Cladophora Confounds Coastal Communities – Public Perceptions and Management Dilemmas

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INTRODUCTION

For the past five years, large accumulations of algae, predominantly *Cladophora sp.,* have been fouling the shores of Lakes Michigan, Huron, Erie and Ontario. Unpleasant conditions associated with algae decay have lead to mounting public complaints and demands for resolution.

The purpose of this paper is to provide background on the nature and extent of *Cladophora* problems along Wisconsin's Lake Michigan shoreline, to address the human dimensions of public perception and to identify possible management actions. The information reported comes from the literature, a November 2004 WDNR survey of beach managers and health officials, communications with resource managers and personal observations.

NATURE OF THE PROBLEM

Cladophora is a filamentous green alga that grows attached to hard substrates within the littoral zone. A common component of freshwater ecosystems, *Cladophora sp.* provide food and shelter for invertebrates and small fish. Problems arise when the conditions of light, nutrients, temperature and substrate are favorable for luxuriant growths over extensive areas.

During midsummer and fall, *Cladophora sp*. senesce, slough off their substrate and drift with waves and currents for some distance before a portion washes ashore and decays. The beached algae may accumulate in mats mixed with decaying zebra mussels, other invertebrates and fish. The combination results in unsightly, malodorous conditions that drive visitors away from popular beaches and force homeowners to keep their windows shut.

Piles of decaying *Cladophora* are more than an annoyance to people strolling on the beach. They may lower property values. *Cladophora sp.* have been linked to taste and odor problems in drinking water and may exacerbate levels of *E. coli* and enterococci bacteria in beach sand and swimming waters, raising questions about beach safety. *E. coli* bacteria are an indicator of fecal contamination, and high numbers prompt managers to close beaches. Recent research shows the stranded *Cladophora* mats may sustain or even nourish the growth of bacteria that come from gull droppings, sewage overflows, or runoff from urban and agricultural areas (Whitman *et al*. 2003; Paul *et al.* 2004).

EXTENT OF THE PROBLEM

In Wisconsin, nuisance conditions have been reported at many sites ranging from northeastern Green Bay and the tip of Door County to Kenosha. *Cladophora* has been observed growing on hard substrates all along the lakeshore, even on Rock Island, a wilderness state park far removed from anthropogenic sources of nutrients. Assessment of the spatial distribution of *Cladophora* beds along Wisconsin's Lake Michigan coast is underway, but more work is needed to understand the factors controlling distribution and abundance of *Cladophora sp.* and to identify areas at risk for nuisance accumulations.

Cladophora strandings extend to Lake Michigan shores in Illinois, Indiana and Michigan and also to portions of Lakes Huron, Erie and Ontario. Only Lake Superior appears to be spared. Clearly, nuisance growths of *Cladophora sp.* in the Great Lakes are not an isolated problem due merely to localized conditions.

The biomass of *Cladophora* that washes ashore varies between years and locations. Mats of stranded algae may be feet thick in some areas – often embayments where waters are calmer and materials tend to collect (e.g. Hika Bay, Cleveland, WI). In other areas, accumulations are minor or non-existent, or the decaying algae may remain submerged offshore or confined to the swash zone. The location, frequency and severity of algae accumulations are likely dictated by a combination of factors including offshore production, prevailing winds, water currents, storms, and nearshore morphology.

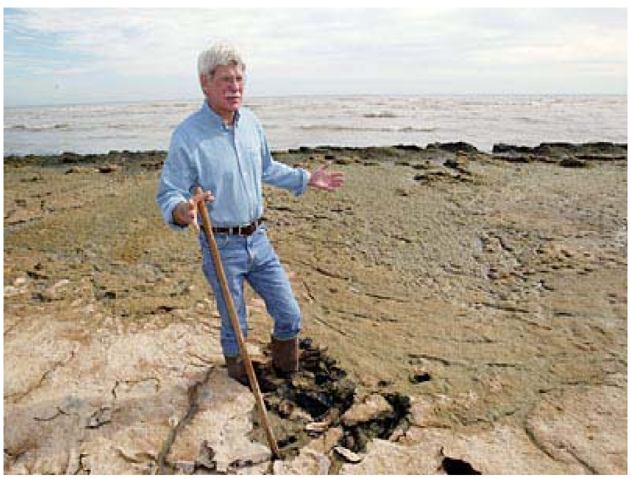

Figure 1. Ron Schaper of rural Cleveland, WI stands shin-deep in decaying algae stranded on the shore near his home, October 20, 2003. Photo by Gary C. Klein, Courtesy of the Sheboygan Press

