ANS
Aquatic Nuisance Species

Volume 3 No. 4 November 1999

DIGEST

FRESHWATER FOUNDATION

Providing current information on monitoring and controlling the spread of harmful nonindigenous species.

Egeria Invades the Sacramento-San Joaquin Delta

By Lars W.J. Anderson

Just when state and federal water resource managers in California felt they had the "bad" actor - *Hydrilla verticillata*- (family Hydrocharitaceae) eradicated, another invasive relative, egeria (*Egeria densa*) has recently spread to one of the state's most vital and sensitive ecosystems. For almost 25 years since hydrilla was discovered in the Golden State, an effective eradication program has kept it in check, and importantly, out of the massive delta created by the Sacramento and San Joaquin rivers, just "upstream" from San Francisco Bay. This massive waterway is not only a critical habitat for fish and wildlife, including the endangered Delta Smelt; it is also the water life-line for some 23 million thirsty southern Californians, and much of the state's multibillion-dollar agricultural economy. It's easy to see the importance of keeping this system healthy and free of intruding pests that can interfere with critical habitats, food webs, and water delivery. Unfortunately, there is no eradication tool or program for egeria.

The saga of noxious aquatic weeds in the Delta actually began when water hyacinth was introduced in the early 1900s and subsequently created huge problems in 1983. The explosion of water hyacinths eventually led to a state-funded control program that has effectively kept it at low levels. Although it's not certain when egeria got its start, populations really began to expand in the mid-1990s, shortly after the end of a six year drought period. It may be that a combination of the low runoff from the Sierra Nevada Mountains and clearer, warmer water conditions facilitated the expansion. It is also likely that the removal of water hyacinth "cover" provided more suitable habitat (particularly available light) for egeria. Whatever the reasons, current surveys by the California Department of Boating and Waterways (CBWW) indicate that egeria occupies more than 3,000 acres at varying densities (see Figure 1). The biomass (standing crop) in some of the most heavily populated sites ranges from 1 to 2 kg/ sq. meter, or nearly 9 tons per acre.

California is not alone in trying to cope with egeria. Several other western states including Oregon and Washington, as well as southeastern areas of the U.S., have varying levels of infestations. Since this plant is freely available in aquarium shops and specialty nurseries in most states, including California, it's not surprising that egeria has been introduced and become widespread.

***Egeria** continued on next page*

Ruffe - a Problem or Just a Pest?

By Raymond M. Newman

The ruffe (*Gymnocephalus cernuus* L., formerly *Acerina cernuua*), a small perch-like fish native to Europe and Asia, was first found in North America in the St. Louis River Harbor, at the western end of Lake Superior, in 1986 (Pratt et al. 1992). They most likely arrived in ballast water from Europe, probably from somewhere in the Danube basin (Stepien et al. 1998). In Europe, ruffe, though often abundant, are of little sport and commercial value due to their small size (rarely larger than 25 cm or 10" and more commonly less than 15 cm) and spiny body. Ruffe are prolific and have a high reproductive potential; they may spawn two to six times during the year and females can produce from 10,000 to over 150,000 eggs during spawning. This high reproductive potential often results in abundant but "stunted" populations with smaller maximum sizes (Popova et al. 1998).

Ruffe are benthic feeders (Ogle 1998), relying on small benthic invertebrates that live in lake and river bottoms. Chironomids are often a dominant component of the ruffe diet. Like perch and walleye, ruffe are well adapted to dark and turbid conditions such as those found in more eutrophic waters. Ruffe possess a well-developed tapetum lucidum, a layer of reflecting plates behind the retina, that enables them to feed in low light to dark conditions. In addition, ruffe have a highly

***Ruffe** continued on page 44*

In This Issue:

Nuisance Notes from Western Regional Panel on ANS 41

Minnesota DNR Tests the Use of 2,4-D in Managing Milfoil 42

Upcoming Meetings 46

Great Lakes Update 47

Aquatic Nuisance Species Digest

Direct questions and comments about *ANS Digest* to: Jeanne Prok, Freshwater Foundation, Gray Freshwater Center, 2500 Shadywood Road, Navarre, MN 55331; (888) 471-9773; e-mail: JeanneR@freshwater.org.

Aquatic Nuisance Species Digest (ISSN 1083-8864) is produced by the Freshwater Foundation, a public nonprofit foundation whose mission is to pursue the sustainable use of freshwater resources through education, conferences, publications and research. Funding for this issue of *ANS Digest* came from the National Sea Grant Program through the Minnesota Sea Grant Program. Minnesota Sea Grant is a statewide program that supports research and public education related to Lake Superior and Minnesota's inland lakes. It is part of the National Sea Grant Program, which supports research and outreach in 31 coastal and Great Lakes states and territories.

Egeria *continued from previous page*

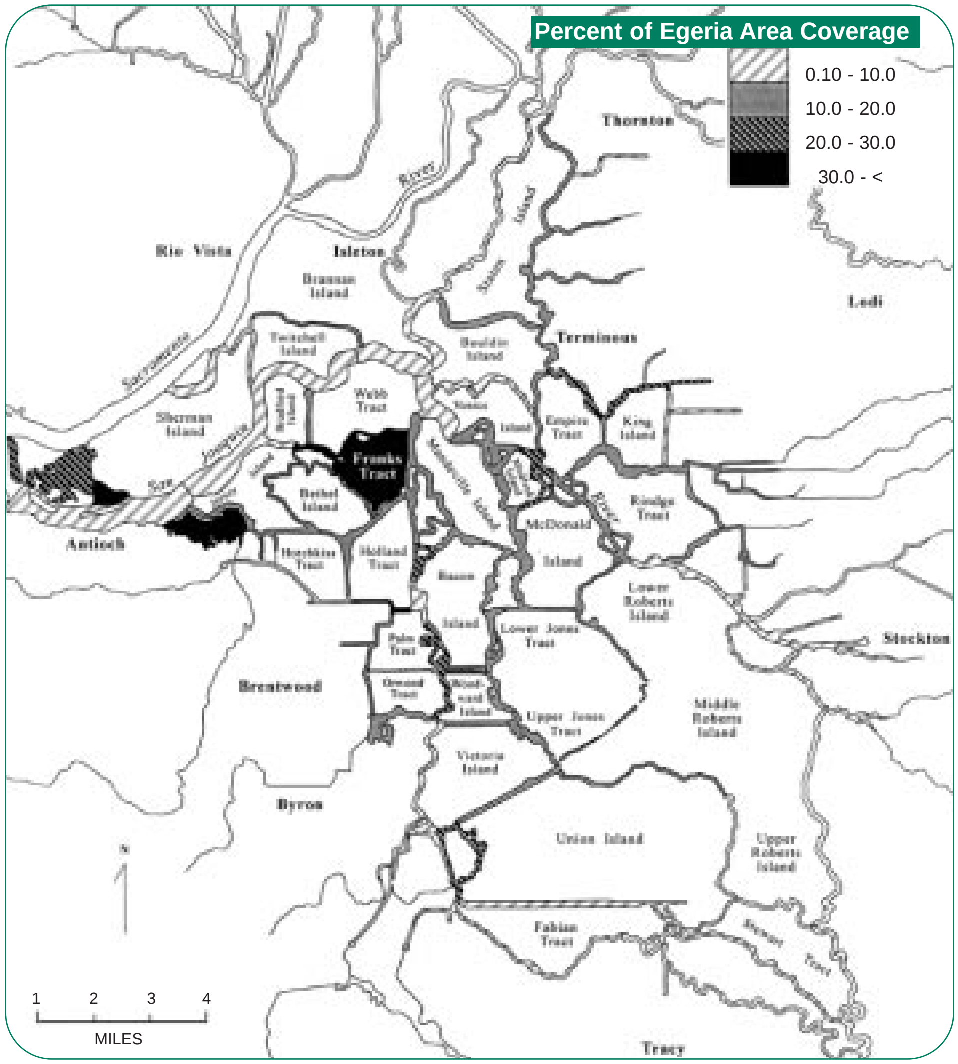


Figure 1. Enlarged view showing the Sacramento-San Joaquin Delta, California. The shaded areas show the locations of Egeria densa infestations: darkest shading indicates the most abundant populations. *(Courtesy of Califorina Department of Boating and Waterways)*

Impacts Caused by Egeria

The first public alarm was sounded in 1994 by marina operators and by some of the commercial vessel operators in the Delta. Large stands of egeria were beginning to block access to boat slips, fishing and swimming areas, and even some boats had begun to experience mechanical problems. Egeria wraps up on propellers, rudders, keels, and the smaller fragments clog cooling systems, which results in burned-out engines. Some interference with irrigation pumps was noted as well. In some areas, property values became affected by the persistent masses of egeria in what were formerly open and aesthetically pleasing delta waterways. Finally, enough waterfront property owners and marina owners reacted. The state legislature was compelled to enact State Assembly Bill 2193 in 1997, which added egeria control to the water hyacinth control program responsibilities of the Department of Boating and Waterways.

