Background Information for the Fish and Wildlife Conservation Commission's Position on Hydrilla Management

To view FWCs Hydrill Management Position Statement visit:
http://myfwc.com//media/1386750/Hydrilla-Mgmt-Position.pdf

HISTORY

The submersed aquatic plant hydrilla was introduced into Florida near Tampa via the aquarium trade during the early 1950s (Schmitz et al. 1991). It was marketed under the name *Indian star vine* indicating its origin; originally shipped to the U.S. from Ceylon (now Sri Lanka). In 1960, a severe infestation of Indian star vine was reported in Snapper Creek, southeast of Miami. The plant was incorrectly identified as *Elodea canadensis* until 1965 when subterranean tubers were discovered attached to Indian star vine growing in Lake Osborne (Palm Beach County). *Elodea canadensis* does not produce subterranean tubers and the plant was then correctly identified as *Hydrilla verticillata* (Blackburn et al. 1969).

The National Invasive Species Council defines an invasive species as non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Invasive plants share several key characteristics including:

- wide dispersal and survival
- multiple reproductive methods
- rapid growth to reproductive maturity
- ecosystem level impacts
- broad environmental tolerance and resistance to management

Hydrilla possesses all of these traits and is ranked by the Nature Conservancy/University of Florida as the second most invasive plant, behind water hyacinth, out of 129 aquatic plants in the U.S. evaluated in their risk assessment tool (Dr. Doria Gordon, personal communication). Hydrilla is on the Florida Department of Agriculture and Consumer Services' list of Class I Prohibited Plants and the U.S. Department of Agriculture Federal Noxious Weed List. Hydrilla is listed by the Florida Exotic Pest Plant Council as a Category I plant:
"These are invasive exotics which are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives. *This definition does not rely on the economic severity or geographic range of the problem, but on the documented ecological damage caused.*"

Hydrilla's spread throughout Florida is typical of invasive species dispersal; introduction followed by a lengthy period of spread to additional sites, culminating in expansion within these systems. Hydrilla was present in most of Florida's large lakes by the late 1970s and expanded within these systems, reaching a statewide apex of almost 100,000-acre standing crop reported in 1994. FWC annual plant inventories report hydrilla presence in as many as 357 (~80%) of Florida's 460 public lakes and rivers since 1982.

BIOLOGY

Only female hydrilla plants have been observed in Florida; therefore, it is believed that it does not reproduce by seeds in this state. However, hydrilla is quite prolific in reproducing via several vegetative means. Fragments that contain as little as a single whorl of leaves are capable of drifting to other parts of a waterbody, settling to the bottom and starting a new colony. Similarly, buds called turions are produced in the leaf axils by the millions per acre during the fall and winter and are distributed throughout the waterbody to start new colonies. Subterranean rhizomes spread out from parent plants producing shoots and root crowns to begin new plants. Hydrilla resists control and eradication efforts via the formation of subterranean turions, also called tubers. Tubers form in the upper few inches of the sediments from mid-September through late March at densities that can exceed millions per acre. Low rates of sprouting have been observed every month of the year and some tubers can lie dormant for years before sprouting and beginning new colonies (Netherland 1997). Drawdowns can stimulate tuber sprouting (Netherland and Haller 2006).

Once hydrilla enters a waterbody, vertical and lateral growth is rapid. Hydrilla needs only 1% surface sunlight to begin active growth (Van et al. 1976, Bowes et al. 1979); far less than native submersed plants. This competitive advantage allows hydrilla to colonize water depths in which most native plants would not survive. During the active growing season (about March through October in central and south Florida), apical tips can grow an inch or more per day and stems can elongate as much as 6-8 inches per day (Glomski and Netherland 2011). Hydrilla branches profusely as it grows, producing nearly 200 shoots from a single stem by the time it reaches the water surface. In a recent study, a single four-inch apical hydrilla shoot was observed to increase to 3,216 inches of growth, producing 157 lateral stems, 190 new shoots, and 35 stolons during a 35-day evaluation period (Glomski and Netherland 2011). This study showed that 191 inches of hydrilla shoot length was being added on a daily basis. Although growth slows as hydrilla reaches the water surface, stems continue to elongate forming dense interwoven mats that interfere with human uses including navigation, flood control, water supply, and recreational activities like swimming, skiing, and fishing. About 80% of hydrilla's biomass is in the upper two feet of the water column.

