WRITTEN FINDINGS OF THE
WASHINGTON STATE NOXIOUS WEED CONTROL BOARD
(July 1995; Updated May 2013)

Scientific Name: *Hydrilla verticillata* (L.f.) Royle

Common Name: Hydrilla

Family: Hydrocharitaceae

Legal Status: Class A

Additional Listing: Federally listed noxious weed, quarantine list (WAC 16-752)

Images: Left. Hydrilla growth from tubers, image credit: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org. Center. Hydrilla infestation Leslie J. Mehrhoff, University of Connecticut, Bugwood.org. Right. Hydrilla stem with whorls of leaves.

Description and Variation: *Hydrilla verticillata* is the only species in the genus *Hydrilla*, so commonly is simply called hydrilla. It is a submersed herb that closely resembles other members of the Hydrocharitaceae, such as *Elodea canadensis* (native to Washington) and *Egeria densa* (native to South America, and invasive in several Washington lakes). Hydrilla can be either monoecious (both male and female flowers on the same plant) or dioecious (male and female flowers on different plants). Each type has some unique growth characteristics, and recent research lead some to propose classifying them as separate species (Benoit 2011). It is the monoecious type that was found in Washington State.

Hydrilla grows rooted to the bottom, submersed in either still or flowing water. The depth of growth depends on the water clarity and substrate type. The dioecious plants tend to form long stems until they near the water surface at which point the stems branch and form dense mats. Stem lengths of up to 30 feet have been recorded in clear Florida water. The monoecious plants tend to be more delicate and branch at the sediment, forming new root crowns and high numbers of stems which then grow toward the surface (Van 1989).

In both types, the leaves are 1 to 4 mm wide and 2 to 25 mm long, with an ovate to linear shape (Cook and Lüönd 1982). They occur in whorls of 3 to 10 leaves along the stem. Leaves generally have spines along the margins and a single spine at the tip, which give the leaves a toothed appearance, visible without magnification. They also often have spines along the lower midrib of the leaf, which will cause the plant to feel rough (more common in the dioecious form). The leaves sometimes have red-brown spots or stripes. There are small (0.5 mm), axillary leaf scales (called squamula intravaginalis) with a fringe of reddish-brown hairs found next to the stem and inserted at the base of the leaf; a character that distinguishes hydrilla from other family members (Cook and Lüönd 1982).

The roots of both types consist of fibrous rhizomes that grow in the sediment to 20 cm deep. Adventitious roots also form at nodes on stem fragments (Cook and Lüönd 1982). Vegetative reproductive structures called turions are produced on both rhizomes and leaf axils or branches (Netherland 1997). Presence of these turions distinguish hydrilla from similar looking plants in the Hydrocharitaceae family. The turions on rhizomes are often called tubers (and will be hereafter in this paper). Tubers are 4 to 15 mm long and often bent to a curved shape. They sometimes have leaf scales, and generally are a creamy brown color, though color can vary from near white to black, depending on substrate (Netherland 1997). The turions are dark green, 3 to 12 mm long, and covered in short stiff scales. Both turions and tubers detach from parent plants (Cook and Lüönd 1982, Netherland 1997).

Hydrilla flowers in summer through fall. Female flowers have three translucent sepals, with white or red streaks, up to 4 mm long; and three transparent petals that are shorter and narrower than the sepals (Cook and Lüönd 1982). Female flowers grow from the leaf axils and float on the water surface. Male flowers develop in a spathe in leaf axils. Spathes are about 1.5 mm across with several pointed bumps at the top. The spathe splits and releases the male flower as a round bud which floats to the surface. The 3 sepals are up to 3 mm long by 2 mm wide, whitish to brown, and petals are about 2 mm long and white to red. Both sepals and petals reflex and pollen is released explosively (Cook and Lüönd 1982). In North America, all dioecious plants are female.

Hydrilla fruits are 5 to 10 mm long and cylindric. The fruit's surface is smooth or may have spiny or linear bumps. The seeds are arranged in a row length-wise in the fruit, and are about 2.5 mm long, smooth and brown (Cook and Lüönd 1982)

Distinguishing monoecioius and dioecious hydrilla is most reliably done with genetic analysis (Madeira et al. 2004). Without genetic analysis, flowering plants are the next most reliable way. In addition, the growth form of the plants, and the number and size of tubers can help distinguish them. However, since the ranges of both varieties increasingly overlap, genetic analysis is often necessary.

Economic Importance:

Detrimental - Hydrilla adversely impacts aquatic ecosystems by forming dense growth that often shades or crowds out native vegetation. Extensive single species stands of hydrilla provides poor habitat for fish and other wildlife. While dense vegetation may contain large numbers of small fish, density levels attained by invasive plant species such as hydrilla, may support few or no harvestable-sized sport fish. Dense mats alter water quality by raising pH, decreasing oxygen under the mats, and increasing temperature. Stagnant water created by hydrilla mats provides good breeding grounds for mosquitoes.