Other impacts of egeria are less obvious. These include the displacement of native pondweed species (*Potamogeton spp.*), impairment of access for waterfowl, and severe shading of the upper water column. The dense upper "canopy" formed by egeria blocks light that would normally be available to the microscopic algae (phytoplankton). The lack of primary production by the phytoplankton inhibits fisheries production since these organisms form the base of the food chain. Some effects remain unclear. For example, how does egeria alter nor-

***Egeria** continued on next page*

mal spawning habitat for salmon, bass and, importantly, the endangered native, Delta Smelt? Presumably, prior to the intrusion by egeria, native fish had adequate habitat provided by native aquatic plant species.

In addition to negative impacts on wildlife, egeria acts like a filter and accelerates deposition of suspended materials. Each year, hundreds of tons of organic and inorganic materials are carried downstream with the seasonal snowmelt. In areas where egeria has formed dense stands, the water is slowed and materials that are normally transported and spread throughout the Delta and upper Bay become entrapped and settle. The net result is localized heavy organic loading of the sloughs; these shallow areas will have to be dredged eventually.

Taking a broader perspective, the persistence and continued spread of egeria in the Delta will also greatly increase the opportunity for the exotic plant to invade lakes, ponds, and streams because thousands of boaters can inadvertently carry hitch-hiking fragments on their trailers, boats, and motors. Since the plant can survive for several days, each boat and trailer becomes a dispersal agent. At this time, there are no statutes or regulations prohibiting the possession or transportation of egeria on a public road or launching of a contaminated boat in public or private California waters.

Interestingly, even in Brazil, in areas presumably close to its native range, *Egeria densa* and *Egeria najas* cause serious interruptions of hydroelectric production. For example, the extensive Sao Paulo state power utility, Companhia Electrica de Sao Paulo (CESP), has periodic shut-downs of its hydro-turbines when huge masses of egeria get plugged in the water intakes. The loss of power, damage to turbines, and millions of dollars of lost revenue, is critical since these systems provide essentially all of the State's electrical power.

Assessing Management Options

Although there have not been extensive studies on the biology of egeria, a few important characteristics are known that are relevant to developing strategies for control. Even though the plant produces abundant flowers (Figure 2), the populations of this dioecious plant in the U.S. are all male. Since there is no seed production, dispersal is dependent on vegetation propagation. Yet, unlike its cousin hydrilla in the Hydrocharitaceae family, egeria does not produce specialized vegetative over-wintering structures such as a turion or tuber. (Note: turions formed by hydrilla -both subterranean "tubers" and those formed on the shoots- can last several years and this makes eradication extremely difficult). Rather, egeria's rhizomes and some larger shoots appear to be the primary structures that promote dispersal. It is these structures that accumulate starch and other reserves, which allow the plant to maintain its foothold through cooler, winter months.

Egeria propagates as a "clone" by forming multiple, branching shoots and rhizomes, and through dispersal of fragments. These fragments break off and are blown by wind on the water surface, or with tidal and rivers flows. In fact, fragments that have new roots and shoots are commonly encountered in the Delta waterways, even miles from the densest populations. Were it not for egeria's lack of tolerance to saline water, or brackish conditions, there would most likely be abundant populations in the upper San Francisco Bay by now. Fortunately, the freshwater-to-brackish water transition zone, though seasonally variable, occurs quite far into the upper reaches of the Bay/Delta. This of course has not prevented the invasion and establishment of many other exotic plants and animals that thrive in saline conditions! The Bay/Delta area is now home to over 200 invasive plant and animal species.

Figure 2. *Egeria densa* shoot-tip and flower. Note that only the male plants are present in the U.S.; therefore no seed production occurs in the Delta.

Site	Half-life (Hours)	Estimated "Wash-out" time (Hours)
White Slough	8	35
Owl Harbor	2-4	12-14
Sandmound Slough	18-20	30-35
Franks Tract	6-7	30-32
Big Break Marina	20-24	40-45
Venice Island	8-10	15-20
Pixley Slough	20-24	90+

Table 1. Dissipation of Rhodamine WT Dye in Typical Egeria-Infested Sites in the Sacramento-San Joaquin Delta

Water movement has a profound effect on management options. In the Delta, diurnal tides create high-velocities (from 1 to 5 mph), depending upon the time of the month, and year, and large water volume exchanges. The net effect is that water moves both upstream and downstream twice each day, depending upon the tidal cycle. This flux of water greatly limits the time during which herbicides can be in contact with egeria. Studies on the "residence time" and movement of dyes, copper-containing herbicides, and the herbicide Sonar (fluridone) have shown that in many areas, there may only be 4 to 6 hours during which a herbicide will be in contact with egeria at the concentration needed for control. In other sites, such as marinas located off the main channels, or "dead-end" sloughs, the residence time may be several days. Table 1 provides some examples of how quickly dilutions occur in typical Delta sites. These data are derived from the dissipation pat-

Egeria *continued on next page*

tern for Rhodamine WT dye, which can be detected at extremely low concentrations. Also, due to the intricacies and irregularities in depths, shape, and contours of the bottom, it is not easy to predict exactly where, and how fast water moves at a particular site. For this reason, the use of dyes will be an important component of the operational plan since it will provide a good indication of conditions in a specific site during a given tidal cycle.

Another problem associated with the Delta flows is the potential for "off-site" movement of herbicide residues as well as the dispersal of viable egeria fragments following mechanical control operations. Of course, herbicide levels can be measured, and monitoring will certainly be part of an operational program that includes these products. Results of studies on copper-containing products indicate that levels in the treated site, and adjacent areas (both upstream and downstream) generally decline to pre-treatment values within 24 hours after applications are made. As part of an extensive assessment of mechanical methods, we have also shown that the fragments capable of regenerating new plants are produced by the thousands even after short harvesting and collection periods of an hour. For example, during, and immediately after harvesting, almost all the fragments collected (>80%) were less than 20 cm long (about 8 inches), and essentially all were able to form new shoots and roots when left in Delta water for a few weeks. Thus, the potential spread of egeria will have to be weighed against other possible management options.

This information indicates that there will need to be a tailored approach to any operational plan for controlling egeria in the Delta. For some circumstances, only a rapid-acting contact type herbicide, such as copper-containing product, will provide adequate efficacy. Open channels and sloughs that have unimpeded flows fit this category. Another rapid-acting contact herbicide diquat may also be suitable in some areas; however, due to the high turbidity in most of the Delta, the efficacy of treatment will be limited. Diquat binds tightly to particles, especially clay, in highly turbid water, and thus becomes unavailable to egeria. If mechanical control is chosen (e.g. cutting and harvesting), then it may be necessary to use floating booms or nets to prevent the myriad of fragments from infesting downstream locations.

For some areas, the systemic herbicide fluridone may be effective if repeated applications (e.g. weekly) are made. The advantage is that this type of herbicide usually provides long-term control since it moves (translocates) into the roots and rhizomes. Our research has shown that contact times of around eight weeks at 10 to 20 parts per billion (ppb) will control egeria. The trick is maintaining this effective environmental concentration range for the two months in water that is moving in complex ways. An alternative we are exploring is use of a granular formulation, which may reduce the frequency of applications required. Another alternative includes liquid sonar, which is currently being investigated, in combination with mechanical control, by CESP, the Brazilian electric power agency.

Is Biological Control an Option?

Given the difficult conditions for both mechanical and herbicide-based management, the desirability of a host-specific biological control is obvious. Unfortunately, at least for now, there are no biological control agents available for egeria. One generalist-type herbivore that has received some approved uses in California, is the triploid (sterile) grass carp. This fish will consume egeria, as well as a plethora of other submersed beneficial aquatic plants. However, it is at present only permitted in fully "secured" systems such as some lakes, ponds, and irrigation systems in southern California. Due to concerns with introductions in natural waterways, it would not be approved for release in the delta system.

Biological control holds hope for the future. First, scientists in Brazil have isolated a fungal pathogen of *E. densa*. Dr. Robson Pitelli, at the UNESP-Botucatu campus, has completed some initial tests which show that the fungus can kill egeria in small containers under laboratory conditions. As with any fungal-type agent, there will need to be extensive testing to ensure that this pathogen only affects egeria, and not other desirable plants, including crops. Also, the transition from small test containers to larger, confined outdoor systems may require more research to determine how this pathogen is best "formulated" and introduced. Second, there is also a South American species of moth in the *Paraponyx* genus that might offer some potential for control. However, in both cases, it is too early to know how practical, and host-specific, the fungus and moth are. Support for more exploration in South America has recently come from the California Dept. of Boating and Waterways. Our laboratory will work with both Brazilian and Argentine scientists over the next several years in an attempt to locate insects that selectively feed on egeria.

