RISE

River Influences on Shelf Ecosystems

RISE 2- W

CRUISE REPORT

R/V Wecoma W0505C

May 29-June 21, 2005

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Area of Operations:

Coastal waters off Washington and Oregon

Itinerary

Depart Newport, Oregon, May 31, 2005
Arrive Newport Oregon, June 21, 2005

Participating Organizations

University of California, Santa Cruz
Oregon State University
University of Washington

Chief Scientists

Dr. Barbara M. Hickey, School of Oceanography, University of Washington
Dr. Bill Peterson, Oregon State University

Personnel

Principle Investigators

Dr. Raphael Kudela, University of California, Santa Cruz
Dr. Evelyn Lessard, University of Washington
Dr. Maeve Lohan, University of California, Santa Cruz
Dr. William Peterson, Oregon State University

Staff

Megan Bernhardt, University of Washington
Dr. Elizabeth Frame, University of Washington (Post Doc)
Dr. Nancy Kachel, University of Washington
Jim Postel, University of Washington
Tracy Shaw, Oregon State University
Geoffrey Smith, University of California, Santa Cruz
Bettina Sohst, University of California, Santa Cruz
Alice Roberts, University of California, Santa Cruz
Dr. Tawnya Peterson, University of California, Santa Cruz

Students

Laura Bodensteiner, Moss Landing Marine Laboratories (grad)
Megan Wehrenberg, Moss Landing Marine Laboratories (grad)
Joe Quartini, University of California, Santa Cruz (undergrad)
Ana Aguilar-Islas, University of California, Santa Cruz (grad)
Carolyn Berger, University of California, Santa Cruz (grad)
Ryan McCabe, University of Washington (grad)
Sherry Palacios, University of California, Santa Cruz (grad)

Cruise Objectives

The purpose of this cruise was to make physical, chemical and biological measurements within the plume of the Columbia River and over the shelves north and south of the river mouth, with the objective of determining the effect of the river plume on regional productivity. Historical observations have shown that in spite of weaker upwelling winds the Washington shelf is more highly productive than much of the Oregon shelf. Comparative measurements of biological rates, chemical constituents including iron and other micro nutrients and plankton growth and grazing as well as community distributions were made in the three regions. These data complement data from three moored arrays deployed in the study area, data from a second ship, the R/V Pt. Sur, that focused on mixing rates and large scale physical, nitrate, fluorescence surveys as well as frontal processes, and data from remote sensing and model studies.

The ship track and sampling stations are shown in Figure 1.

Operations

ADCP lines: entire ship track
Flow-Through system track with T,S,FL sensors: entire ship track
CTD casts: 121
Optical profiles: 40
Satellite-tracked drifter deployments: 19

Samples Collected

Chlorophyll samples: 1402
Nutrient samples: >2000
Microzooplankton samples: 13 profiles for microscopy, plus 12 dilution experiments
FlowCAM samples: ~500
Fe and Mn samples: ~800
Particulate Trace metal samples: ~360
Zooplankton net tows: 94 preserved (vertical plus bongo); 33 live tows

Cruise Summary

PROJECT OVERVIEW

RISE focuses on the highly productive Eastern Boundary river plume originating from the Columbia River – a plume sufficiently large to be of regional importance, yet small enough to allow determination of dominant processes affecting and/or resulting from river plumes, and to facilitate rate comparisons with regions outside the plume. Chlorophyll and primary productivity are not uniform along the Pacific Northwest coast– they are higher in the Columbia River plume and over the shelf north of the river mouth than south of the river mouth. The greater richness of the northern PNW coast is particularly surprising because alongshore wind stress, the primary forcing responsible for macronutrient supply, increases in the opposite direction to the productivity. Historical data have suggested that the Columbia River itself provides little nitrate to the coast, although it does supply large amounts of silicate and as much dissolved iron as the Mississippi River. The overall goal of RISE is to determine the extent to which the regional productivity differences are a result of the presence of the river plume—e.g., it's turbidity, stratification, species composition and nutrient load, as well as its effect on mixing and advection.

RISE has three hypotheses:

- **During upwelling the growth rate of phytoplankton within the plume exceeds that in nearby areas outside the plume being fueled by the same upwelling nitrate.**
- **The plume enhances cross-margin transport of plankton and nutrients.**
- **Plume-specific nutrients (Fe and Si) alter and enhance productivity on nearby shelves.**

The hypotheses are being tested through a combination of field surveys, moored sensor arrays, drifters, remote sensing and biophysical modeling. The field studies uses two vessels, one, the R/V Wecoma, obtaining primarily biogeochemical rate data; the other, the R/V Pt. Sur, obtaining synoptic mesoscale and fine-scale surveys as well as turbulent flux measurements (Fig. 2) The sampling approach will provide a Lagrangian history of mixing and biogeochemical transformations as well as the broader quasi-synoptic view. Comparative studies are being made between regions north and south of the plume where iron and other nutrient sufficiency may differ, as well as in the plume. The time-space context of observed variability is being provided by an array of moored sensors deployed in the plume as well as on the shelf north and south of the plume, and by an array of long-range HF current-mapping radars producing hourly maps of regional surface currents. Satellite-derived AVHRR, chlorophyll, turbidity images as well as synthetic aperture radar (SAR) are being used to determine scales of spatial variability in the plume region and to relate it to primary productivity

This report describes sampling on the second RISE cruise on the R/V Wecoma.

CRUISE SAMPLING OVERVIEW

The RISE 2 R/V Wecoma cruise was highly successful, obtaining data along a track covering the region from 45.2º N to 45.8º N out to longitude 125.5º W (Fig. 1). Measurements included multi disciplinary data (CTD, nutrients from CTD and a towed fish, net tows, plankton identification using a FlowCAM, optical profiles) from sections (Section 1), underway surface surveys (macro and micro-nutrients as well as C, T) using a towed fish (Section 2), profiles of water properties (including optics and plankton) while following a drifter (Section 3), deployment of surface drifters (with C, T) (Section 4), satellite imagery (Section 5), and laboratory studies using water and plankton collected at selected sites (Section 6).

The setting of cruise sampling events within the wind environment during the cruise (upwelling or downwelling-favorable) is shown in Figure 2. Overall, we obtained 121 CTD/nutrient profiles, over 1400 chlorophyll samples, over 600 iron and manganese samples and 40 optical profiles. Satellite imagery (SST and chlorophyll a) was obtained on only a few days due to the generally poor weather. Cruise activities were recorded in a sequential "Event" log (Table 1) from which summary tables discussed below were derived.

1. Water Property Sections (entire RISE WECOMA team)

Winds were variable throughout the cruise, with only slightly more upwelling-favorable than downwelling-favorable periods (Fig. 2). The data might be grouped as occurring in one of three periods: weak but reasonably persistent upwelling-favorable winds (May 30- June 4), strong downwelling winds (June 5) and intermittent upwelling/downwelling-favorable but weak winds (June 6-21) (Fig. 2). The first period includes sections and towed iron fish surface transects along the plume axis (P), and south (CM) and north (GH) lines as well as an underway survey of the south part of the plume (to find the plume axis). The second period, which occurred during spring tides, included an estuary study. Waves from the June 5 storm were still large during our attempt to study fronts on June 6, and we were not able to follow surface fronts for more than an hour or two. The third period included a time series near the river mouth during spring tides, an underway survey of the north plume, a drift study of a northward tending plume (DA), an underway survey of the southern nearshore plume and a CTD line across it as well as an alongshelf survey of a northward plume. The third period also included estuary, frontal and time series during neap tides as well as CTD/iron fish surveys along the Grays Harbor, Cape Meares, Newport and Heceta Bank (BOB) lines.

Patterns and variability of water properties with depth were examined along the north (Grays Harbor, "GH") and south (Cape Meares, "CM" of the river mouth (twice in each location) and along the plume axis (Fig. 3). During our initial surveys, a southwest tending plume was well developed. However the plume was broad and had multiple axes. It extended too far south for complete sampling given the constraints of the cruise plan associated with the two ship operation. Because of the weather on this cruise, northward tending plumes were better developed and more persistent than southwest tending plumes. After the storm of June 5 the plume was trapped fairly close to the Washington coast. A matching plume with slightly higher surface salinities (26 psu vs. 25 psu off Washington) uniform out to 10 miles from the coast hugged the Oregon coast. The inner shelf portion of a well developed northward plume was sampled on June 10-11 at Longbeach (LB line), Grays Harbor (GH), Kalaloch (KA) and near La Push (LP), WA (46.83º). The Longbeach line and also a line along latitude 46.25º (Oceanside, OS), Washington were also sampled during a northward plume period. The latter was done as a follow up to our plume drift (DA). The Pt. Sur towed TRIAXUS on the outer portion of the line while Wecoma sampled the shallower inner part of the line with CTDs. A short line off Haystack Rocks (HS), OR was sampled in order to compare plumes hugging the Oregon and Washington coasts (LB vs. OS) in one wind period. The Newport line and Heceta Bank were also sampled.

Data collected at each station included conductivity (C), temperature (T), light transmission, PAR, oxygen and fluorescence (Fl) profiles, optical backscatter, Fast Repetition Rate Fluorometer (FRRF), ISUS UV nitrate sensor and bottle samples for chlorophyll, plankton and macronutrients, all at selected depths. Both macronutrients and micronutrients were sampled at most stations using a towed fish operated in a vertical mode by slowly lowering the fish to 20 m. Underway data included T, S and Fl (with beam transmission from 2 m) pumped from a depth of about 2 m and 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 sections for temperature, salinity, density, fluorescence, light transmission and oxygen versus depth have been made by Ryan McCabe and are given on the web site with two scales, 0-30 m and 0-200 m). With only a few exceptions, profiles were taken only as deep as 200 m. Deeper stations (to 500 m) were taken off Grays Harbor and Cape Meares to sample the California undercurrent depth range.

Noon optics casts were made most days. Sensors included a Wetlabs AC9, a Satlantic HyperPro II tethered profiling hyperspectral radiometer, a Wetlabs backscatter sensor, and a Wetlabs volume scattering function (VSF) sensor. Matching CTD profiles were also obtained.

A list of CTD stations organized by sample line and including bottle sample types taken is given in Table 2. All lines were sampled from shallow to deep water.

CTD profiles were taken to 200 m where possible. Macro nutrients were taken at the surface, 5 m, 10 m, the chlorophyll maximum 15 m, 30 m, 50 m, 100 m, 150 m and ~5 meters above bottom if the bottom was less than 200 m deep on four of the five sections and also on primary productivity casts.

Upper water column micronutrient samples were taken at selected CTD stations (Tables 1 and 2). Water was pumped for roughly 10 minutes to flush the lines thoroughly before samples were taken. Subsurface vertical iron profiles were obtained at many stations by lowering the fish to the target depths (typically 2 m, 4, 10, 15 and 18 m) while maintaining a slow forward speed. Along the Grays Harbor and the Cape Meares sections and the plume axis section trace metal samples from the bottom nepheloid layer were taken using GO-Flo bottles.

Underway data were collected at 4 m from shipboard sensors. In addition, the Kudela group installed a Seabird temperature and conductivity sensor (SBE-45), Turner fluorometer (Cyclops-7) and Wetlabs transmissometer at 2 m using the forward underway port. This shallower data was very useful and is included on the CTD paper logs.

