Nonindigenous Aquatic Nuisance Species (ANS) State Management Plan (1996)

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Nonindigenous Aquatic Nuisance Species State Management Plan:

A Strategy to Confront Their Spread in Michigan

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I. Executive Summary

Nonindigenous species are plants and animals found beyond their natural ranges and are now part of the North American landscape. Many are highly beneficial. Most U.S. crops and domesticated animals, many sport fish and aquaculture species, numerous horticultural plants, and most biological control organisms have origins

outside Michigan. A large number of nonindigenous species, however, cause significant environmental, socio-economic, and public health damage. The severity of these impacts are not widely recognized, impeding the commitment needed to prevent future introductions. Also, a "crisis response" mentality often limits the vision and opportunity for the prevention of future introductions, leaving the state with control problems that are economically costly, technically challenging, often impossible to solve. Although at least 139 nonindigenous aquatic species have already become established in the Great Lakes ecosystem, future introductions are still highly probable. It is the harmful aquatic nuisance species (ANS), such as the zebra mussel, ruffe, goby, spiny water flea, Eurasian watermilfoil and others that arrived here unexpectedly, which provide the focal point for this State Management Plan (plan).The prevention of unintended introduction is critical in alleviating ANS problems in Michigan and the entire Great Lakes region.

The 1994 summer beach closings on Lake St. Clair, resulting from bacterial contamination and the massive accumulation of aquatic vegetation is a reminder that ecosystems can undergo dramatic changes due, in part, to the introduction of ANS into the Great Lakes Basin. Many changes in Lake St. Clair are attributed to increased water clarity, resulting from the presence of zebra mussels believed to have arrived in 1986.

We cannot completely stop the tide. Perfect screening, detection, and control are impossible for the foreseeable future. Nevertheless, Federal and State policies, designed to protect us from unplanned invasions and the spread of nonindigenous species, are not safeguarding our local and national interests in important areas. The conclusions of a report filed by the Office of Technology Assessment within the United States Congress (Harmful Non-Indigenous Aquatic Nuisance Species in the United States, September 1993) have a number of policy implications. First, the Nation has no real national policy on harmful aquatic introductions; and the current systems are piecemeal and lack adequate rigor and comprehensiveness. Second, many Federal and State statutes, regulations, and programs are not keeping pace with new and spreading nonindigenous pests. Third, better environmental education and greater accountability regarding actions that cause harm could prevent some problems. Finally, faster response and more adequate funding could limit the impact of those that slip through.

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (Public Law 101-646), is the federal legislation which calls upon the states to develop and implement comprehensive state management plans for aquatic nuisance species control. The Act was established for the prevention and control of the unintentional introduction of ANS and is based on the following five objectives:

- Prevent further unintentional introductions of nonindigenous aquatic species;
- Coordinate federally funded research, control efforts and information dissemination;
- Develop and carry out environmentally sound control methods to prevent, monitor and control unintentional introductions;
- Understand and minimize economic and ecological damage;
- Establish a program of research and technology development to assist state governments.

The plan requests funding in the amount of $466,700 over a three-year period and would provide the resources necessary for enhanced information and education efforts, additional monitoring capabilities, and increased technical assistance to private facilities. The resources would also be used for the development of policy options regarding environmental controls and regulations to provide the foundation for a long-term commitment to ANS control in Michigan. In addition, the plan sends the message that the federal government has not met its responsibility to control further introductions of ANS. Existing resources do not adequately address the problem.

While the opportunity for federal funding provided the initial impetus for the development of this plan, it will serve as Michigan's plan of action, to the extent resources allow, even if federal support fails to materialize.

II. The Present State of Affairs

Nonindigenous aquatic species are a source of socio-economic benefits and costs to many sectors of American society and a threat to the maintenance of biological diversity and ecological integrity. The significance of nonindigenous species issues are generally not recognized. Yet, the stakes are hard to overstate. An aquatic nuisance species (ANS) is defined as a waterborne, non-indigenous organism that threatens the diversity or abundance of native species, or the ecological stability of impacted waters, or, that threatens a commercial, agricultural, aquacultural or recreational activity dependent on infested waters. These species have the potential to cause significant ecological problems because they have been introduced into a habitat in which there are no natural controls, such as pathogens, parasites, and predators. Lack of natural controls in a new habitat may allow a species to grow at or near its potential, exponential growth rate. If such

species become established, they may disrupt species relationships in the new habitat. As a nuisance species proliferates, other species relationships change in the habitat. The introduced species may prey upon, outcompete, or cause disease in native species.

Because the Great Lakes are open to the St. Lawrence Seaway for shipping, they have been the recipient of many foreign aquatic nuisance species. Since the 1800's, over 130 such organisms have become established in the Great Lakes Basin. Over one-third of the organisms have been introduced unintentionally in the past 30 years, a surge coinciding with the opening of the St. Lawrence Seaway. With the increased speed of ocean transport and improved water quality conditions in some European countries, zebra mussels, ruffe, gobies, and other pests are now able to survive the journey in ship ballast water from Europe to the Great Lakes. Nonindigenous aquatic nuisance species will continue to arrive in the Great Lakes Basin until the pathways by which these species are introduced are adequately addressed by federal, state, and provincial governments, and responsible actions are taken to reduce the rate of introduction. Nonindigenous species, and the control of their spread, are international issues with potential impacts that span economic, social, health, and ecological concerns. Water used for many applications, including ballast control, food processing, bait industry, exotic pet trade, and the aquarium trade are all sources of introduction of nonindigenous species causing adverse impacts to the Great Lakes.

On November 29, 1990, partly in response to the introduction of zebra mussels into the Great Lakes, Congress passed the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (Public Law 101-646). The major focus of the act is to set up a framework to reduce the risk of unintentional introductions and to monitor and control nonindigenous aquatic nuisance species. The act establishes a federal interagency Aquatic Nuisance Species Task Force responsible for developing a framework to address the problem of nonindigenous aquatic nuisance species. The act also contains specific provisions for controlling zebra mussels and a mandate that the United States Coast Guard promulgate ballast regulations which apply to vessels that enter a United States port on the Great Lakes after operating on the waters beyond the Exclusive Economic Zone (EEZ). The EEZ is defined as an area extending from the baseline of the territorial sea of the United States seaward 200 miles. The Coast Guard ballast water management regulations became effective on May 10, 1993. Because the regulations do not address ballast control measures for vessels operating inside the EEZ, and those entering Great Lakes connected fresh and brackish waters, it provides no safeguards for preventing the dispersion of aquatic nuisance species already established in the United States. The key to the long-term protection of the Great Lakes from unwanted arrivals is to prevent the discharge of ANS contaminated vessel ballast water into the Lakes. Cost effectiveness dictates that the strategic emphasis be placed on prevention of introductions rather than on attempting after-the-fact control of range expansions of ANS. An established nonindigenous organism in the Great Lakes Ecosystem is impossible to eradicate.

Section 1204 of the act is also particularly relevant to the Great Lakes States. This section allows the governor of each state, after notice and opportunity for public comment, to prepare and submit to the nationally appointed Aquatic Nuisance Species Task Force, a comprehensive state management plan which identifies management measures and funding needed to reduce infestations of aquatic nuisance species. Furthermore, development of a state management plan is a key recommendation of Michigan Natural Resources Commission Policy #2001 (Nonindigenous Aquatic Nuisance Species, March, 1993). The plan contained herein requests funding in the amount of $466,700 over a three-year period to carry out the following objectives:

- Prevent new introductions of ANS into the Great Lakes and inland waters of Michigan.
- Limit the spread of established populations of ANS into uninfested waters of Michigan.
- Abate harmful ecological, economic, social and public health impacts resulting from infestation of ANS.

The environmental and economic costs resulting from the invasion of aquatic nuisance species in Michigan will continue to rise if new introductions continue and with the spread of species already released. While the opportunity for federal funding provided the initial impetus for the development of this plan, it will serve as Michigan's plan of action, to the extent resources allow, even if federal support fails to materialize.

Species of Concern

The invasion of the zebra mussel in 1988 helped bring the serious nature of the aquatic nuisance species issue to the public eye. Prior to the zebra mussel invasion, public perception held that resource management agencies have the ability to control alien invaders. While this belief is partially true, control can only be defined as slowing or preventing the spread; range reduction of a species; mitigation of site specific conditions such as allowing for the treatment of water intake systems to remove colonies of zebra mussels; or cleaning beaches after major storm events which wash thousands of dead zebra mussels ashore. Control of aquatic nuisance species is not complete eradication of the nuisance organism from the ecosystem, rather it means a reduction

in abundance or effect of the nuisance.

In the spring of 1988, the zebra mussel (Dreissena polymorpha) was discovered in Lake St. Clair. Scientists believe the zebra mussel was transported to North America in the ballast water of a transatlantic freighter that previously visited a port in Eastern Europe where this mollusk is common. Zebra mussels have now spread to all five Great Lakes and are also found in the Mississippi, Tennessee, Hudson, and Ohio River Basins.

Zebra mussels readily attach to most submerged surfaces including boats, rocky shoals, water intake pipes, navigational buoys, docks, piers, and indigenous species such as clams. They affix themselves to shells of their own species and are able to form dense layered colonies of over 1 million per square meter. The mussels have been able to colonize and foul heat exchangers, valves, and small diameter piping once the organism gains entry into power plants. Irrigation, fire protection, and dust suppression systems have also experienced problems associated with mussel colonization. The U.S. Fish and Wildlife Service assesses the potential economic impact at $5 billion over the next ten years to U.S. and Canadian factories, water suppliers, power plants, ships and fisheries within the Great Lakes Region.

The ability of zebra mussels to filter suspended particles with high efficiency from the water column was established by European researchers. Consequently, one of the early concerns regarding the appearance of zebra mussels in the Great Lakes was the impact on water quality. During the past several years research in the Western and Central Basins of Lake Erie has confirmed preliminary observations that water clarity had increased as a result of filtering activity by dense populations of zebra mussels. However, attributing an increase in clarity to zebra mussels is not as simple and straightforward as it may appear. Other important factors influence water clarity, such as storms that resuspend sediments, nutrients, phytoplankton, and organisms that graze on phytoplankton.

Over the past few decades, nutrients (especially phosphorus) that support phytoplankton growth have been an important determinant of water clarity in Lake Erie. High phosphorus levels support dense populations of algae, causing reduced water clarity. Since the 1960's improved sewage treatment facilities and low-phosphate detergents have successfully reduced phosphorus inputs to Lake Erie by about 50 percent. Researchers from the Ontario Ministry of the Environment recorded the decline of phytoplankton associated with decreasing phosphorous levels from the late 1960's to the present. With the appearance of zebra mussels in 1988, phytoplankton abundance declined significantly and far more rapidly than could be explained by declining phosphorous levels. A decline of phytoplankton also followed the spread of zebra mussels into Lake St. Clair in 1988, western Lake Erie in 1989, and central Lake Erie in 1990. An additional piece of evidence supports the role of zebra mussels in the decline of phytoplankton. The species composition of the phytoplankton community itself also changed. Researchers noted that as phosphorus levels declined, the dominant species of phytoplankton shifted from a blue-green algal community (high phosphorus) to a green algal community (lower phosphorus levels).

