RUFFE CONTROL PROGRAM

Submitted to the

Aquatic Nuisance Species Task Force

by the

Ruffe Control Committee

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[Note: This is a revised draft of the Ruffe Control Program that was approved by the Aquatic Nuisance Species Task Force in 1995. New information and changing circumstances required its revision, as explained within. This draft was prepared for review by the Task Force prior to distribution for public review and comment. Further changes and refinements are expected prior to final approval.]

Updated on:

Contents:

Related Topic Areas:

Surveillance for Ruffe in the Great Lakes, 1998, 1999.
Minutes of the Ruffe Control Committee

INTRODUCTION

The ruffe (*Gymnocephalus cernuus*), a Eurasian fish of the perch family, was introduced to North America in the 1980's, most likely through the ballast water of a seagoing vessel (Pratt et al. 1992). Ruffe larvae were first collected in Duluth Harbor[(1)] in 1986. By 1990, ruffe were the most abundant fish in samples taken from the harbor, and their abundance has continued to increase since (Edwards 1995).

The range of ruffe also expanded. By 1993, ruffe occupied bays and tributaries along Lake Superior's south shore through State of Wisconsin waters, and in 1994 were detected in the Ontonagon River, Michigan, 260 km east of Duluth Harbor. Ruffe have been found intermittently in the Canadian port of Thunder Bay since 1991, apparently transported there in ballast water from Duluth (Slade et al. 1995). In 1995 ruffe were first detected in Lake Huron, in the lower Thunder Bay River at the port of Alpena, Michigan.

The ruffe has become established in nearshore waters of western Lake Superior. Fishery experts concur that eradication is not possible. The ruffe is capable of rapid population increase and range expansion. However, the oligotrophic waters of Lake Superior have slowed its spread. Due to its small size, the ruffe has no current commercial or recreational fishery value. The ruffe is a bottom-dweller; it consumes benthic insects and avoids light. Ruffe have the potential to compete with native fishes, such as yellow perch (Savino and Kolar 1996) and to consume large quantities of eggs of commercially important lake whitefish and similar species (*Coregonus* spp.) (DeSorcie and Edsall 1995). Changes in the ruffe population in the Duluth Harbor are inversely correlated with populations of some native fishes (Edwards 1995).

In 1991 the Great Lakes Fishery Commission (GLFC) organized a special task force of fisheries biologists and administrators to evaluate the status of ruffe in the Great Lakes and to examine what threat it might pose to fishery resources. The Ruffe Task Force concluded that the ruffe is a serious threat to North American fishery resources, and that, unless prompt measures are taken to prevent its further spread, the ruffe will continue to be transported or migrate to new sites in the Great Lakes and much of North America (Ruffe Task Force 1992).

The Aquatic Nuisance Species Task Force (ANS Task Force) determined in April 1992 that the ruffe is an aquatic nuisance species as defined by law(2), that control of ruffe is warranted, and that the control program proposed by the Ruffe Task Force of the Great Lakes Fishery Commission addresses the legal requirements.

The Ruffe Control Committee (Committee) was appointed by the ANS Task Force in July 1992 to develop a control program that will minimize the risk of harm to the environment and the public health and welfare. The goals of the Committee, specified by the ANS Task Force, are:

- to refine the control program,
- to assist in soliciting comments on the control program,
- to identify cooperators to conduct the control program,
- and to provide oversight if the program is approved by the Task Force.

The work of the Committee is guided by the procedures described in the *Aquatic Nuisance Species Program* developed by the ANS Task Force; by the 1992 report *Ruffe in the Great Lakes: A Threat to North American Fisheries* by the GLFC Ruffe Task Force; and by a considerable and growing body of research and monitoring information on ruffe in North America and Europe.

The Committee has met eight times. Two of the meetings included field trips to view ruffe and their habitat. In addition, the Committee held two conference calls, organized a meeting of a ballast water working group, held a session on ruffe biology, and helped to organize meetings and a field trip on the Chicago Sanitary and Ship Canal.

Two companion documents were prepared for the Ruffe Control Committee, predicting environmental and economic outcomes of alternative actions. An "Environmental Assessment", was prepared by the Fish and Wildlife Service dated February 18, 1994.

"Benefits and Costs of the Ruffe Control Program for the Great Lakes Fishery" was prepared by the National Oceanic and Atmospheric Administration, dated December 1, 1994. In early 1995, the Committee sponsored five public meetings throughout the Great Lakes basin to provide information and solicit comment from the public. The comments were described in "Summary of Comments and Recommendations on the Ruffe Control Program", dated June 30, 1995.

The *Ruffe Control Program* was submitted to the ANS Task Force as a final product on June 30, 1995. After ruffe were discovered in Lake Huron in early August 1995, the goal of the Program, (i.e. to contain ruffe to western Lake Superior) was obsolete. The Committee coordinated its November 1995 meeting with the Great Lakes Fishery Commission's Council of Lake Committees (CLC), a group of senior fishery administrators from all Great Lakes fishery jurisdictions. The revised goal and objectives presented here were developed in close coordination with the CLC. The process of developing the control program was described as a case study in aquatic nuisance species control by Busiahn (1996).

GOALS AND OBJECTIVES

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The goal of the ruffe control program is: ***to prevent or delay the further spread of ruffe through the Great Lakes and prevent their spread to other inland lakes and watersheds***.

The goal was modified by the Committee at its meeting of November 9, 1995. The goal of the earlier version of the Program, to contain ruffe to western Lake Superior, became obsolete when ruffe were detected in a tributary to Lake Huron in August 1995.

The program has eight objectives. They are not listed in priority order. All components are necessary to achieve the goal of the program. Some of the activities will be more costly or more visible than others, but this is not an indication of their importance.

- **Population reduction**: Eliminate or reduce reproducing populations, using appropriate technologies, where feasible.

- **Ballast water management**: Minimize the transport of ruffe from western Lake Superior through ballast water management, and support the development of technologies to prevent transport.

- **Population Investigation**: Continue and expand investigations of ruffe populations to evaluate the impact on affected fish communities and to provide information necessary to plan, implement, and evaluate control activities.

- **Surveillance**: Conduct surveillance sampling in likely locations to find newly established populations of ruffe, and designate a single office to compile collections of ruffe.

- **Fish Community Management**: Recommend fish management practices that will improve resilience of fish communities against invasion or dominance by ruffe.

- **Education**: Develop and promote information and education programs to identify ruffe so that they will not be transported alive and so that they will be killed and reported if taken.