Hydrilla interferes with recreational activities such as swimming, boating, fishing and water skiing. It creates navigation hazards by rendering rivers and the shallow areas of lakes impassible to boating traffic. Like Eurasian watermilfoil, hydrilla can form dense tangled mats of vegetation at the water's surface. In addition, hydrilla has the potential to impact power generation and irrigation by clogging dam trash racks and intake pipes (Kirk and Henderson 2006; Langland 1990).

Due to its persistent tubers, hydrilla is more costly and difficult to control than other invasive aquatic plants in Washington. In states where hydrilla has become established, millions of dollars are spent each year for management activities, and in Washington, hundreds of thousands of dollars were spent eradicating it from a small lake system (personal communication K. Hamel 2012; Kirk and Henderson 2006).

Beneficial - Hydrilla is eaten by waterfowl and is considered an important food source by some biologists. In the southeast some anglers believe it provides good fish habitat – an error for the reasons mentioned above unless the hydrilla is highly managed and only makes up a moderate portion of the submersed plant community.

<u>Geographic Distribution</u>: Hydrilla is native to southeast Asia and Australia. It is now found on every continent but Antarctica, likely due to the aquarium trade. In the US, female dioecious plants were introduced to Florida in the early 1950's by an aquarium dealer (Madeira et al. 2004). Genetic analysis has shown that these plants are a triploid hybrid originating from populations native to India and Nepal (Benoit 2011). This dioecious hydrilla has spread throughout the southeastern states as far north as Kentucky and west to Texas. Separate populations are found in California and Arizona. Disjunct populations were also located in Idaho, along the Bruneau River and in Boise, originating in thermally influenced springs, but spreading and surviving in cold water (personal communication Woolf 2013).

Monoecious hydrilla was first found in the mid-1970's in Delaware (Madiera et al. 2004). Genetic analysis has shown that the US monoecious hydrilla is likely a hybrid of the US dioecious variety and plants from Indonesia and Malaysia (Benoit 2011). Monoecious hydrilla has spread throughout the northern Atlantic states as far north as Maine and west to the Great Lakes region (Owens et al. 2012). In the west it is found in California, and was found in Washington in one lake system (Pipe and Lucerne Lakes). It is believed to be eradicated from Washington State; the result of years of focused management.

<u>Habitat</u>: Adapted to temperate and tropical climates, hydrilla grows rooted to the bottom of lakes, ponds, springs, ditches, marshes, wet ricefields, slow streams and rivers, and tidal waters, where it is submersed in either still or flowing water. The depth of growth depends on the water clarity and substrate type.

<u>History</u>: Hydrilla was first introduced into North America by the aquarium trade. California officials have also traced hydrilla infestations to shipments of mail order waterlilies with

hitchhiking hydrilla tubers. Once introduced and established, hydrilla is easily spread through boating and fishing activities.

Growth and Development: Hydrilla is a rooted, submersed plant. Its growth and development varies depending on if it is monoecious or dioecious.

Monoecious – generally is an annual plant in northern latitudes, though has been shown to survive through winters in Florida (Owens et al. 2012). The tubers require a cold period to sprout, and begin to sprout in spring when water warms to about 13 °C. Stems branch along the sediment, taking root to form new root crowns and sending up shoots. New tubers are formed through summer and production increases as day length shortens in fall. Turion production also peaks in fall, and they will sprout the following summer. Monoecious hydrilla puts more energy into tuber and turion production, resulting in greater numbers (though generally smaller in size) than dioecious hydrilla (Netherland 1997, Van 1989).

Dioecious – is a perennial plant (though it dies back when water temperature gets below 10 °C in Idaho (personal communication Woolf 2013)). Tubers sprout year round, and shoots grow to the water surface, where branching occurs. Fewer tubers and turions are produced than on monoecious plants, but production of both increases during shorter day lengths (Netherland 1997, Owens et al. 2012).

Hydrilla has several physiological and morphological adaptations that allow it to out-compete native aquatic vegetation (Anderson 1987):

- It can grow at lower light intensities than many other plants. This makes it difficult to shade out, and allows it to grow for longer periods during the day.
- It can absorb carbon from the water more efficiently than other plants, so it can continue to thrive during the summer when carbon can become limiting.
- It is tolerant of a wide range of water conditions, though water quality and sediment density can influence tuber production and growth.
- It will thrive in flowing water as well as still water. Studies have shown that it actually grows faster in flowing water.
- It will tolerate salinity of up to 13 parts per thousand, so it could encroach upon the outer limits of estuaries (Netherland 1997).

Reproduction: Hydrilla has many effective means of propagation.
Vegetative spread:
Horizontal spread by underground rhizomes and above ground stolons. It can sprout new plants from stem fragments containing as few as two nodes or whorls of leaves. Fragments from rhizomes and root crowns can also form new plants.

The most troubling traits for aquatic plant managers are tuber and turion production. Tubers may remain dormant yet viable for several years in the sediment. In one study, monoecious hydrilla tubers sprouted after 4 years of dormancy in Florida, and it is speculated tubers last longer in the cold water of temperate climates. Tubers sprout between temperatures of 13 to 35 °C (Netherland 1997). Turions, on the other hand, expire after one year (Van and Steward 1990).