The consequences for organisms that rely on phytoplankton as a food source have yet to be accurately determined. Because phytoplankton is the major food source for open water (pelagic) lake food chains, fisheries impacts may result from zebra mussel filtration activity. Excessive removal of phytoplankton from the water column may cause a decline in planktivorous fish species. As a result, populations of planktivorous fish like gizzard shad might decline, and other desirable fishes such as walleye rely on the shad for forage. As zebra mussels settle and attach to firm substrates, there is also concern that extensive colonization of shoal areas in lakes could impair reproduction of certain fish species. The walleye and lake trout are two species which use rocky substrate for spawning and may be affected by colonies of mussels.

One severe biological impact that has been documented is the near extinction of native American unionid clams in Lake St. Clair and in the western basin of Lake Erie. Zebra mussels attach and build colonies on the clams, eventually leading to their death. One of the earliest and most noticeable natural responses is the increased use by diving ducks of areas with large populations of zebra mussels. Diving ducks feed on zebra mussels. Researchers do not believe that feeding of diving ducks alone will significantly reduce zebra mussel populations, however. The zebra mussels' prolific reproductive cycle along with its ability to adapt to many aquatic environments make it a very successful invader. Scientists believe eradication of the mussel is unlikely. Furthermore, American and Canadian research conducted since 1988, indicate an inevitable dispersion of zebra mussels to every temperate waterbody throughout North America.

Another important aquatic nuisance species already established in the Great Lakes Basin is the ruffe (Gymnocephalus cernuus), a small perch-like, Eurasian fish. It was apparently introduced to the Great Lakes in the St. Louis River near Duluth, Minnesota from a ballast discharge. In Europe the ruffe feeds on whitefish eggs and competes with other more desirable fish. The spiny dorsal fins of the ruffe discourage predation by other fish. In Lake Superior, the species of fish that is most affected by the ruffe is the yellow perch.

Populations of perch have declined up to 75% in water bodies where ruffe have become established.

The quagga mussel (Dreissena bugensis) is related to the zebra mussel but is a distinct species. It prefers deeper, colder waters which is consistent with laboratory studies indicating that the quagga has a lower thermal maximum than the zebra mussel. In addition, it may have the same potential as the zebra mussel to clog water intakes. The discovery of this second type of mussel increases the probability that other species of Dreissenidae have been introduced into the Great Lakes.

The round goby (Neogobius melanostomus)is an abundant species with origins in the Black and Caspian Seas. They are a small fish that feed chiefly on bivalves, amphipod crustaceans, small fish, and fish eggs. It is also believed this fish was introduced into the Great Lakes from discharged ballast water. Consumption studies of fish suggests round gobies might have a detrimental impact on native species through competition for food and predation on eggs and young fish.

The spiny water flea (Bythotrephes cederstroemi)is also believed to have entered the waters of the Great Lakes from discharged ballast water. Although its average length is rarely more than one centimeter, this large predaceous zooplankter can have a profound effect on a lake's plankton. The spiny water flea sometimes competes directly with young fish for food. Because this organism can reproduce many times faster than fish, it could monopolize the food supply at times, to the eventual detriment of the fish. Although Bythotrephes can also fall prey to fish, its spine seems to frustrate most small fish, which experience great difficulty swallowing the animal.

The sea lamprey (Petromyzon marinus) has been a serious problem in the Great Lakes for more than 50 years. After more than 30 years of trying to eradicate lamprey, the parasitic invader is making a comeback at the expense of the lake trout fishery in northern Lakes Michigan and Huron. An adult lamprey can kill up to 40 pounds of fish in just 12 to 20 months. A lamprey attaches itself to a fish with a sucking disk, pierces its scales and skin and sucks out body fluids, often killing the fish.

Eurasian watermilfoil (Myriophyllum spicatum), a nonindigenous aquatic plant, reached the midwestern states between the 1950s and 1980s. In nutrient rich lakes watermilfoil can form thick underwater stands of tangled stems and vast mats of vegetation at the water's surface. In shallow areas the plant can interfere with water recreation such as boating, fishing, and swimming. The plant's floating canopy can also crowd out dominant native water plants.

Purple Loosestrife (Lythrum salicaria), is a perennial wetland plant native to Europe and Asia. It was introduced into the United States in the early 1800s and continues to spread. The plant is impacting Michigan wetland ecosystems by changing the structure, function, and productivity of the wetlands. The plant forms dense monoculture stands, sometimes hundreds of acres in size, that displace native vegetation and threaten the biotic integrity of wetland ecosystems. The loss of plant species richness and diversity has eliminated natural foods and cover essential to many wetland wildlife species.

Once established in large, open aquatic systems, harmful, nonindigenous species such as those described above have proven impossible to eradicate. These species represent only a small percentage of the most harmful invaders to arrive in Michigan. Control of numbers and range extensions may, in specific instances, be attempted, although usually at great cost, continuous effort, and limited results.

Michigan Efforts

Responding to the initial invasion of the zebra mussel, a Michigan Zebra Mussel Task Force was formed by the DNR in 1990 to begin looking at the problems associated with the introduction of this organism. The task force was directed by Michigan House Resolution No. 626 to assess the zebra mussel problem in Michigan and submit its findings to the legislature. The Task Force objective was to develop an overall strategy to control the spread of the zebra mussel to uncolonized areas of the Great Lakes and inland waters of Michigan, including development of research priorities and watercraft operational guidelines. Task Force members consisted of representatives from the DNR, Michigan Sea Grant, U.S. Fish and Wildlife Service, Great Lakes Environmental Research Laboratory, Michigan Department of Public Health, Consumers Power Company, Detroit Edison Power Company, Michigan Boating Industries Association, local units of government and universities. The Task Force submitted a final report to the legislature in February 1991. The report provides an overview of the zebra mussel invasion and recommended actions aimed at minimizing the potential damages incurred by this aquatic nuisance species.

On March 11, 1993, the Michigan Natural Resources Commission (NRC) adopted policy #2001 addressing

nonindigenous aquatic nuisance species. The Commission policy supports the scientific finding that the zebra mussel, spiny water flea, sea lamprey, ruffe, round goby, and Eurasian watermilfoil are injurious aquatic nuisance species with the ability to dramatically alter a wide variety of human uses of the Great Lakes Basin ecosystem, including commercial and recreational fishing, power generation, manufacturing, navigation, tourism and beach use, natural area/native species appreciation, and public water supplies. In addition, these aquatic nuisance species have shown to negatively impact species diversity. It is, therefore, the existing policy of the DNR to arrest the rate of spread of these aquatic nuisance species to uncolonized waters, including inland lakes and streams, and to encourage environmentally sound management practices. These practices are defined as studies, actions or programs to prevent introductions or control infestations of aquatic nuisance species that minimize adverse impacts to the structure and function of an ecosystem and adverse effects on non-target organisms and ecosystems while emphasizing integrated pest management (IPM) techniques. IPM is defined as a management system that uses all suitable techniques in an economical and ecologically sound manner to reduce pest populations and maintain them at levels that do not have an economic impact while minimizing danger to humans and the environment. The NRC policy is carried out in part by equipping the public, business and industry, and municipal entities in the region with current knowledge regarding all aspects of the species invasions. To inhibit the spread of these species, people must know where the organisms live, how they behave, how they are transported, how the public will be impacted environmentally and economically, and what specific actions they can take. In addition, these objectives will be further accomplished through legislative initiatives, enforcement, applied research, lake monitoring, approved chemical application, and cooperation with other federal, state, provincial and local governments.

The DNR Fisheries Division, Parks and Recreation Division and the Office of the Great Lakes in the Department of Environmental Quality (DEQ) have responded to the introduction of zebra mussels by establishing an aggressive public information program. The goal of the program is to provide information to arrest the rate of spread of zebra mussels and other ANS to inland lakes and streams and to encourage environmentally sound management practices. The Office of the Great Lakes developed a zebra mussel bulletin entitled, "What Recreational Boaters and Anglers Should Know," which identifies methods to prevent or minimize the transport of zebra mussels to uncolonized waters of the state by boaters and anglers. The education and outreach campaign expanded to include other harmful organisms such as the ruffe, eurasian watermilfoil, and the spiny water flea. Since 1993, over 500,000 advisories have been mailed to registered watercraft owners in the state. This program will continue until the more than 800,000 watercraft owners are provided with this information. In addition, the Fisheries Division and Parks and Recreation Division supply fact sheets and advisories to marinas and baitshops throughout the state. The Parks and Recreation Division has also produced over 1000 zebra mussel advisory signs that are posted at Great Lakes boat ramps throughout the state. The signs warn boaters of how zebra mussels are transported to waters of the state and what specific actions can be taken by boaters to prevent the spread. Boat ramps on inland lakes that have confirmed zebra mussel populations are also posted.

In an effort to detect zebra mussel populations on inland waterbodies, Parks and Recreation Division now conducts a courtesy (skid) pier inspection program. In 1994, a total of 219 courtesy piers were inspected as they were pulled from the water for winter storage. Piers were inspected at boating access sites located on 155 inland lakes without connection to the Great Lakes, 5 inland lakes directly connected the Great Lakes, and 6 inland rivers. Piers at 13 Great Lakes sites were also inspected. Adult mussels were found only on piers pulled from 6 inland lake sites.

Michigan Inland Lake Study

In 1993, the first systematic widespread sampling of inland waters of North America for the presence of zebra mussels was initiated to assess the incidence of overland dispersal into inland freshwater systems in the Lower Peninsula of Michigan. The 33 lakes targeted for this survey were considered to be at high risk of zebra mussel invasion due to large size, close proximity to infested waters, or the presence of public access sites. These are characteristics which typify lakes with higher levels of Transient Boating Activity (TBA). Zebra mussels were detected in 10 of these lakes, providing a limited initial assessment of their inland range expansion.

The zebra mussel sampling program was increased to determine the rates, direction, and spatial patterns of the spread of zebra mussels from last season. Existing inland populations were monitored with the objective of investigating the early population dynamics of zebra mussel invasions and deriving predictive models of the timing and magnitude of future population growth and associated impacts.

A pilot volunteer monitoring program was developed to provide a model for the creation of a large-scale program for long-term detection and monitoring of the invasion of inland waters by nonindigenous nuisance species. The program sought citizen involvement in active zebra mussel monitoring using simple, low cost methodologies as

a means of demonstrating the efficacy of volunteer efforts in gathering scientifically useful data. Goals for the program were: 1) to develop a monitoring network which could be expanded in future years to involve more citizens and lake associations and; 2) to complement the 1994 sampling program.

