ELECTRIC POWER RESEARCH INSTITUTE

Cooling Water Intake Debris Management: *Hydrilla*

Technical Update — *Debris Management Interest Group*

Issue

Hydrilla (*Hydrilla verticillata*) is a submersed, freshwater aquatic plant that can become dislodged from its roots and impinge on cooling water intake structure (CWIS) screens. Large quantities of impinged *Hydrilla* can cause cooling water blockages at power plants. Cooling water blockages can negatively impact facility reliability and result in a loss of revenue.


Left image courtesy of Michael J. Grodowitz, U.S. Army Engineer Research and Development Center http://www.niipp.net/hydrilla/hydrilla-photos/; right image courtesy of Mirant Potomac River Power Station, Alexandria, VA

> Aquatic plants can pose a significant threat to power plant cooling water intake structures (CWIS). In sufficient quantities, hydrilla can block intake screening equipment (for example, bar racks and traveling water screens), leading to reduced cooling water flow or, in extreme cases, structural failure of the screening equipment. Furthermore, the passage of aquatic plants into the circulating water system can result in condenser tube plugging. Cooling water blockage is a concern as it negatively affects facility reliability and results in a loss of revenue. This technical brief provides background on hydrilla as a debris agent at power plant CWIS. It includes information on the plant's biology, spread mechanisms, control strategies, as well as lists of external resources such as key literature, websites, and contact information for technical experts on hydrilla.

Biology

Hydrilla verticillata is also commonly known as water thyme, Florida elodea, and waterweed. It is native to Asia, Australia, Europe, and Africa (Zhang et al. 2010), but is a non-native, invasive species in the U.S. and is considered a Federal Noxious Weed by the U.S. Department of Agriculture. It is a popular aquarium plant and was likely introduced to U.S. waters through the release of an unwanted aquarium specimen.

Hydrilla is adapted to a wide range of environmental conditions (temperature, water chemistry, light levels, carbon dioxide concentrations), and typically outcompetes other native aquatic plants. It is most often found in shallow freshwater habitats, though it is also capable of growth in salinities of up to 7 ppt (Haller 1974).

Hydrilla grows quickly (up to one inch per day) and can reach lengths of up to 30 feet (IDNR 2009). Stands of individual plants form dense vegetative mats near the water surface. These dense floating mats intercept most of the available sunlight, precluding the growth of other aquatic plants. In addition, since Hydrilla can make use of very low light levels (1% of full sunlight), it is able to colonize deeper water than many other aquatic plants.

Hydrilla exists in two forms: monoecious (male and female reproductive parts in one plant) and dioecious (male and female reproductive parts in two separate plants), though the dioecious type dominates in the U.S. The presence of two forms indicates that there were likely two separate introductions to the U.S.

Hydrilla is propagated via four mechanisms: 1) fragmentation, 2) tubers, 3) turions, and 4) seeds (Ruch et al. 2010). Of these four, fragmentation is the dominant means of propagation, as vegetative pieces with as few as one node are capable of regenerating a new plant (NCCES 1992). Tubers are produced at the root end (rhizomes and stolons) of plants and can remain dormant for many years in the sediment before sprouting new plants (Figure 1). Tubers are resistant to most eradication methods because they remain buried in the sediment. Turions are small dormant buds produced among the leaves of the plant (Figure 1). Once freed from the plant, turions root in the sediment and develop into new plants. *Hydrilla* is also capable of producing traditional seeds; however, seeds seem to be of minimal importance in its reproductive strategy (Langeland 1996).

Figure 1. Hydrilla *tubers (top) and turions (bottom).*

Extent and Spread

Hydrilla is a widespread aquatic weed throughout the southeast U.S. and has been documented in other states as well including Texas, Arizona, California, Washington, and some northeast states (New York, Connecticut and Maine). In recent years it has been spreading in the upper Ohio River basin (Evans 2011).