Even with the best luck, extensive, in-depth testing will be required before introducing biological control agents. This means that an effective biocontrol agent is several years away. In the interim, an operational program must go forward. Given constraints imposed by application conditions in the Delta, the Department of Boating and Waterways will need to have the flexibility to choose which approach fits best for each area. Regardless of the methods used, the sensitivity of the habitat, coupled with the complexity of water flows, will necessitate a long-term monitoring program.

As with most water-related issues in California, we can expect a high level of public interest, issues over state and federal agency jurisdictions, and occasional political vibrations that might even hit an "8" on the Richter scale. A prime example is what I call the "copper conundrum". Even though there are accepted, registered products (i.e., both federal EPA and California Department of Pesticide Registration) which contain copper, and are effective in controlling egeria, other regulatory entities known as Regional Water Control Boards, have set limits of metals in water as part of restrictions on "waste-discharge". For copper, this level is 10 ppb, which is far below levels needed for efficacy. Normally from 200 to 1000 ppb copper is applied, depending upon the pH and hardness of the water. Thus, unless the Water Boards do not consider applications of properly applied pesticides (in this case, copper-containing herbicides) as "waste-discharge", copper levels will exceed those set for "discharge" of waste. Although it may seem clear that the "waste" criteria were meant to prevent contamination from such sources as industrial processes, cleaning operations, mining operations, this conflict has yet to be resolved. Stay tuned!

Lars W.J. Anderson, Ph.D. is a research leader at USDA-ARS Aquatic Weed Research Lab, University of California, Davis, CA, 95616. e-mail: lwanderson@ucdavis.edu

Nuisance Notes from the Western Regional Panel on ANS

State Updates

Alaska: Western Regional Panel Contact: Bob Piorowski (907-465-6150).

Arizona: State WRP Contact: Larry Riley, Arizona Game and Fish Department (602-789-3258).

California: The draft National Management Plan was accepted by the ANSTF in August l999. Since it has been warranted, the ANSTF will form a committee to review the draft plan and provide recommendations back to the ANSTF. A public review period will follow. The process should be completed by Spring 2000. Contact: Kim Webb, CALFED, (209-946-6400) X311. State WRP Contact: Randy Brown. CA Dept of Water Resources (916-227-7531).

Colorado: Denver Metro Area Control of the aquatic noxious weed purple loosestrife in the Denver, CO area entered its 7th summer in 1999. The Colorado Division of Wildlife (CDOW) continued to coordinate the effort, providing control training and putting a 4-person crew in the field killing loosestrife for 2 months. The CDOW crew worked mostly on private lands while public agencies, mainly city and county governments, controlled the plant on their own property. Purple loosestrife occurs along three major streams in the Denver area, and at about 130 other isolated sites. Nearly every known purple loosestrife population in the metro area was controlled once again this summer, and the amounts of loosestrife returning at most sites is low. CDOW efforts were assisted by grants from the CO Waterfowl Stamp Fund and the CO Noxious Weed Management Fund this year. State WRP Contact: Chuck Loeffler, CDOW (303-291-7451).

Guam: Brown tree snake control and monitoring program is in place. WRP Contact: Michael W. Kuhlmann (671-734-3942).

Kansas: KSU-USGS-BRD is initiating a study of impacts of Big Head Carp on native fisheries in the Missouri River. A Sericea Lezpedexa Work Group was established to coordinate regional activities to control this invasive weed. KS Boating Regulations posted on state web page include information to stop spread of zebra mussels. <http://www.boatsafe.com/Kansas/zebra_mussels.htm> State WRP Contact: Tom Mosher (316-342-0658).

Montana: An invasive species state management plan steering committee meeting was held in Oct. l999 in conjunction with the Yellowstone Bioinvasion Conference. WZMTF Contact: Tim Gallagher (406-444-2448).

Nebraska: Live zebra mussels were identified on a boat, traveling from the Great Lakes, found at a l00th Meridian check station at Lake McConahey. A Missouri River States Zebra Mussel Workshop for water users is planned for spring 2000. Contact: Steve Scenist, Nebraska Game and Parks (402-471-5443).

Nevada: Giant Salvinia has been identified in the lower Colorado River. An emergency response team has been developed to eradicate Giant Salvinia in this area. The recently adopted state Fisheries Program policy includes a section on management of ANS. State WRP: Contact Jon Sjoberg, NDW (702-486-5127).

New Mexico: The New Mexico zebra mussel informational brochure is being prepared. WRP Contact: Brian Lang, NM Game and Fish Dept (505-827-4628).

North Dakota: The North Dakota Water Education Foundation published a three page article on zebra mussels in their August magazine. Monitoring continues for ANS. State WRP Contact: Terry Steinwand, North Dakota Game and Fish Department (701-328-6313).

Oklahoma: No new infestations of zebra mussels have been reported. Hot summer weather (over 90 degree water temp) reduced densities in the Arkansas River. A presentation was made to the OK Aquaculture Assoc. on zebra mussels and l00th Meridian. An 8 lb pacu (south african) fish was caught at Keystone Lake in August 29, l999. Western Zebra Mussel Task Force Contact: Everett Laney, USACOE (9l8-669-7411).

Oregon: Paul Hemowitz, with Oregon Sea Grant, will be giving a talk called "Aquatic Exotics - Friend or Foe" at the Hatfield Marine Science Center in Newport, OR, on November 2, l999 . State Contact: Andrew Schaedel, Oregon Department of Environment.

South Dakota: The South Dakota Game Fish and Parks (SDGFP) is participating on the WGA's undesirable non-indigenous aquatic and terrestrial species working group. WRP Contact: Dennis Unkenholz,South Dakota Game, Fish and Parks Department (605-733-6770).

Texas: The Texas Parks and Wildlife Dept. hosted the Western Regional Panel Meeting in Austin-Oct. 5-6, l999. State WRP Contact: Bill Harvey (512-389-4394).

Utah: The Utah Invasive Species Work Group has distributed ANS information with boater registration as well ANS signage and brochures. Boat wash stations are being built at Lake Powell. NRA Contact: Randy Radant, Utah Division of Wildlife Resources (801-538-4812).

Washington: WDFW hosted the ANSTF meeting in Olympia,WA in Aug.l999. The ANS State Management Plan received NISA funding for implementation for l999. Contact: Scott Smith, Washington Department of Fish and Wildlife (360-902-2724).

Wyoming: The Interstate Coordination meeting in August l999 on Flaming Gorge NRA included ANS management. WRP Contact: Mike Stone, WGFD (307-777-4559).

Federal Updates

U.S. Fish and Wildlife Service: AN coordinators are available to provide technical assistance to state, federal, and private interests in regard to ANS. Region l (CA,OR,WA,ID, NE,HI) -Denny Lassey, Portland, OR (503-230-5973), Region 2(TX,NM,OK,AZ) - Bob Pitman, Tishomingo, OK (580-384-57l0), and Region 6(MT,WY,UT,CO,ND,SD,NE,KS) - Linda Drees, Manhattan, KS(785 539-3474X20). Sharon Gross, Acting Natl ANS Coord., Arlington, VA (703-358-1718).

Bureau of Reclamation: The Bureau of Reclamation Western Zebra Mussel Task Force<http:/www.usbr.gov/zebra/wzmtf.html>. The Western Regional Panel on Aquatic Nuisance Species Page can be accessed at http://www.wrp-ans.org Contact Tracie Greene (303-445-2205).

U.S Geological Surevey-Southeastern Biological Science Center: The Center maintains a nonindigneous aquatic species geographic information system and current zebra mussel location maps. World Wide Web server (http://www.nfrcg.gov) or contact Amy Bensen (904-378-8181).

Sea Grant: The Pacific Northwest Marine Invasive Species Team (a partnership of Oregon and Washington Sea Grant is in the process of developing a number of NIS outreach materials, including a regional "least wanted" identification brochure and a training video on early detection of new NIS invasions. For more information, contact Paul Hemowitz with Oregon Sea Grant (503-722-6718) or Nancy Lerner with Washington Sea Grant (206-616-8403). The National Sea Grant College Program New York Sea Grant maintains a aquatic nuisance species information clearinghouse and publishes an information review, Dreissena polymorpha. A corbicula library is now being developed. Contact: Charles O'Neill, Jr. (7l6-395-2638). Minnesota Sea Grant. Minnesota Sea Grant is in the process of developing a boat inspection training video for use with boating and fishing public. Contact: Doug Jenson (218-726-8712). California Sea Grant .CA Sea Grant continues to host series of ballast water education workshops throughout west coast. Contact: Jodi Cassell (650-871-7559).