- **Bait fish Management**: Assist jurisdictions in developing model language for regulation of bait harvest and possession.

- **Chicago Sanitary and Ship Canal**: Consider options to prevent the movement of ruffe from the Great Lakes to the Mississippi watershed via the Chicago, Des Plaines, and Illinois Rivers.

REQUISITES TO THE CONTROL PROGRAM

International cooperation between agencies in the United States and Canada is essential to a successful ruffe control program in the Great Lakes. Canadian and U.S. fishery agencies have different authorities, responsibilities, and roles. Public attitudes and access to the political systems are different in the two nations. Toxicants registered for fishery use are also different. Implementation of complementary programs cannot be taken for granted. GLFC and its Lake Committees should be the forum in which governments develop common goals and international communication, cooperation, and coordination. Preventing the spread of ruffe in domestic inland waters will not require the same degree of international cooperation.

Cooperation among Federal, state, and tribal governments and the private sector is also essential. Through representation on the ANS Task Force and the Ruffe Control Committee, government agencies and private interests have jointly developed this control program (Appendix 1). The program provides strategic guidance that can only be implemented through decisive and cooperative action by government agencies and the private sector.

Evaluation of results must be incorporated into tactical planning for and implementation of ruffe control activities. Ineffective control activities should be eliminated or modified based on evaluation. A written report of results of ruffe control activities by all cooperators will be provided annually by the Committee to the ANS Task Force and to the GLFC Lake Committees. After approval of the control program by the ANS Task Force, the Committee will meet once per year or as needed to provide oversight. Activities of the Committee will be reported to the ANS Task Force through minutes of Committee meetings and through oral reports at ANS Task Force meetings.

POPULATION REDUCTION

Objective

Eliminate or reduce reproducing populations, using appropriate technologies, where feasible.

Background

Ruffe populations may be vulnerable to physical or chemical removal in river mouths and bays of the Great Lakes. The temperature preference of ruffe (Hokanson 1977) is similar to yellow perch, *Perca flavescens,* a species that is typically confined to river mouths and bays of Lake Superior. Ruffe sometimes inhabit deeper and colder water than yellow perch in Lake Superior or than European perch, *Perca fluviatilis* in Europe (Bergman 1987), but ruffe populations in Lake Superior are generally associated with river mouths.

The potential for physical removal of ruffe with nets has been evaluated by modeling and field tests. Surveys of the Duluth Harbor have employed electrofishing, fyke nets, gill nets, seines, and trawls. Bottom trawling is an efficient gear for capturing ruffe. Based on survey data, trawling was projected to remove 50% of the ruffe population from the Duluth Harbor with one large vessel or two small vessels operating full-time during the ice-free season (Ruffe Task Force 1992). However, a removal rate of 50% would not effectively reduce the population of a prolific species like ruffe.

Slade and Kindt (1994) conducted field tests of trawling in two river mouths in Wisconsin. Based on declining catch rates, they projected that 16 days of trawling in the Sand River and 28 days in the Iron River would deplete the local populations by 90%. They concluded that removal by trawling may have application in some tributaries where ruffe concentrate in a few limited pools. In estuaries where habitat is more uniform in depth, or those with concentrations of debris, trawling would be less effective. In all cases, trawling to remove ruffe would have adverse impacts on non-target fishes due to handling mortality and stress.

Several dozen modified Windermere traps captured thousands of ruffe in the Duluth Harbor in a 1995-96 study (Edwards et al., MS). This inexpensive, lightweight, collapsible trap may have application for reducing a ruffe population in a limited area. Trapping ruffe would have an advantage over trawling, in that non-target species could be released unharmed.

Ruffe can be readily killed by any of the fish toxicants registered for use in the United States: rotenone, antimycin, TFM, and Bayluscide. Considerations in choosing a toxicant for use on ruffe include the selectivity for ruffe, cost of the chemical, cost of registration if necessary, availability for purchase, and several other technical considerations.

TFM has the most potential for selectivity towards ruffe (Boogaard et al. 1996). Ruffe are about three times more sensitive to TFM than brown trout and 3-6 times more sensitive than yellow perch, and three age-classes of ruffe showed similar sensitivities. Ruffe are more sensitive to antimycin and rotenone than yellow perch, but similar in sensitivity to brown trout, so selective treatments with those compounds is unlikely (Boogaard et al. 1996).

TFM and Bayluscide are restricted use lampricides, and would require special permits for use against ruffe, although a chemical may be applied in the U.S. "against any target pest not specified on the labeling if the application is to the ... site specified on the labeling" (Section 2(ee) of the U.S. Federal Insecticide, Fungicide, and Rodenticide Act). This would allow use in the U.S. waters of the Great Lakes at concentrations permitted for application against sea lamprey. TFM is not available on the commercial market, but is produced only for the Great Lakes Fishery Commission for sea lamprey control under contract with two suppliers.

Boogaard et al. (1996) concluded that treatment with TFM could "control ruffe populations with limited adverse effects on native species". The toxicity of TFM to fish is influenced by pH (at lower pH, toxicity is higher), but the selectivity of TFM for killing ruffe is consistent at all pH values. Cage studies and trawl sampling in the Brule River, Wisconsin in conjunction with a sea lamprey treatment with TFM indicated that more than 97% of the ruffe population was killed, with no significant mortality among endemic fishes (Bills et al. 1992). During a sea lamprey treatment in the Amnicon River, Wisconsin, 76% of caged ruffe were killed, and trawl sampling measured a reduction of 54% in the ruffe population. A sea lamprey treatment in the Middle River, Wisconsin, killed an estimated 78% of the ruffe (Kindt 1995). Higher concentrations of TFM would be required to eradicate ruffe than to eradicate sea lampreys (Boogaard et al. 1996).

In the sea lamprey control program, TFM and Bayluscide cause some mortalities of Oligochaeta and Hirudinea, immature forms of Ephemeroptera, and certain Trichoptera, Simuliidae, and Amphibia. The combination of TFM and Bayluscide may affect some Pelecypoda and Gastropoda, but its overall effects on invertebrates are probably less than those of TFM alone. Granular Bayluscide is likely to induce mortalities among oligochaetes, microcrustaceans, chironomids, and pelecypods. No evidence exists that the lampricides have caused the catastrophic decline or disappearance of any species (Gilderhus and Johnson 1980).