Bottle samples were taken for calibration of both salinity and oxygen CTD sensors. Salinity samples were taken at roughly every third station and processed onboard by Nancy Kachel. Oxygen samples were taken during the last 3 days of the cruise and processed onshore on the following day by Jim Postel.

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 nutrient data require more extensive processing.

Some Preliminary Results:

- No upwelling into inner shelf surface layers was observed at the coast during this cruise, from Newport, OR and Cape Meares, OR in the south to La Push, WA in the north. Surface nitrate was zero everywhere and chlorophyll values were much lower than on the July 2004 survey.
- Based on eight experiments, phytoplankton growth rate was consistently higher (though still low) on the Washington coast (GH line) than the Oregon coast (CM line), where there was little or no measurable phytoplankton growth.
- On the Washington and Oregon coasts, grazing generally was a significant fraction of the phytoplankton growth rates. In the new plume waters around the CR mouth, grazing was low relative to growth, and grazers sparse, indicating that the community was in an early stage of development.
- In many instances, diatoms and protist grazers appeared healthier and were more abundant in the layer below the fresh plume.
- The northward plume along the Washington coast could be traced as far as La Push, WA (our last transect). Plume salinity decreased gradually from about 26 to about 30 psu along the plume axis.
- The plume could be traced near the coast as far south as Heceta Bank, OR.
- Nitrate was near zero in the entire upper 50 m of the water column of the outer shelf on the initial line surveys off WA and OR (and in the upper 30 m at the end of the cruise) and temperatures were higher than normal, a marked change from July 2004. This difference appears to be an interannual difference, perhaps a residual from the El Nino of the preceding winter.
- During both spring and neap tides the river had high nitrate (14-16 μM), but low/undetectable ammonium; this nitrate appeared to be the source for the chlorophyll observed in the plume. This result was very surprising: opposite from our original hypothesis.
- Total dissolved iron and manganese were also present at high concentrations during the ebb tide close to the mouth of the estuary (~ 16 and 110 nM, respectively) and rapidly decreased as the plume moved offshore (~ 1 and 8 nM).
- Egg production rates of *Calanus pacificus* were significantly related to latitude and are evidence that egg production increases northward. These observations support our hypothesis that secondary production is higher off the Washington coast than off the Oregon coast.

2. <u>Water Property Transects</u>

a) Towed iron fish (Maeve Lohan, Geoffrey Smith, Bettina Sohst, Ana Aguilar-Islas, Carolyn Berger)

Water properties near the sea surface were surveyed primarily on five transects over the plume and shelf regions (Fig. 4) (the GH line, the CM line and the axis of a southwest tending plume, as well as a large scale survey over both the Oregon and Washington shelves). On these surveys macronutrients ($NO3$, $PO4$, $SiO4$) were sampled at 2-minute intervals. Samples for total dissolved iron and manganese were taken every 15 minutes except when strong gradients were observed and the sampling frequency was increased to 5 minutes. Measurements were made with a towed fish interfaced to Teflon tubing and pumped using a Teflon diaphragm pump. Underway temperature, salinity and fluorescence data were also collected on these surveys.

b) Ship's underway sensors (Hickey, Palacios, Kudela)

A suite of underway sensors were available at 2 and 4 m. These were towed on three large scale surveys (UW1, UW2, UW3). UW 1 was performed to locate the plume axis. At that time the plume appeared to have more than one axis, including a possible fresh (20 psu) patch near 46º 40' and 125º 40'. The portion of the plume north of the river mouth was sampled on UW2. On UW3, the southern portion of the plume was sampled. These data may supplement data taken with Triaxus on Pt. Sur as the surveys go closer to shore than allowed with Triaxus. On these surveys the Kudela group frequently deployed the FRRF (Fast Repetition Rate Fluorometer) at nighttime as well as optical packages (Wetlabs ACS; hyperspectral absorption/attenuation meter) and an ISUS (in full spectrum mode to capture CDOM as well as to measure nitrate). Discrete CDOM samples were taken on the TRIOS props in benchtop mode.

3. Drift Surveys (McCabe, Hickey, drifters; whole team for water samples)

One drift study was performed. The goal was to follow patches of water from the plume near the river mouth over the continental shelf, examining water properties (salinity, macro and micronutrients and plankton) as the patches aged. Deployment and recovery times and deployment location are listed in Table 3. In the 2004 cruise, we followed a single drifter in drift study mode. This year we decided to follow a patch of drifters so that at least one to three drifters would likely remain in the new water. This strategy proved to be much better. The drift study was also improved over the prior year by having the Pt. Sur perform nearby survey work across the plume. This information provided more data to make decisions as to which drifters to follow and where to take CTDs. In general we attempted to remain just behind the "front" of emerging drifters so as to sample the water as it aged behind that position.

Four Brightwaters GPS-type drifters were deployed to follow water at ~1 m depth inside the river plume. The drifters were equipped with temperature and conductivity sensors, set to record at 3 minute intervals. CTD profiles, net tows, nutrient and chlorophyll bottle casts and macro and micronutrient profile samples with the iron fish were taken at the start of each drift and water was collected for incubation experiments. CTD profiles, nutrient and chlorophyll bottle samples and vertical net tows were taken at 1-4 hour intervals for about 18 hours. After that interval one drifter beached near the river mouth and two drifters turned back around the tidal bulge. One of those drifters (22252) was lost, although some of its data were recovered.

Deckboard dilution experiments (Lessard) were run for 24 hours with water collected midway though the survey. Samples for size-fractionated chlorophyll, picoplankton, nanoplankton and microplankton (FlowCAM and preserved) and macronutrients were taken in each experiment.

Productivity (carbon, nitrogen, silicon) uptake experiments and carbon PE curves (Kudela) were conducted during the drift.

Some Preliminary Results:

Drift DA: The drift study (DA, drifters #22301, 22252, 22255 and 22255 CTDs 100-109) took place on June 10 during a period of weak winds. The drift was begun inside the mouth of the estuary on the greater ebb tide. Four drifters were deployed across the river mouth just outside the estuary. R/V Wecoma followed the drifter pack, while the R/V Pt. Sur sampled north-south lines near 124º 20-24' across the emerging tidal plume. The drifters swept westward at several miles per hour. One curved to the north, one to the south and two initially went straight west, forming a classic curved pattern, the westward drifters leading those on the edges. Eventually the two westward drifters turned northwestward, finally bending back eastward in a nearly circular path. Water samples were made at locations just behind the two leading drifters and at a point between the drifter paths. Water samples included micro and macronutrients as well as plankton and chlorophyll samples. Information from the Pt. Sur helped us identify regions of freshest water. Pt. Sur data confirmed the eastward flow north of the river mouth on the north side of "the bulge".

Although we expected drifters to enter a narrow coastal current band near the coast and travel north, they did not. Our expectations were based on earlier deployments as well as on one expendable drifter (#9126) previously deployed in the area. One beached just north of the river mouth. The other two circled around the bulge, passing the river mouth on its way south. One (#22252) disappeared; the other (#222301 was recovered nearshore south of the river mouth. The drifter that had originally turned south eventually changed course to the north, likely a result of the change in wind direction from southward to northward the following day. It was recovered June 11 on its way toward the river mouth.

Overall, we expect these data to provide very exciting information regarding the bulge area and newly emerging plumes.

3. Satellite Imagery (Kudela)

Satellite imagery during the cruise was provided by the Kudela group, who sent data to the Wecoma ftp site. 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 plume water and regions of higher chlorophyll. Turbidity images look promising for identification of plumes and separation of new and residual plumes. For 2005, we also provided MODIS 250 m true-color images, which are useful for identifying the plume under clear conditions (which were rare during the cruise period).

4. Details of Individual Group Efforts

a) Chemical Analyses (Bruland Group: Maeve Lohan, Geoffery Smith, Bettina Sohst, Ana Aguilar-Islas, Carolyn Berger)

The primary objective of this component of RISE is to examine the influence of the Columbia River plume on macronutrients (nitrate, phosphate and silicic acid) and micronutrient (dissolved and particulate iron and manganese) concentrations on the Washington and Oregon shelves. Two different sampling strategies were undertaken, 1) surface transects using a towed 'fish' which utilizes a Teflon pumping diaphragm pump and Teflon tubing and 2) sub-surface vertical profiles obtained by lowering the 'fish' to 20 m and sampling at 2, 4, 6, 8, 15 and 20 m. Six surface transects were sampled (see Fig. 4). Dissolved inorganic macronutrients were collected on-line and analyzed using appropriate colorimetric methods with a Lachat Instruments QuickChem 8000 Series Flow Injection Automated Ion Analyzer providing nutrients concentrations every 3 minutes. Total dissolved iron and manganese samples were collected discretely using trace metal clean techniques and analyzed onboard by flow injection analysis methods. Detailed sub-surface vertical profiles of macro and micronutrients were also carried out the Cape Meares section, the Grays Harbor section, plume axis and over many of the smaller sections. Particulate samples for trace metals were collected and filtered through 10, 0.4 and 0.03 µm using trace metal clean techniques.

Water samples from the 'fish' were also collected for phytoplankton identification and enumeration by Lessard's group and Chl a by Kudela's group. Samples were taken for iron and manganese from just above and within the nepheloid layer throughout the cruise on both the Oregon and Washington shelves using 8 litre GO-Flo's suspended on Kevlar wire and triggered using a Teflon messenger. Nutrient concentrations were also analyzed on all CTD casts and at the beginning (time zero) and end (time final) of all dilution experiments performed by Lessard's research group.

During both the spring and neap tides a 16-hour time series (sampling once an hour at 2, 4, 10, and 18 m) was carried out at one station close to the mouth of the estuary (P12) to investigate the effect of the tidal signal on macro and micronutrient concentrations. In order to provide the source concentrations of both trace metals and macronutrients, three stations within the estuary were sampled both prior to the ebb and flood tide, during both spring and neap tides. Within the estuary samples were collected for both macro and micronutrients from the "fish" sampler down a depth of 10 m. CTD's were also carried out at these stations. Vertical profiles of macro and micronutrients were also analyzed from the fish at 1-4 hr intervals over 18 hours. In order to examine the influence of photochemistry on both dissolved iron and manganese concentrations, samples were collected during spring and neap tides from within the plume and incubated on deck in Quartz cells. Seven different treatments were carried out in both the light and the dark.

Some Preliminary Results:

- Macronutrients: Approximately 90% of collected samples were analyzed onboard and draft concentrations made available daily. The remaining 10% will be analyzed at UCSC in the near future. The Columbia River plume is easily identified by silicic acid concentrations which exceed 100 µm in surface waters and concentration within the estuary are 220 µM. Nitrate concentrations were higher in the estuary compared to July last year (16 µM compared to 7 µM). Nitrate concentrations rapidly decreased with distance from the mouth of the plume.
- Micronutrients: Total dissolved iron and manganese are also present at high concentrations during the ebb tide close to the mouth of the estuary (~ 16 and 110 nM, respectively) and rapidly decrease as the plume moves offshore (~ 1 and 8 nM). In oceanic waters the iron concentration was in the pico-molar range while the manganese had decreased to 1 nM. It was not possible to analyze all samples collected and these will be analyzed at USCS within the next month. All estuarine samples will be analyzed back at UCSC as these need to be matrix modified and analysis will be carried out using inductively coupled plasma mass spectrometry (ICP-MS).

b) Primary Productivity and New Production (Kudela Group: Raphael Kudela, Atma Roberts, Sherry Palacios, Tawnya Peterson, Joe Quartini, Megan Wehrenberg, Laura Bodensteiner)

The objectives of our component were three-fold. First, we provided near-real time remote sensing (satellite) support for the R/V Wecoma, and made the images available via the pigeon-drop system (shore-based ftp). Second, we conducted biological rate measurements at representative stations for carbon, silicon, and nitrogen (nitrate, ammonium, and urea), along with ancillary measurements such as chlorophyll, particulate organic carbon and nitrogen, biogenic silica, and concentrations of ammonium and urea. We also provided the R/V Point Sur with our Satlantic ISUS UV-Nitrate sensor. Third, we deployed in situ and mapping bio-optical instrumentation to characterize the optical and chemical properties of the water column.