The monitoring program uses the veliger (free-floating larvae) detection methods that are of proven efficacy in the early detection of sparse zebra mussel populations. Plankton sampling for the presence of zebra mussel veligers was employed extensively (50 lakes). Settling plates were also deployed in 13 lakes with confirmed populations. Training sessions on plankton sampling techniques were conducted to train 20 volunteers from 16 lake associations for the pilot "self-help" zebra mussel monitoring program. A simple, standardized protocol for adult detection was developed using a pontoon inspection technique and was deployed by an additional 48 lake associations. Overall, a total of 66 lakes in Michigan were involved in active zebra mussel surveys this past season. Multiple monitoring methods were used at many of these lakes, i.e., plankton sampling and volunteer pontoon boat monitoring. Volunteer sampling at control lakes effectively replicated and complimented professional sampling. In fact, both volunteer monitoring methods show great potential to be employed as a large scale, low cost, inland lake monitoring network. The success of the pilot program indicates that it can clearly serve as a model for more extensive volunteer lake monitoring programs. Overall, the program was supported with great enthusiasm from volunteers and lake associations and demonstrated that trained lay people can produce scientifically valuable information within the context of a large scale aquatic nuisance species lake monitoring project.

As a result of the study, eight new zebra mussel infestations were detected by the 1994 monitoring program. An additional five infestations were detected incidentally by lake front property owners and in one case, by other lake researchers studying native mollusks, for a total of 13 new inland lake infestations in 1994. Eleven of the new infestations have confirmed adult populations. The remaining two lakes are veliger-only detections. Most new populations were detected in the southern portion of the state. Overall, as of November 1994, a total of 25 Michigan inland lakes have displayed some evidence of zebra mussel infestation, 14 with confirmed populations of adult zebra mussels (Figure 1). Almost all lakes exhibiting evidence of zebra mussel infestation have public access sites (24 of 25), indicating that this variable is a significant element in the construction of zebra mussel invasion susceptibility profiles for inland lakes. The study also concluded that secondary dispersal from established inland populations is becoming a significant factor in the development of new infestations.

Population growth in the 14 lakes with known adult populations thus far appear to be consistent with the explosive patterns of growth witnessed in Lake Erie in the late 1980's and early 1990's. In addition, Transient Boating Activity (TBA) appears still to be a major dispersal vector for zebra mussels. All new detections in 1994 occurred in larger lakes with public access sites. Regional "hotspots" of new invasions appear to be in areas heavily used by Great Lakes boaters. Additional evidence also suggests that the role of boating activities of lakefront residents in dispersing zebra mussels to inland lakes cannot be minimized. If lakefront property owners are a high risk dispersal vector, then it is reasonable to suspect that lakes characterized by a high proportion of lakefront residents with permanent residences near heavily infested Great Lakes waters would experience zebra mussel inoculation events more frequently through the transient boating activity of residents.

The study concluded that zebra mussels are dispersing to inland lakes at a significant rate. If the present trends continue, a substantial proportion of inland lakes in Michigan's Lower Peninsula will likely be infested within a decade. As the incidence of inland infestations increase, secondary dispersal through natural and anthropogenic sources will assume a larger role in the process of inland invasions. Emerging invasion rates suggest that if reactive, anti-dispersal efforts are to have any efficacy, they must be mobilized in the window of time between primary regional infestations, i.e., Great Lakes invasion, and subsequent overland dispersal.

Michigan Sea Grant College Program

Michigan Sea Grant is a cooperative program of the University of Michigan and Michigan State University. It is one of 29 Sea Grant programs nationwide, including six programs in the Great Lakes states. Through research and education Sea Grant helps individuals, local communities, coastal businesses, and state and local agencies to develop and wisely use the Great Lakes and ocean resources. Michigan Sea Grant is funded by the National Sea Grant College Program, a part of the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and by the State of Michigan, with cooperation of the U.S. Department of Agriculture through Michigan State University Extension.

Michigan Sea Grant is monitoring the spread of aquatic nuisance species such as the zebra mussel and spiny water flea and disseminating information on their location, life habits, control and disposal. As a result, citizens of the state show an increased level of awareness of aquatic nuisance species issues and potential impacts.

Michigan's citizens have displayed improved knowledge of biological characteristics, increased familiarity with impacts on water users (e.g. recreational boaters, industrial facilities), as well as with effects on Great Lakes ecology (e.g. fish reproduction and growth). Although this level of knowledge seems greater among citizens living along the Michigan shoreline, individuals living inland are also showing a higher level of awareness.

Michigan Sea Grant outreach activities have been identified as an important reason for this change in awareness. A majority of the respondents to a 1992 Michigan water user survey, for example, identified the program's annual conferences and quarterly newsletter Upwellings as important resources for aquatic nuisance species information. In addition, hundreds of thousands of listeners, viewers and readers have been reached through coverage on radio, on TV, in newspapers and in magazines. Objectives of the Michigan Sea Grant Extension Program include:

- 1. Increase public awareness of nonindigenous species related issues and encourage behavior to prevent further introduction and distribution of these species.
- 2. Minimize the economic impacts on Michigan caused by harmful nonindigenous species.
- 3. Minimize duplication of zebra mussel research.
- 4. Expand the existing network of nonindigenous species contacts.

Beginning in 1989, the Michigan Sea Grant Extension spends more than $75,000 annually for activities related to nonindigenous species control.

Financial Impacts

When considering a nonindigenous species prevention and control program, it is important to weigh the program costs against the costs of not having a program. While trying to prevent new biological invasions to the Great Lakes might seem expensive, the costs will be less than the costs incurred to control species after they have invaded an ecosystem. The total cost of controlling zebra mussels alone would equal the cost of regulating ballast water discharges in the shipping industry. Long-term, effective prevention and control of nuisance species will require state and federal funding support beyond current levels.

Control of the sea lamprey provides perspective on the term "control." Control of the sea lamprey can be evaluated by economic, as well as, biological measures. They affect the abundance of large, desirable fish species, such as lake trout and salmon, and therefore affect the fishing and tourist industries supported by those fish. However, control measures are funded below the level necessary to ensure maintenance of the recreational and commercial fisheries. It is evident that control of the zebra mussel and most other ANS introductions will follow a similar pattern.

The Eurasian Ruffe has established itself in Western Lake Superior but has yet to complete its invasion of the rest of the Great Lakes. If not stopped, its conquest of the lakes may inflict damage to the commercial and sport fishing industry in the range of $24 to $214 million per year.

Zebra mussel control measures have substantially increased the operating and maintenance costs of industrial and municipal water supplies. Since 1988, municipalities, utilities, and industries in the region have spent millions of dollars for the removal and control of zebra mussel colonies. The small diameter piping systems which use raw water at these plants and fire protection systems are at greatest risk of becoming clogged due to zebra mussel infestation. Stationary intake screens and intake trash racks which have much larger flows have also been heavily impacted. In addition, offshore intake screens often become heavily fouled and periodically require a significant underwater cleaning effort. The Consumer Power Company has annual company-wide costs to control the zebra mussel which approach $1 million.

In the fall of 1989, the City of Monroe engaged a contractor to mechanically clean their zebra mussel infested water intake. Unseasonably cold weather in December triggered the formation of frazzle ice which, aggravated by the presence of zebra mussels completely blocked the flow of water from Lake Erie to the treatment plant for a period of 56 hours. Restricted flow attributable to the zebra mussel alone was over twenty-five percent. Because the City of Monroe provides water to approximately 50,000 residents, the resulting water emergency caused a substantial financial loss for the numerous businesses and industries that were forced to close, along with narrowly escaping a threat to public health. In 1990, the City of Detroit spent in excess of $800,000 for the inspection, removal and treatment of zebra mussels in their water supply system. The City anticipates annual expenditures between $500,000 and $600,000 to continue control of zebra mussels. A 1991 survey of 99 municipal water plants throughout the Great Lakes Region reported a total cost of $9.1 million for zebra mussel control.

In a September 1994 survey conducted for the Great Lakes Sea Grant Network, 223 municipal and industrial water users were asked questions related to zebra mussel control. A summary of the survey respondents indicate that Lakes Michigan and Erie are the lakes most drawn upon by Great Lakes water users, primarily for municipal drinking water purposes. Over two-thirds of water plants have documented zebra mussel populations. Zebra mussel infestation was lowest among industrial process water plants (50%) and highest among cooling water plants (88%). At nearly all plants where zebra mussels were observed, they were located at intake structures (93%), although they were also found in other locations within the system (primarily in pump stations, traveling screens and trash racks). In 80% of the water systems, zebra mussels appeared after 1989, an indication of the rapid expansion in the Great Lakes and connecting waters.

Despite the high infestation rate of zebra mussels, less than half of the water plants (47.5%) have zebra mussel monitoring programs at their facilities. Where monitoring programs exist, sampling of adults and larvae up to twelve times per year is the most commonly used method. About one-third of the respondents indicated that their facilities have employees responsible for monitoring and controlling zebra mussels. The number of facilities that do have employees assigned to this task has increased over time. However, the average number of plant employees and the average percentage of time they spend on the zebra mussel problem (19%) has not increased. Similarly, while initially there was an increase in the budget for zebra mussel control, average budgets have fallen in the last three years. This may be an indication that better, more cost-effective monitoring and control methods have become available over the years. However, because the zebra mussels are still spreading and because more plants will have to start controlling the pest, overall economic impact and total expenditures for zebra mussel monitoring and control could continue to rise in the foreseeable future.

The zebra mussel has also created additional problems for the treatment of municipal water supplies. This is due to the zebra mussels' filtering activity which removes suspended materials from the water column. Water treatment processes are invariably designed to deal with turbid water, i.e., water with microscopic particulate matter in suspension. Such suspended matter, generally bearing a negative surface charge, form the nucleus for agglomeration when cationic coagulants, such as iron or aluminum salts, are added in the treatment works. When lake water is relatively clear, both natural and chemically induced coagulation processes falter, impacting on efficiency and effluent quality, and necessitating additional treatments which drive costs upwards.

Recent concern has centered on the possibility that zebra mussels could spread to sub- irrigation systems used by farmers for irrigation and drainage of cropland. Since much water is pumped from the Great Lakes onto fields where it seeps into tile systems and drainage ditches, it is possible for zebra mussel larvae (veligers) to enter the irrigation system and attach themselves to the metal pipes and corrugated tubing. Michigan currently has over 20,000 acres of sub-irrigated cropland. Not only may the farmers be impacted by zebra mussels entering the irrigation systems, but this also provides another route for the mussels to migrate to inland waters.

