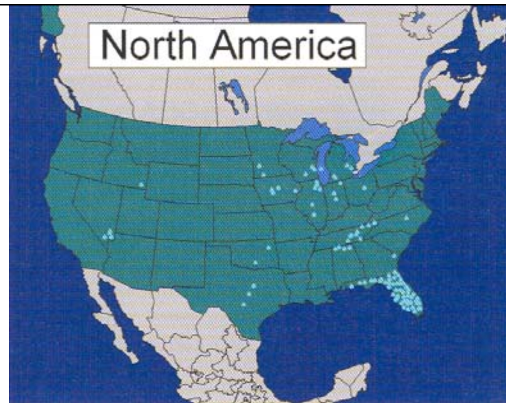
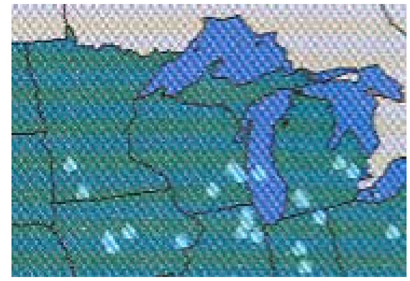
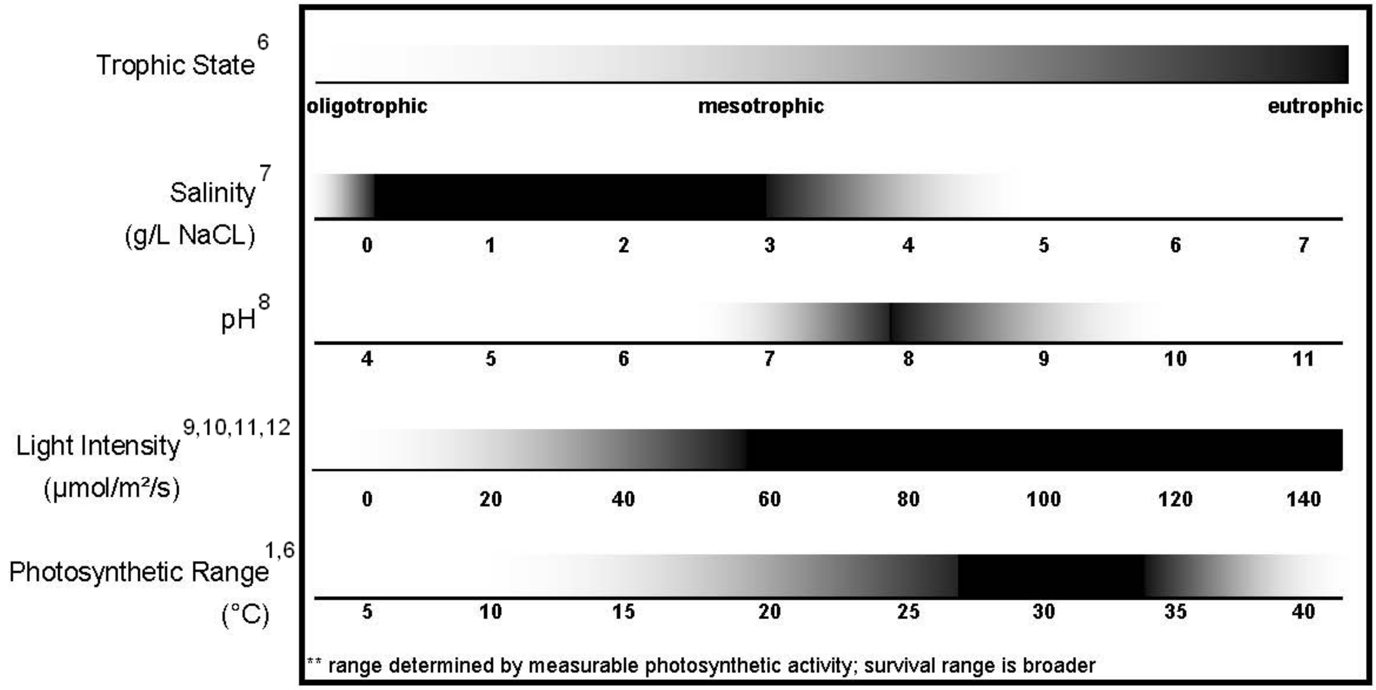
## I. Current Status and Distribution