Zebra Mussels and Eurasian Milfoil Move West: Zebra Mussels were identified in the Missouri River for the first time in April, l999. A 11/2 inch zebra mussel was found on the intake of Mid America Power Company near Sioux City, IA. Zebra mussels were also found on a boat stopped at a l00th Meridian boat check station at Lake McConaughey, Nebraska. In both cases zebra mussels were isolated and no others were found in the immediate vicinity. Eurasian Watermilfoil has been found in Lake Sharpe, the Missouri River Reservoir that extends from Ft. Thompson onto Pierre. This is the first identification of Eurasian Watermilfoil in South Dakota. Voucher specimens will be deposited in the herbarium at South Dakota State University. Monitoring efforts are being stepped up to detect this plant in other waters of the state. For information contact: David J. Ode (SDGFP) (605-773-4227).

California Ballast Water Management Legislation Is Sent to Governor for Signing: California proposed statute AB 703 which launches a "mandatory NISA"-style program administered out of the State Lands Commission (which presently boards vessels to do inspections for oil pollution-related requirements). The program is not permit based, as the bill was originally written; instead, vessels are required to exchange ballast water in open ocean waters, where "exchange" is defined as in NISA. NISA's "good housekeeping" requirements are also made mandatory in the bill. Penalties are $5,000/day per violation (with each day a continuing violation), and the State Lands Commission also has the authority to send a ship back out to sea to do a better exchange if they haven't complied with the law. Unlike NISA, this program is paid for through fees on the dischargers, capped at $1,000 per vessel visit. This money will also pay for three reports: one technical review of the state of aquatic invasions in California coastal waters, one on technological solutions, and one on the effectiveness of a ballast water-exchange program. The bill is has been sent to Governor Davis after passage by legislature. For more information visit: <http://www.sen.ca.gov/htbin/testbin/ca-search-bills-bn>.

Minnesota DNR Tests the Use of 2,4-D in Managing Eurasian Watermilfoil

by Wendy J. Crowell

Eurasian watermilfoil, *Myriophyllum spicatum* (hereafter called milfoil), is a submersed aquatic plant that is native to Eurasia. It is believed to have been introduced to North America some time before 1950 (Couch and Nelson 1985, Smith and Barko 1990). Milfoil is considered a problem in North America because it can produce mats of vegetation at the water's surface that interfere with recreation and other activities. These surface mats may also displace native aquatic vegetation causing negative ecological impacts (Aiken et al 1979).

Milfoil was first discovered in Minnesota in 1987. By the end of the 1989 summer season, the exotic had been discovered in 35 bodies of water in the state (Exotic Species Program,1999). Due to the limited distribution of the plant in the years immediately following its discovery, and the severity of problems caused by milfoil in Minnesota, the Minnesota Department of Natural Resources (MNDNR) initiated aggressive efforts to control the plant. The initial goals of these efforts were to eliminate the plant from individual lakes, prevent the spread of milfoil within infested lakes, and reduce the abundance of milfoil in treated areas. This article describes the effectiveness in using 2,4-dichlorophenoxyacetic acid herbicide (2,4-D) in achieving these goals.

Methods

The MNDNR examined the efficacy of 2,4-D in 31 Minnesota lakes where the entire known milfoil population was treated. These lakes were treated between 1989 and 1993 (Table 1). Not all lakes treated during that time were examined. Most treatments were done with the granular formulation of 2,4-D Aquakleen® applied at 100 lbs per acre. This formulation is now sold under the trade name Navigate®. Attempts were made to find all milfoil in a lake by surveying all apparently suitable habitat with a boat, searching for milfoil visually, and by use of a grapple hook.

Effects of 2,4-D herbicide treatments on milfoil in whole lakes

Table One shows the number of acres of milfoil in 30 lakes where 52 applications of 2,4-D herbicide were made between 1989 and 1993 and the number of acres of milfoil which occurred in the lake the following years.

Effects of 2,4-D herbicide treatments on milfoil in sites within lakes

Information at the individual treatment site level is necessary to accurately differentiate between a failure of an herbicide treatment to kill milfoil and the spread of milfoil to new areas in a lake. We recorded the number of acres of milfoil in 45 sites treated in nine lakes. Between 1991 and 1994 there were a total of 56 applications of 2,4-D herbicide made to those sites. Sites varied in size between 0.05 acres and 10 acres. We compared the number of acres of milfoil treated with 2,4-D herbicide to the number of acres of milfoil which occurred in the treated site the following year (Table 2).

***2,4-D** continued on next page*

Lake	Littoral acres	1989 acres	1990 acres	1991 acres	1992 acres	1993 acres
Auburn	158	<1*	4	13	50*	>50*
Bald Eagle	615	<1*	19	24	30¥	28
Bavaria	73	<1*	15	4	73	73
Bay	1005	44				One plant §
Bryant	64			44	48	56
Christmas †	76				2	0 *
Clearwater	1455	11	26	38¥	100¥	Unknown*
Crystal †	208				9	3
Dutch †	83	<1*	18	2	27	8¥
Eagle †	194				3	4
Fish †						1
Independence	425	1	24	26	95¥	110*
Island †	56			1.4	0 *	21
Knife	1266		17	0 *	14	23
Little Long †	64			1	2	1
Long	131				11	29
Lotus	182				9	40*
Medicine	397		20	5	110*	Unknown*
Minnewashta	371	<1*	36	36	101*	Unknown*
Oscar	505				23	5
Prior	368			34	136	210¥
Pulaski	122			14	90	18
Rebecca	138	<1*	7	8-	60¥	Unknown*
Riley	110		15	15	31*	39*
Schmidt	34		4	6	34¥	34*
Schutz	40		6	5-	40*	Unknown*
Silver	71				38	1
Sugar	357		0.25	0.25	0*	0*
Wabasso	28				2	0*
Waconia	1660	<1*	6	6	10	38
White Bear	1314	1	8	80¥	96¥	71¥

* No treatment done this year
¥ Only partial treatments done
- At least partially treated with a non-2,4-D herbicide
§ Plant was hand pulled by SCUBA diver
† Lakes used for the individual site analysis

Table 1. History of Eurasian watermilfoil infestations that were treated with 2,4-D herbicide in 31 Minnesota lakes done by the MNDNR during 1989 - 1993. Not all lakes treated during that time are listed here. Total milfoil acres shown for each year. Unless noted entire milfoil infestation was treated.

Response	Number of treatments	Percent of treatments in lakes where milfoil was found in a new site the year following treatment
Milfoil eliminated	24	79%
Milfoil reduced	17	76%
No change	2	100%
Milfoil increased	13	100%
Total	56	84%

Table 2. Response of individually treated sites in the year after application to 2,4-D herbicide application for the control of Eurasian watermilfoil in nine Minnesota Lakes between 1991 and 1994.

2,4-D *continued from previous page*

Results and Discussion

Eurasian watermilfoil was not permanently eradicated from any of the 31 Minnesota lakes where the MNDNR attempted to find and treat all the milfoil with 2,4-D herbicide (Table 1). Fourteen of the 30 lakes where 2,4-D herbicide treatments were evaluated experienced a whole lake decrease in milfoil acreage in the lake one year after treatment (Table 1). In three lakes no milfoil was found one year after treatment with 2,4-D (Christmas Lake, Lake Wabasso, and Sugar Lake). In these lakes, the exotic was rediscovered within three years. These lakes had milfoil populations which were generally smaller (mean size = 1.4 acres) than the average population (mean size = 19.4 acres). It is important to note that we cannot conclusively determine whether milfoil was rediscovered in these lakes because: 1) some plants survived treatment with 2,4-D, 2) some milfoil was missed in the original survey and so was left untreated, 3) all milfoil plants were killed by the herbicide and, 4) milfoil may have been subsequently reintroduced into the lake.

The entire littoral zones of two lakes, Bryant and Bavaria were treated with 2,4-D herbicide in two consecutive years. The first treatment of Bryant, in 1992, reduced the density of milfoil, but did not reduce the number of acres of milfoil (Table 1). The second treatment of the entire littoral zone of Bryant in 1993 also failed to reduce the number of acres of milfoil in the lake. Surveys by Hennepin Regional Park District in 1994 confirmed the presence of milfoil throughout the littoral area of Bryant Lake (Barten and Jereczek, 1995). Treatment of the entire littoral zone of Bavaria Lake during 1992 and 1993 reduced the density of milfoil, but failed to reduce the number of acres of the exotic in the lake.

Between 1989 and 1993, the number of acres of milfoil declined in eight of 31 treated lakes (Bay, Oscar, Sugar, Wabasso, Silver, Christmas, Crystal, and Dutch) (Table 1). Since 1993, the number of acres of milfoil has increased in all of these lakes (unpublished data), despite continued aggressive treatment with 2,4-D herbicide. Sugar and Christmas are the only lakes in the group where the MNDNR still attempts to find and treat all of the milfoil.