The impacts due to the zebra mussel may evolve into a multi-million dollar issue for Michigan boaters. Michigan has 800,000 registered boats, more than any other state in the country. Many of these boaters can anticipate increasing costs related to invading zebra mussels. Such costs may include repair of damaged engines as a result of restricted water flow to the cooling systems, increased fuel consumption related to encrusted colonies on boat hulls, increases in marine insurance, as well as costs attributed to preventative maintenance. If boats are left moored in one place for extended periods the boat hulls may become encrusted with the barnacle-like mussels.

Recreational opportunities are being further compromised as thousands of dead zebra mussel shells are washed up on shore causing unsightly and odorous conditions, similar to the alewives that washed ashore in the late 1960's. The shells of dead zebra mussels are also razor sharp and may injure beach-goers. Some underwater shipwrecks have become almost unrecognizable as their surfaces provide ideal substrate for zebra mussel attachment reducing their value for underwater diving purposes. Navigational and marker buoys are vulnerable to the build up of zebra mussels which can lead to the sinking of the buoys and the creation of navigational hazards. Estimates by the U.S. Fish and Wildlife Service place the potential cost of the zebra mussel invasion in North America at between $400 and $500 million per year for the next decade alone.

State and Federal Policy

Nonindigenous species, once established, can be as much a problem as persistent synthetic chemical pollutants because they can modify the ecosystem permanently. The ultimate objective of educational, technical, legislative and regulatory initiatives should be to eliminate new introductions of unwanted nonindigenous organisms in the Great Lakes Region and throughout the United States.

In an attempt to prevent future introductions of aquatic nuisance species and control existing introductions

In an attempt to prevent future introductions of aquatic nuisance species and control existing introductions, Congress passed the Non-Indigenous Aquatic Nuisance Prevention and Control Act of 1990 , (Public Law 101-646). The Act includes provisions to prevent and control infestations of the coastal inland waters of the United States by the zebra mussel and other nonindigenous species; formation of a federal task force to develop and implement environmentally sound methods to prevent, monitor and control unintentional introductions of nonindigenous species into to United States waters; coordinate federal research and disseminate information; establishment of a program of research and technology development and assist the states in the management and removal of zebra mussels; measures to prevent the unintentional introduction of aquatic nuisance species into the waters of the United States through ballast water management. Since passage of the Act, however, appropriations in all categories have fallen far short of authorized amounts. Approximately $30 million was authorized annually for implementation of the Act, yet no funds were appropriated in 1991, approximately $7 million in 1992, $9 million in 1993 and $12 million in 1994.

Of primary importance is federal action in limiting introductions through transoceanic shipping ballast water. At this time Michigan lacks the ability, resources, and authority to require ballast water exchange before a vessel enters United States or Michigan waters. Public Law 101-646 contained specific provisions for controlling zebra mussels and a mandate that the United States Coast Guard promulgate regulations which apply to vessels that enter a United States port on the Great Lakes after operating on the waters beyond the Exclusive Economic Zone (EEZ). The EEZ is defined as an area extending from the baseline of the territorial sea of the United States seaward 200 miles. The Coast Guard ballast water management regulations became effective on May 10, 1993. The regulations do not address vessel operation inside the EEZ or those entering Great Lakes connected fresh and brackish waters. Once in Great Lakes waters, there are no safeguards to prevent the dispersal of ANS from one part of the Great Lakes, to another. State and local officials have had virtually no role in regulating trans-oceanic vessels operating in Michigan waters beyond advocacy for improved federal restrictions.

Potential regulatory authority to control ballast water release in Michigan waters resides in the Water Resources Commission Act, 1929, PA 245. The Water Resources Commission Act has a broad statement of purpose to "regulate, protect, and conserve the water resources of the state." Section 6 of the Act makes unlawful the discharge or release of "injurious substances." This language could be interpreted to include ballast water, given the potential to release aquatic nuisance species. The Section states:

"It shall be unlawful for any person directly or indirectly to discharge into the waters of the state any substance which is or may become injurious to the public health, safety, or welfare; or which is or may become injurious to domestic, commercial, industrial, agricultural, recreational or other uses which are being or may be make of such waters; or which is or may become injurious to the value or utility of riparian lands; or which is or may become injurious to livestock, wild animals, birds, fish, aquatic life, or plants or the growth or propagation thereof be prevented or injuriously affected, or whereby the value of fish and game is or may be destroyed or impaired."

While the rules promulgated to date under the Water Resources Commission Act do not specifically contemplate the restriction, through permit, of ballast water release in Michigan waters, it is appropriate to evaluate this potential authority if federal restrictions prove insufficient. The key to the long-term protection of the Great Lakes from unwanted arrivals is more effective control of the discharge of vessel ballast water into the Lakes. Cost effectiveness dictates that strategic emphasis be placed on prevention of introductions rather than on attempting after-the-fact control of range expansions of aquatic nuisance species.

In addition to control measures being coordinated through Public Law 101-646, the zebra mussel was added to the list of injurious fish, mollusks, and crustaceans by the U.S. Fish and Wildlife Service effective December 9, 1991, under 50 CFR 16.13. This federal action "prohibits importation into, acquisition, or transportation of live zebra mussels, veligers or viable eggs thereof between the continental United States, the District of Columbia, Hawaii, the Commonwealth of Puerto Rico, or any territory or possession of the United States." This prohibition does not prevent entry from European or other countries through Great Lakes connected fresh and brackish waters. It does not provide any control over the spread of the zebra mussel or other non-indigenous species already established in the Great Lakes Basin.

Other Michigan State Laws and Regulations

Sport Fishing Law: 1929 PA 165

The Sport Fishing Law requires a license from the DNR for taking or possessing minnows, wigglers or crayfish, for any other than personal use. It prohibits the import and export to the State of these species without a license, and prohibits all import of minnows and wigglers that are not native to Michigan. It also prohibits the

import of live game fish or eggs except with a permit and prohibits planting fish, fish fry, or spawn without a permit. Violation of the law is a misdemeanor and carries a 90-day jail term, $500 fine or both, as a maximum penalty.

Game Fish in Private Waters: 1957 PA 196

The Game Fish in Private Waters law controls the import of game fish for private use, requiring a license from the DNR. It prohibits the import of "...any other species of fish when the importation of such species would endanger the public fishery resources of this State." The restrictions are defined by rules, promulgated by the DNR Fisheries Division. Violation of this law is also a misdemeanor, and carries a 90-day jail term, $100 fine or both as a maximum penalty.

State Launch Site Special Use Permits

The DNR requires permits for use of state access sites for fishing and boating tournaments according to rules under the enabling legislation for the Department, 1921 PA 17 . The current rules do not contemplate potential cross-contamination of public waters with ANS, so the restrictions are limited in purpose to public safety and protection of property. Rule changes could be made to expand the requirements if appropriate. Short of regulatory action, these events offer a prime opportunity to distribute materials to the boating public about practices that minimize the risk of transporting ANS via live wells, boat hulls and trailers; prior to leaving infested waters, or entry into uninfested waters.

Policies and Procedures

Policy and procedural approaches can also be effective as a means of altering practices without creating a new regulatory program. Certain operations may be a means of transferring ANS that could be minimized through appropriate review and revision of management practices.

The Natural Resources Commission has adopted a Policy on Non-Indigenous Aquatic Nuisance Species, effective March 1993 (#2001). Specific action initiatives for the agency to follow to inhibit and prevent the spread of ANS are identified, principally pertaining to development of a management plan and cooperative education and early detection.

Michigan State Hatcheries do not have a stated policy or program to monitor for ANS occurrence and State hatchery operation is not considered to be a vector for ANS transport since nearly all hatcheries utilize wells (groundwater) as a water supply.

Approach to Consideration of Other New Laws or Regulations

This Management Plan does not advocate the development or adoption of specific new laws or regulations, nor does it specify modifications to existing controls. Additional research, public comment and a review of non-regulatory alternatives will be needed to determine whether new or modified laws, rules or policies are feasible and appropriate. In particular, the regulatory approach should be employed only where it will be more effective than alternative methods of control.

For example, aquaculture is a rapidly expanding form of agriculture in the United States and could be a primary means of introducing and spreading nonindigenous species throughout Michigan waters. Not all aquatic nuisance species come from other continents. Nonindigenous species with potential adverse impacts could be introduced to the Great Lakes from other parts of the United States. Currently, aquaculture is a minimally regulated industry. If the Michigan Legislature should pass legislation, it should allow for inspections and standards to protect waters from the introduction of nonindigenous species. Water used for many applications, including food processing, bait industry, exotic pet trade, and the aquarium trade could all be sources of introduction of nonindigenous species that could cause adverse impacts to the Great Lakes.

Another important potential vector of ANS movement currently unregulated is the bait industry. Large numbers of minnows are be transported and distributed without sufficient screening for the presence of ANS. These practices will be examined and alternative methods of limiting this potential source of release developed with the cooperation and assistance of bait dealers. Other activities that may be considered for future policy or regulatory restrictions include:

- limiting boating access development or mandatory boat inspection programs to protect ecologically

sensitive waters;
- review of private hatchery operations;
- aquatic pet trade;
- use of pisicides to control ANS.

There is a variety of laws and regulations in Michigan which might limit the introduction and distribution of nonindigenous species. The laws and regulations developed over many years and now exist in a complex and fragmented manner. These laws and regulations should be reviewed, consolidated, updated and publicized. Most people in the state are probably not aware of the existing regulations, and the impacts of ignoring those regulations. Moreover, these regulations are often not vigorously enforced. The public, along with other affected parties must be educated about the regulations and possible impacts, and recruited to actively, voluntarily, prevent the introduction and dispersion of nonindigenous aquatic nuisance species. Educating the public is also very important because the public will ultimately bear the costs associated with the control of aquatic nuisance species.

It must be noted that the response of state governments at this time has been somewhat limited. With numerous programs under their supervision already, state management agencies have been hesitant to commit major resources to the aquatic nuisance species issue without a legislative mandate. State legislatures, confronted with shrinking dollars dedicated to natural resource management, are cautious about authorizing new programs.

Ballast Water Control

Ballast water discharge by ships is the most significant source of unintentional introductions of aquatic nuisance species to coastal and estuarine waters of the United States and elsewhere. Ship hull exteriors, seawater pipe systems, ballast water, sewage holding tanks and treatment plants, and anchors and chains play a role in the inadvertent export and import of live organisms.

The Great Lakes is the first place where the United States has established a defense against the introduction of nonindigenous species carried in ballast water. United States regulations controlling the discharge of ballast from all vessels entering from outside the Exclusive Economic Zone (EEZ) into the Great Lakes went into effect in early 1993 and are enforced by the United States Coast Guard, with active assistance from the Canadian Coast Guard and Seaway authorities. The Great Lakes also have some unique defensive advantages because vessel traffic can be controlled at the Saint Lawrence Seaway and mid-ocean exchange with salt water can be used as a verifiable, reasonably cheap, and safe method for impeding the invasion of new freshwater species. However, more effective defenses are needed in order to prevent new invasions over the long term. Development of these new defenses will probably require engineering changes in ballast systems in all vessels engaged in transoceanic trade, whether going to fresh or saltwater ports.

