

Klamath River Plume Study, Part 1: A View from the "Top"

Aerial Photos of Klamath River Mouth and Plume, May 20, 2002 at roughly 2pm PDT
(low tide)

(Photos taken by Dr. G. Crawford from a Coast Guard helicopter)

Facing east, towards the river mouth. A sand bar extended across much of the river mouth; a relatively small channel (~50-100 m wide) connected the river to the ocean.

The southern edge of the river plume was quite distinct as a contrast in color. The lighter water appears to be more riverine.



Looking northward (river mouth is in the upper righthand corner of the picture). Again, the southern edge of the plume was quite distinct.



A view from over top of the sand bar, looking west to the Pacific Ocean. The southern edge of the plume veers northward as the plume moves away from the river mouth.



Klamath River Plume Study, Part 2: Cruise Preparations

(May 21-22, 2002)



Inside the dry lab of the R/V Coral Sea. We tend to take lots of different types of equipment on some oceanographic cruises. It is important to secure all gear on a ship so that wave action doesn't knock your equipment and samples onto the floor.



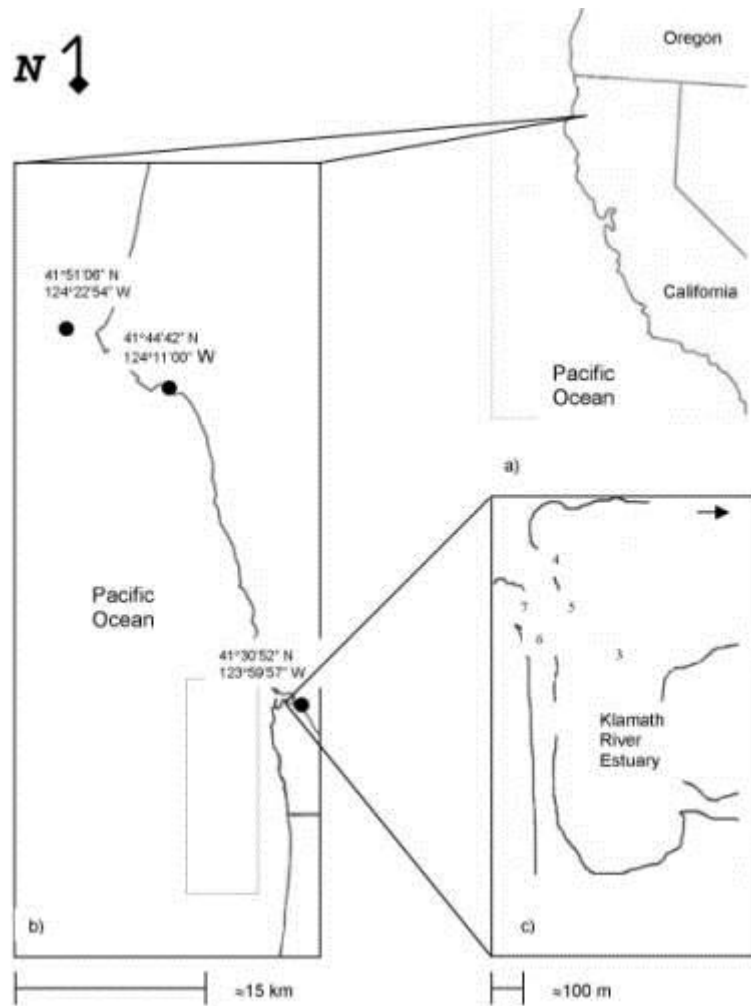
We would draw water samples from various depths using Niskin bottles. Here we are assembling the rack that would be used to mount full bottles and draw subsamples to test for various water properties



Laptop computers were used to control the CTD (which measures temperatures, salinity, and depth).

Klamath River Plume Study, Part 3: Sampling

(May 22-24, 2002)



Maps of the study area: (a) Map of the general location of the primary study area in northern California. (b) The locations of the data collection facilities in relation to the Klamath River mouth. The outlined area represents the area in which all transects were performed during the three day study period of May 22-24, 2002 (both (a) and (b) are modified using the NOAA National Estuarine Atlas, 1984). (c) The general locations of preliminary data collection sites within the Klamath estuary on May 5, 2002).



It took roughly six hours to travel from Humboldt Bay (where the R/V Coral Sea is stationed) to the mouth of the Klamath River.



We finally arrived near the river mouth by mid-day. Weather and wave conditions were mild, which made working conditions pleasant. On the other hand, with no northerly wind forcing, we were unlikely to see the river plume transported southwest as we had been expecting.