Rotenone and antimycin are general use fish toxicants (Marking 1992). Rotenone is registered for use in the U.S. and Canada, while antimycin is registered only in the U.S., and would require a special permit for use in Canada. Rotenone is readily available on the commercial market, while the supply of antimycin is quite limited. Rotenone is detectable by fish, and is not toxic to eggs. Antimycin is not detectable at lethal concentrations, and kills eggs. A bottom release formulation of antimycin has been developed that could reduce concentrations of ruffe in deep water with minimal impact on nontarget fishes. This formulation is not registered and could only be used under emergency or experimental use permits.

Action Plan

Fishery agencies should pursue research projects to develop and test physical and chemical methods of efficiently and selectively removing ruffe. State fishery agencies will decide if piscicide treatments will occur within their jurisdictions, in consultation with affected Native American tribes. The Fish and Wildlife Service will assist the States in conducting and assessing treatments, if they occur.

Researchers should seek new ways to selectively kill ruffe, for example, by screening a large number of chemicals for selective toxicity, or by developing selective parasites or pathogens.

BALLAST WATER MANAGEMENT

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Objective

Minimize the transport of ruffe from western Lake Superior through ballast water management, and support the development of technologies to prevent transport.

Background

Commercial ships docking in Duluth, Superior, Thunder Bay, and other western Lake Superior ports entrain ruffe and other organisms in their ballast tanks. Ruffe small enough to pass through ballast screens are present in Duluth Harbor in all months, and are most abundant during June, July, and August. Reduced growth rates of ruffe in Duluth Harbor due to crowding have increased the risk of entrainment during all months.

Most ships using the Duluth Harbor have round holes of ½-inch diameter on their ballast intakes, which will screen out 95% of ruffe of 2.24 inches total length. A few ships have 9/16-inch holes, which will screen 95% of ruffe of 2.48 inches total length (NBS Lake Superior Biological Station, unpublished).

The GLFC Ruffe Task Force (1992) recommended that ships not take on ballast water from ruffe-inhabited ports from May through July. Maritime industry managers have said that this condition cannot be met without compromising safety. Nevertheless, it is the simplest way to reduce the occurrence of viable ruffe in ballast tanks.

Ballast water transport of organisms is a global problem without ready solutions. Numerous recent studies have evaluated options for ballast water management to prevent transport of viable organisms (for example, Marine Board 1996). The Ruffe Control Committee convened a technical working group on July 29, 1993, to develop a long-term solution to prevent ballast water transport within the Great Lakes. The multi-disciplinary group included expertise in fishery management, fishery biology, toxicology, biogeography, ship operations, port operations, marine engineering, marine safety, regulatory and legislative processes, and diving. The group screened 29 ballast water management options, and recommended 12 options for action or further study, based on biological effectiveness and practical feasibility (Appendix 2).

Action Plan

Since May 1993, seagoing vessels entering the Great Lakes from beyond the U.S. 200-mile exclusive economic zone have been required by law to exchange ballast water on the high seas, or to take other action that will prevent the introduction of nonindigenous species via ballast water (Weathers and Reeves 1996). The U.S. and Canadian Coast Guards monitor compliance with the mandatory program. These measures will reduce or eliminate the risk of new introductions of ruffe into the Great Lakes.

The Great Lakes maritime industry implemented a voluntary plan in 1993 to reduce the risk of transporting ruffe out of western Lake Superior ports (Appendix 3) (Ryan 1996). Under the plan, company dispatchers maximize loads out of these ports to minimize the need for taking on ballast water. Ships that must take on ballast from ruffe-inhabited ports should exchange ballast water in the open waters of Lake Superior west of a line drawn between Grand Portage, Minnesota and a point one mile east of the Ontonagon River, Michigan. If ballast cannot be exchanged in that zone, it will be accomplished in other locations at least 40 fathoms (240 ft) deep and 15 miles from shore. The U.S. and Canadian Coast Guards will have access to ballasting records from the shipping companies to monitor compliance with the plan. Development of the plan was led by the Lake Carriers' Association, with participation by the Canadian Shipowners Association, Seaway Port Authority of Duluth, Thunder Bay Harbour Commission, Shipping Federation of Canada, and the U.S. Great Lakes Shipping Association.

In 1996, a ballast water technology demonstration project was initiated to test filtration on-board a Great Lakes ship as a means of preventing ballast water transport of organisms. The results of the project will be directly applicable to ruffe, as well as a variety of other nonindigenous species. The project is co-chaired by the Lake Carriers' Association and the Northeast Midwest Institute, and guided by a multi-stakeholder steering committee. Funding is provided by the Great Lakes Protection Fund and a variety of federal and state agencies. Installation of the technologies, and monitoring and evaluation of their effectiveness will be completed in mid-1997.

If cooperative methods of eliminating the ballast water transport of ruffe are unsuccessful, then existing laws prohibiting the possession or release of ruffe should be enforced against the maritime industry. The U.S. and Canada should authorize their respective Coast Guards to regulate ballasting by lake vessels. As a last resort, ships should be prohibited from taking on ballast water in ports inhabited by ruffe until ways are developed to prevent the transport of ruffe.

POPULATION INVESTIGATION

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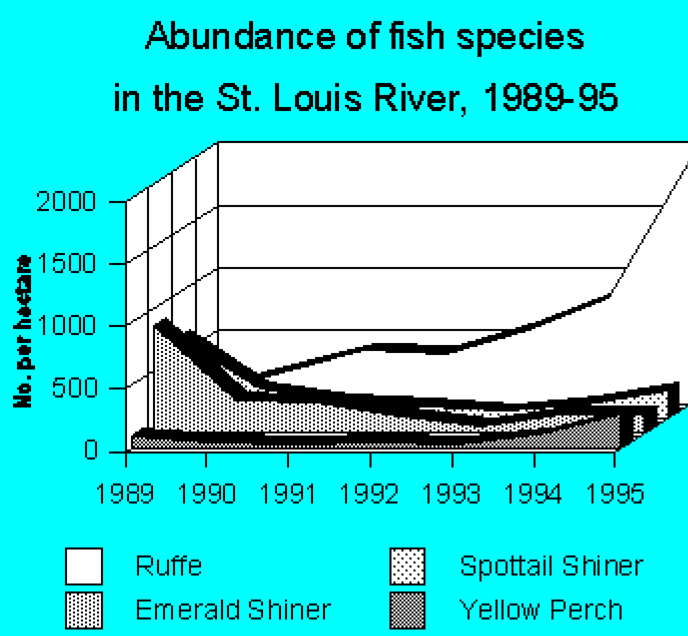

Data from the Lake Superior Biological Station, Great Lakes Science Center, National Biological Service

Objective

Continue and expand investigations of ruffe populations to evaluate the impact on affected fish communities and to provide information necessary to plan, implement, and evaluate control activities.

