Columbia River Plume 2006
OSU Ocean Mixing
Nash, Kilcher, Moum et al.

CR05 Cruise Report (RISE Pt. Sur, May 21-31 2006)

OSU Ocean Mixing Group Summary:

Participants:

Pt. Sur – Ocean Mixing Group: Jonathan Nash, Levi Kilcher, Alexander Perlin, Greg Avicola;
Pt. Sur – UW: Emily Spahn (Alex Horner-Devine; Seattle)
Pt. Sur – undergraduate interns: Robin Bjorquist and Alexandra Cwalina
Ocean Mixing Group home-support: Jim Moum (w/ Ray Kreth, Mike Neely-Brown and Emily Shroyer)

Measurements by the Ocean Mixing Group characterize and quantify the mechanisms by which oceanic water is entrained into the freshwater plume. We identify high frequency/high wavenumber motions and understand the dynamics responsible for generating turbulence. Our measurements of chlorophyll, optical backscatter, acoustic backscatter, density, velocity and turbulence are obtained rapidly and with high vertical and horizontal resolution. They span the full water column (from 1 m beneath the ocean surface to 3 cm from the bottom) and capture both near-surface fluxes and bottom boundary layer (BBL) dynamics. Details of our instrumentation and measurement locations are summarized in tables 1 and 2. Timing and locations of these observations are shown in Figures 1 and 2.

Cruise Summary:

Prior to the cruise, we (Hicky, MacCready, Kudela, Lessard, etc.) had big plans for a coordinated 2-ship experiment following an aging plume to the south during upwelling-favorable winds. As luck would have it, winds were moderately strong and downwelling-favorable during the first phase of our cruise. In fact, winds were so strong and seas so large that the Captain suggested we move into the estuary on 5-23 which we happily did. We obtained a 36-h timeseries in the estuary (broken into 3 continuous segments as a result of some instrument failures) while the larger R/V Wecoma stayed outside to sample.

Once the plume had developed into a beautiful shore-hugging northward buoyant coastal current, we headed to the Grays Harbor line to sample its evolution and turbulence. We stayed on the Grays Harbor line for 72 h, getting 21 transects in as far as 9-m water depth. An example transect is shown in Figure 3. We had hoped to capture a reversal to upwelling-favorable winds, followed by plume thinning and intensified near-surface mixing, but this never materialized. Instead winds backed off a bit and turned onshore. However, strong Northerlies did not occur during this time period, so the plume never reverted to its classic southward form. We spent the remainder of the cruise in the CRP nearfield, sampling the E-W line 4 a total of 48 times and the N-S line 1 a total of 33 times. During these periods, we found the river plume to be thinner than in previous years, from a dynamical perspective, such that the plume's velocity and turbulent extent does not extend to the bottom (contrasting 2005; see figure 3). This was the Ocean Mixing Group's first sampling of the plume both at high river flow and during strong downwelling, so we are initially unable to assess the relative importance of these two factors.

A detailed cruise log (analysis/cr06/doc/CR06-cruiselog.doc) is also available from Jonathan Nash (nash@coas.oregonstate.edu).

