Michigan's
Aquatic Invasive Species
State Management Plan 2013 Update

Prevention, Detection, and Management in Michigan Waters

A Cooperative Effort of the
Michigan Department of Environmental Quality
Michigan Department of Natural Resources
Michigan Department of Agriculture and Rural Development
Michigan Department of Transportation

In Consultation and Partnership with Other Interested Parties

Coordinated by:
Water Resources Division
Michigan Department of Environmental Quality
P.O. Box 30458
Lansing, Michigan 48909-7958
517-335-4176

Approved by the Aquatic Nuisance Species Task Force on June 17, 2013

Table of Contents

EXECUTIVE SUMMARY 1
Acknowledgements 3
List of Acronyms and Species 4
1 INTRODUCTION 6
1.1 PURPOSE AND SCOPE OF THE AIS SMP 7
1.2 HISTORY AND DEVELOPMENT OF THE SMP 10
1.3 AIS BACKGROUND 13
1.3.1 Environmental and Economic Effects 13
1.3.2 Historical AIS Timeline 16
1.3.3 Policy Background 16
1.3.4 Species of Concern 18
1.4 ACCOMPLISHMENTS 19
2 STRATEGIC PLANNING 19
2.1 GOALS 19
All Goals 21
2.2 GOALS I AND II - PREVENT NEW INTRODUCTIONS AND LIMIT DISPERSAL OF AIS: VECTOR AND PATHWAY APPROACH 22
2.2.1 Shipping and Boating 24
Maritime Commerce - Ballast Water 24
Maritime Commerce – Hull, Anchor, and Superstructure Fouling 28
Water Recreation (includes boating, fishing, and other recreational equipment) 28
Research and Monitoring Activities 30
2.2.2 Habitat Alteration 31
Habitat Modification and Restoration 31
Canals, Lift Locks, and St. Marys River Compensating Works 34
Transportation Facilities 36
2.2.3 Use and Trade of Organisms 38
Organisms in Trade 38
Fishing - Live Bait 40
Fish Stocking and Hatchery Activities 41
2.3 GOAL III – DEVELOP A STATEWIDE INTERAGENCY EDRR PROGRAM TO ADDRESS NEW INVASIONS OF AIS 42
2.3.1 Background and Current Status 43
2.3.2 Program Structure 44
2.4 GOAL IV - MANAGE AND CONTROL AIS TO MINIMIZE THE HARMFUL ENVIRONMENTAL, ECONOMIC, AND PUBLIC HEALTH EFFECTS RESULTING FROM ESTABLISHED POPULATIONS 46
2.4.1 Management and Control Process 46
2.4.2 Current Programs 47
3 IMPLEMENTATION TABLE 49
4 PROGRAM MONITORING AND EVALUATION 68
5 RECOMMENDATIONS 68
6 REFERENCES 71
APPENDIX A TIMELINE
APPENDIX B ACCOMPLISHMENTS
APPENDIX C SPECIES OF CONCERN
APPENDIX D LAWS AND REGULATIONS

EXECUTIVE SUMMARY

Michigan's aquatic ecosystems are experiencing significant negative effects from aquatic invasive species (AIS) that are already present, and the state's waters are continually threatened by new invasions. The most widely used definition of invasive species that is derived directly from the National Invasive Species Council is as follows:

> "An invasive species is defined as a species that is not native and whose introduction causes, or is likely to cause, economic or environmental harm or harm to human health."

The introduction of AIS into the Great Lakes and inland state waters is a source of biological pollution that threatens not only the ecology of the region and states' water resources, but also the economic and public health conditions of the region and states. The introduction of AIS into the Great Lakes and inland state waters is a source of biological pollution that has significant negative effects on natural resources, human health, recreational opportunities, and other human values throughout the state and region. AIS may compete with native species for food and habitat, and can directly or indirectly harm or displace native species, degrade habitat, and alter food webs and energy flow. AIS can also have significant economic effects on waterfront property values, tourism, utilities, and other industries (Lovell et al. 2005).

AIS enter and disperse in Michigan waters through various human-assisted vectors including: maritime commerce, fishing and aquaculture, canals and diversions, the trade of live organisms, and tourism and development activities (Lodge and Finnoff 2008, Pimentel et al. 2000). Actions taken to date to prevent the introduction of new AIS include regulatory and voluntary efforts, educational programs to increase awareness, monitoring and surveillance efforts, and management/control efforts by a variety of partners. However, much work remains to protect Michigan waters from new introductions of AIS from around the world, other waters across the country, and adjacent areas of the Great Lakes watershed as well as minimize the harmful effects of AIS already in Michigan waters.

This comprehensive AIS State Management Plan (SMP) outlines new actions for implementation in addition to maintaining and enhancing existing efforts to adequately prevent the introduction of new AIS, prevent the dispersal of established AIS, detect and respond to new invaders, and manage and control AIS to minimize the harmful effects of AIS in Michigan waters, including the Great Lakes, connecting channels, rivers, streams, inland lakes, and wetlands. This AIS SMP identifies strategic actions in categories including legislative and policy, regulation (including compliance, enforcement, and inspection), information and education, research and monitoring, and early detection and rapid response (EDRR). The prevention of nonnative, aquatic organisms including microorganisms (typically pathogens), algae, aquatic vascular plants, zooplankton, macroinvertebrates, fish, reptiles, amphibians, mollusks, and crustaceans, as well as any other animals that enter and establish populations in Michigan waters and cause harm to the environment, economy, or human health are considered using a vector and pathway approach. The vector is the physical means by which an AIS is transported to a new region, primarily by humans, whether deliberate or accidental (e.g., OIT) and the pathway is the specific route of transfer within a vector by which an AIS is moved from one ecosystem to another (e.g., use of live bait while fishing). This SMP integrates and builds upon existing AIS prevention and control efforts.

The goals of this SMP are designed to address different stages of AIS invasion: the introduction of AIS transported from water bodies outside of Michigan waters; the dispersal of established, reproducing AIS populations in Michigan to other water bodies within the state; and the colonization of AIS populations within water bodies, including the harmful effects resulting from colonization. Goals are not numbered in order of priority.

The four goals addressed by the SMP are:

- Goal I: Prevent new introductions of AIS into Michigan waters.
- Goal II: Limit the dispersal of established populations of AIS throughout Michigan waters.
- Goal III: Develop a statewide interagency EDRR Program to address new invasions of AIS.

- Goal IV: Manage and control AIS to minimize the harmful environmental, economic, and public health effects resulting from established populations.

Goals I and II focus on preventing new introductions and limiting the dispersal of AIS throughout Michigan waters (Great Lakes and inland waters) using a vector and pathway approach. AIS may be introduced to and dispersed within Michigan waters through three general categories of vectors and pathways: shipping and boating, habitat alteration, and the use and trade of organisms. AIS are prevented by identifying and blocking or interrupting these pathways. For example, recreational boating is identified as a pathway for the dispersal of AIS. A strategic action to block this pathway is to provide education to boaters to clean, drain, and dry boats, trailers, and other equipment.

Goal III concentrates on EDRR by addressing the critical period between introduction and establishment of a new AIS population when the focus of management must shift rapidly from prevention to control, containment, and eradication.

Goal IV addresses the management and control of AIS to minimize the harmful environmental, economic, and public health effects resulting from established populations. Eliminating these effects entirely may not be possible given the technical and economic challenges surrounding invasive species. However, a combination of control efforts, adaptive management, and restorations can reduce effects.

Recommendations

The following represents a summary of the AIS priorities for Michigan. These are ongoing activities that should be continued and enhanced, newly initiated activities that have short-term funding, and unaddressed or minimally addressed activities that require attention. A detailed list of strategic actions organized by the goals, vector, and pathway is presented in Section 3, Implementation Table.

The recommendations listed below are categorized as overarching concepts that apply to all goals or ranked within three tiers of priorities.

Overarching Recommendations That Apply to All SMP Goals:

- Promote public/private collaboration to leverage expertise and resources as a mechanism to address Michigan's AIS priorities.
- Continue and enhance state agency communication and coordination.
- Continue and enhance information and education efforts.
- Secure sustainable long-term funding for Michigan's AIS Program to ensure implementation of this SMP.

Michigan Tier 1 AIS Priorities:

- Prevent the introduction of AIS through canals and waterways, specifically Asian carp through the Chicago Area Waterways System.
- Prevent the introduction of AIS through ballast water discharges.
- Prevent the introduction of AIS through OIT.

Michigan Tier 2 AIS Priorities:

- Develop capacity for EDRR activities, including monitoring and detailed response planning, coordinated at regional and state scales.

Michigan Tier 3 AIS Priorities:

- Support AIS management and control efforts, especially through technical assistance and the development of best management practices.

Acknowledgements

The authors of this Aquatic Invasive Species (AIS) State Management Plan (SMP) update thank the authors of the Lake Superior Aquatic Invasive Species Complete Prevention Plan (Lake Superior Binational Program 2010). The basic premise of this SMP – to frame prevention and control in the context of vectors and pathways, as opposed to the traditional species (or taxa) approach – was adapted from the Lake Superior Plan. Organizational structure and text from the Lake Superior Plan were heavily used in the preparation of this SMP with permission. In addition, text was used from A Model Comprehensive State Management Plan for the Prevention and Control of Nonindigenous Aquatic Nuisance Species: A Report to the Great Lakes States (Glassner-Shwayder 1996). Funding support for the preparation of this SMP update was provided by the United States Fish and Wildlife Service as part of a Great Lakes Restoration Initiative grant. The following individuals contributed to the SMP's concept, writing, or review. In addition, the comments submitted by partners, including the Aquatic Nuisance Species Task Force and Michigan's AIS Advisory Council, during the SMP's external review period are greatly appreciated.

AIS Team (in alphabetical order including past and present members):

Tom Alwin, Water Resources Division, MDEQ
Matt Ankney, Wildlife Division, MDNR
Nancy Barr, Animal Industry Division. MDARD
Eric Bacon, Water Resources Division, MDEQ
Mike Bryan, Pesticide and Plant Pest Management Division, MDARD
Roger Eberhardt, Office of the Great Lakes, MDEQ
Emily Finnell, Office of the Great Lakes, MDEQ
Jason Fleming, Parks and Recreation Division, MDNR
Tom Goniea, Fisheries Division, MDNR
Todd Grischke, Fisheries Division, MDNR
Anne Hokanson, Water Resources Division, MDEQ
Steve Huff, Law Enforcement Division, MDNR
Todd Losee, Water Resources Division, MDEQ
Christian LeSage, Fisheries Division, MDNR
Sarah LeSage, Water Resources Division, MDEQ (Michigan AIS Program Coordinator)
Amy Lounds, Water Resources Division, MDEQ
Bethany Matousek, Project Planning Division, MDOT
Tammy Newcomb, Fisheries Division, MDNR
Nick Popoff, Fisheries Division, MDNR
Matt Preisser, Office of the Great Lakes, MDEQ
Lindsay Ross, Parks and Recreation Division, MDNR
Alicia Selden, Parks and Recreation Division, MDARD
Dave Schuen, Project Planning Division, MDOT
Sue Tangora, Wildlife Division, MDNR
Kevin Walters, Wildlife Division, MDNR
Mart Williams, Fisheries Division, MDNR

List of Acronyms and Species

Acronyms
AIS: aquatic invasive species
AIS-HACCP: Aquatic Invasive Species-Hazard Analysis and Critical Control Point
ANC: aquatic nuisance control
ANS: aquatic nuisance species
APHIS: Animal and Plant Health Inspection Service
BMP: best management practice
CAWS: Chicago Area Waterways System
COC: Certificate of Coverage
CSSC: Chicago Ship and Sanitary Canal
CWA: Clean Water Act
EDRR: early detection and rapid response
FD: Fisheries Division, MDNR
GLANSIS: Great Lakes Aquatic Nonindigenous Species Information System
GLC: Great Lakes Commission
GLFC: Great Lakes Fishery Commission
GLRC: Great Lakes Regional Collaboration
GLRI: Great Lakes Restoration Initiative
GLWQA: Great Lakes Water Quality Agreement
ICS: incident command system
IJC: International Joint Commission
IMO: International Maritime Organization
LED: Law Enforcement Division, MDNR
MDAG: Michigan Department of Attorney General
MDARD: Michigan Department of Agriculture and Rural Development
MDEQ: Michigan Department of Environmental Quality
MDNR: Michigan Department of Natural Resources
MDNRE: Michigan Department of Natural Resources and Environment
MDOT: Michigan Department of Transportation
MISC: Michigan Invasive Species Coalition
MISIN: Midwest Invasive Species Network
MNFI: Michigan Natural Features Inventory
MOD: Marketing and Outreach Division, MDNR
MSU: Michigan State University
NANPCA: Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990
NEPA: National Environmental Policy Act
NGO: nongovernmental organization
NISA: National Invasive Species Act of 1996 (expired in 2002)
NOBOB: no ballast on board
NREPA: Natural Resources and Environmental Protection Act, 1994 PA 451, as amended
NPDES: National Pollutant Discharge Elimination System
OGL: Office of the Great Lakes, MDEQ
OIT: organisms in trade
PRD: Parks and Recreation Division, MDNR
SMP: State Management Plan
USACE: United States Army Corps of Engineers
USCG: United States Coast Guard
USDA: United States Department of Agriculture
USDOT: United States Department of Transportation
USEPA: United States Environmental Protection Agency
USFWS: United States Fish and Wildlife Service
USGS: United States Geological Survey
VGP: Vessel General Permit

VHS: viral hemorrhagic septicemia
WLD: Wildlife Division, MDNR
WRD: Water Resources Division, MDEQ

Species
Asian carp (*Hypophthalmichthys molitrix*)
Bighead carp (*Hypophthalmichthys nobilis*)
Black carp (*Mylopharyngodon piceus*)
Brazilian elodea (*Egeria densa)*
Common reed (*Phragmites australis*)
Curly-leaf pondweed (*Potamogeton crispus*)
Eurasian ruffe (*Gymnocephalus cernus*)
Eurasian water milfoil (*Myriophyllum spicatum*)
European frogbit (*Hydrocharis morsus-ranae*)
Fanwort (*Cabomba caroliniana*)
Flowering rush (*Butomus umbellatus*)
Giant hogweed (*Heracleum mantegazzianum*)
Giant salvinia (*Salvinia molesta*)
Grass carp (*Ctenopharyngodon idella*)
Hydrilla (*Hydrilla verticillata*)
invasive Phragmites (*Phragmites australis*)
Japanese knotweed (*Fallopia japonica*)
Large-scale silver carp (*Hypophthalmichthys harmandi*)
Parrot feather (*Myriophyllum aquaticum*)
Purple loosestrife (*Lythrum salicaria*)
Quagga mussel (*Dreissena bugensis*)
Round goby (*Neogobious melanostomus*)
Rusty crayfish (*Orconectes rusticus*)
Sea lamprey (*Petromyzon marinus*)
Silver carp (*Hypophthalmichthys*)
Starry stonewart (*Nitellopsis obtusa*)
Water chestnut (*Trapa natans*)
Water hyacinth (*Eichhornia crassipes*)
Water lettuce (*Pistia stratiotes*)
Water thyme (*Hydrilla verticillata*)
Whirling disease (*Myxobolus cerebralis*)
Zebra mussel (*Dreissena polymorpha*)

1 INTRODUCTION

Michigan's aquatic ecosystems are experiencing significant negative effects from Aquatic Invasive Species (AIS) that are already present in the state's waters and are continually threatened by new invasions. AIS may also be known as nonindigenous, nonnative, nuisance, exotic, or alien species; however, these terms have slightly different meanings and care should be taken to use terms appropriately.

The most widely used definition of invasive species that is derived directly from the National Invasive Species Council is as follows:

"An invasive species is defined as a species that is not native and whose introduction causes, or is likely to cause, economic or environmental harm or harm to human health."

The introduction of AIS into the Great Lakes and inland state waters is a source of biological pollution that has significant negative effects on natural resources, human health, recreational opportunities, and other human values throughout the state and region. For example, AIS may:

- Directly outcompete native species for resources like food and habitat causing displacement or reduced populations of native species to the point of biological significance.
- Affect the composition and structure of aquatic communities and cause cascading changes throughout aquatic food webs resulting in indirect negative effects.
- Degrade habitat and negatively affect wildlife and water quality.
- Decrease sportfishing opportunities and therefore have negative economic effects on recreation and tourism industries.
- Degrade shorelines and wetlands for human use and therefore have negative economic effects on recreation and tourism industries (e.g., Zebra mussels fouling beaches and invasive Phragmites decreasing hunting and fishing opportunities).
- Negatively affect human and wildlife health (e.g., Zebra mussels linked to botulism).
- Decrease property values (e.g., invasive Phragmites blocking views).
- Alter wildfire frequency and intensity causing negative ecological effects and increased cost in fire management and damages (e.g., invasive Phragmites).
- Negatively affect commercially valuable species.
- Increase costs to utilities and municipalities (e.g., control of Zebra mussels at water intakes).

It should be recognized that many nonnative species are not invasive species and support human livelihoods or a preferred quality of life. These species are not considered AIS; therefore, they are not covered by this plan.

This State Management Plant (SMP) uses the term "aquatic invasive species"; however, other plans, programs, and organizations may prefer other terms such as "aquatic nuisance species," "nonindigenous species," and "exotic species" that are often used interchangeably. These terms can have different meanings, especially when used in a legal context, so caution should be used. The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA) and the resulting grant program through which the United States Fish and Wildlife Service (USFWS) provides support for implementation of this SMP use the term "aquatic nuisance species" (ANS). As this SMP relates to the NANPCA and grant program, the term AIS and ANS are used interchangeably. Further guidance, clarification, and examples regarding the nuances of the definition of the term invasive species are provided in an Invasive Species Advisory Committee white paper (Invasive Species Advisory Committee 2006). This white paper is intended for policy interpretation; regulatory decisions may benefit from a formal risk assessment process.

The Great Lakes and connecting channels and rivers form the largest surface freshwater system in the world. This freshwater system, along with Michigan's inland lakes, streams, rivers, and wetlands represent an invaluable resource and are therefore justifiably a top natural resource management priority.

The Great Lakes region has been affected by both the intentional and unintentional introduction of AIS since the settlement of the region by Europeans (Mills et al. 1993, Ricciardi 2001). Since the 1800s, at least 182 nonindigenous aquatic organisms have colonized habitats of the Great Lakes ecosystem. These species include: algae (27), vascular plants (55), invertebrates (66), fish (28), and bacteria and viruses (6) (National Oceanic and Atmospheric Administration 2011). Roughly 55% of these species are native to Eurasia; 13% are native to the Atlantic Coast. Prior to the encouragement of new ballast water management practices in 2005 (see Section 2.2.1), a new nonindigenous species was being discovered in the Great Lakes, on average, once every 28 weeks (Ricciardi 2006; Great Lakes Environmental Research Laboratory 2009). Since 2006, no new nonindigenous aquatic species have become established in the Great Lakes basin; however, sufficient monitoring programs to detect new invaders do not exist. Many organisms go undetected until effects are documented. It should be noted that not all of these nonindigenous species are invasive (i.e., harmful), and in fact some are beneficial species.

AIS enter and disperse in Michigan waters through various human-assisted vectors including: maritime commerce, fishing and aquaculture, canals and diversions, the trade and movement of live organisms, and tourism and development activities (Lodge and Finnoff 2008, Pimentel et al. 2000). Nonhuman vectors may also be a factor in AIS dispersal. Historically, shipping has resulted in high levels of invasions in global temperate regions, including the Great Lakes basin (Molner et al. 2008), and the trade of live organisms has resulted in the intentional and unintentional introduction of AIS. A changing climate is likely to increase opportunities for nonnative species to successfully invade Michigan waters as warmer temperatures accelerate reproductive cycles and increase the likelihood of a wider range of nonnative species becoming established.

Actions taken to date to prevent the introduction of new AIS include regulatory and voluntary efforts by both public and private entities. Many activities serve as models using innovative, strategic approaches. A wide variety of educational programs have increased awareness of the introduction pathways to prevent new AIS, such as those aimed at recreational boating and invasive OIT (both at the industry level and the consumer level). Government agencies and nongovernmental partners monitor for existing and new AIS and provide assessments of AIS management efforts. However, much work remains to protect Michigan waters from new introductions of AIS from around the world, other waters across the country, and adjacent areas of the Great Lakes watershed as well as minimize the harmful effects of AIS already in Michigan waters.

1.1 PURPOSE AND SCOPE OF THE AIS SMP

This comprehensive AIS SMP outlines new actions for implementation in addition to maintaining and enhancing existing efforts to adequately prevent the introduction of new AIS, prevent the dispersal of established AIS, detect and respond to new invaders, and manage and control AIS to minimize the harmful effects of AIS in Michigan waters, including the Great Lakes, connecting channels, rivers, streams, inland lakes, and wetlands. This AIS SMP identifies strategic actions in categories including legislative and policy, regulation (including compliance, enforcement, and inspection), information and education, research and monitoring, and early detection and rapid response (EDRR). The prevention of nonnative, aquatic organisms including microorganisms (typically pathogens), algae, aquatic vascular plants, zooplankton, macroinvertebrates, fish, reptiles, amphibians, mollusks, and crustaceans, as well as any other animals that enter and establish populations in Michigan waters and cause harm to the environment, economy, or human health are considered using a vector and pathway approach.

Organisms that enter and establish populations in Michigan waters and cause harm to the environment, economy, or human health are considered using a vector and pathway approach. The vector is the physical means by which an AIS is transported to a new region, primarily by humans, whether deliberate or accidental (e.g., OIT) and the pathway is the specific route of transfer within a vector by which an AIS is moved from one ecosystem to another (e.g., use of live bait while fishing). This SMP also integrates and builds upon existing AIS prevention and control efforts.

This AIS SMP addresses the protection of all of Michigan's surface waters (Table 1). Michigan lies almost entirely within the watersheds of Lakes Superior, Michigan, Huron, and Erie. The Great Lakes contain 20% of the world's fresh surface water and are a unique natural resource. The protection of the Great Lakes and connecting channels is shared by the United States and Canadian federal governments; the states of Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio, Pennsylvania, and New York; and the Canadian Provinces of Ontario and Quebec as well as various tribal organizations. The state maintains jurisdiction over approximately 45% (by surface area) of the 4 bordering Great Lakes. In addition to the shared management of the Great Lakes, various inland waters cross state borders (i.e., waters in Wisconsin, Ohio, and Indiana). As such, this AIS SMP is designed to work in conjunction with AIS prevention, detection, and management efforts at the national, regional, and state/provincial level, including the ANS Task Force Strategic Plan and other state AIS SMPs.

Table 1. Michigan Atlas (all values are approximations).

Topic	Number	Area	Length	Source
State population	**10 million**			**United States Census Bureau 2008 Estimate**
State surface area		**96,760 mi^2**		**Sommers 1977**
Great Lakes, Great Lakes bays, and Lake St. Clair		**42,167 mi^2 (~45% of total Great Lakes area)**		**United States Geological Survey (USGS) National Hydrography Dataset (NHD) (1:24,000 scale)**
Inland lakes and reservoirs with surface area ≥ 0.1 acre	**46,000**	**872,109 acres**		**USGS NHD (1:24,000 scale)**
Rivers and streams (including connecting channels)			**76,439 mi**	**USGS NHD (1:24,000 scale)**
Wetlands		**5,583,400 acres**		**USFWS National Wetland Inventory**

Michigan's landscape can be described by five distinct ecoregions that exhibit relatively similar geological landform characteristics (Omernik and Gallant 1988): Southern Michigan/Northern Indiana Till Plains, Northern Lakes and Forests, North Central Hardwood Forests, Huron-Erie Lake Plains, and Eastern Corn Belt Plains (Figure 1). Factors used to delineate ecoregions include climate, soils, vegetation, land slope, and land use. This framework provides information on the environmental characteristics that tend to occur within each ecoregion. In general, the Northern Lakes and Forests and North Central Hardwood Forests ecoregions tend to support coldwater aquatic communities within at least a portion of their systems, and groundwater inputs tend to be substantial. Soils in the northern portion of the state typically exhibit poorer nutrient content than in bordering ecoregions to the south.

Waters in the southern portion of the state are typically influenced by richer soils, and rivers are typically lower gradient. Drainage ditches and channelized rivers have been a common solution to assist drainage of areas that are too wet for settlement and agricultural needs. Agricultural land use is more common in these ecoregions compared to the northern Lower Peninsula and Upper Peninsula. A majority of Michigan's population centers are located in the southern Lower Peninsula.

AIS have dramatic indirect and direct effects on all types of Michigan waters across the state. In general, the southern portion of the state is more heavily affected by AIS; however, species like invasive Phragmites and Eurasian water milfoil are dispersing northward and into the Upper Peninsula while other species like Eurasian ruffe are restricted to the northern waters of the Great Lakes.

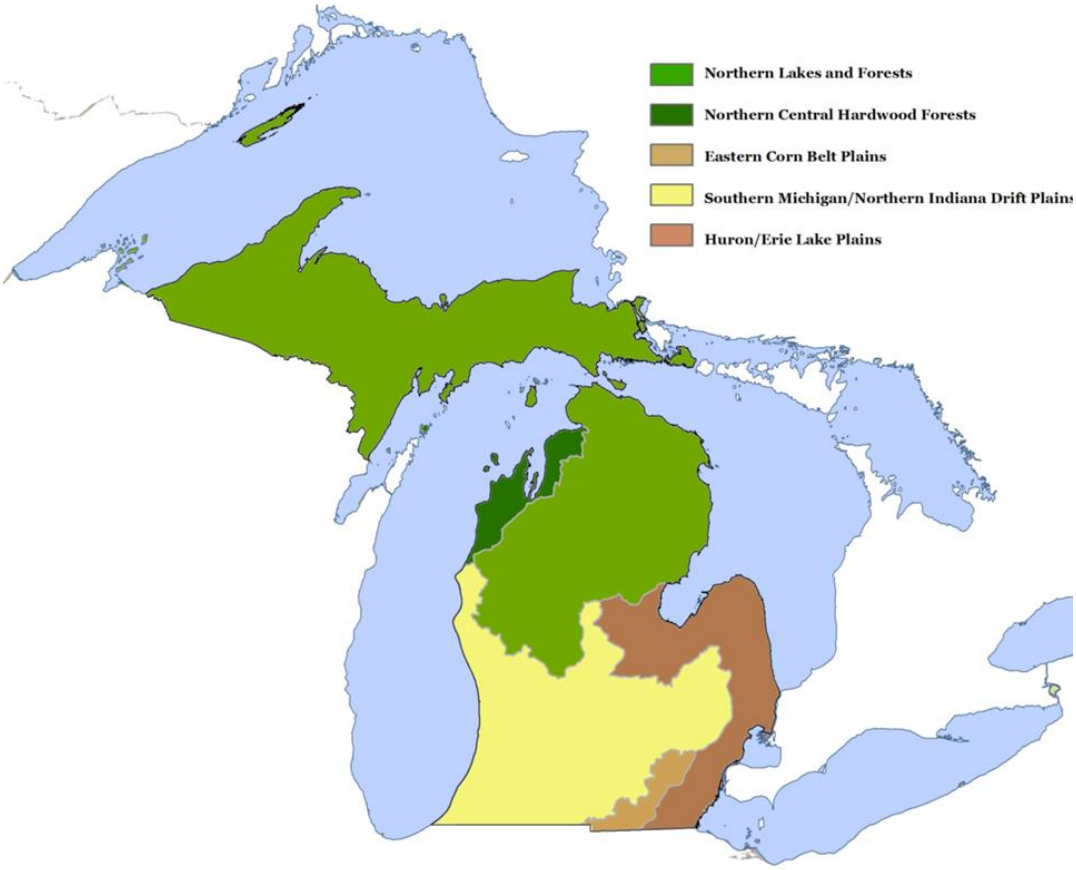

Figure 1. Scope of Michigan AIS SMP with Major Ecoregions (Level III) (adapted from Omernik and Gallant 1988).

Recent research has demonstrated that preventing the dispersal of invasive organisms from colonized areas (i.e., containment) is the most effective way to reduce the likelihood of new invasions at the landscape scale (Drury and Rothlisberger 2008). Therefore, the focus of this SMP is on the prevention of new AIS to Michigan waters through interruption of the most significant vectors for new introductions. The prevention actions recommended in this SMP should be effective in preventing both the entry of new organisms into Michigan waters and the transfer and dispersal of organisms among and within water bodies in the state (both Great Lakes and inland waters). This SMP also aims to minimize the risks posed by invasive species to the environment, economy, or human health, and to protect environmental values such as biodiversity and sustainability.

While prevention of new invasions is a focus of this SMP, some new invasions are inevitable, even with the best prevention programs. Therefore, early detection and further development of a response capacity for new invasions and existing invasions that are limited in extent are also an important component of the SMP. Additionally, the SMP addresses management and control efforts to minimize effects from established AIS populations using a coordinated, science-based approach.

Many partners share responsibility for protecting Michigan waters from the introduction of new AIS. Commitment and coordination between the international, federal, state, provincial, tribal, and local government agencies, along with nongovernmental organizations (NGO), industries/businesses, and private landowners are needed to effectively implement the provisions of the SMP and ensure organized commensurate actions. Initiatives at all of these levels have been and will continue to be important tools in the effort to prevent AIS introductions and dispersal and manage existing AIS populations.

Implementation of this SMP on a statewide basis will require significant commitment and coordination between all of these groups.