Almost all life forms may exist on board cargo and passenger ships. The loading, transportation and unloading of the more visible terrestrial species are generally controlled by port regulation, national laws, international agreements and by good ship practice. Thus, human migrants, plants, animal cargos, and pets (dogs, cats, and other mammals, as well as birds, reptiles, amphibians and fish) are screened by customs, health, immigration, agricultural officials and veterinarians. On the other hand, the discharge of ballast water contributing less visible, yet potentially harmful waterborne organisms are not adequately controlled. These unintentional releases within the last 65 years have been and continue to be, most frustrating to the Great Lakes states and Canada as they can dramatically alter the delicate balance of the Great Lakes ecosystem.

Four principal types of water are found on board ships. The first is "incidental", and includes rainwater, waves and sea spray breaking on deck, water used in deck lines and bilge water collected in cargo holds and engine rooms. This type of water either flows off the decks or is actively pumped out once or several times a day in accordance with the provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL). The second is "potable water", and includes drinking water and water used for showers, cooking, and galley washing. This water is also drained overboard after use. The third is "engine room water". Included here are cooling water and boiler make-up water. Some of this water is discharged at greater than ambient temperatures, but is quickly diffused and cooled in the ocean. The fourth type of shipboard water is "waste water". Included here is saltwater (from oceans and seas) and freshwater (from lakes and rivers) taken aboard intentionally for ballasting and for sanitary systems. This water will then require disposal at some distant point.

While the first three water types are generally no longer held as being vectors for the transportation of harmful organisms, the fourth water type holds great potential for such accidental movements (in early seafaring days the intercontinental movement of drinking water in barrels and casks is believed to have led to the accidental

introduction of a number of species, including mosquitoes). Attention is focused here on the modern-day uptake and disposal of ballast and sanitary system waters.

All ships on long international voyages have provisions to carry between 25 and 35% of their deadweight tonnage in the form of ballast water. Ideally, ships should complete each leg of a voyage loaded with cargo and would never need to carry ballast water. In practice, this does not happen frequently and most ships take on ballast even in a partially loaded condition. As an example, the ballast water configurations on ocean-going vessels visiting the Great Lakes are shown in Figure 2. In general, ballast water piping is of relatively large diameter and individual filling pipes contain a more or less significant quantity of water as well. The water that comes on board contains the animals and plants typically found in the ships surroundings; those that successfully enter and survive have passed through the intake gratings (usually each hole is less than 2 cm in diameter) and through impeller pump blades. While in the ballast tanks the water may be efficiently oxygenated during the voyage. After filling a tank to the top (pressing up), a small quantity is pumped out to avoid pressure from building on the tank top. This action creates an air space or wedge (about 5 cm in height) at the tank top. With each roll and pitch of the vessel this air is expelled and a new charge is taken in. The surging ballast water inside the tank may thus renew its oxygen capacity to its saturation point, thereby providing the organisms with sufficient oxygen for survival. Food for these organisms, during the time intervals involved (two or three weeks as typical) is probably not limiting, nor does the constant dark appear to be a biological problem.

Long-term strategies for effectively eliminating the risk of intercontinental transfers of harmful organisms by shipping will require a coordinated regional approach, possibly a global one. Examination of ships and their discharges, new and continued research and development, and implementation of existing and anticipated measures will necessitate coordination worldwide if programs are to be as effective as they could be at preventing introductions of harmful organisms. There is reason to hope and to expect that the present fleet can eventually be replaced with ships designed to facilitate the carrying out of effective preventive measures with safety and with reasonable ease. In fact, there are ships in today's fleet that with relatively minor retrofitting might be capable of bringing their ballast water to temperatures sufficiently high enough to ensure that no ballast-borne organisms survive trans-Atlantic voyages. Relatively self-contained solutions such as thermal treatment requires no handling of chemicals that may be harmful to receiving waters and this should be rigorously pursued.

Some long-term alternatives such as heating ballast (thermal treatment), using biocidal paints, chemical disinfectants, ozone, deoxygenation, ultrasound, electricity, microwaves, rapid pressure changes, or even screens and filters in combination with other treatments, may have feasibility in the immediate future for some portion of the fleet. The significance of the issue of harmful invasions introductions via shipping is sufficient to warrant the immediate pursuit of each and every opportunity that would serve prevention strategies.

International cooperation and coordination is an essential component of an effective and practical program to prevent ship transfers of aquatic organisms. International consultation with such organizations as the International Maritime Organization is essential to national initiatives. International coordination and cooperation should be sought for both overall strategy and related technology research and development. The need for international cooperation does not, however, preclude the need for individual states to devise regional strategies based upon their own specific concerns and circumstances.

Similarly the cooperation of shippers and ships' crews should be actively recruited wherever possible in order to maximize the effectiveness of preventive programs. Keys to shipping industry cooperation are an understanding of the problem, reasonable-cost preventive procedures, and positive feedback to cooperators. Preventive programs should be as effective and environmentally safe as possible. Although regulations may or may not be necessary or desirable in the short term or in certain circumstances, resource managers should seek legislative authority which would permit rapid action as necessary. Comprehensive regulations will almost certainly be needed eventually in order to implement long-term solutions and to help ensure responses that are consistent with the magnitude of the problem.

An excellent example of cooperative efforts was the adoption of voluntary ballast water management guidelines by the maritime industry to control the range expansion of the ruffe from Duluth Harbor, Minnesota. Support of the guidelines came from the Lake Carriers' Association, U.S. Great Lakes Shipping Association, Seaway Port Authority of Duluth, Thunder Bay Harbor Commission, Canadian Shipowners Association, and the Shipping Federation of Canada. The guidelines demonstrate that owners and operators of vessels in the domestic and international trade on the Great Lakes recognize their role in assisting the governments of United States and Canada in controlling the introduction and spread of nonindigenous species.

Integrated Pest Management Control

Michigan residents are fortunate to have and enjoy abundant, fresh, clean surface and groundwater. Natural lakes and ponds are plentiful, and artificial lakes and ponds continue to be designed and developed. Clean and attractive water systems can quickly become undesirable or even a liability when invaded by nuisance weeds or other nonindigenous pests. Several factors influence how and why a pest becomes established in an aquatic area. Thus, several management decisions must be made to effectively and safely recover the lost qualities of water.

A system known as integrated pest management (IPM) is often a useful way to effectively manage pests in complex biological systems using a variety of pest management tools. IPM is defined as a management system that uses all suitable techniques in an economical and ecologically sound manner to reduce pest populations and maintain them at levels that do not have an economic impact while minimizing danger to humans and the environment. IPM may combine biological control, pest resistance, autocidal, cultural, and mechanical and physical control technologies with limited use of chemical pesticides. However, IPM is not a purview for "renovative" chemical treatments of aquatic plants in lakes, including native species. IPM uses monitoring and other decision making tools to gauge the health of the ecosystem, and consequently requires an understanding of the biology and ecology of the resource, the pest, and the pest's natural enemies.

Research establishes the needed economic thresholds and natural suppression factors. An understanding of the effectiveness of the control technologies and damage caused by different stages of pests is important. Because IPM does not necessarily rely on chemical pesticides, quick, simple, inexpensive but accurate tools are needed to monitor the environment and implement programs before a pest becomes an economic problem.

The goal of IPM is to reduce pest impacts to an acceptable level. Typical components of an IPM program are:

- 1. Site evaluation and detection.
- 2. Pest identification.
- 3. Economic, aesthetic and recreational significance.
- 4. Selection and use of management methods.
- 5. Evaluation of management methods used.

Control of pests should be considered only when native species are threatened by the invasions of non-native organisms, when pests hinder recreational activities or other water usages, or when they detract from the aesthetics of the waterbody. These undesirable situations can influence the value of property adjacent to the water body as well as the quality of life of the people living there. How and when to implement pest management tactics will vary by location. A selected pest management procedure must be economical and have minimal potential for harming people, nontarget species and the environment, yet, effectively reduce the nuisance. Improved economics as it relates to aquatic business and property values, enhanced aesthetics and pursuit of recreational activities are the primary incentives that lead to a coordinated aquatic IPM program. Clearly identifying goals for each waterbody, determining when treatment is necessary and identifying the most opportune time to take action to achieve these goals are all components of an IPM program. These goals and decisions should be clearly stated, understood and acceptable to everyone involved: the riparians, visitors to the waterbody, the DNR and the pest manager.

Once a pest problem is recognized, the biology and the habits of the pest understood, and the economic, aesthetic or recreational impacts identified, then an appropriate method or combination of methods can be selected to manage the pest. Management methods must be effective, practical, economical and environmentally sound. Proper method selection requires familiarity with all available management methods. Evaluate the benefits and risks of each management method applied to a given situation. Preventative, physical, mechanical, biological and chemical methods should be evaluated for short- and long-term effectiveness, applicability to the situation, level of pest control desired, environmental implications and cost. Understanding what actions or events led to a pest problem may allow a resource manager to recommend a change in practices to correct or prevent a certain condition.

Research Initiatives

Once introduced and established in an open aquatic system, nonindigenous species have proven impossible to eliminate. While effective means may be found to control these organisms at some ecological or socio-economic level of acceptance, in most cases little can be done to minimize ecosystem impacts and resulting resource losses. Emphasis, therefore, should be placed on preventing the introduction of ANS into the system.

First, the means of introduction must be identified. Second, research should focus on establishing cost-effective, practical methods of prevention. For example, ballast water discharge is an important vector for ANS introductions in the Great Lakes. Strategies must be developed to effectively eliminate this source of introduction without imposing undue hardships on the shipping industry. Strategies for eliminating other means of ANS introductions, such as intentional release, opening of canals, accidental release, etc. must be examined in a similar fashion. In addition, not all introduced species become widespread and abundant. An examination of life history characteristics and past dispersal patterns in other aquatic environments worldwide can identify those species most likely to spread into and colonize the Great Lakes.

The scientific ability to predict the spread of an established ANS (i.e., a viable reproducing population) is dependent on knowledge of the species' environmental requirements and its dispersal mechanisms, which allow it to reach new areas where environmental conditions are favorable for growth and reproduction. Most ANS have been introduced and spread by anthropogenic activities (e.g., ship ballast, boats, aquarium trade, etc.). However, the mechanisms by which dispersal occurs is often unique to each species and is usually determined after geographic range extensions occur.