Hydrilla gets most of its nitrogen and phosphorus for growth from the sediments (McFarland and Barko 1987). As is the case with most submersed plants, these nutrients can be released into the water column by live as well as senescing plants (Carpenter and Lodge 1986) where they are available for algae growth. Hydrilla surface mats provide structure and support for epiphytic and filamentous algae that can become quite dense from late spring through early fall. Collectively, this surface plant mass can impact waterbody ecology at an ecosystem level. Underlying plants can be severely limited by lack of light, reducing native submersed plant abundance. Oxygen and pH levels can fluctuate widely during a 24-hour period, creating poor habitat for many native plants as well as invertebrate and fish species (Colon-Gaud et al. 2004, Carpenter and Lodge 1986). While hydrilla photosynthesis during the day can saturate the water column with oxygen, the plant respires at night and becomes a consumer of oxygen. The result can be severely depressed dissolved oxygen concentrations in the early morning hours. A 2010 evaluation in large hydrilla-infested areas of Lake Tohopekaliga (Osceola County) and Orange Lake (Alachua County) demonstrated that oxygen levels just a few inches below the surface were lower than 0.5 ppm during the day and night (Netherland, personal communication). During periods of several cloudy or rainy days, fish kills have been associated with dense hydrilla cover. Surface water temperatures exceeding 100º F have been reported in hydrilla mats in Florida, further reducing the ability of water to hold dissolved oxygen and making survival difficult for many plant and animal species. Lower sediment oxygen levels reduce microbial breakdown of detritus and accelerate organic sediment accumulation. Leaf and shoot material senesces and falls to the bottom throughout the year. Joyce et.al. (1992) found that unmanaged hydrilla contributed more than double the organic detritus on an annual basis than hydrilla managed at low levels. Additionally, managing hydrilla before it reached the water surface resulted in the formation of fewer and smaller tubers.

<u>AFFECTS ON FISH AND FISHERIES</u>

In Florida lakes, hydrilla at low to moderate coverage can provide a benefit to fish populations when native submersed vegetation is limited or absent. Like most submersed vegetation, hydrilla provides substrate for high densities of macroinvertebrates, which serves as a food source for fish, and cover from predation (Moxley and Langford 1982). Production and survival of juvenile sport fish (e.g., largemouth bass, bluegill) have been positively correlated to increased coverage of aquatic macrophytes (Hoyer and Canfield 1996, Maceina 1996) including hydrilla (Moxley and Langford 1982, Tate et al. 2003, Sammons et al. 2005). Similarly, sub-adult and harvestable largemouth bass abundance on large Florida lakes (≥ 55 ha) increased with increasing vegetation and reached an asymptote at 40-60% coverage but declined when coverage exceeded 60% (Hoyer and Canfield 1996, Maceina 1996). Studies have indicated that hydrilla infestations (e.g., > 60% coverage) can adversely affect growth and condition of sport fish species (Colle and Shireman 1980, Maceina and Shireman 1982, Sammons et al. 2005). Thus, intermediate levels of aquatic plant coverage (20-40%) have been suggested to meet the needs of anglers and non-angling groups (Bonvechio and Bonvechio 2006). Colle (1982) and Shireman et al. (1983) suggest a three-dimensional component and recommend no more than 10% volume and 30% cover of submersed aquatic plants to encourage maximal fish growth and high standing crops of harvestable sportfish.