Milfoil acres were reduced the year following treatment with 2,4-D herbicide in 75% of the individual treatments which were observed. At 24 (43%) of the treatment sites examined, milfoil could not be found within the treated site the year after treatment. At an additional 18 (32%) of the treatment sites the milfoil acreage at the site was reduced the year after herbicide treatment. Milfoil acreage stayed the same at two of the treatment sites and increased at 13 (23%) of the treatment sites (Table 2).

Although milfoil abundance was often reduced at the treatment sites, it continued to be found in new areas in most of the treated lakes. Regardless of how successful the 2,4-D treatments were at reducing milfoil acreage, there were new milfoil sites in the treated lakes after 84% of the milfoil treatments (Table 2). Sites where milfoil acres increased in size the year following treatment occurred only in lakes where the lake-wide distribution of milfoil increased as well.

There are various factors which can effect the efficacy of 2,4-D to control milfoil. Assuming that milfoil is actively growing, the effect of 2,4-D on plants is determined by the concentration of herbicide that they are exposed to and the duration of exposure (Getsinger and Netherland, 1997). Factors which can reduce the exposure of plants to 2,4-D herbicide include water depth (Adams, 1983), water movement due to wind, convection or advection (Smith et al, 1995), and calcium both in lake water and deposited on plants as marl (Riverdale Chemical Company, 1993).

Though application of 2,4-D generally reduced the acres of milfoil in a site, we usually found some milfoil after treatment. Similarly, Goldsby et al. (1978) observed in Melton Hill Reservoir in Tennessee that treatment of milfoil colonies throughout the entire reservoir with a granular formulation of the butoxyethyl ester of 2,4-D was effective in reducing total acres of milfoil; although surviving colonies remained throughout the reservoir.

Implications for Management

The MNDNR's experience with attempts to use 2,4-D herbicide to eradicate milfoil is consistent with experience elsewhere, which indicates that efforts to eradicate this exotic are "...rarely, if ever, likely to succeed" (Smith and Barko, 1990:60). Our experience in attempting to prevent the spread of milfoil within a lake is also consistent with the observation by Smith and Barko (1990:60) that efforts to prevent the spread of milfoil within a lake may slow its expansion, but rarely prevent its dispersion within a lake.

In a lake where the plant is not widespread, treatment of all sites found to have milfoil can limit the abundance of the exotic in these sites, but it is unlikely to prevent the spread of milfoil to additional sites within the lake. The MNDNR believes that realistic goals for use of 2,4-D as well as other herbicides and methods of control in lakes where milfoil is widespread are to:

- give users of the lakes relief from the nuisances caused by milfoil, and
- reduce the amount of milfoil near water accesses or boat ramps to reduce the chances for boaters to accidentally transport fragments of the exotic to another body of water.

Currently there are 105 water bodies in Minnesota known to be infested with Eurasian watermilfoil. During the summer of 1998 the MNDNR treated milfoil in seven lakes where attempts were made to reduce the lakewide abundance of the plant, and funds were provided to assist in the control of nuisance milfoil growths in an additional 34 lakes (Exotic Species Program 1999).

Acknowledgments

Many people have assisted in the control of Eurasian watermilfoil in Minnesota by doing lake surveys for milfoil and by supervising herbicide applications. I would like to acknowledge the work of MNDNR staff Jed Anderson, Terry Ebinger, Dan Swanson, Mike Halverson, Rick Walsh, Jim Stewart, Howard Krosch, Steve Enger, Marilyn Danks, Luke Skinner, Mike Patrick, Tom Sak, and Donna Perleberg and MNDNR summer interns Chris Borland, Pat Rivers, Greg Rowley, Eric Jensen, Jim Smart, Denise Wolvin, Reva Kos, Annette Dzieweczynski, John Schoon, and Jill Ronning. In addition I would like to thank Chip Welling, Steve Enger, Dave Wright, Nicole Hansel-Welch, and Donna Perleberg for their assistance in reviewing earlier drafts of this report.

Wendy J. Crowell is the Eurasian Watermilfoil Program Coordinator for the Minnesota Department of Natural Resources, Ecological Services Station, 500 Lafayette Road, St. Paul, MN, 55155-4025. e-mail: wendy.crowell@dnr.state.mn.us

2,4-D *continued on Page 46*

Ruffe *continued from page 37*

developed lateral line system, including a network of sensory pores in the head, which also enables them to function under low or no light condition. Ruffe appear to avoid light and will move to deeper, darker waters in the day and return to shallow water at night (Ogle et al. 1995).

Should We Be Concerned?

When ruffe were first found in the Duluth Harbor there was great concern that they would increase rapidly and result in the demise of an important walleye fishery in the harbor then spread to the lower Great Lakes and affect important walleye and yellow perch fisheries in Lakes Michigan, Huron, and Erie. Evidence from Europe also suggested that ruffe would consume whitefish eggs (Adams and Tippett 1991) which could pose a problem for valuable North American whitefish populations in the Great Lakes. As expected, ruffe did increase and by 1991, estimated at over two million fish, became the most abundant species found in St. Louis River bottom trawl assessments (Bronte et al. 1998). While ruffe increased, abundances of other common forage fish such as perch, shiners, troutperch, and bullheads appeared to decrease (Jensen et al 1996).

Experimental and observational studies in Europe indicated that ruffe could out-compete European perch (*Perca fluviatilus*) and other fish (Bergman 1991, Bergman and Greenberg 1994) for benthic food resources, particularly in low light or poor water clarity conditions. However, some studies at the 1997 International Symposium on Ruffe (Gunderson 1998, Gunderson et al. 1998) suggested that ruffe would have fewer impacts than expected (e.g., Bronte et al. 1998) and projected the view that ruffe would be a nuisance but might not cause major disruptions to fish communities and invaded ecosystems as earlier predicted. Although a lab study indicated significant diet overlap between ruffe and perch and the potential for competition in the wild (Fullerton et al. 1998, see also Savino and Kolar 1996), Brazner et al. (1998) indicated that vegetated coastal habitats might provide native fish a refuge from ruffe. Bronte et al. (1998) suggested that declines in St. Louis River Harbor native fish communities following the establishment of ruffe reflected natural variation unrelated to the increasing abundance of ruffe and were not due to ruffe impacts alone. These results were interpreted by some to mean the ruffe would have little effect on native fish communities.

More recent research suggests that although ruffe may not have the impact of zebra mussels or *Hydrilla*, they do have the potential to affect native fish such as perch and may also have broader ecosystem-level effects. In research funded by Minnesota Sea Grant, Henson and Newman (*in press*) found that ruffe food consumption and digestion are less influenced by temperature than are perch, supporting other work that indicates that ruffe are temperature generalists (Bergman 1987, Hölker and Thiel 1998). Ruffe can better locate, consume and process food at colder temperatures than perch. More importantly, however, Henson and Newman (*in press*) found that ruffe grow less efficiently than perch on a diet of macroinvertebrates. In other words, compared to perch, substantially more benthic prey items are required to support growth of an equal biomass of ruffe. Given the rapid increase of ruffe populations, they are likely affecting food resources available to native fishes.

Figure 1. Trout Perch, Perch, and Ruffe *(Gymnocephalus cernuus L.,* formerly *Acerina cernuua).*

The validity of these observations was further extended by a series of enclosure experiments conducted in a lake tributary to the St. Louis River. The four meter diameter enclosures extended from the water surface to the lake bottom. Each enclosure was stocked with varying densities of ruffe and perch. Because the enclosures were open to the natural sediments, they contained a natural array of benthic and planktonic forage species. These experiments clearly showed that ruffe would outcompete perch for food. Even when the effect of overall fish density was accounted for, perch growth was suppressed significantly in the presence of ruffe (Henson 1999, Henson et al. *unpublished manuscript*). Conversely, perch had little effect on ruffe growth. A combination of interference and resource competition appeared to be the cause of the suppressed perch growth rates. Ruffe generally consumed two to three times more food than perch in the same mesocosm. Furthermore, both overall fish density and presence of ruffe had significant effects on benthic prey density (Schuldt et al. 1999, Schuldt et al., unpublished manuscript). The effects on prey density were not extreme, however, given the relatively short duration of the experiments (5-6 weeks). Due to the higher foraging efficiency (Bergman 1987, Savino and Kolar 1996) but lower conversion efficiency of ruffe (Henson and Newman *in press*), and the explosive population growth and long term persistence of high density ruffe populations in natural systems (Bronte et al. 1998, Popova et al. 1998), it is likely that ruffe will have substantial long term effects on benthic food webs and native fish communities (see also Winfield et al. 1998).

