VT profile
291	6/22/03	12:25		48	19.68	125	20.39	LAB05	CTD241	Nick's Sample
292	6/22/03	12:55		48	19.72	125	20.37	LAB05	Fe Sampler Profile	Fe
293	6/22/03	16:34		48	16.10	125	10.58	LA05	CTD242	microzooplantkton
294	6/22/03	18:54		48	19.39	125	4.11	LA04	CTD243	Nutrients, VT, CHL
295	6/22/03	19:54		48	22.82	124	57.69	LA03	CTD244	VT, CHL
296	6/22/03	21:08		48	26.29	124	51.48	LA02	CTD245	Nutrients, VT, CHL
297	6/22/03	22:05		48	29.24	124	43.63	LA01	CTD246	Nutrients, VT, CHL
298	6/22/03	22:44		48	29.12	124	42.00	EH1	CTD247	VT
299	6/23/03	1:53		48	23.10	124	22.76	JDF1	CTD248	VT
300	6/22/03	4:53		48	14.00	123	43.00	JDF2	CTD249	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 of Travel	CTD Cast Nos. W-E	Sta IDs	Nutrient sites	Fe Samples	Lessard Samples	Lessard Expts.
6/2/2003	CTD-test		1					
6/3/2003	EH1-Mooring		2	EH1				
6/3-6/4/03	Copalis Beach	E-W	9-3	CB01-CB07	CB1,2,4,6	CB2,4,5		
6/4/2003	Kalaloch Beach	W-E	10-16	KB7-KB1	KB1,2,4,6	KB1,3		
6/4/2003	Kalaloch Beach		17-18	KB1				KB1
6/5/2003	La Push	E-W	26-19	LP8-LP1	LP1,2,4,5,7	LB3,8		
6/5/2003	Ozette	W-E	27-35	OZ9-OZ1	OZ1,2,4,7		OZ1,4,7	
6/5-6/6/2003	Cape Flattery	E-W	45-40, 38-36	CF1-CF9	CF1,2,4,6,8		CF4,6	
6/6/2003	LaPerouse A	W-E	46-56	LA11-LA1	LA1,2,4,6,		LA4,6	
6/7/2003	LaPerouse AB	E-W	66-57	LAB1-LAB10	LAB1,2,3,4,		LAB3, 5,7	
6/7-6/8/03	LaPerouse B	W-E	67-78	LB15-13,11-5,3,1	LB1,3,5,7,		LB8,10	
6/8/2003	LaPerouse BC	E-W	85-79	LBC1-LBC7	LB1,2,4,6		LBC4	
6/8-6/9/03	LaPerouse C	E-W	94-86	LC10-LC3,1	LC1,3,5,7			
6/9-6/10/03	Drift A		95-97	DA1-DA2	DA2	DA1(96)	DA1(96)	DA1 (95)
6/10/2003	EH3-Mooring		98	EH3				
6/10/2003	LaPerouse AB		99,100	LAB5,4				
6/10/2003	Drift A		101,102	DA3,4	DA3			
6/10/2003	EH3-Mooring		103	EH3		EH3		
6/10-6/11/03	Drift A		104-109	DA5-DA10	DA7,10	DA5,6,10		DA9
6/11/2003	LaPerouse AB		110	LAB5	LAB5			
6/12/2003	Drift B		111,112	DB1	DB1 (111)			DB1 (111)
6/12/2003	Drift A		113	DA11	DA11			
6/12/2003	Drift B		114	DB2	DB2	DB2		
6/12/2003	Drift A		115	DA12	DA12	DA12	DA12	
6/13/2003	Drift B		116-118	DB3,4	DB3,4 (116,117)			DB4 (118)
6/13/2003	Canyon	N-S	119-121	C7,5	C7,5	C5,6		
6/14/2003	Drift B		122	DB5	DB5			
6/13-6/14/03	Canyon	N-S	123-126	C4-C1	C4,3,1	C3,4		
6/14/2003	Drift B		127	DB6	DB06			

6/14/2003	LaPerouse A	E-W	133-128	LA1-LA6	LA2,4,6	LA2,6		
6/15/2003	Drift B		134-136	DB7-9	DB7			
6/15/2003	Canyon	S-N	137-143	C8-C14	C8,10,12,	13,14		
6/15/2003	Drift B		144-145	DB10	DB10			DB10 (145)
6/15-6/16/03	LaPerouse AB	E-W	151-146	LAB1-LAB6	LAB1,2,4,6	LAB1,2,4,6		
6/16/2003	Drift B		152	DB11	DB11			
6/16/2003	LaPerouse B	E-W	159-153	LB9-LB1				
6/16/2003	Drift B		160	DB12	DB12	DB12	DB12	
6/16/2003	EH1-Mooring		161	EH1	EH1	EH1		
6/16/2003	Juan de Fuca		162	JDF1	JDF1	JDF1		
6/17/2003	Coast Transit	N-S	163-167	CF1,OZ1,LP1,KB1,CB1	CF1,OZ1,LP1,KB1,CB1			
6/17/2003	Kalaloch Beach	W-E	168-170	KB3-1	KB2,1			
6/17-6/18/03	Kalaloch Beach		171-174	KB1,2,1.5,1	KB1 (171)			
6/18/2003	Copalis Beach	E-W	181-75	CB1-CB7	CB1,2,4,6		CB2,4,6	
6/18/2003	La Push	W-E	182-188	LP7-LP1	LP1,2,4,6		LP1	LP1
6/18-6/20/03	Drift C		189-202	DC1-DC12	DC4,12		DC12	
6/20/2003	EH2-Mooring		203	EH2				
6/20/2003	Cape Flattery to LAB6	E-W	207-204	FL3-1,CF1				
6/20/2003	La Perouse AB		208-211	LAB6	LAB6 (209)			LAB6 (210)
6/20/2003	La Perouse AB		212	LAB10		LAB10		
6/21/2003	La Perouse AB	W-E	213-222	LAB10-LAB1	LAB1,2,4,6,8,10		LAB6	
6/21-6/22/03	La Perouse B	E-W	234-223	LB15-13,11-5,3,1	LB1,2,4,6,8,10			
6/22/2003	La Perouse A	W-E	235-240	LA10-5	LA6			
6/22/2003	La Perouse AB		241	LAB5		LAB5		
6/22/2003	La Perouse A	W-E	242-246	LA5-1	LA1,2,4			
6/22/2003	EH1-Mooring		247	EH1				
6/23/2003	JDF1		248	JDF1				
6/23/2003	JDF2		249	JDF2				