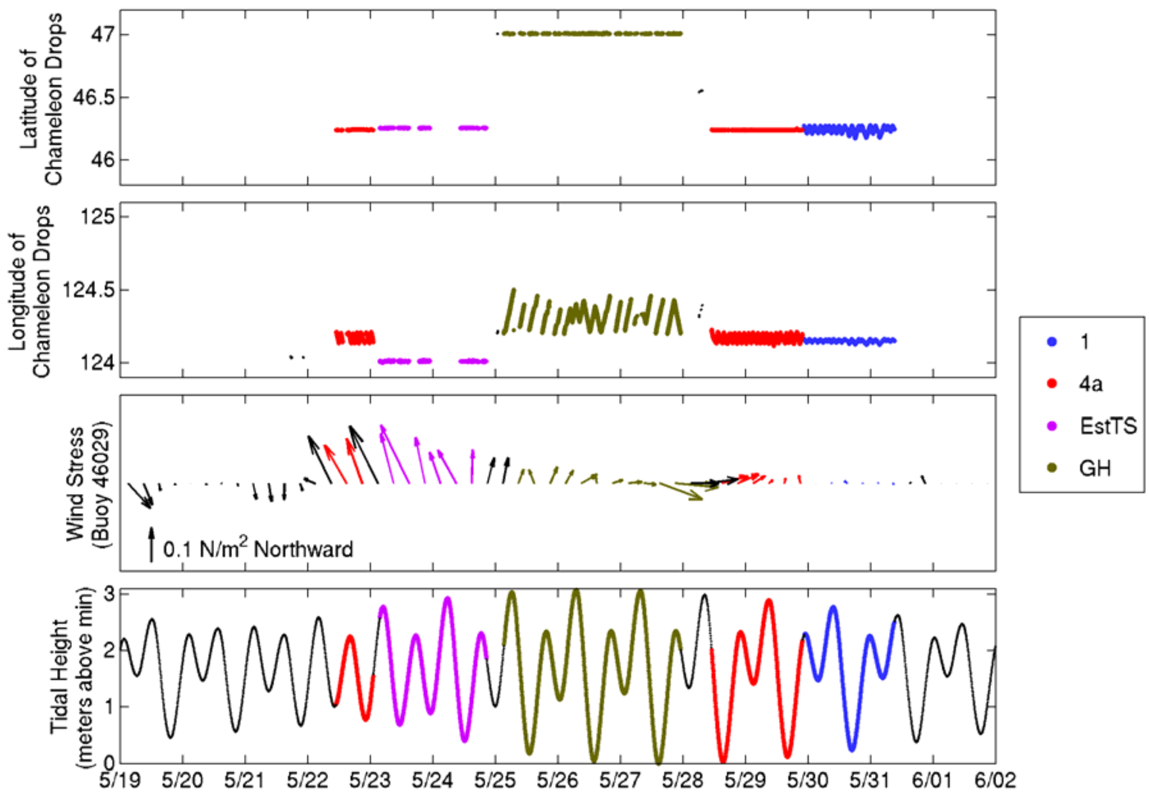

Figure 1: Timing of Pt Sur operations relative to tides and winds.