Successful implementation of Michigan's AIS SMP requires communication and collaboration with partners throughout the basin. The Great Lakes Panel on ANS is one of several forums in which Michigan actively participates that provides an opportunity to work with other Great Lakes states and provinces as well as researchers and other interested parties on this important issue. The mission of the Great Lakes Panel on ANS is to coordinate the development of education, research, and policy to prevent new AIS from entering the Great Lakes basin and to control and mitigate those AIS populations already established. This regional panel of the ANS Task Force provides an opportunity to tap into and contribute to the collective AIS prevention and management effort at both a regional and national level. The Great Lakes Panel on ANS is directed to perform the following tasks:

- Identify Great Lakes priorities.
- Assist/Make recommendations to the national ANS Task Force.
- Coordinate exotic species program activities in the region.
- Advise public and private interests on control efforts.
- Submit an annual report to the national ANS Task Force describing prevention, research, and control activities in the Great Lakes basin.

Michigan's AIS SMP has been developed within the larger context of work occurring regionally in the Great Lakes as well as nationally and internationally. An example of ongoing regional work includes that of the Great Lakes Panel on ANS and an example of upcoming regional work is the updated 2012 Great Lakes Water Quality Agreement (GLWQA) between the United States and Canada. The GLWQA has two new annexes that deal directly with invasive species, Annex 5 on Discharge from Ships and Annex 6 on Aquatic Invasive Species. Recommendations from individual SMPs in Great Lakes states will inform development of the two relevant annexes.

The remainder of the text below provides detailed information on AIS background and strategic planning in Michigan. In addition, there are multiple appendices and tables included with this SMP:

- The Implementation Table highlights the goals, objectives, and strategic actions associated with the SMP and lists a measure of success/evaluation, lead agency, estimated cost, and status of each.
- Appendix A presents a timeline of events that have most significantly shaped AIS issues in the region and that are relevant to AIS in Michigan.
- Appendix B summarizes specific accomplishments since the 2002 SMP update.
- Appendix C lists species of concern for Michigan compiled from existing sources of information.
- Appendix D lists relevant laws and regulations pertaining to AIS in Michigan and the SMP.

1.2 HISTORY AND DEVELOPMENT OF THE SMP

Michigan's first SMP, "Nonindigenous Aquatic Nuisance Species State Management Plan" (Office of the Great Lakes [OGL] 1996), was approved in 1996 under the auspices of the NANPCA. At the time, it was among the first state SMPs in the nation approved by the federal ANS Task Force. In 2002, Michigan prepared an update to the original SMP, "Michigan's Aquatic Nuisance Species State Management Plan Update: Prevention and Control in Michigan" (OGL 2002). Additional background information and history can be found in the original 1996 SMP. Both the 1996 SMP and 2002 update can be found at www.michigan.gov/aquaticinvasives.

Since 2002, implementation of the SMP has occurred as resources allowed (see Appendix B), but has been limited by lack of funding and consistent coordination between the state agencies. AIS management and control efforts most often occurred on a site-specific basis and have been driven by the interest and ability of a particular agency, property owner, stakeholder, or interest group.

Beginning in 2010, the State of Michigan received a significant increase in funding from a federal Great Lakes Restoration Initiative (GLRI) grant to address priority AIS actions. Michigan's work plan for this GLRI grant focused on establishing a more formal, cohesive AIS Program, updating the AIS SMP, and implementing priority strategic actions (see Section 5, Recommendations) in the AIS SMP. A full-time AIS Program Coordinator was established and is housed within the Michigan Department of Environmental Quality's (MDEQ) Water Resources Division (WRD). Funding is also being used to support staff in a newly established interdepartmental AIS Core Team with representatives from each of the state agencies with environmental or natural resource responsibilities: MDEQ's WRD and OGL; Michigan Department of Natural Resources' (MDNR) Fisheries Division (FD), Wildlife Division (WLD), Parks and Recreation Division (PRD), and Law Enforcement Division (LED); Michigan Department of Agriculture and Rural Development's (MDARD) Pesticide and Plant Pest Management Division and Animal Industry Division; and Michigan Department of Transportation's (MDOT) Project Planning Division.

With capacity funding in place, in early 2011 the newly organized AIS Core Team staff began efforts to again revise the AIS SMP. This current SMP summarizes the significant progress made since the 2002 update and provides new guidance to continue AIS prevention and control efforts. This SMP retains the same general purpose and goals of the previous plans: to guide efforts to prevent new introductions, limit the spread of established species, and abate the harmful effects of AIS. Most importantly, unlike earlier versions, this SMP takes a new organizational approach to prevent AIS introductions by identifying the vectors and pathways used by AIS to enter the state or disperse within the state, and then identifying the actions necessary to block or interrupt each of these pathways. This approach is further detailed in Section 2.2. In addition, this SMP includes a new goal to develop a statewide interagency EDRR Program to address new AIS invasions.

To develop this SMP, Michigan's AIS Program staff reviewed existing AIS prevention and control plans, as well as other strategic documents for the Great Lakes basin, and reviewed and expanded on the 2002 AIS SMP update (OGL 2002). This current update builds off of and uses language, concepts, and recommendations from a variety of sources including:

- Lake Superior AIS Complete Prevention Plan (Lake Superior Binational Program 2010)
- Great Lakes Regional Collaboration (GLRC) Strategy to Restore and Protect the Great Lakes (GLRC 2005)
- Michigan Great Lakes Plan (OGL 2009)
- A Model Comprehensive State Management Plan for the Control of Nonindigenous Aquatic Nuisance Species: Report to the Great Lakes States (Glassner-Schwayder 1996)
- Other state, provincial, federal, and tribal AIS management and EDRR plans
- Proposed 2010 Plan for the Prevention, Detection, Assessment, and Management of Asian Carps in Michigan Waters (MDNR 2012)
- Strategic Framework for the Management and Control of Invasive Phragmites in Michigan (Great Lakes Commission [GLC] 2011 Draft)

In addition, several specific EDRR documents were used including:

- The Great Lakes Water Quality Agreement: 2009-11 Priority Cycle Report on Binational Aquatic Invasive Species Rapid Response (International Joint Commission [IJC] 2011)
- Rapid Response to New Aquatic Invasive Species in Michigan: *Hydrilla verticillata*; A Case Study (Hydrilla Task Force 2006 Draft), and Quality Assurance Project Plan for Mounting a Response to New Aquatic Invaders (MDNR 2011a).

While this SMP was prepared primarily by state agency staff, input received from partners and stakeholders was an important part of the SMP development. Feedback received from previous meetings was used to prepare the first draft of the SMP, and comments received during a public notice period of a draft version of this SMP were incorporated into the final product. Comments addressed almost all sections of the SMP. Many changes were incorporated into this final SMP based on comments received,

and other comments and suggestions will be taken into consideration during the implementation of strategic actions.

Table 2. Summary of review periods and public input opportunities used to generate the draft and final versions of the SMP.

Date	Input Opportunity
2008-2009	More than 20 meetings held throughout the state by the OGL. These meetings were held to prepare and implement the Michigan Great Lakes Plan, which includes an AIS component.
March 2008	Michigan's Call to Action on AIS. A key input meeting to exchange information with partners and stakeholders through presentations and breakout sessions and information from this meeting was incorporated into the draft plan.
November 2010	Michigan Department of Natural Resources and Environment's (MDNRE) Michigan Asian Carp Prevention Workshop
March 2011	Phragmites Invasions in Michigan: A Symposium to Build Capacity for Management. This was a cooperative effort by the MDNRE and the GLC.
March 2011 to March 2012	Advance notice of the SMP revision was announced during many key meetings including open meetings of the Natural Resources Commission and the Agriculture Commission.
March 23, 2012 to May 1, 2012	The draft SMP was made available to the public for a comment period. Notice was distributed via the MDEQ Calendar, the MDNR and MDEQ Web sites, a press release, through various listserves, and direct e-mails to known interested groups and individuals, including representatives from key industries. Written and verbal comments were received.
April 12, 2012	Public meeting on the draft SMP. The purpose of the public comment period and meeting was to identify gaps and strengthen the overall SMP. Specifically, feedback was solicited on the SMP's priorities, strategic actions, existing partnerships, and the need for new partnerships.
March 29, 2012 to May 17, 2012	ANS Task Force preliminary review. Written comments were submitted to the MDEQ.
April 6, 2012 to July 18, 2012	Michigan's AIS Advisory Council review and discussion during open meetings. Written recommendations were submitted to the MDEQ.

A detailed response to public comment is contained in a separate document available at www.michigan.gov/aquaticinvasives. Several of the most noteworthy public comments and how they were or will be addressed include:

- General support of the SMP priorities and overall approach was noted.
- The lack of long-term funding for AIS SMP implementation is a concern. Recommendations on AIS Program funding will be made by Michigan's AIS Advisory Council as described below.
- Lengthy timelines for implementation are a concern. Some of the target dates for strategic actions were moved up based on current staffing levels, especially those related to AIS education and outreach.
- The need for strong communication, education, and outreach efforts was highlighted as a concern. These efforts are listed as an overarching priority for SMP implementation in Section 5, Recommendations.
- Clarification on the definition of AIS was suggested. The definition of AIS was modified based on public comments and recommendations from Michigan's AIS Advisory Council as described below.

Legislation creating a new Michigan AIS Advisory Council, Part 414, Aquatic Invasive Species Advisory Council, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), was passed and made effective immediately on December 21, 2011. The AIS Advisory Council is composed of a wide variety of members representing diverse interests and was tasked with providing recommendations on the draft SMP. AIS Advisory Council recommendations were provided to the MDEQ's WRD on July 18, 2012, and changes were incorporated into this final SMP. In particular, the AIS Advisory Council provided recommendations on the definition of AIS as directed by Part 414 of the NREPA. In addition, the AIS Advisory Council serves to enhance communication between partners as well as contribute recommendations in key areas including ballast water regulation, OIT, the management and control of invasive Phragmites, and funding for the implementation of the SMP. AIS Advisory Council recommendations are to be suitable for collaboration with other Great Lakes states and Canadian provinces and will be considered during implementation of this SMP. For additional information on Michigan's AIS Advisory Council see www.michigan.gov/aquaticinvasives.

1.3 AIS BACKGROUND

1.3.1 Environmental and Economic Effects

Newly introduced and established AIS can disrupt natural ecosystem balance and can cause costly economic effects even if effective prevention and control mechanisms are implemented. Effects are often compounded by the opportunistic nature of AIS including rapid resource consumption and reproduction and the lack of natural predators leading to low mortality rates. The direct effects of some of the most abundant and influential AIS have been documented; however, the full extent of direct and indirect harmful effects of many other AIS are not known or are difficult to quantify. Usually, the effects of AIS are unanticipated and long-lasting.

Many Great Lakes researchers and managers consider AIS the most important and immediate threat to Great Lakes ecosystems and their food webs as well as a primary threat to native biodiversity (Sala et al. 2000; Dextrase and Mandrak 2005). The United States Environmental Protection Agency (USEPA) asserts that invasive species are the second-highest contributing factor to species extinction in aquatic environments worldwide (USEPA 2011). Roughly 42% of the species listed as threatened or endangered are considered at risk primarily because of nonindigenous species (Wilcove et al. 1998).

Ecosystem disruptions caused by AIS can create significant cascading changes such as alterations to:

- Food webs and energy flow
- Nutrient dynamics
- Biodiversity
- Ecosystem stability

AIS may also:

- Directly compete with native species for limited resources including: habitat, spawning areas, food, and light.
- Decrease the fitness of native species (growth, survival, and reproduction) through aggressive behavior; prey upon native species at multiple life stages.
- Increase native species mortality via direct parasitism and disease or by creating environmental conditions for increased pathogen production.
- Hybridize with native species.
- Alter the physical characteristics of aquatic habitats and alter water quality.
- Degrade habitat by providing less desirable food or nesting sites for native species.

In addition to environmental effects, AIS can have negative economic effects to valuable water resources of the Great Lakes region. These effects include:

- Decreased waterfront property values.
- Decreased aesthetic (visual and odor) and recreational value of aquatic resources including swimming, boating, sport fishing, and hunting.
- Decreased tourism and opportunity for wildlife viewing.
- Loss of commercial fisheries.
- Damage to infrastructure and equipment.
- Increased costs for raw water users including industry and drinking water supply.

In addition, AIS can affect Tribes of the United States and First Nations of Canada due to the risk to native species that are culturally significant for subsistence, or species used in a variety of traditional medicinal and cultural practices. Of paramount concern is the financial burden associated with AIS management and control efforts as well as the negative side effects that control efforts may also have on native species.

According to the 2011 National Survey of Fishing, Hunting, and Wildlife Associated Recreation, more than 90 million Americans spent more than $144.7 billion on wildlife-related recreation in 2011. This spending supports millions of jobs in industry and businesses (United States Department of the Interior 2011). In the Great Lakes region alone, more than 1.5 million United States jobs are directly connected to the Great Lakes (over 525,000 of these jobs in Michigan), generating $62 billion in wages annually (Vaccaro and Read 2011).

Tourism and recreation in the Great Lakes region not only supports 217,635 jobs, but enhances the quality of life for roughly 83 million residents (Vaccaro and Read 2011). Nearly 4.3 million recreational boats are registered in the eight Great Lakes states, which is nearly one-third of all registered boats in the United States. In 2009, Michigan alone had over 800,000 registered boats ranking the state 3rd in the nation in the number of recreational boaters. In 2003, Great Lakes registered boaters spent nearly $16 billion, which supported roughly 107,000 jobs (GLC 2007). Michigan boaters spent $3.9 billion on trip and equipment related expenses, which supported roughly 51,000 jobs (GLC 2007).

Annually, many residents and nonresidents of the Great Lakes region use the abundant natural resources, including 9.2 million anglers, 4.6 million hunters, and 23.2 million wildlife watchers, which are estimated to generate $26.5 billion each year for the region (United States Department of the Interior 2011). Michigan ranks 3rd in the nation in licensed hunters (more than 750,000) who contribute $1.3 billion annually to our economy and generate $153 million in state tax revenue. More than 3.2 million people, age 16 and older, participated in wildlife viewing activities, adding $2.7 billion to the economy. Michigan ranks 5th in the nation in numbers of licensed resident and nonresident anglers, with 1.1 million anglers who contribute $2 billion annually to our economy and generate $225 million in state tax revenue. Michigan had 1.2 and 1.1 million licensed anglers in 2010 and 2011, respectively. With 22 million visitors annually, state parks and recreation areas play an important role in Michigan's tourism industry, contributing $580 million to the state's economy (MDNR 2011b).

Economic effects from AIS are manifested in the form of losses (e.g., loss of recreational and commercial fishing opportunities and effects on waterfront property values and tourism) and costs of management and control. Exact AIS management and control costs are difficult to quantify; however, the following represents expenditure estimates for three of the most pervasive and longest established AIS.

Sea lampreys invaded the upper Great Lakes in the 1910s and prey on, weaken, and often kill large fish and have resulted in serious long-lasting, negative effects to the Great Lakes fish community. The Great Lakes Fishery Commission (GLFC), established in 1955 to control this AIS, currently spends in excess of $20 million each year for Sea lamprey control (Fisheries and Oceans Canada 2008) using a variety of techniques. As an example of part of this program, the St. Marys River lampricide treatment costs approximately $4.2 million per treatment (USEPA 2005). The Canadian and United States governments have financially supported the GLFC's Sea lamprey control efforts for over 30 years. Although the Sea

lamprey control program has been successful in reducing populations, the program has demonstrated that it is impossible to completely eliminate Sea lampreys in the Great Lakes. The control program will need to continue into the future to maintain the Sea lamprey population at levels that minimize their effects.

After invading the Great Lakes in the late 1980s and becoming broadly established by the 2000s, zebra and Quagga mussels have completed altered energy flow in the Great Lakes. The total cost to treat zebra and Quagga mussels in the Great Lakes during the period 1989 to 2000 is estimated at $750 million to $1 billion (Government Accountability Office 2005). The median additional operating costs due to biofouling effects on raw water use aggregated over all Great Lakes facilities (including nuclear and fossil fuel power plants, municipal water supplies, and industrial facilities) is roughly $27 million per year (Rothlisberger et al. 2012). In addition, these invasive mussels interfere with commercial fishing, recreational boating, sport fishing, and shipping by adhering to the hulls and motors of watercraft. In 2005 the cost of removing the mussels from watercraft in the Great Lakes was estimated at $19.5 million per year (Pimentel 2005).

Eurasian water milfoil and other invasive and nuisance aquatic plant and algae species rapidly expanded in the Great Lakes basin in the 1980s and 1990s and now cost approximately $24 million annually in Michigan to control and manage (Bondra 2011). Aquatic invasive plants can interfere with recreational activities such as swimming, fishing, water skiing, and boating as well as significantly alter the ecology of water bodies. Once these species become well-established within a water body, they are often difficult or impossible to completely eradicate. The financial burden of the management and control of aquatic invasive plants in Michigan inland lakes is placed largely upon the riparian landowners.

In 2012, the Andersen Group published a report, “The Cost of Invasive Species to the Great Lakes States.” Commissioned by The Nature Conservancy, the report analyzes the economic effect of existing AIS on businesses and households in Great Lakes states. The summary notes that industries directly affected by AIS employ more than 125,000 people across the Great Lakes and that total costs exceed $100,000,000 per year (Rosaen et al. 2012).

When economic losses from all AIS-caused environmental effects are summed, the total economic effect (damage and management/control costs) of AIS in the Great Lakes region is estimated to be as high as $5.7 billion per year (Pimentel 2005). The Great Lakes sport and commercial fishing are the most affected industries with losses estimated at $4.5 billion per year (Pimentel 2005). Such effects are attributable to the changes in energy flow and reduction of native fish populations, directly caused by competition for resources with invasive species.

Annual losses to the Great Lakes region by ship-born invasive species is estimated to be at least $200 million due to effects to sport fishing, commercial fishing, wildlife watching, and raw water usage (Lodge and Finnoff 2008). Economic costs of aquatic and terrestrial invasive species to the United States are estimated at up to $137 billion per year (Pimentel et al. 2000).

Rehabilitation and restoration efforts, including ameliorating the effects of AIS, in the Great Lake region are costly; however, the economic benefit of restoring the Great Lakes through environmental improvements has been valued at $18-31 billion for the Great Lakes region. The total benefits are estimated at $30-50 billion when short-term multiplier effects are included (Austin et al. 2007). This estimate includes quantifiable environmental services, but does not incorporate the less tangible benefits of an improved environment such as enhanced quality of life, improved human health, increased business investment, and avoidance of other losses associated with further environmental degradation (Vaccaro et al. 2009). Furthermore, this does not include the value of Michigan's many inland lakes, streams, and wetlands.

Additional information summarizing and providing examples of the environmental and economic effects of AIS in the Great Lakes basin can be found in the Lake Superior Complete AIS Prevention Plan (Lake Superior Binational Program 2010).

1.3.2 Historical AIS Timeline

Appendix A of this SMP highlights significant AIS events relevant and specific to the State of Michigan. The timeline is not an all-inclusive list of events, but rather a snapshot of those events that have most significantly shaped AIS issues in the state. The timeline begins with the connection of Lakes Ontario and Erie with the opening of the Welland Canal in 1829. In addition to allowing the passage of vessels between the lakes, this event opened up a key pathway for organisms to disperse to the upper Great Lakes. While there are many events not covered in the scope of this timeline and undoubtedly more significant events will occur in the future, Appendix A contains the historical information important to the development of this SMP. In addition, the IJC and GLFC have created a Web version of a timeline, "Aquatic Invasive Species: Then and Now," that includes information from a Great Lakes basin perspective available at http://www.ijc.org/rel/ais-timeline/.

1.3.3 Policy Background

This section seeks to highlight some of the highest profile and most relevant policy and legislation with implications for AIS in Michigan. However, additional legislation, policies, and more details about specific legislation can be found in the sections below and in Appendix D.

There are multiple pieces of federal legislation that are relevant to this SMP and the management of AIS in Michigan. The NANPCA of 1990 and its subsequent reauthorization and amendment in the form of the National Invasive Species Act of 1996 (NISA) created the ANS Task Force and mandated a coordinated federal invasive species program to help specific regions and states better address invasive species issues. NANPCA was primarily created in response to the Zebra mussel invasion of the Great Lakes, where ballast water introduction had caused serious ecological and economic effects. Although the Zebra mussel invasion of the Great Lakes has played a central role in prompting passage of the federal legislation, NANPCA has been established to prevent the occurrence of all new AIS introductions and to limit the dispersal of all AIS already in United States waters.

The NANPCA, established for the prevention and control of the unintentional introduction of nonindigenous ANS, is based on the following five objectives as listed in Section 1002 of the NANPCA:

- To prevent further unintentional introductions of nonindigenous ANS.
- To coordinate federally funded research, control efforts, and information dissemination.
- To develop and carry out environmentally sound control methods to prevent, monitor, and control unintentional introductions.
- To understand and minimize economic and ecological damage.
- To establish a program of research and technology development to assist state governments.

The primary components of the NANPCA:

- Required vessels entering ports on the Great Lakes to exchange ballast water and meet other requirements, with voluntary guidelines for similar actions on other waters of the United States.
- Authorized a number of studies and monitoring programs to assess the spread of AIS and develop methods for controlling them.
- Required the development of Armed Services ballast water programs as well as the establishment of the Ballast Water Management Demonstration Program.
- Authorized the establishment of the ANS Task Force.
- Established a mechanism for regional collaboration and coordination through the establishment of the ANS Task Force Regional Panels.
- Authorized the development of an AIS Program to be housed within the USFWS.
- Established the State\Interstate ANS Management Plan Grant program managed by the USFWS, through which states can develop and implement a comprehensive state management plan for the prevention and control of ANS.

The NISA amended NANPCA "To provide for ballast water management to prevent the introduction and spread of nonindigenous species into the waters of the United States, and for other purposes." The NISA authorized:

- The production of guidelines for how to guard against the introduction and dispersal of invasive species.
- Regulations for vessel operations and crew safety, and education and training programs to promote compliance.
- Funding for research on environmentally sound methods to control the spread of invasive species.
- Ecological surveys for certain environmentally sensitive regions of the country.
- Establishment of the National Ballast Information Clearinghouse to provide data about ballasting practices and compliance with guidelines.

The NISA officially expired in 2002. Stakeholder groups and members of Congress have been working to pass another revision titled, the Nonindigenous Aquatic Invasive Species Act, though the new legislation has not passed as of publication of this SMP.

The federal Lacey Act targets the trafficking of illegal wildlife, fish, and plants. Under the Lacey Act, it is unlawful to import, transport, or possess certain species and plant products. Other species require a specific import declaration. Furthermore, the injurious wildlife provisions of the Lacy Act prevent illegal introductions of invasive species and the importation and interstate transport of animal and plant species determined and declared to be injurious and may be regulated by the Secretary of the Interior.

The federal Clean Water Act (CWA) provides for protection of surface water quality in the United States. The statute employs regulatory and nonregulatory tools to achieve the broad goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. Multiple sections of the CWA directly or indirectly pertain to AIS including the regulation of ballast water discharges (see Section 2.2.1 of the SMP for more information). In addition, Section 404, Wetlands, of the CWA has potential implications for AIS rapid response and control activities by regulating the discharge of dredged or fill material that may contain and/or spread AIS. For more information and the complete text of the CWA, see http://www.epa.gov/regulations/laws/cwa.html.

Part 413, Transgenic and Nonnative Organisms, of the NREPA was last amended in 2009 and provides a list of prohibited and restricted invasive species within the state. In addition to creating a list of both restricted and prohibited species, the NREPA: defines possession regulations; lays out a permitting process; and lists violations, penalties, and liabilities. In general, penalties and fines for violations involving prohibited species are more severe than those associated with restricted species with maximum penalties of up to 5 years of imprisonment and $1,000,000 in fines. The Michigan Natural Resources Commission is authorized to add or delete species from each list (other than an insect or plant species) in consultation with the MDARD. After the consultation and at least 30 days prior to the Natural Resources Commission issuing the order, the MDNR must post a copy of the proposed order on the MDNR's Web site and submit the proposed order to the Michigan Legislature and relevant Senate and House of Representatives committees. The Michigan Commission of Agriculture may add or delete insect and plant species through a similar process in consultation with the MDNR. Part 413 also creates an invasive species fund within the state treasury. Money collected from civil fines and permit fees under the NREPA are to be deposited in the fund. Subsequently, the funds are then available to the MDNR and MDARD for administration of Part 413 and public education about AIS.

Local governments concerned about AIS control and management and the potential negative effects of AIS on the local community may develop ordinances to either manage or control AIS. For example, Peninsula Township passed an ordinance to allow for inspection for and treatment of invasive Phragmites along the Great Lakes shoreline. Also, both Glen Lake Township and Empire Township adopted ordinance language, at the request of the Glen Lake Association, making it illegal to launch a boat in the townships or the Glen Lake/Crystal River watershed that has not been washed and cleared of ANS. While Zebra mussels are found in this watershed, Eurasian water milfoil and several other invasive

species found in other lakes in the region have not become established in Glen Lake. The Glen Lake Association's work and experience on these issues hold valuable lessons for future efforts in the region and the state.

1.3.4 Species of Concern

Michigan's SMP takes a vector/pathway approach at addressing AIS prevention; however, consideration of individual plant and animal species will remain important, not only for prevention but also for EDRR actions of new invaders and ongoing control and management of established populations. From a regulatory perspective, several existing federal and state laws have been enacted with the explicit purpose of setting forth regulations, including outright prohibitions against possessing, selling, moving, or introducing certain individual species; others regulate the control and management of established populations (e.g., Part 33, Aquatic Nuisance Control, and Part 413 of the NREPA; see Appendix D for a detailed list of laws and regulations). Appendix C identifies the species currently prohibited or restricted in Michigan based on existing federal and/or state law. Some of these species are not yet known to be present within the state, while others have been present in certain parts of the state for decades, resulting in significant management and control costs. Appendix C provides the current coarse-scale statewide distribution of each species, based on best available knowledge and also provides a list of the most significantly harmful AIS established in Michigan waters, the pathway of introduction, and the year sighted in the Great Lakes basin.

Several invasive aquatic plant species have widespread distribution in Michigan, especially in the Lower Peninsula: Curly-leaf pondweed, Eurasian water milfoil, Japanese knotweed, and invasive Phragmites or Common reed. Starry stonewort and Fanwort are locally abundant in certain areas of the Lower Peninsula and Giant hogweed has been found in isolated areas. Purple loosestrife is widespread, but biological control is reducing populations, especially in the Lower Peninsula. As noted in the Introduction and Section 1.3.1, these species have significant harmful effects to both the environment and the economy.

Control efforts for the above established plant species are currently underway in some areas of the state and have historically been led at the local or regional level. The management responsibility (including financing the effort) usually rests with the owner of the infested property. In many cases, control measures (e.g., mechanical harvesting or pesticide treatments) on a given water body have been conducted on an annual basis for decades. For hundreds of lakes and ponds with established populations and little hope of eradication unless new management techniques become available, active management is required with the goal of suppressing the species and minimizing the effects. It is considered a recurring and necessary – yet costly – activity for many riparian property owners. With regard to invasive Phragmites, Michigan's AIS Advisory Council is charged with making recommendations for its management and control in the state (see Section 1.2 for more information on Michigan's AIS Advisory Council).

Surveillance and management efforts supported by a GLRI grant are currently underway for six aquatic plants with no known or limited distribution in Michigan: Flowering rush, Water lettuce, Water hyacinth, European frogbit, Brazilian elodea, and Parrot feather (see Section 2.3.1 for more information on this project).

The Great Lakes Sea lamprey control program is one of the few examples of successful invasive fish management. The GLFC, in cooperation with partner agencies, conducts this ongoing program to maintain Sea lamprey at population levels that lessen the effect to the Great Lakes fishery. Other widespread or locally abundant AIS for which feasible management tools are not currently available (e.g., Rusty crayfish, Eurasian ruffe, Round goby, Zebra mussel, and Quagga mussel) remain a concern for Michigan natural resource managers and citizens. Efforts are ongoing to track research on control options, promote best management techniques, and enforce laws to limit the dispersal of these species.

Viral hemorrhagic septicemia (VHS) is an extremely serious viral disease of fresh and saltwater fish and is a concern in the Great Lakes region of the United States and Canada. The disease can cause large-scale fish kills and have severe economic consequences. To date, VHS has been found in the following Michigan waters: Lake Huron including Saginaw Bay, the St. Clair River, Lake St. Clair, the Detroit River, and Lake Erie and all tributaries up to the first dam or barrier. VHS also has been documented in Budd Lake in Clare County and in Baseline Lake in Washtenaw County. VHS is listed under the United States Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) National Animal Health Reporting System as a Reportable Disease. For more information on the VHS problem and management efforts see Section 2.2.3 of this report and www.michigan.gov/vhs.

Several high profile AIS not currently in Michigan waters have the potential to cause significant harm: Bighead carp, Silver carp, fish in the snakehead family (family Channidae), Hydrilla or water thyme, and Water chestnut. These priority species, in addition to other species with limited distribution, should be reported directly to the MDNR. Additional information regarding the identification and reporting of AIS is available at www.michigan.gov/invasivespecies.