Basic understanding of ANS biology and documentation of past modes of dispersal can be used to establish likely future dispersal mechanisms. Once dispersal mechanisms are identified for individual established ANS, proper safeguards and international protocols can be developed to prevent and/or slow the spread to uninfested areas. Such safeguards and protocols may also be applicable to preventing the spread of new, not-yet established ANS. Analysis and identification of past and possible future dispersal mechanisms of ANS will enhance the ability to control and mitigate the impact these species may impose on the ecosystem.

Since the arrival of the zebra mussel in the Great Lakes Basin, the United States and Canada have made tremendous strides toward effective collaboration and dissemination of scientific research. The willingness to collaborate has resulted in a substantial amount of published literature in a relatively short amount of time. This in turn has minimized the duplication of efforts and maximized resource allocation. In 1993, over $5 million was spent on ANS research at the federal level in the United States and Canada. Approximately two-thirds of U.S. ANS research is conducted at academic institutions. In contrast, the majority of Canadian ANS research is conducted at large government-operated institutions.

Research has focused on a basic understanding of the life history and population dynamics of the zebra mussel. This research was necessary to monitor the response of the Great Lakes to the zebra mussel and to determine biological characteristics that would guide further research efforts to develop effective, ecologically safe, and economically feasible control measures. Review of existing research literature in conjunction with new research in the areas of life history, population dynamics, physiology and behavior, genetics, parasites, and diseases of the zebra mussel is necessary. This research will allow the regulatory agencies to determine the organism's vulnerability to particular control alternatives. Information on the ecological and environmental tolerances of the zebra mussel was necessary to determine the potential geographic limits of infestation. This information has helped predict which native species and habitats are most likely to be affected by the zebra mussel.

The development of a coordinated research program for ANS requires an unprecedented level of communication and cooperation between researchers, regulatory agencies, and Great Lakes industries. Today, the most urgent need is for reliable and up-to-date information identifying research that is underway or planned. To continue to be effective, investigators must be knowledgeable about and have timely access to research that has taken place and is being planned in the United States and Canada. Six special areas of research have been identified by the Great Lakes Panel to continue to define the impacts of ANS on the Great Lakes:

- 1. Biology/life history.
- 2. Ecosystem effects.
- 3. Socio-economic analyses: cost and benefits.
- 4. Control and mitigation.
- 5. Prevention of introduction.
- 6. Reducing the rate of spread.

At the state level, the DNR has four Great Lakes Research Stations which are involved in monitoring Great Lakes fish stocks. The major thrusts of the studies are to measure changes due to harmful invaders or anything else. The stations help measure progress of sea lamprey control by monitoring lake trout wounding rates and recovery of lake trout stocks. They are monitoring fish stocks in Saginaw Bay to assess the effects of zebra mussels, white perch and the reintroduction of walleye. The DNR has been a leader in lake trout

restoration research and in monitoring the effects of sea lamprey in the upper Great Lakes. However, recent budget constraints are limiting the DNR's ability to maintain any research at current levels.

An emerging research need is the ability to describe the mechanisms by which ANS spread to "unconnected" or inland waters of the State. Some of the pathways include, but may not be limited to, boaters, fishermen, birds and waterfowl, bait shops, sub-irrigation and tile drains, and intentional introductions by citizens. All of these mechanisms add to the dispersion rate of ANS and some limited research in Michigan has begun investigating these issues.

Summary

A successfully established nonindigenous organism in the Great Lakes ecosystem should be regarded as impossible to eradicate. The problem of unplanned introductions of ANS to the Great Lakes Basin ecosystem is a complex issue. Control will require coordinated, collaborative, and innovative approaches. Overall cost effectiveness dictates that the emphasis should be placed on prevention of introductions rather than on attempting after-the-fact control of harmful organisms. Unplanned introductions of nonindigenous plants and animals have caused so many problems that the ultimate objective of any preventive program should be no discharge/or introduction of these organisms in the Great Lakes. This is consistent with the commitments made by the governments of the United States and Canada under the Great Lakes Water Quality Agreement. This Agreement was made to maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin ecosystem. The potential costs due to the introduction of ANS to the Great Lakes make it imperative that all reasonable steps be taken to prevent their unplanned introduction.

III. The Plan

The purpose of the plan is to outline an implementation strategy for aquatic nuisance species control in the State of Michigan and provide direction to the Department of Environmental Quality (MDEQ), Department of Natural Resources (MDNR), and the Office of the Great Lakes (OGL) for achieving the objectives of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (Public Law 101-646). Funding needed to implement the plan is estimated to be $466,700 over a three-year period in the following areas:

- Preventing new introductions of ANS into the Great Lakes and inland waters of Michigan.
- Limiting the spread of established populations of ANS into uninfested waters of Michigan.
- Abating harmful ecological, economic, social and public health impacts resulting from infestation of ANS.

Attaining these goals will be realized with objectives ranging from information and education, impact assessment, monitoring, research, regulation and policy. The plan details these objectives and specific activities for achieving them. The plan also provides the framework for a long-term commitment by the State of Michigan to combat ANS. The plan does not advocate the development or adoption of specific new laws or regulations, nor does it specify modifications to existing controls, however. Additional research, public comment and a review of non-regulatory alternatives will be needed to determine whether new or modified laws, rules or policies are feasible and appropriate. In particular, the regulatory approach should be employed only where it will be more effective than alternative methods of control. The plan was developed as a reference for coordinated action to address the prevention, control and impacts of ANS.

Information and Education

Problem: Many people are not aware of the adverse impacts of ANS and how they may be affected personally. They may also be uncertain what actions they can take to prevent the spread of ANS from one place to another, or how much difference their individual actions can make.

Strategy: Inform and educate the appropriate public/private groups on ANS impacts, the value of a healthy lake ecosystem that supports a diverse native aquatic community, and the control tactics needed to protect the aquatic community from the spread of aquatic nuisance species. Focus on changing the behavior of user groups to control the spread of targeted aquatic nuisance species. Also, volunteer groups such as the lake associations and outdoor recreation groups will be actively recruited to become involved in outreach efforts.

Activity A: Assess and expand existing ANS information and education programs. Develop strategy for targeted I/E efforts between program administrators.

Description: Many organizations, including the Michigan Department of Natural Resources (DNR), Department

Description: Many organizations, including the Michigan Department of Natural Resources (DNR), Department of Environmental Quality (DEQ), Office of the Great Lakes (OGL), Great Lakes Commission, and the Michigan Sea Grant College Program have responded to the invasion of aquatic nuisance species with educational campaigns. These efforts are sometimes overlapping and duplicative. In order to limit this duplication and expand existing programs, an assessment of the educational programs will be conducted. Recommendations will be developed to enhance existing programs.

Activity B: Update existing DNR, DEQ and OGL brochures, pamphlets, etc., on ANS. Develop new information and education materials, including a video and public service announcements on the potential harm to Michigan's aquatic environment and distribute to boating groups, lake associations, outdoor writers, local television and radio stations, etc. Also use billboard signs to educate watercraft users.

Description: As new introductions of ANS introductions occur, and as the range of ANS expand, updated information must be provided to the public to help slow and prevent their spread.

Activity C: Disseminate information through the watercraft registration system, and fishing and hunting license systems. Also disseminate information through billboard messages, conservation officers in their respective communities, and fisheries biologists in the district offices of the Department of Natural Resources.

Description: Since 1994, over 500,000 informational brochures have been distributed through the watercraft registration system with the assistance of the Secretary of State. This effort will be continued and expanded to the motor vehicle registration system, the fishing and hunting license systems and through conservation officers within the Department of Natural Resources. Also, many boaters and fishers request information from district biologists about local conditions and opportunities. Up to date information should be available to these professionals via e-mail, internet, or other postings to share by the public.

Activity D: Existing zebra mussel advisories will be updated to promote the prevention of other ANS transported by means of watercraft recreation. Advisories will be posted at all launch sites prior to invasion.

Description: Zebra mussel advisories have been posted at all DNR administered public boating access sites on the Great Lakes and connecting waters, and inland lakes where zebra mussels have been discovered. However, there is a need to update the advisories and post at all inland lake launch sites administered by the DNR, in addition to those not administered by the DNR. Approximately 40% of all Great Lakes access sites are not administered by the DNR. Zebra mussels and other ANS are dispersing to inland lakes at a significant rate. If present trends continue, a substantial proportion of inland lakes in Michigan's Lower Peninsula will likely be infested within a decade. As the incidence of inland infestations increase, secondary dispersal through natural and anthropogenic sources will assume a larger role in the process of inland invasions.

Research and Monitoring

Problem: The spread of aquatic nuisance species into uninfested waters is largely via human activity, such as boat transfers, ballast exchange, bait and tackle handling, water transport, and ornamental and landscape practices. Limiting the spread of such species is problematic due to both the numerous pathways for infestation, and the complex ecological characteristics associated with the establishment and subsequent proliferation and spread of a given aquatic nuisance species.

Strategy: Develop monitoring programs that determine presence, distribution, and abundance of ANS in Michigan waters. Conduct research to reduce the potential of these species to spread further into uncolonized waters. Study impacts on aquatic community of native plants and animals.

Activity A: Expand statewide the Inland Lakes "Self-Help" zebra mussel monitoring and include additional ANS, such as the ruffe, goby, and spiny waterflea.

Description: The purpose of the Inland Lakes Advanced "Self-Help" Program is to empower citizens to monitor inland lake water quality. Data collected by citizens will be an important part of the research base needed for an expanded early detection program. Expansion of the program will occur to increase the number of lakes participating, therefore permitting timely warnings to lake users and managers to establish local response plans if species are discovered. Monitoring programs that rely on volunteer participation from lake front property owners and lake associations can be used on a large scale at minimal cost. The greatest potential is for generating data on the patterns of dispersal that can be incorporated into anti-dispersal programs in parts of the country yet to experience invasions. The program will be carried out by the Michigan Sea Grant College Program with assistance from citizen organizations and the Michigan Department of Environmental Quality.

Activity B: Identify a list of target lakes that are highly susceptible to ANS invasion, based on geography, recreational use patterns, water quality characteristics, and information on species especially sensitive to disruption by ANS.

Description: Transient Boating Activity (TBA) appears to be the major dispersal vector for zebra mussels and other ANS. Regional "hotspots" of new inland invasions appear to be in areas heavily used by Great Lakes boaters. Additional evidence also suggests that the role of the boating activities of lakefront residents in dispersing aquatic nuisance species should not be minimized. Moreover, secondary dispersal from established inland populations is becoming a significant factor in the development of new infestations. If lakefront property owners are a high risk dispersal vector, then it is reasonable to suspect that lakes characterized by a high proportion of lakefront residents with permanent residences near heavily infested Great Lakes waters would experience ANS inoculation events more frequently through the transient boating activity of residents. Research will be conducted to determine the geographic areas with the highest risk for invasion of the zebra mussel and other ANS.