Some Preliminary Results:

- Remote Sensing: As expected, satellite imagery was somewhat haphazard, but we did have some clear days when the plume was identifiable (Table 4). The turbidity product from MODIS is particularly promising, and appeared to provide a good indicator of the Columbia River plume, as well as the remnants of previous plumes. A summary of good images will be provided post-cruise, and will be made available at http://oceandatacenter.ucsc.edu.

- *Rate Measurements*: A summary of the rate measurements conducted is provided in Table 5. We emphasized measurement of primary production using a combination of uptake versus irradiance (PE) curves from single depths, single-depth (50% light) measurements for larger surveys, and typically one full vertical profile (6 light depths) per day, incubated using simulated in situ (deckboard) incubators. At several stations, we used the stable tracers $^{15}NO_3$ and $^{15}NH_4$ to estimate nitrogen uptake. At selected stations we also measured ^{15}N-urea and ^{32}Si uptake rates. Incubations were conducted using standard methods, for 3-24 hours. At a subset of stations, filtrate was collected for analysis of ammonium regeneration rates. Primary production was generally low, and showed less of an onshore-offshore trend than in 2004. There was very little difference between Cape Meares and Grays Harbor lines.
- *Chl a* measurements were collected from the upper water column for most stations with full profiles at productivity stations, and full profiles on the transect lines. Most Chl a samples were collected on Whatman GF/F filters (nominal pore size 0.7 µm), but a subset of 20, 10, 5 and 1 µm filters were also collected. At productivity stations, biogenic silica, POC/PON, ammonium, urea, and total suspended solids were also measured. As part of the mooring deployment, chlorophyll and nutrient samples were also collected by the Dever group; we processed the chlorophyll data, and will process the (frozen) nutrient samples in the lab.
- *Bio-Optics*: Typically once per day (around local noon) we deployed optical packages (described above) to characterize the inherent and apparent optical properties of the water column. We also instrumented the CTD package with a HOBI Labs HS6 (backscatter meter), Chelsea FRRF, and Satlantic ISUS UV-Nitrate sensor. These were operating on most CTD casts. These instruments provide an estimate of the water color, particle backscatter, attenuation, and fluorescence. These data will be used primarily for validation of the satellite algorithms, and for characterization of the different water mass types. To complement the optical measurements, a series of discrete water samples were also collected for CDOM (colored dissolved organic material) and a* (particle absorption) spectra, typically at 0, 5, and 10 m depths.

Expected Data Availability:

All chlorophyll samples were processed on board, and will be available immediately after QA/QC of results. All C14 samples were counted on board, and will be available immediately after QA/QC. The other rate measurement samples need to be processed in the lab, with final calculations dependent on the availability of final nutrient values. Bio-optical data and satellite imagery are available immediately, but need to be post-processed to include post-cruise calibration (optics). We will also produce time-averaged satellite imagery post-cruise.

c) Microzooplankton and Plankton Community Structure, Growth and Grazing Rates (Lessard

Group: Evelyn Lessard, Elizabeth Frame, Megan Bernhardt)

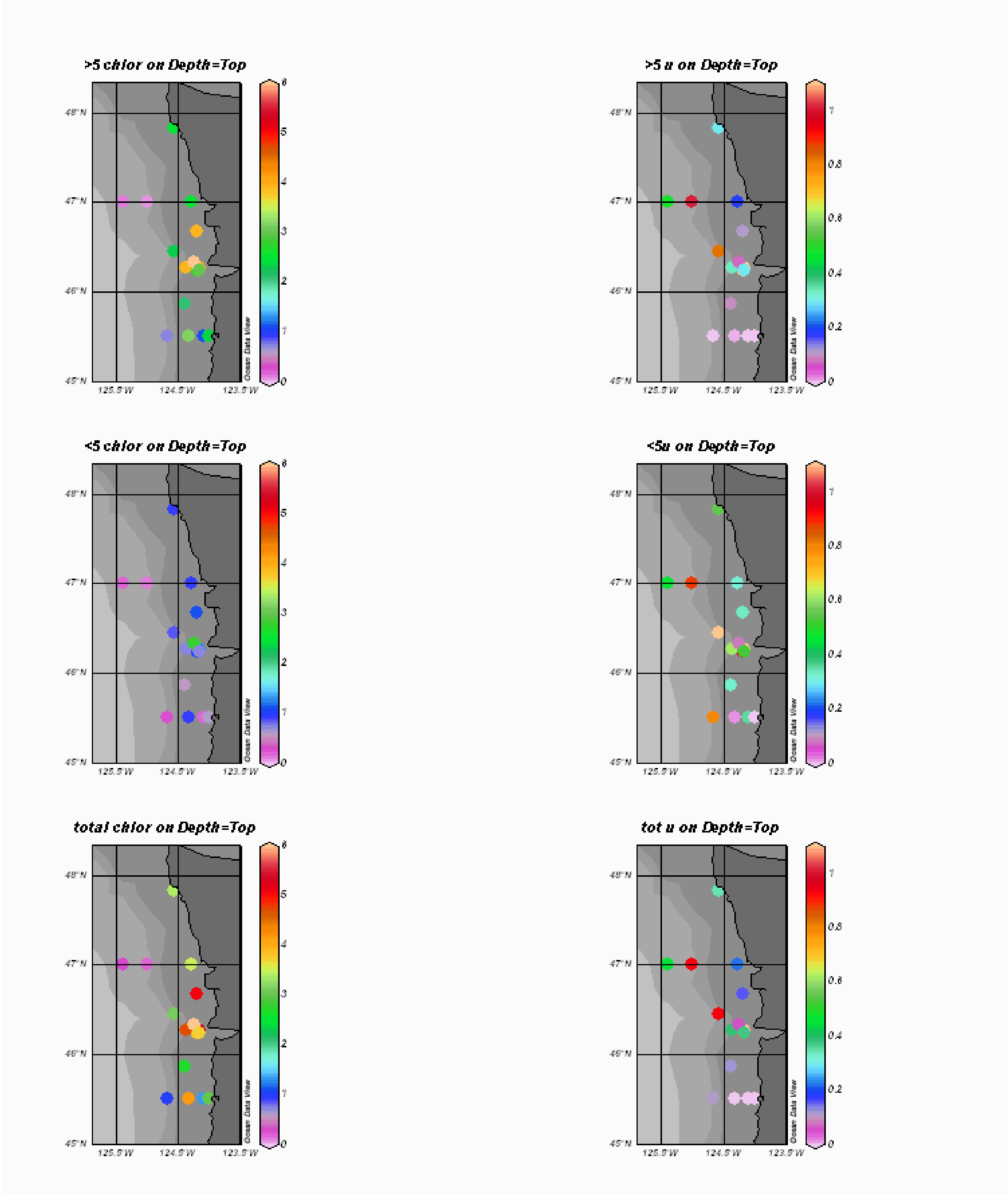
The main objective of this component of the RISE project is to determine and compare the growth and grazing mortality rates of phytoplankton and assess the community composition in the Columbia River plume, Washington and Oregon coasts. The results will help address our central hypotheses that the Washington coast is more productive than the Oregon coast due to the influence of the Columbia River Plume. We used the dilution method to experimentally determine the growth and grazing rates of the whole and size-fractionated phytoplankton community, as well as specific taxa. We used an imaging-in-flow cytometer (FlowCAM) as well as fixed samples, to follow the in situ spatial and temporal changes in the abundance of the major phytoplankton and microzooplankton taxa.

We performed 20 dilution experiments. Eight were performed on the Grays Harbor (WA) line and Cape Meares (OR) lines, as well as four others along the Washington and Oregon coasts. Nine experiments were run in or near the Columbia River mouth, at different times of the tidal cycle and following drifters. Dilution experiment locations, chlorophyll biomass as well as preliminary growth and grazing rates of the total, >5 μm and <5 μm chlorophyll are shown in the figure below.

The FlowCAM was invaluable for providing near real-time assessments of plankton community composition, which helped guide our experimental planning. We processed over 700 samples during surveys, both from the CTD and Fe fish sampler, which will be used to quantify patterns in distribution of the major taxa of phytoplankton and heterotrophic protists. This will give us an unprecedented fine scale map of plankton taxa tied to concurrent chemical (macronutrients and micronutrients) and hydrographic information.

Some Preliminary Results:

- In contrast to the healthy diatom-dominated communities in July, 2004, phytoplankton standing stock was relatively low, and >5 µm phytoplankton (mainly diatoms) comprised a smaller proportion of the total (ca. 75% vs 95%). In coastal and aged plume waters, nitrate was not detectable, diatoms looked unhealthy, and growth rates were low (<0.2 d^{-1}) and nutrient-limited.
- Phytoplankton growth rates were high (>1 d^{-1}) and not nutrient limited only in newer (fresher) plume waters where nitrate was measurable.
- Based on eight experiments, phytoplankton growth rate was consistently higher (though still low) on the Washington coast (GH line) than the Oregon coast (CM line), where there was little or no measurable phytoplankton growth.
- On the WA and OR coast, grazing generally was a significant fraction of the phytoplankton growth rates. In the new plume waters around the CR mouth, grazing was low relative to growth, and grazers sparse, indicating that the community was in an early stage of development.
- In many instances, diatoms and protist grazers appeared healthier and were more abundant in the layer below the fresh plume.



Size-fractionated chlorophyll biomass, growth and grazing rates from dilution experiments.

d) Macrozooplankton (Peterson Group: Bill Peterson, Leah Feinberg)

1Zooplankton research during the RISE-2-W cruise was directed at determining if there are regional differences in copepod and euphausiid production in shelf waters off Washington and Oregon. This work addresses the RISE hypothesis that phytoplankton biomass and production should be higher off Washington than Oregon and that zooplankton production will in turn be higher as well. Towards this end, we set forth the following research objective:

to determine if molting and egg production rates of several copepod and euphausiid species are higher in coastal waters off Washington as compared to coastal waters off Oregon.

Growth rates of adult copepods were estimated by measuring their egg production rates in 24 h incubations. Growth can be estimated in this manner because copepods cease to grow once adulthood is reached and partition all excess energy into reproduction. Thus, measurement of copepod egg production rate is a measure of adult female growth rates. Since female copepods produce eggs every day, measurements of egg production are a measure of daily growth rate.