Tuber densities have been found of 1,000 or more per square meter (Netherland 1997). The tubers and turions can withstand ice cover, drying, and herbicides.

Monoecious hydrilla has an ability to form tubers rapidly and although these tubers are generally smaller than those of dioecious hydrilla, they are produced in greater numbers and are capable of germinating at lower water temperatures. The high density of shoots produced by monoecious hydrilla may also increase its capacity for fragmentation.

Seeds – Seedling viability is variable and likely dependent on whether parent plants are diploid or triploid, monoecious or dioecious (Benoit 2011). In populations in the US, the monoecious variety can set viable seed. However, the presence of seedlings appears to be rare, so seed production may be a minor means of reproduction.

Control:

Response to Herbicides:
The most notable recent development is the recognition that hydrilla has developed genetic strains resistant to the herbicide fluridone in the southeast US. This resulted from over-reliance on that systemic herbicide, due to a lack of other effective choices. Genetic tests have been developed to test for resistance prior to treatment if fluridone is planned for use (Benoit 2011).

In recent years, other systemic herbicides have been developed and registered for aquatic use. In addition to fluridone, penoxsulam, imazamox and bispyribac-sodium have shown effectiveness against hydrilla (Netherland 2011) and can be used in Washington. Due to eradication of hydrilla from Washington prior to registration by EPA and permitted use by the State of these three new products, consultation with recent literature and aquatic plant managers with current hydrilla management experience would be prudent prior to use.

Endothall and diquat are contact herbicides used when immediate control of vegetation is needed. (Langland et al. 2009). Diquat is fast-acting, and has been used on dioecious hydrilla in the Bruneau River, Idaho where flow limits contact time. Other more recently registered contact herbicides allowed for use in Washington are flumioxazin and carfentrazone-ethyl. Effectiveness of these products against hydrilla should be investigated in recent literature and by consulting personnel currently involved with hydrilla management.

The monoecious hydrilla population in Washington was eradicated by using low concentrations of the granular formulation of fluridone repeatedly, along with diver hand pulling once the population was reduced. Herbicide use was continued until several years after the last hydrilla plant was seen to be sure that any remaining sprouting tubers would be affected. Divers monitored the population (and continue to do so) to ensure no additional plants have returned. Additional information is available at the King County website
http://www.kingcounty.gov/environment/waterandland/lakes/plants/weed-identification/hydrilla/eradication-project.aspx

Note: Use of pesticides in water is regulated in Washington. All applicators must have an aquatic endorsement on their pesticide applicators license, which is issued by the Washington

Department of Agriculture. In addition, coverage under a permit issued by the Department of Ecology is required. See http://www.ecy.wa.gov/programs/wq/pesticides/index.html for details.

Response to Mechanical Methods: Because this plant spreads readily through fragmentation, mechanical controls such as cutting and harvesting should be used only when the extent of the infestation is such that all available niches have been filled. Using mechanical controls while the plant is still invading will tend to enhance its rate of spread.

In Florida, specially designed aquatic plant harvesters are used to cut and collect hydrilla from waterways (Langland 1990). Hydrilla harvesting is mainly performed to open boat lanes through dense hydrilla beds for navigation. Because hydrilla produces high biomass, the cost of harvesting hydrilla is also high (personal communication, K. Hamel, 1995).

Response to Cultural Methods: Localized control (in swimming areas and around docks) can be achieved by covering the sediment with an opaque fabric which blocks light from the plants. Hand pulling by scuba divers can also be effective for very small patches. The divers must be patient and conscientious as tubers must be pulled up along with the plants. Plant material removed from the water should be securely bagged and thrown into the garbage or composted. As with disposal of all aquatic weeds, ensure that no viable fragments or reproductive structures can enter another waterbody.

Biocontrol Potential: Worldwide surveys for natural hydrilla enemies were begun in 1981. A number of insects were identified, quarantined and tested, and eventually released in Florida and other states (Langeland 1990). Results from these initial insect releases were generally disappointing. Additional biocontrol agents continue to be sought and evaluated, including fungal pathogens as well as insect herbivores.

The triploid grass carp, also known as the white amur, is an herbivorous Asian carp. It has been used to control hydrilla growth in the southeastern US and other parts of the world (Langeland 1990). Because it is an exotic species, its introduction is tightly regulated, and only the sterile triploid fish are allowed to be introduced in most states, including Washington. In addition, grass carp are available only by obtaining a permit from Washington Department of Fish and Wildlife.

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<u>Rationale for Listing</u>: On June 1, 1995, hydrilla, an invasive, nonnative aquatic plant, was discovered in the 73 acre Pipe/Lucerne Lake system in the Auburn area of King County, WA. This was the first known occurrence of this extremely invasive freshwater plant in the Pacific Northwest.

Once established, hydrilla outcompetes native plant species and destroys freshwater recreational opportunities by forming extensive surface mats. Like other aquatic plants that form monocultures, hydrilla is a destroyer of aquatic ecosystems.