Yet, it is likely that these effects will be difficult to detect in natural systems given natural variability in both benthic resources and fish populations. The difficulty is that these effects will likely be persistent and may be cumulative. Simulation models by Brenton (1998) of ruffe-perch interactions in the St. Louis River Estuary indicate that ruffe can suppress perch population abundance by 41% compared to baseline conditions without ruffe. If both species were constrained to one or few benthic prey for food, ruffe would always drive perch to extinction within 25 years. Although we must use caution when extrapolating from simulated populations, these

Ruffe *continued on next page*

results suggest that drastic effects on perch may take many years to appear, but, at least under model conditions, ruffe ultimately may have serious consequences for perch.

Can They Be Stopped or Controlled?

When ruffe were first recognized in the St. Louis River system several options were considered for control. Chemical control was rejected because it would have a major effect on native fishes, it likely would not eradicate ruffe, and the size of the area would make chemical control prohibitively expensive (Busiahn 1997). It was decided that enhancing native predators, such as walleye and northern pike, via stocking and angling restrictions, would be the best approach. Unfortunately, the native predators did not consume many of the spiny ruffe in the early years of the program (Ogle et al. 1996) and the enhanced predator populations may have contributed to the declines of native fishes while the ruffe population continued to increase. Although walleye and northern pike predation on ruffe has slightly increased in recent years (Mayo et al. 1998), perhaps in part due to reduced availability of preferred prey, the levels of predation are too low to control the ruffe population (Mayo et al. 1998). It is now estimated that the ruffe infestation is at six million fish. Thus biological control with generalist predators does not appear to be an effective control measure.

Ruffe are well established in the upper Great Lakes and will likely spread to the lower Great Lakes and inland waters.

Since the initial establishment of ruffe, some progress has been made on selective chemical controls. Although not highly specific to ruffe, several general piscicides are more toxic to ruffe than many native species and some degree of selective control can be achieved (Boogaard et al. 1996, Busiahn 1997). However, chemical control is expensive and often controversial (e.g., Buhsian 1997) and until highly selective toxicants are developed it is unlikely that chemical control will be used extensively, except perhaps for isolated limited infestations far outside the ruffe's current range.

One of the aims of the Ruffe Control Committee of the ANS Task Force, which was formed in 1992 to recommend actions to limit the spread and impact of ruffe, was to inhibit their spread from the St. Louis River and western Lake Superior to eastern Lake Superior and the other Great Lakes (Busiahn 1997). Chemical control and mechanical harvesting were proposed for the eastern-most areas colonized by ruffe. These measures proved controversial and were never substantially implemented, and ruffe slowly spread along the south shore of Lake Superior to Ontonagan, Michigan. In 1995, ruffe appeared in the Thunder Bay River at Alpena, Michigan on Lake Huron (Busiahn 1997), likely the result of ballast water transfer from Duluth Harbor (Busiahn 1997). Given that spread out of Lake Superior had now occurred, the goals were revised to prevent or delay further spread through the Great Lakes and to prevent spread to inland waters. Ruffe have not yet spread to inland waters, in part due to the extensive educational campaigns by Great Lakes states and provinces, particularly Minnesota. Continued education programs, backed by laws regulating transport and water transfers, should help delay or prevent spread to inland waters and other watersheds.

Although traditional mechanical, chemical, and biological control techniques have not proven effective, recent research holds promise for inhibiting spread and possibly controlling populations. Maniak et al. (*in review*) have shown that ruffe are repelled by alarm odors released by injured ruffe. This alarm substance might be useful to exclude ruffe from particular areas, such as ballast water intakes, spawning grounds or passages to other inland waters. Murphy et al. (1999) have determined that ruffe release a sex pheromone that might eventually be used to attract and trap ruffe in the wild. Flynn et al. (1998) have developed antibodies for ruffe sperm that might be capable of disrupting reproduction. Further work on these systems is required to determine if they can be used in natural field conditions.

Prospect

Ruffe are well established in the upper Great Lakes and will likely spread to the lower Great Lakes and inland waters. However, continued educational programs and legislation to prevent their transport and introduction to other water bodies will greatly prevent and slow their spread. Given their potential for serious ecological impacts and thus economic impacts, projected at $24 to $214 million annually (Leigh 1998), efforts to inhibit and delay their spread should not cease. Further research may turn up more feasible control measures in the interim and even a five or ten-year delay could be enough to develop effective controls that would prevent further range expansion.

Raymond M. Newman is an Associate Professor at the Department of Fisheries and Wildlife, University of Minnesota, 1980 Folwell Avenue, St. Paul, MN 55108 U.S.A. rum@fw.umn.edu

For more information visit the following web sites:
http://www.fw.umn.edu/research/ruffe/
http://www.ansc.purdue.edu/sgnis/www/ruffe.htm
http://www.great-lakes.net/envt/exotic/ruffe.html
http://nas.er.usgs.gov/fishes/accounts/percidae/gy_cemn.html

Literature Cited

Adams, C. E., and R. Tippett. 1991. Powan, Coregonus lavaretus (L.), ova predation by newly introduced ruffe, Gymnocephalus cernuus (L.), in Loch Lomond, Scotland. Aquaculture and Fisheries Management 22: 239-246.

Bergman, E. 1987. Temperature-dependent differences in foraging ability of two percids, Perca fluviatilis and Gymnocephalus cernuus. Environmental Biology of Fishes 19:45-53.

Bergman, E. 1991. Changes in abundance of two percids, Perca fluviatilis and Gymnocephalus cernuus, along a productivity gradient: relations to feeding strategies and competitive abilities. Canadian Journal of Fisheries and Aquatic Sciences 48: 536-545.

Bergman, E., and L. A. Greenberg. 1994. Competition between a planktivore, a benthivore, and a species with ontogenetic diet shifts. Ecology 75:1233-1245.

Boogaard, M.A., T.D. Bills, J.H. Selgeby, and D.A. Johnson. 1996. Evaluation of piscicides for control of Eurasian ruffe (Gymnocephalus cernuus). North American Journal of Fisheries Management. 16: 600-607.

Ruffe *continued on next page*

Ruffe *continued from previous page*

Brazner, J. C., D. K. Tanner, D. A. Jensen, and A. Lemke. 1998. Relative abundance and distribution of ruffe (Gymnocephalus cernuus) in a Lake Superior coastal wetland fish assemblage. Journal of Great Lakes Research 24: 293-303.

Brenton, B.D. 1998. Simulating the effects of invasive ruffe on walleye and yellow perch population dynamics in Great Lakes waters. M.S. Thesis, University of Michigan, Ann Arbor. 103 pp.

Bronte, C. R., L. M. Evrard, W. P. Brown, K. R. Mayo, and A. J. Edwards. 1998. Fish community changes in the St. Louis River estuary, Lake Superior, 1989-1996: Is it ruffe or population dynamics? Journal of Great Lakes Research 24: 309-318.

Busiahn, T. R. 1997. Ruffe control: A case study of an aquatic nuisance species control program. Pages 69-86 in F. M. Ditri (eds). Zebra Mussels and Aquatic Nuisance Species. Ann Arbor Press, Inc, Chelsea, MI.

Flynn, K., P. Schoff, and J. Holy. 1998. Localization of ruffe testicular antigens by a panel of antibodies Journal of Great Lakes Research 24: 379-382.

Fullerton, A. H., G. A. Lamberti, D. M. Lodge, and M. A. Berg. 1998. Prey preferences of Eurasian ruffe and yellow perch: comparison of laboratory results with composition of Great Lakes benthos. Journal of Great Lakes Research 24:319-328.

Gunderson, J. 1998. Overview of the International Ruffe Symposium. Aquatic Nuisance Species Digest 2: 34-35.

Gunderson, J. L., M. R. Klepinger, C. R. Bronte, and J. E. Marsden. 1998. Overview of the International Symposium on Eurasian Ruffe (Gymnocephalus cernuus) Biology, Impacts, and Control. Journal of Great Lakes Research 24: 165-169.

Henson, F.G. 1999. Competition between ruffe (Gymnocephalus cernuus) and yellow perch (Perca flavescens) and the influence of temperature on growth and gastric evacuation of ruffe. MS Thesis, University of Minnesota, St. Paul, MN.

Henson, F.G. and R.M. Newman. In press. Effect of temperature on growth at ration and gastric evacuation rate of ruffe (Gymnocephalus cernuus). Transactions of the American Fisheries Society.

Hölker, F., and R. Thiel. 1998. Biology of ruffe (Gymnocephalus cernuus (L.)) - a review of selected aspects from European literature. Journal of Great Lakes Research 24:186-204.

