Columbia River Plume 2005
OSU Ocean Mixing
Nash, Kilcher, Moum et al.

CR05 Cruise Report (RISE Pt. Sur, Aug 2-27, 2005)

OSU Ocean Mixing Group Summary:

Participants:

Pt. Sur – Ocean Mixing Group: Jonathan Nash, Levi Kilcher, Alexander Perlin, Ray Kreth, Mike Neely-Brown, Sam Kelly;
Pt. Sur – UW: Emily Spahn (Alex Horner-Devine; Seattle)
Pt. Sur – Volunteers: Robin Bjorquist, Denis Franklin
Ocean Mixing Group home-support: Jim Moum (w/ Greg Avicola 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 or measurements are summarized in table 1.

During our 2004 operations, we did not adequately resolve the dominant tidal signals, nor did we have sufficient coordination between the complimentary operations on the Pt. Sur (physical and geological) and Wecoma (biological and chemical). Farfield plume sampling of turbulence in 2004 was limited in extent.

These guided our 2005 sampling strategy:

1. Unaliased transects must be sampled rapidly enough to capture the tidal evolution (non-sinusoidal tidal cycle requires sub-hour repeats and 25-h duration), implicitly limiting the tidally-resolved transect length to O(10-km)
2. Frontal advection and evolution occurs over 20-km scales that must be captured in a front-tracking mode, different from (1).
3. Offshore plume structure and turbulence must be captured, requiring systematic and repeated sampling over OR and WA shelves.
4. Coordinated two-ship experiments must be planned in advance but executed according to each ship's independent operating procedures.

Cruise Summary:

Data return was excellent. Two ship coordination also went smoothly, with more than 6 days of highly-coordinated operations. Our primary measurements are obtained using Chameleon, our loosely-tethered vertical microstructure profiler. Time between Chameleon profiles is approximately 1-4 minutes (depending on profile depth; vertical profiling speed is 95 cm/s) at ship speeds of 1.5-7 knots through the water. Despite numerous winch failures, 14500 profiles of turbulence were obtained with >80% duty cycle (transits, instrument repairs, rescues, CTD profiles and crew exchange occupied <20% of cruise time). A Biosonics 120 kHz echosounder and RD Instruments 1200 kHz ADCP were both mounted on over-the-side pole mounts at 1-m depth; shipboard 300 kHz ADCP, flow-through and met data augment these observations.

Columbia River Plume 2005
OSU Ocean Mixing
Nash, Kilcher, Moum et al.

The following summarizes the timeline and spatial extent of our observations, and our coordination with the Wecoma (see figures 1-3):

1. 60 h on OR shelf line and BBL (3 occupations, 1 w/ Wecoma)
2. 48 h on WA shelf line and BBL (2 occupations, 1 w/ Wecoma)
3. 3.5 days along plume axis capturing frontal evolution out to 124.5 W (4 occupations 2 w/ Wecoma)
4. 26 h in-estuary timeseries (w/ Wecoma)
5. 4 days cross-axis structure (2 occupations)
6. 2 days near-field timeseries (2 occupations, w/ Wecoma)
7. 3 days along-axis near-field structure (2 occupations)
8. LISST Sediment concentrations were made from 8/17-8/27.

Details of our transects are given in figures 2, 3 and table 2.

Sample transects in the plume nearfield during ebb tide are shown in Figures 4 & 5. Each transect was acquired in ~1 h and contains at least 50 vertical profiles. Shown from top to bottom are 880 nm optical backscatter (scat), biological fluorescence (flr), salinity (S), dissipation rate of turbulent kinetic energy (ε), turbulent diffusivity (K_ρ), east (U) and north (V) velocity, and 120 kHz acoustic backscatter (Echo). Figure 4 shows a transect from S to N along line 1; figure 5 shows a W to E transect along line 4.

Shown in figure 6 is a 24-hour time series obtained with the R/V Wecoma during a coordinated estuary station occupation.

A detailed cruise log (analysis/cr05/docs/CR05_cruiselog.doc) is also available from Jonathan Nash (nash@coas.oregonstate.edu).