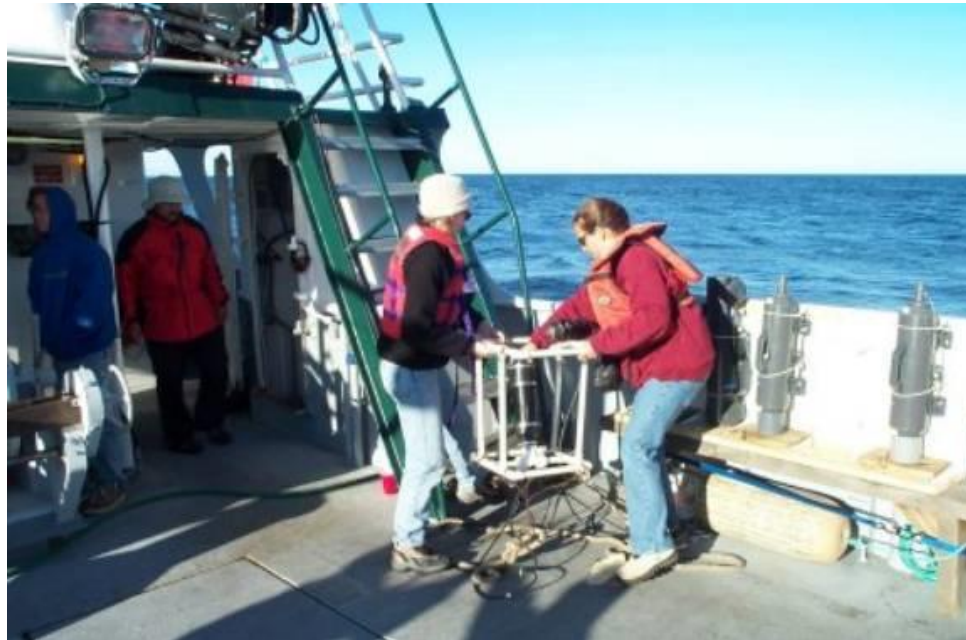
Preparing the CTD. We lowered this device at various locations offshore to search for the surface plume.



We also did bottle casts to sample water properties at various depths.



Once the bottles were brought back onto the ship, they were stored in the bottle rack and subsamples were drawn to measure pH, salinity, temperature, and total suspended sediments.



We used an underwater camera system to look for evidence of sediments, possibly carried to sea by the river plume. The camera and light source, mounted in the white PVC pipe assembly shown above, was lowered over the side of the vessel into the near-surface waters.



Under some conditions, we could see particle flocs (aggregations) in the waters.