Leigh, P. 1998. Benefits and costs of the ruffe control program for the Great Lakes fishery. Journal of Great Lakes Research 24: 351-360.

Maniak, P.J., R.D. Lossing, and P.W. Sorensen. In review. Injured Eurasian ruffe, Gymnocephalus cernuus, release an alarm pheromone which may prove useful in their control. Journal of Great Lakes Research.

Mayo, K. R., J. H. Selgeby, and M. E. McDonald. 1998. A bioenergetics modeling evaluation of top-down control of ruffe in the St. Louis River, western Lake Superior. Journal of Great Lakes Research 24: 329-342.

Murphy, C.A., P.J. Maniak, and P.W. Sorensen. 1999. Functional and biochemical characterization of a novel sex pheromone in the Eurasian ruffe, Gymnocephalus cernuus. Ninth International Zebra Mussel and Aquatic Nuisance Species Conference, Duluth, Minnesota, April 1999.

Ogle, D. H. 1998. A synopsis of the biology and life history of ruffe. Journal of Great Lakes Research 24: 170-185.

Ogle, D. H., J. H. Selgeby, R. M. Newman, and M. G. Henry. 1995. Diet and feeding periodicity of ruffe in the St. Louis River Estuary, Lake Superior. Transactions of the American Fisheries Society 124:356-369.

Ogle, D.H., J. H. Selgeby, J. F. Savino, R. M. Newman, and M. G. Henry. 1996. Predation on ruffe by native fishes of the St. Louis River Estuary, Lake Superior, 1989-1991. North American Journal of Fisheries Management 16:115-123.

Popova, O. A., Y. S. Reshetnikov, V. I. Kiyashko, Y. Y. Dgebuadze, and V. N. Mikheev. 1998. Ruffe from the former USSR: Variability within the largest part of its natural range. Journal of Great Lakes Research 24: 263-284.

Pratt, D. M., W. H. Blust, and J. H. Selgeby. 1992. Ruffe, Gymnocephalus cernuus: newly introduced in North America. Can. J. Fish. Aquat. Sci. 49: 1616-1618.

Savino, J. F., and C. S. Kolar. 1996. Competition between nonindigenous ruffe and native yellow perch in laboratory studies. Transactions of the American Fisheries Society 125:562-571.

Schuldt, J.A., C. Richards, and R.M. Newman. 1999. Effects of Eurasian ruffe on food resources and native yellow perch in experimental mesocoms. Bulletin of the North American Benthological Society 16(1): 163.

Stepien, C. A., A. K. Dillon, and M. D. Chandler. 1998. Genetic identity, phylogeography, and systematics of ruffe Gymnocephalus in the North American Great Lakes and Eurasia. Journal of Great Lakes Research 24: 361-378.

Winfield, I. J., R. Rosch, M. Appelberg, A. Kinnerback, and M. Rask. 1998. Recent introductions of the ruffe (Gymnocephalus cernuus) to Coregonus and Perca lakes in Europe and an analysis of their natural distributions in Sweden and Finland. Journal of Great Lakes Research 24: 235-248.

2, 4-D *continued from page 43*

Literature Cited

Adams, R.W. 1983. Guidelines for the use of the herbicide 2,4-D to control Eurasian watermilfoil in British Columbia. Lake Restoration, Protection and Management Proceedings of the 2nd Annual Conference, North American Lake Management Society. October, 1982, Vancouver, British Columbia. US EPA. 200 -213.

Aiken, S. G., P. R. Newroth, and I. Wile. 1979. The Biology of Canadian Weeds. 34. Myriophyllum spicatum L. Can. J. Plant Sci. 59: 201 -215.

Riverdale C 1993. Riverdale herbicide. Specimen label. Riverdale Chemical Company, Glenwood Illinois, 60425.

Barten, J.M., and J.C. Jereczek. 1995. Studies on the incidence, control, and affect of Eurasian watermilfoil (Myriophyllum spicatum) in lakes adjacent to Hennepin Parks. Unpublished report by the Suburban Hennepin Regional Park Reserve District, 3800 County Rd.. 24, Maple Plain, MN 55359 submitted to the Metropolitan Council, 230 East Fifth St., St. Paul, MN 55101.

Couch, R. and E. Nelson. 1985. Myriophyllum spicatum in North America. Proceedings First International Symposium on Watermilfoil (Myriophyllum spicatum) and related Haloragaceae species. July 23 -24, 1985. Vancouver, B.C., Canada. Aquatic Plant Management Soc. Vicksburg, Miss. 8-18.

Getsinger, K.G. and M.D. Netherland. 1997. Herbicide concentration/exposure time requirements for controlling submersed aquatic plants: summary of research accomplishments. Misc. Paper A-97-2. U.S. Army Corps of Engineers, Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, Mississippi, 39180.

Goldsby, T.L., A.L. Bates and R. A. Stanley. 1978. Effect of water level fluctuation and herbicide on Eurasian watermilfoil in Melton Hill Reservoir. J. Aquatic Plant Management. 16:34-38.

Exotic Species Program 1999. Harmful exotic species of aquatic plants and wild animals in Minnesota: Annual Report for 1998. Minnesota Department of Natural Resources, St. Paul, MN.

Smith, C.S., and J. Barko. 1990. Ecology of Eurasian watermilfoil. J. Aquatic Plant Management. 28:55-64.

Smith, C.S., W.F. James, J.W. Barko, and H.L. Eakin. 1995. Studies of water movement in vegetated and unvegetated littoral areas. Technical Report A-95-3, Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, Mississippi, 39180.

Upcoming Meetings

National ANS Task Force Meeting

December 1-2, 1999
U.S. Fish and Wildlife Service Headquarters
Arlington, Virginia
Contact: Sharon Gross, USFWS, 703-358-2308
Sharon_gross@fws.gov

61st Midwest Fish and Wildlife Conference

December 5-8, 1999
Sheraton Chicago Hotel and Towers
Chicago, Illinois
Contact: Glen Kruse, Illinois DNR, 217-785-8774
gkruse@dnrmail.state.il.us

International Conference on Risk Analysis in Aquatic Animal Health

February 8-10, 2000
Paris, France
Contact: Dr. K. Suguira, 33-1-44-151888
k.sugiura@oie.int

10th International Aquatic Nuisance Species and Zebra Mussel Conference

February 13-17, 2000
Westin Harbour Castle
Toronto, Ontario, Canada
Contact: Elizabeth Muckle-Jeffs, Conference Administrator, 1-800-868-8776
profedge@renc.igs.net

Send meeting announcements to:
Jeanne Prok, ANS Digest
2500 Shadywood Rd., Navarre, MN 55331
e-mail: JeanneR@freshwater.org
Deadline for the next issue is January 15, 2000

News from the Great Lakes Panel on Aquatic Nuisance Species

ANS UPDATE

Summer/Fall 1999 Volume 5, No. 3

Great Lakes Panel Update

The Panel met Oct. 19-20, 1999 in Chicago, Ill. The meeting featured discussions on the Great Lakes Action Plan, draft recommendations from the Panel's workshop on ballast water management, and an update on federal legislation and appropriations. The three Panel committees reviewed a draft Panel workplan for FY2000 and associated issues.

The Panel's business meeting was followed by the Great Lakes Nonindigenous Invasive Species Workshop, sponsored by the U.S. EPA's Great Lakes National Program Office with assistance from the Great Lakes Commission. A briefing paper on the scope of invasive species in the region, prepared by Great Lakes Commission staff, was distributed to all participants to generate dialogue and information exchange on prevention, control, detection/monitoring and outreach/education concerning nonindigenous species. **Contact:** Kathe Glassner-Shwayder, Great Lakes Commission, 734-665-9135, shwayder@glc.org.

Washington Watch

Both the House and Senate this year made ANS control a priority within serious budget constraints. All NISA authorized programs are slated for funding at or above the FY1999 level. Report language accompanying the bills further emphasizes the importance Congress places on ANS control efforts. The House directed the Sea Grant program to conduct research related to public health risks posed by pathogens released in ballast water discharges in ports around the country. House, Senate and conference report language accompanying the Transportation Appropriations bill all reflect a need for increased emphasis on U.S. Coast Guard research efforts addressing ballast water issues. **Contact:** Rochelle Sturtevant, Senate Great Lakes Task Force, Northeast Midwest Institute, 202-224-1211, rochelle_sturtevant@levin.senate.gov.

News from Around the Basin

ILLINOIS: The state ANS management plan is now ready to be submitted to the ANS Task Force. In October DNR and USFWS biologists found live specimens of round goby in the Sanitary and Ship Channel in locations as far as eleven miles downstream from the proposed electrical barrier site to be constructed by the U.S. Army Corps of Engineers (USACE) by May of 2000. **Contact:** Rod Horner, IL DNR, 309-968-6837, RHORNER@dnrmail.state.il.us.