Background

Biological information on known ruffe populations and co-existing fish communities is necessary to plan and evaluate control activities, and to modify or eliminate ineffective control activities. This includes basic information on population dynamics, behavior, and distribution. Population investigations conducted since 1988 (e.g. Selgeby and Edwards 1995) have been essential in developing this control program. Other cooperators in this work have included the Wisconsin Department of Natural Resources, U.S. Environmental Protection Agency (EPA) Environmental Research Laboratory, the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), and the University of Minnesota-Duluth. The U.S. Fish and Wildlife Service has funded population investigations by the National Biological Service since 1993. The Wisconsin Department of Natural Resources has funded and published a comprehensive review of published literature on ruffe (Ogle 1995).

Action Plan

The Lake Superior Biological Station of the NBS Great Lakes Science Center will continue to assess ruffe and the fish community in the Duluth Harbor and other colonized locations to observe temporal changes in populations. The frequency of sampling in Duluth Harbor was constant from 1989 through 1994, then reduced in 1995-96 to allow assessment to be conducted in 10 estuaries east of Duluth Harbor on the south shore of Lake Superior. These 10 estuaries provide a range of dates of initial colonization by ruffe.

The population of ruffe in Duluth Harbor should also be characterized genetically to determine if more than one introduction was made from Europe, and, if ruffe are found outside western Lake Superior in the future, to determine if it is a new introduction or an expansion of the range from western Lake Superior. Specimens from any new occurrence of ruffe should be frozen as soon as possible after capture so they can be genetically tested.

North American scientists are encouraged to build and maintain communication with European scientists to share information on ruffe biology and control. An International Ruffe Symposium will be held in March 1997 in Ann Arbor, Michigan, sponsored by the Great Lakes Sea Grant Network with cooperation by ruffe researchers and managers, to foster this interaction.

SURVEILLANCE

Objective

Conduct surveillance sampling in likely locations to find newly established populations of ruffe, and designate a single office to compile collections of ruffe.

Background

Surveillance provides timely information on the range of ruffe through detection of newly established populations. Knowledge of the range of ruffe is needed to plan and evaluate control activities. In 1992, the U.S. Fish and Wildlife Service (FWS) initiated a surveillance project in western Lake Superior (Slade and Kindt, 1992), which has expanded in subsequent years to include all the Great Lakes. Ontario Ministry of Natural Resources has conducted surveillance in Canadian waters of the Great Lakes. Ruffe surveillance in the Great Lakes by all agencies has been reported jointly since 1993 (Slade et al. 1994, Slade et al. 1995, Kindt et al. 1996).

Action Plan

Sites likely to be colonized will be regularly sampled with bottom trawls or other nets to detect the presence of ruffe. Sampling will be conducted at sites where ruffe may be transported in ballast water, as well as sites they are likely to occupy on their own. Survey questionnaires will be mailed to fishery managers, commercial fishers, and others likely to encounter ruffe.

The Fishery Resources Offices of FWS will coordinate and/or conduct surveillance on each of the Great Lakes. The Ontario Ministry of Natural Resources (OMNR) will conduct surveillance in Canadian waters of the Great Lakes. Surveillance will be closely coordinated with the investigation of established populations, so that information on sampling techniques, distribution, and biological characteristics of ruffe will be shared.

Assistance will be provided to fishery management agencies and fishing groups on the Great Lakes in educating anglers about the ruffe, so that they will report them if they catch them. The Great Lakes Sea Grant Network has published a "Ruffe Watch" identification card for distribution to anglers, commercial fishers, and others who might encounter ruffe.

Established methods for inter-agency communication (e.g. Lake Committees and Council of Lake Committees) will be expanded to include ruffe collections, and the FWS Ashland Fishery Resources Office is designated to receive reports of new ruffe colonies. Findings of the surveillance program (both positive and negative) will be reported annually to the GLFC Lake Committees. New occurrences of ruffe will be reported immediately to the Committee and to all affected governments and agencies. The Southeastern Biological Science Center in Gainesville, Florida, will include confirmed ruffe sightings in its nonindigenous species data base, and publish maps of ruffe distribution.

FISH COMMUNITY MANAGEMENT

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Objective

Recommend fish management practices that will improve resilience of fish communities against invasion or dominance by ruffe.

Background

Biological control methods should be considered as part of any program of integrated pest management (Sawyer 1980). Enhancement of predator populations has been attempted as a biological control strategy for ruffe. During 1989-93, the Wisconsin and Minnesota Departments of Natural Resources attempted to increase populations of walleye, northern pike, and muskellunge in the Duluth Harbor by restricting harvest and by stocking fingerlings of these species as well as adult northern pike. The intent of the restrictive regulations was to reduce angler harvest by 50%. The 5-year plan has run its course, and evaluation of its results is complete.

Food habits of walleye, northern pike, burbot, smallmouth bass, yellow perch, black crappies, and brown bullheads were studied from 1989 to 1994 (Selgeby and Edwards 1995, Ogle et al. 1996, Mayo 1996). In general, the occurrence of ruffe in predator stomachs has increased, but predation failed to prevent the ruffe population from increasing or expanding out of Duluth Harbor. Ogle et al. (1996) found no ruffe in the stomachs of 967 walleye during 1989-91, but in 1992-94, ruffe made up 6% of the fish eaten by walleye (Selgeby and Edwards 1995). Ruffe made up 1-4% of the fish consumed by northern pike in 1989-91, and increased to 12-19% in 1992-94. The consumption of ruffe by smallmouth bass increased steadily over the period to 26% of fish eaten in 1994, but the smallmouth bass population declined during the same time. Most ruffe eaten were age-0 or small age-1 fish (Ogle et al. 1996).

Mayo (1996) modeled the bioenergetics of the system using data on predator stomach contents, predator biomass, and ruffe abundance. Only in 1992 did predation remove a significant portion of the ruffe population. Estimates for the consumption of available ruffe are: 1991 - 26%, 1992 - 47%, 1993 - 34%, and 1994 - 24%. Ruffe made up 73-90% of available prey biomass, based on trawl samples, but a much smaller proportion of prey items in stomachs. Northern pike and walleye were the only predators that consumed a significant quantity of ruffe in the Duluth Harbor in 1991-1994. Walleye biomass did not increase significantly during the study period as would be expected in a stocking program. Stocking almost 18,000 adult pike in 1991 may have contributed to the increase in predation on ruffe in 1992.