Activity C: Assess the transport mechanisms potentially responsible for new ANS introductions into Michigan waters with a view toward preventing the occurrences and dispersal of ANS in the inland waters.

Description: The mechanisms mediating the dispersal of ANS potentially differ between confluent and inland waters, with inland waters being entirely or highly immune to inoculation by certain vectors such as currents, ballast water, and large fishing vessel water. Nevertheless, the Great Lakes and inland waters remain susceptible to many other dispersal agents, such as "controlling" aquatic vegetation through mechanical harvest operations. A study will be conducted to determine additional transport mechanisms. In addition, this study will update recommendations to prevent ANS from entering the inland waters of Michigan from outlying, adjacent, and non-adjacent waters.

Activity D: Review private sector transport, culture, and stocking of aquatic organisms (plants and fish) for food, sport, hobby, gardening, biological control, and other non-public purposes and develop recommendations to minimize the spread of ANS by these sectors.

Description: Private fish hatchery operations, the wholesale bait industry and others have been identified as potential vectors for the spread of ANS, within and outside the state. Millions of pounds of minnows are currently transported and distributed without sufficient screening for ANS. With the assistance of hatchery operations and the wholesale bait industry, the Fisheries Division of the Department of Natural Resources will conduct a comprehensive study of these activities to determine the extent for which they may contribute to the spread of ANS. Alternative methods of limiting this potential source of ANS introductions, such as the separation of baitfish species, will be developed. Additional vectors will monitored through an on-going process.

Activity E: Develop Integrated Pest Management (IPM) techniques and guidelines to apply in aquatic systems where ANS are present.

Description: A system known as integrated pest management can be a useful way to effectively manage pests in complex biological systems using a variety of pest management tools. IPM is defined as a management system that uses all suitable techniques in an economical and ecologically sound manner to reduce pest populations and maintain them at levels that do not have an economic impact while minimizing danger to humans and the environment. IPM may combine biological control, pest resistance, autocidal, cultural, and mechanical and physical control technologies with limited use of chemical pesticides. IPM uses an ecosystem perspective and other decision making tools to gauge the health of the ecosystem, and consequently requires an understanding of the biology and ecology of the resource, the pest, and the pest's natural enemies. IPM is not a purview for "renovative" chemical treatments of aquatic vegetation in lakes, including native species.

Activity F: Develop a comprehensive inventory of the presence, range, and distribution of native unionids in Michigan. Evaluate the impacts of zebra mussels on these species in inland waters.

Description: Zebra mussels has severely impacted large populations of native unionids in Lake St. Clair and Lake Erie. In addition, poaching of these unionids is on the increase in Michigan waters because of declining unionids on a national scale. The industry value in the United States is approximately $50 million per year. These native unionids (mollusks and clams) perform vital functions of water clarification and removal of toxins. Michigan and the Great Lakes Basin was once one of the major centers of diversity of this group in the world. Research and monitoring of native species will be conducted to determine presence, range, and distribution throughout Michigan. Recommendations will be developed to protect native unionids in inland waters.

throughout Michigan. Recommendations will be developed to protect native unionids in inland waters.

Activity G: Expansion of the purple loosestrife biological monitoring and control program at three new sites annually.

Description: Purple loosestrife is a highly competitive wetland plant forming large monotypic stands that displace native vegetation. This loss of species richness and diversity results in the elimination of natural foods and cover essential to many wetland inhabitants, including waterfowl, rails, muskrat, many fish and songbirds. In 1994, after reviewing the potential impacts of biological control, the Michigan Department of Natural Resources Wildlife Division, along with many other Midwest states, released 5000 leaf eating beetles (Galerucella calmariensis and G. pusilla) at test sites for control of purple loosestrife. In addition, a research program to evaluate the results of the introduction began. This program will expand to include three new sites annually.

Activity H: Develop a procedures handbook for state agencies, counties and townships that conduct activities on or near Michigan waters to prevent further spread of ANS.

Description: Many agencies carry out activities in or near waters infested with ANS. Examples of these activities include fish population studies, fish planting, dam or canal excavation, dredging, irrigation, and many others. A handbook will be developed targeted at state agencies that carry out these activities to prevent the spread of ANS.

Activity I: Develop a program to link municipal and industrial water supply systems to monitor zebra mussel presence, density, and distribution throughout Michigan. Identify control measures targeted at the zebra mussel for dissemination on the internet.

Description: The financial impacts imposed on municipal and industrial water supply systems since the zebra mussel invasion have been extreme. The ability to anticipate zebra mussel invasion and deploy state-of-the-art control technologies can be crucial in minimizing the resultant impacts while lowering operation and maintenance costs. The Michigan Sea Grant College Program is uniquely positioned to develop a program to link municipalities and industries on the Internet to share current control technologies.

Policy and Regulation

Problem: There are a variety of laws and regulations in Michigan and the United States which might limit the introduction and distribution of nonindigenous species. The laws and regulations have developed over many years and now exist in a complex and fragmented manner. Moreover, these regulations are often not vigorously enforced. Most people in the state are probably not aware of the existing regulations, and the impacts of ignoring those regulations.

Strategy: Existing laws and regulations will be reviewed, consolidated, updated and publicized. In addition, innovative and alternative policy initiatives to enhance ANS control will be explored.

Activity A: Conduct a comprehensive review of all state statutes, regulations, and penalties pertaining to the possession, transport, and control of ANS and develop and recommend actions to improve regulations at the state level. As part of this activity, other Great Lakes states regulations will be reviewed to determine level of effectiveness.

Description: In Michigan there are a variety of laws and regulations to limit the introduction and distribution of nonindigenous species. The laws and regulations have developed over many years and now exist in a complex and fragmented manner. These laws and regulations will be reviewed, consolidated, updated and publicized.

Activity B: The federal consistency provisions of the Coastal Zone Management Act (Public Law 92-583) will be examined to determine if authority exists to prevent the introduction and spread of ANS by current ballast water discharge practices. Alternative ballast control techniques will be explored.

Description: Federal consistency is an important tool that the Michigan Coastal Zone Management Program can use to assist in the implementation of the ANS Plan. The federal consistency provisions of the Coastal Zone Management Act require all federal permits, licenses and financial assistance loans to be consistent with federally approved state coastal management programs. State certification of consistency is required prior to federal issuance of federal license, loan or permit. Federal activities must be consistent to the maximum extent practicable with state coastal programs. The CZMA requires federal agencies to submit consistency

determinations for all activities affecting the coast. State coastal management plans review the submitted information for compliance with the substantive requirements of state regulatory statutes. A state may concur with the federal determination and find the activity inconsistent. The CZMA includes an appeal mechanism for those aggrieved by a consistency decision.

Activity C: Explore development of an interstate decision-making protocol for ANS management.

Description: Michigan cannot protect itself in isolation from the region. The recent event occurring in the region dealt with the question of whether or not the U.S. Fish and Wildlife Service should treat rivers in Wisconsin to control the spread of the ruffe was both traumatic for many and inconclusive. There is clearly a potential interstate impact of individual state decisions and practices with regard to controlling (or not controlling) the spread of ANS, yet there is also clearly an issue of state rights. The feasibility of developing an interstate agreement will be undertaken.

Activity D: Incorporate language into existing draft bills on "aquaculture development" and "aquatic species protection" to prevent the spread of ANS.

Description: The DNR and the DEQ have been working to develop an "Aquatic Species Protection Act" to improve conservation and protection of aquatic species that are not listed "game" species or protected through by statutes. The new statute would require that recreational and commercial uses of these species be authorized by permit, and it would prohibit the import, export, release, or possession of protected species. In addition, the Michigan Department of Agriculture has been working with the Michigan Aquaculture Advisory Committee in writing the "Michigan Aquaculture Development Act" to define, regulate and foster the development of aquaculture as an agricultural enterprise in Michigan. An effort will be undertaken by the agencies to include language in these bills that offer protection from the introduction and spread of aquatic nuisance species.

Activity E: Explore public and private funding opportunities to establish a nonindigenous nuisance species program within the DEQ.

Description: To date, the DNR and the DEQ has no program dedicated specifically for ANS control. The limited control activities surrounding ANS are funded within the existing framework of various natural resource programs. This has led to the fragmentation of data collection and compromised information dissemination, thus limiting the effectiveness of ANS controls. A study will be conducted to explore public and private funding opportunities to establish a formal ANS program within the State of Michigan.

Implementation Tables

Goal 1 - Information and Education

Strategy: Inform and educate the appropriate public/private groups on ANS impacts, the value of a healthy lake ecosystem that supports a diverse native aquatic community, and the control tactics needed to protect the aquatic community from the spread of aquatic nuisance species. Focus on changing the behavior of user groups to control the spread of targeted aquatic nuisance species.

Activities	Lead	Cooperating Organizations	Budget
A. Assess and expand existing ANS information and education programs. Develop strategy for targeted I/E efforts between program administrators.	Office of the Great Lakes	Michigan Department of Natural Resources, Michigan Sea Grant College Program	$7,500
B. Update existing DNR, DEQ and OGL brochures, pamphlets, etc., on ANS. Develop new information and education materials, including a video and public service announcements on the	Office of the Great Lakes	MDNR-Fisheries Division, Wildlife Division, Parks and Recreation Division, Michigan Sea Grant College Program	$37,000

announcements on the potential harm to Michigan's aquatic environment and distribute to boating groups, lake associations, outdoor writers, local television and radio stations, etc. Also use billboard signs to educate watercraft users.		Program	
C. Disseminate information through the watercraft registration system, and fishing and hunting license systems. Also disseminate information through billboard messages, conservation officers in their respective communities, and fisheries biologists in the district offices of the Department of Natural Resources.	Office of the Great Lakes	MDNR-Fisheries Division, Wildlife Division, Law Enforcement Division, Michigan Secretary of State	$14,000
D. Existing zebra mussel advisories will be updated to promote the prevention of other ANS transported by means of watercraft recreation. Advisories will be posted at all launch sites prior to invasion.	MDNR-Parks and Recreation Division	Fisheries Division, Office of the Great Lakes	$32,000

Implementation Tables

Goal 2 - Research and Monitoring

Strategy: Develop monitoring programs that determine presence, distribution, and abundance of ANS in Michigan waters. Study impacts on native flora and fauna. Conduct research to reduce the potential of these species in Michigan waters to spread further into uncolonized waters.