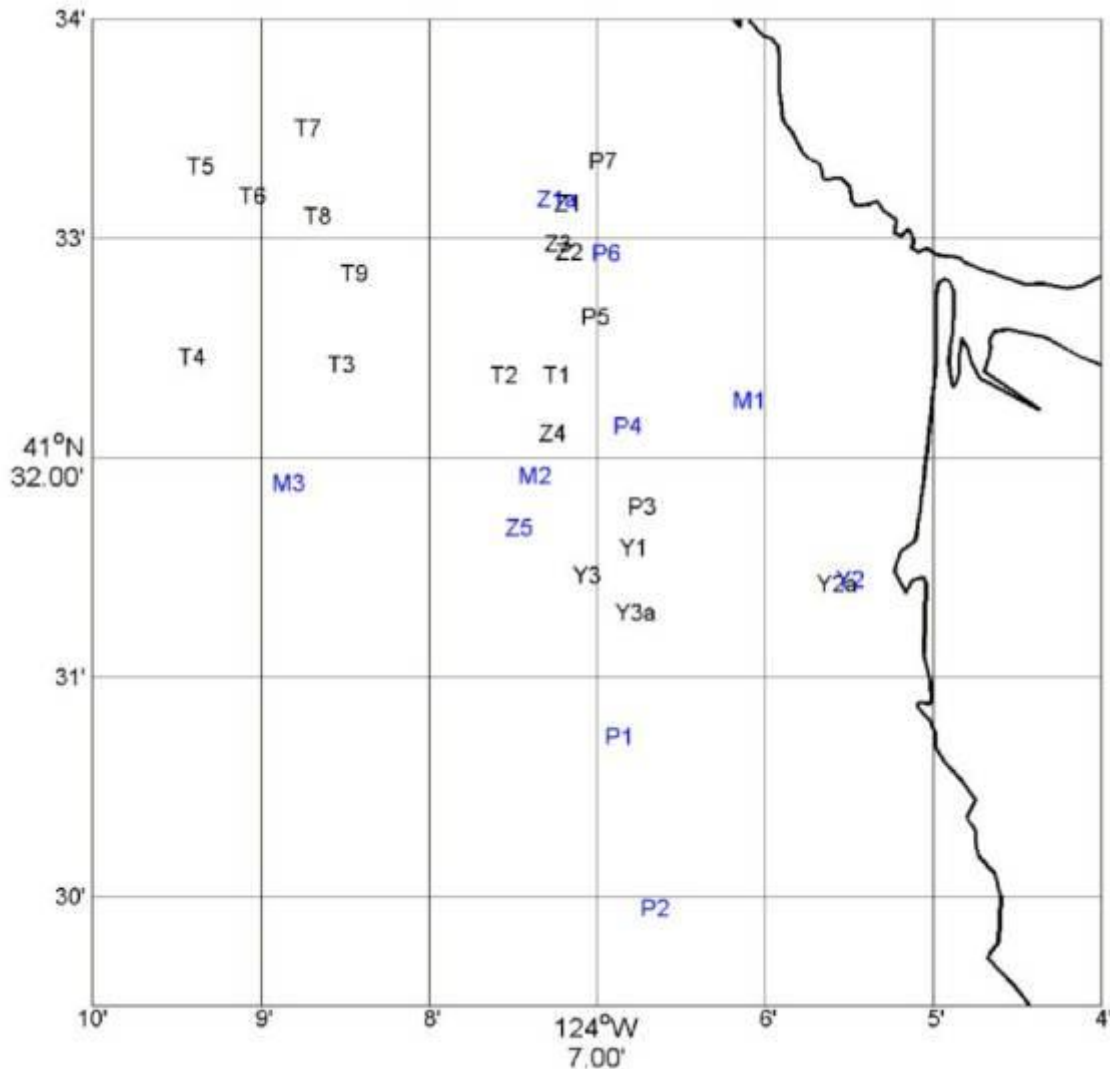


Samples of pH were run through a chemical analyzer.

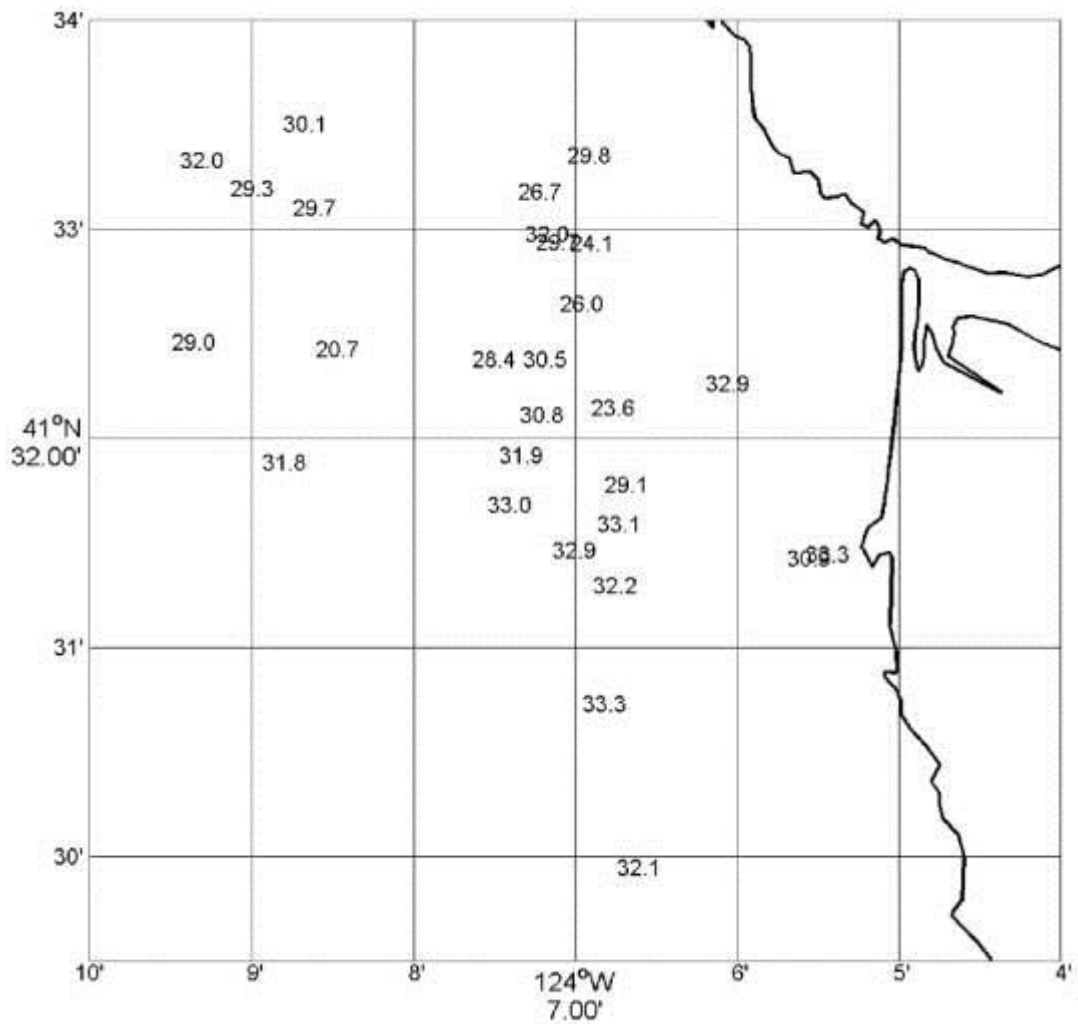


To determine total dissolved sediments, water samples were filtered and dried. Here is the collection of suspended sediment samples obtained during the cruise at a variety of depths and locations. The samples varied in coloration somewhat, from light green to dark green.