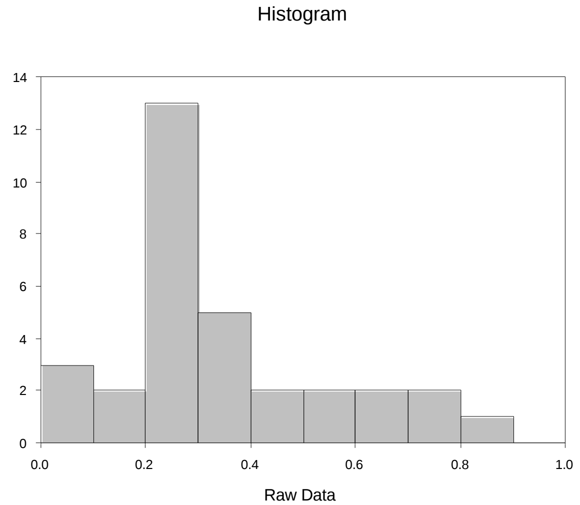
For the euphausiids, we measured both molting rates and egg production rates. Molting rates are measured in short-term incubations (48 h). We incubate 30 animals individually in 500 ml jars, monitor the incubations at 12 h intervals for 48 h, and recover the molts at each time point. Length of the molt is measured as is the length of the molter. The difference in length represents a measure of an individual's growth. Length is converted to weight from established length-weight regressions, then growth rate is calculated from data on the change in weight with time.

Euphausiids produce a brood of eggs on an approximately weekly basis (with interbrood periods ranging from 3 to 40 days), thus measurements of brood size are viewed more as an index of growth rate, rather than a direct measure of growth rate. Since we have now measured brood size of hundreds of females, we know the overall mean (and variance) of brood size thus any new measurements are expressed in terms of anomalies from the long-term mean. This approach allows use of brood size measurements as an indicator of regional variations in euphausiid productivity. During the RISE-2W, we measured egg production rates for the copepods *Calanus pacificus* and *C. marshallae*, and molting rates and brood sizes of the euphausiids, *Euphausia pacifica* and *Thysanoessa spinifera*.

Zooplankton were also surveyed on two other cruises, one immediately prior to RISE 2W (NOAA Ship McArthur) and one during the RISE cruise (Fishing Vessel North Star). Since zooplankton were sampled extensively during those other cruises, we did not do as much plankton net sampling on RISE 2W as was done last year. We did make rate measurements on the McArthur cruise and include those data here.

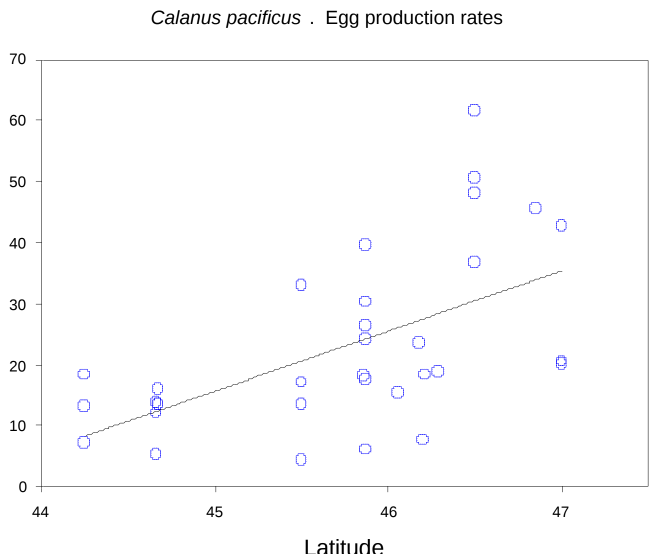
Some Preliminary Results:

The Northeast Pacific was in an unusually warm state during spring and early summer of 2005 and in many respects, the ecosystem appeared to be under the influence of a major El Nino event. However, there was no El Nino at the equator and thus no forcing of the NE Pacific through on oceanic pathway. Perhaps there existed an atmospheric teleconnection. Whatever the cause of the warm ocean in 2005, the zooplankton community composition was quite anomalous. Warm water copepod species dominated the planktonic ecosystem whereas cold water species which are usually present at this time of year, were either rare or absent. Thus, our egg production measurements were made chiefly on the warm water *Calanus pacificus* with only a few measurements on the cold water species, *Calanus marshallae.* As for the euphausiids, there were no differences in species composition however the dominant species, *Euphausia pacifica*, were smaller in size in June 2005 compared to other years at this time.

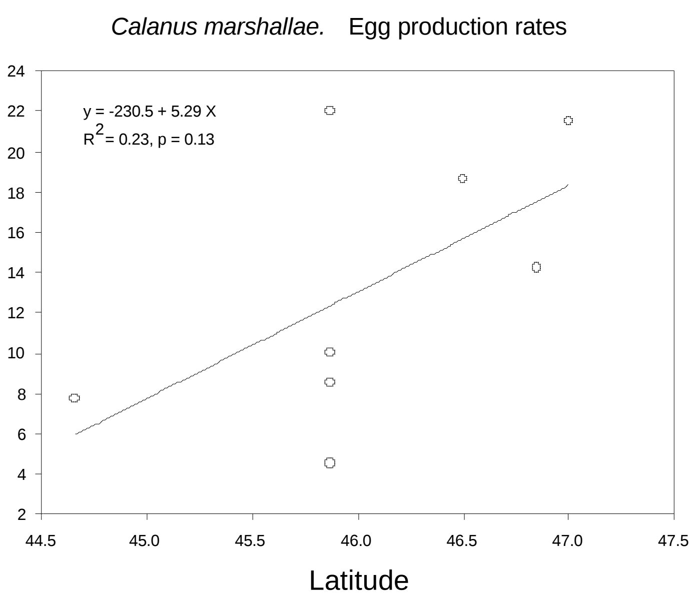


Eggs produced by the copepods and euphausiids were counted each day, therefore we can present here our estimates of egg production rates (copepods) and brood sizes (krill). However, the molting rate data have not yet been analyzed as this involves careful measurements of molts back in the shore-based laboratory and these have not been completed.

For *Calanus pacificus*, we completed 33 incubations on a total of 426 females. The histogram to the left shows the distribution of the data in units of proportion of the maximum rate. The average was 22.7 eggs per female per day and this value is about 0.37 of the maximum rate. Thus, egg production rates were very low in June 2005.

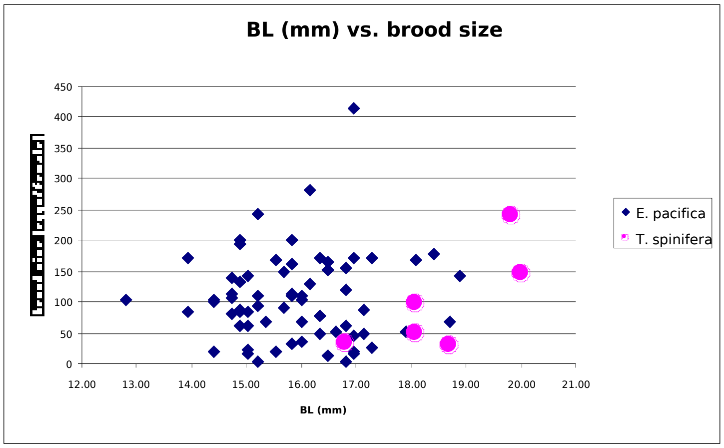


Egg production rates of *Calanus pacificus* were significantly related to latitude (see below) and are evidence that egg production is higher off Washington than Oregon. These observations support our hypothesis that secondary production is higher in coastal of Washington as compared to Oregon. A chart showing spatial variations is given in a figure at the end of this report.



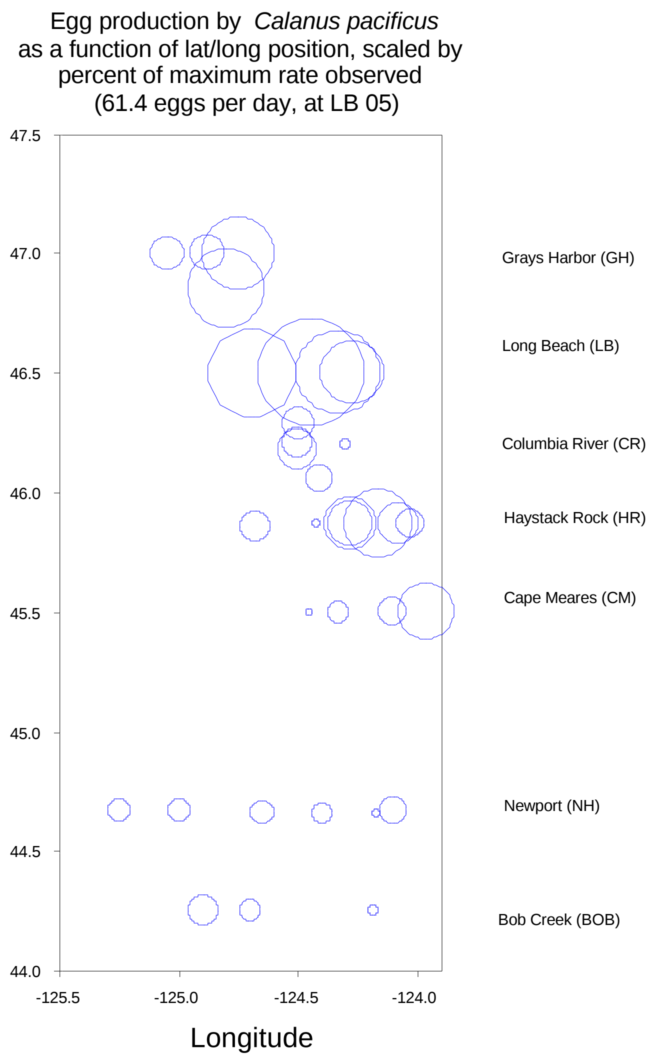
For *Calanus marshallae*, the mean egg production rate was 13.4 eggs per female per day. As with *Calanus pacificus*, this value is quite low, and was similar to *C. pacificus* in that the mean rate was 0.38 of the maximum rates (of 35 eggs per female per day).

Brood sizes for *Euphausia pacifica* in the RISE study were low compared to measurements made off Oregon from 2000-2004. Mean brood size for four years of measurements off Oregon is 152 eggs per brood. During the RISE cruise, we measured an average of 106 eggs per brood, and coincidentally, this is exactly the same brood size as measured last year on RISE 1W. These values are 70% of the climatological mean of 152 eggs per female measured in Oregon waters, suggesting that brood sizes in both 2004 and 2005 are lower than the climatological average.



We only incubated 6 female *Thysanoessa spinifera* indicated by the pink circles in the figure to the left. The mean brood size was 93.3 eggs per female. This value is 80% of the climatological mean of 115 eggs per female.

We found no relationship between euphausiid brood size and either water depth or latitude for either species.



"Chart" showing spatial variations in egg production of the copepod *Calanus pacificus*. Note that egg production was far higher off Washington (Long Beach) than off Oregon. Data were collected from both the R/V Wecoma (RISE 2W) – Cape Meares to Grays Harbor and on the R/V McArthur just prior to the Wecoma cruise (Bob Creek and Newport).

e) Drifter Deployments (McCabe, Hickey)

Brightwaters GPS drifters were deployed to delineate patterns and speeds of currents over the Washington and Oregon shelves and near river mouth. All drifters were deployed to track the top ~1 m of water. Deployment times and positions as well as recovery times are listed in Table 3. All drifters measured temperature (T) and some were additionally outfitted with conductivity (C) sensors. For the CT drifters, data were recorded internally at 3 min intervals. Expendable drifters (T only) transmitted data every 30 min via Argos satellites. Satellite data were stored at UW and transmitted to the ship by Amy MacFadyen and Sue Geier. A few of the expendable drifters collected data through July.