Figure 2. *Cladophora* coats the rocks and beach at Newport State Park, August 26, 2004. Photo by Victoria A. Harris, UW Sea Grant Institute

PUBLIC PERCEPTIONS

Up and down the Wisconsin coast of Lake Michigan, people are upset, bewildered and frustrated by the noxious accumulations of *Cladophora* on the shoreline. In advanced stages of decomposition, it may be difficult to recognize the decaying algae as plant material. Because of its septic odor, the organic mess has been mistaken for manure or sewage from failing septic systems or municipal sewer overflows. In the swash zone, the algae may turn into a brown-black organic soup with an oily sheen, prompting some people to suspect an industrial waste or oil spill.

Worsening conditions in 2003 led to numerous complaints to public officials, state legislators and the WDNR and to growing demands for action. Fingers were pointed at a few notable point sources of phosphorus, such as Milwaukee MSD and large feedlot operations. This is understandable because of frequent media coverage of Milwaukee's combined sewer overflows and concern over pending permits for feedlot expansions. It is prudent to control individual sources of pollution to the lakes. However, excessive *Cladophora sp.* production has become a system-wide problem, requiring a better understanding of its causes and a system-wide approach to management.

FACTORS CONTROLLING *CLADOPHORA* ABUNDANCE AND THEIR MANAGEABILITY

Four essential environmental conditions are needed for *Cladophora sp.* to flourish (Hiriart-Baer *et al.*): hard substrate; water temperatures in the range of 10-25^{o}C; adequate light; and nutrients, particularly phosphorus. Determining which of these conditions have changed to promote *Cladophora* production in the lake(s) is essential for limiting nuisance algae accumulations along shorelines.

The dolomite bedrock and boulders of western Lake Michigan have historically provided ample substrate for *Cladophora sp.* and the expansion of zebra and quagga (*Dreissena polymorpha* and *Dreissena bugensis*) mussel beds may provide some additional substrate for algae attachment. The potential influence of lower lake levels on the amount of hard substrate within the littoral zone or on nearshore nutrient fluxes is not clear. Excessive *Cladophora* production has coincided with periods of low lake levels, both now and in the 1960s, leading to speculation about lake level influence on controlling factors. However, lake levels will continue to fluctuate and are not feasibly managed. Summer water temperatures of the lake are not known to have changed appreciably, nor are they logistically manageable.

Dreissenid mussels are generally believed to have increased water clarity in parts of the Great Lakes, including Lake Michigan, allowing light to penetrate to greater depths and expanding the area habitable by *Cladophora sp.* However, long term data sets of secchi depths from the western and central basins of Lake Erie (Barbiero and Tuchman 2004) and from lower (southern) Green Bay (Qualls 2003, Harris *et al.* 2005) show no persistent increases in transparency, likely due to weak stratification in these shallower basins and substantial loading and resuspension of suspended solids. Initially, water clarity increased in Lake Erie and Green Bay immediately following zebra mussel invasion, but increased secchi depths have persisted only in the deeper eastern basin of Lake Erie and northern regions of Green Bay.

Regardless of their impacts on water transparency and expansion of littoral zones, zebra and quagga mussels are now permanent inhabitants of the Great Lakes with no known means of control. Therefore, efforts to reduce *Cladophora* are focused on phosphorus levels in the lakes and the potential for limiting inputs.

PHOSPHORUS IN LAKE MICHIGAN

Problems with *Cladophora* in the Great Lakes date back to the mid-1950s and 60s, when nutrient levels, particularly phosphorus, were considerably higher. Both localized and wide-spread eutrophic conditions were evidenced by abundant benthic and planktonic algae. Following the 1972 Amendments to the Clean Water Act, municipal wastewater discharges of phosphorus were limited to 1 mg/l and the allowable phosphate content of household detergents was reduced. Phosphorus levels in the lakes declined and nuisance algae blooms largely subsided by the early 1980s (Hiriart-Baer *et al*.).