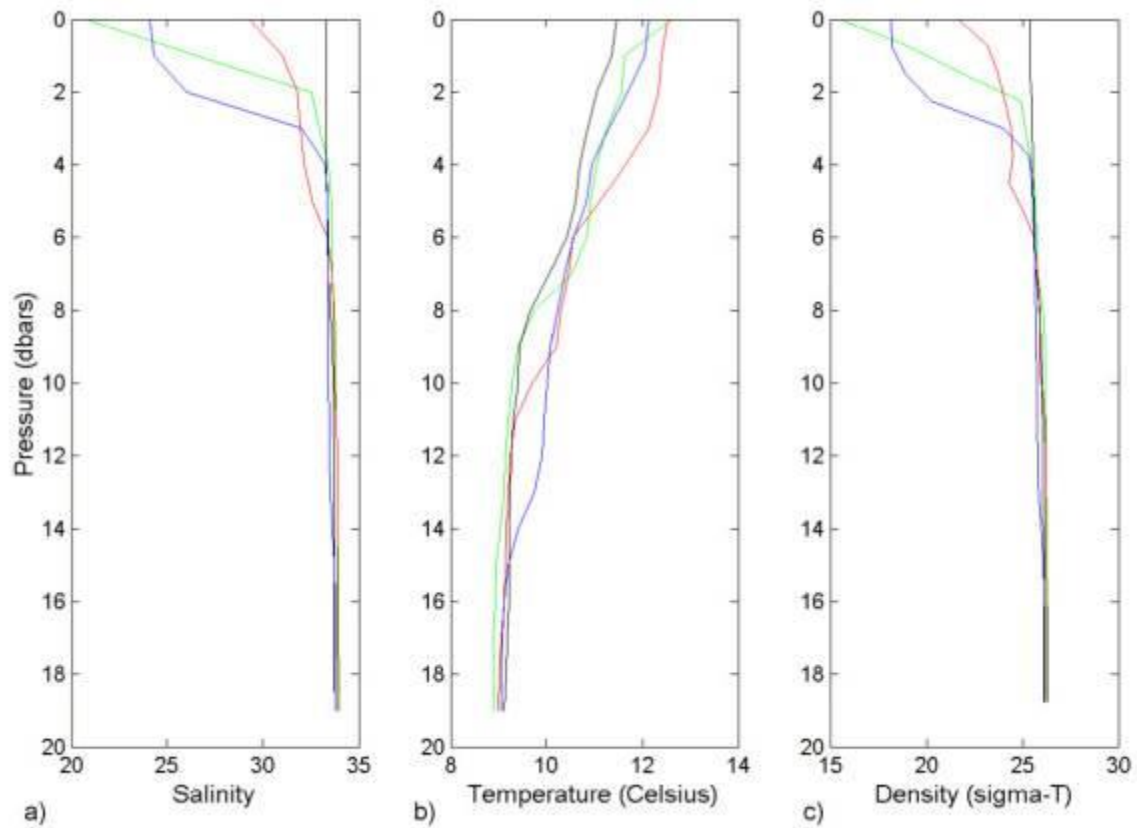
Klamath River Plume Study, Part 4: Some Results