Mayo used a selectivity index to account for the relative abundance of prey species in the community versus their occurrence in the stomachs of northern pike, walleye, smallmouth bass, yellow perch, and brown bullhead. All avoided ruffe as a prey item in each year of the study. Knight and Vondracek (1993) noted that walleye in Lake Erie prefer to prey upon soft-rayed fishes (such as emerald shiner) over spiny-rayed fishes (such as ruffe), and questioned the feasibility of biological control of spiny-rayed invaders through predation. Ogle et al. (1996) agreed that predation is unlikely to effectively control ruffe during early stages of colonization in the Great Lakes, because native predators will likely consume few ruffe if soft-rayed fish or yellow perch are available. Mayo (1996) noted that the Duluth Harbor is an open system allowing stocked predators to freely move out, and suggested that predator enhancement may be more successful in a closed system like an inland lake.

In general, a mature, undisturbed biological community is a more efficient user of the available energy in the community, and will be more resilient against invasion or dominance by ruffe. A disturbed, or simplified, community cannot maximize its use of the available energy. Disturbances tending to simplify aquatic ecosystems in the Great Lakes include exotic species introductions, as well as nutrient input, and extraction of biomass, especially at a specific trophic level.

The attributes of undisturbed, mature ecosystems are:

1) More energy capture
2) More effective use of energy
3) Higher total system throughput
4) More cycling of energy and matter
5) Higher average number of trophic levels (more levels of consumption)
6) More complex food webs
7) Higher respiration (processing more energy)
8) Higher transpiration (in terrestrial systems)
9) Larger ecosystem biomass
10) More types of organisms (diversity)

Managing under an ecosystem approach, managers will attempt to maintain the maturity of ecosystems, while still deriving benefits for humans. Past fishery management strategies targeting "maximum sustainable yield" were not successful, because managers do not know how to achieve sustainability. Future managers need to be open to non-traditional management techniques and strategies. For example, a traditional fishery management strategy of size limits selectively removes a particular size group from the population. To maintain naturally occurring size distributions of fish, a non-traditional strategy might include limiting the anglers' take by restricting harvest of fish within two inches of each other in length.

In another example, the intense removal of targeted size ranges of coregonines (herring and chubs) by commercial harvesters disturbed the Great Lakes ecosystem. Because they were the prey of lake trout, the removal of coregonines caused the breakdown of efficient energy use by lake trout. The exotic fishes smelt and alewife persisted, consuming plankton previously used by coregonines. However, the transfer of energy between trophic levels was disrupted in terms of the system's ability to maximize its use of the available energy. Intensive exploitation has the same systemic effects on aquatic communities as exotic species and nutrification. Educating people about their effects on the ecosystem is a key to managing human impacts. Catch and release angling is a result of education, allowing the more people to benefit with less impact on ecosystem function.

"Biological pollution" by nonindigenous species is likely the most damaging of all the perturbations to an aquatic system because of its permanence. "Biological resilience" is a natural mechanism that separates communities. A mature, undisturbed system is more resilient to invasions or overlapping of communities. To defend communities against future invasions, management strategies focussing on building resilience should be examined. A mature system is better at "keeping the weeds out".

It may be asked if resilience is possible in a system where nonindigenous predators prey on nonindigenous prey. However, the goal should be a functional community that sustains itself with minimal human input, not necessarily pristine conditions. Exotics that are naturalized may be part of that community. Planning for fish community resilience should seek to define desired conditions, which may range from "original or pristine" to "favor native species" to "maximize self-organizing characteristics". Improvements in water quality by pollution prevention has allowed some introduced organisms to survive where they earlier would not.

Action Plan

The efforts of fishery management agencies to manage for greater maturity and resilience of fish communities will be greatly aided if North American society is successful in "closing the door" to new exotic species. Ballast water management must be improved to prevent additional colonization, and other vectors must be effectively regulated. The spread of ruffe to the lower Great Lakes should be delayed as long as possible to to gain time to increase fish community resilience. (See "Population Reduction" section.)

North American society should explicitly consider whether major changes in economic activity are needed to reduce perturbations to the ecosystem. One example of a major change would be to separate the lake and saltwater commercial fleets in the Great Lakes to prevent new ballast water importations. Another would be to eliminate the commercial sale of live bait organisms. If such controversial changes in economic activity are given serious consideration, society must also consider unintended consequences, for example the environmental impact of rail or truck transport versus ships. Careful and full assessments of environmental and economic impacts of current practices and alternative strategies would be required.

Intentional perturbations, such as stocking and harvest regulation, should be more deliberately thought through, and their results measured (e.g. food availability, competition, indirect effects of removing prey, presence of naturally sustaining population of the same species). The effects of fish stocking may be a reduction in native prey fish, thus favoring ruffe. Managers should consider the effects of other predators on ruffe, for example burbot. If stocking predators, managers should consider stocking a species and size that is an effective ruffe predator.

Aquatic habitat should be restored and protected to foster fish community resilience. Natural fish production can be restored by re-connecting segmented river systems by dam removal and by providing fish passage. Habitat may be enhanced where feasible to foster the desired fish community composition. If the spread of ruffe cannot be prevented, managers must learn how to live with ruffe, but focus on healthy habitat to promote resilience in the future.

Improving our long-term knowledge and understanding of the status of fish stocks and fish community dynamics is a pre-requisite to managing for resilience. This will require consistent funding. Too often, decreasing fishery management budgets prevent needed follow-through. Agencies need management alternatives that cost less. A long-term option is to broaden the funding base for ecosystem management beyond fishing license revenue. Adequate funding will be more likely if public understanding is increased on the economic and ecological impacts of ruffe and other exotics. This will require more systematic and consistent public education on exotics and fishery management techniques.

Managers should identify and focus on areas likely to be colonized and most impacted by ruffe, and regulate the harvest (e.g. by slot size limits) to maximize predation on invaders. Northern Lake Huron is an especially dysfunctional system due to the abundance of sea lampreys from the St. Marys River. It is a highly disturbed system with low resilience, and is most vulnerable to ruffe invasion. Its fish community includes many soft-rayed prey fish, and relatively few predators. The lack of lamprey control in this area will likely foster ruffe invasion and successful colonization.

EDUCATION

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Objective

Develop and promote information and education programs to identify ruffe so that they will not be transported alive and so that they will be killed and reported if taken.