Asian carp are a series of highly invasive fish species capable of causing economic, ecological, and human health harm. Michigan considers five species of carp that are native to Asia to be a threat. Those species include Bighead carp, Black carp, Grass carp, Silver carp, and Large-scale silver carp. All of these carp species have the potential to disrupt the Great Lakes food chain. While Bighead, Silver, Black, and Large-scale silver carp are not currently established in the Great Lakes or Michigan's inland waters, Grass carp can be found in isolated waters in Michigan and the Great Lakes region. All five species are illegal to possess, transport live, or stock within Michigan.

Bighead and Silver carp species are of particular and immediate concern. They are spreading uncontrolled throughout streams, rivers, and lakes in the Mississippi River basin and are just a few miles from Lake Michigan near Chicago, Illinois. In 2012 Bighead and Silver carp DNA was found in Lake Erie. See Section 2.2.2 for more information on Asian carp and the CWAS.

Please refer to the Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS) at http://www.glerl.noaa.gov/res/Programs/glansis/glansis.html for more information on the life histories, the pathways and timing of introduction, and effects of these species. Many other nonnative aquatic species are established in Michigan waters; however, they are not known to be invasive or their effects are unknown at this time. Additional information on these species as well as a more extensive watch list for species not yet known to be established in the Great Lakes basin is also available from GLANSIS. For the most part, strategic actions contained in Section 3, Implementation Table, are not focused on individual species; rather, strategic actions are broad in scope and often apply to multiple species.

1.4 ACCOMPLISHMENTS

The 2002 update of the SMP recommended actions in three categories: (1) legislation and policy; (2) information and education; and (3) research and monitoring. The actions were described in narrative form as well as presented in implementation tables. Appendix B of this SMP adds to the original implementation tables by summarizing accomplishments made since 2002 with a "status update" and "comments" section. This appendix not only highlights accomplishments since the last update of the SMP but also serves to help guide future actions by showing ongoing work and work yet to be completed.

2 STRATEGIC PLANNING

2.1 GOALS

Ongoing effort is required to block the pathways that AIS use to enter and disperse in Michigan waters, to detect and respond to new invaders, and to manage and control new and established populations. The goals of this SMP are designed to address different stages of AIS invasion: the introduction of AIS transported from water bodies outside of Michigan waters; the dispersal of established AIS populations in Michigan to other water bodies within the state; and the colonization of AIS populations within water

bodies, including the harmful effects resulting from colonization. Goals are not numbered in order of priority. The four goals addressed by the SMP are:

- Goal I: Prevent new introductions of AIS into Michigan waters.
- Goal II: Limit the dispersal of established populations of AIS throughout Michigan waters.
- Goal III: Develop a statewide interagency EDRR Program to address new invasions of AIS.
- Goal IV: Manage and control AIS to minimize the harmful environmental, economic, and public health effects resulting from established populations.

Goal I: Prevent new introductions of AIS into Michigan waters.

Problem Description

The introduction and establishment of AIS in Michigan waters can cause long-term environmental, economic, and public health effects. A reactive and delayed "crisis-response" approach overlooks the significance of the prevention of new introductions. This approach leaves the region with AIS management problems that are economically costly and technically challenging, if not impossible to solve, and which are usually irreversible. Although at least 182 nonindigenous aquatic species already have been introduced into the Great Lakes ecosystem, new introductions are still highly likely (National Oceanic and Atmospheric Administration 2011). Given limited resources and the extreme difficulty of eliminating established AIS, the prevention of new introductions is critical in ameliorating AIS problems. The unpredictable, unanticipated, and long-lasting nature of effects from AIS highlights the importance of having prevention as a top priority.

Multiple mechanisms transport new AIS into Michigan waters including: direct hydrologic connection, ballast water discharge from transoceanic and interlake shipping, and OIT. These pathways present regulatory challenges due to the involvement of multiple government agencies at multiple levels. Cooperative efforts between state, federal, and international agencies are critical to block pathways and promulgate and enforce regulations.

Other pathways that increase the potential for new introduction of AIS to Michigan waters include the aquaculture industry, recreational boating and angling, the bait industry, and fish stocking activities. In cases where laws or regulations do exist in these areas, they are frequently not well-publicized and/or enforced. User groups that could potentially introduce AIS into Michigan waters may not be adequately informed of AIS prevention practices. Research on prevention strategies to minimize AIS transport is critical in the effective prevention of AIS introductions.

Goal II: Limit the dispersal of established populations of AIS throughout Michigan waters.

Problem Description

The dispersal of established AIS populations already in the state, but whose populations are limited in numbers and/or geographic scope is largely anthropogenic. AIS may be transferred from the Great Lakes to inland water bodies, and then from one inland water body to another. Limiting the dispersal of AIS is problematic due to the numerous pathways of movement and the complex ecological characteristics associated with these species. Human activities that contribute to the dispersal of AIS within Michigan waters include: recreational boating and angling, illegal fish stocking, bait handling, and habitat modification. Resource user groups may not be aware of existing populations of AIS and reasons they cause problems locally, regionally, and beyond. The probability of AIS populations expanding to other waters can increase when resource user groups are not aware of how their routine activities can cause the dispersal of AIS into uninfested water bodies.

Goal III: Develop a statewide interagency EDRR Program to address new invasions of AIS.

Problem Description

Historically, Michigan had few management tools available to take action either on a short-term or long-term basis. This deficiency is particularly apparent during the critical period between introduction and establishment of a new AIS population when the focus of management must shift rapidly from prevention to control, containment, and eradication. It is during this brief window after introduction where the opportunity exists to stop the permanent establishment of a new AIS population. Intervention following early detection is a critical strategy for preventing the establishment of new AIS populations. EDRR efforts increase the likelihood that invasions will be addressed successfully while populations are still localized and population levels are not beyond those that can be contained and eradicated.

Goal IV: Manage and control AIS to minimize the harmful environmental, economic, and public health effects resulting from established populations.

Problem Description

Populations of AIS are rarely, if ever, eradicated once they become established (Fuller et al. 1999, Lodge et al. 2006). Strategies to control AIS and minimize their associated effects in infested water bodies are not always available or technically and/or economically feasible. Additionally, control strategies must be designed to minimize significant unintended environmental or public effects. Actions to manage and control AIS are frequently impeded by circumstances such as the absence of political support and the lack of resources, needed to effectively develop and implement control strategies.

All Goals

Several general objectives apply to all four goals. For example, information and education materials to increase awareness of the problems associated with AIS and the value of a healthy aquatic ecosystem that supports a diverse native aquatic community are applicable for prevention, detection, and management goals and are applicable to a wide variety of audiences. In addition, cohesive and effective AIS information education programming is critical to strengthening public and private support for and statewide participation in AIS prevention, detection, and management strategies.

Climate change is neither a vector nor a pathway of AIS introduction, but is considered a stressor that affects the ability of a species to become established (or survive) and expand its range. Climate change is: altering ecosystem conditions, causing increased atmospheric carbon dioxide, modifying precipitation patterns, increasing water and atmospheric temperatures, and altering nitrogen distribution. For example, increased rainfall and flooding may facilitate the dispersal of invasive plant seeds by flotation. Increased water temperatures can provide more favorable conditions for a broader range of invasive species to grow and reproduce, and higher ambient air temperatures can allow AIS to shift their ranges northward and become invasive in new areas (USEPA 2008). Some nonnative species that are not considered harmful today may even respond favorably to climate change and display more harmful invasive characteristics in the future. Researchers are investigating the link between rising water temperatures in Lake Superior and increased breeding, spawning, and feeding cycles of Sea lamprey resulting in larger lamprey that are more effective predators for a longer period of time each year (Wisconsin Sea Grant 2010). While there is a clear need for more research to determine the effects of climate change on invasive species, this SMP recognizes the importance of climate change awareness and considers adaptive management as a key tool for responding to changes (Burgiel and Muir 2010).

The general objectives and strategic actions that apply to all four goals are presented in Section 3, Implementation Table. Several of these general objectives are also included in more detail under individual goals.

2.2 GOALS I AND II - PREVENT NEW INTRODUCTIONS AND LIMIT DISPERSAL OF AIS: VECTOR AND PATHWAY APPROACH

AIS may be introduced to and dispersed throughout Michigan waters through a number of different vectors and pathways. This SMP addresses potential AIS invasion into and dispersal within Michigan waters through three general categories of vectors and pathways: shipping and boating, habitat alteration, and the use and trade of organisms (Figure 2). Within each category, there are a number of vectors and pathways of concern. Definitions for these terms are given below.

> **Category**: Grouping of related vectors.
>
> **Vector**: The physical means by which an AIS is transported to a new region, primarily by humans, whether deliberate or accidental.
>
> **Pathway**: The specific route of transfer within a vector by which an AIS is moved from one ecosystem to another.

For example, in the "shipping and boating" category, water recreation is considered a vector for AIS introduction, and individual pathways within this vector can include boating (e.g., trailers and livewells).

The following sections describe the most significant vectors and pathways. Objectives and strategic actions (see Section 3, Implementation Table) addressing each vector and pathway have been identified to address Goal I (preventing new AIS introductions) and Goal II (limiting the dispersal of AIS). The intention of this SMP is to address the major vectors and pathways that have the potential to introduce AIS to Michigan waters. Other miscellaneous or minor pathways that are largely terrestrial in nature but may affect aquatic ecosystems (e.g., horses, all-terrain vehicles, passenger vehicles, etc.) are not discussed. However, additional vectors or pathways may be included in subsequent plan updates if research demonstrates their significance.

It should be noted that the vector and pathway approach addresses Goals I and II and focuses on the prevention of new introductions and the dispersal of existing AIS populations. Goals III and IV are separate from the vector and pathway approach and focus on addressing EDRR plans and the harmful effects caused by AIS populations, respectively.

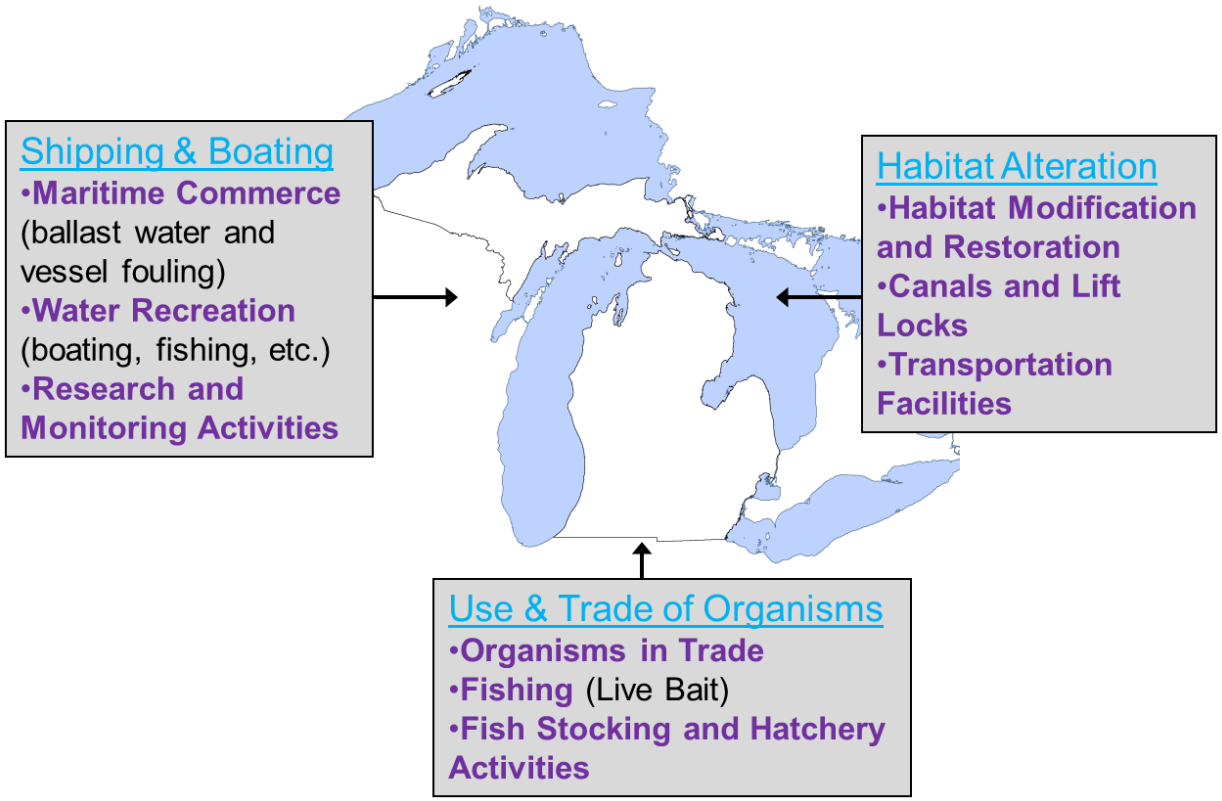

Figure 2. Prevention of AIS in Michigan Waters: Vectors and Pathways Concept Map (Adapted from Lake Superior AIS Complete Prevention Plan [Lake Superior Binational Program 2010]).

The vectors and pathways presented in the following sections do not have relative risk ratings at this time.[1] While much is known about past introductions of AIS, new regulations, educational programs, and other actions have likely had a positive effect on blocking or reducing some pathways. Historical introductions of aquatic nonindigenous species (note, the use of "nonindigenous" does not denote harm) have been both unintentional and deliberate and via a variety of pathways. Risk for future introductions, however, includes components of both: (1) pathway availability, and (2) potential damage from particular species that may use that pathway. Limited reliable and valid information exists about either component for AIS, though research is ongoing. The purpose of this SMP is not to assign risk to pathways or to identify the most damaging species that may arrive, but rather the SMP's purpose is to identify the pathways used by a variety of species and to work on a broad front to block those pathways to protect Michigan waters from new AIS.

[1] ***Risk is considered the likelihood that AIS will be introduced through a pathway and the potential effects (ecological and economic) caused by the AIS in the event that an introduction does occur.***

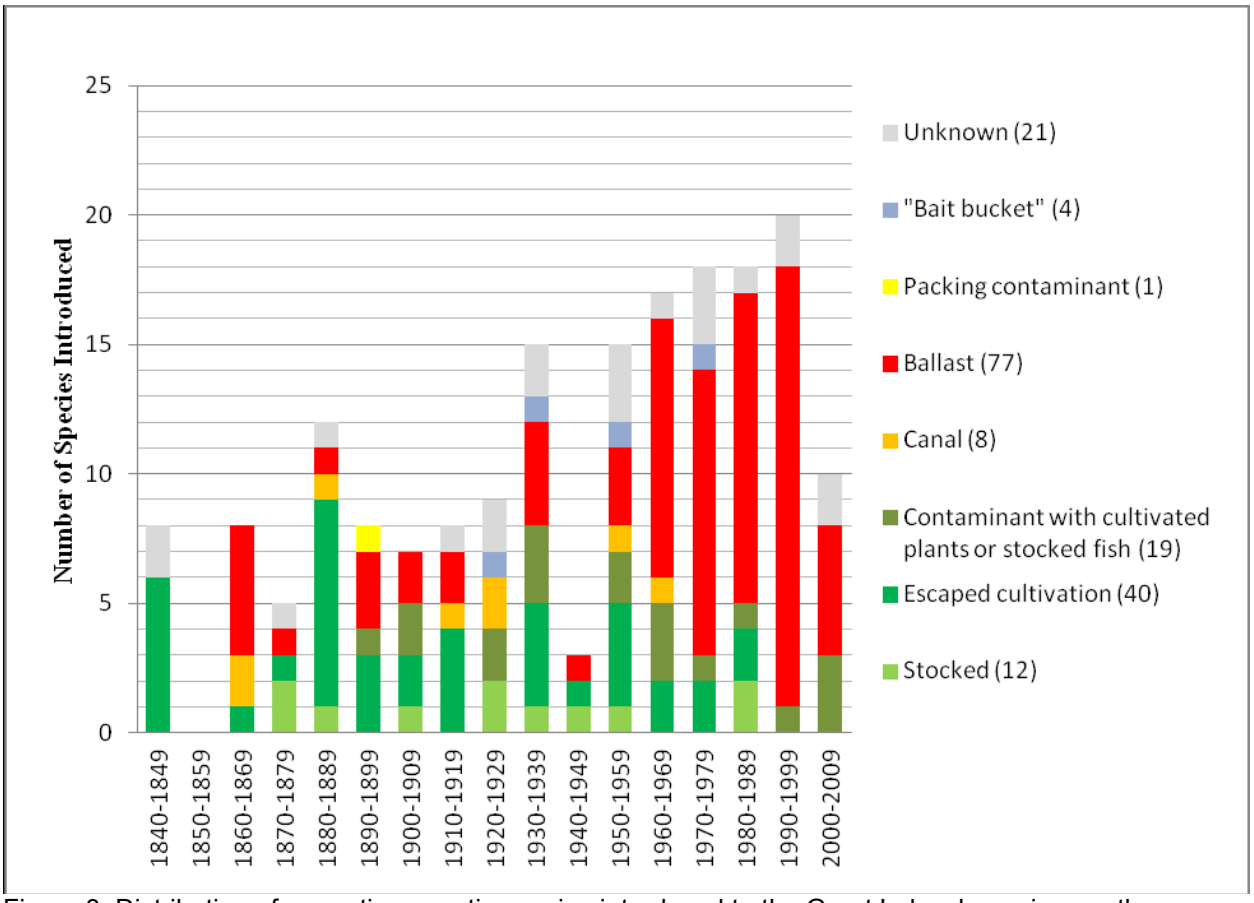

Figure 3. Distribution of nonnative aquatic species introduced to the Great Lakes by various pathways (Source GLANSIS).

In the sections that follow, each of the categories, vectors, and pathways are discussed. The narrative for each individual pathway consists of a problem description, the current status, and a set of broad objectives. Refer to Section 3, Implementation Table, for more detail on the specific strategic actions associated with each of the objectives.

2.2.1 Shipping and Boating

Maritime Commerce - Ballast Water

Problem Description

Ballast water is taken on board large vessels to provide stability and balance during a voyage and during the loading/unloading of cargo. Oceangoing vessels (also known as Salties) that transit the Great Lakes through the St. Lawrence Seaway have the potential to introduce new AIS to the Great Lakes basin when ballast water contaminated with AIS taken on board from another region is discharged. Conservatively, 55% of the nonindigenous species that established populations in the Great Lakes during the period following expansion of the St. Lawrence Seaway (from 1959 onward) are attributed to ballast water release (Kelly et al. 2009), although this number could be as high as 70% (Holeck et al. 2004).

The National Biological Invasion Shipping Study (Reid and Carlton 1997) reported a total annual foreign ballast water discharge into the Great Lakes of 1,395,461 metric tons in 1991. The number of oceangoing vessel arrivals to the Great Lakes basin and the number of metric tons of ballast water

discharged is expected to increase in the future given the increase in world trade and a concomitantly growing global shipping fleet that consists of larger and faster vessels (National Research Council 2011).

Ballast water is typically drawn into tanks from surrounding port water without treatment and routinely contains diverse organism assemblages, from viruses and bacteria to macroinvertebrates and fish. There is tremendous temporal and spatial variation in the concentration of organisms present in a ship's unexchanged ballast water with numbers as high as 300 million cysts of dinoflagellates in a single tank (Hallengraeff and Bolch 1992).

United States Geological Survey (USCG) regulations requiring vessels to exchange low-salinity or coastal ballast water for midocean saltwater were put into place for the Great Lakes in 1993. In 2005 vessels declaring no ballast on board (NOBOB) were encouraged by the USCG to conduct saltwater flushing prior to entering the Great Lakes. Since NOBOB vessels carry residual ballast water and sediments that have the potential to harbor invasive species, flushing was seen as a means of reducing the threat of new introductions. In 2008 the St. Lawrence Seaway Development Corporation made flushing a requirement for all NOBOB vessels.

Over 90% of the vessels entering the Great Lakes are NOBOB (Grigorovich et al. 2003). While ballast water exchange and saltwater flushing practices have a strong effect in reducing organisms in uptake ballast water, residual biota are still present in exchanged/flushed ballast water tanks and some may be resistant to high salinity.

Background and Current Status

Considerable regulatory activity at the international, national, and state levels is underway to require treatment of ballast water prior to discharge to meet an established standard for the concentration of living organisms. This activity is summarized below. Research regarding ballast water treatment efficacy and standard monitoring protocols is ongoing; however, additional technical knowledge to support regulatory activities is needed (e.g., testing methods).

International

Ballast water management was brought to the attention of the International Maritime Organization (IMO) in 1988 by the Canadian government in a joint report submitted by the IJC and the GLFC. In 1993 the IMO requested that all Member States (i.e., countries) implement voluntary guidelines based on the Canadian ballast water management guidelines, which were revised by the Marine Environmental Protection Committee and then formally adopted in 1997 as Assembly Resolution A 868(20). The Resolution also requested the committee to work towards completion of a legally binding convention and guidelines for uniform implementation.

For six years (1998-2003), the United States, an interagency effort lead by the USCG, played a lead role in the development of the IMO's International Convention for the Control and Management of Ships' Ballast Water and Sediments (Convention). The Convention was adopted at the International Conference on Ballast Water Management for Ships in February 2004. The Convention establishes two standards, D-1 and D-2, and a timetable for their implementation, pending ratification by at least 30 Member States representing 35% of the world's commercial shipping tonnage. D-1 is a ballast water exchange standard and D-2 sets maximum permissible limits on live organisms in ballast discharge based on size or taxonomic category. The Convention will enter into force 12 months after it has been ratified by 30 Member States, representing at least 35% of the world's merchant shipping tonnage. As of January 2, 2013, the Convention was ratified by 36 Member States representing 29% percent of the world's merchant shipping tonnage. As of publishing this SMP, the United States has not ratified the Convention, but Canada ratified in 2010.

Federal

The USCG, the St. Lawrence Seaway Development Corporation (a federal agency within the United States Department of Transportation [USDOT]), and the USEPA have requirements to reduce the effect of ballast water discharges to the Great Lakes. The USCG implements a national Ballast Water Management Program. Central to that program is a quantitative standard for the allowable concentration of living organisms in the ballast water discharged from ships in waters of the United States. There are also mandatory practices for all vessels operating in the waters of the United States. These include avoiding or minimizing ballast water uptake in specific areas, discharging minimal amounts of ballast water in coastal and internal areas, maintaining a ballast water management plan, requiring ballast water exchange for certain oceangoing vessels, and training vessel personnel on appropriate ballast water management procedures.

The St. Lawrence Seaway Development Corporation, in partnership with their Canadian counterparts in the St. Lawrence Seaway Management Corporation, require oceangoing vessels to comply with ballast water management practices from the Shipping Federation of Canada, including ballast water exchange procedures, enforced through USCG regulations. In addition, Lakers (i.e., vessels that operate entirely within the Great Lakes) are required to comply with management practices provided by the Lake Carriers' Association and the Canadian Shipowners' Association.

The USEPA regulates ballast water discharges under the National Pollutant Discharge Elimination System (NPDES) Program, usually through the Vessel General Permit (VGP). Implementation of the VGP for discharges incidental to the normal operation of vessels (including ballast water discharges) began in February 2009. In addition to generally reflecting USCG requirements, the VGP requires that all NOBOB vessels entering any United States waters from outside the United States Exclusive Economic Zone conduct saltwater flushing and that all vessel discharges must be controlled as necessary to meet any applicable water quality standards.

In 2009 Michigan, along with several environmental organizations, challenged the USEPA VGP arguing that the USEPA failed to regulate ballast water discharges in a manner that satisfies Michigan Water Quality Standards and protects the Great Lakes from AIS. Through negotiations with the USEPA, a settlement agreement was reached in May 2011 that outlines a process for the USEPA to establish common protective standards for ballast water discharges to United States waters. The next draft permit was released on November 30, 2011. A final permit is expected on or by March 15, 2013.

The USEPA's VGP was also challenged in May 2009 by the Lake Carriers' Association, Canadian Shipowners Association, and American Waterways Operators based on three claims: (1) they contended that the USEPA erred in failing to provide notice and an opportunity for comment on the final VGP, which contained the states' Section 401 Water Quality Certification conditions; (2) they charged that it was arbitrary and capricious for the USEPA to issue the VGP without considering the ill-effects of the state certification conditions; and (3) they alleged that the USEPA failed to consider the costs of compliance with the state certification conditions in assessing the effect of the VGP on small businesses. The states of Michigan and New York filed an amicus brief in support of the USEPA on those issues. In July 2011 the United States Court of Appeals for the District of Columbia Circuit Court issued its opinion denying the petitions for review filed by the various shipping interests. The court held that the USEPA was legally required to incorporate the states certification conditions into the VGP.

Vessels of the United States Armed Forces are exempt from the USCG's Ballast Water Management Program and the VGP's requirements. The various branches of the Armed Forces have their own policies and management practices regarding ballast water, mostly based on IMO guidelines. Recreational vessels are not regulated under the VGP; however, Congress passed the Clean Boating Act in 2008 as an amendment to the CWA. The Clean Boating Act requires the USEPA to identify discharges incidental to the normal operation of recreational vessels, which may include the discharge of AIS, for which management practices are reasonable and practicable to develop. At this time, the USEPA has not proposed regulations under this act.

State

In 2001 Michigan legislation was passed requiring the MDEQ to determine annually whether ballast water management practices are being complied with by all vessels operating on the Great Lakes and the St. Lawrence Seaway. Oceangoing vessels are required to report compliance with the Code of Best Management Practices for Ballast Water Management developed by the Shipping Federation of Canada. Nonoceangoing vessels (Lakers) are required to report compliance with a set of voluntary best management practices (BMP) developed by the Lake Carriers Association and the Canadian Shipowners Association. A list of the ships reporting compliance with the voluntary BMPs is maintained on the MDEQ's Internet site (www.michigan.gov/deqballastwaterprogram). In 2010 over 246 vessels complied with the MDEQ reporting requirements.

In June 2005 Michigan legislation was signed establishing the requirement for a ballast water discharge permit for oceangoing vessels operating in Michigan ports. This legislation does not address Lakers. Michigan's Ballast Water Control General Permit for Port Operations and Ballast Water Discharge (MIG140000) was issued in October 2006 and became effective on January 1, 2007. This General Permit requires oceangoing vessels to use one of four approved ballast water treatments, or an alternative treatment based on an effectiveness demonstration to the MDEQ, to prevent the discharge of AIS during port operations or to certify that they are not discharging ballast water. Certificates of Coverage are issued under the General Permit to individual permittees and can be renewed yearly. As of December 2011, a total of 212 Certificates of Coverage had been issued to vessels under the General Permit by the MDEQ since 2007.

Michigan's first ballast water control general permit expired on January 1, 2012. The MDEQ reissued this General Permit on March 9, 2012, with minimal changes to ensure that any ballast water discharges from oceangoing vessels that occur before the USEPA issues its next VGP receive treatment to prevent AIS. If the USEPA's next VGP contains appropriate ballast water discharge limitations and other controls to sufficiently prevent AIS introductions to the Great Lakes, then the MDEQ will rescind its general permit when the next VGP becomes effective. If the next VGP is issued by the USEPA on March 15, 2013, without environmentally protective ballast water discharge limitations/conditions, then the MDEQ may elect to modify its general permit at that time to include numeric concentration-based ballast water discharge limitations for live organisms and/or update the ballast water treatment methods section of the permit.

Minnesota and Wisconsin also have specific state laws and regulations establishing ballast water discharge standards or management programs. Other Great Lakes states without such specific ballast water laws and regulations that have established ballast water standards or other controls as part of their CWA Section 401 Water Quality Certifications of the VGP include: Illinois, Indiana, New York, Ohio, and Pennsylvania.

Legislation creating a new Michigan AIS Advisory Council (Part 414 of the NREPA) was passed and made effective immediately on December 21, 2011. The AIS Advisory Council is composed of a wide variety of members representing diverse interests and was tasked with providing recommendations on Michigan's Section 401 Water Quality Certification of the VGP. AIS Advisory Council recommendations are to be suitable for collaboration with other Great Lakes states and Canadian provinces. Recommendations regarding Michigan's Section 401 Water Quality Certification of the VGP were submitted to the MDEQ's WRD on June 25, 2012, and changes were incorporated into the final certification, which was submitted to the USEPA on September 27, 2012. For additional information on Michigan's AIS Advisory Council see www.michigan.gov/aquaticinvasives

The objectives and strategic actions that apply to Goals I and II: Prevent new AIS introductions and limit the dispersal of AIS via maritime commerce-ballast water are presented in Section 3, Implementation Table.

Maritime Commerce – Hull, Anchor, and Superstructure Fouling

Problem Description

AIS, such as snails, mussels, sponges, algae, and other organisms, can be introduced to and dispersed around Great Lakes waters by attaching to hulls, anchors, and other exterior surfaces, fouling oceangoing shipping vessels, Lakers, barges, or other vessels. Sea-chest grating, a rectangular recess in the hull of a vessel that provides an intake reservoir from which piping systems draw raw water, have been identified as hot-spots for biofouling (Sylvester and MacIsaac 2010). Once a vessel is at port, the organisms can release their larvae into the water or attach themselves to port infrastructure (Smithsonian Environmental Research Center 2004). Foreign organisms attached to exterior surfaces can also be dislodged and released when a ship is being cleaned, is in dry dock for repairs or painting, and when vessels are tied dockside (due to rubbing against the dock).