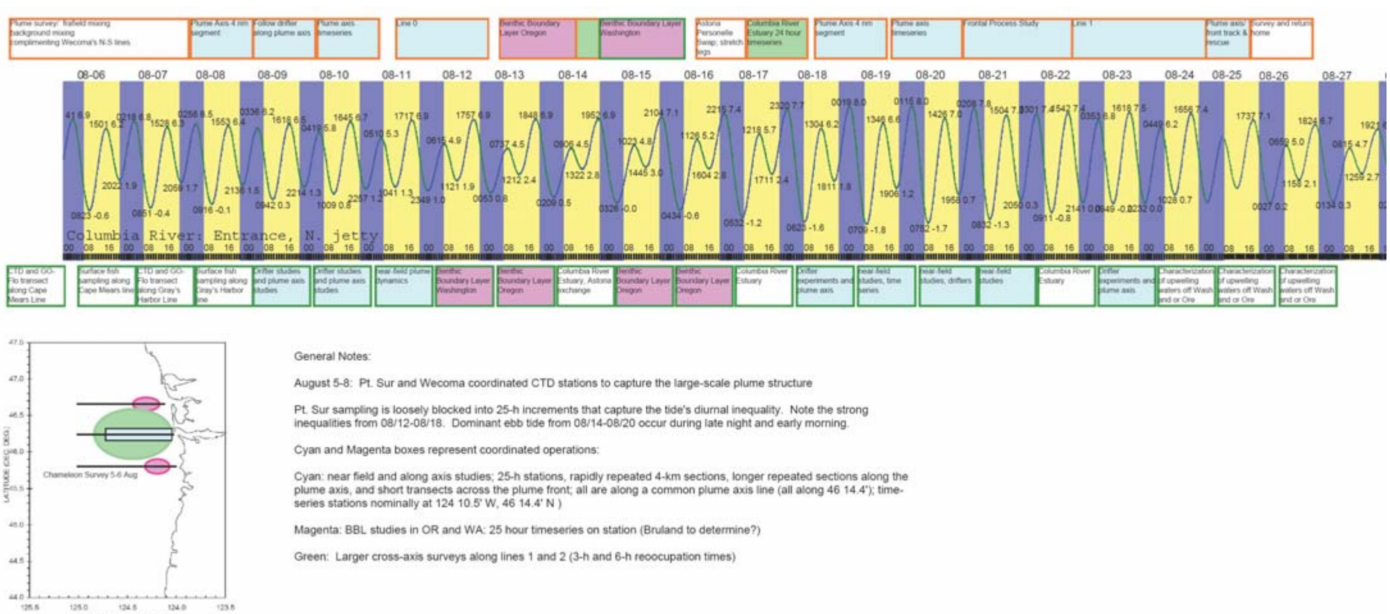


Figure 1: Overview of Pt. Sur and Wecoma's operations.