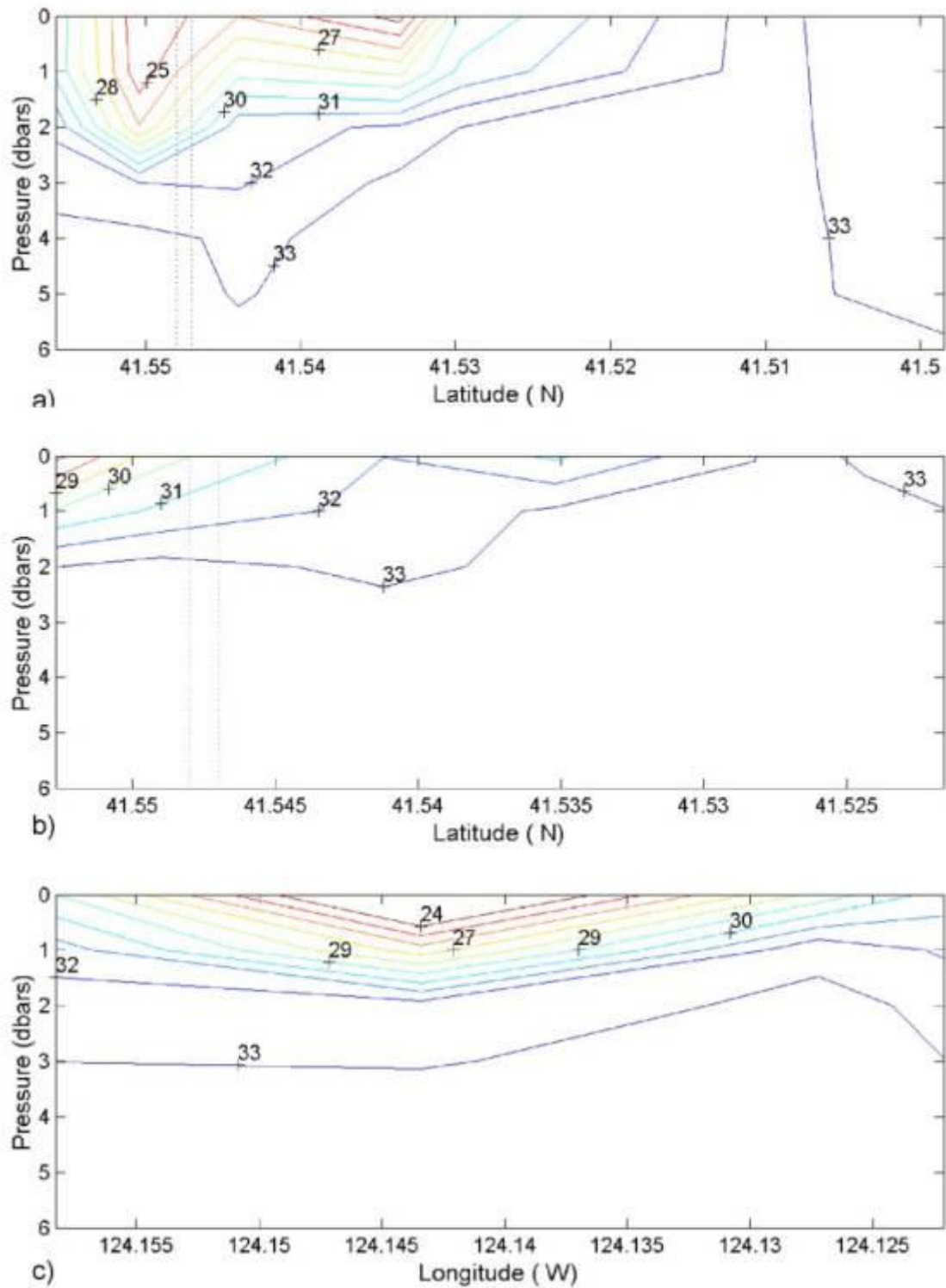
Map of the stations occupied within the primary study area from May 22 to 24, 2002. The bold line outlines the northern California coastline in the area surrounding the mouth of the Klamath River (the mouth is denoted by a break in the solid line). Stations labeled in blue indicate 'complete' stations, where all applicable measurements were conducted, and stations labeled in black indicate 'incomplete' stations, where only CTD and Secchi depths were measured. Not shown on this map are four sampling stations which were occupied south of the primary study area: stations P0 (41.17° N, 124.20° W), S1 (41.19° N, 124.30° W), S2 (41.19° N, 124.28° W), and S3 (41.20° N, 124.30° W).



Map of surface salinities (composite for all three days). Salinities ranged from 23.6 to 33.3. There is no clear pattern, but part of the problem is variability. Salinity was still the best indicator of the plume location; temperature, pH, and total suspended solids were not well-correlated with salinity measurements.