Since 1983, levels of total phosphorus in offshore waters of the Great Lakes have been relatively stable, except for Lake Ontario where levels are declining (Fig. 3) (D. Rockwell, GLNPO, U.S. EPA, pers. comm.). With the exception of some exceedances in Lake Erie, all the lakes are attaining their respective target concentrations established by the International Joint Commission's Water Quality Board in 1987, under the Great Lakes Water Quality Agreement. In particular, total phosphorus in Lake Michigan is consistently below its target of 7 ug/l.

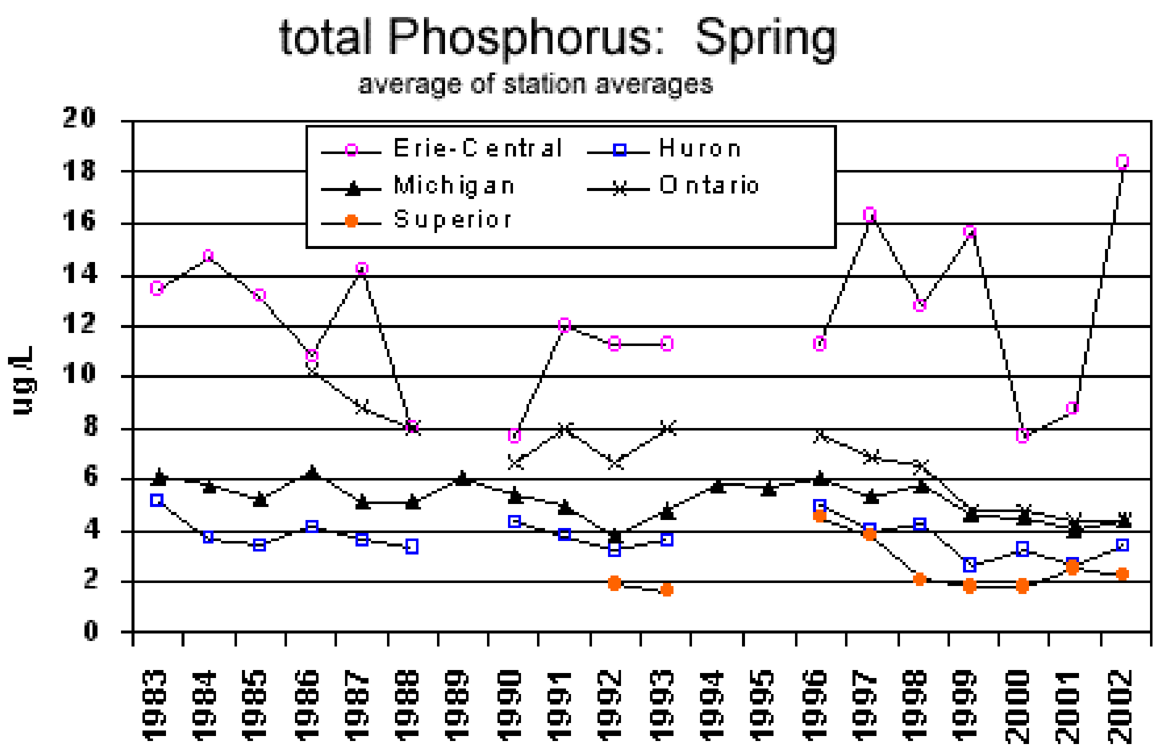

Figure 3. Average spring concentration of total phosphorus in offshore waters of the Great Lakes. From David Rockwell, GLNPO, U.S. EPA.

Hecky et al. (2004) propose a conceptual model, the nearshore shunt, to explain the apparent contradiction between high benthic productivity in the nearshore and low phosphorus concentrations in the offshore waters. They suggest that dreissenid mussels have re-engineered the bio-physical environment of the littoral zone and altered nutrient recycling, packaging and transport. Through their extraordinary filtering capacity, the mussels capture and retain nearshore inputs of phosphorus, redirecting nutrient and energy flow to the nearshore benthic community and away from the offshore pelagic zone. Before the invasion of dreissenid mussels, they suggest offshore concentrations of phosphorus more closely reflected nearshore inputs.