Activities	Lead	Cooperating Organizations	Budget
A. Expand statewide the Inland Lakes "Self-Help" zebra mussel monitoring and include additional ANS, such as the ruffe, goby, and spiny waterflea.	Michigan Sea Grant College Program	Office of the Great Lakes, Michigan Lake and Stream Association	$54,000
B. Identify a list of target lakes that are highly susceptible to ANS invasion, based on geography, recreational use patterns, water quality characteristics, and information on species especially sensitive to disruption by ANS.	Office of the Great Lakes	MDNR-Parks and Recreation Division, Fisheries Division, Wildlife Division, Michigan Sea Grant College Program	$6,200
C. Assess the transport mechanisms potentially responsible for new ANS introductions into Michigan	Office of the Great Lakes	MDNR-Parks and Recreation Division, Fisheries	$3,500

introductions into Michigan waters with a view toward preventing the occurrences and dispersal of ANS in the inland waters.		Fisheries Division, Wildlife Division, Michigan Sea Grant College Program	
D. Review private sector transport, culture, and stocking of aquatic organisms (plants and fish) for food, sport, hobby, gardening, biological control, and other non-public purposes and develop recommendations to minimize the spread of ANS by these sectors.	Fisheries Division	MDNR-Law Enforcement Division, Office of the Great Lakes, Michigan Aquaculture Association, Michigan Fish Growers Association	$4,000
E. Develop Integrated Pest Management (IPM) techniques and guidelines for applications in aquatic systems where ANS are present.	Office of the Great Lakes	Michigan Dept of Natural Resources, Michigan Dept of Agriculture, Michigan Sea Grant College Program,	$53,000
F. Develop a comprehensive inventory of the presence, range, and distribution of native unionids in Michigan. Evaluate the impacts of zebra mussels on these species in inland waters.	Michigan Natural Features Inventory-Wildlife Division, Fisheries Division	Michigan Dept of Natural Resources, Michigan Dept of Environmental Quality, U.S. Fish and Wildlife Service, National Biological Service, Universities, Utilities	$140,000
G. Expansion of the purple loosestrife biological monitoring and control program at three new sites annually.	Wildlife Division	U.S. Fish and Wildlife Service	$32,000
H. Develop a procedures handbook for state agencies, counties and townships that conduct activities on or near Michigan waters to prevent the further spread of ANS.	Office of the Great Lakes	Michigan Departments of Natural Resources, Environmental Quality, Transportation, Public Health	$16,000
I. Develop a program to link municipal and industrial water supply systems to monitor zebra mussel presence, density, and distribution throughout Michigan. Identify alternative control technologies targeted	Michigan Sea Grant College Program	Office of the Great Lakes, municipalities and industry sectors.	$26,000

at the zebra mussel for dissemination on the internet.			

Implementation Tables

Goal 3 - Regulation and Policy

Strategy: Existing laws and regulations will be reviewed, consolidated, updated and publicized. In addition, innovative and alternative policy initiatives to enhance aquatic nuisance species control will be explored.

Activities	Lead	Cooperating Organizations	Budget
A. Conduct a comprehensive review of all Office of the Great state statutes, regulations, and penalties Lakes pertaining to the possession, transport, and control of ANS and develop and recommend actions to improve regulations at the state level. As part of this activity, other Great Lakes states regulations will be reviewed to determine level of effectiveness.	Office of the Great Lakes	Michigan Dept of Natural Resources, Michigan Dept of Agriculture, Michigan Dept of Public Health, Michigan Office of Attorney General	$18,000
B. The federal consistency provisions of the Coastal Zone Management Act (Public Law 92-583) will be examined to determine if authority exists to prevent the introduction and spread of ANS by current ballast water discharge practices. Alternative ballast control techniques will be explored.	Land and Water Management Division	National Oceanic and Atmospheric Administration, U.S. Department of Agriculture, Michigan Department of Environmental Quality, Michigan Department of Natural Resources	$11,000
C. Explore development of an interstate decision-making protocol for ANS management.	Office of the Great Lakes	Great Lakes Commission	$3,000
D. Incorporate language into existing draft bills on aquaculture development and aquatic species protection to prevent the spread of ANS in the state.	Fisheries Division	Office of the Great Lakes, Michigan Department of Environmental Quality, Michigan Department of Natural Resources, Michigan Department of Agriculture	$2,000
E. Explore public and private funding opportunities to establish a nonindigenous species	Office of the Great Lakes	Michigan Dept of Environmental Quality, Michigan Department of	$7,500

program within the DEQ.		Natural Resources	

Implementation Schedule

January 1, 1996 - December 31, 1998

Section 1204(a)(2)© requires that a state management plan include a schedule for implementing the plan, including a schedule of annual objectives. It is difficult to develop a highly detailed implementation schedule because of funding ambiguities in the program. Full implementation of the plan is dependent upon federal aid. If Michigan implements the program without federal assistance, the program would be considerably scaled back and would take much longer to carry out the strategic actions.

Strategy	Jan-Mar 1996	Apr-June 1996	July-Sept 1996	Oct-Dec 1996	Jan-Mar 1997	Apr-June 1997	July-Sept 1997	Oct-Dec 1997	Jan-Mar 1998	Apr-June 1998	July-Sept 1998	Oct-Dec 1998
Information and Education												
A												
B												
C												
D												
Monitoring, Impact Assessment and Research												
A												
B												
C												
D												
E												
F												
G												
H												
I												
Regulation and Policy												
A												
B												
C												
D												
E												

Annual Objectives

January 1996 - December 1996

- 1. Hire staff and establish necessary contracts.
- 2. Complete assessment of ANS information and education programs. Complete development of strategy for targeted I/E efforts between program administrators.
- 3. Complete update of DNR, DEQ, OGL brochures, pamphlets, etc. Complete new educational materials responding to recent invasions, including a video and public service announcements on the species harmful to Michigan's aquatic environment.
- 4. Continue disseminating information through the watercraft registration system, fishing and hunting license systems, and the motor vehicle registration system.
- 5. Complete review of all state statutes pertaining to the possession, transport, and control of ANS and develop and recommend actions to improve measures at the state level.

develop and recommend actions to improve measures at the state level.

- 6. Complete review of the federal consistency provisions of the Coastal Zone Management Act (Public Law 92-583) to determine if activities that impact coastal areas, such as the discharge of ballast water, can be used to assist in preventing the spread introduction and spread of ANS.
- 7. Complete feasibility study of developing of an interstate decision-making protocol for ANS management.
- 8. Complete effort to incorporate language into existing draft bills on aquaculture development and aquatic species protection to prevent the spread of ANS in the state.
- 9. Complete review of private sector transport, culture, and stocking of aquatic organisms for food, sport, hobby, gardening, biological control, and other non-public purposes.
- 10. Negotiate contract and begin inventory of the presence, range, and distribution of native unionids in Michigan. Evaluate the impacts of zebra mussels on these species in inland waters.
- 11. Complete site identification and procedures for the "Self Help" inland lake monitoring program. Conduct first-year monitoring of inland waters. Evaluate and revise protocols as appropriate.
- 12. Complete site identification of target lakes that are highly susceptible to ANS invasion, based on geography, recreational use patterns, and water quality characteristics.
- 13. Assess the transport mechanisms potentially responsible for new ANS introductions into Michigan waters with a view toward preventing the occurrences and dispersal of ANS in the inland waters.
- 14. Begin development of procedures handbook for state agencies, counties and townships that conduct activities on or near Michigan waters to prevent the spread of ANS.
- 15. Begin development of Integrated Pest Management (IPM) techniques and guidelines for applications in aquatic systems where ANS are present.
- 16. Begin expansion of purple loosestrife biological monitoring and control program.
- 17. Begin updating and posting advisory signs at all Great Lakes boat launch sites and inland lake sites, before ANS expand statewide.
- 18. Begin development of a program to link municipal and industrial water supply systems to monitor zebra mussel presence, density, and distribution throughout Michigan. Identify innovative control measures targeted at the zebra mussel.
- 19. Explore public and private funding opportunities to establish a nonindigenous species program within the Department of Natural Resources.
- 20. Evaluate first year ANS State Management Plan efforts.

January 1997 - December 1997

- 1. Complete second-year monitoring of inland waters. Evaluate and revise protocols as required.
- 2. Continue disseminating information through the watercraft registration system, fishing and hunting license systems, and the motor vehicle registration system.
- 3. Propose legislative and regulatory changes for resolving legal deficiencies and inconsistencies.
- 4. Complete development of a procedures handbook for state agencies, counties and townships regarding the prevention and control of nonindigenous aquatic species.
- 5. Continue inventory of the presence, range, and distribution of native unionids in Michigan. Evaluate the impacts of zebra mussels on these species in inland waters and complete recommendations for species protection.
- 6. Complete development of Integrated Pest Management (IPM) techniques and guidelines for applications in aquatic systems where ANS are present.
- 7. Complete program which links municipal and industrial water supply systems to current monitoring and control technologies.
- 8. Continue updating and posting ANS advisory signs at Great Lakes boat launch sites and inland lake sites, as ANS expand statewide.
- 9. Continue to review nonindigenous aquatic species literature and research; update educational materials as required.
- 10. Continue purple loosestrife biological monitoring and control program.
- 11. Continue to investigate alternative control and remediation techniques, methods, and proposals. Disseminate observations to the public. Encourage innovative approaches to nonindigenous aquatic species control and remediation.
- 12. Evaluate second year ANS State Management Plan efforts.

January 1998 - December 1998

- 1. Conduct third-year monitoring of inland waters. Evaluate and revise protocols as required.

- 2. Continue updating and posting ANS advisory signs at Great Lakes boat launch sites and inland lake sites, as ANS expand statewide.
- 3. Continue disseminating information through the watercraft registration system, fishing and hunting license systems, and the motor vehicle registration system.
- 4. Identify additional needs for ANS identification kits as new species are discovered.
- 5. Complete inventory of the presence, range, and distribution of native unionids in Michigan. Evaluate the impacts of zebra mussels on these species in inland waters and complete recommendations for species protection.
- 6. Continue to review nonindigenous aquatic species literature and research, update educational materials as required.
- 7. Continue purple loosestrife biological monitoring and control program.
- 8. Continue to investigate control and remediation techniques, methods, and proposals. Disseminate information to the public. Encourage innovative approaches to nonindigenous aquatic species control and remediation.
- 9. Complete final report of State Management Plan accomplishments.
- 10. Seek alternative funding to continue monitoring and survey programs.

Public Comment Period

On March 10, 1995, Michigan's Nonindigenous Aquatic Nuisance Species State Management Plan was made available for a 45-day public review and comment period. Notice of the availability of the plan was announced in a statewide press release and in the Department of Natural Resources Calendar. Three hundred copies were printed and all were subsequently distributed. Written comments were received from twenty-six individuals representing fifteen different agencies and organizations. To the extent possible, the comments were addressed and information incorporated in the final document. A summary of the public comments can be obtained by contacting the Office of the Great Lakes. In addition, questions or comments about the State Management Plan should be directed to the Office at 517-373-3588.

Document prepared by Mark Coscarelli, Environmental Specialist, Office of the Great Lakes.

Appendix A

Referenced Materials

The following documents were used in the development of the information presented in this plan.

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