***Cylindrospermopsis raciborskii***
***(previously Anabaenopsis raciborskii)***

| **a. Range** | **Global/Continental** | **Wisconsin** |
|---|---|---|
| **Native Range**<br>Great Lakes strain may have originated in South America[1] | <br><br>*Figure 1: U.S. Distribution Map[2]* | <br>*Figure 2: Midwest Distribution Map[2]* |
| **Abundance/Range** | | |
| Widespread: | Tropical and subtropical regions[1] | Not applicable |
| Locally Abundant: | Some temperate areas of northern hemisphere[1]; low levels of toxins reported in Indiana[3] | Lake Michigan basin[6], Lake Erie[1], and a few southern Wisconsin lakes; however there are no detectable toxins[4] |
| Sparse: | Undocumented | Undocumented |
| **Range Expansion** | | |
| Date Introduced: | First described in Indonesian island of Java, 1912[5] | 1980's or earlier[4] |
| Rate of Spread: | Rapid under optimal conditions; 357,592 cells/mL in Lake Lemon, Indiana[3] | Rapid in temperate regions; U.S. strain may have originated in South America[1] |
| **Density** | | |
| Risk of Monoculture: | High | High |
| Facilitated By: | Warm temperature, eutrophic conditions | Warm temperature, eutrophic conditions |
| **b. Habitat** | Lakes, reservoirs, streams, rivers, ponds, shallow systems | |
| **Tolerance** | Chart of tolerances: Increasingly dark color indicates increasingly optimal range | |




| | |
|---|---|
| **Preferences** | Low flow; low water level; low nitrogen to phosphorous ratio; high water temperature; stable thermal stratification; increased retention time; high pH; high sulfate concentration; anoxia in at least some strata; high turbidity; high incident irradiation; low macrophyte biomass[1;] high total phosphorus and chl-a[3]; requires high levels of reactive phosphorous[13,14] |
| **c. Regulation** | |
| Noxious/Regulated: | *Not regulated* |
| Minnesota Regulations: | *Not regulated* |
| Michigan Regulations: | *Not regulated* |
| Washington Regulations: | *Secondary Species of Concern* |
| **II. Establishment Potential and Life History Traits** | |
| **a. Life History** | Filamentous cyanobacteria; two distinct morphotypes: straight and curly[15,16] |
| **Fecundity** | High |
| **Reproduction**<br>Importance of Spores:<br>Vegetative: | Asexual (binary fission, budding, or fragmentation)<br>Not applicable<br>Akinetes may persist as spores in sediments for long periods of time[13,14]; akinete formation may be triggered by cold temperatures or large temperature fluctuations[13,14]; akinetes rarely develop in native range[17] |
| **Hybridization** | Undocumented; distinct morphologies are thought to be the same genetically |
| **Overwintering**<br>Winter Tolerance:<br>Phenology: | <br>High; akinetes can survive cold winters and germinate when water temperature reaches 22-23°C[3,12]<br>*Cylindrospermopsis* spp. typically not detected until August or September in Wisconsin[4] |

| **b. Establishment** | |
|---|---|
| **Climate** | |
| Weather: | In Ontario, blooms appear to be controlled by water temperature rather than nutrients[18] |
| Wisconsin-Adapted: | Yes |
| Climate Change: | May contribute to the expansion of this species in temperate latitudes[12,18] |
| **Taxonomic Similarity** | |
| Wisconsin Natives: | Medium; other native cyanobacteria |
| Other US Exotics: | High; *Cylindrospermopsis* spp., but *C. raciborskii* is of greatest concern due to ability to produce toxins |
| **Competition** | |
| Natural Predators: | Some rotifers can graze on straight, but not coiled trichomes of cyanobacteria[19]; some rotifers and copepods may cut filaments to a size that is edible by other zooplankton[20] |
| Natural Pathogens: | Undocumented |
| Competitive Strategy: | Capable of fixing atmospheric nitrogen[9,21]; high phosphorus uptake affinity, storage capacity[22]; may compete well for light in destratified and artificially mixed reservoirs[23,24]; gas vesicles help *C. raciborskii* regulate buoyancy and facilitate movement through the water column[3] |
| Known Interactions: | Undocumented |
| **Reproduction** | |
| Rate of Spread: | High; bloom densities reach $10^8$-$10^9$ filaments/L[(8)] |
| Adaptive Strategies: | Morphological variation in trichomes and heterocysts occurs depending on abiotic conditions[16,25,26] |
| **Timeframe** | Can reproduce very rapidly under optimal conditions |
| **c. Dispersal** | |
| Intentional: | Unlikely |
| Unintentional: | Shipping, recreational boating, waterfowl, wind[6]; import of tropical fish[8]; live bait waters[27] |
| Propagule Pressure: | High; fragments easily accidentally introduced |