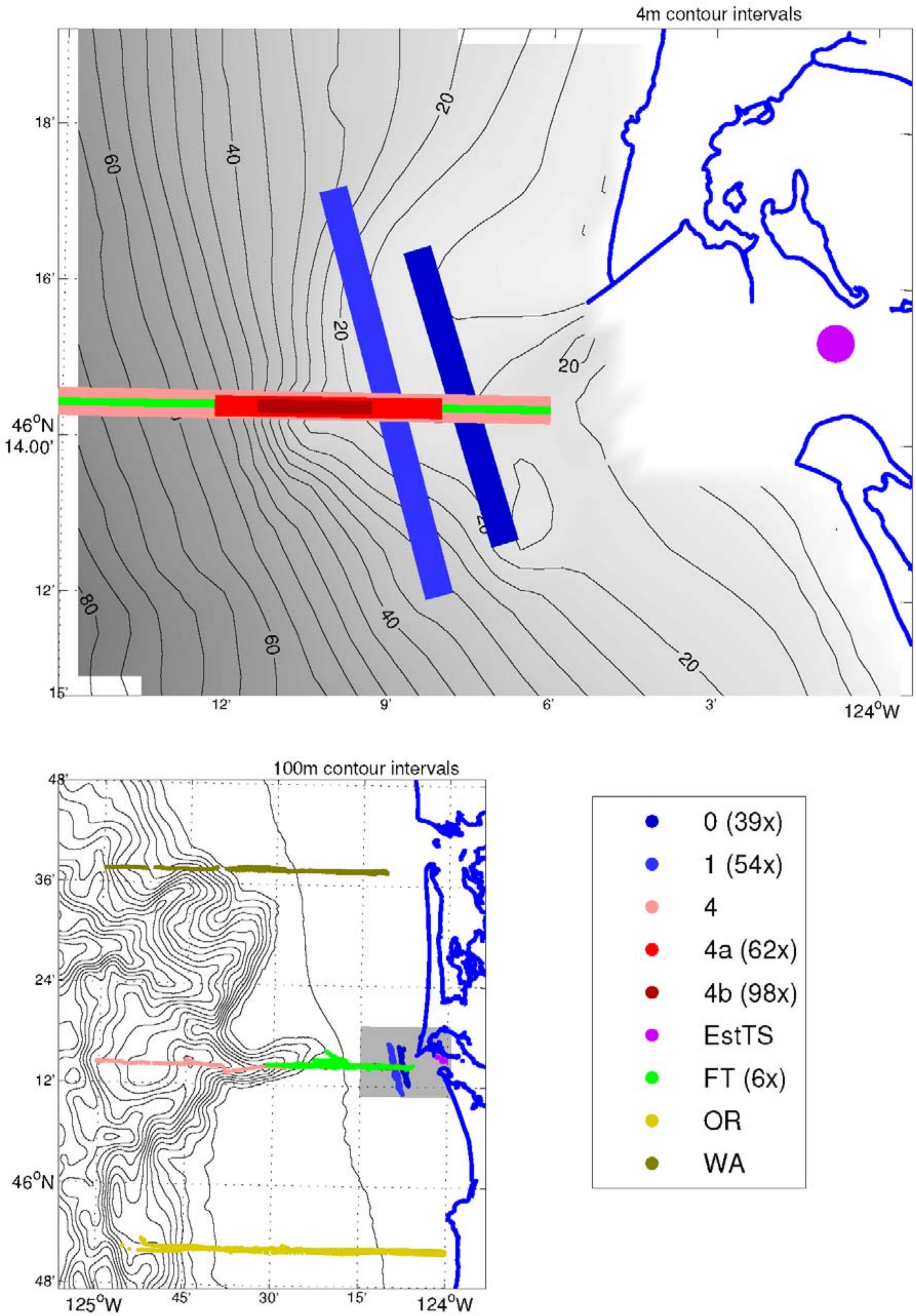


Figure 2 Location of Chameleon measurement transects during 2005 Pt. Sur cruise (CR05-Aug)