Background

Understanding and support by the public is necessary to the success of any aquatic nuisance control program. The general public must be aware that short-term, local perturbations are likely to be caused by control actions, but are necessary to prevent long-term, widespread adverse effects of aquatic nuisance species. Anglers and commercial fishers must be aware of the potential presence of ruffe in their fishing waters, so they can report new occurrences. Anglers must know what to do with ruffe that they catch (i.e. kill and freeze them, except where possession is prohibited by law).

Public education actions taken to date include a "Ruffe Watch" identification card, a field guide to exotic species, and other brochures published by the Sea Grant Network with cooperation from State, Provincial, and Federal agencies; information posters at State and Provincial boat landings; pictures and other information in State and Provincial angling regulation pamphlets; and an identification poster and a video on the ruffe produced by FWS.

Action Plan

The Committee encourages all cooperating entities to become involved in an effort to inform and alert public water users of the distribution, identification, and dispersal mechanisms of ruffe, as well as what to do if a suspected ruffe is caught. These efforts should emphasize the role of the public in monitoring and prevention strategies.

The Committee encourages jurisdictions to enact appropriate regulations regarding possession of ruffe. Where ruffe populations are established, possession should be prohibited. Where future colonization is possible or likely, anglers should be encouraged to retain dead suspected ruffe, and turn over specimens to conservation authorities.

The Sea Grant Program is designated to take the lead role in public education regarding the ruffe in the U.S., because Sea Grant has an established network of programs and agents throughout the Great Lakes region. The Committee also recognizes and encourages the efforts of state, provincial, tribal, and federal natural resource agencies that have developed educational materials on the ruffe and other exotic nuisance species. Non-governmental groups such as the Great Lakes Sport Fishing Council and the Ontario Federation of Anglers and Hunters have also contributed significantly to education on the ruffe through newsletters, meetings, and personal contacts.

Additional education activities are needed. Identification posters or photographs should be available to agencies and businesses throughout the Great Lakes region. Television should be used to reach a wider audience through public service announcements and educational television shows. The producers of fishing shows should be provided with information and specimens.

All educational materials, especially those supported by public funds, should be reviewed by the Committee for consistency and scientific accuracy before production. In addition, all educational activities on the ruffe should be coordinated with the Information and Education Strategy of the Great Lakes Panel.

BAIT FISH MANAGEMENT

Objective

Assist jurisdictions in developing model language for regulation of bait harvest and possession.

Background

The live bait industry is a potential vector contributing to the spread of ruffe. Ruffe were probably introduced into Loch Lomond, Scotland, 250 km from its previously reported range, through discarded live bait of pike anglers (Adams 1994). Bait bucket transfers potentially threaten the fisheries of inland waters, and must be prevented through education and legal prohibition. The States of Minnesota, Wisconsin, and Michigan have prohibited or restricted the taking of baitfish from Lake Superior. Northwestern Lake Huron, where ruffe were first discovered in 1995, is a major harvesting area for live bait fish (i.e. shiners), and prohibiting commercial harvest there would have major economic impacts.

The total value of the live bait industry in the U.S. and Canada has been estimated to be about $1 billion. Based on a mail survey of the industry done in 1992, Meronek (1993) estimated the total volume of bait fish sold in Ohio, Michigan, Illinois, Wisconsin, Minnesota, and South Dakota to be 546,421 gallons, worth $145 million. The most important species in terms of value and volume in the six states are the fathead minnow, lake shiner, and white sucker.

Bait dealers advising the Committee argue convincingly that Meronek's study under-estimated the volume and value of the live bait industry in Michigan, a point that was acknowledged by Meronek in his report. In Michigan, bait fish harvesters are required to report their catch to the State, but reported catches are even lower than Meronek's estimates. Bait dealers often under-report information because they don't want their competition to find out about their business, or because they are suspicious of government agencies.

The conclusion accepted by the Committee and participants from the live bait industry is that the industry is economically important, but accurate economic figures are not available. Any future surveys of the industry should be co-sponsored by an industry group to get greater participation and validity of results.

Meronek estimated that in the six-state region, 67% of bait fish are harvested from the wild and 33% are cultured. The estimate for Michigan is similar: 68% wild, 32% cultured. All lake shiners and white suckers are harvested from the wild. Over time, cultured bait fish have become an increasing proportion of the number sold. Industry participants attribute this to decreasing access to waters for harvesting wild fish.

The main concern expressed by participants from the bait industry was the potential for declining access to waters for the harvest of wild bait fish. The closure of Michigan waters of Lake Superior to commercial bait fish harvest for ruffe control was cited as precedent (though Michigan's reported harvest from Lake Superior was zero), and harvesters do not want to lose access to Lake Huron, where a large harvest is taken annually (43% of Michigan bait fish in 1993).

Bait dealers from Michigan maintain that the current system of harvesting wild shiners and suckers in the Great Lakes is healthy and desirable and should be maintained. Seining for shiners is done on calm, sunny days on beaches, not preferred habitat for ruffe. Use of cultured bait fish may be increasing, but wild harvest has many advantages in the Great Lakes region, where the short growing season, high land value, and other factors limits bait culture development.

Action Plan

The live bait industry is economically important, but an increased awareness of environmental impacts is changing public perspectives on environmental risks. The formerly "acceptable" level of non-bait fish in bait tanks is no longer acceptable. Zero tolerance should be the standard. Therefore, the Committee bases its recommended actions on two goals:

- Prosperous live bait industry.
- Clean live bait industry (no exotics).

Several levels of sale must be considered when developing strategies to prevent the transfer of exotic species through the bait fish industry. These include the harvester, wholesaler, retailer, and angler. The Committee recommends an integrated approach, with all levels of sale bearing some responsibility for reducing the risk of introducing exotic species, in addition to the ultimate user, the angler. An integrated strategy would identify and take action at all critical control points in live bait commerce where risk can be reduced.

Involvement by participants in the live bait industry is necessary when decisions are made on regulations or other management actions to prevent the spread of ruffe. Accordingly, the Committee recommends that the ANS Task Force appoint a representative of the bait industry as a member of the Ruffe Control Committee.

This involvement should include reporting of ruffe or other exotic species when detected by live bait harvesters, wholesalers, or retailers. Possession of *dead* ruffe by bait dealers who intend to report the finding should not be prohibited. Agencies should consider recognizing and/or rewarding the reporting of new exotics, as long as these incentives do not encourage false reporting. Agencies and industry trade groups should inform all segments of the industry how to identify ruffe and what to do if a suspected ruffe or other exotic is found.