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
3819	Clearwater	6/3/03 14:48	48	15.15	125	30.49	7/29/03 15:20	-	Timed out
3861	Clearwater	6/7/03 5:30	48	19.71	125	20.38	7/31/03 10:52	-	Timed out
3860	Brightwater 104a	6/9/03 18:55	48	15.97	125	27.68	6/12/03 13:44	A	Ceased transmitting
3818	Brightwater 104a	6/12/03 2:30	48	19.70	125	20.39	6/16/03 13:30	B	Recovered
3917	Clearwater	6/16/03 18:36	48	29.38	124	42.05	8/1/03 7:05	-	Timed out (no temp)
3818	Brightwater 104a	6/18/03 16:00	47	49.50	124	40.69	6/20/03 2:30	C	Recovered

Table 4. Dates and file name of available satellite imagery

Sea Surface Temperature
2003_0602_1431_sst-blowup.jpg
2003_0602_1431_sst.jpg
2003_0602_306_sst.jpg
2003_0604_0426_sst.jpg
2003_0605_1357_sst-blowup.jpg
2003_0606_0402_sst-blowup-R.jpg
2003_0606_0402_sst-blowup.jpg
2003_0606_0402_sst-R.jpg
2003_0606_0402_sst.jpg
2003_0608_1504_sst-blowup.jpg
2003_0609_0328_sst-blowup.jpg
2003_0609_0328_sst.jpg
2003_0613_0425_sst-blowup.jpg
2003_0613_0425_sst.jpg
2003_0615_1526_sst-blowup.jpg
2003_0615_1526_sst.jpg
2003_0616_1515_sst.jpg
2003_0618_1452_sst-blowup.jpg
20030605_041407PDT_5daycomp.jpg
20030605_041407PDT_WA.jpg
Ocean colour
2003_0602_1324_chl.jpg
2003_0604_1446_chl.jpg
2003_0606_1429_chl.jpg
2003_0608_1412_chl.jpg
2003_0615_1403_chl.jpg
2003_0618_1428_chl.jpg
2003155200800.jpg
2003167214501.jpg
NW20031662103_rrs670.jpg
NW20031672006_rrs670.jpg

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

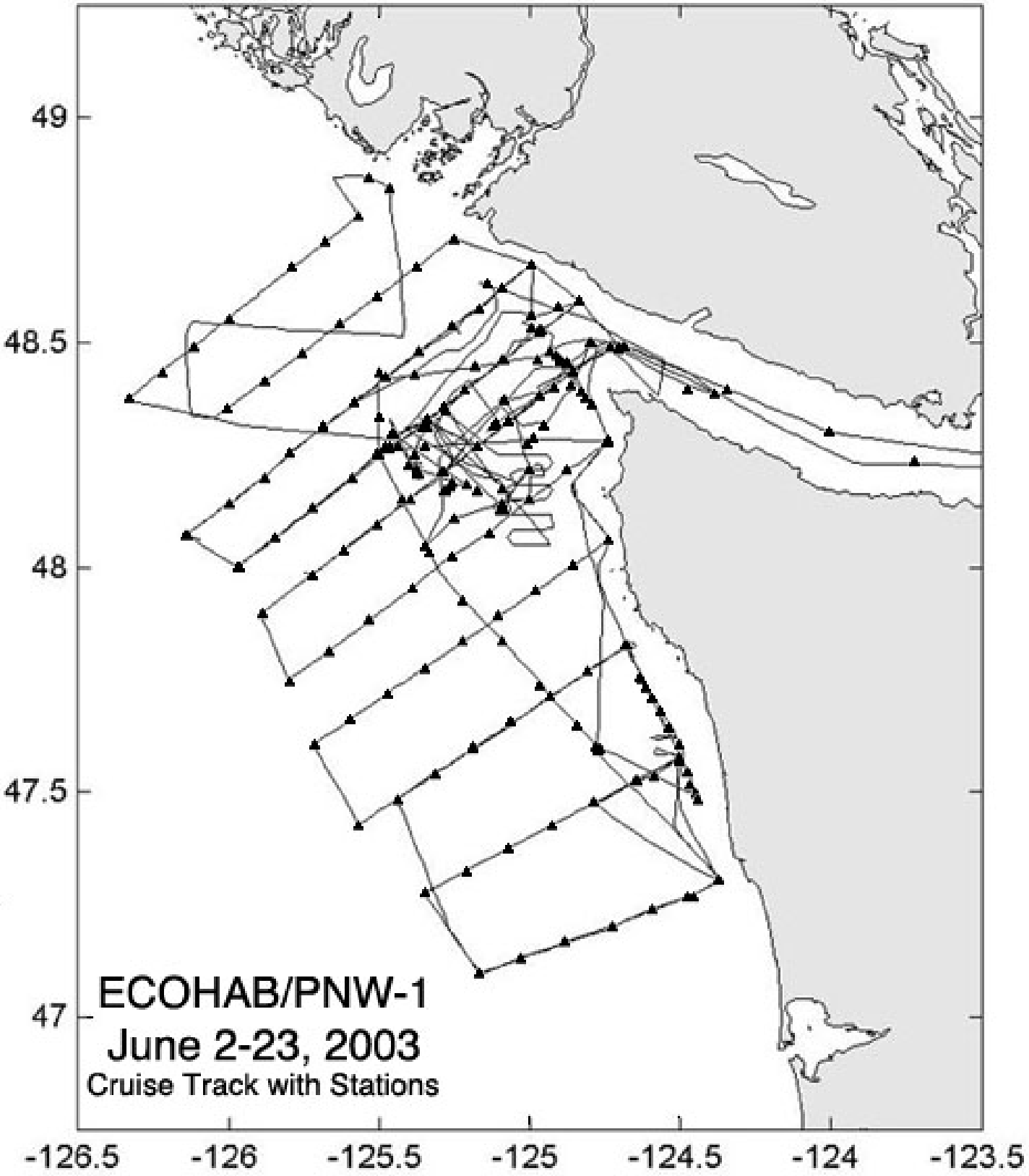
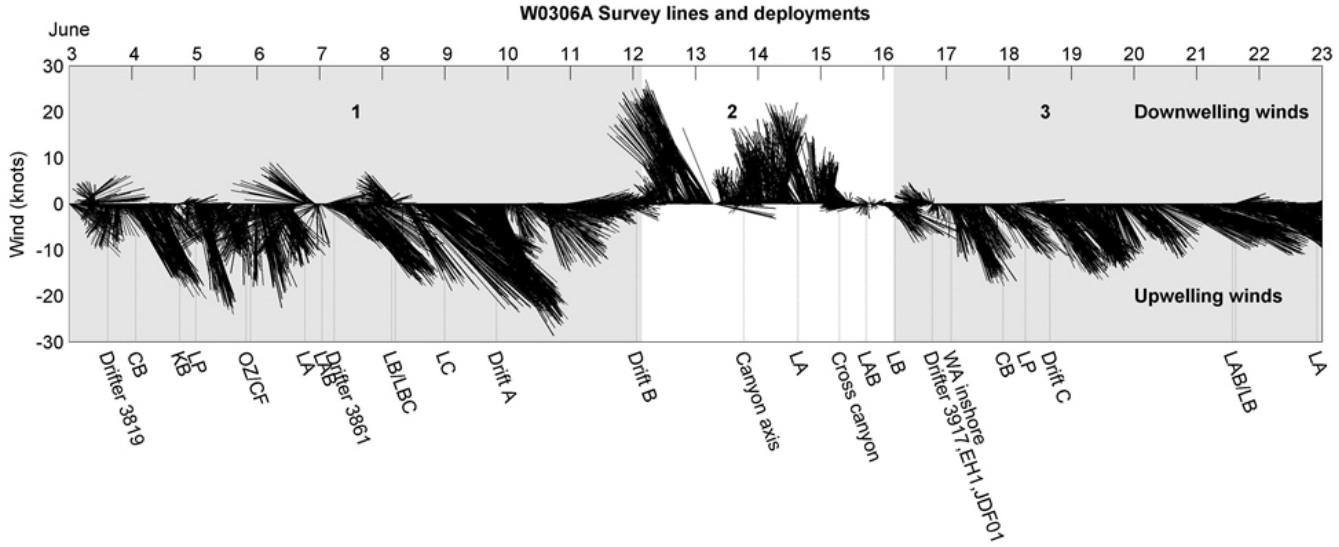