Some Preliminary Results:

May 30: Two expendable drifters (T only) were deployed on the GH line at the mid and outer shelf (drifter 8856 at GH7 and 8852 at station GH5). The drifters initially moved south. However, 8852 moved onshore north of the river mouth. A shoreward jet north of the river mouth was also confirmed by drifter 22252 which was deployed June 3 just off the river mouth. These drifters entered a fast-moving northward coastal current. Drifter 8852 remained close to shore and was eventually recovered inside Grays Harbor. Drifter 8856 moved shoreward south of the river mouth. This drifter then continued south, parallel to the coast (with only a couple of wind-induced reversals) until timing out near Cape Blanco, OR.

June 3: Five CT drifters were deployed at ~3 AM LT on the greater ebb tide (22252, 22249, 22362, 22300, 22255, north to south). All drifters initially traveled westward. Subsequently, the most southern drifter (22255) turned south and beached on the Oregon coast about 10 miles south of the river mouth the next day. The most northern drifter (#22252) circled east, joined a nearshore coastal current flowing northward and beached at about the same time on the Washington coast about 15 miles north of the river mouth. These beachings occurred during a period of very weak, slightly northward winds. Two of the central drifters (22362 and 22249) turned north but began to turn onshore and were recovered because expendable drifters had already shot shoreward north of the bulge into the very nearshore region. Another drifter deployed near the center of the mouth (22300) initially went 2-3 miles farther west in the initial outflow. This drifter managed to escape and move south for several days halfway to Cape Meares. It was recovered before beaching as it moved onshore on June 5 during a period of strong northward winds.

Expendable drifter 8857 was deployed over Astoria canyon. This drifter moved southward halfway to Cape Meares. It then turned eastward during the period of strong northward (downwelling-favorable) winds. It returned north almost to the river mouth where it circled, then turned south. It eventually made its way south to the Cape Meares line by June 12, and then beached near Neskowin, OR.

June 5: Three CT drifters (22301, 22249 and 22362) were time-released during the greater ebb tide from a single location inside the estuary. One drifter (22362) beached inside the estuary and was subsequently recovered off the north jetty. Drifter 22249 turned north after exiting the estuary. It joined the nearshore northward coastal current but was recovered off Long Beach, WA the same day because it was in shallow water and northward winds were pushing drifters onshore. The third CT drifter deployed in this study (22301) turned south after exiting and then began circling in the shipping lanes. This drifter was therefore recovered prior to expected stronger northward winds.

June 6: Two expendable drifters (8861 - offshore, 9126 - nearshore) were deployed just off Long Beach, WA. Drifter 8861 moved south until a large wind event forced it shoreward near Manzanita, OR. This drifter then turned north until it reached the Columbia River mouth, where it began moving offshore. This drifter then continued south until it ceased transmitting off Coos Bay, OR. Drifter 9126 remained confined near Long Beach. This drifter moved in and out of Willapa Bay multiple times before beaching just north of the Bay's mouth.

June 9: Four CT drifters (22255, 22252, 22249, and 22301) were deployed across the river mouth during the greater ebb. This pack of drifters was followed as part of a drift-study. All four drifters arced offshore and to the north and then circled back east. The northernmost drifter (22255) beached just north of the river mouth. Drifters 22252 and 22249 circled back south across the river mouth. Drifter 22252 was lost to ship strike but drifter 22249 was successfully recovered. Drifter 22301 was also recovered moving shoreward towards the river mouth.

June 11: Two drifters were deployed during the transit from La Push, WA to the river mouth. One (8852) was deployed at GH7, the other (8854) farther south and closer to shore. Both drifters initially moved south, passing the Columbia River mouth. They then moved onshore near Manzanita, OR, and continued north toward the river mouth. Drifter 8854 beached just south of the river mouth, while 8852 turned south. Drifter 8852 continued moving in a southwestward direction.

June 15: Four CT drifters (22255, 22249, 22301, and 22300) were deployed across the river mouth during the greater ebb. The two northernmost drifters (22255 and 22249) quickly circled north and headed towards shore. Drifter 22249 was recovered in very shallow water just north of the river mouth, while drifter 22255 moved south. This drifter crossed the river mouth and was recovered just south of the shipping lanes. The southernmost drifter (22300) initially headed southwest and was recovered just after turning north and shoreward during downwelling-favorable winds. Drifter 22301 was outfitted with a Scufa fluorometer/transmissometer (R. Kudela, UCSC). This drifter arced offshore and then north before being recovered.

June 16: Expendable drifter 8859 was deployed near station GH9. This drifter initially moved in a southeast direction very close to Long Beach, WA. The drifter then turned south and began moving offshore near Cape Meares, OR.

June 17: Expendable drifter 9121 was deployed near GH9. This drifter also began moving in a southeast direction, and almost beached on Long Beach. It then followed drifter 8859 south, but then moved very close to shore near Manzanita, OR. This drifter stayed near the coast and eventually beached just south of Newport, OR during downwelling-favorable winds.

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 2005 cruise successful. This research was supported through the Coastal Oceanographic Processes Program (CoOP) of the National Science Foundation, Award No. 0239089.

List of Tables and Figures with Captions and Appendices (web site only)

Data figures are included in text portion (Lessard, Peterson).

Web Only (password protected)

Appendix A: Sections, all lines, for T, S, and Fl, O_2 Attenuation. Two versions are given—one, plotted on the scale 0-30 m; a second one plotted on the scale 0-200 m.

Appendix B: Drifter tracks for expendable drifters deployed during the RISE-2W cruise. Dots indicate one day intervals.

Table 1. Event Log LASTYEAR'S: CTD casts are numbered sequentially; Station ID's include GH (Grays Harbor section), CM (Cape Mears section), P (plume section or stations), A (Astoria canyon), E (estuary), T1 or T2 for first and second times sampled), UW (underway transects or accompanying CTD stations), D (A,B,C,D,E; drift stations).

Event Number	Month	Day	C	End Time (GMT)	Latitude	Longitude	Instrument	Cast #	Station	Water Depth (m)	Cast Depth (m)	Samples
1	7	8	23:13		45 29.82	124 00.0	CTD	1	Test	42	32	EL-Plankton, RK-Optics
2	7	8	23:25		45 29.82	124 00.0	Hand Net		Cast	42	0	EL-Plankton
3	7	8	23:53		45 29.45	124 01.19	fish			1.4		iron, Mn, nutrients
4	7	9		5:47	45 55.33	124 30.66	fish					
5	7	9	15:40		46 12.47	124 05.01	CTD	2	P1-T1	20	14	Bottles, Optics, PP
6	7	9	15:55	16:40	46 12.47	124 05.01	Go Flow	1	P1-T1	20	15	1 go flo
7	7	9	17:00	17:05	46 12.47	124 05.01	Vertical Net	1	P1-T1	19	15	plankton
8	7	9	17:15		46 12.47	124 05.01	fish		P1-T1			iron, Mn, nutrients
9	7	9	17:56		46 09.58	124 06.91	CTD	3	P2-T1	42	36	Bottles
10	7	9	18:25	18:30	46 09.58	124 06.94	Vertical Net	2	P2-T1	42	40	plankton
11	7	9	18:35	18:51	46 09.58	124 06.94	Go Flow	2	P2-T1	42	38	iron, Mn
12	7	9	19:38		46 06.75	124 06.91	CTD	4	P3	72	68	Bottles
13	7	9	20:03	20:08	46 06.75	124 06.91	Vertical Net	3	P3	72	69	zooplankton
14	7	9	20:03	20:15	46 06.68	124 09.1	AC9		P3	72	30	light
15	7	9	20:03		46 06.68	124 09.1	PRR		P3	72	30	light
16	7	9	21:27		46 04.83	124 10.72	CTD	5	P4	87	76.9	Bottles
17	7	9	21:52		46 04.132	124 10.695	Vertical Net	4	P4	87	84	plankton
18	7	9	22:07	22:22	46 04.262	124 10.358	Go Flow	3	P4	87	84	iron, Mn
19	7	9	23:04		46 01.38	124 12.39	CTD	6	P5	94	87	Bottles
20	7	9	23:25		46 01.271	124 12.305	Vertical Net	5	P5	94	90	plankton
21	7	10	0:30		45 55.81	124 16.63	CTD	7	P6	127	119.6	Bottles
22	7	10	0:56		45 55.497	124 16.717	Vertical Net	6	P6	127	100	plankton
23	7	10	1:07	1:32	45 55.37	124 16.88	Go Flow	4	P6	128.5	123	iron, Mn
24	7	10	2:33		45 50.37	124 20.10	CTD	8	P7	150	140	Bottles
25	7	10	3:04		45 50.33	124 20.09	Vertical Net	7	P7	150	100	plankton
25a	7	10	4:08		45 44.68	124 23.97	CTD	9	P8	157	140	
26	7	10	4:35		45 44.615	124 23.998	Vertical Net	8	P8	157	100	plankton
27	7	10	4:50		45 44.615	124 23.99	fish		P8			removed fish
28	7	10	5:44		45 38.85	124 27.89	CTD	10	P9	199	185	
29	7	10	6:20		45 38.85	124 27.89	Vertical Net	9	P9	199	100	
30	7	10	6:34		45 38.624	124 27.652	Bongo	1	P9	199	100	
31	7	10	7:30		45 33.35	124 31.74	CTD	11	P10	390	200	
32	7	10	8:10		45 33.35	124 31.74	Vertical Net	10	P10	390	100	
33	7	10	19:33		46 14.0	124 09.5	Drifter 22300		DA-1			Surface Drifter CT
34	7	10	19:42		46 13.97	124 09.51	CTD	12	DA-1	23	19.9	Bottles
35	7	10	20:46		46 13.57	124 12.78	CTD	13	DA-2	61	53	EV's Bottles @2m
36	7	10	21:10		46 13.57	124 12.78	Vertical Net	11	DA-2	63	59	live tow
37	7	10	21:23		46 13.57	124 12.78	Vertical Net	12	DA-2	63	59	plankton
38	7	10	22:10	0:23	46 13.57	124 16.78	Vertical fish	1	DA-2	63	15	Fe, Nuts, Mn, 6x vertical
39	7	11	1:10		46 13.33	124 16.15	CTD	14	DA-3	87	78	Bottles
40	7	11	1:30	2:00	46 13.32	124 16.71	Go Flow	5	DA-3	92	84	Fe, Nuts, Mn,
41	7	11	2:06		46 13.32	124 16.71	Vertical Net	13	DA-3	92	88	plankton
42	7	11	5:06		46 13.99	124 17.20	CTD	15	DA-4	95	86.8	
43	7	11	5:37		46 13.99	124 17.20	Vertical Net	14	DA-4	95	90	plankton
44	7	11	6:52		46 13.94	124 17.806	Bongo	2	DA-4	96	50	plankton
45	7	11	9:19				3/4m net	1	DA-5	120	50	live vertical tow
46	7	11	9:32				3/4m net	2	DA-5	120	50	live oblique tow
47	7	11	10:53		46 15.733	124 22.391	Vertical Net	15	DA-6	164	100	plankton
48	7	11	11:16		46 16.13	124 23.01	CTD	16	DA-6	248	200	nutrients
49	7	11	16:45		46 14.26	124 31.14	CTD	17	DA-6	646	50	
50	7	11	19:45		46 15.22	124 18.99	CTD	18	P11	121	50	
51	7	11	20:42		46 15.10	124 18.91	CTD	19	P11	118	107	
52	7	11	22:26	23:27	46 15.00	124 19.20	Vertical fish	2	P11			Fe, Mn, Nuts
53	7	11	21:30		46 15.10	124 18.91	PRR		P11		30	
54	7	11	21:30		46 15.10	124 18.91	AC9 & HS6		P11		25	
55	7	11	21:30		46 15.10	124 18.91	TSRB		P11		25	