Hydrilla is spread between water bodies primarily by plant fragmentation. Fragments attached to boats, trailers, and fishing equipment are often transported between water bodies (Figure 2). Detached fragments can regenerate new plants within days. Once established within a waterbody, tubers and turions, in addition to fragments, facilitate its rapid spread. Evidence also indicates that waterfowl and other birds can act as vectors after ingesting and regurgitating *Hydrilla* tubers and turions (IDNR 2006, NCCES 1992).

Once established, *Hydrilla* is very efficient at quickly dominating the native aquatic flora. In addition, its life history includes a dormant tuber stage that is particularly resistant to standard control approaches.

Figure 2. Hydrilla *wrapped around boat propeller and sign warning against inadvertent transfer of* Hydrilla *(inset).*

Control

Hydrilla can be controlled through mechanical, physical, chemical, biological, and cultural means (Figure 3). Often, more than one approach is necessary for effective control.

Figure 3. Hydrilla *control methods. From top left: mechanical control with a weed harvester (image from Aquarius Systems), physical control by dredging (image from U. of FL - http://plants.ifas.ufl.edu/manage/control-methods/physical-control, biological control with grass carp (image from Sutton et al. 2006), and chemical control by helicopter application of herbicide (image from U of Fl website (http://plants.ifas.ufl.edu/manage/control-methods/chemical-control/adjuvants).*

Mechanical control refers to the removal of the vegetative portions of the plant either by hand or with a machine. Weed harvesters are floating vessels designed to cut and collect the top few feet of the plant (Figure 3). Harvested material is disposed of onshore. Mechanical control is a viable means for quickly addressing severe *Hydrilla* infestations; however, it is not a permanent solution as the cut stem will quickly regrow. In addition, fragments released during harvesting can contribute to the re-growth of new plants. Weed harvesters are also specialized, custom-built equipment and can be expensive (Gettys et al. 2005).

Physical control includes techniques aimed at disturbing the physical habitat in order to discourage *Hydrilla* growth. Physical control methods include dredging (Figure 3, top right) dewatering of affected areas (with excavation or dredging of affected areas), application of dyes to limit available light for photosynthesis, and installation of pond liners/barriers to prevent settlement of new plants. Although physical control methods typically result in fast results, they can be expensive and disruptive to the ecological balance of the infested water body.

Chemical control is accomplished through the application of Environmental Protection Agency (EPA)-approved aquatic herbicides (Figure 3, bottom left). Herbicides generally fall into two categories: contact herbicides and systemic herbicides. As their name suggests, contact herbicides kill on contact and are therefore fast-acting and lend themselves well to spot treatments of problem areas. Systemic herbicides are typically enzyme inhibitors and are, by design, slow-acting. Systemic herbicides are applied repeatedly at relatively low doses over the course of a comprehensive treatment schedule. Factors affecting the effectiveness of both types of herbicides include the volume of the waterbody to be treated and the rate/velocity of water exchange.

Of the commercially available products, flouridone is the most popular for large-scale infestations and when the goal is long-term management. Flouridone is a slow-acting systemic herbicide and requires at least 60 days exposure (Hetrick and Langeland 2012). Endothall, a contact herbicide, has also recently become popular in Florida for control of large-scale infestations and the required exposure time is much less (between 12 and 72 hours).

Biological control includes efforts to introduce natural enemies of *Hydrilla*. Every effort is made to select target-specific agents to minimize impacts to non-target plants. Introduction of biological agents is strictly controlled by the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS). Currently, the most effective and widely used biological control agent for *Hydrilla* is the triploid (sterile) grass carp (*Ctenopharyngodon idella*) (Sutton et al. 2012) (Figure 3, bottom right), though past research has also evaluated the potential of insects for controlling *Hydrilla* though with little success (Gettys et al. 2005; Hetrick and Langeland 2012). Grass carp are used when infestations are in closed systems such as ponds or lakes and are unlikely to be approved for use in open systems for ecological reasons. An integrated approach is also promoted in which a biocide application is administered to initially remove the bulk of the *Hydrilla* followed by a stocking of grass carp to control the new growth that later arises (Sutton et al. 2012).