Figure 2. Time series of shipboard vector winds during cruise



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 three survey periods are also shown.

Figure 3. Theoretical survey grid and locations of moored arrays

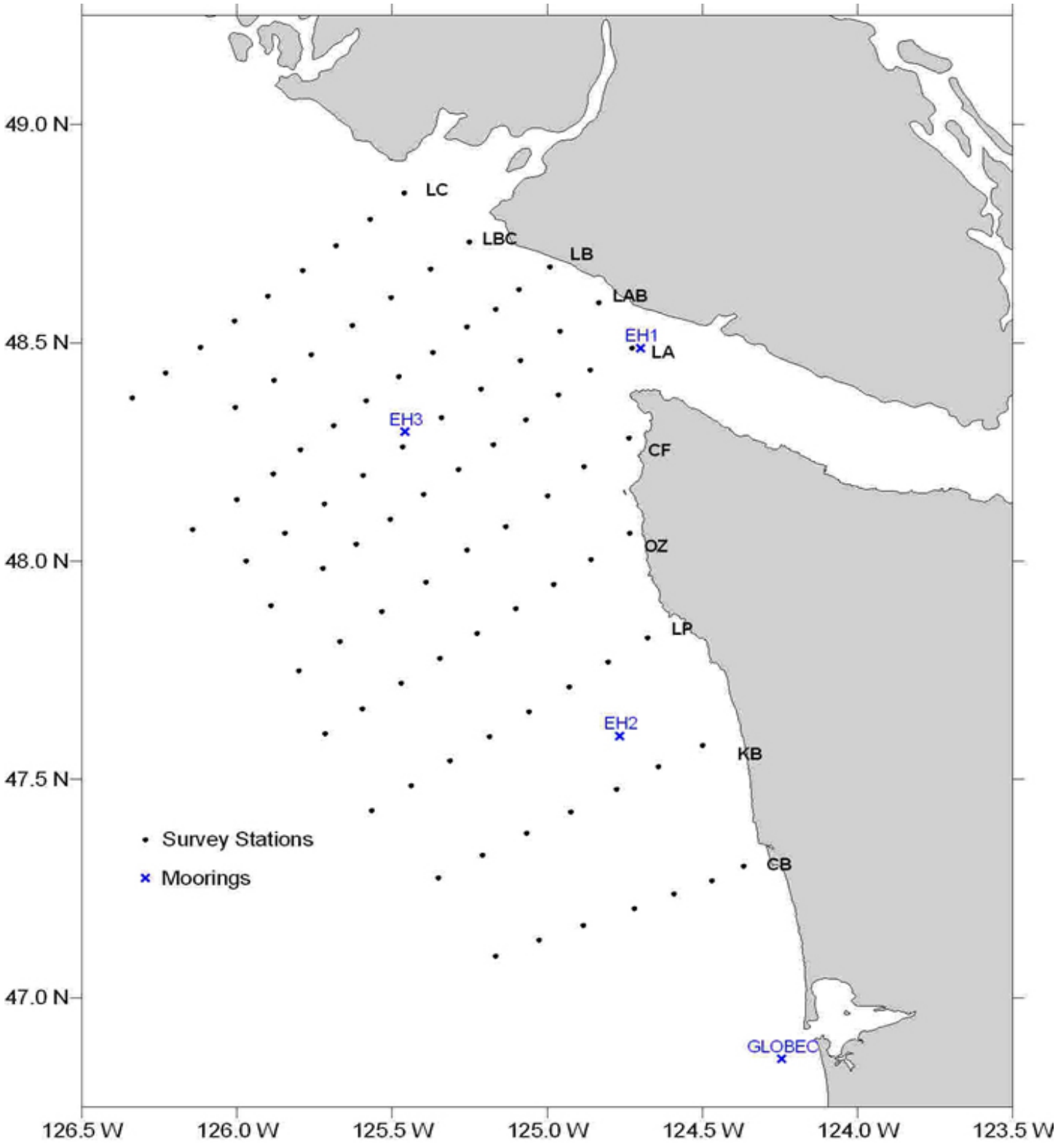


Figure 4a. CTD station numbers for Survey 1

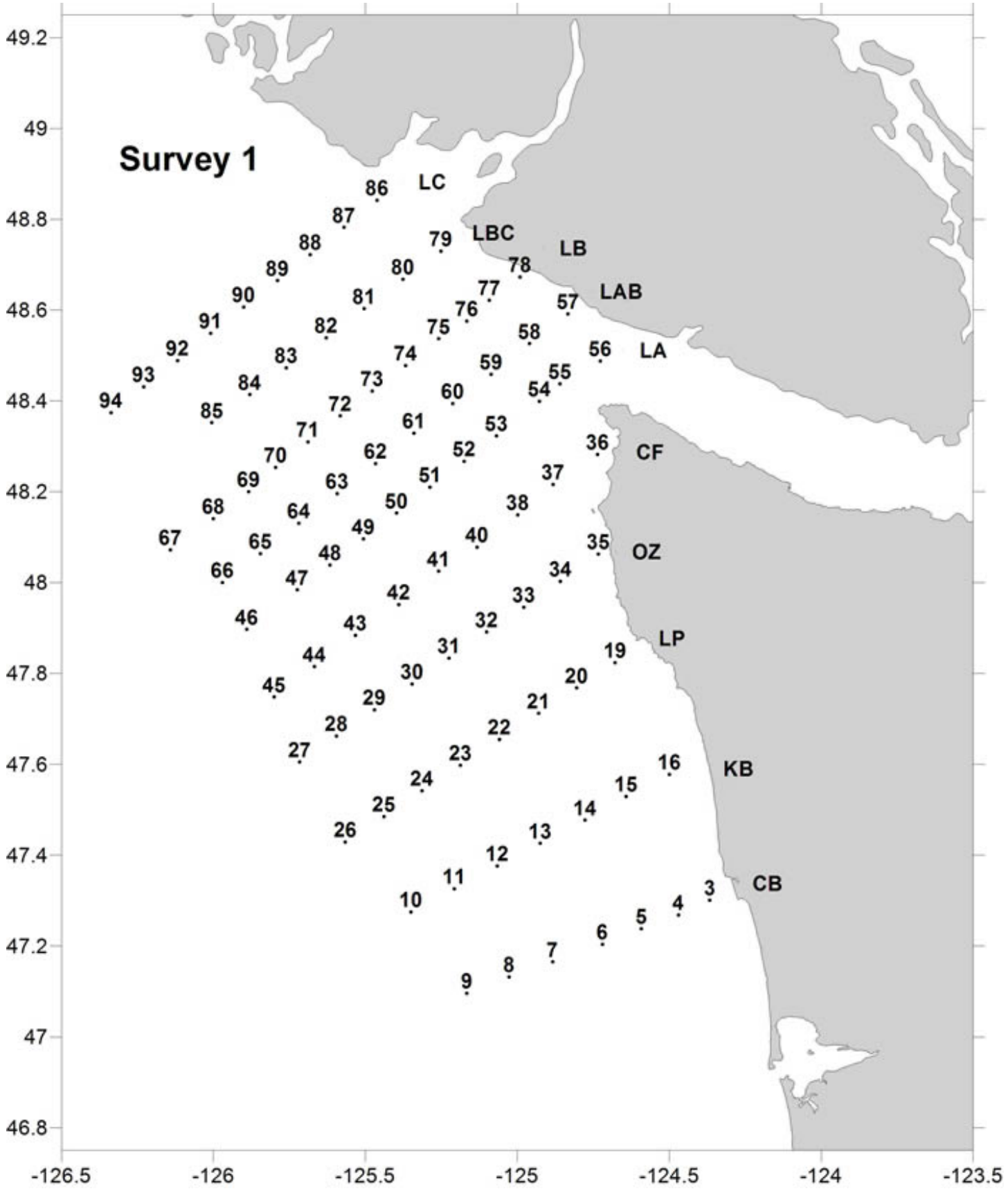


Figure 4b. CTD station numbers for Survey 2

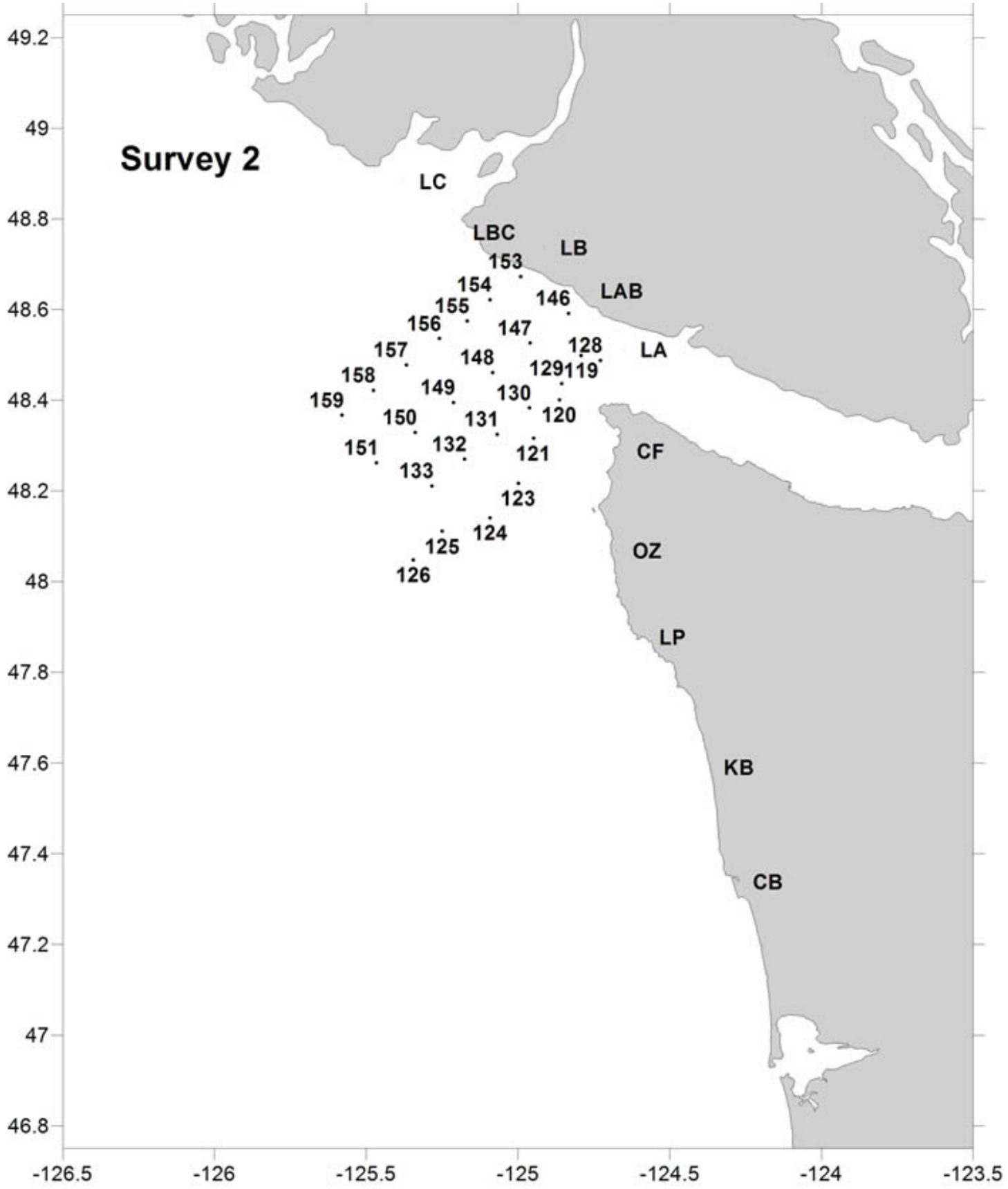