56	7	11	22:15		46	15.10	124	18.91	Vertical Net	16	P11	120	100	plankton-Euphausiids
57	7	11	23:45		46	15.22	124	19.04	CTD	20	P11	122	115	
58	7	12	4:47		46	11.98	124	30.01	CTD	21	A1	142	135	Nuts @135 & 120m only
59	7	12	5:15		46	11.98	124	30.01	Vertical Net	17	A1	142	100	
60	7	12	5:29		46	11.98	124	30.01	Bongo	3	A1	142	100	
61	7	12	6:07		46	14.58	124	29.96	CTD	22	A2	600	200	
62	7	12	6:40		46	14.58	124	29.96	Vertical Net	18	A2	600	100	
63	7	12	6:50		46	14.58	124	29.96	Bongo	4	A2	600	100	
64	7	12	8:52		46	17.97	124	29.79	CTD	23	A3	132	125	Nuts @125 & 120m
65	7	12	9:17		46	17.97	124	29.79	Vertical Net	19	A3	132	100	
66	7	12	9:32		46	17.97	124	29.79	Bongo	5	A3	132	100	
67	7	12	14:01		46	59.97	124	13.41	CTD	24	GH1	17	9.3	
68	7	12	14:50	15:30	47	00.00	124	17.34	Vertical fish	3	GH2			
69	7	12	14:20		46	59.97	124	13.41	Vertical Net	20	GH1	17	13	
70	7	12	15:33		47	00.00	124	17.36	Vertical Net	21	GH2	37	33	
71	7	12	15:50		47	00.00	124	17.36	CTD	25	GH2	37	30	
72	7	12	16:05		47	00.00	124	17.38	Drifter		GH2	38		9121-Exp
73	7	12	16:33		47	00.00	124	17.37	CTD	26	GH2	37	30	
74	7	12	17:10	17:51	46	59.78	124	21.60	Vertical fish	4	GH3	47	15	Fe, Mn, Nuts, chl a
75	7	12	17:52		46	59.97	124	21.60	CTD	27	GH3	48	40	
76	7	12	18:15		46	59.97	124	21.60	Vertical Net	22	GH3	48	44	
77	7	12	18:55	19:38	46	59.80	124	29.5	Vertical fish	5	GH4	75	22	Fe, Mn, Nuts, chl a
78	7	12	19:47		46	59.79	124	29.48	Vertical Net	23	GH4	73	68	live tow
79	7	12	19:56		46	59.79	124	29.48	Vertical Net	24	GH4	73	68	plankton
80	7	12	20:05	20:20	46	59.765	124	29.454	AC9		GH4	73	35	light
81	7	12	20:25	20:40	46	59.762	124	29.450	TSRB		GH4	73	40	light
82	7	12	20:40	20:48	46	59.520	124	29.239	PRR		GH4	73	30	light
83	7	12	20:56		46	59.45	124	29.38	CTD	28	GH4	73	66	
84	7	12	21:20	21:30	46	59.22	124	29.82	Go Flow	8	GH4	75	70	Fe, Mn, Nuts
85	7	12	22:40		46	59.95	124	37.51	CTD	29	GH5	94	86	
86	7	12	22:59		46	59.95	124	37.5	Vertical Net	25	GH5	95	90	
87	7	12	23:50	0:23	46	59.97	124	45.29	Vertical fish	6	GH6	134	15	Fe, Mn, Nuts
88	7	13	0:31		46	59.99	124	45.30	CTD	30	GH6	135	125	
89	7	13	0:51		47	0.00	124	45.3	Vertical Net	26	GH6	135	100	
90	7	13	0:44		46	59.97	124	53.18	CTD	31	GH7	173	166	
91	7	13	2:06		46	59.97	124	53.18	Vertical Net	27	GH7	173	100	
92	7	13	2:55	3:25	46	59.95	124	58.59	Vertical fish	7	GH8	219	20	Fe, Mn, Nuts
93	7	13			46	59.95	124	58.59	Vertical Net	28	GH8	214	100	plankton
94	7	13	3:49		46	59.95	124	58.51	CTD	32	GH8	200	194.8	
95	7	13	5:35		46	59.99	125	02.84	CTD	33	GH9	1059	500	
96	7	13	7:55		46	45.00	124	47.81	CTD	34	LI-1	183	170	no water samples
97	7	13	8:33		46	45.00	124	47.81	Bongo	6	LI-1	184	100	
98	7	13	17:57		46	13.53	124	10.21	CTD	35	P12a	36	28	
99	7	13	18:20	19:09	46	13.59	124	10.13	Vertical fish	8	P12a	33	15	Fe, Mn, Nuts
100	7	13	19:20		46	13.59	124	10.13	Vertical Net	29	P12a	37	33	
101	7	13	19:20	19:37	46	13.536	124	10.246	AC9		P12a	37	30	optics
102	7	13	19:40	19:50	46	13.536	124	10.246	TSRB		P12a	37	30	optics
103	7	13	19:50	20:00	46	13.507	124	10.260	PRR		P12a	37	30	optics
104	7	13	22:05		46	13.53	124	10.150	CTD	36	P12b	37	28	
105	7	13	22:40	23:12	46	13.40	124	10.62	Vertical fish	9	P12b	43	20	Fe, Mn, Nuts
106	7	13	23:23		46	13.53	124	10.27	Vertical Net	30	P12b	37	15	
107	7	13	23:30		46	13.53	124	10.27	Vertical Net	31	P12b	37	32	
108	7	13	23:38		46	13.53	124	10.27	Vertical Net	32	P12b	37	32	live tow
109	7	14	2:07		46	13.53	124	10.29	CTD	37	P12c	37	32	
110	7	14	2:18	3:04	46	13.53	124	10.30	Vertical fish	10	P12c	37	20	Fe, Mn, Nuts
111	7	14	3:13		46	13.54	124	10.29	Vertical Net	33	P12c	35	30	
112	7	14	5:58		46	13.54	124	10.29	CTD	38	P12d	38	30	
113	7	14	6:16		46	13.54	124	10.29	Vertical Net	34	P12d	38	32	
114	7	14	8:17		46	13.54	124	10.29	live net 3/4m	3	P12e	38	30	
115	7	14	10:25		46	13.54	124	10.30	Vertical Net	35	P12e	35	30	
116	7	14	10:03		46	13.55	124	10.32	CTD	39	P12e	36	29.7	
117	7	14	14:08		46	13.54	124	10.27	CTD	40	P12f	35	26.9	
118	7	14	14:30	15:07	46	13.52	124	10.60	Vertical fish	11	P12f	41	15	Fe, Mn, Nuts
119	7	14	15:20		46	13.52	124	10.60	Vertical Net	36	P12f	36	32	
120	7	14	15:40	16:05	46	13.557	124	10.257	AC9 & HS6	40	P12f	36	4	
121	7	14	16:22		46	13.54	124	10.259	CTD	41	P12g	36	29	Evelyn's water
122	7	14	18:06		46	13.53	124	10.27	CTD	42	P12h	37		productivity cast
123	7	14	18:20	19:52	46	13.53	124	10.37	Vertical fish	12	P12g			Fe, Mn, Nuts
124	7	14	19:00	19:52	46	13.53	124	10.37	AC9 & HS6		P12g	37	30	optics
125	7	14	19:57		46	13.53	124	10.37	Vertical Net	37	P12g	38	34	