Current Status

Recent research has investigated the potential risk of hull fouling as a pathway of AIS. Drake and Lodge (2007) quantified the risks of hull fouling in Lake Ontario and demonstrated that biofouling represents a potential risk for species introduction in freshwater lakes, although the degree of fouling per vessel is variable, based on environmental conditions and other factors. Sylvester and MacIsaac (2010) investigated the composition of the invertebrate community from exterior scrapings of 20 oceangoing vessels entering the Great Lakes and concluded that hull fouling appears to pose a low risk of introductions of new species capable of surviving in the Great Lakes compared to ballast water discharges. Although one individual of a freshwater worm not yet reported in the Great Lakes and many marine organisms were found during the Sylvester and MacIsaac study. Metal hulls and antifouling paints are used on many vessels as an AIS deterrent. Compounds used in the past pose problems due to harmful effects to ambient water quality. The development of alternative antifouling systems that are effective and safe is currently underway, but still poses a challenge.

Prevention of AIS introduction and dispersal via hull, anchor, and superstructure fouling is included in some federal regulations. For example, the USEPA's VGP includes requirements to minimize the introduction of AIS from chain locker effluent and underwater ship husbandry discharges (i.e., hull cleaning). The introduction and dispersal of AIS via hull, anchor, and superstructure fouling is also covered generically under Section 324.3109 of Part 31, Water Resources Protection, of the NREPA, which reads as follows: (1) A person shall not directly or indirectly discharge into the waters of the state a substance that is or may become injurious to any of the following: (a) to the public health, safety, or welfare; (b) to domestic, commercial, industrial, agricultural, recreational, or other uses that are being made or may be made of such waters; (c) to the value or utility of riparian lands; (d) to livestock, wild animals, birds, fish, aquatic life, or plants or to their growth or propagation; and (e) to the value of fish and game. At this time there are no Michigan specific rules or permit requirements pertaining to hull, anchor, and superstructure fouling of commercial vessels.

The objectives and strategic actions that apply to Goals I and II: Prevent new AIS introductions and limit the dispersal of AIS via maritime commerce-hull, anchor, and superstructure fouling are presented in Section 3, Implementation Table.

Water Recreation (includes boating, fishing, and other recreational equipment)

Problem Description

One of Michigan's greatest natural assets is the abundance of water resources available throughout the state. Bordering 4 Great Lakes, 35,000 miles of navigable streams, more than 11,000 inland lakes greater than 5 acres, and thousands of square miles of wetlands, water-related recreation opportunities in Michigan are vast. Water-related recreation includes boating (via speedboat, pontoon, rowboat, canoe,

kayak, jet ski, ferries, etc.), fishing, swimming, diving, snorkeling, rafting/tubing, wildlife watching, and hunting.

This myriad of water resources and recreational activities provides jobs and money through tourism; unfortunately, they also allow for the movement of AIS to occur quickly and aggressively. AIS can be dispersed with the movement of equipment (e.g., boats and trailers) from one body of water to another.

Recreational boating and other related activities can have the ability to disperse AIS by:

- Dispensing boat live wells or bilge water into bodies of water.
- Inadequate drying or disinfecting live wells.
- Inadequate cleaning of exterior components of watercraft, trailers, fish lines, water apparel, and downrigger cables.
- Transporting and dumping bait fish (i.e., infected fish, species introduction, etc.).

Angling and other recreational equipment can also be a vector for AIS movement. For example, the dispersal of *Didymosphenia geminata* has been linked to the use of felt soled waders. This invasive algae, commonly known as didymo or rock snot, multiplies rapidly and forms dense mats that affects stream habitat and can clog water intakes and pipes. Other AIS, like spiny waterfleas can be spread between waters on fish lines and downrigger cables.

Preventative measures can limit the dispersal of AIS. Information and education is available to assist boaters and anglers on proper equipment cleaning techniques. Oftentimes the preventative measures to help facilitate control occur after the introduction of an AIS. Even in areas where information about current laws and preventative measures are readily available to all water users, noncompliance remains an issue.

Current Status

Congress passed the Clean Boating Act in 2008 as an amendment to the CWA. The Clean Boating Act requires the USEPA to identify discharges incidental to the normal operation of recreational vessels, which may include the discharge of AIS, for which management practices are reasonable and practicable to develop. At this time, the USEPA has not proposed regulations under this act.

The transportation of inspection and cleaning of equipment is of paramount importance to prevent the transport of AIS between bodies of water. Placing a boat, boating equipment, or boat trailer in Michigan's water when an aquatic plant is attached is considered a civil infraction under Chapter 324, Section 41325, of the NREPA. This law does not regulate boat washing or the removal of any aquatic animals, parasites, or microorganisms from boating equipment, nor does it include nonboating water-related recreational equipment, such as fishing waders.

Fisheries Order 245 requires that a boat being transported over land be drained of all water contained in the live wells and bilge upon leaving a body of water. This order prevents the dispersal of aquatic organisms through water contained in the live well or bilge and needs additional enforcement to increase its effectiveness.

These rules allow the state to have some enforcement capacity in the dispersal of AIS; however, there has been little to no documentation filed on the effectiveness of these two measures. Instead, the State of Michigan has worked with other agencies to establish volunteer organizations and provide educational materials on AIS awareness.

The Clean Boats, Clean Waters program is an opportunity for volunteers to help stop the dispersal of AIS across the state. Volunteers play an important role in preservation and protection of Michigan waters and are the key to reaching hundreds of recreational users. The mission of the Clean Boats, Clean Waters program is to promote water resource protection by actively involving individuals in preventing the dispersal of harmful AIS. The Clean Boats, Clean Waters program is sponsored by Michigan Sea Grant

and is adapted from the Wisconsin Department of Natural Resources' program. Statewide training workshops are held and resource handbooks, tool kits, and educational information are available. Through this program, volunteers are trained to organize and conduct watercraft inspection demonstrations and education programs in their communities.

In addition to preventing the dispersal of AIS, volunteers who participate in the Clean Boats, Clean Waters program have the opportunity to serve as a reporting and monitoring mechanism. Clean Boats, Clean Waters volunteers collect information from boaters regarding the lakes they visit frequently. When AIS are discovered on a boat or boating equipment, volunteers are instructed to take a sample and send it in to the nearest Sea Grant office for verification. This information could facilitate EDRR of newly discovered AIS in a body of water. Similar programs exist in other Great Lakes states creating a network of volunteers.

The MDNR also administers over 1,000 developed boat launches in 82 of the 83 counties in Michigan. The MDNR also maintains 17 harbor facilities and provides development funds for 67 marinas across the state. The MDNR has also funded other boating and aquatic recreation-related projects with local communities through state and federal grant programs. Development of these facilities is funded by the constitutionally protected Waterways Fund from the NREPA. Waterways Funds derive primarily from watercraft registrations (51% of total registrations) and the gas tax (1.7% of total marine and land). These funds are the primary source of revenue for infrastructure development and replacement for waterways facilities.

Recent changes (December 16, 2010) of the previous statute, MCL 324.78110, have further restricted activities eligible for Waterways Funds. Activities funded by the Waterways Fund do not include boat washing stations, disinfectant stations, AIS control, and weed control outside of managing navigation lanes.

With restrictions in the use of Waterways Funds and the level of current staffing to maintain these sites, the MDNR is looking at other options for preventing and limiting the dispersal of AIS. While state efforts towards preventing AIS dispersal at launch facilities are limited, many nonprofit organizations have been available to provide boat washing stations or AIS control.

The MDNR's PRD may enter into an agreement with local nonprofit organizations for the purpose of allowing boat washing opportunities at state access sites. It is recognized by the PRD that boat washing alone will not keep AIS from entering a watershed and priority is placed in the effort for educating the boating public on values of controlling the dispersal of AIS. The organization is responsible for the maintenance and operation of the boat washing facility. Participation in boat washing is not mandated, nor can the organization responsible for operating the site require a boat operator to participate in the activity.

In addition to an MDNR Use Permit, all discharges of wastewater to surface waters of the state are prohibited unless authorized by an NPDES permit. Persons/organizations wishing to operate a boat wash station may need to obtain an NPDES permit from the MDEQ, depending on site-specific conditions. Authorization via an NPDES permit may include effluent limitations, monitoring requirements, and associated fees.

The objectives and strategic actions that apply to Goals I and II: Prevent new AIS introductions and limit the dispersal of AIS via water recreation are presented in Section 3, Implementation Table.

Research and Monitoring Activities

Problem Description

Federal and state agencies, Tribes, universities, NGOs, volunteer groups, and contractors use field assessments to collect information on the status of water quality, biological communities, and aquatic habitats. Large and small vessel surveys use sampling equipment such as gill nets, trawls, trap nets,

water quality testing equipment, and scuba gear or they employ onboard or in-water remote sensing equipment to collect information. Equipment, including boats, used in multiple aquatic environments within the state or across state lines could result in the introduction and dispersal of AIS from one area to another if equipment is not properly decontaminated (Olson et al. 2000).

Research, testing, and educational facilities may introduce or disperse AIS through specimen shipment or disposal. A shipment may also contain unwanted hidden organisms within the packaging or holding water. Improper disposal of such packaging material may inadvertently introduce or disperse AIS, especially microscopic organisms, into the local ecosystem. Discarded, unpreserved research samples also pose a threat if proper laboratory protocol is not followed to ensure live samples are not released into the environment.

Current Status

In response to growing issues with fish pathogens, most recently VHS, the MDNR's FD includes requirements for collecting, transporting, and holding live fish from the wild in scientific or cultural collector's permits. These requirements include equipment disinfection and disposal of fish and water procedures. Collector's permits are issued to other federal and state agencies, Tribes, consultants, universities, and any other entity desiring to take, catch, or kill and possess aquatic species.

Each state agency may have its own policies or procedures and staff training to prevent the introduction and dispersal of AIS. For example, the MDEQ's WRD has a policy for aquatic survey equipment disinfection for staff and their contractors and grantees to prevent the dispersal of VHS and other AIS. Equipment cleaning techniques are included as part of annual prefield season training for WRD staff conducting montoring activities. Addtionally, the MDNR's FD has an ANS control policy and disinfection protocols for field surveys, which is part of the the Manual of Fisheries Survey Methods II (Hilt 2000).

Minnesota Sea Grant, in partnership with other Sea Grant programs in Michigan, Illinois-Indiana, Ohio, New York, Pennsylvania, and Wisconsin developed the AIS-Hazard Analysis and Critical Control Point (HACCP) Program (Minnesota Sea Grant 2011). AIS-HACCP is a self-inspection system for reducing the risk of dispersing AIS through aquaculture, hatchery, scientific, natural resource, and baitfish harvesting activities. This education and training program has been applied to research, monitoring, and assessment operations throughout the Great Lakes basin to help staff prevent AIS contamination or release.

Implementation of an AIS-HACCP program in Michigan has been focused on private aquaculture and baitfish industry personnel as well as MDNR and other state and federal resource agency personnel and Tribal staff. Recent activities have focused on preventing the dispersal of VHS, and a series of Biosecurity/AIS-HACCP Workshops have been conducted in the region (Gunderson and Kinnunen 2002; Gunderson and Kinnunen 2004).

The objectives and strategic actions that apply to Goals I and II: Prevent new AIS introductions and limit the dispersal of AIS via research and monitoring activities are presented in Section 3, Implementation Table.

2.2.2 Habitat Alteration

Habitat Modification and Restoration

Problem Description

There are many different types of projects that include modification or restoration of aquatic habitats that may also lead to the introduction or dispersal of AIS. The most common project types are listed below; however, there may be others that are not covered here.

Dredging

Dredging projects occur throughout the Great Lakes and many inland lakes, streams, and wetlands in Michigan. These projects are often necessary in order to maintain accessibility within existing navigation channels or canals, or for the creation of new access channels and canals. AIS can be introduced or dispersed on dredging equipment, carried in dredge spoils, or by being mixed into the moving water column during the dredge operation. Dredge spoils, which may contain plant material and insect or animal species, may be used as offsite fill material in some cases and can be a source for introduction of AIS into adjacent wetlands or water bodies.

Federal governmental agencies in both the United States and Canada conduct very large-scale dredging projects to maintain navigability in the Great Lakes and connecting waters and for maintenance of harbors and navigation aides. These projects include dredging of a significant volume of sediment, but there are only a few agencies conducting these projects and the number of sites is limited. Funding limitations in the United States has caused a recent reduction in the number of navigation channels and harbors annually dredged by the federal government.

Private and commercial small-scale dredging projects are much more common throughout the Great Lakes and within tributary watersheds. Although these projects are smaller, this may be a more significant vector for AIS introduction or dispersal than the larger federal projects due to the more widespread activity throughout the basin, and due to the use of the same privately owned dredge equipment that is used and transported between many water bodies and many sites throughout the region or state. The construction of new connecting channels or canals between inland lakes can also lead to the dispersal of AIS from one water body to another through the dredging itself or simply by connecting the two habitats.

Development

Development projects often require fill within wetlands, and may also include road crossings of streams or wetlands with side slope fill throughout the state. These projects are conducted by private developers, although various transportation and utility agencies also undertake these types of activities. Some of these fill effects are temporary, such as construction access roads, construction pads, culverts or bridges, sediment traps or ponds; although, some fill for development purposes is permanent. Temporary fill that is removed can result in the introduction or dispersal of invasive species by eliminating the native plant species and native animal habitat conditions, increasing turbidity and salinity in the vicinity of the temporary fill area, and by the use of nonnative plant species for stabilization of the fill.

Storm water runoff over fill areas can create a source of sedimentation within the adjacent wetland or water body, which is an ideal site for invasive plant introduction. Invasive plant species often thrive on the fine silt and saline sediments that begin to accumulate within wetlands adjacent to fill slopes, temporary or permanent. Development sites also often use fertilizers or pesticides that can infiltrate the fill, or sheet flow down slope into adjacent wetlands or water bodies. Many native plant and animal species are not well adapted to live in an environment with high nutrients or pesticides such as these, and invasive species can out-compete the native species in these areas.

Storm water discharge outlets can also facilitate the dispersal of AIS. These outlets can be constructed and maintained by a variety of entities including governmental, private, commercial, and industrial. Storm water outlets increase nutrients and salinity into the aquatic habitats, cause sediment and silt accumulation, increase the water temperature, and alter the natural hydrology of the ecosystem. All of these factors can lead to the loss of native species and produce ideal conditions for the introduction or dispersal of AIS.

Shoreline stabilization projects and construction of ornamental ponds and other landscaping features can also modify natural habitat areas leading to the introduction or dispersal of AIS. Most of these projects are conducted by individual landowners or property management agencies, although commercial facilities and governmental agencies also conduct some of these activities. Shoreline stabilization utilizing

bioengineering methods are a growing design trend and are ecologically preferable to seawalls and rock riprap, but the plantings used to stabilize these projects are not always native species. If landowners use nonnative species, these plants can escape into the natural environment. Ornamental ponds and other landscaping features can introduce invasive species to adjacent habitats through escape or overland dispersal. Fish can move through outlet channels or over land into adjacent streams during flood events, and plants can disperse overland through roots and rhizomes or through seed dispersal. Also, these landscaping techniques often use fertilizers or other chemicals that can enter adjacent water bodies altering the natural habitat in a way that makes it more vulnerable to the introduction or dispersal of AIS.

Water Level Control

Water level control structures and augmentation wells on inland lakes and streams can be significant factors that influence the introduction and dispersal of AIS. Water level control and augmentation wells are typically managed under lake level laws or court orders by private landowners, though many dams are managed by public or governmental agencies, particularly county drain commissioners. Water levels may be managed to maintain desired recreational uses or aesthetic qualities, or with the direct intent of controlling invasive or nuisance species. Prevention of natural annual water level fluctuation can severely degrade habitat conditions for native plants and animals, and can even eliminate appropriate habitat for some species altogether. Stable water levels can increase temperature; alter natural nutrient cycling; diminish critical nesting, spawning, and cover habitat; and provide ideal conditions for many AIS that are better adapted to this type of environment. Resource managers for state and federal agencies and private companies often use dykes and water level control structures on managed wildlife habitat areas and on wetland restoration projects to improve wetland or waterbird habitat. Intentional manipulation of water levels can be used to manage against invasive species, but many times the management goals of a specific site are targeted for a specific species, and the result is stable water levels and increased invasive plants or animals other than the targeted species.

Dam Removals

Dam or other barrier removal projects on inland streams are often proposed as a means to restore natural stream function, habitat connectivity, and fishery values. However, many dams are currently serving as upstream (i.e., further inland) barriers to the movement of AIS, particularly fish species. Because dam removal projects have the potential to significantly alter the chemical, physical, and biological characteristics of the stream as well as the potential to pass AIS, pathogens, and chemical contaminants, these projects require detailed site-specific evaluation of the positive and negative effects of the dam removal.

Management of Nuisance Aquatic Plants and Algae

In addition to changes to physical aspects of aquatic habitat, there are biological components that may be altered. Aquatic plant communities are manipulated each year in thousands of lakes and ponds across the state through ongoing management efforts to control the growth of nuisance macrophyte and algae growth. “Nuisance” growth may include both native and nonnative species that can affect swimming, fishing, and other recreational uses, water access, aesthetics, and biodiversity. AIS may be introduced or dispersed in two ways: through improperly sited practices (e.g., harvesting in lakes that contain aquatic plants that disperse through fragmentation), and the frequent movement of contaminated lake management equipment (e.g., boats, harvesters, trailers, cutters, hoses, spreaders, and hoppers) between water bodies. For additional information on the management of AIS see Section 2.4, Goal IV.

<u>Current Status</u>

The State of Michigan issues permits for construction activities such as dredging, filling, water level control, storm water discharge, shoreline stabilization projects, and construction of ponds within 500 feet of a lake or stream or 1000 feet of the Great Lakes. These activities are regulated by several statutes within the NREPA (see below for a list of applicable statutes). Michigan has authority to administer Section 404 of the CWA in most areas of the state, and this program review is administered through the

same regulatory review process as the NREPA process. The state also administers the certification process of Section 401 of the CWA through the NREPA review process as some federal dredging projects do not require permits under the NREPA and therefore receive Section 401 review and certification separately. Permits issued by the state for habitat modification activities in lakes, streams, wetlands, or the Great Lakes include specific conditions to ensure projects use BMPs.

The United States Army Corps of Engineers (USACE) also has federal jurisdiction over specific navigable waters including the Great Lakes, connecting channels, other waters connected to the Great Lakes where navigational conditions are maintained, and wetlands directly adjacent to these waters. The USACE requires field staff and contractors to follow BMPs aimed at stopping the introduction and dispersal of AIS.

Local agencies including counties, cities, townships, and other municipalities may administer ordinances and other permits for construction activities, habitat modification and restoration activities, and soil erosion control measures. The soil erosion and sedimentation control programs are commonly administered by the counties, authorized by the State of Michigan.

Local units of government conduct certain lake management activities under several authorities. The formation of lake improvement boards is set forth by Part 309, Inland Lake Improvements, of the NREPA. Under the Township Special Assessment Act (PA 188 of 1954, as amended), townships may create special assessment districts, including the levying of assessments of benefitting properties, to direct improvement of lakes. This may include installation of sewers, construction of outlet control structures, or macrophyte management.

Individual landowners with property adjacent to waters of the state have certain riparian rights and have the legal authority to make modifications to the property or bottomland under their control, sometimes (but not always) subject to government approval. See www.michigan.gov/deqwater for additional information.

The objectives and strategic actions that apply to Goals I and II: Prevent new AIS introductions and limit the dispersal of AIS via habitat modification and restoration are presented in Section 3, Implementation Table.

Canals, Lift Locks, and St. Marys River Compensating Works

Problem Description

Canals are man-made waterways used for transporting goods, commodities, and people between water bodies. Some canals connect previously separated water bodies, while others were created on natural waterways to improve the passage for ships (e.g., channelization and deepening of rivers). Most canals provide recreational activities and serve other important roles. Lift locks are found on many major canal systems and provide a mechanism for transporting boats between waterways having different water levels, typically around impassible boating waters. Canals and locks can be a mechanism for facilitating the introduction and dispersal of AIS along and between waterways because they may provide artificial connections across previously unconnected basins.

Several prominent canals and lift locks exist throughout the Great Lakes basin. Though not all are located within the State of Michigan, each affects the quality of our waters by providing a pathway for new species. The Erie Canal, opened in 1825, runs east-west across the State of New York and connects the Atlantic Ocean-bound Hudson River near Albany, New York, to the Buffalo River and Lake Erie. It played an important economic and cultural role in the westward expansion across the State of New York. However, the Erie Canal is believed to have facilitated the movement of Sea lamprey from the Atlantic coastal drainages into inland waters.

The Welland Canal connects Lake Ontario and Lake Erie across the Province of Ontario, Canada. Constructed in various segments since the 1820s, the canal forms an important link in the St. Lawrence Seaway, allowing ships to bypass Niagara Falls. Subsequent improvements made to the Welland Canal and other portions of the St. Lawrence Seaway have facilitated the movement of oceangoing ships to and

from the Great Lakes. The canal and associated lift locks have also facilitated the dispersal of the Sea lamprey and other species from Lake Ontario into the other Great Lakes.

In 1855 lift locks were first constructed at Sault Ste. Marie, Michigan, to allow vessels to bypass the 21-foot drop at the St. Marys River rapids and travel between Lake Superior and the lower Great Lakes. Development of navigation and hydropower infrastructure has removed most of the St. Marys River rapids, and since the early 1900s, has prevented the free flow of water and thus free movement of fish between Lake Huron and Lake Superior. Fish and other aquatic species now only gain access to Lake Superior by swimming under an open compensating gate at the head of the rapids (water velocities are too strong for most fish to swim against them) or by accompanying a vessel through the "Soo Locks" as it is lifted up to Lake Superior.

The Portage Canal, or Portage Lake Canal, was dredged in the 1860s. It is part of the Keweenaw Waterway that bisects the Keweenaw Peninsula in Michigan's Upper Peninsula. Though a partially natural waterway, the man-made improvements and ongoing management of certain segments has created a more defined, artificial connection across the peninsula between the inland waters and Lake Superior on the east and west ends. It is likely that Eurasian ruffe used this pathway in its eastern expansion along the south shore of Lake Superior and increased its rate of invasion by doing so (USFWS 2007).

The Chicago Sanitary Ship Canal (CSSC) was completed in 1900 with the primary purpose of diverting sewage away from Lake Michigan, the source of Chicago's drinking water. It is now one component of the larger Chicago Area Waterways System (CAWS), which consists of 78 miles of canals and modified streams located within Cook County and surrounding counties. The CAWS serves important economic, recreational, and other roles for the region. However, this man-made system created an artificial hydrological connection between the Great Lakes and the Mississippi River basins and has led to the unintentional transfer of AIS between the two basins. For example, Zebra mussels have been exported out of the Great Lakes through this route and are now found throughout the Mississippi River basin. Other species found in the Mississippi River, most notably Asian carps, are on the doorstep of the Great Lakes and may be able to access the Great Lakes via CAWS. Considerable resources are being used to prevent the introduction and dispersal of Asian carps into the Great Lakes basin.

The compensating works in the St. Marys River at Sault Ste. Marie (Michigan and Ontario) consists of 16 gates that control outflow from Lake Superior into the St. Marys River rapids, allowing water to be diverted from the rapids to the 3 hydropower facilities (USACE 2006). Because the compensating works control water level and flow, the structures also affect natural water temperature variations and dissolved oxygen content. These changes to the water environment may increase AIS populations. The most notable example is the Sea lamprey. The St. Marys River is a significant source of Sea lampreys and can produce more Sea lampreys than all other Great Lakes tributaries combined attributable to the high quality Sea lamprey habitat.

Two to five of the compensating gates are always at least partially open to supply water to the remnant St. Marys River Rapids. During a period of flow measurements and gate operation testing in the 1980s to mid-1990s, all of the gates were open for significant periods of time. In 1997 USFWS Sea lamprey control staff monitoring a lamprey trap in the Big Carp River approximately 5 miles upriver from the rapids documented an 18-fold increase in the number of spawning phase adults captured, not including sterile male Sea lampreys that had been released in the lower river. It is thought that the increased flow in the rapids overwhelmed the discharge from the four hydropower facilities on the St. Marys River, where adult Sea lampreys are usually captured, and stimulated significantly more lamprey to swim up the rapids and migrate through the compensating gates. In 1997 the trap catch at the hydropower facilities was 40% of the usual catch in years when the gates were at normal settings (Lake Superior Binational Program 2010).

Current Status

Most of the major Great Lakes canal and lift lock systems, including the Erie Canal, Welland Canal, and CAWS, are not located within the State of Michigan and the state has no direct authority over management or operations. These systems are operated by a combination of various federal and state agencies and regional decision-making bodies. The USACE plays the lead role in many of the systems, including the CAWS, the Keweenaw Waterway, and the United States canal and lift lock system at Sault Ste. Marie. Currently in the CSSC, the USACE conducts numerous activities related to monitoring of Asian carp, including the operation and maintenance of the three electrical barriers, surveillance activities (e.g., environmental DNA), and rotenone applications. The IJC, through its Lake Superior Board of Control, has authority over water flow levels at the St. Marys River compensating works. Several hydropower facilities are located near the St. Marys River locks and are operated by private utilities and the USACE. The New York State Canal Corporation is responsible for the operation and maintenance of the Erie Canal. Movement of marine traffic through the Welland Canal is managed by the St. Lawrence Seaway Management Corporation, a Canadian not-for-profit corporation.

The State of Michigan participates in many binational and regional advisory bodies, including the Council of Great Lakes Governors, the IJC, the GLC, the GLFC, the GLRC, and the Asian Carp Regional Coordinating Committee. These groups have wide-ranging roles; however, in a general sense, they all strive to protect and restore the Great Lakes through coordinated planning and implementation of activities, including management, assessment, and communication. Each has identified AIS prevention and control as a major priority area for the Great Lakes, and has issued recommendations or position statements and/or conducted feasibility studies related to CSSC and CAWS.

In Michigan, several notable activities have occurred that bear particular relevance to the canal pathway. The state has cooperated with the GLFC, USFWS, and other partners to control and monitor populations of the Sea lamprey, which gained access to the Great Lakes through man-made canals. In 2010, driven by the potential for the expansion of Asian carps into the Great Lakes, the MDNR released its Asian Carps Management Plan. The Asian Carps Management Plan recommends strategic actions for prevention, communication, detection, assessment, and management of Asian carps in Michigan waters.

The objectives and strategic actions that apply to Goals I and II: Prevent new AIS introductions and limit the dispersal of AIS via canals, lift locks, and St. Marys River compensating works are presented in Section 3, Implementation Table.

Transportation Facilities

Problem Description

Transportation facilities, such as roadways, railways, and trail ways, have been identified by the State of Michigan as a pathway for the movement of AIS. Although this pathway is largely focused on terrestrial species, there are certain wetland facultative species that move along roadside ditches and other transportation corridors (e.g., invasive Phragmites). AIS that spread along roadways and other transportation corridors threaten public safety (e.g., fires, views, proper drainage, etc.) and ecological functions and values (e.g., biodiversity) along roadways and adjacent habitats.

In Michigan, there are over 120,000 miles of public roads and numerous railways and trail ways that offer pathways for AIS movement. MDOT has jurisdiction over 9,655 miles of road that make up the state trunkline system consisting of Michigan, Interstate, and United States routes. There are 90,208 miles of road under county jurisdiction and 21,247 miles that are owned and operated by cities and villages. Although the state trunkline system accounts for only 8.1% of centerline miles, it carries 53% of all traffic and 70% of commercial truck traffic.

For decades, MDOT has been working with the Federal Highway Administration, USDOT, county road commissions, and many other agencies to implement numerous laws and policies aimed at effective vegetation management, promotion of native plants and wildflowers, and control of invasive species in the

state's transportation corridors. Recently the spread of invasive Phragmites has become a significant threat to public safety and the ecological health of the roadsides throughout Michigan. In addition to invasive Phragmites, the State of Michigan remains vigilant in EDRR to new AIS recognizing that some roadside maintenance activities can inadvertently spread AIS very quickly throughout the state.

Current Status

Currently transportation agencies in Michigan operate under several state and federal laws and other guidance documents to ensure proper identification, management, and control of AIS. In addition to the activities outlined in Section 3, Implementation Table, transportation agencies operate under the following laws and policies:

- Federal Highway Administration guidance on invasive species, National Environmental Policy Act (NEPA) analysis, and funding requirements.
- USDOT guidance to state departments of transportation.
- MDOT's invasive species policy, background information, and current practices.
- MDOT's Roadside Vegetation Management Manual; a resource guide that includes AIS control strategies on roadsides.
- MDOT's Standard Specification Manual; a resource used for all contracts for all work activities and assists companies in bidding projects. The manual includes sections on excavation, soil bed preparation, planting specs, seed specs, maintenance, and other items in regards to the management of AIS.

Although transportation agencies take significant steps to stop the spread of AIS, there are still many actions that can improve construction and mowing practices. For example, continuing to develop AIS-specific BMPs for mowing and construction activities.

MDOT has an active and effective program to address invasive species, consistent with its mission statement and roadside operational goals. MDOT cooperates with other agencies in their control efforts to the extent that limited resources allow. Through public and private partnerships, transportation agencies can limit the introduction and spread of AIS via roadways.

Roadside Ditch AIS Management

Most of MDOT's management of invasive species or other problem plants is done by the use of herbicides. Herbicide applications are made by certified pesticide applicators as part of MDOT's roadside spray program. In addition to the required certification, the applicators receive annual training on topics such as chemicals, spray rates, plant species, and laws and regulations governing pesticides. MDOT also employs various cultural control methods such as mowing, timing, and cleaning of equipment to minimize the spread of invasive plants. Currently MDOT spends approximately $1.5 million on invasive Phragmites control and management in roadside ditches.