Figure 4c. CTD station numbers for Survey 3

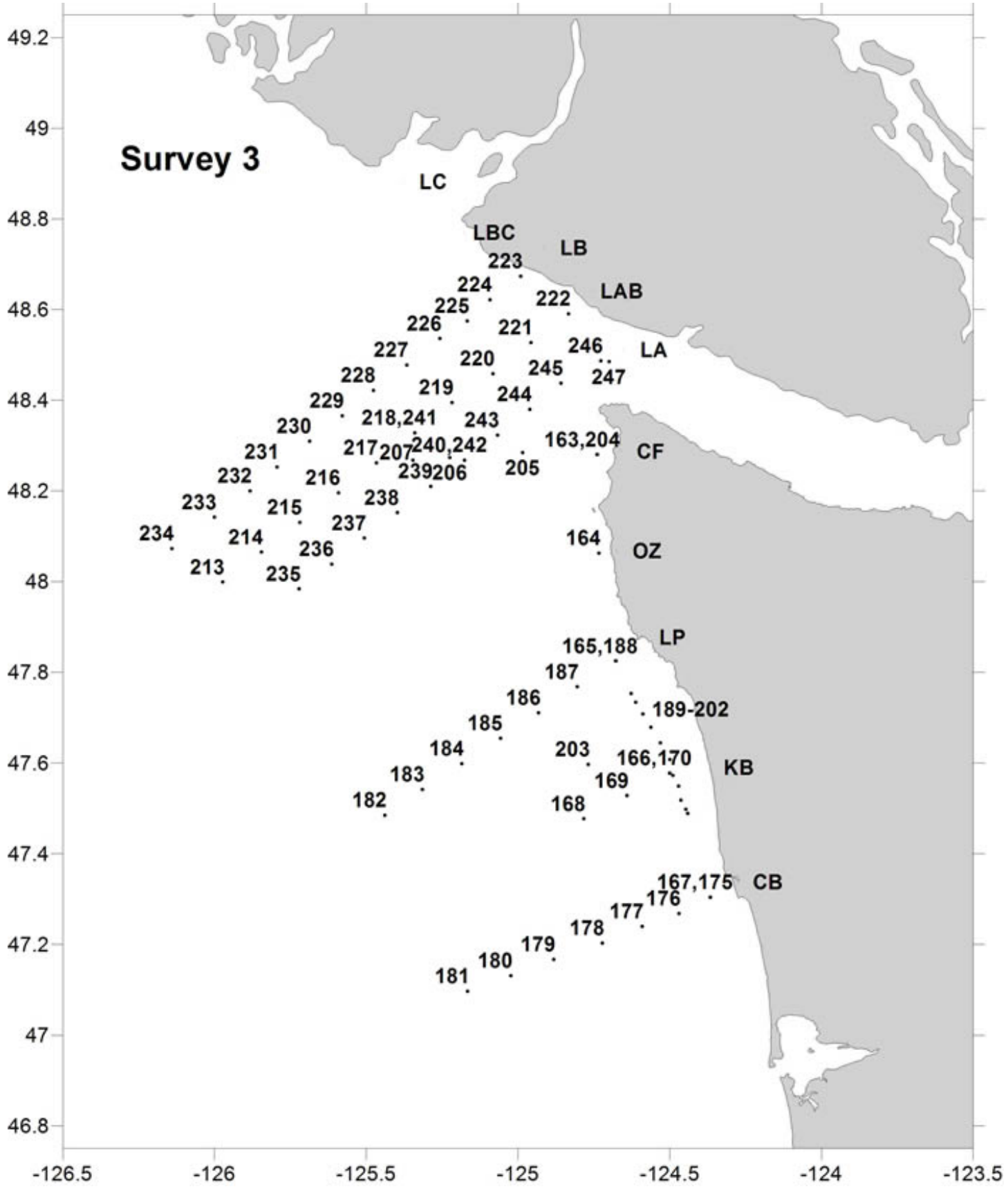


Figure 4d. CTD station numbers for the canyon survey

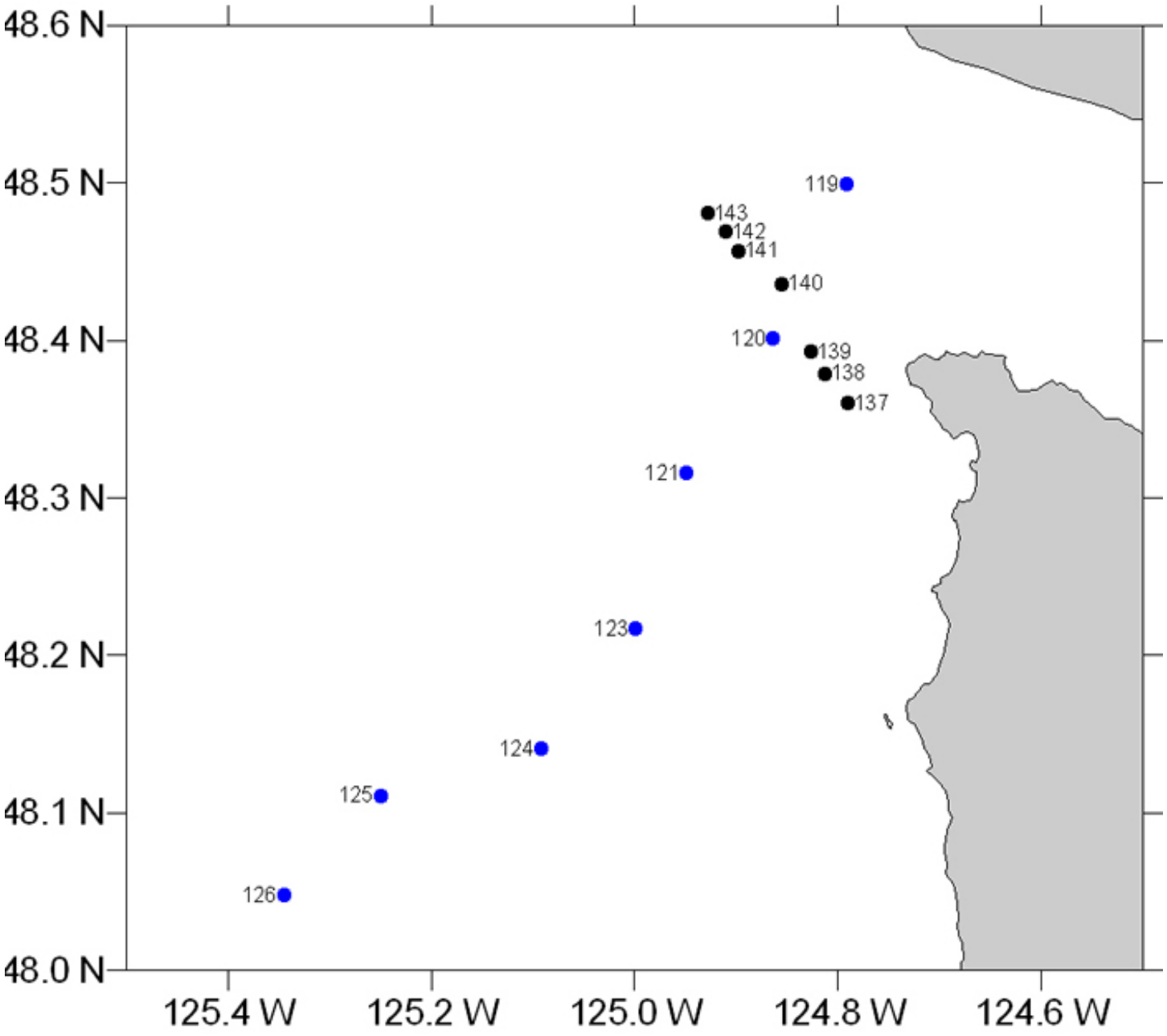


Figure 5a. Drifter track during