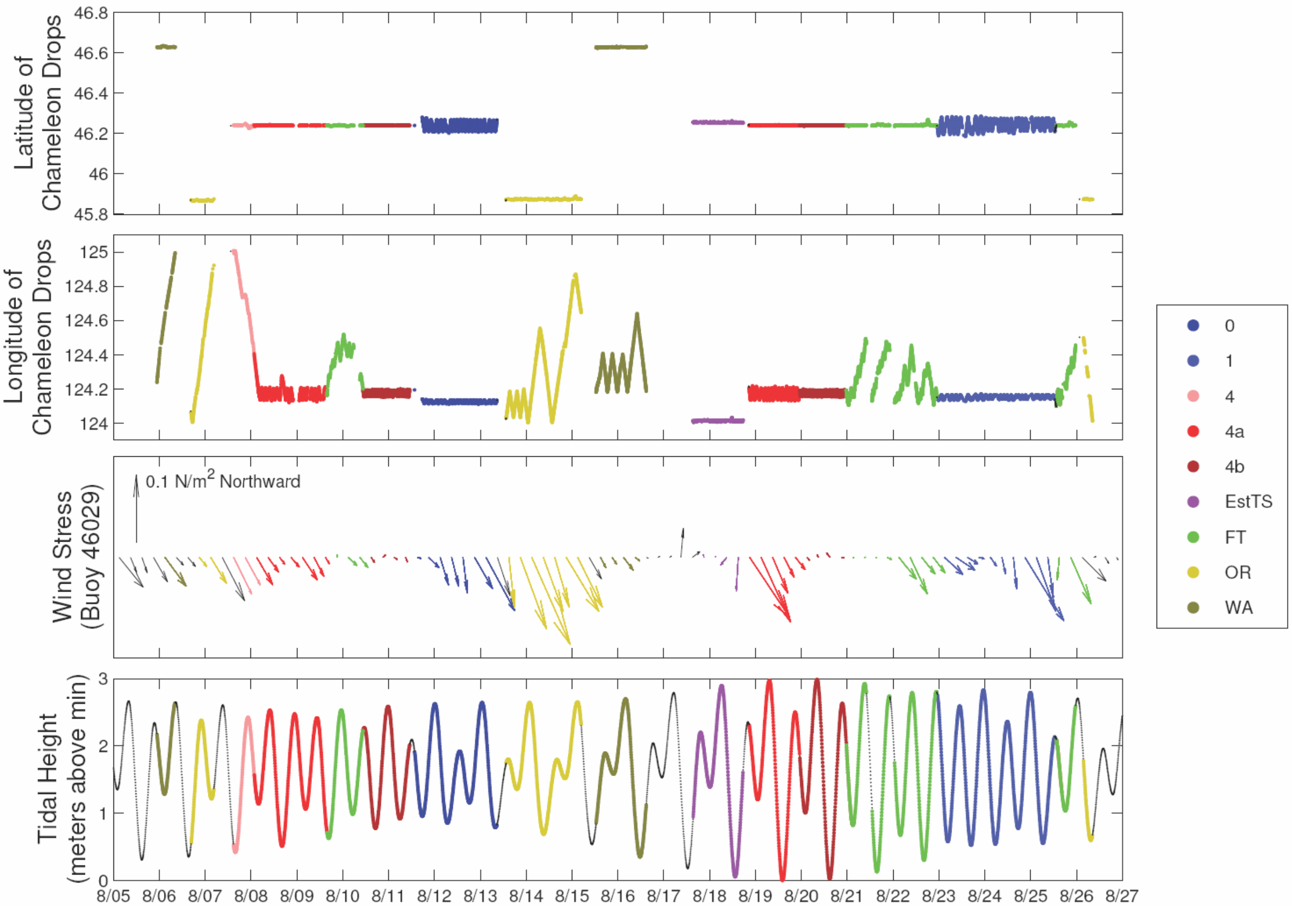


Figure 3 Location and timing of turbulence sections with respect to tides a N Jetty and winds at 46029.

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
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 photographed every 2 minutes	Plume front and wave packet location relative to ship and shore.
LISST-100	Optical particle counter mounted on CTD	Sediment concentration & size distribution

Table 1: Instrumentation.

Line 0	0N 46° 16.436′ N 124° 08.308′ W	0S 46° 12.686′ N 124° 05.938′ W
Line 1	1N 46° 17.198′ N 124° 10.050′ W	1S 46° 10.189′ N 124° 07.312′ W
Line 2	2N 46° 21.862′ N 124° 16.155′ W	2S 46° 02.689′ N 124° 06.000′ W
Line 3	3N 46° 26.519′ N 124° 28.364′ W	3S 45° 56.406′ N 124° 15.242′ W
Line 4	4E 46° 14.4′ N 124° 6.0′ W	4W 46° 14.4′ N 124° 30.0′ W
Line OR	ORE 45° 52.000′ N 124° 02.000′ W	ORW 45° 52.000′ N 125° 00.00′ W
Line WA	WAE 46° 37.700′ N 124° 11.000′ W	WAW 46° 37.700′ N 125° 00.00′ W
Estuary	Estuary 46° 15.3′ N 124° 1.0′ W	

