Active particle-based modeling of blooms of a mixotrophic ciliate in the lower Columbia River Estuary

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Lagrangian particle tracking is performed based on output from a very high resolution realistic SELFE three-dimensional finite element model simulation of the Columbia River Estuary circulation for April through August 2009. Massive red blooms develop in summer each year in the main channels of the Columbia River estuary. These blooms are identified with very high concentrations of Myrionecta rubra, a mixotrophic planktonic ciliate that at times acts as an autotroph in the estuary by utilizing cryptophyte-derived chloroplasts. Observational studies have suggested that while the red blooms occur in the strongly tidally driven and rapidly flushed main channels of the estuary, the source region for the chloroplasts is a shallow semi-enclosed region along the northern edge of the estuary called Ilwaco Harbor (in Baker Bay). The duration of Myrionecta rubra blooms (over 30 days) well exceeds the flushing time in the estuary (0.5-5 days). So particle based modeling of the growth, transport, mixing, motility and mortality of Myrionecta rubra is performed to determine possible mechanisms by which the ciliates could both attain their food source from the shallow peripheral regions and form and sustain the intense blooms in the rapidly flushed main channels. Technical complexities such as particle behavior in the rapidly wetting and drying embayments, and active particle 'patch' formation within the unstructured grid framework are directly addressed.