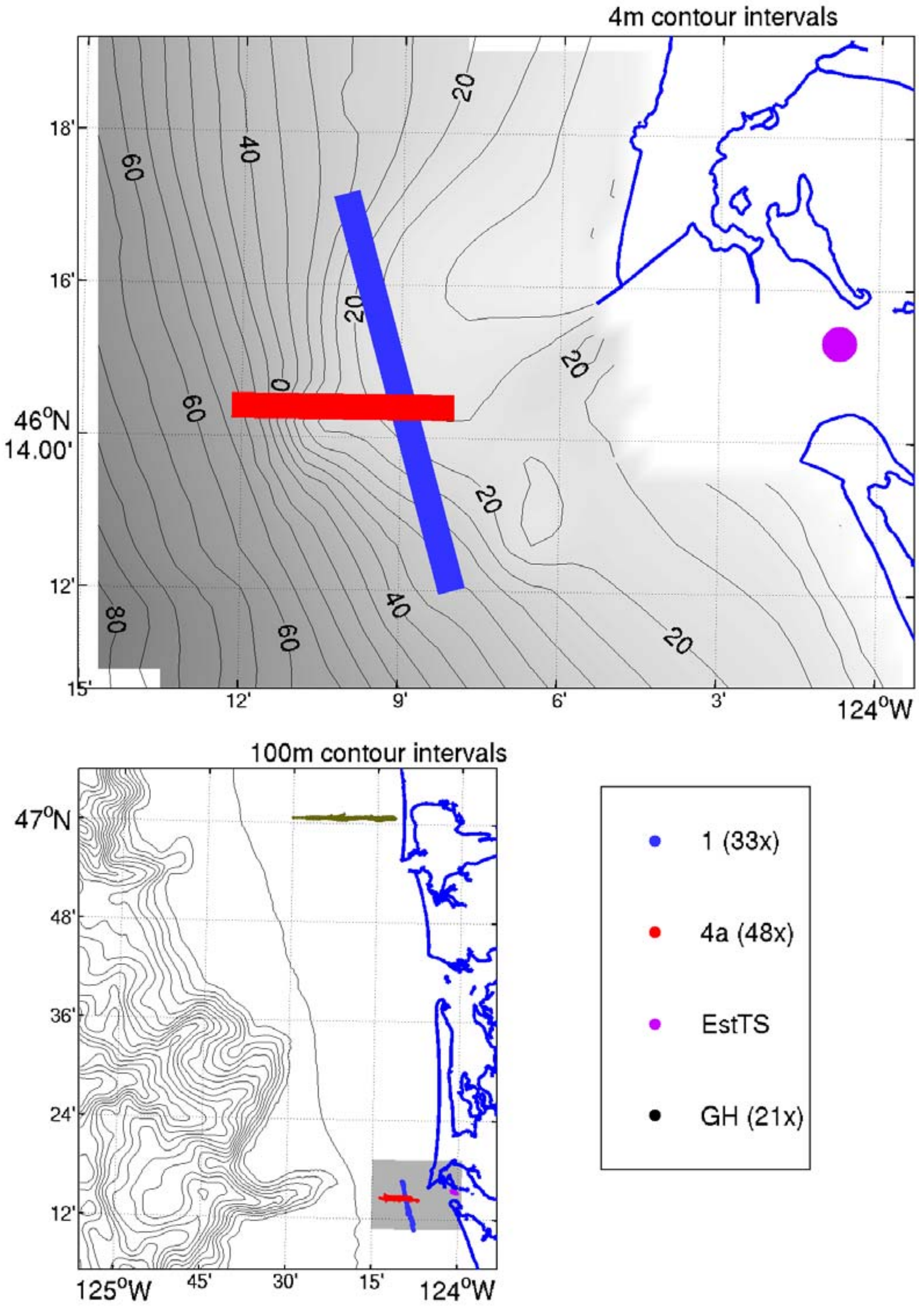

Figure 2: Location of Chameleon measurement transects during 2005 Pt. Sur cruise (CR05-Aug)

Instrument	**Sensor**	**Measurement**
Chameleon (a loosely-tethered vertical microstructure profiler)	Airfoil shear probes 3-component accelerometers (IC sensors)	turbulent energy dissipation rate turbulent eddy diffusivity turbulent buoyancy flux
	PME Accurate Conductivity, Thermometrics FP07 thermistor, Endevco 500 psi pressure	CTD, 3 cm salinity, density; 1 cm temperature
	Seapoint Sensors 880 nm optical backscatter	suspended sediment plus plankton
	Seapoint Sensors Chlorophyll sensor (Fluorometer)	proxy for chlorophyll; <10 cm vertical scales
	3-component pitot tube	3-component velocity at ~10-cm scales.
Biosonics Echosounder	120 kHz acoustic transceiver, pole mounted at 1-m depth , 0.1 msec pulse length, 2 m to 110 m (or bottom), 2 Hz sample rate.	Images salinity microstructure and biological layers with 10 cm vertical and 1-m horizontal resolution
1200kHz RDI Workhorse ADCP	Pole mounted at 1-m depth; 0.5 m blank distance; 1-m depth bins; 1 second time bins, all ping data saved.	velocity from z=2 to 120 m with 15-second (10-30 m) horizontal and 1-m vertical resolution
Shipboard radar	X-band radar was tuned to sea clutter and digitally recorded every 30 s.	Plume front and wave packet location relative to ship and shore.
Satlantic ISUS	Optical nitrate sensor mounted on CTD	Nitrate with O(1m) vertical resolution.
LISST-25	Optical particle counter mounted on CTD	Sediment concentration & size distribution

Table 1: Instrumentation.