As with any biological control, introduction of non-native species must be carefully weighed against its potential ecological risk.

Cultural control is accomplished by educating the public and stakeholders on how to take preventive measures to preclude the spread of *Hydrilla*. Given that inadvertent introduction of plant fragments is a major problem, educating recreational boaters and fisherman has long been a goal of cultural control efforts.

Case Study

Hydrilla Management in Piedmont Reservoirs Using Herbicides and Triploid Grass Carp: A Case Study (Manuel et al. 2013)

A group of five reservoirs operated by Duke Energy Corporation (Duke) were selected for evaluation of a three-step *Hydrilla* management program. Four of the reservoirs were on the Catawba River (North and South Carolina) and one on Belews Creek (North Carolina). The three-step management program was comprised of early detection, herbicide application and grass carp stocking, and maintenance grass carp stocking over time.

The sites selected were sparsely populated (1-3%) with *Hydrilla*, though its distribution was wide within the reservoirs. Early detection of *Hydrilla* was accomplished through visual surveys conducted by Duke Energy mosquito control crews that were already conducting field efforts related to mosquito control. Once visually identified, field crews determined the extent (and GPS coordinates) of the *Hydrilla* infestation by sampling with a rake attached to a retrieval rope. Next, Komeen, a contact herbicide, was applied to the *Hydrilla*. In most cases, repeated herbicide treatments continued until stakeholders had approved the use of grass carp as the next management step. After approval, triploid grass carp were stocked at a density of 20 fish per surface acre of *Hydrilla*-infested water. After *Hydrilla* has been sufficiently controlled, maintenance stocking was done at a density of one fish per eight surface acres of the entire reservoir.

In all but one reservoir, control of *Hydrilla* growing in the water column was achieved within one year of stocking grass carp. Only one reservoir experienced a small and brief *Hydrilla* resurgence; however, the floating mat of *Hydrilla* was quickly eliminated with a contact herbicide treatment.

The management approach taken by Duke Energy at these reservoirs emphasizes the importance of early detection and frequent monitoring in concert with herbicide treatment and grass carp introduction for effectively controlling invasive *Hydrilla* infestation before they have spread too widely. While other management approaches have experienced multi-year lag periods when using only grass carp stocking as a control method, Duke Energy's approach demonstrated that an integrated approach using herbicides and grass carp can provide much faster control.

Key Resources

Literature

Balciunas, J.K., M.J. Grodowitz, A.F. Confrancesco, and J.F. Shearer. 2002. Hydrilla. pp. 91-114 In Van Driesche, R., B. Blossey, M. Hoddle, S. Lyon, and R. Reardon (Eds.), *Biological Control of Invasive Plants in the Eastern United States*, USDA Forest Service Publication FHTET-2002-04, 413 p. Available at: http://www.invasiveplants.net/monitor/7Hydrilla.aspx

Gettys, L.A., W.T. Haller, and M. Bellaud, eds. 2005. Biology and Control of Aquatic Plants: A Best Management Practices Handbook. Aquatic Restoration Foundation, Marietta, GA. Available here: http://www.aquatics.org/aerf_handbook.pdf

Websites

California Invasive Plant Council:
http://www.cal-ipc.org/ip/management/ipcw/pages/detailreport.cfm@usernumber=57&surveynumber=182.php

Cornell University Cooperative Extension, Tompkins County:
http://ccetompkins.org/environment/invasive-species/hydrilla

Friends of Claytor Lake:
http://www.focl.org/programs/hydrilla-management-plan/

Northeast Aquatic Nuisance Species Panel (includes links to 4 case studies):
http://www.northeastans.org/hydrilla/hydrillaprofile.htm

Texas A&M AgriLife Extension:
http://aquaplant.tamu.edu/management-options/hydrilla/

University of Florida Center for Aquatic and Invasive Plants:
http://plants.ifas.ufl.edu/

USACE Aquatic Plant Information System (APIS):
http://el.erdc.usace.army.mil/apis/PlantInfo/plantinfo.aspx?plantid=15

USDA Agricultural Research Service (technical publications of the Agricultural Research Service):
http://www.ars.usda.gov/services/TekTran.htm?criteria=hydrilla&field=all&search.x=20&search.y=2

USDA National Invasive Species Information Center:
http://www.invasivespeciesinfo.gov/aquatics/hydrilla.shtml

Washington State Department of Ecology:
http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua001.html

Experts

Below is a list of experts in various areas of invasive aquatic weed research and/or management.