Anglers often prefer to fish in or near aquatic plants (Wilde et al. 1992, Slipke et al. 1998). Because of hydrilla's ability to grow in limited sunlight in depths up to 15 m (Langland 1996) it can provide offshore habitat in areas where native vegetation may be limited or absent. In Florida, many anglers prefer to fish within or around the edges of offshore stands of hydrilla. Angler catch rates for largemouth bass and harvest of black crappie have been positively correlated to hydrilla coverage (Maceina and Reeves 1996, Bonvechio and Bonvechio 2006). However, when hydrilla coverage limits access, angler effort and catch have been shown to decline resulting in economic loss to the community (Colle et al. 1987, Slipke et al. 1998). Conversely, hydrilla at intermediate levels on Lake Okeechobee accounted for $4 million in recreational value (Furse and Fox 1994). Fisheries managers must also consider the angler use of the resource. Species-directed effort may shift with increasing hydrilla coverage because largemouth bass anglers prefer higher levels of aquatic vegetation and others (e.g., catfish, sunfish anglers) prefer less vegetation (Slipke et al. 1998). While the management of hydrilla is necessary to keep the plant from covering the whole lake, and such management may be expensive, fisheries managers must consider the primary use of the resource (e.g., recreational activities, swimming etc.) and which sportfish are being targeted when determining the level of hydrilla management.

AFFECTS ON WATERFOWL

Hydrilla may serve to replace some of the lost functions and values associated with emergent marshes in that it provides essential waterfowl food resources, both directly and indirectly, in areas where waterfowl may not normally occur. Hydrilla can displace native desirable plants, yet can also maintain or increase attractiveness to waterfowl and other species. Numerous studies document the important relationship between hydrilla and wintering waterfowl concentrations (Gasaway et al. 1976, Joyce et al. 1980, Johnson and Montalbano 1984, Johnson and Montalbano 1987) and the importance of hydrilla as a food source for ducks, coots, and common moorhens (Montalbano et al. 1978, Montalbano et al. 1979, Hardin et al. 1984, O'Meara et al. 1982, Mulholland 1983). In a study designed to quantify waterfowl preferences of seven wetland plant communities in Lake Okeechobee, Johnson and Montalbano (1984) reported that waterfowl not only preferred hydrilla over native plant communities, but hydrilla also supported a higher diversity of waterfowl species.

In hydrilla-infested systems, waterfowl and other wetland wildlife benefit from management strategies that allow for the presence of substantial acreage of topped-out hydrilla during fall and winter. This approach would be particularly beneficial in systems that are unlikely to provide other quality habitat (i.e., waterbodies with poor light penetration, algae-dominated systems, or minimum coverage of desirable aquatic macrophytes). FWC waterfowl managers recognize the potential to manage hydrilla for the benefit of wildlife, but advocate the replacement of hydrilla with native submersed plant communities of sufficient density, quality, and abundance to maintain desirable populations of waterfowl.

HYDRILLA GROWTH AND ECONOMIC IMPACT

Moderate coverages of hydrilla can provide some ecological benefits, especially in waters where little or no submersed structure would occur otherwise. However, without intensive, frequent, and expensive management efforts, hydrilla can quickly become problematic; capable of filling the water column and covering nearly the entire water surface in many of Florida's shallow waters. Through rapid growth and expansion, hydrilla has routinely demonstrated its ability to impair ecologic functions and human uses of some of Florida’s largest waterbodies, forming dense canopies across thousands of contiguous acres in just 1-2 growing seasons after introduction or since the last control effort. FWC plant inventory records indicate the 60-acre hydrilla colony first reported in 7,500-acre Lake Weohyakapka (Polk County) during May, 1992, expanded to infest 7,100 acres by August 1993. Similarly, hydrilla expanded from fewer than 2,000 acres inventoried during 1999 in 28,000-acre Lake Istokpoga (Highlands County) to nearly 20,000 acres in 2000.

Hydrilla management is also important from an economic perspective. Milon et al. (1986) reported nearly $11 million in economic values associated with sport fishing on Orange and Lochloosa Lakes (Alachua County) in 1985. Colle et al. (1987) calculated a 90% loss in revenues associated with an 83% reduction in angler utilization when hydrilla covered Orange Lake in 1976 and 1977. Searcy (1993) estimated that flooding potential in Lake Istokpoga would increase from a one in ten year to a one in one hundred year event when hydrilla matted across approximately half the surface area of this 28,000 acre lake. Therefore, responsible resource management requires diligent monitoring and appropriate management when hydrilla becomes established in Florida lakes and rivers.