AIS Management at Construction Sites

In addition to maintenance activities, MDOT has been increasing attempts to control some of the plants during construction and final seeding of disturbed right-of-ways. Notes have been developed to either remove certain species as a construction activity, or to specify control measures and/or limit excavation activities to minimize the dispersal of AIS as a result of various earth disturbances.

The objectives and strategic actions that apply to Goals I and II: Prevent new AIS introductions and limit the dispersal of AIS via transportation facilities are presented in Section 3, Implementation Table.

2.2.3 Use and Trade of Organisms

Organisms in Trade

Problem Description

Aquatic plants and animals that have been introduced through channels of trade pose a significant threat to Michigan waters. For the most part, these OIT have been obtained deliberately, such as plants and animals popular for the aquarium, ornamental pond trade, or as culinary products. AIS can be introduced or dispersed into Michigan waters by the pet/aquaria and ornamental pond trade, or by aquaculture. Channels of trade include traditional sales to and through retail stores or markets, as well as increasing sales through the global internet marketplace.

AIS obtained through trade find their way into lakes and streams through a variety of pathways. Although well intentioned, uneducated consumers may purposefully release unwanted pets or plant species and associated pathogens, believing it is a humane action without knowing the damaging consequences to the environment. Each year, the MDNR's FD receives reports of various species of piranhas, Pacus, and other aquarium fish, usually from Lake St. Clair, Muskegon Lake, and Lake Erie with less frequent reports from inland waters (Gary Whelan, MDNR, FD, personal communication). An example of aquarium origin pathogens being introduced is *Heterosporis* sp., a microsporidan parasite that causes extensive muscle damage, which likely came from a Southeast Asian ornamental fish released into Great Lakes basin waters. Release may be through direct disposal of organisms to lakes and streams or through aquarium water disposal into the storm sewer system.

The live food fish industry also poses a risk of introducing AIS into Michigan waters through the improper disposal of shipping material containing AIS and through consumers that may release live fish purchased at food markets directly into water bodies for cultural or spiritual reasons. For example, it is possible that Asian carps may be introduced through the cultural practice of prayer animal release (Severinghaus and Chi 1999). Aquaculture can lead to unwanted introductions of AIS since cultured species are usually not native to the area or waters in which they are being raised or bred. This can occur by escapement from poorly secured facilities, illegal releases, or from inundation by flooding of facilities but is undocumented in Michigan waters. Unintentional escape of AIS can occur from water gardens via seed dispersal by wind, water, animals, or humans or via overflow (e.g., flood event) from a pond into the nearest natural body of water.

AIS can also be distributed unintentionally and unknowingly through sales of aquatic species as contaminant species associated with legitimately sold species, or through misidentification and unfamiliarity with a given species common or scientific name. Contaminant species may be fragments of a similar plant species, snails, minute invertebrates, fish, and amphibians or may be parasites or disease organisms. AIS as contaminants come in both macroscopic and microscopic forms. Macroscopic forms include common species such as Water hyacinth. Microscopic forms can include algae and cyanobacteria that may cause algal blooms when environmental conditions are ideal for rapid population growth. A study conducted in Minnesota showed that almost 93% of plant orders contained unwanted plants, seeds, mosses, fungi, snails, or fish (Maki and Galatowitsch 2004). Ten percent of the orders in the study included regulated aquatic invasive plant species, including Hydrilla, Giant salvinia, Curly-leafed pondweed, and Purple loosestrife. With the United States water garden industry valued at $1 billion annually, the potential for movement of regulated species is tremendous.

Plants and seeds that are known to be AIS may be purchased for the purpose of habitat restoration either through retail stores or the internet. Thus, AIS may be purchased and planted either intentionally or unintentionally.

There continues to be purposeful underground movement of exotic species, including AIS, for private collections and cultural traditions. In addition to sales, distribution often occurs to friends, neighbors, and other members of gardening and aquarium clubs.

In the late 1990s USDA officials determined that the Internet had become a new pathway for sale of regulated organisms, through on-line auctions, Internet discussion, interest groups, and chat rooms (Suiter and Sferrazza 2007). This new method of trafficking in illegal plants and animals could lead to the introduction and dispersal of unwanted AIS into United States, Great Lakes, and Michigan waters.

Current Status

Amendments made to Part 413 of the NREPA (MCL 324.41301 *et seq*.) during the period of 2003 through 2009 established a list of prohibited and restricted AIS and thereby regulated the sale and possession of the listed species as prohibited and restricted species. These organisms include a number of species that were commonly sold in trade. The NREPA outlines responsibilities for the MDNR and the MDARD in enforcement of MCL 324.41301 *et seq*. in providing species descriptions.

Part 413 (MCL 324.41331) specifies that information on the regulated species and the requirements of the NREPA will be maintained on the MDNR and MDARD Web sites, although the details are limited and fail to address outreach and education. See Section 1.3.3, Policy Background, for more details regarding Part 413.

While the USDA regulates the interstate movement of regulated noxious weeds, including 19 species of aquatic/wetland species, that authority does not necessarily extend to enforcement within the boundaries of a particular state. Most enforcement is done through permits or working through grants and agreements. Under the Noxious Weed Control and Eradication Act of 2004 (7 U.S.C. 7781), the USDA may work with state governments and recognized weed management entities to control or eradicate federal noxious weeds, although funding has become limited in recent years.

The Michigan Aquaculture Development Act, 1996 PA 199 (MCL 286.871 *et seq.*), identifies that only certain species of fish and other aquatic organisms are approved for aquaculture production. Facilities are required to be registered with the MDARD. Section 29a (MCL 287.729a) of the Animal Industry Act, 1988 PA 466 (MCL 287.710 *et seq.*), also requires that aquaculture organisms brought into Michigan from another state must be accompanied by a fish disease inspection report. Organisms with clinical signs of disease may not be imported into Michigan and aquaculture organisms may not be imported from aquaculture facilities with a history of disease. MDARD authorities are restricted to registered aquaculture operations, which are considered to be agricultural entities under the Michigan Aquaculture Development Act and are thus protected under the Michigan Right to Farm Act. One area of weakness is the existence of mobile aquaculture outlets from out-of-state vendors that do not appear to be under any type of state regulation when they sell fish for private waters.

Part 459, Propagation of Game Fish in Private Waters, of the NREPA (MCL 324.45901 *et seq.*), provides oversight authority to the MDNR for the importation of game fish or eggs in Michigan without a permit, and this authority is a shared responsibility between the MDNR and MDARD depending upon the use of the fish for stocking or aquacultural production. Permits issued under this law can be conditioned to restrict the movement of incidental AIS into the state. Additionally, anyone stocking fish in public waters is required under the same act in MCL 324.48735 to obtain a permit from the MDNR for such actions. These fish stocking permits are conditioned to prevent AIS, in particular key pathogens, from being stocked in public waters. This authority is limited to public waters, which are defined in practice as those with permanent connections to other waters, waters that have been stocked by the State of Michigan in the past, or as waters with public access. Private ponds without permanent connections or public access are not regulated with respect to fish stocking by any state laws.

Legislation creating a new Michigan AIS Advisory Council (Part 414 of the NREPA) was passed and made effective immediately on December 21, 2011. The AIS Advisory Council is composed of a wide variety of members representing diverse interests and is tasked with providing recommendations on the prevention of introduction and dispersal of AIS through trade in the form of a comprehensive report. The report will include recommendations on risk assessment and screening, harmonizing federal and state law, establishing a disease-free organisms program, an education program for buyers and sellers, a

connection of regulations and education to the Pure Michigan advertising campaign, and financial resources for implementing recommendations. AIS Advisory Council recommendations are to be suitable for collaboration with other Great Lakes states and Canadian provinces.

The objectives and strategic actions that apply to Goals I and II: Prevent new AIS introductions and limit the dispersal of AIS via OIT are presented in Section 3, Implementation Table.

Fishing - Live Bait

Problem Description

Live bait may be imported into Michigan from other states and countries by either State of Michigan licensed nonresident or resident wholesale minnow dealers. Live bait can be harvested from Michigan waters for recreational or commercial purposes. Examples of live bait include: (1) invertebrates such as earthworms, leaf worms, nightcrawlers, wax worms, spikes, leeches, grubs, wigglers (generally refers to burrowing mayflies – *Hexagenia* sp.), crickets, grasshoppers, and crayfish; (2) vertebrates such as minnows, suckers, and other baitfish; and (3) fish eggs (e.g., roe). Commercial harvest is limited to minnows, wigglers, and crayfish in Michigan and requires a license from the MDNR.

The importation, distribution, use, and disposal of live bait are all possible mechanisms by which AIS can be inadvertently introduced or dispersed throughout the Great Lakes basin. Licensed and unlicensed (illegal) resident or nonresident wholesale dealers sell live bait to other licensed wholesale and retail minnow dealers, such as bait shops, who then sell the live bait to individual consumers. Commercial and recreational/personal harvest and transportation of live bait may introduce or disperse AIS via contaminated gear and equipment such as nets, bait wells and buckets, boats, trucks, and trailers. Live bait may be contaminated with AIS that are pathogens, which poses a risk for future AIS introductions and range expansions. The broad implementation of AIS-HACCP training in the bait industry has reduced the risk from commercial bait operations.

Ultimately, the responsibility of using and disposing of bait properly falls on the anglers. The use and improper disposal of live bait by anglers may unintentionally introduce or disperse AIS into or throughout Michigan waters. Furthermore, AIS could be introduced or dispersed by improper disposal of transport medium such as water, dirt, and moss that are contaminated with nonindigenous species (e.g., microorganisms, plants, invertebrates, and vertebrates). For example, nightcrawlers are invasive; therefore, all worms and packaging should be discarded in a trash receptacle.

Current Status

The movement and control of AIS in this resource area has been highlighted with the arrival of VHS in the Great Lakes basin. This pathogen makes a good case history of how to manage the emergence of new AIS and provides valuable lessons for future invasions. Since 2006, Great Lakes fisheries managers have expressed concern over the dispersal of VHS, a nonnative pathogen that infects a broad range of fish species, causing hemorrhage, anemia, and death (Plumb and Hanson 2011). The USDA's APHIS issued a Federal Order in October 2006 prohibiting the importation of 37 species of live fish that are susceptible to VHS, from 2 Canadian provinces (Ontario and Quebec) into the United States and the interstate movement of the same species from the 8 states (Michigan, Ohio, Indiana, Illinois, Wisconsin, Minnesota, Pennsylvania, and New York) bordering the Great Lakes. Subsequent amendments to the USDA's APHIS emergency order allow: movement of listed species between Great Lakes states with the appropriate fish health certification and approval of state competent authorities (shared in Michigan between MDARD and MDNR); movement to slaughter and testing facilities; and the angler movement of live fish within the same contiguous water.

Over the last several years, agencies have implemented emergency regulations and management plans to slow the dispersal of the virus into the Great Lakes basin. For example, Lake Superior's Isle Royale National Park enacted emergency regulations that are still in place prohibiting the use of bait for angling and requiring the cleaning of boats in park waters. Together, the United States National Park Service

(USNPS) and Grand Portage Band of Chippewa Indians responded to this threat to Lake Superior waters by developing a VHS Prevention and Response Plan that addresses transport pathways into Lake Superior (NPS 2008a). In 2008 Pictured Rocks National Lakeshore also initiated emergency restrictions to prevent the dispersal of VHS due to the imminent threat to park fishery resources (NPS 2008b).

Regulations pertaining to the movement of live bait vary by country and by state. For instance, it is illegal to import or take crayfish, salamanders, and live fish or leeches for use as bait into Ontario, Canada. Michigan allows the importation of certified disease-free minnows for live bait but does not allow the export of live bait, while Minnesota prohibits imports of live bait. The State of Michigan allows native species of baitfish, such as minnows, shiners, and suckers, to be imported as live bait but does not allow the import of any crayfish species. Again, Part 413 of the NREPA provides a list of prohibited and restricted invasive species within the state, some of which are reared in other states for sale as bait but are prohibited in Michigan.

Approximately 90% of the reported commercial minnow harvest, comprising mainly spottail and emerald shiners, in Michigan is from Great Lakes sources with approximately 80% of that from Saginaw Bay, the St. Clair River, and their tributaries (Goniea 2011). The remaining 10% of the reported commercial minnow harvest in Michigan is from inland sources with Higgins and Houghton Lakes in Roscommon County receiving the most harvest.

Michigan's main mechanism to address fish pathogen issues is Fisheries Order 245 - Fisheries Disease Control Order. Fisheries Order 245 establishes regulations to control the spread of fish pathogens through state-licensed baitfish retail and wholesale operations, recreational anglers and boaters, and persons stocking or transporting fish. Among other general statewide provisions of Fisheries Order 245, provision number 18 restricts the release of baitfish that are on the Susceptible Fish Species list, in any public waters of the State of Michigan, unless that person is fishing and the baitfish are attached to a hook. The order provides for a baitfish disease certification process; management areas that control where anglers can use uncertified bait since certified disease-free bait can be used statewide; time frames for use of uncertified and certified disease-free bait; and a baitfish facility certification process. Fisheries Order 245 also requires imported baitfish that are on the Susceptible Fish Species list to be certified disease free.

The objectives and strategic actions that apply to Goals I and II: Prevent new AIS introductions and limit the dispersal of AIS via fishing-live bait are presented in Section 3, Implementation Table.

Fish Stocking and Hatchery Activities

Problem Description

Public, private, and tribal agencies stock lakes in the Great Lakes basin with fish from hatcheries in an effort to aid in species recovery; meet fisheries management objectives; and sustain, improve, or enhance sport fishing opportunities. Hatchery practices are not without potential risk and AIS may inadvertently be introduced into an ecosystem if preventative measures are not employed and efficient. AIS may reside on contaminated gear, in water used during transportation, and in or on the fish. Fish may also be infected with diseases, viruses, pathogens, and parasites. Robust species like New Zealand mudsnails that can endure environmental stress, such as the application of disinfectants used to thwart the introduction of AIS in the fish transfer and stocking processes, are also a special concern (Zaranko et al. 1997; Richards et al. 2001; Hall et al. 2003). Fish hatcheries whose water supply is dependent on surface waters run a higher risk of contamination than those that draw water from other sources, such as well water.

Most fish hatchery facilities rely on commercially-formulated fish meal products (pellets) as the main nutritional source for reared fish, particularly for coldwater species. In some cases, live minnows are used as a food source, in particular for walleye and muskellunge rearing, and these minnows typically are not reared by the hatcheries themselves. Rather, they are imported from outside sources, usually the prairie region of South Dakota, North Dakota, and Minnesota, presenting another opportunity for AIS

introduction into the Great Lakes basin. While stocking practices are highly scrutinized to reduce biosecurity risks, the act of fish stocking presents another vector to disperse AIS throughout waters of the state, including diseases, viruses, pathogens, and parasites. Also, the movement of hatchery trucks among facilities poses certain risks as well, since diseases, viruses, pathogens, and parasites may be present at certain facilities and not others. The disinfection of all equipment, including gear, trucks, hoses, and nets are important and required at all state facilities.

Unauthorized fish stocking is the introduction or transfer of fish that is not authorized by a federal, provincial, tribal, or state fisheries management agency. Unauthorized stocking is typically conducted for the purpose of creating new recreational fishing opportunities or manipulating existing fish stocks to introduce food into stunted fish lakes. These practices are illegal due to their harmful nature and negative effect on existing recreational, commercial, and bait fisheries (USFWS 2006). For example, pink salmon were intentionally introduced into Thunder Bay of Lake Superior through an unauthorized fish stocking in 1956 (Mills et al. 1994).

Current Status

Public, private, and tribal stocking of fish is regulated in the Great Lakes Basin. States regulate fish stocked in public waters through various stocking permits for public waters. Federal and State agencies and provincial and tribal governments follow the guidance on fish importation and pathogen control in the GLFC's Great Lakes Model Fish Health Program (Hnath 1993, but completing major revision at this time). In Canada, intentional introductions and transfers of aquatic organisms for fish stocking are also restricted by a National Code on the Introductions and Transfers of Aquatic Organisms.

In Michigan, the authority and regulation for stocking live fish in public waters falls under state statute, specifically Section 48735 of the NREPA. MCL 324.48735 reads: "A person shall not plant any spawn, fry, or fish of any kind in any of the public waters of this state or any other waters under the jurisdiction of this state without first obtaining a permit from the department that states the species, number, and approximate size or age of the spawn, fry, or fish to be planted and the name and location of the waters where the spawn, fry, or fish shall be planted." The stocking of fish into private waters by individuals is not regulated by the State of Michigan, where private waters are defined as those with no permanent connection to other waters, no public access, and have never been stocked with public fish.

Fish health certifications are required for all public water stockings in Michigan. For salmonids, all species to be stocked in public waters must be certified free of pathogens, such as Infectious Haematopoietic Necrosis virus, Infectious Pancreatic Necrosis virus, Whirling disease, and VHS virus. For nonsalmonids, stocked fish must be free of pathogens specific to that species and all must be certified free of VHS. For example, cyprinids and percids must be certified free of Heterosporis sp. to be permitted for stocking in public waters.

The objectives and strategic actions that apply to Goals I and II: Prevent new AIS introductions and limit the dispersal of AIS via fish stocking and hatchery activities are presented in Section 3, Implementation Table.

2.3 GOAL III – DEVELOP A STATEWIDE INTERAGENCY EDRR PROGRAM TO ADDRESS NEW INVASIONS OF AIS

The most effective and efficient means of reducing the effect of invasive species beyond prevention is to respond efficiently to new invasions or existing outlier populations of invasive species. Even the best prevention program cannot keep all invasive species out, but a program that responds quickly, uses cost-effective methods, and engages key stakeholders will minimize the threat of invasions affecting the waters of Michigan. The purpose of this section of the SMP is to highlight the necessary components for developing EDRR capacity for new AIS invasions within the State of Michigan. Objectives for this goal are listed at the end of this section.

2.3.1 Background and Current Status

Michigan initiated the process to create components of a rapid response system, with efforts focusing on a rapid response plan for Hydrilla. While extensive, the draft report was not finalized and questions remain on roles, responsibilities, and procedures to implement such a response (Hydrilla Task Force 2006).

Michigan has extensive biological monitoring programs that satisfy a variety of purposes (Dupre 2011). AIS may be detected through incidental observance during the course of these monitoring activities depending on level of crew training and knowledge. However, there are currently no statewide monitoring programs designed specifically to target AIS.

The MDNR's WLD received a GLRI grant (EPA R5-GL2010-1) in October 2010 for the development of an EDRR Program in Michigan. This three-year grant project provides funding for one full-time employee housed in the WLD that works in collaboration with partner agencies to define program standards, develop an EDRR framework, and then implement the strategic actions that are outlined in Section 3, Implementation Table. This grant project also provides funding to control and/or eradicate six aquatic invasive plant species that had been reported (but not confirmed) in Michigan. These species are: Flowering rush, Water lettuce, Water hyacinth, European frogbit, Brazilian elodea, and Parrot feather. See Section 2.3.1 for more information on this project.

The following information highlights some of the current work that is underway as part of this project and outlines the framework that will be used to implement a newly created statewide EDRR Program that will be informed by the outputs from this project. In addition, any new EDRR activities will integrate with existing activities and plans including The Proposed Plan for the Prevention, Detection, Assessment, and Management of Asian Carps in Michigan Waters (MDNR 2012), and binational rapid response planning efforts that are under development by the IJC and other partners.

Michigan is addressing AIS early detection and response needs by conducting interdisciplinary, multijurisdictional training and by establishing the Midwest Invasive Species Information Network (MISIN). The MISIN database is led and managed by Michigan State University and captures, aggregates, and distributes invasive species data statewide to help direct monitoring efforts and alert resource managers to new detections. However, a comprehensive decision-support system, integration of current monitoring efforts, an adequately trained professional and volunteer work force, and a manual of best treatment techniques for new invaders are lacking. Additional resources are needed to develop these and to expand and maintain the MISIN, so that real-time, quality data can be uploaded to local, regional, and global databases to inform response activities.

Building upon Michigan's experience and tools developed from these initiatives and guided by the Draft Rapid Response Plan for Hydrilla, the MDNR and MDEQ, with input from partners, will build and implement an EDRR for aquatic invaders. The state agencies will work in conjunction with Michigan Natural Features Inventory (MNFI) to gather and use the best scientific data available to detect, assess, prioritize, survey, monitor, and treat high threat invasive species. This builds on an existing contract with MNFI to address terrestrial and wetland invaders in a strategic and cost-effective manner. This project addresses shortcomings in the current program: (1) lack of focus on all aquatic invaders; (2) lack of resources; and (3) a program and process to implement rapid response efforts.

The EDRR plan will be designed to direct efforts towards the highest priority species and sites in Michigan using a defined decision-support framework. The process for determining priorities will continue to be refined but will ultimately focus on four goals: (1) treating all new high threat invaders; (2) closing vectors and pathways; (3) managing and controlling outliers of high threat invaders already established; and (4) taking advantage of available resources to successfully contain or eradicate high threat AIS. The MDNR's WLD will review the National Wildfire Coordinating Group's Basic Incident Command System (ICS) and other systems to help define an effective decision-support system for invasive species response in Michigan. The benefit of using a model similar to the ICS for complex response activities is that hundreds of state and nonprofit employees are already trained in this system.

After development of the decision-support framework that includes potential AIS responses, a mock rapid response exercise will test the effectiveness and completeness of the program. The exercise will identify gaps in knowledge, capability, and responsibilities. The EDRR plan should be evaluated annually and refinements continuously implemented to address gaps, shortfalls, and opportunities. Additionally, this project will build success by using prevailing monitoring protocols at strategic locations. This will ensure management and control activities are applied to the highest priority sites in Michigan.

Management and control efforts offer opportunities to engage and train stakeholders and the public about the EDRR. The MDNR's WLD will use AIS management efforts for training stakeholders, outreach to media outlets, and general project dissemination. The MDNR will demonstrate effectiveness of EDRR through treatments applied at 15 sites containing isolated populations of aquatic invasive plants.

Typically, invasive species control efforts in Michigan have been applied by a locally-driven network of resource managers who have the knowledge, motivation, and adequate resources to mount a sustainable effort against invasive species. This ground-up model supports decisions that treat invasive species in high quality habitats such as dunes, shoreline, coastal wetlands, and remnant natural communities or other locations such as a private landowner's lake or a township park. What the current model lacks is a comprehensive statewide evaluation of Michigan's new invaders and coordinated response mechanisms to contain, and in some cases, eradicate new invaders before they become widespread.

2.3.2 Program Structure

The following sections of the EDRR Program are intended to follow in sequential order. The duration of a response will vary depending on the unique circumstances presented by each event. It is important to note that even though these are chronological steps, many will overlap, and all steps should be considered throughout a response event (i.e., planning and communication are vital throughout the program, but have a separate, goal-specific step when responding to a new invader).

Surveillance

Establishing and maintaining a well-trained surveillance network is critical to early detection efforts. Observers need to be aware of current invasive species distribution, in addition to being able to recognize potential new invaders. While some observers in the surveillance network may have specific directives and/or projects focused specifically on invasive species, it is important to also take advantage of the many programs and projects that may indirectly encounter invasive species.

Accurate and timely reporting of any potential new sites of concern requires defined protocols and procedures for follow-up verification. A reporting system needs to be readily available to any potential observer and needs to provide immediate feedback to managers when new threats are suspected.

Verification

Newly reported AIS must be verified by a recognized expert. When possible and deemed necessary, samples should be verified by a second expert. Voucher specimens should be retained and stored properly for future analysis.

Assessment

An on-site assessment of a newly verified AIS must be conducted to determine the extent of infestation. An initial assessment should include, at a minimum: population estimate/distribution, potential for establishment, pathways that lead to introduction, pathways that could further disperse the population, potential short-term and long-term effects, and site accessibility for potential treatment options.

Planning and Communication

Following an accurate assessment, a response plan must be developed in conjunction with or shared with relevant stakeholders and partners, depending on the scenario. A response plan must have inherent flexibility in order to accommodate circumstances that may be difficult to predict or control. There may be little or no information available for newly introduced invasive species that relates to a particular situation (i.e., treatment and control strategies), so preparing multiple strategies may be required.

Upon verification of an invasion and the assembly of a response team, an assigned lead agency will work with partners to develop a communications plan. The communications plan should consider providing information to the general public; local, state, and federal decision makers; project partners; and any others determined to be appropriate by the response team.

An important consideration in response plan development is funding, as the unpredictability of invasive species introduction and detection make budgeting this program difficult. In addition, as multiple agencies may at times be involved, funding a response could become collaborative, but also more complex or constrained.

Implementation

Due to the broad range of potential response plans that may be developed, general implementation principles need to be in place to allow for adaptive management practices. These principles will include sections that address environmental and economic effects, personal safety, public support/awareness, regulatory compliance, and other key areas as identified by the lead agency and team members. These general principles will also be applicable during the initial response planning and need to be in place prior to any future planning events.

During a rapid response event that is complex, involves multiple agencies or jurisdictions, and involves efforts outside of normal agency activities, the ICS format or elements of the ICS may be used. From the general ICS principles, the corresponding officer will develop event-specific guidelines, as needed.

Monitoring of Response Activity

A site-specific monitoring program must also be developed as part of a response plan. The duration, scope, and intensity of the monitoring program will need to be compatible with the specific treatment actions taken (if any), and may also be limited by available funding. Monitoring efforts should be tasked during planning, with specific timelines established for reporting to the response team.

Monitoring programs should be standardized to allow for multiple groups to work on the same site at different times, if necessary. A predetermined set of terms and metrics that provide accurate and useful data for decision-makers needs to be agreed upon by the partners involved.

Since an adequate monitoring program may likely exist over several years, the ICS will not serve this stage of the response effectively. As such, maintaining a working relationship between the response team members will be especially important during this stage.

Finalize EDRR Plans and Maintain Preparedness

Developing and maintaining an active EDRR Program will require consistent cooperation and coordination between partner agencies, as well as volunteers, NGOs, and all other available stakeholders. Public outreach and education, regular staff training, and a general heightened social awareness of the importance of EDRR are critical to the success of the program. Once the program has been fully implemented, long-term funding and public support will need to be acquired in order to carry on the work of the current grant project.

The objectives and strategic actions that apply to Goal III: Develop a statewide interagency EDRR Program to address new invasions of AIS are presented in Section 3, Implementation Table.

2.4 GOAL IV - MANAGE AND CONTROL AIS TO MINIMIZE THE HARMFUL ENVIRONMENTAL, ECONOMIC, AND PUBLIC HEALTH EFFECTS RESULTING FROM ESTABLISHED POPULATIONS

Eliminating the significant harmful environmental, economic, and public health effects from AIS entirely may not be possible given the technical and economic challenges surrounding invasive species. However, a combination of control efforts, adaptive management, and restorations can minimize their effects. Objectives for this goal are listed at the end of this section.

2.4.1 Management and Control Process

The management and control of AIS may be undertaken by a number of entities, ranging from federal and state agencies to local governmental agencies, Tribal entities, NGOs, or private property owners. The entity responsible for AIS management and control may be the property owner where the species is present; however; there are exceptions to this (e.g., Sea lamprey control is undertaken by the federal government).

The first step to manage and control AIS is to assess the environmental, economic, and public health effects from existing AIS to determine if control and/or management practices should be used. This assessment should include a set of formal scientific methods for establishing the probabilities and magnitudes of undesired effects resulting from the invasion. The assessment should include quantitative determination of the current and potential abundance and distribution of the invader and its current and likely effects. It should be noted that a lengthy assessment process may not be prudent for a rapid response to new invasions as it may slow down the response and obstruct success. Existing standardized assessment tools and partnerships with other organizations and groups should be considered during this step.

Once an assessment has taken place, specific management and control procedures should be prioritized using a combination of criteria that examine invasions with the highest likelihood for successful control, that protect the highest value areas, and prevent outlier invasions. This prioritization can be facilitated with the use of a decision tree. Further investigation and research on the use of chemical and other control techniques should be conducted as part of the preinvasive assessment process to determine applicability and effectiveness. Permitting for biological treatment (bio-control), chemical treatment, and mechanical/physical control methods should also be investigated to ensure compliance.

Management and control of AIS should focus on eradication techniques that are the most ecologically and economically feasible. Additionally, negative effects from the management and control process must be carefully considered before implementation occurs. Control strategies, regulations, and permitting processes should continually be evaluated for effectiveness and unintended side effects and subsequently modified or discontinued based on these findings.

Restoration treatments should be made an integral part of control and management efforts to help guard against future reinvasions and to mitigate effects from previous invasions and subsequent treatments. Assessment of the ecosystem's current condition and restoration potential across a range of spatial scales allows managers to strategically control and eradicate invasive species and to restore areas with high value such as important fish and wildlife habitat, navigation, recreation, and economic development. These efforts can result in lower control costs, increased effectiveness, and improved chances for restoration success.

An education and outreach program is a key component of the management and control process to inform and engage riparian land owners, volunteers, and partner groups. Education and outreach should focus on invasive species identification, monitoring, and control options. The program should also be designed to build support for a cooperative effort to manage AIS.