Line 1	1N 46° 17.20´ N 124° 10.05´ W	1S 46° 10.19´ N 124° 07.31´ W
Line 4	4E 46° 14.4´ N 124° 6.0´ W	4W 46° 14.4´ N 124° 30.0´ W
Line GH	GHE 47° 0.7´ N 124° 11.8´ W	GHW 47° 0.7´ N 124° 30.0´ W
Estuary	Estuary 46° 15.3´ N 124° 1.0´ W	

Table 2: Station Locations

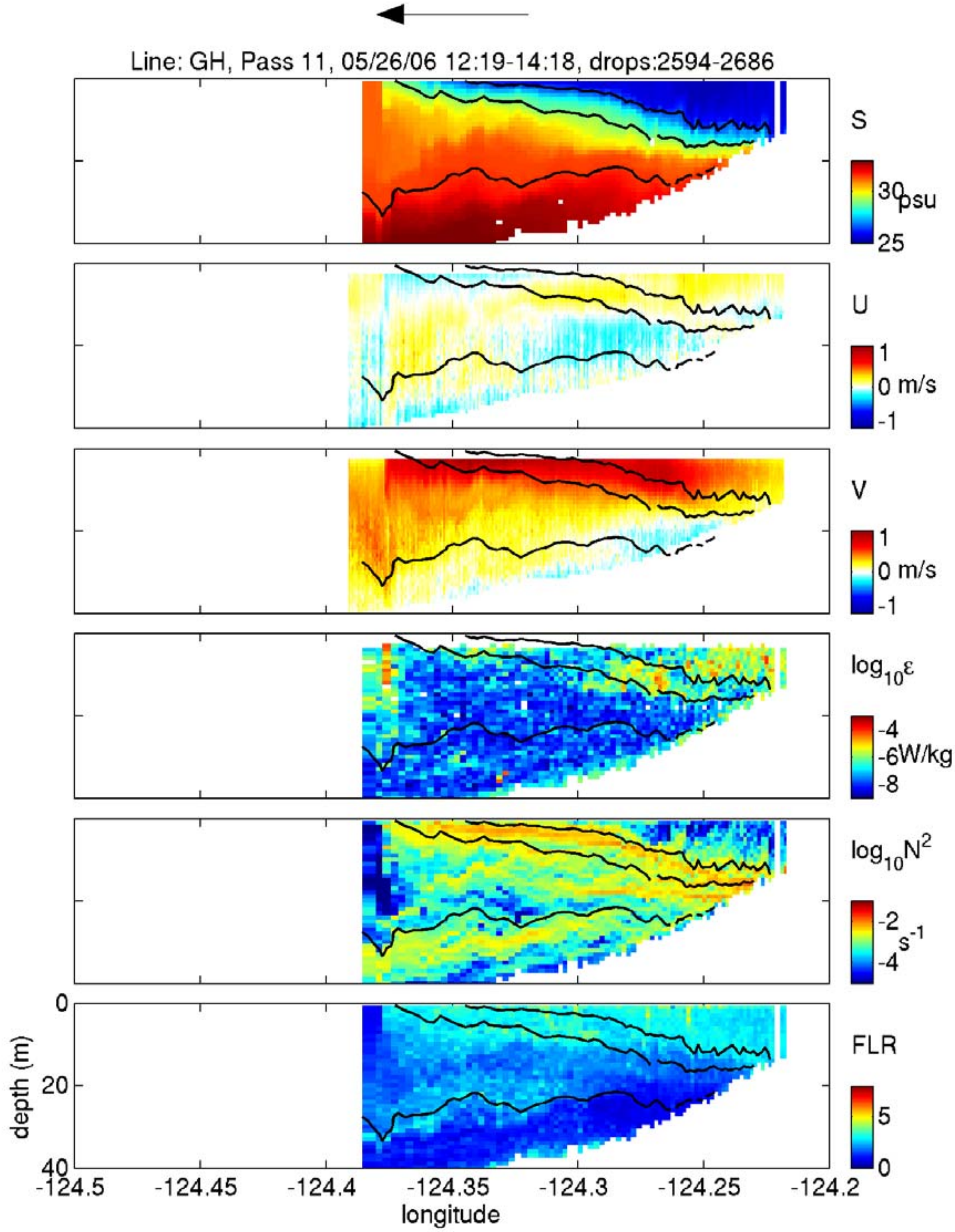

Figure 3: E-W transect along the Grays Harbor on 5/26/2006 during mild downwelling favorable winds. While the salinity appears to decrease inshore, the northward velocity maximum is well offshore of the freshwater maximum. Strong turbulence, weaker currents, and reduced stratification on the inshore edge of the front suggests that entrainment and turbulent bottom stresses are most important in the shallows.