Table 2: Station Locations

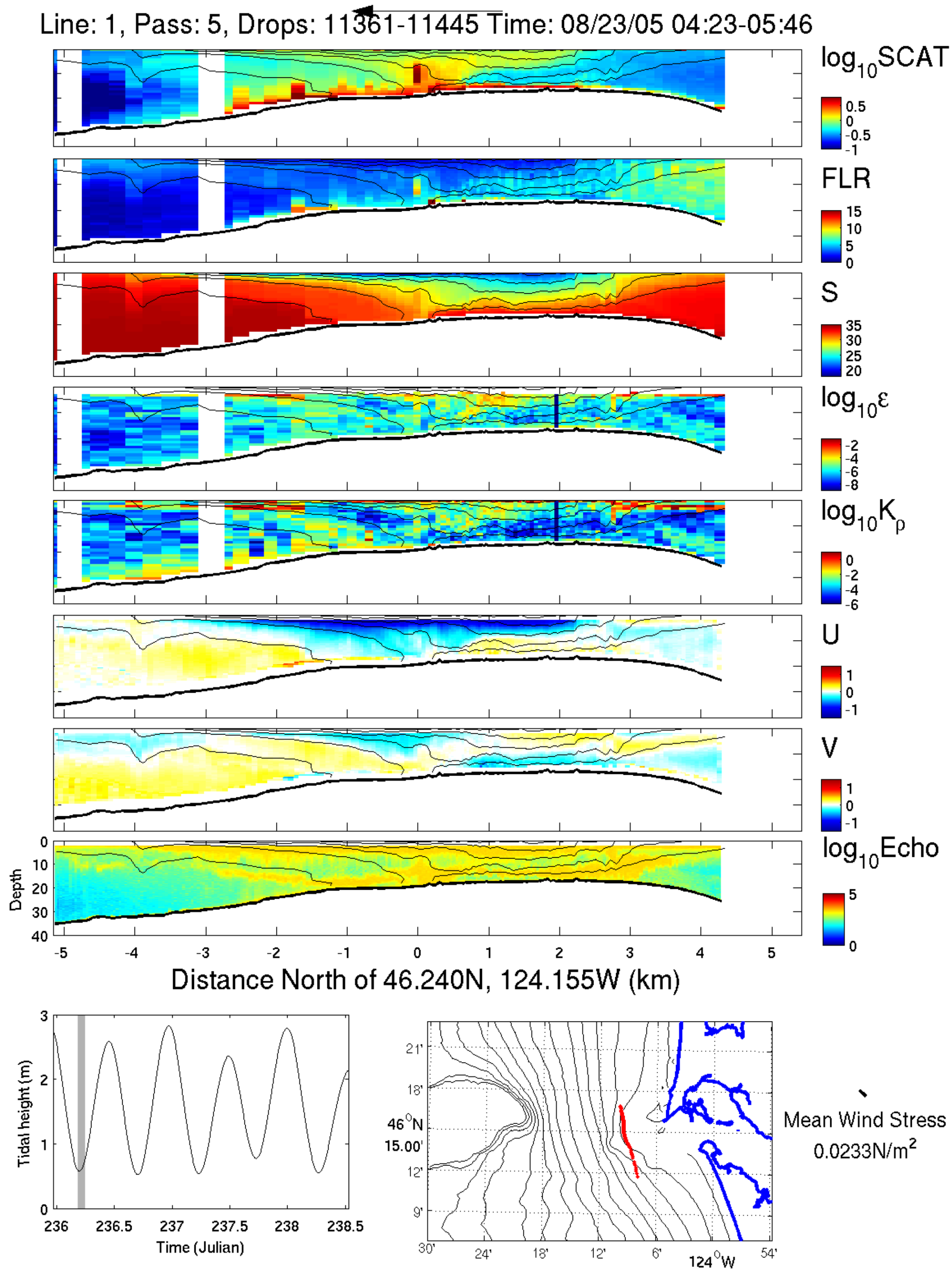


Figure 4: cross-axis transect along line-1 at low tide during weak, upwelling-favorable winds.