2.4.2 Current Programs

Outside of state agencies, there is significant effort being exerted by local and private partners in Michigan to manage AIS in various targeted efforts. Most often, these management and control efforts are funded at the local level, which poses a problem in some areas of the state where local resources are scarce. Partnerships can be extremely effective and can often work to address onsite chemical, mechanical, and biological controls of species, as well as work towards EDRR activities and address education and outreach goals for local communities. Several of the current programs identified below rely heavily on partner involvement.

One example of these partner efforts is the work being done throughout the state by various NGOs to manage the dispersal of invasive Phragmites. Partnerships have formed in several regions in Michigan to help private landowners identify invasive Phragmites on their property, form an appropriate management plan that typically includes chemical and physical control measures, obtain required permits, and find appropriate contractors to carry out the work. Many of these groups have had significant local and regional success managing this plant. This is just one example of the type of local and regional partnerships that have been very effective managing AIS in Michigan, and there are other examples of these groups dealing with other AIS.

The Michigan Invasive Species Coalition (MISC) seeks to facilitate cooperation and information sharing among various groups. MISC addresses both terrestrial and aquatic invasive species. In particular, additional information on Stewardship Network Clusters and Cooperative Weed Management Areas can be found at www.michiganinvasives.org. These groups are very active in many areas of the state and serve a critical role not only in the management and control aspect of AIS, but also in AIS prevention.

Chemical Control

Aquatic Nuisance Control (ANC) Program

Excessive aquatic plant growth often negatively affects recreational and economic interests. The removal of aquatic plants (both native and nonnative) is often necessary to achieve relief from nuisance conditions that may interfere with recreational access and use of the aquatic resource as well as degrade the quality of the aquatic resource. Chemical control is commonly employed in order to gain relief from aquatic invasive plants.

The application of aquatic pesticides (algaecides and herbicides) is regulated under Part 33 of the NREPA, and requires a permit prior to any application of herbicides to waters of the state. The MDEQ's ANC Program is responsible for reviewing applications and issuing permits for use of these pesticides. The ANC Program maintains a Web page with management, regulatory, and permitting information related to aquatic plant control www.michigan.gov/anc.

NPDES

Starting in 2012, a number of AIS control activities may require coverage under an NPDES permit. These activities include: Aquatic Nuisance Plant and Algae Control, Aquatic Nuisance Animal and Fish Reclamation, and Mosquito and Other Flying Pest Control. Information on when NPDES coverage is needed can be found at www.michigan.gov/deqnpdes under "pesticide control."

Mechanical Control of Aquatic Invasive Plants

Mechanical treatment (e.g., mowing, tilling, or burning) of certain AIS plant species is often a necessary part of an effective AIS management plan. For instance, mowing or burning of invasive Phragmites after chemical treatment removes dead stems and promotes native plant regeneration. If mowing is used as the mechanical treatment method, the vegetation cutting should be conducted only in those areas where AIS are present, avoiding adjacent wetland areas where native species are dominant. In wet areas, mowing AIS as mechanical treatment is most often done in the winter when the ground is frozen, which

provides better and safer access to these areas, as well as minimizes effects to small animals and native plants. In some situations, where intensive habitat restoration includes water level manipulation and long-term AIS monitoring and control, tilling may be an integral part of a management plan. Tilling or disking of plant roots and soil is not an effective mechanical treatment method for invasive Phragmites. These activities promote the spread of invasive Phragmites, as the broken rhizomes and seeds are dispersed and sprout new growth.

Prescribed burning after chemical treatment is another very effective method of mechanical treatment of AIS (e.g., invasive Phragmites). This method is typically used on very large sites, and in more rural areas. Prescribed burning does not require a permit from the State of Michigan, but may require approval from the local unit of government. Some municipalities require additional approvals for certain activities, such as controlled burns. Please contact your local authorities for more information.

Regulations on mechanical treatment options vary among water bodies in the state. It is recommended that authorities undertaking mechanical treatment for AIS check with the MDEQ regarding current regulations for any specific location.

Biological Control

Biological control can be a useful tool for mitigating an established population of an unwanted invasive species. In classical biological control, inoculative releases of natural enemies can lead to colonization and eventual widespread buildup of the natural enemy followed by the resultant reduction in the population of the invasive species. Due to the self-replicating nature of the natural enemies, biological control programs can be extremely cost effective. The slow buildup of natural enemies can be effective as a long-term solution; however, it would not be appropriate in EDRR Programs. Managers should realize that biological control never results in 100% control and therefore is most practical where greatly reduced population levels are acceptable, such as in an integrated pest management strategy.

One factor that often limits widespread use of biological control is finding suitable natural enemies of the introduced pest species. Although natural enemies may exist in the country of origin, significant research is needed to assure that the natural enemy species does not attack nontarget organisms in the proposed release area. Natural enemies ideally should have a narrow host range and preferably only the target species. A particularly successful example of AIS biological control has been the reduction of Purple loosestrife populations in Michigan through the introduction by the MDNR and other partners including the United States Forest Service, conservation districts, and Tribal entities, of two species of leaf-feeding beetles beginning in 1994. By 2000 widespread reduction in Purple loosestrife populations was noted statewide. Natural enemies have also been used to combat Eurasian water milfoil in Michigan. This program used a native species of weevil that shows preference to feeding on the introduced Eurasian water milfoil. More recently there has been promising research on the development of biological controls on Common reed.

Similar challenges occur with programs to control fish and mollusks. An example of successful control with spin-off benefits was the control of alewives through the release of chinook and coho salmon. This effort resulted in reducing alewives populations while stimulating recreational fishing, thus benefiting the Michigan economy. The State of Michigan continues to support the development of biological controls as viable options for long-term management and control of established AIS populations.

ANC by MDNR on State Park Properties

Any involvement with management and control of AIS on state park properties is subject to the permitting process administrated by the MDEQ and all applicable administrative rules. The MDNR's PRD evaluates requests for participation in weed control programs at state lakes and streams on a case-by-case basis. Under the authority of Section 30907 of the NREPA, the MDNR may enter into proceedings for making lake improvements. If the process reaches the point of forming a lake board, the MDNR is required to provide expertise but not financial contributions unless it is deemed necessary by the MDNR. Any financial action taken by the PRD shall have approval from the MDNR or their designee. The MDNR

does not enter into agreements for participation of weed control unless proper reviews of all relevant determining factors are considered.

Determining factors for proposed improvements include, but are not subject exclusively to:

- Chemical and biological methods for treatment.
- Effects on ecosystem (natural communities, hydrology, water quality, etc.).
- Cost of participation by the MDNR (measured benefits).
- Local long-term management plan and practices for effects on a water body and local ordinances prohibiting uses.

Contact made either through a lake board, a local governing board, associations, or other similar groups must be forwarded to the PRD's Resource Management Section chief for review. All proposed treatments for use on any body of water adjacent to or surrounded by PRD properties must be reviewed by PRD's Stewardship Unit staff. Input must also be sought from the regional watershed management units of the MDNR's FD. All decisions are made on a case-by-case basis.

Aquatic weed control on PRD properties where historical recreational areas are affected (e.g., marinas, channels, boat basins, etc.) are approved by the district supervisor and reviewed by the PRD's Stewardship Unit for advisory purposes. The PRD is subject to the adherence of all MDEQ permits for ANC.

All requests for use of PRD boating access sites for weed harvesting operations must be approved by the unit supervisor and must have permission from the MDEQ. Weed harvesting projects by other organizations, associations, or other groups utilizing PRD access sites must be approved through MDNR Policy 26.04.04 (Use Permit).

Consideration should be given to:

- Type of equipment being used at the access site.
- Time of the year and the effect on the boating public.
- Location for temporary storage of equipment and/or harvested vegetation.
- Optimal harvesting schedule related to historic recreation patterns.
- Type of aquatic plant being controlled.

The objectives and strategic actions that apply to Goal IV: Manage and control AIS to minimize harmful effects are presented in Section 3, Implementation Table.

3 IMPLEMENTATION TABLE

The Implementation Table presents each goal and its associated objectives and strategic actions. Measures of success, lead state agency, cooperating agency or organizations, estimated cost, and status are also given for each strategic action. This table will be used as a guide for implementing the SMP, tracking progress, assigning roles, and contributing to program evaluation.

Table 2. Michigan Aquatic Invasive Species State Management Plan Implementation Table.

Strategic actions are organized by goal, vector, and objective; numbering system does not imply prioritization. See the Recommendation section of the AIS SMP for a list of generalized priority activities. Many of these strategic actions are currently being addressed through the existing State of Michigan AIS Core Team coordinated by the MDEQ's WRD, which currently has short-term funding through a GLRI grant at 5 or more full-time employees (FTE) (~$750,000/year). The AIS Core Team consists of MDEQ's WRD and OGL; MDNR's FD, WLD, LED, and PRD; MDARD; and MDOT. This GLRI grant also currently provides additional funding for projects (e.g., education and outreach, eDNA monitoring, etc.) to implement various strategic actions. This table includes a coarse estimate of current state costs to assist in determining funding levels. It should be recognized there are significant costs for the prevention and management of AIS to other partners including other agencies, industries, and citizens.

I. All Goals: Prevent new AIS introductions, limit the dispersal of AIS, early detection and rapid response, and manage and control AIS							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
I.A. Prevent and manage AIS through coordination and collaboration with partners at multiple scales from regional to local.	I.A.1. Support creation of a new Great Lakes regional initiative to address priority AIS issues to be implemented at the state and provincial level.	Regional AIS Initiative in place.	2014	OGL	MDEQ; MDNR; federal, regional, state, provincial, and local agencies; Tribes; NGOs; regulated community; industry; academia; and other stakeholders	Minimal - less than 0.3 FTE (<$48,000/per year).	Ongoing
	I.A.2. Implement the SMP and ensure communication on AIS issues through interdepartmental coordination.	Conduct monthly AIS Core Team meetings. Report number of strategic actions completed and in progress.	Annually	AIS Core Team	MDAG and MDNR's Forest Resources Division	AIS Core Team[1]	Ongoing
	I.A.3. Identify long-term roles and responsibilities of state departments and divisions for AIS prevention and control.	Create "who does what" list with contact information. Distribute to state agencies and post on Web sites.	2013	AIS Core Team		AIS Core Team	Ongoing
	I.A.4. Coordinate with state and regional partners and stakeholders.	Number of existing partnerships strengthened or maintained. Number of new partnerships. See additional strategic actions listed below. Participate in Great Lakes Plan on ANS.	Annually	AIS Core Team	Federal, regional, state, provincial, and local agencies; Tribes; NGOs; regulated community; industry; academia, boating, and angling organizations.	AIS Core Team. Additional support for travel currently provided by GLRI grant.	Ongoing
I.B. Prevent and manage AIS by providing information and education materials to increase awareness.	I.B.1. Develop a cohesive and effective information/education planning document that outlines consistent messaging, prioritizes pathways and audiences, and identifies available resources and media outlets and their effectiveness.	Conduct an inventory and evaluate existing resources and distribution methods, including those from other states, regions, and provinces. Create Michigan-specific planning document and implement recommendations in the plan. Report number of recommendations implemented.	Planning document by 2013; review every 5 years thereafter. Report # recs. implemented annually	AIS Core Team	Sea Grant; federal, state, tribal, and local agencies; and NGOs	Could be addressed through the existing AIS Core Team. Printing and distribution costs currently supported by GLRI grant.	Efforts initiated
	I.B.2. Improve and increase Internet access to AIS information by developing collaborative, state-specific AIS Web sites.	Renovate all Web sites and maintain relevant up-to-date content.	2013; review annually thereafter	DNR-WLD; DEQ-WRD; DARD	AIS Core Team, MOD, and MNFI	AIS Core Team	Ongoing
	I.B.3. Provide information via State of Michigan AIS awareness week.	Evaluate previous efforts, implement improvements, and continue to implement awareness week as appropriate.	Annually	DEQ-WRD	AIS Core Team	AIS Core Team. Additional funding may needed to fully implement.	Ongoing
	I.B.4. Develop state AIS Program brochure, PowerPoint presentation, and other relevant material.	Develop materials and make available.	2013	AIS Core Team	MOD	Could be addressed through the existing AIS Core Team.	No current focused efforts
	I.B.5. Provide training for AIS identification, monitoring, reporting, and treatment.	AIS training program/class offered to 100% relevant staff and partners.	2016; review annually thereafter	AIS Core Team	MNFI, Sea Grant, academia, and industry	AIS Core Team. Additional funding needed to conduct training.	Limited efforts

[1] ***Many of these strategic actions are currently being addressed through the existing State of Michigan AIS Core Team coordinated by the WRD, which currently has short-term funding through a GLRI grant at 5 or more FTEs (~$750,000/year). The AIS Core Team consists of the MDEQ's WRD and OGL; MDNR's FD, WLD, LED, and PRD; MDARD; and MDOT.***

I. All Goals: Prevent new AIS introductions, limit the dispersal of AIS, early detection and rapid response, and manage and control AIS (Continued)							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
I.C. Prevent and manage AIS through legislation and regulation.	I.C.1. Support the actions of Congress in the process of reauthorizing NISA and other federal actions to address the control and prevention of AIS.	Track and provide timely comments on federal legislation, as needed.	As needed	AIS Core Team		Could be addressed by existing AIS Core Team[2].	Ongoing/ as needed
	I.C.2. Implement Section 324.41313 of the NREPA by posting information regarding prohibited and restricted species on State of Michigan Web sites.	Web sites accurately reflect statute requirements. Review content and update as needed.	2012; review annually	WLD, FD, and MDARD	AIS Core Team	AIS Core Team	Ongoing
	I.C.3. Implement Section 324.41323 of the NREPA that requires reporting on prohibited and restricted species issues to the Governor and Legislature.	Submit report.	2013; annually	WLD, FD, and MDARD	AIS Core Team	Could be addressed through the existing AIS Core Team.	Efforts initiated
	I.C.4. Evaluate and amend Section 324.413 of the NREPA to ensure availability of the invasive species fund.	Investigate and make recommendations for changes in a written report.	2013	WLD	AIS Core Team	AIS Core Team	Ongoing
I.D. Prevent and manage AIS through the development of new tools and information.	I.D.1. Evaluate available risk assessment tools to create a Michigan-specific list of prioritized high risk species. Utilize a science-based approach for the prohibited and restricted species list.	Evaluate and make written recommendations on the use of risk assessment tools. Implement the use of tools within existing regulatory framework. Review tools.	Recommen-dations - 2013; Implement by 2015; Review annually.	AIS Core Team	Michigan AIS Advisory Council	AIS Core Team. May need additional funding for contract work.	Ongoing
	I.D.2. Conduct, support, or promote research on new testing methods to detect AIS.	Track and evaluate research. Participate in work groups.	Annually	FD and WRD	Academia, federal, regional, state, and provincial agencies	AIS Core Team	Ongoing
	I.D.3. Develop and promote BMPs to prevent and limit the dispersal of AIS through all vectors.	Evaluate existing efforts and develop new BMPs, provide electronic access to BMPs. Review and update.	2015; review annually	AIS Core Team	Sea Grant; academia; federal, regional, state, and provincial agencies; and industries	AIS Core Team	Limited efforts
I.E. Prevent and manage AIS using adaptive management in response to climate change.	I.E.1. Characterize the direct and second order interactions between climate change and AIS.	Support/track and evaluate research focused on AIS response to climate change predictions for Michigan, evaluate the available research, and identify gaps in research.	2014; review annually	AIS Core Team	Academia; federal, state, provincial, and local agencies; Tribes; and NGOs	Unknown	Ongoing on a limited basis
	I.E. 2. Develop climate change adaptation strategies for AIS.	Using available research and existing adaptation planning tools, draft climate change adaptation strategies for AIS by vector/pathway, taxonomic group, species, landscape position, or region, as appropriate. Adaptation strategies should have a statewide as well as local scale focus.	2015	AIS Core Team or external contractor/ NGO	Federal, state, provincial, and local agencies; Tribes; NGOs; and academia.	Unknown	No current efforts
	I.E.3. Identify areas where climate change policies could negatively affect AIS management.	Review policies, including policies focused on climate change, for AIS implications. Coordinate with appropriate agencies to address AIS concerns.	2015	AIS Core Team	Federal, state, provincial, and local agencies; Tribes; NGOs; and academia	AIS Core Team. Possible additional funding needed as part of a special project.	No current focused efforts
	I.E.4. Support potential synergies between climate change and AIS policy, such as ecosystem-based adaptation and enhancing ecosystem resilience.	Work with appropriate agencies to incorporate climate change adaptation strategies for AIS into existing or new policies and programs.	2016	AIS Core Team	Federal, state, provincial, and local agencies; Tribes; NGOs; and academia	AIS Core Team. Possible additional funding needed as part of a special project.	No current focused efforts

[2] ***Many of these strategic actions are currently being addressed through the existing State of Michigan AIS Core Team coordinated by the WRD, which currently has short-term funding through a GLRI grant at 5 or more FTEs (~$750,000/year). The AIS Core Team consists of the MDEQ's WRD and OGL; MDNR's FD, WLD, LED, and PRD; MDARD; and MDOT.***

I. All Goals: Prevent new AIS introductions, limit the dispersal of AIS, early detection and rapid response, and manage and control AIS (Continued)							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
I.F. Prevent and manage AIS through sustainable dedicated funding of a comprehensive State of Michigan AIS Program.	I.F.1. Evaluate potential funding sources (other than federal grants), and develop and submit a proposal in pursuit of stable long-term AIS program funding.	Develop and submit funding proposal.	2013	AIS Core Team	Michigan AIS Advisory Council	AIS Core Team	Efforts Initiated
	I.F.2. Pursue and obtain funding for AIS specific activities through federal grants.	Report number of grant applications submitted, number of grants obtained, and funds secured by the State of Michigan. Report % of objectives in SMP with full funding.	Annually	AIS Core Team	Federal, state, provincial, and local agencies	AIS Core Team	Ongoing
	I.F.3. Provide funding support to external partners through grant programs for AIS monitoring, research, control, and education information projects, as appropriate and as resources allow.	Evaluate current grant programs and determine the need for new resources. Report number of projects funded with associated dollar amounts.	Annually	MDNR, MDEQ, and MDARD	-	Portions of FTEs to administer grants from other state programs. Funding for projects is variable. Currently no dedicated funding for AIS project grants.	Ongoing on a limited basis

II. Goals 1 and 2: Prevent new AIS introductions and limit the dispersal of AIS via Maritime Commerce - Ballast water

Objective	Strategic Action	Measure of Success	Target Date	Lead State Agency	Cooperating Agency or Organizations	Estimated State Cost	Status in Michigan
II.A. Prevent introductions of AIS through the development and implementation of state and federal ballast water legislation and regulation.	II.A.1. Implement current ballast water reporting program per Section 3103a of Part 31 of the NREPA.	Issue report.	Annually	OGL	Regulated community	Minimal; a small portion of an existing FTE.	Ongoing
	II.A.2. Implement state ballast water control permitting program per Section 3112 of Part 31 of the NREPA (see Objective B, Strategic Action #2).	See Objective B, Strategic Action #2.	See Objective B, Strategic Action #2	WRD	Regulated community	Currently, approximately 0.25 of an FTE addresses the permit related strategic actions. An additional 0.5 FTE is used to address the remaining ballast water-related strategic actions. Total = $107,000/year.	Ongoing
	II.A.3. Ensure state and federal ballast water legislation and regulations are tied to current environmental protection issues and needs.	Evaluate existing state legislation and update if needed. Track and provide timely comments and actions on new ballast water control legislation and regulations proposed at the state and federal levels including regulations proposed by the USCG and the USEPA's next VGP. Report number of comment letters submitted.	State legislation - 2015 Federal legislation - annually	OGL and WRD	International and federal agencies (e.g., USCG and USEPA), other Great Lakes states, provinces, Tribes, academia, regulated community, etc.		Ongoing
	II.A.4. Develop and issue a Section 401 Water Quality Certification for the USEPA's draft next VGP with conditions necessary to ensure ballast water and other discharges incidental to the normal operation of commercial vessels are protective of Michigan waters.	Issue, deny, or waive 401 Certification.	October 1, 2012	WRD	Other Great Lakes state agencies		Completed 2012; ongoing review
II.B. Prevent introductions of AIS by oceangoing vessels through continued implementation of Michigan's ballast water permit program.	II.B.1. Ensure Michigan's Ballast Water Control General Permit reflects the latest technology and regulatory information and protects water quality.	Evaluate and, if necessary, revise Michigan's Ballast Water Control General Permit.	At least every 5 years – 2017	WRD	Other state agencies, academia, industry, and regulated community		Completed 2012; ongoing review
	II.B.2. Process applications and issue COCs, when applicable, under Michigan's Ballast Water Control General Permit to oceangoing vessels.	Report number of COCs issued.	Annually	WRD	-		Ongoing
	II.B.3. Ensure compliance with permit requirements.	Evaluate the compliance mechanisms in the Great Lakes region and make recommendations on the need for the development of enhanced compliance inspection/enforcement activities in a written report. Initiate enforcement action(s) against any vessel that fails to apply for COC.	2015 Enforcement - as needed	WRD	International and federal agencies (e.g., USCG), and other Great Lakes state and provincial agencies		Ongoing, but limited in scope
II.C. Prevent introductions of AIS by promoting common ecologically protective ballast water discharge regulations in the Great Lakes basin through effective communication/ coordination and if necessary, legal action.	II.C.1. Participate in relevant regional work groups, panels, meetings, and workshops	Participate in GLP on ANS and in Ballast Water Collaborative meetings. Number of meetings attended.	Annually	WRD and OGL	International and federal agencies (e.g., USCG and USEPA), other Great Lakes states, Tribes, academia, regulated stakeholders, etc.		Ongoing
	II.C.2. Participate in ballast water regulatory processes that affect the Great Lakes basin.	Communicate with USCG, other states, National Park Service, Canadian provinces, and USEPA as outlined in the 2011 settlement agreement and through meetings.	As needed	WRD and MDAG	OGL		Ongoing

II. Goals 1 and 2: Prevent new AIS introductions and limit the dispersal of AIS via Maritime Commerce - Ballast water (Continued)							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
II.D. Prevent introductions of AIS by advancing the state of technical knowledge regarding ballast water issues through research and development of protocols.	II.D.1. Conduct, support, or promote research on ballast water treatment, BMPs, and ballast water discharge compliance monitoring techniques.	Track and evaluate research.	As needed	WRD	International and federal agencies (e.g., USCG and USEPA), other Great Lakes states, Tribes, academia, regulated stakeholders, etc.	Currently no state budget for conducting research; therefore, only tracking and evaluating research.	Ongoing
	II.D.2. Support the development of sampling protocols, methods and analytical processes, and help create and implement the framework necessary to generate high quality data needed to populate invasion risk/propagule release models for the Great Lakes.	Track and evaluate research.	As needed	WRD			Ongoing
II.E. Prevent introductions of AIS from ballast water through information and education.	II.E.1. Initiate, promote, or support ballast water information/education efforts.	Identify audiences, identify and evaluate existing efforts, identify the need for new efforts, and make recommendations. Number of recommendations implemented.	2013	WRD	Other Great Lakes states	See previous page on FTEs funded for ballast water related activities	No current efforts

III. Goals 1 and 2: Prevent new AIS introductions and limit the dispersal of AIS via Maritime Commerce - Hull, Anchor, Superstructure Fouling							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
III.A. Prevent introductions of AIS through the development and implementation of BMPs and state and federal legislation and regulation.	III.A.1. Identify and evaluate existing applicable legislation, regulations, and BMPs; and evaluate the need for new efforts.	Produce a briefing on the current status.	2014	WRD	International and federal agencies (e.g., USCG and USEPA), other Great Lakes states, Tribes, academia, regulated community, etc.	Minimal budget requirements. Additional efforts could be absorbed into ballast water activity funding.	No current focused efforts
III.B. Prevent introductions of AIS by promoting common ecologically protective measures in the Great Lakes basin through communication/ coordination, research, and information/ education.	III.B1. Communicate and coordinate with other Great Lakes states, provinces, nationally important states, and federal agencies.	Participate in conference calls and workshops as needed. Number of calls/workshops.	2014	WRD			Ongoing
	III.B.2. Conduct, support, or promote research on treatment technologies, anti-fouling agents, BMPs, and monitoring techniques.	Track and evaluate research.	As needed	WRD			No current focused efforts
	III.B.3. Initiate, promote, or support hull, anchor, and superstructure information/education efforts.	Identify and evaluate existing efforts, the need for new efforts, and make recommendations. Number of recommendations implemented.	2014	WRD			No current focused efforts

IV. Goals 1 and 2: Prevent new AIS introductions and limit the dispersal of AIS via Water Recreation (includes boating, fishing, and recreational equipment)							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
IV.A. Prevent introductions and limit the dispersal of AIS through increased awareness, implementation, and enforcement of state legislation, regulation, and permitting.	IV.A1. Post signs at MDNR public launch locations per Section 324.41325 of the NREPA (movement of plant species via boats, boating equipment, or boat trailer).	Percentage of MDNR boat launch sites with signs posted. Review locations during annual inspections.	Post signs - 2013; review annually	PRD	MDNR's Forest Resources Division, WLD, and WRD	Included in general budget. Travel included in standard maintenance and inspection duties.	Ongoing
	IV.A.2. Provide and encourage the use of appropriate signage at additional state-owned, federal, and private locations. Provide the ability to use supplemental signage as needed at state-owned locations for local issues.	Number of State of Michigan signs provided. Review and approve additional local materials as needed.	2013; report annually	PRD	WLD, WRD, lake associations, local municipalities	Minimal; requires review by staff for approving additional signage.	Ongoing
	IV.A.3. Enforce existing laws and regulations; e.g., Section 324.41325 of the NREPA (movement of plant species via boats, boating equipment, or boat trailer) and Fish Order 245 - Fish Disease Control (drain live wells and bilges).	Number of inspections and compliance percentage during on-site visits.	Annually	LED	Local law enforcement agencies, and PRD	Part of regular conservation officer duties.	Ongoing, but level of effort is variable
	IV.A.4. Ensure state and federal laws and regulations regarding water recreation are tied to current environmental protection issues and needs.	Evaluate existing state laws and regulations, and update if needed. Track and comment on recreational boating regulations proposed at the federal level.	State laws - every 5 years as a minimum Federal laws – as needed	AIS Core Team	USEPA	AIS Core Team[3]	Ongoing
	IV.A.5. Ensure appropriate regulation and permitting of boat washes.	Evaluate boat wash discharges and permit issuance. Revise as needed.	2015	WRD	Lake associations, marinas, Sea Grant.	Minimal, included in general WRD budget.	Ongoing
IV.B. Prevent introductions and limit the dispersal of AIS by providing information and education on AIS prevention to resource users including boaters, anglers, scuba divers, etc.	IV.B.1. Provide information and education materials, including "Stop Aquatic Hitchhikers!" messaging to recreational water-related recreation groups through a variety of media.	Evaluate existing information and education materials, develop new materials, and distribute messages about AIS prevention BMPs. Create a plan containing recommendations of distribution methods. Plan implemented (yes/no).	2014; review annually	PRD, FD, LED, and MOD	WRD, OGL, WLD, MUCC, Sea Grant, NGOs, MDOT, Great Lake state and provincial agencies, and local municipalities	Could be addressed by AIS Core Team. Additional funds will be needed to obtain and distribute AIS prevention BMP messages. No dedicated funding for this effort.	Ongoing but limited in scope
	IV.B.2. Partner with programs such as *Clean Boats, Clean Waters* to distribute informational and educational resources.	Continue existing efforts and increase partnerships.	Annually	PRD and MOD	Sea Grant and OGL		Ongoing
	IV.B.3. Hold events and training sessions through volunteer organizations to demonstrate care of recreation equipment to prevent the dispersal AIS.	Evaluate opportunities; and develop program, plan, and hold events. Report number of events.	Plan by 2014; report annually	PRD	WRD, Sea Grant, NGOs, lake associations, etc.	Volunteer efforts would be provided by outside groups; no cost to staff.	No current focused efforts
	IV.B.4. Provide easily accessible information on boat washes to assist with utilization in Michigan.	Evaluate existing information, develop new information, and post on MDNR and MDEQ Web sites.	2014	PRD and WRD	Sea Grant, NGOs, and lake associations	Could be addressed by AIS Core Team	No current focused efforts
IV.C. Prevent introductions and limit the dispersal of AIS via recreational boating through coordination and partnerships.	IV.C.1. Partner with local communities on boat washing at sites through operating agreements annually.	Develop list of existing efforts, priority locations, and potential partners for new locations. Evaluate list and implement program. Number of partnerships.	Develop list - 2014; report annually	PRD	WRD and lake associations	Variable in staff time for on-site reviews and documentation creation.	Process is in place; no focused efforts
	IV.C.2. Participate in Michigan Clean Marina Program.	Number of certified state-owned harbors.	Annually	PRD	OGL, Sea Grant, academia, other Great Lake state agencies and Sea Grants, federal agencies, NGOs, and marina industries	Variable; depends on location and cost to implement changes. Participation in this program has a fixed cost.	12 state-owned harbors participate; no planned efforts to increase

[3] Many of these strategic actions are currently being addressed through the existing State of Michigan AIS Core Team coordinated by the WRD, which currently has short-term funding through a GLRI grant at 5 or more FTEs (~$750,000/year). The AIS Core Team consists of the MDEQ's WRD and OGL; MDNR's FD, WLD, LED, and PRD; MDARD; and MDOT.