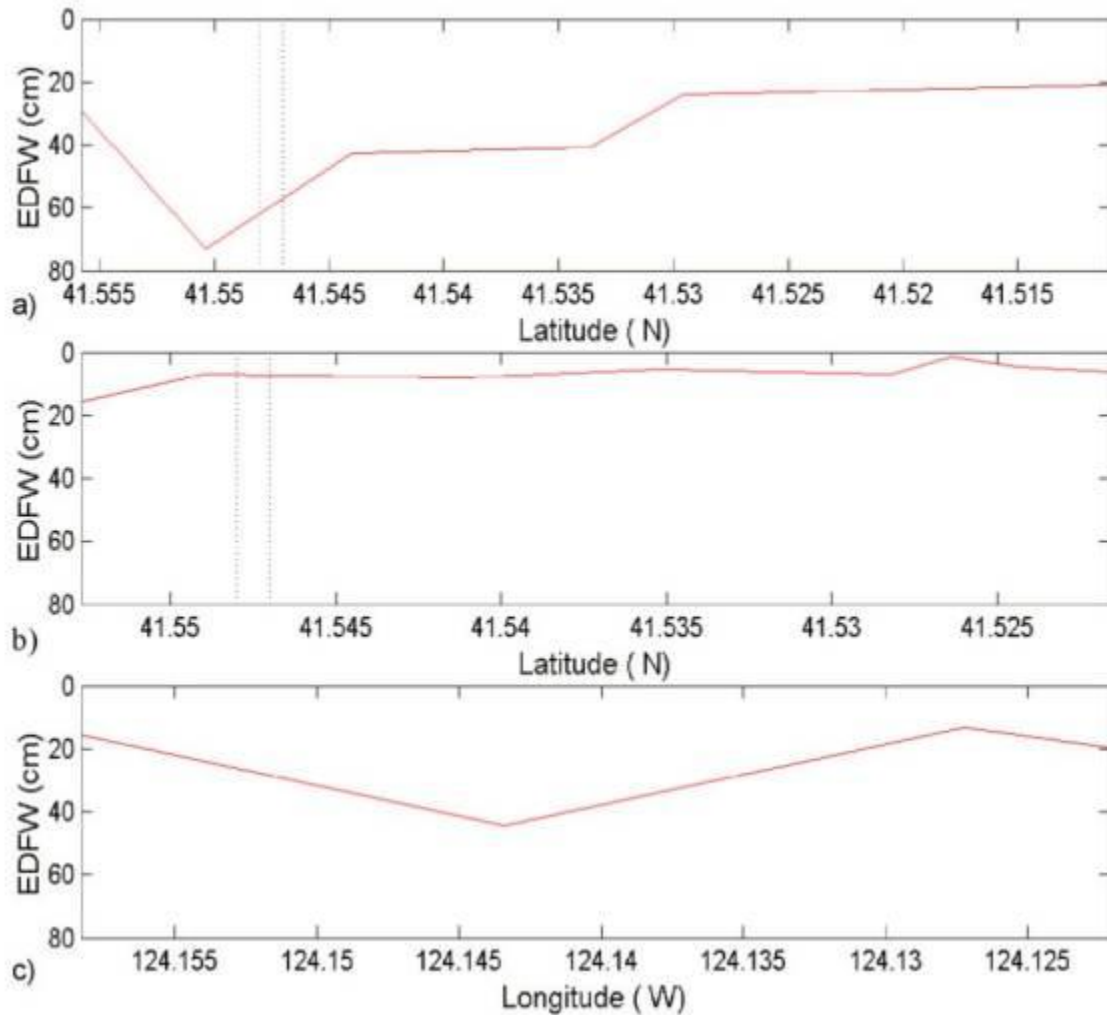


Vertical profiles of (a) salinity, (b) temperature ($^{\circ}\text{C}$), and (c) density ($\sigma\text{-T}$), at four stations located within the primary study area. Salinity values are given on the Practical Salinity Scale. Black lines correspond to station P1; red lines correspond to station P6; green lines correspond to station T3; and blue lines correspond to station T6. See above for the location of each station.