METHODS OF CONTROL

Between 1980 and 2010, nearly $223 million were spent controlling more than 431,000 acres of hydrilla in Florida public lakes and rivers to conserve their key uses and functions. Mechanical harvesting has proven too slow, expensive, ecologically disruptive, and non-selective for controlling invasive plants, particularly hydrilla that reproduces via fragmentation. Sterile grass carp provide good hydrilla control in small lakes and ponds but are difficult to contain in larger systems that are open to other lakes and rivers. Additionally, grass carp are not selective foragers and will consume most aquatic plant species once hydrilla is controlled or if the stocking rate is too high. Several insect species have been studied and released for hydrilla control but have not proven effective. Most hydrilla control in Florida is achieved via herbicides registered with the U.S. Environmental Protection Agency and the Florida Department of Agriculture and Consumer Services. Fall or winter fluridone herbicide applications can reduce tuber formation. However, other control methods do not impact tubers or tuber sprouting (Netherland and Haller 2006). Experience shows that economic and environmental impacts are reduced by preventing or eradicating pioneer hydrilla colonies.

Hydrilla is an extremely dynamic plant demonstrating much greater genetic variability than was initially thought possible. Although hydrilla in Florida is thought to have resulted from one introduction in the early 1950s, Overholt et.al. (2008) identified at least 127 unique genotypes from 205 samples taken in central and south Florida. Increasing tolerance issues have surfaced with fluridone and dipotassium salt of endothall, two of the most widely used and depended-upon herbicides in Florida’s hydrilla management program. All five of the newly registered herbicide compounds being evaluated for hydrilla control in Florida are similar to fluridone in that they target a single plant-specific enzyme. A single mutation could lead to wide-scale resistance in this rapidly spreading plant. Therefore, the frequency and scale of hydrilla management with herbicides must be properly planned, implemented and monitored to ensure future availability of cost-effective and environmentally compatible hydrilla management technologies.

CONCLUSION

Florida's freshwater lakes and rivers are important resources that are treasured by residents and visitors to the state. These systems provide recreational opportunities in the way of hunting, fishing, boating, wildlife viewing, etc. Many of Florida's waterways are part of flood control systems that are critical in protecting human health, safety and property. Without healthy populations of fish and wildlife in lakes and rivers, the economic benefits to local communities that are generated by these recreational activities would be lost. There is a lot to be lost economically, socially and ecologically if these resources are not properly managed.

Aquatic plants are the foundation for healthy fish and wildlife in aquatic systems. Aquatic plant control is a tool used to achieve healthy and sustainable fish and wildlife resources. When fish and wildlife resources are affected, the stakeholders who enjoy or depend on them are also affected. A broad diversity of stakeholders utilize Florida's public lakes and rivers and each have their own preference for how aquatic plants should be managed. For example, duck hunters and bass fisherman may both want hydrilla, but not always to the same extent and in the same location of a water body; boaters, swimmers, and property owners typically don't want any hydrilla. FWC will determine the level of hydrilla management on a waterbody by waterbody basis using a risk-based approach with input from resource management partners and local stakeholders.

REFERENCES

Blackburn, R. D., L. W. Weldon, R.R. Yeo, and T.M. Taylor. 1969. Identification and distribution of certain similar appearing submersed aquatic weeds in Florida. Hyacinth Control Journal 8: 17-21.

Bonvechio, K.I. and T.F. Bonvechio. 2006. Relationship between habitat and sport fish populations over a 20-year period at West Lake Tohopekaliga, Florida. North American Journal of Fisheries Management 26:124-133.

Bowes, G.E., T.K. Van, L.A. Garrard, and W.T. Haller. 1979. Adaptation to Low Light Levels by Hydrilla. Journal of Aquatic. Plant Management 15:32-35.

Carpenter S.R. and D.M. Lodge. 1986. Effects of Submersed Macrophytes on Ecosystem Processes. Aquatic Botany 341-370.

Colle, D.E. and J.V. Shireman. 1980. Coefficients of condition for largemouth bass, bluegill, and redear sunfish in hydrilla-infested lakes. Transaction of the American Fisheries Society 109:521-531.

Colle, D. E. 1982. Hydrilla--Miracle or Migraine for Florida's Sportfish. Aquatics, June, pg. 6.