126	7	14	20:10		46	13.53	124	10.37	Vertical Net	38	P12h	38	34	
127	7	14	20:15	20:25	46	13.414	124	10.284	TSRB		P12h	37	25	optics
128	7	14	20:29	20:40	46	13.414	124	10.284	PRR		P12h	37	25	optics
129	7	14	22:09		46	13.54	124	10.35	CTD	43	P12i	38	32	
130	7	14	22:30	23:53	46	13.16	124	10.89	Fe fish	13	P12i	48		Fe, Mn, Nuts
131	7	14	23:11		46	13.166	124	10.879	AC9 & HS6		P12i	47	30	optics
132	7	14	23:51		46	13.37	124	10.47	Vertical Net	39	P12i	48	44	
133	7	15	2:07		46	13.54	124	10.26	CTD	44	P12j	38	29	
134	7	15	2:45		46	13.54	124	10.26	Vertical Net	40	P12j	39	32	
135	7	15	5:05		46	13.53	124	10.27	CTD	45	P12k	38	30	naked CTD-no bottle samples
136	7	15							Vertical fish	15	P12L	38		
137	7	15	6:06		46	13.53	124	10.27	CTD	46	P12L	38	30	
138	7	15	6:25		46	13.53	124	10.27	Vertical Net	41	P12L	38	32	
139	7	15	7:29		46	15.69	124	17.96	3/4m net	4	LI-2	100	50	vertical live tow
140	7	15	7:44		46	15.69	124	17.96	3/4m net	5	LI-2	100	50	oblique live tow
141	7	15	14:04		45	29.95	123	59.23	CTD	47	CM-1	19	12	
142	7	15	14:19		45	29.95	123	59.23	Vertical Net	42	CM-1	20	16	
143	7	15	14:30	14:44					Vertical fish	16	CM-1	20	2	Fe, Mn, Nuts
144	7	15	15:13		45	29.97	124	03.07	CTD	48	CM-2	67	60	
145	7	15	15:00	15:20	45	30.0	124	03.08	Vertical fish	17	CM-2	67	20	Fe, Mn, Nuts
146	7	15	16:15		45	30.0	124	03.08	Vertical Net	43	CM-2	67	63	
147	7	15	16:20	16:59	45	30.0	124	03.1	Go Flow		CM-2	68	61	Fe, Mn, Nuts
148	7	15	17:26		45	30.0	124	07.12	CTD	49	CM-3	98	92	
149	7	15	17:50	18:18	45	30.0	124	07.11	Vertical fish	18	CM-3	98	95	Fe, Mn, Nuts
150	7	15	18:21		45	30.0	124	07.11	Vertical Net	44	CM-3	98	94	
151	7	15	19:12		45	29.99	124	15.00	CTD	50	CM-4	155	148	
152	7	15	19:37		45	29.81	124	14.28	AC9 & HS6		CM-4			
153	7	15	20:00	20:10	45	29.81	124	14.28	PRR		CM-4			
154	7	15	20:10		45	29.713	124	14.081	TSRB		CM-4			
155	7	15	20:40	21:15	45	29:85	124	14.94	Vertical fish	19	CM-4	155	20	Fe, Mn, Nuts
156	7	15	21:13		45	29:85	124	14.94	Vertical Net	45	CM-4	156	100	
157	7	15			45	29:85	124	14.94	Go Flow				141	Fe, Mn, Nuts
158	7	15	22:54		45	29.95	124	23.16	CTD	51	CM-5	191	183	
159	7	15	23:10	0:02	45	29.97	124	23.07	Vertical fish	20	CM-5	190	20	Fe, Mn, Nuts
160	7	16	0:10	0:50	45	29.97	124	23.07	Go Flow		CM-5	190		Fe, Mn, Nuts
161	7	16	0:54		45	29.97	124	23.07	Vertical Net	46	CM-5	190	100	
162	7	16	6:04		46	13.50	124	08.51	CTD	52	DB-1	24	18	
163	7	16	6:55	7:08	46	13.496	124	08.514	AC9 & HS6		DB-1	25	20	optics
164	7	16	19:13		46	13.55	124	10.25	CTD	53	DB-2	36	32	
165	7	16	19:50	20:36	46	13.58	124	10.27	Vertical fish	21	DB-2	36	8	Fe, Mn, Nuts
166	7	16	19:20		46	13.58	124	10.27	AC9 & HS6		DB-2	36	20	
167	7	16	19:20		46	13.58	124	10.27	TSRB		DB-2	36	25	
168	7	17	0:47		45	56.602	124	19.917	3/4m net	6	TH-9	140	100	live vertical tow
169	7	17	6:07		46	17.69	124	23.59	3/4m net	7	A4	190	40	live oblique tow
170	7	17	8:36		46	23.516	124	21.092	3/4m net	8	A5	87	40	live oblique tow
171	7	17	13:04		46	14.53	124	12.26	CTD	54	DC-1	55	45	nut
172	7	17	13:40	14:14	46	14.56	124	18.64	Vertical fish	22	DC-1	108	8	Fe, Mn, Nuts
173	7	17	14:24		46	14.61	124	18.91	CTD	55	DC-2	112	2	Evelyn's water
174	7	17	15:36		46	14.50	124	22.73	CTD	56	DC-3	130	50	Raphe's productivity
175	7	17	16:08		46	14.56	124	24.64	Vertical Net	47	DC-4	182	100	
176	7	17	16:36		46	14.56	124	24.64	CTD	57	DC-4	246	134	
177	7	17	17:20	17:45	46	14.62	124	26.03	Vertical fish	23	DC-4	207	8	Fe, Mn, Nuts
178	7	17	19:04		46	14.88	124	27.69	CTD	58	DC-5	534	200	
179	7	17	19:20	19:55	46	15.13	124	28.42	Vertical fish	24	DC-5	507	8	Fe, Mn, Nuts
180	7	17	20:10		46	15.13	124	28.42	Vertical Net	48	DC-5	504	100	
181	7	17	20:10	20:20	46	15.192	124	28.675	AC9 & HS6		DC-5	519	30	optics
182	7	17	20:24		46	15.196	124	28.68	TSRB		DC-5	515	30	optics
183	7	17							PRR		cancelled			
184	7	17	22:08		46	15.66	124	28.57	CTD	59	DC-6	471	200	
185	7	17	22:39		46	15.66	124	28.57	Vertical Net	49	DC-6	466	100	
186	7	17	22:49		46	15.66	124	28.57	3/4m net	9	DC-6	466	100	live vertical tow
187	7	18	1:14		46	15.01	124	27.75	CTD	60	DC-7	511	250	
188	7	18	1:15	1:58	46	14.60	124	27.62	Vertical fish	25	DC-7	550	8	Fe, Mn, Nuts
189	7	18	2:22		46	14.60	124	27.62	Vertical Net	50	DC-7	550	100	
190	7	18	4:01		46	13.46	124	27.49	CTD	61	DC-8	175	175	
191	7	18	4:50	5:12	46	13.06	124	27.52	Vertical fish	26	DC-8	148	8	Fe, Mn, Nuts
192	7	18	6:25		46	13.06	124	27.52	Vertical Net	51	DC-8	148	100	
193	7	18	5:59		46	12.72	124	27.54	CTD	62	DC-9	148	140	
194	7	18	6:34		46	12.72	124	27.54	3/4m net	10	DC-9	146	40	oblique live tow
195	7	18	9:27		46	13.90	124	27.39	CTD	63	DC-10	313	200	nuts

196	7	18	10:03		46	13.90	124	27.39	Vertical Net	52	DC-10	313	100	
197	7	18	10:15		46	14.10	124	26.93	Bongo	7	DC-10	384	100	
198	7	18	12:00	15:00					Vertical Tow	T4				
199	7	18	15:00		46	12.79	124	26.83	CTD	64	DC-11	152	138	productivity cast
200	7	18	16:00	16:43	46	12.79	124	28.35	Vertical fish	27	DC-11	137	8	Fe, Mn, Nuts
201	7	18	16:55		46	12.79	124	28.35	Vertical Net	53	DC-11	143	100	
202	7	18	19:12		46	13.95	124	31.96	CTD	65	DC-12	677		
203	7	18	19:45	20:23	46	14.76	124	32.44	Vertical fish	28	DC-12	522		Fe, Mn, Nuts
204	7	18	20:30		46	14.76	124	32.44	AC9 & HS6		DC-12		30	optics
205	7	18	20:45		46	16.015	124	32.433	PRR		DC-12		30	optics
206	7	18	21:20		46	16.015	124	32.433	TSRB		DC-12		30	optics
207	7	18	21:10		46	16.015	124	32.433	Vertical Net	54	DC-12	175	100	
208	7	18	22:46		46	08.19	124	39.81	CTD	66	BW-1	303	100	
209	7	19	0:15		46	08.12	124	39.56	Vertical Net	55	BW-1	285	100	
210	7	19	0:25		46	08.12	124	39.56	3/4m net	11	BW-1	285	100	oblique live tow
211	7	19	2:39		46	18.60	124	27.90	CTD	67	DC-13	137	130	
212	7	19	3:12		46	18.74	124	27.39	Vertical Net	56	DC-13	137	100	
213	7	19	5:30		46	28.92	124	07.43	CTD	68	DD-1	23	18	
214	7	19	8:20		46	20.52	124	28.25	CTD	69	DC-14	133	125	nuts
215	7	19	10:10		46	21.44	124	28.61	Vertical Net	57	DC-14	133	100	
216	7	19	10:34		46	21.44	124	28.61	3/4m net	12	DC-14	133	40	live tow
217	7	19	14:38		46	21.26	124	27.95	CTD	70	DC-15	129	118	
218	7	19	15:10	15:25	46	20.946	124	27.884	AC9 & HS6		DC-15	129	30	optics
219	7	19	15:40		46	20.946	124	27.884	Vertical Net	58	DC-15	127	100	
220	7	19	16:07		46	20.79	124	27.76	CTD	71	DC-16	130	80	
221	7	19	21:40		46	16.63	124	10.56	CTD	72	UW-1	33	25	
222	7	19	22:40		46	16.67	124	15.41	CTD	73	UW-2	71	67	
223	7	19	23:40		46	16.73	124	20.30	CTD	74	UW-3	153	143	
224	7	20	0:05		46	16.73	124	20.30	Vertical Net	59	UW-3	150	100	
225	7	20	1:44		46	21.29	124	12.59	CTD	75	UW-4	42		
226	7	20	3:17		46	24.39	124	06.71	CTD	76	UW-5	19	11.6	
227	7	20	8:32		46	58.46	124	29.98	3/4m net	13	GH2.7	18	50	vertical live tow
228	7	20	9:35		46	56.95	124	41.97	3/4m net	14	GH6	125	100	vertical live tow
229	7	20	9:51		46	56.95	124	41.97	3/4m net	15	GH6	125	40	oblique live tow
230	7	20	10:53		46	54.92	124	51.47	Vertical Net	60	GC	527	100	
231	7	20	11:08		46	54.92	124	51.47	3/4m net	16	GC	527	40	oblique live tow
232	7	20	15:31		46	15.85	124	27.37	CTD	77	DC-17	406	200	
233	7	20	16:35		46	15.85	124	27.37	Vertical Net	61	DC-17	406	100	
234	7													
235	7	20	16:08	17:20	46	14.47	124	26	Vertical fish	31	DC-17	406	8	Fe, Mn, Nuts
236	7	21	0:10	0:42	46	11.62	123	49.44	Go Flow		E-1	14.4	2	Fe, Mn, Nuts
237	7	21	0:43		46	11.62	123	49.15	CTD	78	E-1	15	10	
238	7	21	1:00	1:35	46	11.34	123	54.32	Go Flow		E-2	15	2	Fe, Mn, Nuts
239	7	21	1:35		46	11.33	123	54.32	CTD	79	E-2	15	10	
240	7	21	7:48		46	44.81	124	30.22	Vertical Net	62	CF-22	184	100	
241	7	21	8:11		45	44.67	124	30.41	3/4m net	17	CF-22	184	40	oblique live tow
242	7	21	9:11		45	44.90	124	44.90	Vertical Net	63	CF-15	148	100	
243	7	21	9:30		45	45.05	124	45.05	3/4m net	18	CF-15	148	40	oblique live tow
244	7	21	15:18		46	14.54	124	10.80	CTD	80	DE-1	40	30	
245	7	21	16:30		46	14.56	124	16.33	CTD	81	DE-2	82	76	
246	7	21			46	14.67	123	59.87	Go Flow		E-3	18	2	Fe, Mn, Nuts
247	7	21	18:26		46	14.67	123	59.87	CTD	82	E-3	18	13	
248	7	21	18:30		46	11.36	124	54.12	Go Flow		E-4	13	2	Fe, Mn, Nuts
249	7	21	19:35		46	11.36	124	54.12	CTD	83	E-4	13	7	
250	7	21	20:00		46	11.75	123	49.15	Go Flow		E-4		2	Fe, Mn, Nuts
251	7	21	20:27	20:45	46	11.65	123	49.31	CTD	84	E-5	13	7	
252	7	21			46	11.65	123	49.31	Go Flow		E-5			
253	7	22	1:26		46	13.31	124	29.36	CTD	85	DE-3	175	163	
254	7	22	2:09		46	13.31	124	29.36	Vertical Net	64	DE-3	146	100	
255	7	22	7:41		45	29.98	124	20.13	Vertical Net	65	CM-16	180	100	
256	7	22	7:52		45	30.05	124	20.36	3/4m net	19	CM-16	180	40	oblique live tow
257	7	22	9:25		45	30.01	124	03.41	Vertical Net	66	CM-3	72	100	
258	7	22	9:36		45	30.01	124	03.41	3/4m net	20	CM-3	72	40	oblique live tow
259	7	22	15:09		45	56.07	124	02.13	CTD	86	UW-6	55	49	
260	7	22	15:31		45	56.07	124	02.13	Vertical Net	67	UW-6	54	50	
261	7	22	18:37		46	03.28	124	21.53	CTD	87	UW-7	123	117	
262	7	22	18:59		46	03.28	124	21.53	Vertical Net	68	UW-7	123	100	
263	7	22							Optics					
264	7	22	21:22		46	10.95	124	10.27	CTD	88	UW-8	57	51	
265	7	22	21:45		46	10.95	124	10.27	Vertical Net	69	UW-8	58	54	