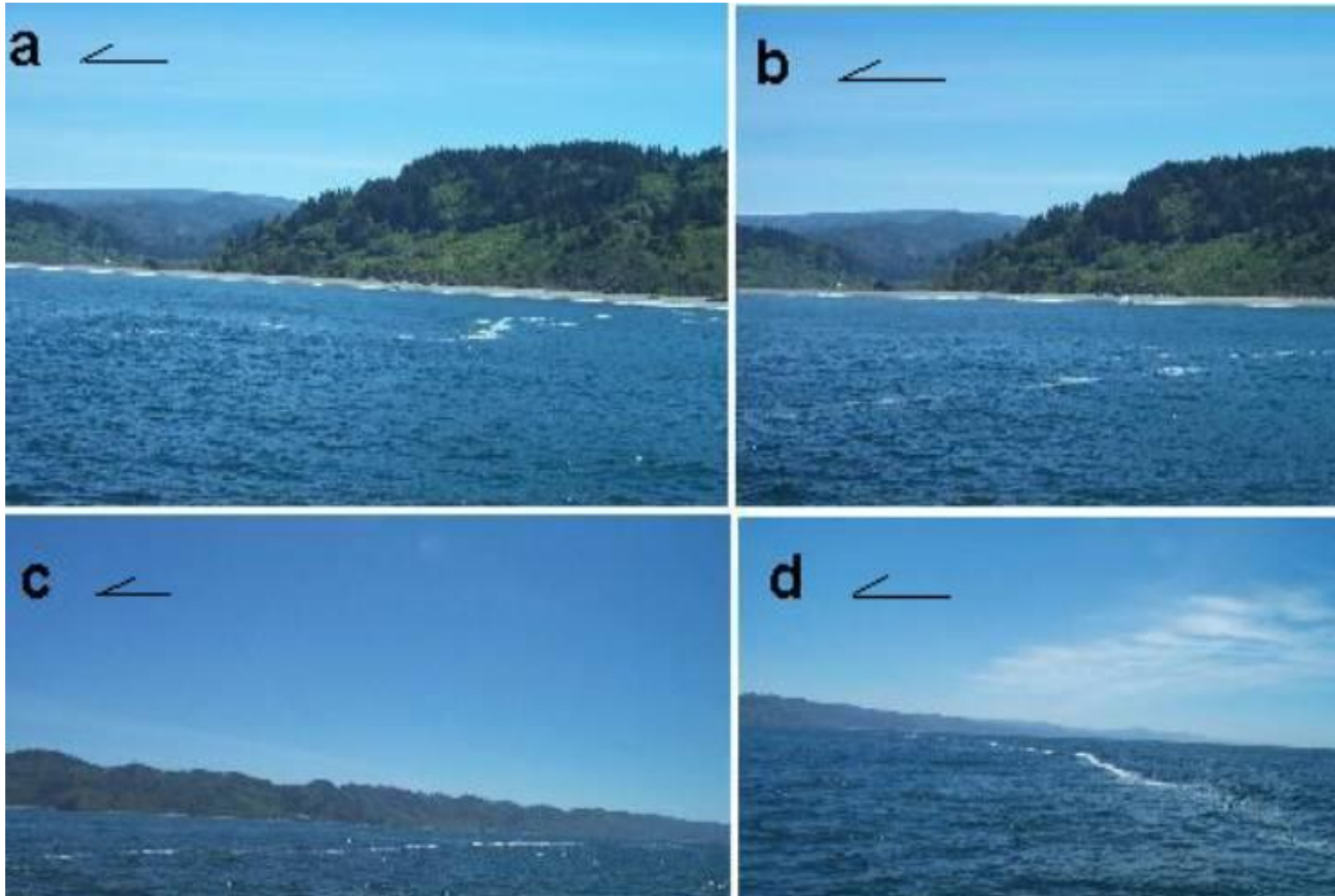


Salinity contours for various transects: (a) Along-shore salinity-depth contour plot of the north-south oriented P transect (stations P1-P7), (b) along-shore salinity-depth contour plot of the north-south oriented Z transect, along with three stations from the Y transect (stations Z1a, Z2, Z3, Z4, Z5, Y1, Y3 and Y3a), and (c) cross-shore salinity-depth contour plot of the four stations along the T transect, with east-west orientation (stations

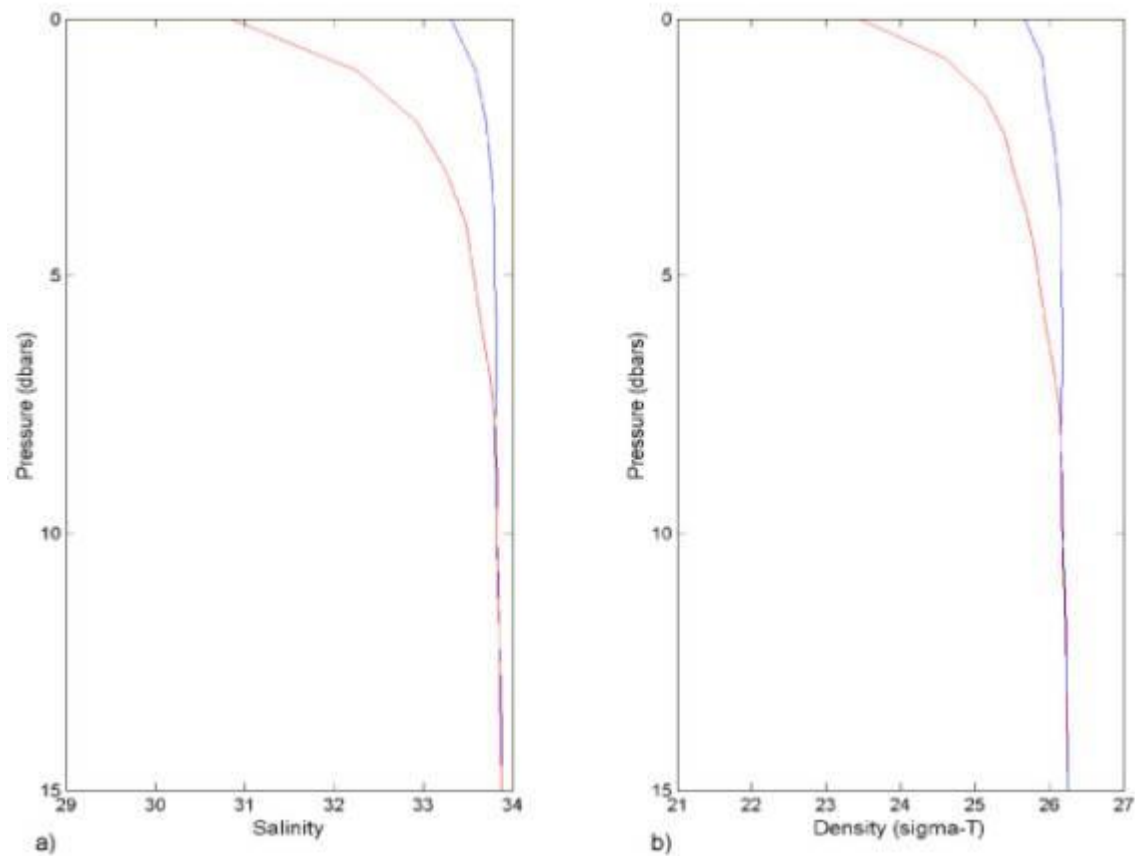
T1-T4). Solid colored lines represent isohalines; salinity values are given on the Practical Salinity Scale. Green-blue lines indicate fresher water (lower salinity) and red-orange lines indicate more saline water. Depth is given in terms of pressure (decibars). Latitude and longitude are given in decimal degrees. The dotted lines in parts (a) and (b) represent the approximate latitudes of the Klamath River mouth.