Drift A (3860) with CTD cast numbers

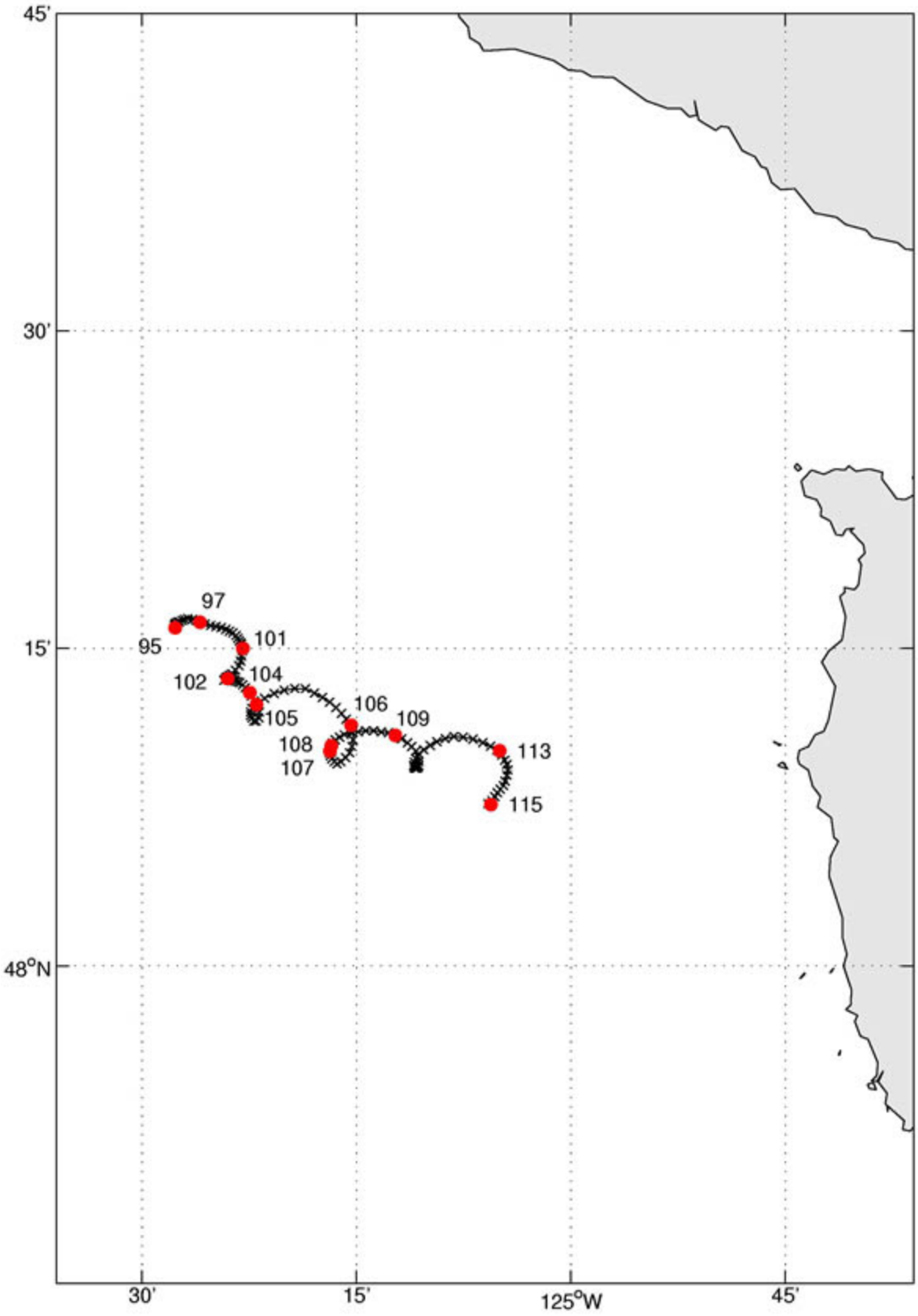


Figure 5b. Drifter track during Drift B (3818) with CTD cast numbers

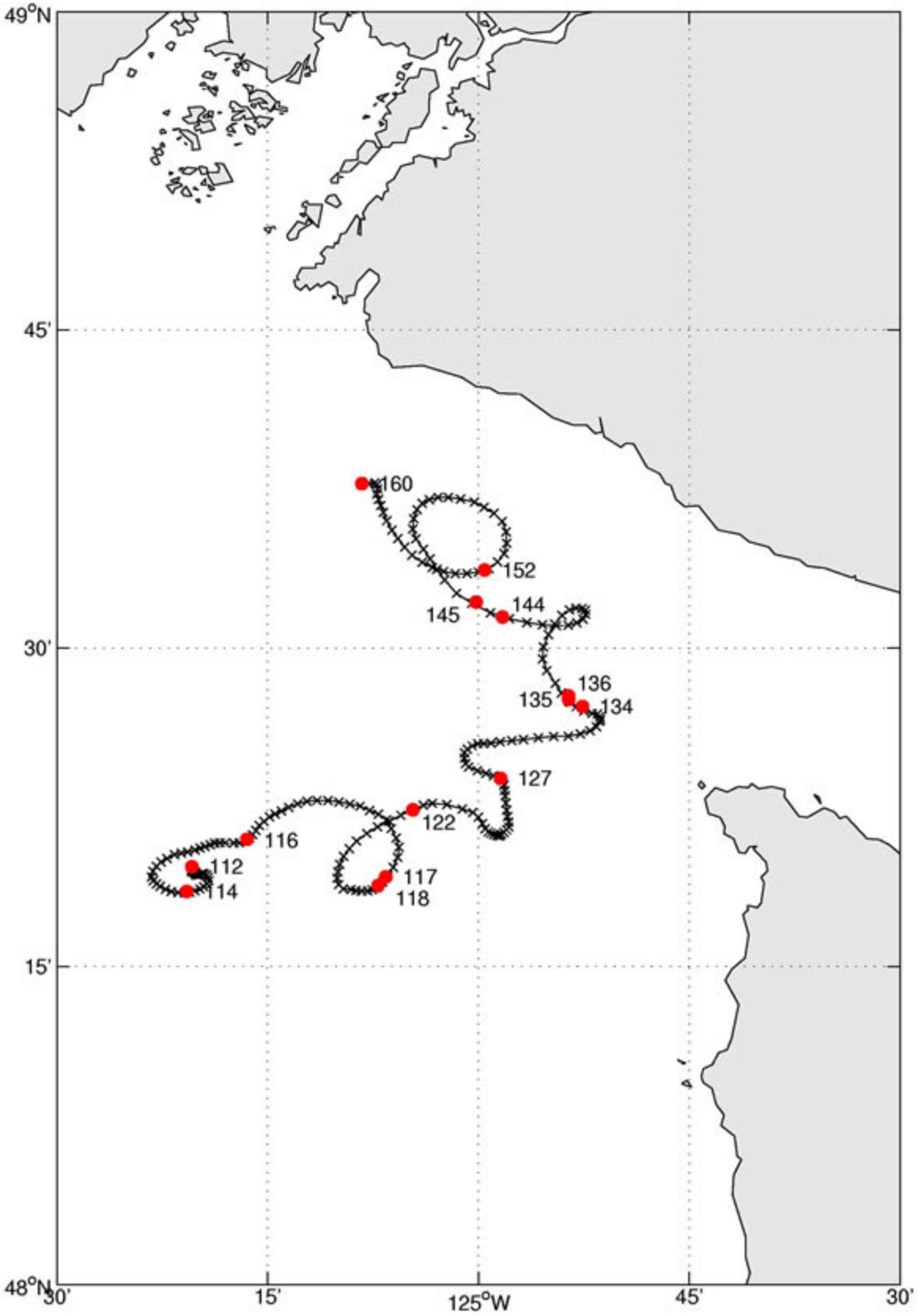