Colle, D.E., J.V. Shireman, W.T. Haller, J.C. Joyce and D.E. Canfield Jr. 1987. Influence of hydrilla on harvestable sport-fish populations, angler use, and angler expenditures at Orange Lake, Florida. North American Journal of Fisheries Management 7:410-417.

Colon-Gaud, J.C., W.E. Kelso and D.A. Rutherford. 2004. Spatial Distribution of Macroinvertebrates Inhabiting Hydrilla and Coontail Beds in the Atchafalaya Basin, Louisiana. Journal of Aquatic Plant Management 42:85-90.

Furse, J.B. and D.D. Fox. 1994. Economic fishery valuation of five vegetation communities in Lake Okeechobee, Florida. Proceedings of the Annual Conference of Southern Association of Game and Fish Agencies 48:575-591.

Glomski, L.A. and M.D. Netherland. 2011. Does Hydrilla Grow an Inch Per Day? *In review* submitted to Journal of Aquatic Plant Management.

Gasaway, R.D., S. Hardin, and J. Howard. 1976. Factors influencing wintering waterfowl abundance in Lake Wales, Florida. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 31:77-83.

Hardin, S., R. Land, M. Spelman, and G. Morse. 1984. Food items of grass carp, American coots, and ring-necked ducks from a central Florida lake. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 38:313-318.

Hoyer, M.V. and D.E. Canfield Jr. 1996. Largemouth bass abundance and aquatic vegetation in Florida lakes: an empirical analysis. Journal of Aquatic Plant Management 34:23-32.

Johnson, F.A., and F. Montalbano III. 1984. Selection of plant communities by wintering waterfowl on Lake Okeechobee, Florida. Journal of Wildlife Management 48:174-178.

Johnson, F.A., and F. Montalbano III. 1987. Considering waterfowl habitat in hydrilla control policies. Wildlife Society Bulletin 15:466-469.

Joyce, J.C., W.T. Haller, and D. Colle. 1980. Investigation of the presence and survivability of hydrilla propagules in waterfowl. Aquatics, Volume 2, Number 3.

Joyce, J.C., K.A. Langeland, T.K. Van, and V.V. Vandiver. 1992. Organic Sedimentation Associated with Hydrilla Management. Journal of Aquatic Plant Management 30:20-23.

Langeland, K.A. 1996. *Hydrilla verticillata* (L.F.) Royle (Hydrocharataceae), "The perfect aquatic weed". Castanea 61:293-304.

Maceina, M.J. and J.V. Shireman. 1982. Influence of dense hydrilla infestation on black crappie growth. Proceedings of the Annual Conference of Southern Association of Game and Fish Agencies 36:394-402.

Maceina, M.J. and W.C. Reeves. 1996. Relations between submersed macrophyte abundance and largemouth bass tournament success on two Tennessee River impoundments. Journal of Aquatic Plant Management 34:33-38.

Maceina, M.J. 1996. Largemouth bass abundance and aquatic vegetation in Florida lakes: an alternative interpretation. Journal of Aquatic Plant Management 34:43-47.

McFarland, D., and J.W. Barko. 1987. Effects of Temperature and Sediment Type on Growth and Tuber Formation in Hydrilla. Journal of Freshwater Ecology 4:245-252.

Milon, J.W., J. Yingling, and J.E Reynolds. 1986. An Economic Analysis of the Benefits of Aquatic Weed Control in North-Central Florida with Special Reference to Orange and Lochloosa Lakes. Economics Report 113. UF Food and Resource Economics Department. 52p.

Montalbano, F., III, W.M. Hetrick, and T.C. Hines. 1978. Duck foods in central Florida phosphate settling ponds. Pages 247-255 in D. E. Samual, J.R. Stauffer, C.H. Hocutt, and W.T. Mason, editors. Proceedings of the symposium on surface mining and fish/wildlife needs in the eastern United States. U.S. Department of Interior, Fish and Wildlife Service OBS-78/79.

Montalbano, F., III, S. Hardin, and W.M. Hetrick. 1979. Utilization of hydrilla by ducks and coots in central Florida. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 33:36-42.

Moxley, D.J. and F.H. Langford. 1982. Beneficial effects of hydrilla on two eutrophic lakes in central Florida. Proceedings of the Annual Conference of Southern Association of Game and Fish Agencies 36:280-286.

