Toxic Alexandrium blooms in the western Gulf of Maine: The plume advection hypothesis revisited

Anderson, D. M., B. A. Keafer, W. R. Geyer, R. P. Signell, T. C. Loder

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ABSTRACT: The plume advection hypothesis links blooms of the toxic dinoflagellate *Alexandrium fundyense* in the western Gulf of Maine (GOM) to a buoyant plume derived from river outflows. This hypothesis was examined with cruise and moored-instrument observations in 1993 when levels of paralytic shellfish poisoning (PSP) toxins were high, and in 1994 when toxicity was low. A coupled physical-biological model simulated hydrography and *A. fundyense* distributions. Initial *A. fundyense* populations were restricted to low-salinity nearshore waters near Casco Bay, but also occurred in higher salinity waters along the plume boundary. This suggests two sources of cells—those from shallow-water cyst populations and those transported to shore from offshore blooms in the eastern segment of the Maine coastal current (EMCC). Observations confirm the role of the plume in *A. fundyense* transport and growth. Downwelling-favorable winds in 1993 transported the plume and its cells rapidly alongshore, enhancing toxicity and propagating PSP to the south. In 1994, sustained upwelling moved the plume offshore, resulting in low toxicity in intertidal shellfish. *A. fundyense* blooms were likely nutrient limited, leading to low growth rates and moderate cell abundances. These observations and mechanisms were reproduced by coupled physical-biological model simulations. The plume advection hypothesis provides a viable explanation for outbreaks of PSP in the western GOM, but should be refined to include two sources for cells that populate the plume and two major pathways for transport: one within the low-salinity plume and another where *A. fundyense* cells originating in the EMCC are transported along the outer boundary of the plume front with the western segment of the Maine coastal current.