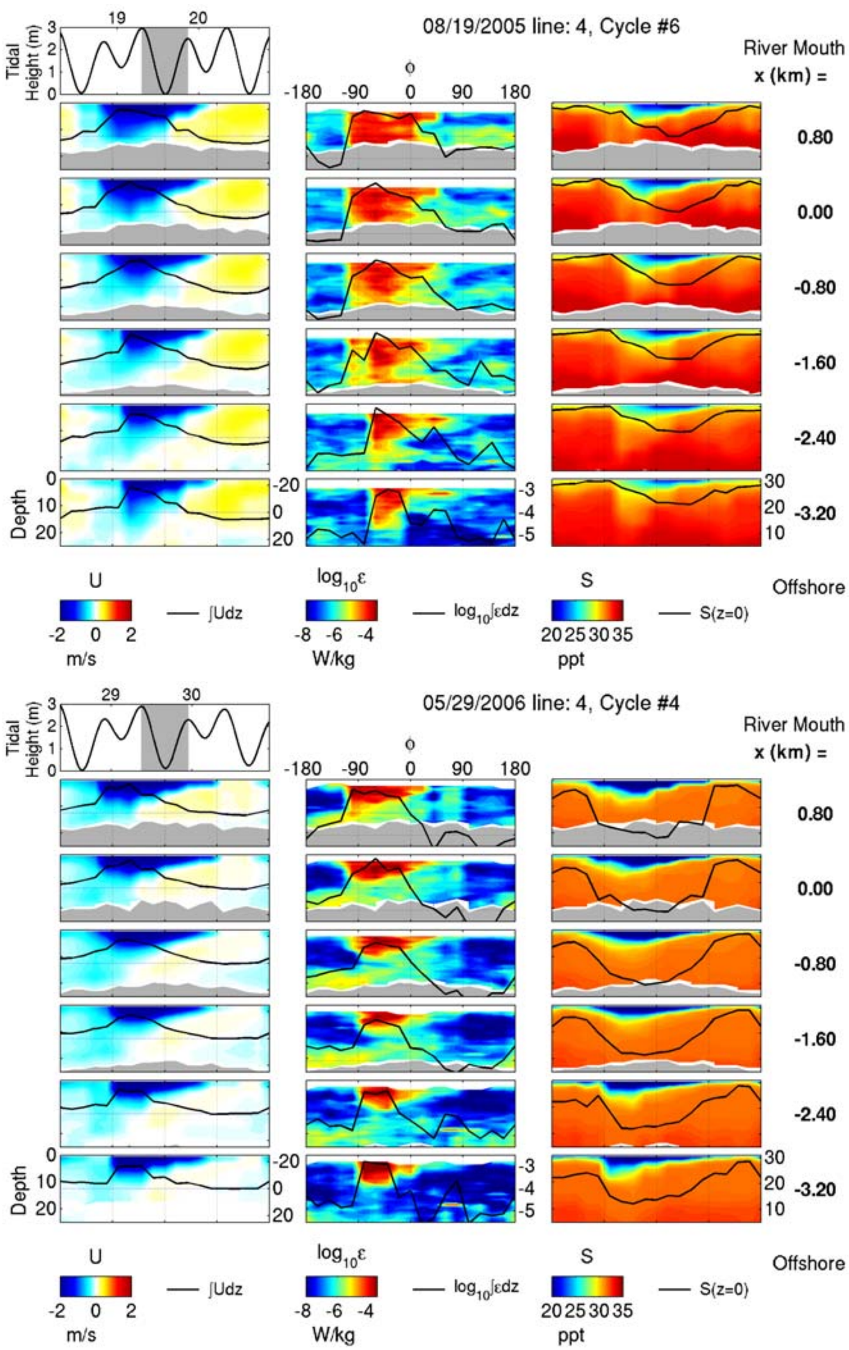

Figure 4: Depth-phase plots of velocity, turbulence and salinity as a function of distance along the plume axis in 2005 (top) and 2006 (bottom). Solid lines represent depth averages. These illustrate the shift in 2006 (downwelling, high flowrate) towards a thinner plume with intense turbulence extending further offshore, much weaker return flow, and generally reduced salinity (in both plume and bottom waters) as compared to 2005.