Mulholland, R. 1983. Feeding ecology of the common moorhen and purple gallinule on Orange Lake, Florida. Thesis, University of Florida, Gainesville, Florida, USA.

Netherland, M.D. 1997. Turion Ecology of Hydrilla. Journal of Aquatic Plant Management 35:1-10.

Netherland, M.D. and W.T. Haller. 2006. Impact of Management on the Sprouting of Dioecious Hydrilla Tubers. Journal of Aquatic Plant Management 44:32-36.

O'Meara, T.E., W.R. Marion, O.B. Myers, and W.M. Hetrick. 1982. Food habits of three bird species on phosphate-mine settling ponds and natural wetlands. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 36:515-526.

Overholt, W. A., R. Copeland, D. Williams, J. Cuda, B. Nzigidahera, E. Nkubaye, F. Wanda and B. Gidudu. 2008. Exploration for natural enemies of Hydrilla verticillata in East/Central Africa and genetic characterization of worldwide populations. Report submitted to the Florida Fish and Wildlife Conservation Commission for the period July-December, 2008.

Sammons, S.M., M.J. Maceina, and D.G. Partridge. 2005. Population characteristics of largemouth bass associated with changes in abundance of submersed aquatic vegetation in Lake Seminole, Georgia. Journal of Aquatic Plant Management 43:9-16.

Schmitz, D.C., Nelson, B.V., Nall, L.E., and J.D. Schardt. 1991. Exotic Aquatic Plants in Florida: A Historical Perspective and Review of the Present Aquatic Plant Regulation Program. In: Proceedings of the Symposium on Exotic Pest Plants (Center, T.D. et al., eds.), Held on November 2-4, 1988, University of Miami, Rosenstiel School of Marine and Atmospheric Science, Miami, Florida. United States Department of the Interior, National Park Service Document, Washington D.C. Pages 303-323.

Searcy, H. L. 1993. Lake Istokpoga Feasibility Study. Contract C-3019 with South Florida Water Management District.

Shireman, J. V., W. T. Haller, D. E. Colle, and D. F. DuRant. 1983. Effects of Aquatic Macrophytes on Native Sportfish Populations in Florida. Pp. 208-214 In: Proceedings of the International Symposium on Aquatic Macrophytes, September 18-23, 1983, Nijmegen, The Netherlands.

Slipke, J.W., M.J. Maceina, and J.M. Grizzle. 1998. Analysis of the recreational fishery and angler attitudes toward hydrilla in Lake Seminole, a southeastern reservoir. Journal of Aquatic Plant Management 36:101-107.

Tate, W.B., M.S. Allen, R.A. Myers, E.J. Nagid and J.R. Estes. 2003. Relation of age-0 largemouth bass abundance to hydrilla coverage and water level at Lochloosa and Orange lakes, Florida. North American Journal of Fisheries Management 23:251-157.

Van, T.K., W.T. Haller, and G. Bowes. 1976. Comparison of Photosynthetic Characteristics of Three Submersed Aquatic Plants. Plant Physiology 58:761-768.

Wilde, G.E., R.K. Riechers, and J. Johnson. 1992. Angler attitudes toward control of freshwater vegetation. Journal of Aquatic Plant Management 4:111-119.

HYDRILLA MANAGEMENT ISSUE TEAM

Sponsor Tim Breault, Director, Division of Habitat and Species Conservation

Team Leader William Caton, Invasive Plant Management

Team Members Joe Benedict, Hunting and Game Management
Jim Estes, Fish and Wildlife Research Institute
Scott Hardin, Invasive Species Management
Bill Pouder, Freshwater Fisheries Management
Jay Russel, Law Enforcement
Jeff Schardt, Invasive Plant Management
Kent Smith, Aquatic Habitat Conservation Restoration
Liz Sparks, Office of Recreation Services
Zach Welch, Species Conservation Planning

Team Support Facilitator - Perran Ross, University of Florida
Facilitator - Craig Faulhaber, Species Conservation Planning
Facilitator - Camille Soverel, Law Enforcement
Recorder - Ryan Hamm, Invasive Plant Management