In contrast to the open lake, high concentrations of total phosphorus have persisted in the waters of Green Bay of Lake Michigan (Fig. 4), causing hypereutrophic conditions in the southern bay, grading toward oligotrophic conditions in the northern bay (Richman *et al*. 1984, Harris *et al.* 2005). Levels remain well above the target recommended by the Science and Technical Advisory Committee (STAC) for the Lower Green Bay Remedial Action Plan. In fact, summer average total phosphorus concentrations increased by 22.5% in lower Green Bay following the invasion of zebra mussels ($p<0.0001$), due mainly to increases since 1999 (Qualls 2003, Harris *et al.* 2005). Estimates of annual Fox River phosphorus loads since 1999 do not indicate significant change (D. Robertson, USGS, pers. comm.). Only a portion (34 - 49%) of the increased total phosphorus concentration may be explained by reduced water volume in the lower bay due to lower lake levels (Harris *et al.* 2005). We attribute the remaining increase to other influences on internal nutrient fluxes, possibly zebra mussels.

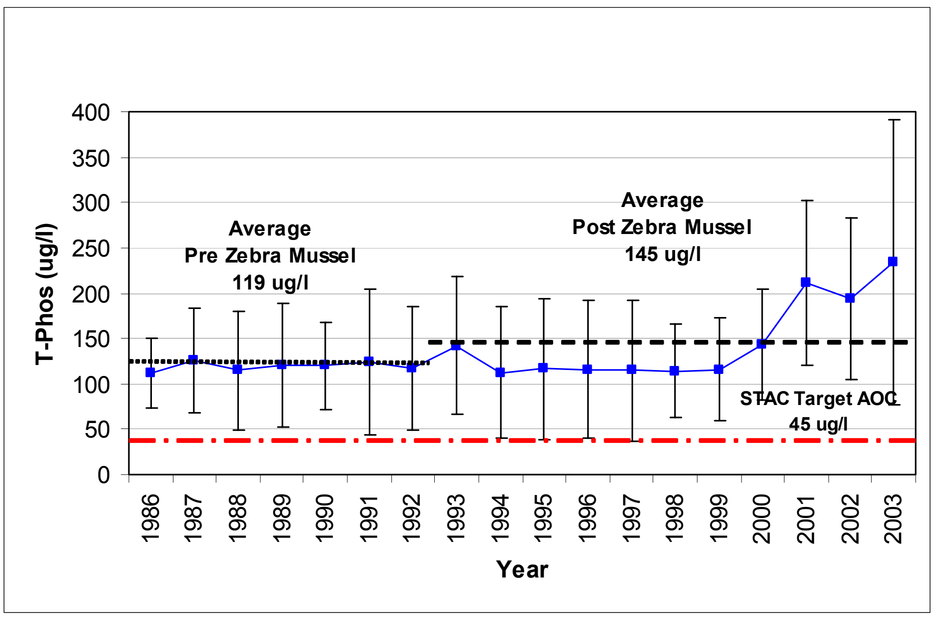

Fig. 4. Average summer total phosphorus for lower Green Bay (zones 1-3) before and after zebra mussel invasion (Qualls 2003, Harris *et al.* 2005).

Phosphorus levels in Green Bay are important to Lake Michigan. A phosphorus budget for the lake was developed as part of the Lake Michigan Mass Balance Study (Fig. 5). While the largest source of phosphorus to Lake Michigan waters is internal recycling from sediments, Green Bay contributes a substantial portion of the external loading to the lake (Kreis *et al*. 2004). The rest comes from direct tributary loading to the lake and atmospheric deposition. Of all the major tributaries monitored in 1994-95, the Fox River discharged the largest phosphorus load (Fig. 6). Therefore, any strategy to reduce phosphorus inputs to Lake Michigan must address Green Bay and the Fox River, as well as other tributaries.