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Impact of a Myrionecta rubra red tide on the Columbia River estuary

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The Columbia River estuary hosts high heterotrophic activity but low primary productivity due to high turbidity and light limitation of photosynthesis, and yet for at least a decade large, vivid red water blooms of Myrionecta rubra have occurred in the estuary during late summer. The ciliate, M. rubra, has the unique ability to acquire chloroplasts from its prey, cryptophyte algae, through a process known as karyoklepty. To better understand the nature of this association within the context of the Columbia River estuary, multiple genetic markers for uncovering genetically distinct members of M. rubra and of its cryptophyte prey were used on water samples from different years and sites located throughout the estuary and the coastal ocean north of the river. The 16S rDNA sequences of the cryptophyte chloroplasts from water collected in the estuary main channels were affiliated most closely with Teleaulax amphioxeia and were identical in 2007 and 2008, suggesting that M. rubra preys on the same species of cryptophyte each year. Our study provides evidence that M. rubra in the Columbia River estuary has an oceanic origin and that blooms first develop in Ilwaco Harbor, a shallow, recirculating area, bordering the estuary. Ilwaco Harbor likely represents a refugia for M. rubra cells and its cryptophyte prey where the ciliate can feed and acquire cryptophyte plastids before being transported upstream on the incoming (flood) tide into the Columbia River estuary main channels. Once in the main channels, M. rubra patches were associated with waters characterized by high bacterial production, high particulate and dissolved organic matter, and low nitrate and ammonium compared to non red-water patches. Microbial diversity and abundance were most highly correlated with ammonium, and high dissolved organic nitrogen was present in waters with low nitrate, suggesting that inorganic nutrients are the preferred nitrogen source. M. rubra 18S rRNA genes were detected in the absence of identifiable cells or characteristic pigments in waters near the estuary bottom, suggesting that biomass generated by the blooms remains within the estuary, thereby contributing to the organic carbon pool and fueling heterotrophic activity after bloom decay. This karyokleptic interaction with a cryptophyte enables M. rubra to thrive in the estuary in summer and therefore to exert a disproportionate influence over carbon production and cycling in the system.

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