Figure 5c. Drifter track during Drift C (3818) with CTD casts numbers

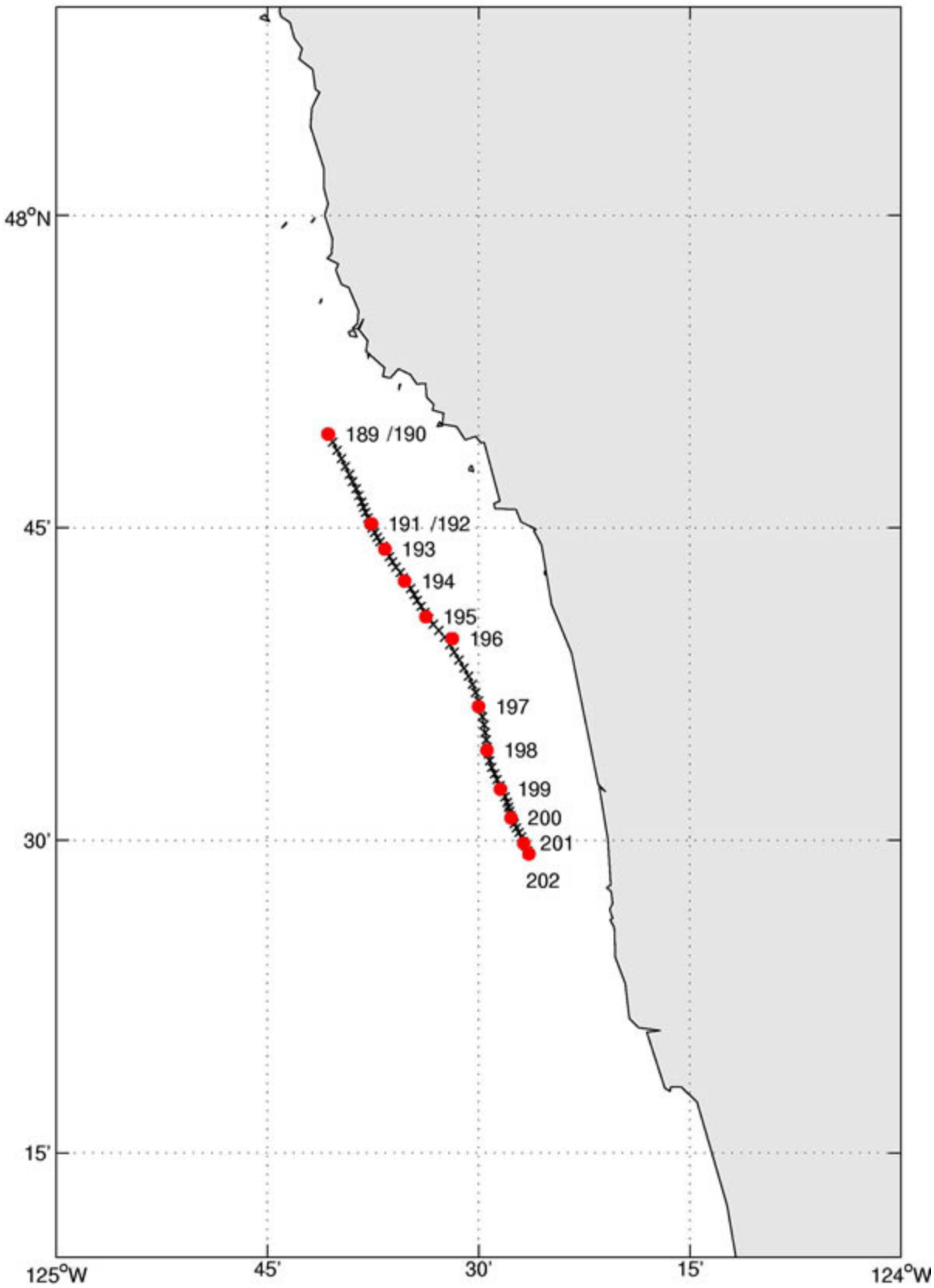
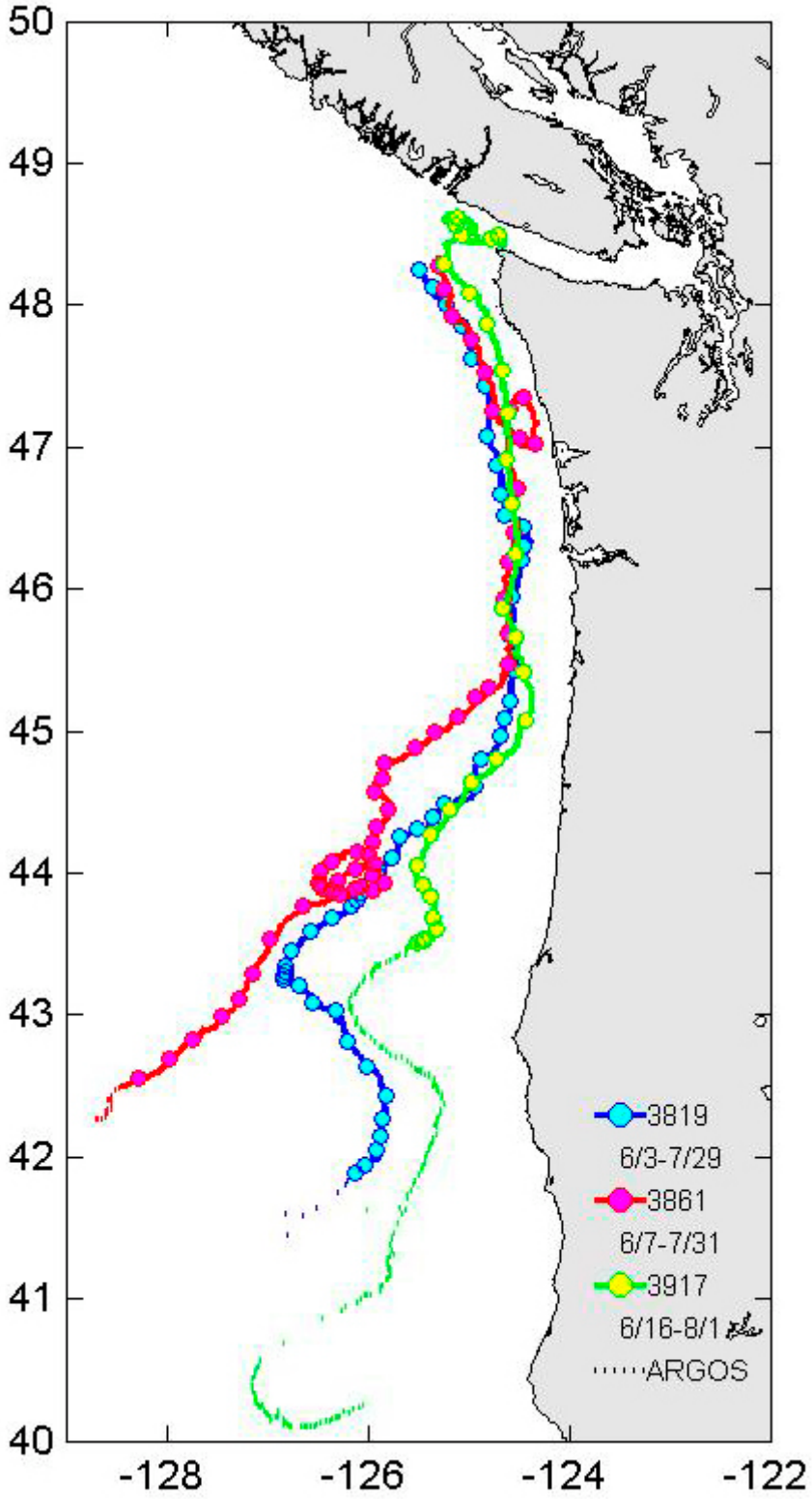
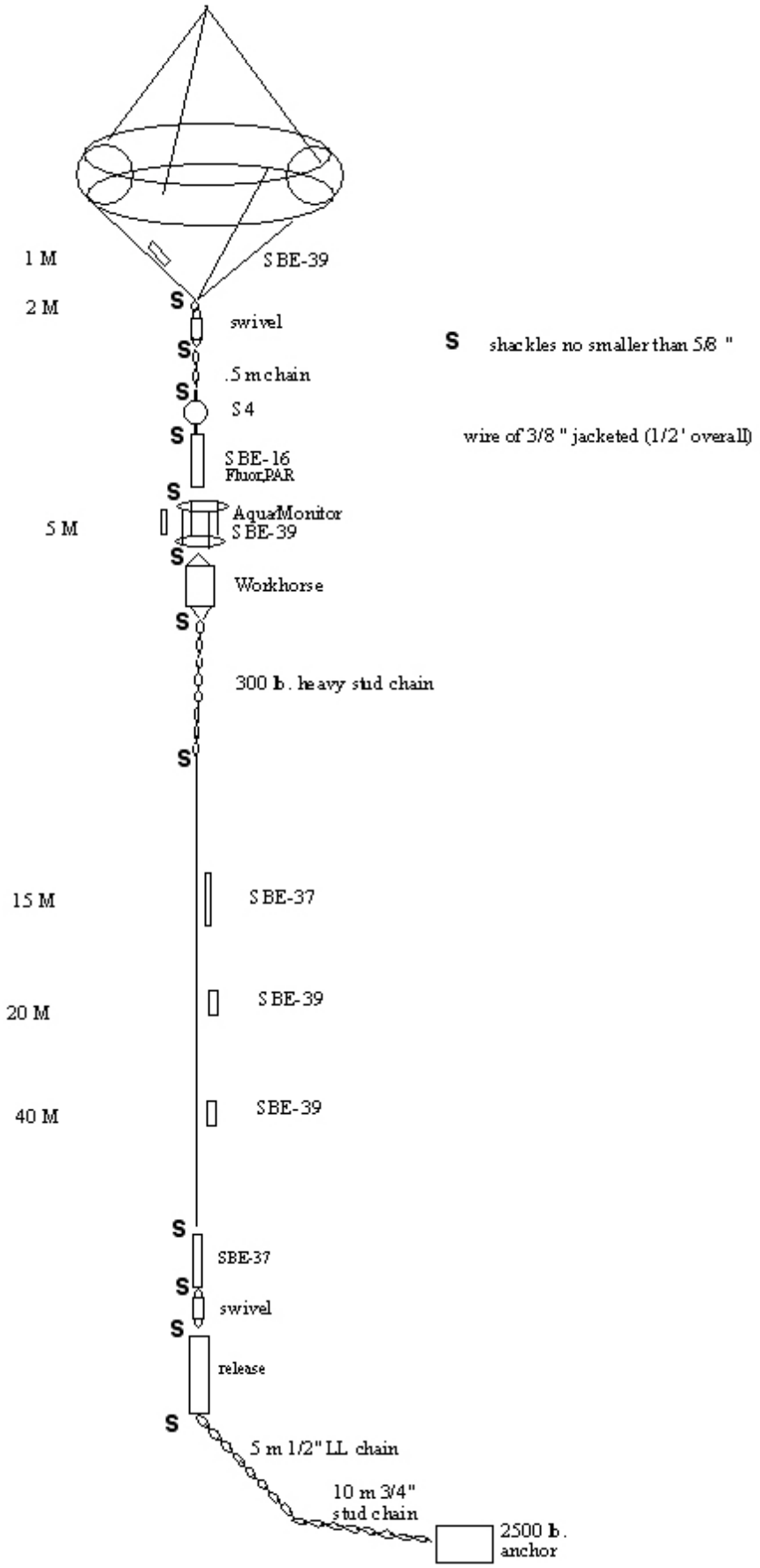


Figure 6. Trajectories of expendable drifters deployed during the cruise



Drifters were deployed off of Northern Washington and moved southward. Colored dots represent 1 day.

Figure 7. Mooring schematic



Wind and PAR sensors are mounted on the buoy tower (not shown).