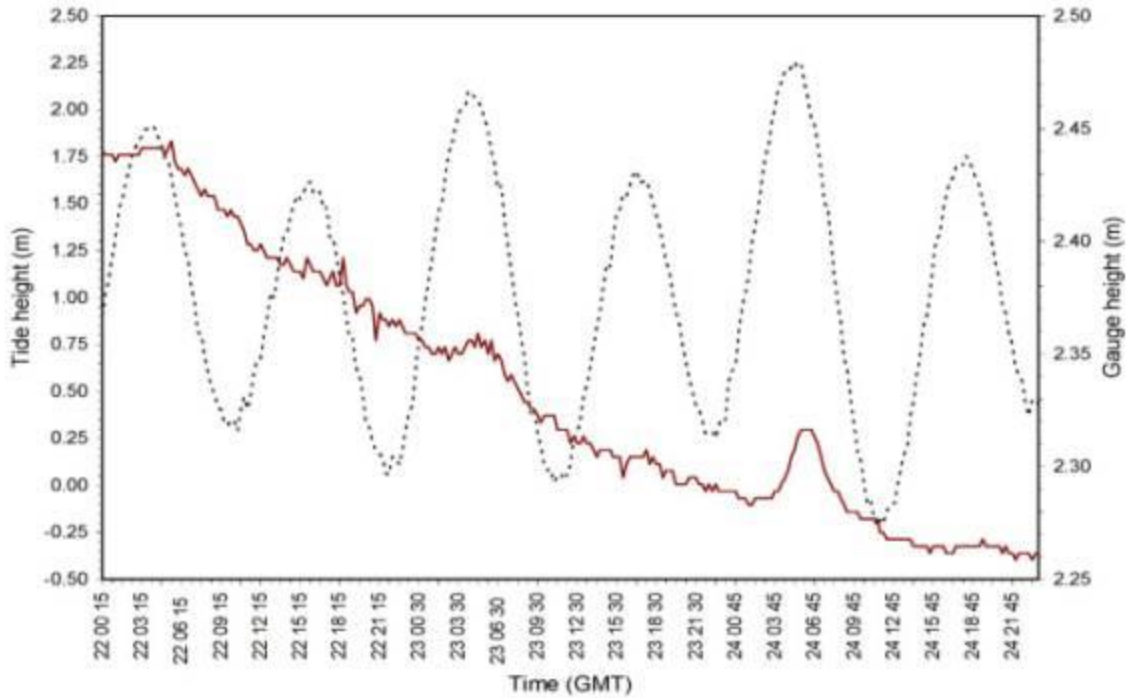
Equivalent depth of freshwater (EDFW) along various transects: (a) Along-shore equivalent depth of freshwater (EDFW) profile of the north-south oriented P transect (stations P1-P7), (b) along shore EDFW profile of the north-south oriented Z transect, along with three stations from the Y transect (stations Z1a, Z2, Z3, Z4, Z5, Y1, Y3 and Y3a), and (c) cross-shore EDFW profile of the four stations along the T transect (stations T1-T4). EDFW values are given in centimeters, and latitude and longitude are given in decimal degrees. The dotted lines in parts (a) and (b) represent the approximate latitudes of the Klamath River mouth



Photographs taken from the R/V Coral Sea on May 23, 2002 at stations Y2 and Y2a as the plume interface (marked by a foam line) neared the vessel from the north (a-c) and moved beyond the vessel to the south (d). The arrows point in the approximate direction of true North.



Vertical profiles of (a) salinity and (b) density (sigma-T) for stations Y2 and Y2a. Red lines correspond to station Y2; blue lines correspond to station Y2a. Depth is given in terms of pressure (decibars). The surface waters became distinctly more fresh and buoyant as the front expanded past the vessel. Timing of the southwardly-expanding front suggested it may have been a consequence of Klamath River water partially dammed in the estuary during the previous flood tide which was then released on the subsequent ebb.



Tidal elevations (m) for Crescent City (41.74° N, 124.18° W) plotted with river gauge height (m) from the Klamath River estuary (41.51° N, 123.99° W) from May 22 to 24, 2002. Black dotted lines correspond to tidal elevations, while solid blue lines correspond to river gauge heights. The average tide delay between Crescent City and the Klamath River mouth is roughly 20 minutes (M. Henner, pers. comm.). Water level increases measurably at the river gauge after the higher high tide each day; the effect is more pronounced on May 24 than on May 22, possibly as a consequence of dropping water levels, increasing tidal range, or both. The peak in the river gauge observations appears roughly 40 minutes after HHW at the mouth. Assuming an average water depth of 3.4m, the shallow water phase speed is 5.8 m/s; the associated transit time for the tide up the 9.8 km stretch from river mouth to river gauge is 28 minutes, which compares favorably with the delay observed at the gauge. It may well be that the propagation of high tide up the river also suppresses some of the freshwater flow out of the river on the flood tide.