266	7	22	23:26		46	17.88	124	10.64	CTD	89	UW-9	33	26	
267	7	23	1:05		46	24.99	124	10.06	CTD	90	UW-10	33	25	
268	7	23	1:50		46	25.02	124	06.90	CTD	91	UW-11	20	14	
269	7	23	8:28		45	46.81	124	27.37	CTD	92	CF-20	166	150	
270	7	23	9:01		45	47.39	124	27.66	Bongo	6	CF-20	165	50	
271	7	23	14:05		45	30.00	123	59.434	Vertical Net	70	CM-1	20	15	
272	7	23	14:17		45	30.00	123	59.434	Optics		CM-1	20	15	
273	7	23	14:38		45	30.00	123	59.25	CTD	93	CM-1	20	12	EL Water
274	7	23	15:14		45	29.98	123	59.21	CTD	94	CM-1	20	13	
275	7	23	16:15		45	29.99	124	03.07	Vertical Net	71	CM-2	68	63	
276	7	23	16:20	16:38	45	29.99	124	03.07	Optics		CM-2	66	62	
277	7	23	16:43		45	29.99	124	03.08	CTD	95	CM-2	67	60	
278	7	23		17:27	45	29.97	124	03.08	Go Flow	18	CM-2	61		Fe, Mn, Nuts
279	7	23	18:18		45	30.00	124	07.09	CTD	96	CM-3	96	89	
280	7	23	18:39		45	29.95	124	07.09	Go Flow	19	CM-3	96		Fe, Mn, Nuts
281	7	23	19:15		45	29.95	124	07.09	Vertical Net	72	CM-3	96	92	
282	7	23	19:35		45	29.95	124	07.09	Vertical Net	73	CM-3	96	90	live tow
283	7	23	20:51	21:10	45	29.9	124	15.07	CTD	97	CM-4	155	147	
284	7	23	21:13		45	29.9	124	15.09	Go Flow	20	CM-4	155	140	Fe, Mn, Nuts
285	7	23	21:40		45	29.9	124	15.09	Vertical Net	74	CM-4	155	100	
286	7	23	22:04	22:20	45	29.9	124	15.12	AC9 & HS6		CM-4	155	50	
287	7	23	22:20	22:45	45	29.9	124	15.12	TSRB		CM-4	155	45	
288	7	23	23:50		45	30.04	124	23.07	CTD	98	CM-5	191	183	
289	7	24	0:14		45	30.04	124	23.07	Vertical Net	75	CM-5	191	100	
290	7	24	1:30	1:52	45	29.96	124	30.98	CTD	99	CM-6	460	200	
291	7	24	1:52		45	29.96	124	30.98	Vertical Net	76	CM-6	467	100	
292	7	24	2:04		45	29.96	124	30.98	3/4m net	21	CM-6	467	100	live vertical tow
293	7	24	3:30		45	29.95	124	39.03	Vertical Net	77	CM-7	483	100	
294	7	24							Optics					
295	7	24	3:59		45	29.95	124	39.03	CTD	100	CM-7	474	200	
296	7	24	17:00		47	00.01	124	13.38	CTD	101	GH-1	17	10	
297	7	24	17:15	17:32	47	00.00	124	13.39	AC9 & HS6		GH-1	17	14	
298	7	24	18:28		46	59.99	124	17.40	CTD	102	GH-2	37	29	
299	7	24			46	59.99	124	17.40	Go Flow	21	GH-2	37	26	Fe, Mn, Nuts
300	7	24	19:02		46	59.99	124	17.40	Vertical Net	78	GH-2	36	32	
301	7	24	19:12		46	59.9	124	17.2	AC9 & HS6		GH-2	36	32	optics
302	7	24	19:30		46	59.9	124	17.2	HTSRB		GH-2	36	25	
303	7	24	20:23		46	59.98	124	21.5	CTD	103	GH-3	47	40	
304	7	24	20:39		46	59.98	124	21.5	Go Flow	22	GH-3	47		Fe, Mn, Nuts
305	7	24	21:00		46	59.98	124	21.5	Vertical Net	79	GH-3	46	42	
306	7	24	21:09		46	59.98	124	21.5	Vertical Net	80	GH-3	46	42	Live tow
307	7	24	22:54		46	59.98	124	29.48	CTD	104	GH-4	72	65	
308	7	24	23:09		46	59.99	124	29.51	Vertical Net	81	GH-4	72	68	
309	7	24	23:19		46	59.99	124	29.51	3/4m net	22	GH-4	72	60	vertical live tow
310	7	24	23:25	23:40	46	59.99	124	29.51	AC9 & HS6		GH-4			optics
311	7	25	0:58		46	59.97	124	37.55	CTD	105	GH-5	95	88	
312	7	25							Go Flow	23	GH-5		83	
313	7	25	1:44		46	59.96	124	37.49	Vertical Net	82	GH-5	95	90	
314	7	25	1:55		46	59.96	124	37.49	3/4m net	23	GH-5	95	90	vertical live tow
315	7	25			46	59.96	124	45.32	CTD	106	GH-6	135		
316	7	25		3:50	46	59.96	124	45.32	Go Flow	24	GH-6	145		
317	7	25	4:01		46	59.96	124	45.32	Vertical Net	83	GH-6	135	121	Fe, Mn, Nuts
318	7	25	5:11		46	59.96	124	53.19	CTD	107	GH-7	170	163	
319	7	25	5:39		46	59.96	124	53.19	Vertical Net	84	GH-7	170	100	
320	7	25	5:50		46	59.96	124	53.19	AC9 & HS6		GH-7	170	65	
321	7	25	6:53		46	59.99	124	58.48	CTD	108	GH-8	190	175	Nuts
322	7	25	7:24		46	59.99	124	58.48	Vertical Net	85	GH-8	190	100	
323	7	25	8:36		46	59.97	125	02.85	CTD	109	GH-9	960	200	
324	7	25	9:00		46	59.97	125	02.85	Vertical Net	86	GH-9	960	100	
325	7	25	14:18		46	59.97	124	13.43	CTD	110	GH-1	18	12	Evelyn's water
326	7	25	16:00		47	00.01	124	13.41	CTD	111	GH-1	18	11.2	
327	7	25	17:23		46	54.98	124	15.12	CTD	112	QB1	26	18	
328	7	25	21:26		46	42.59	124	10.52	CTD	113	QB2	19	13	
329	7	26	1:35		46	24.98	124	07.09	CTD	114	QB3	22	15	
330	7	26	2:57		46	26.11	124	18.10	CTD	115	RN	72	64	
331	7	26		3:28	46	26.11	124	18.10	vertical fish		RN	72		Fe, Mn, Nuts
332	7	26	3:34		46	26.11	124	18.10	3/4m net	24	RN	71	60	vertical live tow
333	7	26	5:27		46	09.92	124	11.88	CTD	116	RC	72	64	Nuts, Chl
334	7	26	7:45		46	03.01	124	05.88	CTD	117	RS	69	64	
335	7	26	10:18		45	50.00	124	28.29	3/4m net	25	HP22	160	40	oblique live tow

336	7	28	13:23	44 14.98	124 22.03	CTD	118	BOB2	89	80	No bottles
337	7	28	16:22	44 39.07	124 24.74	CTD	119	NH15	92	85	Surface bottle for Bill
338	7	28	16:38	44 39.07	124 24.74	Vertical Net	87	NH15	92	85	
339	7	28	17:45	44 38.59	124 18.51	CTD	120	NH10	82	72	Surface nuts & chl - Bill
340	7	28	17:53	44 38.59	124 18.51	Vertical Net	88	NH10	82	75	
341	7	28	19:10	44 39.11	124 10.51	CTD	121	NH05	59	50	Surface nuts & chl - Bill
342	7	28	19:22	44 39.11	124 10.51	Vertical Net	89	NH05	60	55	
343	7	28	20:01	44 39.13	124 06.01	CTD	122	NH01	29	25	Surface nuts & chl – Bill
344	7	28	20:10	44 39.13	124 06.01	Vertical Net	90	NH01	29	25	

Table 4. Satellite Imagery

4-Jun	155 F	F
5-Jun	156 P	F
6-Jun	157 P	P
7-Jun	158 F	F
8-Jun	159 P	G
9-Jun	160 G	**VG**
10-Jun	161 N	P
11-Jun	162 N	P
12-Jun	163 **VG**	F
13-Jun	164 F	P
14-Jun	165 P	P
15-Jun	166 P	F
16-Jun	167 N	P
17-Jun	168 N	P
18-Jun	169 F	**VG**
19-Jun	170 F	**VG**
20-Jun	171 G	**E**
21-Jun	172 N	F

N=no data; P=poor; F=fair; G=good; VG=very good; E=excellent

Filenames:
A2005dddhhmmss_chl = chlorophyll
A2005dddhhmmss_trb = turbidity
A2005dddhhmmss_sst = SST
A2005dddhhmmss_sst.1218=expanded scale SST
2005_DDD_wn.hdf.png = AVHRR SST daily composite

Table 5. Kudela group data collection

RISE-2W Incubations

Cast #	14C			32Si		15N3		15N4		15Ur		Notes
	Profile	50%	PE	Profile	50%	Profile	50%	Profile	50%	Profile	50%	
C03	X	X		X	X	X	X	X	X	X	X	
C04		X					X					
C05		X					X					
C06		X					X					
C07		X					X					
C08		X					X					
C09		X					X					
C14	X	X		X	X	X	X	X	X	X	X	
C27	X	X		X	X	X	X	X	X	X	X	
C33	X	X		X	X	X	X	X	X	X	X	
C35		X					X					
C36		X					X					
C37		X					X					
C38		X					X					
C39		X					X					
C40		X					X					
C41	X	X		X	X	X	X	X	X	X	X	
C47	X	X	X	X	X	X	X	X	X			
C48		X					X		X			
C50		X	X				X					
C51		X					X					
C79	X	X	X	X	X	X	X	X	X			
C84		X	X				X		X			
C94	X	X	XX	X	X	X	X	X	X			2-DEPTH PE CURVE
C95		X	X	X	X	X	X	X	X			
C100		X	X		X		X					
C101	X	X	XX	X	X	X	X	X	X			2-DEPTH PE CURVE
C104			XX									2-DEPTH PE CURVE
C105		X	XX									2-DEPTH PE CURVE
C108		X										
C114	X	X		X	X	X	X	X	X			
C125		X					X		X			
C126	X	X		X	X	X	X	X	X			
C127		X					X		X			
C128		X					X					
C130		X					X					
C131		X					X					
C132		X					X					
C146	X	X	X	X	X	X	X	X	X	X	X	
C151			X									
C155			XX									2-DEPTH PE CURVE
C162	X	X	X	X	X	X	X	X	X			PROBLEMS WITH LSC
C163	X	X					X		X			PROBLEMS WITH LSC
C164		X					X		X			PROBLEMS WITH LSC
C165		X	X				X		X			PROBLEMS WITH LSC
C166		X					X		X			PROBLEMS WITH LSC
C167		X					X					PROBLEMS WITH LSC
C168		X					X					PROBLEMS WITH

C170		X					X			LSC PROBLEMS WITH LSC
C173			X							
C175		X					X		X	
C177		X	X				X		X	
C178		X					X		X	
C183	X	X	X	X	X		X		X	
C184		X					X		X	
C186		X	X				X		X	
C194	X	X	X	X	X	X	X	X	X	
C195		X					X		X	
C196		X					X		X	
C197		X	X				X		X	
C198		X					X		X	
C199		X					X			