The Committee recommends that regulatory agencies change the definition of "bait fish". The Committee recommends that definitions of bait fish be consistent among jurisdictions. The definition should specify legal bait fish species, rather than illegal species (though some bait dealers oppose this approach, on the grounds that the regulations would be too complicated). For example, the Ontario Fishery Regulations define bait fish as referring to the following fish:

- the sucker family
- the stickleback family
- lake herring (of the whitefish family)
- the darter subfamily
- the trout-perch family
- the sculpin family
- crayfish
- the minnow family except carp and goldfish
- the mudminnow family.

The end user of live bait, the angler, shares the responsibility for preventing the spread of ruffe and other nonindigenous species. Regulatory agencies should enact regulations (if they do not currently have them) prohibiting the discarding of live bait in the water, and should stress this point in angler education. For additional protection against transport of ruffe, agencies may require that bait fish harvested for personal use be used in the same water where harvested. As an alternative approach, agencies should consider consistent regulations for commercial and non-commercial harvest and possession of bait fish.

The Committee recommends that the live bait dealers or industry groups develop a quality assurance program. For example, discrete lots of fish could be sealed and tagged as "clean bait", with a phone number and contact names to trace their source and provide further information. Such an approach may be effective advertising, outcompeting markets not certifying "clean bait".

If regulatory agencies encourage increased propagation of bait fish to prevent spread of ruffe or other nonindigenous fishes, the Committee recommends that this be accompanied by financial assistance to the regional industry for research and development. If this is not done, increased importation of bait fish from other states, where bait fish propagation is well established, would be required to meet the demand.

Some bait fish species in high demand, such as emerald shiners, are not cultured. When these species are harvested from the wild, harvesters should use gear and methods that minimize the risk of catching ruffe.

Training is needed for conservation officers to encourage consistent and effective enforcement of bait harvest and possession regulations. Training on species identification will be especially important if regulatory agencies adopt the Committee's recommendation on definition of bait fish.

Management of the live bait industry would benefit from additional research. Needs identified by the Committee include: biological assessment of populations of bait fish species in the Great Lakes; development of harvesting or sorting gear that is more selective to target species; more accurate information on the economic impact of the live bait industry; and a more detailed risk assessment of the bait industry as a vector of spreading nonindigenous species. The last point could be addressed by assembling data on the spread (or lack of spread) of other nonindigenous fish, for example white perch or rudd, to inland waters.

CHICAGO SANITARY AND SHIP CANAL

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Objective

Consider options to prevent the movement of ruffe from the Great Lakes to the Mississippi watershed via the Chicago, Des Plaines, and Illinois Rivers.

Background

Historically the divide between the Great Lakes basin and the Mississippi watershed at Chicago was only about 15 feet above the level of Lake Michigan. The Chicago River and the Calumet River, both fed by numerous tributaries, flowed into Lake Michigan. The Des Plaines River flowed south and west to the Illinois River and the Mississippi. However, the portage between watersheds was short, and even flooded at two locations during wet periods, so that navigation by canoe was sometimes possible (Ryder 1995).

The Illinois and Michigan (I&M) Canal was constructed from 1836 to 1848 to provide barge transportation between Chicago and the Illinois River. Water was pumped into this elevated waterway from the South Branch of the Chicago River, reversing its flow for part of the year. Another canal was constructed in 1862 linking the Calumet River system with the Des Plaines River.

Water pollution and resulting disease caused thousands of deaths in early Chicago. In 1889 the Metropolitan Sanitary District of Greater Chicago was created to reverse the flow of the Chicago River to flush waste waters away from Lake Michigan. The 28-mile Sanitary and Ship Canal was completed in 1900, its flows regulated by locks. In 1910 the 8-mile North Shore Channel was constructed, connecting Lake Michigan with the North Branch of the Chicago River. In 1922, the 16-mile Cal-Sag Canal was constructed to reverse the flow of the Calumet River. Currently there are 5 locations where water from

Lake Michigan enters the Chicago waterways, through which nonindigenous species may disperse.

A series of U.S. Supreme Court decisions has limited the amount of water diverted from Lake Michigan. Today the Chicago waterways constitute a highly regulated system of channels, canals, rivers, tunnels, locks, and diversion gates that is heavily used for commercial and recreational navigation. The system is managed by the Metropolitan Water Reclamation District of Greater Chicago and the U.S. Army Corps of Engineers. Leakage from Lake Michigan at the Chicago lock has drawn protest from other Great Lakes states, and construction began in March 1996 to correct the problem.

The concern for dispersal of nonindigenous species through the Chicago waterways includes species other than ruffe. According to Sparks and Marsden (1996), "Within the last five years, the Mississippi River and its tributaries have been invaded from the north by the zebra mussel, and from the south by the spiny water flea (*Daphnia lumholtzi*). . . . At least six other invasive species are already in the Great Lakes, poised to enter the Mississippi Drainage the same way the zebra mussel did: by passing through the canal system at Chicago, then down the Illinois River.... Any invader of the Great Lakes has the potential to invade the entire Mississippi Drainage by following the same route as the zebra mussel." For example, the round goby (*Neogobius melanostomus*) has become established in the Calumet River near the head of the Cal-Sag Canal.

An initial meeting was held in November 1995 to develop strategies to create a dispersal barrier to prevent the spread of nonindigenous species through the canal system. The ANS Task Force has requested the Ruffe Control Committee to fully identify the problem and the stakeholders potentially affected. The list of stakeholders and necessary cooperators is long, and includes the Corps of Engineers, Metropolitan Water Reclamation District, several agencies of the State of Illinois, the 28-state Mississppi Interstate Cooperative Resource Association, the Port Authorities of Chicago and Indiana, US Environmental Protection Agency, Friends of the Chicago River, and others.

Whatever the considerations of stakeholders, resource managers are responsible for informing the public that sharing genetic material between drainage basins can be compared to extinction, in the sense that it changes those systems permanently. If no action is taken to prevent it, the dispersal of ruffe and other nonindigenous species will permanently degrade the fisheries and aquatic ecosystems of dozens of states in the Mississippi River basin.

Action Plan

The Committee recommends that the ANS Task Force establish a separate committee on Chicago waterways. The Ruffe Control Committee will help to identify potential members and participants, and should maintain linkages with the Chicago Waterways Committee. The new committee needs expertise on the economic and environmental impacts of alternative transport, and should compile information regarding current use of the system for recreational boating and commercial shipping, estimates of the value of this transport mechanism, and estimates of the cost of alternative strategies.