V. Goals 1 and 2: Prevent new AIS introductions and prevent the dispersal of AIS via Research and Monitoring Activities							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
V.A. Prevent introductions and limit the dispersal of AIS through state policies, procedures, and permits.	V.A.1. Evaluate, coordinate, and improve current AIS prevention policies, procedures, and training (prevention and species identification) of state agency staff that conduct field activities including research, monitoring, inspections, and site surveys.	Number of policies and procedures evaluated and updated.	2014	AIS Core Team	Other Great Lakes state agencies, Sea Grant, and academia	AIS Core Team[4]. Additional funding needed for increased training.	Ongoing; policies and training variable per division; increased coordination needed
	V.A.2. Evaluate current AIS prevention language and BMPs on cleaning equipment, proper disposal of specimens, and reporting of new AIS infestations included in permits, grants, and contracts for research.	Number of permits, grants, and contracts evaluated and updated.	2014	AIS Core Team	-	AIS Core Team	Ongoing; language currently being used in some cases; increased coordination needed
V.B. Prevent introductions and limit the dispersal of AIS by promoting protective measures through communication and coordination with others and information and education.	V.B.1. Encourage others conducting research and monitoring activities to implement AIS prevention policies, procedures, and training.	Identify needs and methods of communication.	2014	AIS Core Team	Federal agencies, other Great Lakes state agencies and provinces, Tribes, local governments, NGOs, academia, regulated community, industry, etc.	AIS Core Team	No focused efforts

[4] Many of these strategic actions are currently being addressed through the existing State of Michigan AIS Core Team coordinated by the WRD, which currently has short-term funding through a GLRI grant at 5 or more FTEs (~$750,000/year). The AIS Core Team consists of the MDEQ's WRD and OGL; MDNR's FD, WLD, LED, and PRD; MDARD; and MDOT.

VI. Goals 1 and 2: Prevent new AIS introductions and limit the dispersal of AIS via Habitat Modification and Restoration							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
VI.A. Prevent introductions and limit the dispersal of AIS through the existing water permitting process.	VI.A.1. Evaluate BMPs for AIS prevention, review water permitting program standard conditions, and incorporate BMP conditions where appropriate.	Number of permit programs evaluated and number of permits with AIS BMP language incorporated.	2015; review and update, if needed, every 5 years	WRD	AIS Core Team	Portions of FTEs in existing programs.	Permits currently in effect; AIS not specifically addressed
VI.B. Prevent introductions and limit the dispersal of AIS through coordination and information and education on AIS BMPs.	VI.B.1. Support local governments by providing information on AIS BMPs and by coordinating efforts on implementation.	Number of new informational pamphlets or tools created and number of pamphlets distributed or made available electronically.	2016	WRD or WLD	Land conservancies, local governments, other regional agencies, watershed groups, and NGOs	These new activities will require funding above and beyond the AIS Core Team. Funding requirements roughly at 1 FTE ($142,230/year), and additional one-time funding for publications, trainings, or projects.	No current publications on AIS BMPs targeted at local municipalities; some local governments have AIS ordinances, but no unified approach or partnership between state and local level
	VI.B.2. Promote BMPs for private landowners.	Number of new informational pamphlets or tools created and number of pamphlets distributed or made available electronically.	2016	WRD or WLD	Land conservancies, local governments, and other regional agencies		No current publications on AIS BMPs targeted at private landowners
	VI.B.3. Partner/coordinate with other state and local agencies that offer training and certification programs to promote BMPs for AIS management to private contractors, construction contractors, landscapers, etc.	Number of partnerships established and number of training programs with AIS BMPs information incorporated.	2016	WRD or WLD	Land conservancies, local governments, and other regional agencies		No current focused efforts

VII. Goals 1 and 2: Prevent new AIS introductions and limit the dispersal of AIS via Canals, Lift Locks, and St. Marys River Compensating Works							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
VII.A. Prevent introductions and limit the dispersal of AIS through communication/ coordination and if necessary, legal action.	VII.A.1. Ensure continued operation of existing short-term preventative measures at the CAWS.	Participate in work groups including the Asian Carp Regional Coordinating Committee as well as other efforts as needed.	Annually	FD and OGL	WRD, federal agencies (e.g., USACE and USFWS), Great Lakes states, and Tribes	Portions of FTEs in existing programs combined with AIS Core Team[5]. Special projects would require additional funding.	Ongoing
	VII.A.2. Provide support to maintain, and where appropriate, enhance the existing measures, including the electric barriers, rotenone treatments, environmental DNA monitoring, etc.	Participate in work groups including the Asian Carp Regional Coordinating Committee as well as other efforts as needed. Number of work groups and special projects (e.g. rotenone treatments).	Annually	FD and OGL	WRD, federal agencies (e.g. USACE and USFWS), Great Lakes states, and Tribes		
	VII.A.3. Promote hydrological separation between the Great Lakes and Mississippi River basins as a long-term solution by providing support to studies that investigate hydrological separation.	Number of work groups participated in.	Annually	MDAG, FD, OGL, and WRD	Federal agencies, Great Lakes states, and Tribes		Ongoing
	VII.A.4. Promote hydrological separation between the Great Lakes and Mississippi River basins as a long-term solution by providing official state positions on pathway closure and canal and lift lock operations.	Correspondence transmitted from Michigan to federal agencies (yes/no). Legal action taken (yes/no).	Annually	MDAG	FD, WRD, OGL, Great Lakes States and provinces, and Tribes		Ongoing
	VII.A.5. Promote and support the research and implementation of measures to prevent the introduction of Asian carp and other AIS at entry points other than the CAWS.	Number of work groups participated in.	Annually	FD and WRD	OGL, federal agencies (e.g., USACE and USFWS), Great Lakes states and provinces, and Tribes		Ongoing
	VII.A.6. Evaluate man-made connections between waters in Michigan.	Prepare briefing paper that contains recommendations for further action.	2017	WRD, OGL, FD, WLD, and PRD	Local governments		
	VII.A.7. Mitigate incidental passage of fish and other species through the lift locks at Sault Ste. Marie.	Follow the activities of the Lake Superior Board of Control and provide recommendations. Number of meetings attended. Recommendations proved (yes/no).	Annually	FD	Federal agencies (e.g. USACE) and Tribes		Ongoing
	VII.A.8. Promote water flow regimes that serve to benefit AIS prevention or minimize dispersal. Continue to support the investigation of new strategies to increase sea lamprey trapping on the St. Marys River.	Participate in lake technical committees (yes/no).	Annually	FD	WRD, U.S. and Canadian federal agencies (e.g., USACE and USFWS), Tribes, states, provinces, GLFC, USFWS, IJC, and power companies		Ongoing

[5] ***Many of these strategic actions are currently being addressed through the existing State of Michigan AIS Core Team coordinated by the WRD, which currently has short-term funding through a GLRI grant at 5 or more FTEs (~$750,000/year). The AIS Core Team consists of the MDEQ's WRD and OGL; MDNR's FD, WLD, LED, and PRD; MDARD; and MDOT.***

VIII. Goals 1 and 2: Prevent new AIS introductions and limit the dispersal of AIS via Transportation Facilities							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
VIII.A. Prevent introductions and limit the dispersal of AIS through existing legislation, regulation, and permitting processes.	VIII.A.1. Ensure that NEPA documents include a determination of the likelihood that projects may introduce or disperse AIS and describe measures that will be taken to avoid and minimize potential harm from invasive species.	Percentage of NEPA documents reviewed for AIS effects.	Annually	MDOT	Federal Highway Administration, county road commissions, local governments, and other regional agencies	Based on individual project requirements and/or maintenance funding; $100,000-$250,000 per year.	Ongoing
	VIII.A.2. Encourage transportation authorities to develop vegetation management plans that include BMPs for invasive species.	Number of approved vegetation plans and number of informational pamphlets and other tools (e.g., mobile device applications) created and distributed or made available electronically.	Annually	MDOT	WD, WRD, local road agencies, Great Lakes states and provinces, Tribes, and MISC	Portions of FTEs in existing programs combined with AIS Core Team[6]. Special projects would require additional funding.	Ongoing
	VIII.A.3. Prevent AIS from further dispersal or spread within road right-of-ways.	Number of miles of road right-of-ways monitored for AIS and AIS control actions taken.	Annually	MDOT	WD, WRD, and local road agencies	Based on individual project requirements and/or maintenance funding; $100,000-$250,000 per year.	Ongoing
VIII.B. Prevent introductions and limit the dispersal of AIS through information collection.	VIII.B.1. Encourage statewide right-of-way inventories of vegetation that map existing invasive plant infestations to provide information for NEPA analysis.	Development of a statewide centralized database that contains the locations of invasive species to be used by planning and maintenance staff.	2015	MDOT	WD, WRD, local road agencies, Great Lakes states and provinces, Tribes, and MISC	Portions of FTEs in existing programs combined with AIS Core Team. Special projects would require additional funding.	Ongoing
VIII.C. Provide information and education on AIS prevention to managers.	VIII.C.1. Encourage training of vegetation managers at the state and local levels. Integrated pest management principles should be included in this training.	Number of trainings and informational pamphlets and tools (e.g., mobile device applications) created and distributed or made available electronically.	Annually	MDOT and MDEQ	WD, WRD, local road agencies, Great Lakes states and provinces, and Tribes	Portions of FTEs in existing programs combined with AIS Core Team. Special projects would require additional funding.	Ongoing
	VIII.C.2. Develop guidelines for BMPs for construction activities relating to transportation projects. Provide trainings on BMPs for mowing, equipment cleaning, and construction mat handling.	Number of BMP guidelines developed and trainings offered.	2016	MDOT and MDEQ	WD, WRD, local road agencies, Great Lakes states and provinces, Tribes, and MISC	Portions of FTEs in existing programs combined with AIS Core Team. Special projects would require additional funding.	No current publications on AIS BMPs targeted at transportation projects

[6] ***Many of these strategic actions are currently being addressed through the existing State of Michigan AIS Core Team coordinated by the WRD, which currently has short-term funding through a GLRI grant at 5 or more FTEs (~$750,000/year). The AIS Core Team consists of the MDEQ's WRD and OGL; MDNR's FD, WLD, LED, and PRD; MDARD; and MDOT.***

IX. Goals 1 and 2: Prevent new AIS introductions and limit the dispersal of AIS via OIT							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
IX.A. Prevent introductions and limit the dispersal of AIS through implementation of existing legislation, regulation, and permitting processes pertaining to OIT.	IX.A.1. Implement current laws and regulations through MDEQ, MDNR, and MDARD staff training on identification of AIS and statute requirements.	Percentage of relevant staff trained. Goal is 100%.	2014; update training every 3 years	LED, FD, and MDARD	-	Some training funded through existing programs.	Ongoing but inconsistent efforts
	IX.A.2. Identify regulated industries and maintain contact lists of businesses involved in trade of aquatic organisms.	Contact lists current (yes/no).	2014; review and update annually	MDARD, FD, WLD, and LED	Industry	AIS Core Team[7]. Project funding from GLRI grant at a one-time allocation of $162,230.	Ongoing but inconsistent effort depending on industry type
	IX.A.3. Implement current laws and regulations through compliance inspection and enforcement at businesses and private sales, and through transportation routes.	Number of inspections and compliance rates. Goal is 100% compliance. Create briefing that identifies the need for new efforts (e.g., internet sales) and contains recommendations on implementation of new inspections. Number of recommendations implemented.	Inspections - annually; Briefing - 2014; Number of recommen-dations implemented - annually	MDARD and LED	USDA and industry	Additional inspection efforts currently funded through the AIS Core Team supplementary $133,500 from short-term federal grant for special projects.	Ongoing but inconsistent effort depending on industry type
	IX.A.4. Evaluate existing state laws and regulations and the utilization of a risk assessment process to identify new AIS threats. Make changes to the state prohibited/restricted species list as appropriate.	Create report containing recommen-dations on the need for new laws/ regulations (e.g., mobile aquaculture) and the use of risk assessment. Percentage of time risk assessment process used to identify and add new species to state prohibited and restricted species lists; goal is 100%.	Report – 2013; Review and update list - annually	MDARD, FD, and WLD	Michigan AIS Advisory Council, federal agencies, other state agencies and provinces, Tribes, local governments, NGOs, academia, regulated community, industry, etc.	AIS Core Team. Additional funds estimated at $142,230/year to create report and evaluate species, develop and distribute materials, and to initiate new accreditation program. Additional funds may be needed to print materials.	No current focused efforts
	IX.A.5. Evaluate the discrepancies between state, provincial, and federal regulated AIS lists and modify Michigan list as appropriate.	Evaluate discrepancies and present recommendations in a written briefing. Number of recommendations implemented.	2013; review annually	MDARD, FD, and WLD			No current focused efforts
	IX.A.6. Promote protective federal legislation.	Track and provide timely comments on federal legislation, in particular, the Lacey Act and new OIT legislation.	As needed	FD and WLD	Federal agencies (e.g., USFWS), other Great Lakes states		
IX.B. Prevent introductions and limit the dispersal of AIS by providing AIS information and education to the OIT industry and consumers.	IX.B.1. Implement/support industry awareness campaigns promoting the responsible acquisition, distribution, and disposal of aquatic OIT.	Identify target industry audiences, identify available informational materials, and develop new materials if needed. Conduct AIS identification workshops and distribute informational material. Write articles for major trade journals. Number of events, articles, and materials distributed.	Identify and develop materials - 2015; Report #s - annually	MDARD and MDNR	Michigan AIS Advisory Council, federal agencies, other state agencies, Sea Grant, and industry		No current focused efforts
	IX.B.2. Implement/support consumer awareness campaign promoting proper disposal of aquatic OIT (e.g., Habitattitude).	Identify target audiences, identify available materials, and develop new materials. Distribute information through conventional and social media. Number of outreach activities.	Identify and develop materials - 2015; report annually	MDARD and MDNR	Michigan AIS Advisory Council, federal agencies, other state agencies, and industry		Limited/ inconsistent efforts
	IX.B.3. Develop and implement campaign to enhance consumer awareness and proper disposal of regulated AIS.	Identify target audiences, identify available informational materials, and develop new materials if needed. Distribute informational material through conventional and social media. Number of outreach activities.	Identify and develop materials - 2015; Report #s - annually	MDARD and MDNR	Michigan AIS Advisory Council, federal agencies, other state agencies, and industry		No current efforts

[7] ***Many of these strategic actions are currently being addressed through the existing State of Michigan AIS Core Team coordinated by the WRD, which currently has short-term funding through a GLRI grant at 5 or more FTEs (~$750,000/year). The AIS Core Team consists of the MDEQ's WRD and OGL; MDNR's FD, WLD, LED, and PRD; MDARD; and MDOT.***

IX. Goals 1 and 2: Prevent new AIS introductions and limit the dispersal of AIS via OIT (Continued)							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
IX.C. Prevent introductions and limit the dispersal of AIS by promoting a voluntary stewardship accreditation program.	IX.C.1. Establish OIT accreditation programs for nursery and aquarium industries.	Identify BMPs and evaluate existing programs in other states. Program developed and in place (yes/no).	2017; review annually thereafter	MDARD	FD, WLD, Michigan AIS Advisory Council, federal agencies, other state agencies, and industry	See above	No current efforts

X. Goals 1 and 2: Prevent new AIS introductions and limit the dispersal of AIS via Fishing - Live Bait							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
X.A. Prevent introductions and limit the dispersal of AIS by licensed wholesale and retail minnow dealers and licensed commercial minnow harvesters through regulations and voluntary practices.	X.A.1. Implement current laws and regulations regarding licensing, prohibited species, and fish health certification.	Conduct inspections to ensure compliance. Number of inspections and compliance rate. Report unlicensed bait distribution and enforcement results.	Annually	FD and LED	Michigan AIS Advisory Council, federal agencies, other state agencies and provinces, and industry	Additional inspection efforts currently funded through the AIS Core Team[8] as well as supplementary $133,500 from same short-term federal grant for special projects.	Ongoing
	X.A.2. Ensure laws and regulations reflect current environmental protection issues and needs. Promote regional consistency.	Evaluate existing laws and regulations and update if needed. Laws and regulations protective (yes/no).	Every 5 years as a minimum	FD	LED, MDARD, and other state agencies and provinces	Portion of existing FTE funded through other programs.	Ongoing
	X.A.3. Ensure license language (including bait harvesters) includes proper disposal of unwanted organisms and reporting of potential AIS.	Evaluate language, make recommendations for changes, and implement changes, if appropriate. License language includes protective provisions (yes/no).	2014; review annually	FD	Industry	Portion of existing FTE funded through other programs and AIS Core Team.	Ongoing
	X.A.4. Encourage voluntary disease testing when appropriate.	Evaluate the need for efforts.	As needed	FD	MDARD and industry	-	Ongoing
	X.A.5. Support and promote voluntary AIS-HACCP training and the distribution of identification materials for priority species.	Evaluate efforts and create and implement plan to expand efforts. Plan implemented (yes/no).	2015	FD	MDARD and industry	AIS Core Team	No current focused efforts
X.B. Prevent introductions and limit the dispersal of AIS from improper collection, use, and disposal of live bait via anglers through information and education and regulations.	X.B.1. Implement current laws and regulations.	Enforce laws and regulations as appropriate. Number of angler contacts and compliance rate.	Annually	FD and LED	Anglers	Portion of existing FTE funded through other programs.	Ongoing
	X.B.2. Ensure laws and regulations reflect current environmental protection issues and needs. Promote regional consistency.	Evaluate existing laws and regulations and update if needed. Laws and regulations protective (yes/no).	Every 5 years as a minimum	FD and LED	Anglers	Portion of existing FTE funded through other programs.	Ongoing
	X.B.3. Continue information/education efforts and evaluate new opportunities to increase angler awareness of AIS issues, laws, regulations, and prevention techniques.	Evaluate existing efforts and the need for new efforts, including the use of surveys to determine angler knowledge base. Create plan with recommendations. Plan implemented (yes/no).	2014; review annually	FD	Bait retailers and anglers	Portion of existing FTE funded through other programs and AIS Core Team.	Ongoing

[8] Many of these strategic actions are currently being addressed through the existing State of Michigan AIS Core Team coordinated by the WRD, which currently has short-term funding through a GLRI grant at 5 or more FTEs (~$750,000/year). The AIS Core Team consists of the MDEQ's WRD and OGL; MDNR's FD, WLD, LED, and PRD; MDARD; and MDOT.

XI. Goals 1 and 2: Prevent new AIS introductions and limit the dispersal of AIS via Fish Stocking and Hatchery Activities							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
XI.A. Prevent introductions and limit the dispersal of AIS via aquaculture practices by State of Michigan facilities and other facilities through laws, regulations, permits, and policies/ procedures.	XI.A.1. Implement/enforce current laws and regulations regarding permitting, prohibited species, and fish health certification.	Enforce laws and regulations as appropriate. Number of inspections and compliance rate. Evaluate existing laws and regulations and update if needed	Inspections - annually; Review laws - every 5 years as a minimum	FD, LED, and MDARD	Federal agencies, Tribes, and industry	Unknown	Ongoing
	XI.A.2. Use AIS-HACCP training at State of Michigan facilities as a method to identify and eliminate potential risks.	Review fish rearing (including the use of minnows as a food source), transportation, stocking, equipment disinfection, and hatchery practices. Modify policies and procedures if needed. AIS-HACCP Plan in place (yes/no).	2014; review annually	FD and MDARD	Sea Grant	Portion of existing FTE funded through other programs and AIS Core Team[9].	Ongoing, but update needed
	XI.A.3. Identify and encourage the use of AIS preventative procedures through communication with other facilities including federal, Tribal, and private.	Communicate relevant information or emerging issues as they arise.	As needed; review annually	FD and MDARD	Federal, Tribal, and private hatcheries	Portion of existing FTEs funded through other programs.	Ongoing
XI.B. Prevent introductions and limit the dispersal of AIS by fish stocking and hatchery activities by private facilities into privately owned waters through laws and regulations.	XI.B.1. Implement/enforce current laws and regulations regarding prohibited species and fish health, and evaluate the need for additional measures for regulation of stocking private waters.	Enforce laws and regulations as appropriate. Evaluate existing laws and regulations and update if needed.	2015	FD and MDARD	Private hatcheries, pond management industry, and Sea Grant	Portion of existing FTE funded through other programs and AIS Core Team.	No current focused efforts
XI.C. Prevent introductions and limit the dispersal of AIS by fish stocking and hatchery activities by private facilities into privately owned waters through information/ education.	XI.C.1. Distribute informational/ educational materials, including the encouragement of voluntary AIS-HACCP training and planning.	Identify existing efforts and available materials, evaluate the need for expanded efforts, and create a plan with recommendations. Plan implemented (yes/no).	2015	FD and MDARD	Private hatcheries, pond management industry, and Sea Grant	Portion of existing FTE funded through other programs and AIS Core Team. Additional funding may be needed to print or purchase materials.	No current focused efforts

[9] ***Many of these strategic actions are currently being addressed through the existing State of Michigan AIS Core Team coordinated by the WRD, which currently has short-term funding through a GLRI grant at 5 or more FTEs (~$750,000/year). The AIS Core Team consists of the MDEQ's WRD and OGL; MDNR's FD, WLD, LED, and PRD; MDARD; and MDOT.***

XII. Goal 3: Develop a state-wide interagency early detection and rapid response program to address new invasions of AIS							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
XII.A. Continue existing early detection efforts.	XII.A.1. Ensure continued operation of existing short-term preventative and rapid response measures at the CAWS and other entry points.	Support active and collaborative monitoring of Asian carps in Michigan waters using environmental DNA and other tools. Participate in committees or collection efforts as needed.	As needed	FD	WRD, OGL, MDAG, and federal and Great Lakes state agencies	-	Ongoing
	XII.A.2. Ensure information is available on AIS that have limited distribution in Michigan.	Lists of species and distribution maintained (yes/no).	Annually	WRD	FD, PRD, WLD, industry, NGOs, MiCorps, MNFI, and MSU	Portion of existing FTE funded through other (ANC) programs. AIS Core Team.[10]	Ongoing, especially for aquatic plants
XII.B. Develop a mechanism for early detection and reporting of AIS.	XII.B.1. Develop a list of high risk AIS not currently found in Michigan.	List developed and reviewed/updated (yes/no).	2014; review annually	WLD, FD, WRD, and MDARD	Federal agencies, Great Lakes state agencies, academia, MNFI, and industry	AIS Core Team. Additional funds may be needed to conduct risk assessments (see OIT pathway).	Limited efforts
	XII.B.2. Establish a cohesive, statewide monitoring and reporting program using existing state agency field staff and all available external partners.	Inventory existing efforts and identify the need for additional efforts and a long-term statistically valid monitoring program. Develop and implement a coordination plan. Plan developed and implemented (yes/no). Update and implement MDEQ's "A Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters." Strategy updated with AIS content (yes/no).	Coordination plan - 2015; Monitoring strategy document – 2013	WLD, FD, and WRD	PRD, NGOs, MNFI, and federal and Great Lakes state agencies	AIS Core Team. Portion of existing FTEs funded through other programs to conduct monitoring, but additional funds may be needed to increase AIS-specific monitoring activities.	Extensive general monitoring is ongoing with the potential for incidental observance of AIS. Limited AIS-specific monitoring exists and coordination is lacking. "Strategy" implementation ongoing and update underway.
	XII.B.3. Establish and maintain a network of well-trained volunteers. Promote reporting of AIS sightings.	Maintain support for existing volunteer monitoring efforts, and expanded AIS specific efforts. Develop a message for how to report AIS and promote to the general public and specific user groups.	Annually	WRD	PRD, MiCorps, NGOs, MNFI, and MSU Extension	Portion of existing FTEs funded through other programs. AIS Core Team.	Ongoing
	XII.B.4. Establish protocols and procedures for newly reported threats.	Protocols and procedures, including communication chains (local and state) and notification confirmation plans, developed and made available (yes/no).	2013	WLD	PRD, WRD, FD, MDARD, MNFI, MSU, and academia	Currently funded by 3-year USEPA grant with project funding at ~$1,000,000 (EDRR grant). Long-term funding needed to maintain and expand efforts.	Ongoing
	XII.B.5. Provide support to develop, expand, and maintain AIS reporting and tracking databases.	Provide funding and expertise to support the addition of 10 aquatic plant species to the Midwest Invasive Species Information Network. Number of species added.	2014	WLD	PRD, WRD, FD, MDARD, MNFI, MSU, and academia		Ongoing

[10] ***Many of these strategic actions are currently being addressed through the existing State of Michigan AIS Core Team coordinated by the WRD, which currently has short-term funding through a GLRI grant at 5 or more FTEs (~$750,000/year). The AIS Core Team consists of the MDEQ's WRD and OGL; MDNR's FD, WLD, LED, and PRD; MDARD; and MDOT.***

XII. Goal 3: Develop a statewide interagency early detection and rapid response program for AIS (Continued)							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
XII.C. Assess reports of newly identified AIS.	XII.C.1. Develop a list of recognized experts and qualified labs for AIS verification.	List, using National Oceania and Atmospheric Administration list as a model, developed and made available (yes/no).	2014	WLD	WRD, FD, MDARD, MNFI, MSU, and academia	Currently funded by 3-year USEPA grant with project funding at ~$1,000,000 (EDRR grant). Long-term funding needed to maintain and expand efforts.	Ongoing
	XII.C.2. Develop an assessment tool to aid in planning responses.	Evaluate existing information and develop tools that capture all necessary on-site and contextual information. Tool developed and available (yes/no).	2014	WLD	WRD, FD, PRD, MDARD, MNFI, MSU, and academia		Ongoing
	XII.C.3. Identify an assessment team(s) and build capacity for on-site data collection.						
	XII.C.4. Prioritize response efforts based on assessment and threat potential (as defined in objective B).						
XII.D. Develop response planning strategies that promote coordinated control efforts between agencies and partners.	XII.D.1. Identify the roles and responsibilities of partners in creating an immediate response plan.	Conduct mock exercise(s) at different scales (including binational) to test EDRR Program for effectiveness and refinement. Number of mock exercises.	2015	WLD	AIS Core Team; MNFI; MSU; federal, Great Lakes state, and provincial agencies; Tribes; and local governments	Currently funded by 3-year USEPA grant with project funding at ~$1,000,000 (EDRR grant). Long-term funding needed to maintain and expand efforts.	Ongoing
	XII.D.2. Determine individual components that will be needed within a general response plan (treatment options, legal/regulatory, local public support, monitoring, etc.).						
	XII.D.3. Implement a variation of the ICS for consistent use of terminology and structure between partners.						
	XII.D.4. Prepare a notification system (such as a listserv) for partners that would be contacted in the event of a new invasive detection.						
	XII.D.5. Consult department communications staff regarding timelines and approval processes for providing multiagency response information to the public regarding a new invasive detection.						
XII.E. Develop implementation principles (i.e., environmental effects and safety issues).	XII.E.1. Use implementation principles based on the ICS format during a rapid response event. Develop event-specific guidelines.	Conduct mock exercise(s) at different scales (including binational) to test EDRR Program for effectiveness and refinement. Number of mock exercises.	2015	WLD	AIS Core Team; MNFI; MSU; federal, Great Lakes state, provincial, and local agencies; and Tribes	Currently funded by 3-year USEPA grant with project funding at ~$1,000,000 (EDRR grant). Long-term funding needed.	Ongoing
XII.F. Use adaptive management to monitor, evaluate, and modify program effectiveness.	XII.F.1. Develop a monitoring program compatible with specific treatment actions.	Implement as needed in response to AIS. Track and evaluate rapid response efforts for other species and locations.	N/A	MDNR and MDNR	AIS Core Team; MNFI; academia; federal, Great Lakes state, and provincial agencies; Tribes; local municipalities; and NGOs	Unknown	As needed
	XII.F.2. Adapt existing protocols to ensure consistency, compatibility, and effectiveness with AIS management.						
	XII.F.3. Identify topics to be included in an after action report, and provide a timeline and format for team members to follow.						
XII.G. Secure a stable funding source for EDRR efforts.	XII.G.1. Generate a list of potential funding sources to implement a response plan (local, tribal, state, and federal).	Develop a briefing paper outlining options for funding rapid response efforts (refer to Asian carp plan and oil spill contingency fund for examples). Briefing paper developed (yes/no).	2015	WLD	AIS Core Team; MNFI; academia; federal, Great Lakes state, and provincial agencies; Tribes; and local governments	Currently funded by 3-year USEPA grant with project funding at ~$1,000,000 (EDRR grant). Long-term funding needed to maintain and expand efforts.	Ongoing
	XII.G.2. Develop a plan to prepare for the use of crosscut, interagency budgets by developing a funding plan.						
	XII.G.3. Research options for creating an AIS emergency response fund.						