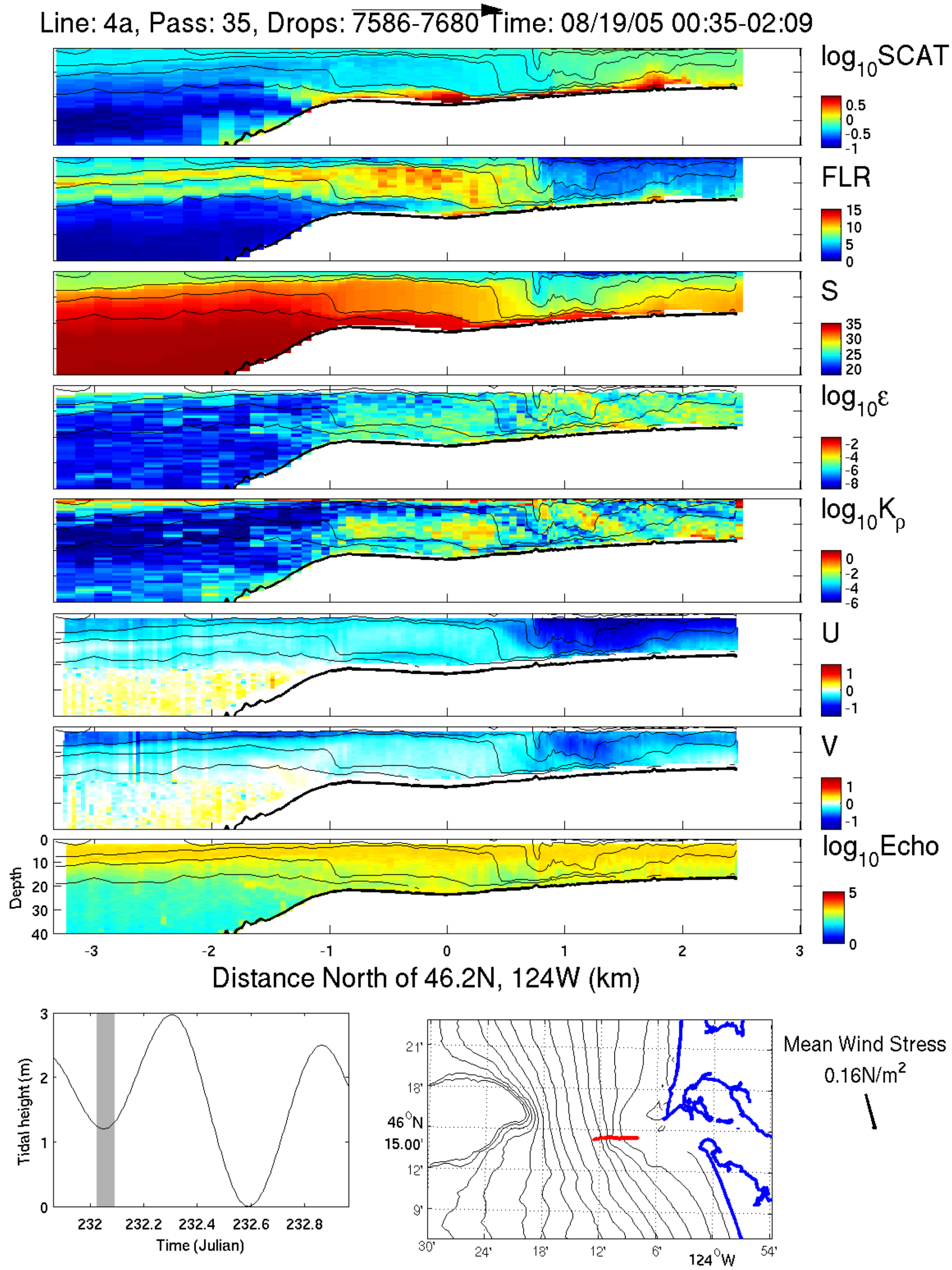
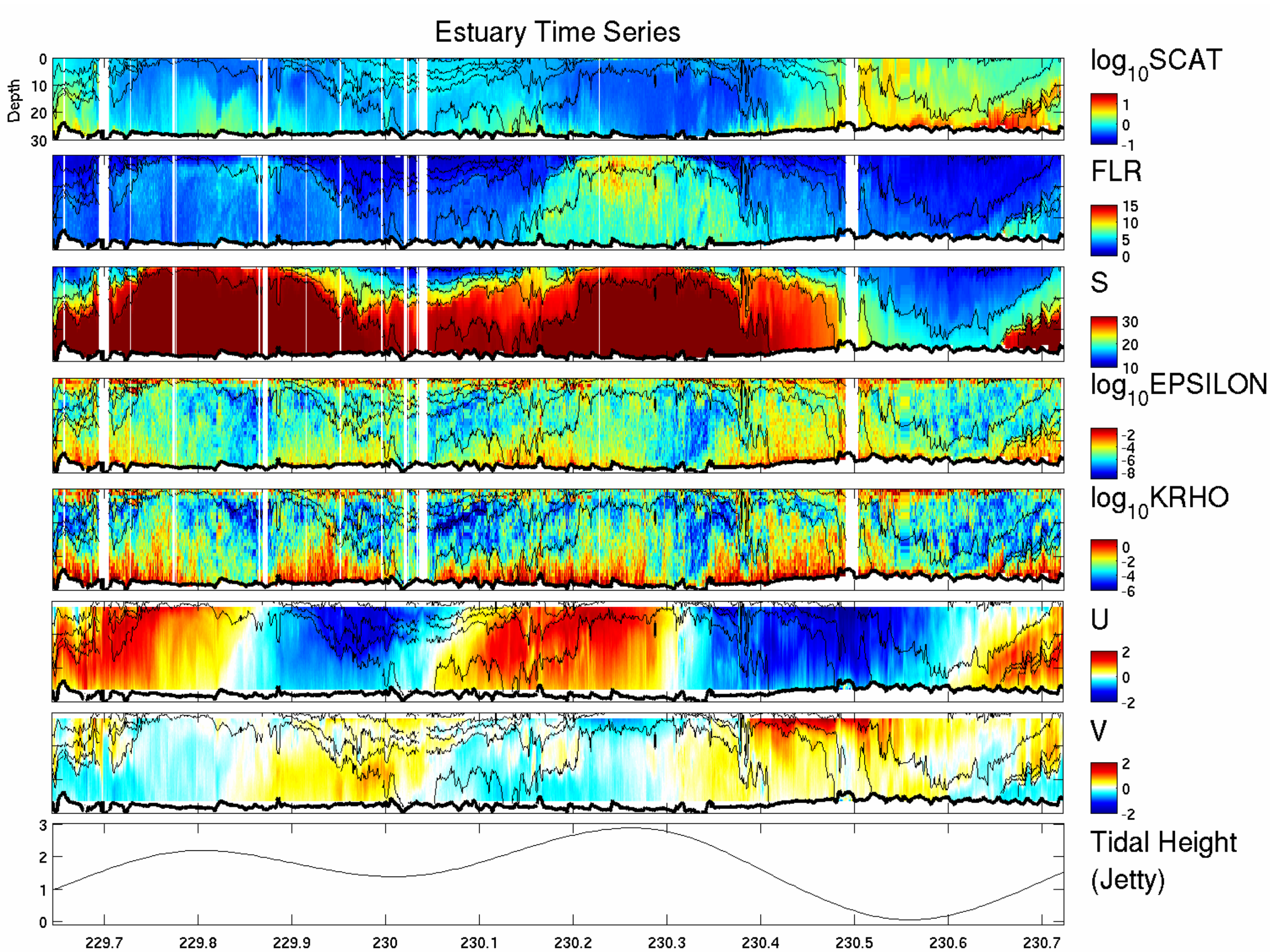


Figure 5: Along-axis transect at low tide during moderate upwelling-favorable winds. Transect shows multiple freshwater fronts, strong vertical displacements, patchy turbulence, and complicated patterns of biological fluorescence and sediment loading.

Columbia River Plume 2005
OSU Ocean Mixing
Nash, Kilcher, Moum et al.



24-hour time series at the estuary station (46° 15.3′ N, 124° 1.0′ W) on JD 230. Note strong asymmetry resulting from diurnal inequality.