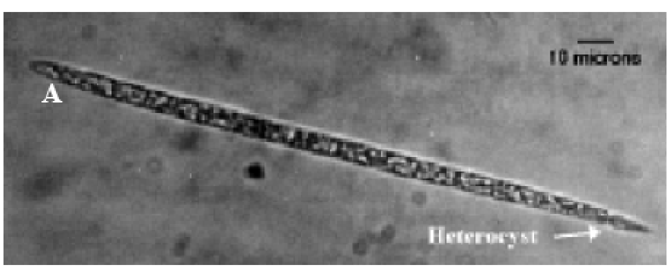


*Figure 3: Straight morph; Courtesy Ann St. Amand*[2]
*Figure 4: Curly morph; Courtesy Ann St. Amand*[2]

| **III. Damage Potential** | |
|---|---|
| **a. Ecosystem Impacts** | |
| **Composition** | Potential to cause algal blooms in and below the euphotic zone (not at the surface)[28]; some rotifers and caldocerans exhibit reduced feeding rates, growth rates, or growth potential[29]; may be responsible for fish kills in Brazil[30]; assumed responsible for cattle deaths in Australia[31] |
| **Structure** | Undocumented |

| | |
|---|---|
| **Function** | Undocumented |
| **Allelopathic Effects** | Cylindrospermopsis known to bioaccumulate in mollusks and crayfish and is toxic to some[32]; some strains found to affect snails[33] |
| **Keystone Species** | Undocumented |
| **Ecosystem Engineer** | Undocumented |
| **Sustainability** | Undocumented |
| **Biodiversity** | Appears to reduce the size and diversity of zooplankton[34] and phytoplankton[35,36] |
| **Biotic Effects** | Impacts native species at multiple trophic levels |
| **Abiotic Effects** | Reduced light penetration[4]; not prone to self-shading[37] |
| **Benefits** | Undocumented |
| **b. Socio-Economic Effects** | |
| **Benefits**<br>Caveats | Undocumented<br>Not applicable |
| **Impacts of Restriction** | Increase in monitoring, education, and research costs |
| **Negatives** | Some strains capable of producing cylindrospermopsin, a toxin affecting human liver and kidneys[38]; some strains capable of producing anatoxin-a, saxitoxins, and paralytic shellfish poisons (PSPs)[3,38]; has the potential to be genotoxic or carcinogenic in humans[39,40]; can cause acute skin reactions[1]; decreases aesthetic appeal; beach closures[4] |
| **Expectations** | More negative impacts can be expected in warm, shallow, turbid systems |
| **Cost of Impacts** | Decreased recreational and aesthetic value; decline in ecological integrity; increased monitoring expenses |
| **"Eradication" Cost** | Quite expensive |
| **IV. Control and Prevention** | |
| **a. Detection** | |
| Crypsis: | High; microscopic algal expertise needed; only a few labs are able to measure toxins, and the cost per sample is high[27] |
| Benefits of Early Response: | Allows time for rapid response action plans to be implemented |
| **b. Control** | |
| **Management Goal** | Nuisance relief |
| Tool: | Copper sulfate (and other chemical algaecides)[41] |
| Caveat: | Destroys algal cells, but can cause an immediate increase in free toxins[41] |
| Cost: | Expensive |
| Efficacy, Time Frame: | Temporary control; repeated treatments increase probability of chemical resistance[41] |
| Tool: | Chlorination, ozonation, or UV photocatalysis[42] |
| Caveat: | Formation of byproducts and their respective toxicity is still unknown[42] |
| Cost: | Expensive |
| Efficacy, Time Frame: | Only feasible for drinking water facilities |
| Tool: | Derivatives of 9,10-anthraquinone (natural compound)[43] |
| Caveat: | Studies still in progress on long-term effects |
| Cost: | Expensive |
| Efficacy, Time Frame: | Selective control potential still uncertain |

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