Wind-induced plume and bloom intrusions into Willapa Bay, Washington

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ABSTRACT: The physical oceanography and chlorophyll distribution in Willapa Bay and the adjacent coastal ocean were measured during an upwelling-downwelling wind cycle in late May 1999. Coastal conditions were determined shipboard during two sets of five cross-shelf transects conducted 4 d apart, and instrument moorings simultaneously recorded wind velocity in the nearshore zone and biophysical water properties within Willapa Bay. The results demonstrate that estuarine physical oceanography and chlorophyll concentrations were determined by processes occurring in the nearshore ocean, and these in turn were forced by variation in wind stress. At the start of the study period, southerly winds produced downwelling conditions that forced the Columbia River plume against the coast, and low salinity water was advected into Willapa Bay. This water was relatively low in chlorophyll (<2 mg m^{-3}). As the winds switched to an equatorward direction, coastal upwelling ensued and the Columbia plume was replaced by cold, salty water nearshore. A phytoplankton bloom exceeding 10 mg m^{-3} was generated on the shelf with its core located 10 to 40 km from the estuarine mouth. The upwelling-favorable winds then relaxed, and the bloom was apparently advected across the shelf to the coast and subsequently into Willapa Bay, where instruments recorded pulses of chlorophyll entering the estuary on flood tides. Weak downwelling conditions were prevalent for the next several days, and the Columbia River plume returned to the coast where it mixed with the chlorophyll-enriched waters in the nearshore before entering the estuary. These results demonstrate that primary productivity generated in coastal waters can be transported to estuaries, where it is likely an important yet episodic food source for estuarine organisms.