James Balyszak
Cornell Cooperative Extension
Area of Expertise: Integrated weed management strategies
E-mail: stophydrilla@gmail.com
Phone: 607.257.2340

Greg Cope
North Carolina State University
Area of Expertise: Toxicity of hydrilla herbicides on other aquatic organisms
E-mail: greg_cope@ncsu.edu
Phone: 919.515.5296

Kurt Getsinger
U.S. Army Corps of Engineer Research and Development Center
Area of Expertise: Chemical and physiological control of aquatic plants
E-mail: Kurt.D.Getsinger@usace.army.mil
Phone: 601.634.2498

Lyn Gettys
University of Florida
Area of Expertise: Biology, physiology, ecology and integrated control methods for aquatic and wetlands weeds
E-mail: lgettys@ufl.edu
Phone: 954.577.6331

Mike Grodowitz
U.S. Army Corps of Engineer Research and Development Center
Area of Expertise: Invasive species biology and management and use of insect biological control agents for the management of noxious vegetation
E-mail: Michael.J.Grodowitz@usace.army.mil
Phone: 601.634.2972

Bill Haller
University of Florida
Area of Expertise: Biology and management of invasive aquatic weeds, aquatic herbicide screening
E-mail: whaller@ufl.edu
Phone: 352.392.9615

Linda Nelson
U.S. Army Corps of Engineer Research and Development Center
Area of Expertise: Chemical management of invasive aquatic and wetland plants, integrated weed management, restoration of aquatic and wetland habitats
E-mail: Linda.S.Nelson@usace.army.mil
Phone: 601.634.2656

Mike Netherland
U.S. Army Corps of Engineer Research and Development Center and University of Florida
Area of Expertise: Management of submersed invasive plants; efficacy of aquatic herbicides
E-mail: mdnether@ifas.ufl.edu
Phone: 352-392-0335

Jeff Schardt
Florida Fish and Wildlife Conservation Commission
Area of Expertise: Invasive plant management
E-mail: jeff.schardt@myfwc.com
Phone: 850.617.9420

Mike Smart
U.S. Army Corps of Engineer Research and Development Center
Area of Expertise: Aquatic plant ecology, management of nonindigenous aquatic plants
E-mail: Mike.Smart@usace.army.mil
Phone: 972.436.2215

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Balciunas, J.K., M.J. Grodowitz, A.F. Confrancesco, and J.F. Shearer. 2002. Hydrilla. pp. 91-114 In Van Driesche, R., B. Blossey, M. Hoddle, S. Lyon, and R. Reardon (Eds.), *Biological Control of Invasive Plants in the Eastern United States*, USDA Forest Service Publication FHTET-2002-04, 413 p. Available at: http://www.invasiveplants.net/monitor/7Hydrilla.aspx

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Sutton, D.L. V.V. Vandiver Fr., and J.E. Hill. 2012. Grass carp: A fish for Biological Management of Hydrilla and other Aquatic Weeds in Florida. University of Florida, Institute of Food and Agricultural Sciences (IFAS). Bulletin 867.

Zhang, J., G. Wheeler, M. Purcell, and J, Ding. 2010. Biology, Distribution, and Field Host Plants of *Macroplea japana* in China: An Unsuitable Candidate for Biological Control of *Hydrilla verticulata*. Florida Entomologist 93(1): 116-119.

Contact Information

For more information on EPRI's Cooling Water Intake Debris Management Interest Group activities contact Douglas Dixon at ddixon@epri.com or 804-642-1025 for genral EPRI information, contact the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com).

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Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com