The U.S. Army Corps of Engineers will lead a demonstration project to test technologies for a dispersal barrier. The Great Lakes Protection Fund has indicated an interest and may provide support for the demonstration project. The Illinois Natural History Survey and the Metropolitan Water Reclamation District are the primary cooperators in the project.

The *National Invasive Species Act*, passed by Congress in October 1996, requires the Corps of Engineers to "investigate and identify environmentally sound methods for preventing and reducing the dispersal of aquatic nuisance species ... through the Chicago River Ship and Sanitary Canal, including any of those methods that could be incorporated into the operation or construction of the lock system.... [and to] no later than 18 months after the date of enactment ... issue a report to the Congress that includes recommendations...."

RESEARCH NEEDS

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The Committee is acutely aware of the small selection of control methods available to achieve the goal of the Program, and encourages basic research to expand the options. There is a particular need for new tools to eradicate founder populations at low numbers.

Specifically, the Committee recommends that the ANS Task Force and its member agencies pursue opportunities to conduct research to fill the following information needs.

1. Distribution of ruffe, including seasonal distribution in Lake Superior and its tributaries and diurnal distribution of larvae within the water column.

2. Environmental determinants of seasonal distribution and movements, including temperature, light, and other habitat characteristics.

3. Effects of ruffe colonization on aquatic biodiversity in Lake Superior bays and estuaries.

4. Characterization of the genetics of North American ruffe, and comparison with Eurasian populations.

5. Development and registration of effective chemical control measures, for example bottom formulations of piscicides.

6. Identification and evaluation of attractants and repellents (e.g. pheromones, sound waves).

7. Research on ballast water management options.

8. Research leading to biological means of control.

9. Describe characteristics of baitfish commerce in Great Lakes states, including harvest gear, sites and quantities and commercial traffic patterns, and identify risk of ruffe transport.

10. Identify and test methods for implementing a dispersal barrier in the Chicago Sanitary and Ship Canal.

11. Develop ecological theory for fish community resilience in the face of colonization by ruffe, and recommend and test means of increasing resilience through fishery and habitat management.

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APPENDIX 3.

GREAT LAKES MARITIME INDUSTRY VOLUNTARY BALLAST WATER MANAGEMENT PLAN FOR THE CONTROL OF RUFFE IN LAKE SUPERIOR PORTS

Owners and operators of vessels in the domestic and international trade on the Great Lakes recognize their role in assisting the governments of the United States and Canada in controlling the introduction and spread of non-indigenous fish species. We recognize that control must be on many fronts, including ballast water management, chemical control, predatory fish control, and other mechanisms. Vessels must use ballast water for safety purposes to provide adequate stability, trim, propulsion, maneuverability, and hull stress control. Recognizing these constraints, the marine industry will do everything within its power, consistent with safety and stability, to decrease the spread of known unwanted non-indigenous species. The introduction of new species from outside the system is under the control of the U.S. and Canadian Coast Guards through ballast water exchange regulations prior to entry into the system. This plan deals with the control of the spread of the European Ruffe from Western Lake Superior ports, in particular, Duluth/Superior or other harbors where Ruffe colonies are documented.

FOR VESSELS DEPARTING LAKE SUPERIOR PORTS *WEST* OF BALLAST

DEMARCATION LINE;

1) Operators of vessels pumping ballast water onboard in the above harbors, with ballast line intakes equipped with screens fitted with holes larger than ½" in diameter, are restricted at all times of the year in their pumping out of ballast water from these harbors into the Great Lakes or their Connecting Channels or harbors. This ballast water should be pumped out west of a ballast demarcation line <u>one mile east of Ontonagon, Michigan</u> and Grand Portage, Minnesota. Ballast water from these harbors must not be pumped out within 5 miles of the south shore of Lake Superior while west of the ballast demarcation line. Ballast exchange should take place in water at least 20 fathoms (120 feet) deep.

2) Operators of vessels pumping ballast water onboard in the above harbors, with ballast line intakes equipped with screens fitted with holes ½" in diameter or less, are restricted only during the period between May 15 and September 15 in their pumping out of ballast water from these harbors into the Great Lakes or their Connecting Channels or harbors. During this 4-mouth period, these vessels should pump out the harbor ballast water west of a ballast demarcation line <u>one mile east of Ontonagon, Michigan</u> and Grand Portage, Minnesota. Harbor ballast water must not be pumped out within 5 miles of the south shore of Lake Superior while west of the ballast demarcation line. Ballast exchange should take place in water at least 20 fathoms (120 feet) deep.

3) If ballast exchange is not completed at the time the vessel reaches the demarcation line, exchange may continue in Lake Superior, but only in waters at least 40 fathoms (240 feet deep) and 15 miles from shore. In all cases, exchange must stop before proceeding east of 86 west.

FOR VESSELS DEPARTING LAKE SUPERIOR PORTS *EAST* OF BALLAST DEMARCATION LINE;

4) Vessels departing Thunder Bay should limit pumping ballast onboard as in paragraphs 1) and 2) above. These vessels may exchange ballast in Lake Superior, but only in waters at least 40 fathoms (240 feet deep) and 15 miles from shore. In all cases, exchange must stop before proceeding east of 86 west.

FOR *ALL* VESSELS DEPARTING LAKE SUPERIOR PORTS;

5) Operators of vessels pumping in ballast water from the above harbors and leaving the harbor with that water will maintain a record showing the amount of ballast water taken, the means of control, if any, and the location where the treated or untreated harbor ballast water was pumped out.

6) The ballast water records will be available for review by U.S. or Canadian Coast Guard personnel, who will begin a program of monitoring.

7) The above requirements will be waived for vessels which attest by means of a log entry that the harbor ballast water from the above harbors will not be pumped out within

the Great Lakes/St. Lawrence Seaway System (at least until reaching salt water). Masters of these vessels recognize that ballast water from the above harbors must not be pumped out in any other fresh or brackish water port and thus should exchange ballast with salt water.

VOLUNTARY BALLAST WATER MANAGEMENT PLAN CO-SPONSORED BY:

- Canadian Shipowners Association - The Thunder Bay Harbour Commission - Shipping Federation of Canada

- Lake Carriers' Association - Seaway Port Authority of Duluth - U.S. Great Lakes Shipping Association

With consultation from USCG, CCG, US Fish and Wildlife Service

1. "Duluth Harbor" as used here refers to the estuary of the St. Louis River at the extreme western end of Lake Superior, and includes St. Louis Bay, Allouez Bay, and the commercial harbors of Duluth, Minnesota and Superior, Wisconsin. The area encompasses about 13,000 acres of water.
2. Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, Public Law 101-646.