XIII. Goal 4: Manage and Control AIS to minimize harmful effects							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
XIII.A. Manage AIS through permitting and certification.	XIII.A.1. Review applications for state permits and certifications for control of AIS and provide decisions in a timely manner.	Implement existing state permitting programs. Report number of applications reviewed and percent reviewed/issued within required time.	Annually	WRD	Federal and local agencies, aquatic plant management, and other industry	Currently approximately 6 FTEs ~$853,000 (funded through other existing programs).	Ongoing
	XIII.A.2. Ensure effectiveness of permits and permitting process.	Evaluate permits and permitting process and implement streamlining/improvements (e.g., general permit and/or combined permitting for AIS control activities).	Every 5 years as a minimum	WRD	Regulated community, aquatic plant management, and other industry		Ongoing
XIII.B. Identify priority AIS for control based on effects, habitat, and likelihood for success in control or elimination of pathway and methods for control.	XIII.B.1. Conduct, promote, and support research and development of control options including pesticide, physical, and biological controls or BMPs for plants, animals, and diseases.	Track and evaluate research.	As needed	WRD, WLD, and MDARD	MNFI, federal agencies, academia, aquatic plant management, and other industry	Portions of existing FTEs funded through other programs	Ongoing
	XIII.B.2. Assess the ecological, social, and public health effects from AIS and determine if there are appropriate control actions to limit the effects.	Evaluate existing guidance and develop new guidance for determining whether to implement a control program and what types of control actions to use. Number of new guidance documents.	2015	WRD and WLD	PRD, MNFI, academia, aquatic plant management, and other industry	Portion of existing FTEs funded through other programs. AIS Core Team.[11]	No current efforts
XIII.C. Strategically implement AIS control and restoration through existing programs and new programs.	XIII.C.1. Control aquatic invasive plants and restore native plants at state parks and recreation areas.	Identify priority areas for control and implement management efforts. Number of sites/acres treated/restored.	Annually	PRD	WLD and WRD	~$170,000/year (funded by other existing programs)	Ongoing
	XIII.C.2. Control aquatic invasive plants and restore native plants on other state properties and private areas.	Identify priority areas for control and implement management efforts. Number of sites/acres treated/restored.	Annually	WLD	Local partners and MISC	Unknown	Ongoing
	XIII.C.3. Implement the MDNR's Mute Swan Control Program.	Number of mute swans removed per year and progress towards goal of 0 mute swans on MDNR property and 0 population growth in state.	Annually	WLD	USDA Wildlife Services	Unknown	Ongoing
	XIII.C.4. Continue to implement the Great Lakes Sea Lamprey Program.	Provide support as needed. Issue permits or certifications to USFWS.	Annually	FD and WRD	Federal agencies, Tribes, states, provinces, and academia	Portions of existing FTEs funded by other programs.	Ongoing
	XIII.C.5. Provide technical assistance and support for local and regional groups (Cooperative Weed Management Areas, counties, conservation districts, etc.) developing and implementing AIS management plans.	Evaluate the need for guidance documents or Web site updates. Provide support as needed.	As needed	WLD and WRD	PRD, MNFI, Sea Grant, MSU, and MISC	Portions of existing FTEs funded through other programs.	Ongoing, but these efforts could be expanded
	XIII.C.6. Determine the need for and implement new control programs.	Evaluate current programs, make recommendations for modifications, and implement new programs	Evaluate annually	MDNR and MDEQ	Federal, state, provincial, local agencies, and NGOs	Unknown	Efforts initiated
	XIII.C.7. Amend existing or develop new protocols and BMPs to include restoration activities to mitigate effects of AIS.	Evaluate existing methods (including criteria for determining priority sites) and develop new protocols, if needed. Standard protocols available (yes/no).	2017	WLD	PRD, MNFI, and MDEQ	Unknown	Limited efforts
	XIII.C.8. Document successful management/restoration projects involving treatment and recovery from AIS effects including examples from private lands, public lands, and efforts involving NGOs.	Document projects in briefing papers or other written format and make available to partners.	2017	MDNR and MDEQ	MNFI, Sea Grant, MSU, NGOs, federal agencies, Tribes, states, provinces, and local governments	Portions of existing FTEs funded by other programs. Could be addressed by AIS Core Team[12].	Limited efforts

[11] ***Many of these strategic actions are currently being addressed through the existing State of Michigan AIS Core Team coordinated by the WRD, which currently has short-term funding through a GLRI grant at 5 or more FTEs (~$750,000/year). The AIS Core Team consists of the MDEQ's WRD and OGL; MDNR's FD, WLD, LED, and PRD; MDARD; and MDOT.***

XIII. Goal 4: Manage and Control AIS to minimize harmful effects (Continued)							
Objective	**Strategic Action**	**Measure of Success**	**Target Date**	**Lead State Agency**	**Cooperating Agency or Organizations**	**Estimated State Cost**	**Status in Michigan**
XIII.D. Evaluate control strategies for effectiveness and modify as needed (adaptive management).	XIII.D.1. Develop and implement tracking systems and protocols for posttreatment site visits.	Evaluate existing methods and develop new protocols, if needed. Standard protocols available and used (yes/no).	2017	MDNR and MDEQ	MNFI, Sea Grant, MSU, NGOs, federal agencies, Tribes, states, provinces, local governments, and MISC	Portions of existing FTEs funded through other programs. Could be addressed by AIS Core Team.	Limited efforts
XIII.E. Develop education and information programs for riparian owners, volunteers, local government, and partners.	XIII.F.1. Provide information on BMPs and safe and appropriate treatment techniques, including Integrated Pest Management, where appropriate.	Evaluate existing materials and the need for new materials. Develop and distribute materials. Number of materials distributed or available on Web site.	2017	MDNR and MDEQ	Sea Grant, MSU Extension, and local governments	Portions of existing FTEs funded through other programs. Could be addressed by AIS Core Team. Additional funds may be needed to create and print materials.	Limited efforts

[12] ***Many of these strategic actions are currently being addressed through the existing State of Michigan AIS Core Team coordinated by the WRD, which currently has short-term funding through a GLRI grant at 5 or more FTEs (~$750,000/year). The AIS Core Team consists of the MDEQ's WRD and OGL; MDNR's FD, WLD, LED, and PRD; MDARD; and MDOT.***

4 PROGRAM MONITORING AND EVALUATION

The SMP and program will be evaluated at least every two years, as resources allow, by issuing a report similar in format to Appendix B (Accomplishments) of this SMP. This report will be compiled by the AIS Core Team (see Section 1.2 for more information). The report will identify program actions and activities and their associated lead organization, cooperators, status, and comments. Issues affecting progress in implementing this plan will also be identified in this report, including how other physical, chemical, and biological stressors are affecting the effectiveness of management actions and the success of objectives. The Implementation Table in Section 3 will serve to guide the program monitoring and evaluation process as it includes predetermined measures of success for each strategic action identified within the SMP. The report will also include the status of new invasions (if known) and will describe new AIS as they are discovered (e.g., location, pathway of introduction, etc.), including prevention efforts, or the lack thereof, which failed to prevent the species from being introduced into Michigan. The SMP itself will be updated as needed and as resources allow to incorporate new information and to modify goals, objectives, and strategic actions.

5 RECOMMENDATIONS

The following represents a summary of the AIS priorities for Michigan. These are ongoing activities that should be continued and enhanced, newly initiated activities that have short-term funding, and unaddressed or minimally addressed activities that require attention. Priorities are based on the most pressing issues in Michigan and the Great Lakes basin; therefore, related strategic actions will be addressed accordingly in this iteration of the SMP. These priorities are consistent with the other documents used to inform the development of this SMP, including the GLWQA.

The recommendations listed below are categorized as overarching concepts that apply to all goals or ranked within three tiers of priorities. A detailed list of strategic actions organized by the goals, vector, and pathway is presented in Section 3, Implementation Table. Key strategic actions from the Implementation Table are listed at the end of each recommendation.

Overarching Recommendations That Apply to All SMP Goals:

- <u>Promote public/private collaboration to leverage expertise and resources as a mechanism to address Michigan's AIS priorities</u>. Collaborative efforts and partnerships from regional to local scales need to be continued and increased to maximize AIS prevention, EDRR, and management and control efforts. Support is needed to address many areas including local management efforts, research gaps, and BMPs. The newly established Michigan AIS Advisory Council, which is composed of a wide variety of members representing diverse interests, will enhance communication between partners as well as contribute recommendations regarding several of Michigan's priorities listed below. Key strategic actions: I.A.1 and I.A.4.

- <u>Continue and enhance state agency communication and coordination</u>. The newly established interdepartmental AIS Core Team, which is composed of representatives from each of the state agencies with environmental or natural resource responsibilities, experienced its first year of activities with notable improvements in communication and strategy among the departments and divisions. Key strategic actions: I.A.2 and I.A.3.

- <u>Continue and enhance information and education efforts</u>. A more coordinated and effective information and education plan with consistent messaging that prioritizes pathways and audiences, identifies available resources, and engages traditional media outlets as well as the emerging social media needs to be developed and implemented. Education and outreach efforts should address all SMP goals and multiple pathways. Key strategic actions: I.B.1-5.

- <u>Secure sustainable long-term funding for Michigan's AIS Program to ensure implementation of this SMP</u>. Historically, AIS prevention and control activities in Michigan have been limited or sporadic largely due to inadequate funding. In 2010 the State of Michigan received a significant

increase in funding from a federal GLRI grant to address priority AIS actions. This funding is short-term, and a reliable long-term funding source is needed. At a minimum, the AIS Program should be funded to implement the highest priority strategic actions identified in this SMP and to maintain the current level of effort. This minimal funding level would support several full-time employees in Michigan's AIS Core Team and provide a modest budget for projects. Additional funding would support projects (e.g., statewide AIS monitoring and grants).

In addition to long-term AIS Program funding, AIS activities need to be better integrated into existing organizational frameworks to ensure SMP implementation at some level regardless of funding. The funding estimates presented in this SMP are specific to state agencies. It should be recognized there are significant costs for the prevention and management of AIS to other partners including other agencies, industries, and citizens.

Michigan's AIS Advisory Council is tasked with making recommendations on AIS Program funding, which includes funding mechanisms for the implementation of this SMP. The AIS Advisory Council will consider various scenarios ranging from maintaining the current level of effort to an enhanced program that could include AIS management and control grants; additional prevention, education and outreach, and enforcement components; and EDRR funds. Key strategic actions: I.F.1-3 and XII.G.1-3.

The goals of this SMP are designed to address different stages of AIS invasion: the introduction of AIS transported from water bodies outside of Michigan waters; the dispersal of established, reproducing AIS populations in Michigan to other water bodies within the state; and the colonization of AIS populations within water bodies, including the harmful effects resulting from colonization. All four of the SMP goals: (1) prevent new AIS introductions, (2) limit the dispersal of AIS, (3) develop EDRR capacity for new AIS invasions, and (4) manage and control AIS, are important to protect and enhance Michigan's natural resources; therefore, strategic actions for each of these goals are included in this SMP. However, the unpredictable, unanticipated, long-lasting, and costly nature of effects from AIS highlights the importance of having prevention as a top priority. EDRR to new AIS invasions occurs during the brief window after introduction where the opportunity exists to stop the permanent establishment of a new AIS population. Intervention through EDRR is a critical strategy for preventing the establishment of new AIS populations; therefore, EDRR is justified as a secondary priority. Priorities listed here are focused on the broad goal or the prevention of AIS via pathways. By nature, this approach includes all taxa (i.e. plants, animals, and other organisms).

Michigan Tier 1 AIS Priorities:

- <u>Prevent the introduction of AIS through canals and waterways, specifically Asian carp through the CAWS.</u>
  Continue existing efforts to expedite federal action on the hydrologic separation of the Great Lakes and Mississippi River basins, especially at the CAWS. Key strategic actions: VII.A.3.

- <u>Prevent the introduction of AIS through ballast water discharges</u>.
  Continue existing efforts to prevent AIS via ballast water from oceangoing vessels through Michigan's state ballast water discharge permit, influence ballast water regulations on the federal level to ensure a protective national standard, and coordinate with Great Lakes states and provinces. Key strategic actions: II.A.2, II.A.3, II.C.1, and II.C.2.

- <u>Prevent the introduction of AIS through OIT.</u>
  Significant progress has been made to reduce disease and dispersal of invasive species through transmission and sale of bait fish and aquaculture. However, large scale efforts to prevent AIS via this vector have been limited by the lack of funding to implement existing laws and regulations and to address more diffuse trade pathways such as internet and pet shop sales. Enhanced efforts to address OIT are needed, including developing and implementing a science-based risk assessment process to inform the prohibited and restricted species lists (Part 413 of the NREPA) or to develop lists of permitted species. At the same time, growth and economic viability of

aquatic livestock operations must also be considered. Key strategic actions: IX.A.3, IX.A.5, IX.B.2, and IX.B.2.

Michigan Tier 2 AIS Priorities:

- Develop capacity for EDRR activities, including monitoring and detailed response planning, coordinated at regional and state scales.
  Existing public and private EDRR efforts, including a current state project funded by a three-year grant through the federal GLRI, are patchy and largely focused on certain aquatic plants. Additional regional efforts focused specifically on Asian carp are also underway. These efforts should be continued, enhanced, and expanded to other taxa. In addition to supporting EDRR activities, a successful monitoring program can demonstrate the effectiveness or limitations of our current prevention and control activities, identify new or previously unknown vectors of AIS, and increase our ability to predict new invasive threats and their potential sources. The currently limited state efforts should be expanded and coordinated using existing field staff and all available external partners. Long-term support and scientifically defensible methodologies are needed. Key strategic actions: XII.B.2, XII.B.3, XII.C, and XII.D.

Michigan Tier 3 AIS Priorities:

- Support AIS management and control efforts.
  Often, the management and control of AIS may be undertaken and funded by local governmental agencies, NGOs, or private property owners. Technical assistance and the development of BMPs for AIS management and control are needed. Key strategic actions: XIII.B.1 and XIII.C.5.

6 REFERENCES

Austin, J. C., S. Anderson, P. N. Courant, and R. E. Litan. 2007. America's North Coast. A Benefit Cost Analysis of a Program to Protect and Restore Great Lakes. Washington, DC: Brookings Institution.

Bondra, J. 2011. Personal communication with Joe Bondra, President, Cygnet Enterprises Inc., Flint, MI, on November 11, 2011.

Burgiel, S.W. and A.A. Muir. 2010. Invasive Species, Climate Change and Ecosystem-Based Adaptation: Addressing Multiple Drivers of Global Change. Global Invasive Species Programme (GISP), Washington, DC, United States, and Nairobi, Kenya.

Dextrase A. and N.E. Mandrak. 2005. Impacts of invasive alien species on freshwater fauna at risk in Canada. Biol. Invasions. 2005; 8:13–24.

Drake, J.M. and D.M. Lodge. 2007. Hull fouling is a risk factor for intercontinental species exchange in aquatic ecosystems. Journal of Aquatic Invasions 2 (2): 121-131.

Drury, K.L.S., and J.D. Rothlisberger. 2008. Offense and defense in landscape-level invasion control. Oikos 117(2): 182-190.

Dupre, S. 2011. An Assessment of Early Detection Monitoring and Risk Assessments for Aquatic Invasive Species in the Great Lakes-St. Lawrence Basin. Prepared for the IJC Work Group on Aquatic Invasive Species Rapid Response.

Fisheries and Oceans Canada. 2008. Centre of Expertise for Aquatic Risk Assessment Web site: http://www.dfo-mpo.gc.ca/science/coe-cde/ceara/index_e.htm. Accessed January 2009.

Fuller, P. L., L. G. Nico, and J. D. Williams. 1999. Nonindigenous Fishes Introduced into Inland Waters of the United States. American Fisheries Society, Special Publication 27, Bethesda, MD.

Glassner-Shwayder, K. 1996. A Model Comprehensive State Management Plan for the Prevention and Control of Nonindigenous Aquatic Nuisance Species: A Report to the Great Lakes States. Environmental Quality and Resource Management Program, Great Lakes Commission.

Goniea, T. 2011. Personal communication with Tom Goniea, MDNR, Fisheries Division, September 9, 2011, and a 2010 Commercial Bait Harvest Summary presentation.

GLC. 2007. Great Lakes Recreational Boating's Economic Punch. Available at: http://www.glc.org/recboat/pdf/rec-boating-final-small.pdf

GLC. 2011. Draft Strategic Framework for the Management and Control of Invasive Phragmites in Michigan.

GLRC. 2005. Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes.

Government Accountability Office. 2005. Federal Executive Order 13112 of February 3, 1999: Invasive Species GAO, 2005. Invasive Species; Progress and Challenges in Preventing Introduction into U.S. Waters via the Ballast Water in Ships. U.S. Government Accountability Office. GAO-05-1026T.

Great Lakes Environmental Research Laboratory. 2009. Aquatic Invasive Species Web site. Available at: http://www.glerl.noaa.gov/res/Programs/ais/. Accessed March 18, 2009.

Grigorovich, I.A., R.I. Colautti, E.L. Mills, K. Holeck, A.G. Ballert, and H.J. MacIsaac. 2003. Ballast-mediated animal introductions in the Laurentian Great Lakes: retrospective and prospective analyses. Can. J. Fish. Aquat. Sci. 60: 740-756.

Gunderson, J.L. and R.E. Kinnunen. 2002. The HACCP approach to prevent the spread of aquatic nuisance species by aquaculture and baitfish operations. In R.E. Kinnunen, editor. Environmental Strategies for Aquaculture Symposium Proceedings (December 2000). 62nd Midwest Fish and Wildlife Conference, Minneapolis, MN. NCRAC CD Series #101, NCRAC Publications Office, Iowa State University, Ames, IA.

Gunderson, J.L. and R.E. Kinnunen. 2004. Aquatic nuisance species-Hazard analysis and critical control point training curriculum. Second Edition. Michigan Sea Grant Publication No. MSG-00-400.

Hall, R., J.L. Tank, and M.F. Dybdahl. 2003. Exotic snails dominate nitrogen and carbon cycling in a highly productive stream. Frontiers in Ecology and the Environment 1(8):407-411.

Hallengraeff, G. M. and C. Bolch. 1992. Transport of diatom and dinoflagellate resting spores in ships' ballast water: implications for plankton biogeography and aquaculture. Journal of Plankton Research 14:1067-1084.

Hilt, Amy. 2000. Aquatic nuisance species control policy for Fisheries Division field surveys. Chapter 24 *in* Schneider, James C. (ed.) 2000. Manual of fisheries survey methods II: with periodic updates. MDNR, Fisheries Special Report 25, Ann Arbor, MI.

Hnath, J. 1993. Great Lakes fish disease control policy and model program. Great Lakes Fishery Commission, Special Publication 93-1. 53 pages.

Holeck, K., E.L. Mills, H.J. MacIsaac, M. Dochoda, R.I. Colautti, and A. Ricciardi. 2004. Bridging troubled waters: understanding links between biological invasions, transoceanic shipping, and other entry vectors in the Laurentian Great Lakes. BioScience 10: 919-929.

Hydrilla Task Force. 2006. Draft Rapid Response to New Aquatic Invasive Species in Michigan; Hydrilla verticillata; A Case Study. Prepared for Michigan's Aquatic Nuisance Species Council.

IJC. 2011. Great Lakes Water Quality Agreement: 2009–11 Priority Cycle Report on Binational Aquatic Invasive Species Rapid Response. Prepared by the Aquatic Invasive Species Rapid Response Work Group for the IJC. Special Publication 2011–06, Windsor, Ontario, Canada.

Invasive Species Advisory Committee. 2006. Invasive Species Definition Clarification and Guidance White Paper. Submitted by the Definitions Subcommittee of the Invasive Species Advisory Committee. April 27, 2006.

Kelly, D.W., G.A. Lamberti, and H.J. MacIsaac. 2009. The Laurentian Great Lakes as a case study of biological invasion. Pp. 205-225. In: Bioeconomics of Invasive Species. R.P. Keller, D.M. Lodge, M.A. Lewis, and J.F. Shogren, editors. Oxford University Press.

Lake Superior Binational Program. 2010. Lake Superior Aquatic Invasive Species Complete Prevention Plan. Prepared by the Lake Superior Binational Program Lake Superior Work Group. September 14, 2010 draft. Available at: http://www.epa.gov/glnpo/lakesuperior/index.html.

Lodge, D. and D. Finnoff. 2008. Invasive Species in the Great Lakes: Costing Us Our Future. Annual Losses to Great Lakes Region by Ship-Born Invasive Species at Least $200 Million. Preliminary Research Results. Available at: http://www.glu.org/fr/node/208. Accessed December 29, 2011.

Lodge, D.M., S. Williams, H. MacIsaac, K. Hayes, B. Leung, S. Reichard, R.N. Mack, P. B. Moyle, M. Smith, D.A. Andow, J. T. Carlton, and A. McMichael. 2006. Biological invasions: recommendations for U.S. policy and management. Ecological Applications 16:2035-2054.

Lovell, S. J., S.F. Stone, and L. Fernandez. 2005. The Economic Impacts of Aquatic Invasive Species: A Review of the Literature. Agricultural and Resource Economics Review 35(1): 195-208.

Maki, K. and S. Galatowitsch. 2004. Movement of invasive aquatic plants into Minnesota (USA) through horticultural trade. Biological Conservation 118:389-396.

MDNR. 2011a. Quality Assurance Project Plan for Mounting a Response to New Aquatic Invaders, Revised March 14, 2011; Plan document for Grant Number EPA R5-GL2010-1. MDNR, Wildlife Division, P.O. Box 30444, Lansing, MI, 48909, USA. Uncirculated project planning document, used by project team members.

MDNR. 2011b. Natural Resources Boost Michigan's Economy Web site. Available at: http://www.michigan.gov/dnr/0,1607,7-153-38948-121641--,00.html. Accessed August 28, 2011.

MDNR. 2012. Proposed 2010 Plan for the Prevention, Detection, Assessment, and Management of Asian Carps in Michigan Waters. Fisheries Division Special Report 60. Original released October 2010; revised May 2012.

Mills, E.L., J.H. Leach, J.T. Carlton, and C.L. Secor. 1993. Exotic Species in the Great Lakes: A History of Biotic Crises and Anthropogenic Introductions. Journal of Great Lakes Research. 19(1):1-54.

Mills, E.L., J.H. Leach, J.T. Carlton, and C.L. Secor. 1994. Exotic Species and the Integrity of the Great Lakes. BioScience. Vol. 44, No. 10, pp. 666-676.

Minnesota Sea Grant. 2011. Aquatic Invasive Species – Hazard Analysis and Critical Control Point Web site. Available at: http://www.seagrant.umn.edu/ais/haccp. Accessed December 29, 2011.

Molner, J.L., R. Gambosa, C. Revenga, and M. Spalding. 2008. Assessing the global threat of invasive species to marine biodiversity. Front Ecol Environ 6(9): 485-492.

National Oceanic and Atmospheric Administration. 2011. National Center for Research on Aquatic Invasive Species, Great Lakes Environmental Research Laboratory: Great Lakes Aquatic Nonindigenous Species Information System. Accessed May 2011. www.glerl.noaa.gov/res/Programs/glansis/glansis.html.

National Research Council. 2011. Assessing the relationship between propugule pressure an invasion risk in ballast water. National Academies Press. 123 pp.

NPS. 2008a. Isle Royale National Park News Release. Available at: http://www.nps.gov/isro/upload/News%20Release%20bait%20and%20boats%20April_21_08.doc. Accessed December 29, 2011.

NPS. 2008b. Press Release: Emergency Restrictions Regarding VHS. Available at: http://www.nps.gov/piro/parkmgmt/vhs-restrictions.htm. Accessed December 29, 2011.

OGL. 1996. Nonindigenous Aquatic Nuisance Species State Management Plan. Michigan Department of Environmental Quality.

OGL. 2002. Michigan's Aquatic Nuisance Species State Management Plan Update: Prevention and Control in Michigan Waters. Michigan Department of Environmental Quality.

OGL. 2009. Michigan Great Lakes Plan: Our Path to Protect, Restore, and Sustain Michigan's Natural Treasures. Michigan Department of Environmental Quality.

Olson, A., J. Goen, and N. Lerner. 2000. Washington Sea Grant booklet – Handling and Disposal of Non-Native Aquatic Species and Their Packaging. Publication WSG-MR 00-01. Available at: http://www.wsg.washington.edu/communications/online/handling.pdf.

Omernik, J. and A. Gallant. 1988. Ecoregions of the Upper Midwest States. USEPA, Envir. Res. Lab. Publication #EPA/600/3-88/037.

Pimentel, D., L. Lach, and R. Zuniga. 2000. Environmental and economic costs of nonindigenous species in the United States. Biol Sci 50:53–65.

Pimentel, D. 2005. Aquatic nuisance species in the New York State Canal and Hudson River Systems and the Great Lakes Basin: An economic and environmental assessment. Environmental Management 35 (5): 692-701.

Plumb, J.A. and L.A. Hanson. 2011. Health maintenance and prinicipal microbial diseases of cultured fishes, 3rd Edition. Wiley-Blackwell Publishing, Ames, IA.

Reid, D.M. and J.T. Carlton. 1997. Shipping study 1-A: A study of the introduction of aquatic nuisance species by vessels entering the Great Lakes and Canadian waters adjacent to the United States. Final Report to U.S. Dept. of Transportation and U.S. Coast Guard. Report No. CG-D-17-97. 86 pp.

Ricciardi, A. 2001. Facilitative Interactions Among Aquatic Invaders: Is an "Invasional Meltdown" Occurring in the Great Lakes? Canadian Journal of Fisheries and Aquatic Sciences. 58:2513-2525.

Ricciardi A. 2006. Patterns of invasion in the Laurentian Great Lakes in relation to changes in vector activity. Divers. Distrib. 12, 425–433.

Richards, D., L. Cazier, and G. Lester. 2001. Spatial distribution of three snail species including the invader *Potamopyrgus antipodarum* in a freshwater spring. Western North American Naturalist 1(3):375-380.

Rosaen, A.L., E.A. Grover, C.W. Spencer. 2012. The Costs of Aquatic Invasive Species to the Great Lakes States. Anderson Economic Group LLC, 1555 Watertower Place, Suite 100, East Lansing, MI 48823. http://www.AndersonEconomicGroup.com

Rothlisberger, J.D., D.C. Finnoff, R.M. Cooke, and D.M. Lodge. 2012. Ship-Borne Nonindigenous Species Diminish Great Lakes Ecosystem Services. Ecosystems, Online First™. Available at: http://www.springerlink.com/content/k241g07796330286/fulltext.pdf. Accessed March 13, 2012.

Sala, O., F.S. Chapin, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kinzig, R. Leemans, D.M. Lodge, H.A. Mooney, M. Oesterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker, D.H. Wall. 2000. Biodiversity-global diversity scenarios for the year 2100. Science, Vol. 287, No. 5459, pp. 1770-1774.

Severinghaus, L.L., and L. Chi. 1999. Prayer animal release in Taiwan. Biological Conservation 89:301-304.

Smithsonian Environmental Research Center. 2004. Hull fouling. Available at: http://www.serc.si.edu/labs/marine_invasions/vector_ecology/fouling.jsp. Accessed December 29, 2011.

Sommers, L.M. (ed). 1977. Atlas of Michigan. Michigan State University Press.

Suiter, K. and S. Sferrazza. 2007. Published in G.W. Witmer, W.C. Pitt, and K.A. Fagerstone, editors. 2007. Managing vertebrate invasive species: proceedings of an international symposium. USDA/APHIS Wildlife Services, National Wildlife Research Center, Fort Collins, CO, USA.

Sylvester, F. and H.J. MacIsaac. 2010. Is vessel hull fouling an invasion threat to the Great Lakes? Diversity and Distributions, 16: 132-143.

United States Department of the Interior. 2011. 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Fish and Wildlife Service, U.S. Department of Commerce, U.S. Census Bureau.

USACE. 2006. St. Marys River. Available at: http://www.lre.usace.army.mil/greatlakes/hh/outflows/discharge_measurements/st_marys_river/. Accessed December 29, 2011.

USEPA. 2005. Estimating the Economic Impacts of Aquatic Invasive Species. Presentation at the 14th International Conference on Aquatic Invasive Species. Key Biscayne, FL, May 14-16, 2006. www.icais.org/pdf/2006ppt/Lovell_Sabrina.pdf

USEPA. 2008. Climate Change and Aquatic Invasive Species (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/014. Available at: http://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=188305#Download. Accessed March 8, 2012.

USEPA. 2011. Web page - Water: Habitat Protection: Invasive Species. Available at: http://www.epa.gov/owow/invasive_species/. Accessed August 2011.

USFWS. 2006. Alaska Region. Invasive Species Pathways. Available at: http://alaska.fws.gov/fisheries/invasive/pathways.htm. Accessed February 9, 2012.

USFWS, 2007. Surveillance for Ruffe in the Great Lakes. National Fish and Wildlife Conservation Office. Available at: http://www.fws.gov/midwest/ashland/Ruffe/surv_07.html. Accessed April 14, 2009.

Vaccaro, L. and J. Read. 2011. Vital to Our Nation's Economy: Great Lakes Jobs 2011 Report. Michigan Sea Grant.

Vaccaro, L., D. Scavia, D. Sivaraman, and B. Sederberg. 2009. Michigan's Economic Vitality: The Benefits of Restoring the Great Lakes. Michigan Sea Grant.

Wilcove, D.S., D. Rothstein, J. Bubow, A. Phillips, E. Losos. 1998. Quantifying threats to imperiled species in the United States. Bioscience 48 (8), 607-615.

Wisconsin Sea Grant. 2010. Funded Projects: 2010-2012 Directory of People and Projects. Available at: http://www.seagrant.wisc.edu/home/Portals/0/Files/Research%20Projects/10-12_UWSG_ProgramDirectory.pdf. Accessed March 13, 2012.

Zaranko, D., D. Farara, and F. Thompson. 1997. Another exotic mollusc in the Laurentian Great Lakes: the New Zealand native *Potamopyrgus antipodarum* (Gray 1843) (Gastropoda, Hydrobiidae). Canadian Journal of Fisheries and Aquatic Sciences 54:809-814.