INDIANA: A zebra mussel page is being designed for the IN DNR Division of Fish and Wildlife. This site will include a list of locations where zebra mussels have been observed in Indiana, regulations, policy statements, and links to other web sites. **Contact:** Randy Lang, IN DNR, 317-232-4094, lang@fw.dnr.in.us.

MINNESOTA: The DNR has focused recent efforts on increasing public awareness of the ANS issue. Almost 250 copies of the TV special "Aquatic Invaders: The Cutting Edge Technology Report" have been distributed. To enhance boater contact, DNR watercraft inspectors began visiting high-use, non-infested lakes to raise awareness of ANS laws. Sea Grant and the DNR staff assisted with the production of a national ANS video for boaters. The video, starring John Ratzenberger (Cliff Claven from "Cheers"), is expected to be released this winter. **Contact:** Jay Rendall, MN DNR, jay.rendall@dnr.state.mn.us.

NEW YORK: Earlier this year, New York submitted a proposal to the ANS Task Force requesting federal funding for FY1999. Two of the three proposed projects received funding: continuation of the Finger Lakes zebra mussel monitoring project, and rewriting New York's state ANS management plan. New York's original management plan was written prior to March 1998 (before model state guidance was developed by the ANS Task Force). New York will revise the existing plan to be consistent with the new federal guidance. **Contact:** Bill Culligan, NYS DEC, 716-366-0228, nysdecdk@netsync.net.

OHIO: Ohio has received a third year of funding from the USFWS for its state ANS management plan. The funding will be used for the implementation of the following initiatives: national and regional coordination; interagency and constituent coordination; information assessment and development; and ANS research, monitoring and control. The ANS Advisory Team and Steering Committee are in the process of completing a review of Ohio's existing ANS laws, along with the Panel's model guidance. Based on their reviews and input, appropriate changes may be recommended to state agencies. **Contact:** Randy Sanders, OH DNR, 614-265-6344, randy.sanders@dnr.state.oh.us.

ONTARIO: The MNR is working in partnership with the Canadian Aquarium Clubs Association to create a fish rescue program to reduce the release of aquarium pets. Efforts are underway to establish a toll-free hotline and a network of aquarium clubs and retailers that will take unwanted aquarium pets. **Contact:** Ed Paleczny, ON MNR, 705-755-1890, ed.paleczny@mnr.gov.on.ca.

PENNSYLVANIA: Sea Grant instituted a new system for anglers to report goby catches to the Sea Grant office. Round gobies have been tracked from the Ohio/Pennsylvania state line to the Presque Isle Bay channel. Reports from anglers confirm their spread from the Ohio to the New York state line. Assessments from The Fish and Boat Commission show that goby populations have literally exploded in Pennsylvania waters of Lake Erie in 1999. **Contact:** Kelly Burch, PA DEP, 814-332-6816, burch.kelly@dep.state.pa.us.

WISCONSIN: Data collected in July 1999 on the Mississippi River at Prairie du Chien by the USACE indicates greater than 90% mortality of native mussels and no recruitment due to zebra mussel infestation. Monitoring results from DNR staff and volunteers confirm zebra mussels in six additional lakes, including Lake Winnebago, Wisconsin's largest inland lake. Next spring, the DNR will begin posting signs on uninfested waters to alert boaters of the precautions they should take to avoid ANS spread. **Contact:** Ron Martin, WI DNR, 608-266-9270, martir@dnr.state.wi.us.

National ANS Task Force

The most recent ANS Task Force meeting was held in August in Olympia, WA. The Task Force discussed several issues, including a recommendations to establish committees to develop a prevention and management programs for Caulerpa taxifolia and the Chinese mitten crab; establishment of a Gulf Regional Panel; and a request to the Western Regional Panel to develop a generic protocol for emergency response to aquatic invasive species. The next meeting of the ANS Task Force is scheduled in Washington, D.C. on Dec. 1-2, 1999 (see Upcoming Events). **Contact:** Sharon Gross, USFWS, Acting Executive Secretary, ANS Task Force, 703-358-2308, Sharon_Gross@fws.gov.

Upcoming Events

Meeting of the National ANS Task Force. Dec. 1-2, 1999; USFWS Headquarters, Arlington, VA. **Contact:** Sharon Gross, USFWS, Acting Executive Secretary, ANS Task Force, 703-358-2308, Sharon_Gross@fws.gov.

Taking Stock of Our Future: A Conference on the Impacts of Fish Stocking in the Great Lakes, Dec. 5, 1999, Chicago, Ill., in conjunction with the Midwest Fish & Wildlife Conference. **Contact:** Jennifer Nalbone, Great Lakes United, 716-886-0142, jen@glu.org.

10th International Aquatic Nuisance Species and Zebra Mussel Conference. Feb. 14-18, 2000. Westin Harbour Castle, Toronto, Ontario, Canada. **Contact:** Elizabeth Muckle-Jeffs, 800-868-8776, profedge@renc.igs.net or conference web site, www.zebraconf.org.

On The Bookshelf

Nonindigenous Freshwater Organisms: Vectors, Biology, and Impacts. 1999. Edited by Renata Claudi and Joseph Leach. Lewis Publishers.

Fanwort Invades Ontario Waters. August 1999. **Contact:** Ed Paleczny, ON MNR, 705-755-1890, ed.paleczny@mnr.gov.on.ca.

Attention Anglers: New Bait Import and Harvest Regulations. **Contact:** Chris Brousseau, ON MNR, Chris.Brousseau@mnr.gov.on.ca

Full copies of the *ANS Update*, a quarterly newsletter prepared by the Great Lakes Panel on Aquatic Nuisance Species, are available upon request from the Great Lakes Commission. The feature article of this issue (Vol. 5, No. 3) is authored by William J. Rendall, Minnesota Department of Natural Resources, and is titled, *National Voluntary ANS Guidelines: A Strategy to Interrupt Recreational Pathways of Spread.* **Contact:** Kathe Glassner-Shwayder, Great Lakes Commission, 734-665-9135, shwayder@glc.org.

FRESHWATER FOUNDATION

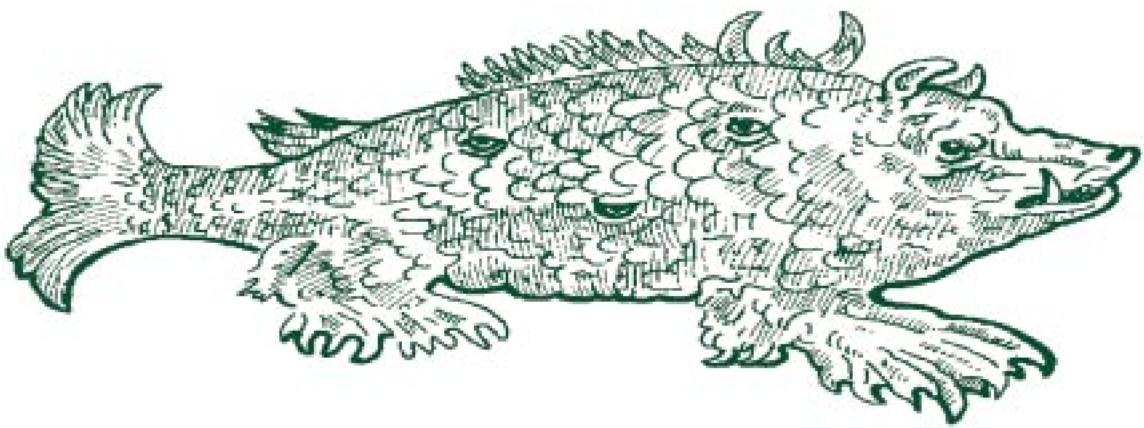
Aquatic Nuisance Species Digest

GRAY FRESHWATER CENTER

2500 Shadywood Road • Navarre, MN 55331

Did this newsletter reach the right desk?

If not, please let us know so we can correct the name and/or the address on our mailing list. If you know someone who would like to be added to our mailing list, or if you wish to have your own name dropped, please send that information to the address above.



We don’t want to be a nuisance...

...but we would like your help! The *ANS Digest* is published by the Freshwater Foundation and is funded by the National Sea Grant Program through the Minnesota Sea Grant College Program. Due to budget limitations and escalating costs, we ask that you help by making a donation to support the *Digest.* Your assistance is appreciated.

❑ ***Yes,*** I want to contribute.

Friend	❑ \$10-\$19
Patron	❑ \$20-\$49
Sponsor	❑ \$50 or more
Other	❑ \$______

____
Name

____
Address

____

____
City, State, Zip

Make checks payable to:
Freshwater Foundation

Mail to: ANS Digest
Gray Freshwater Center
2500 Shadywood Road
Navarre, MN 55331

Thank You!