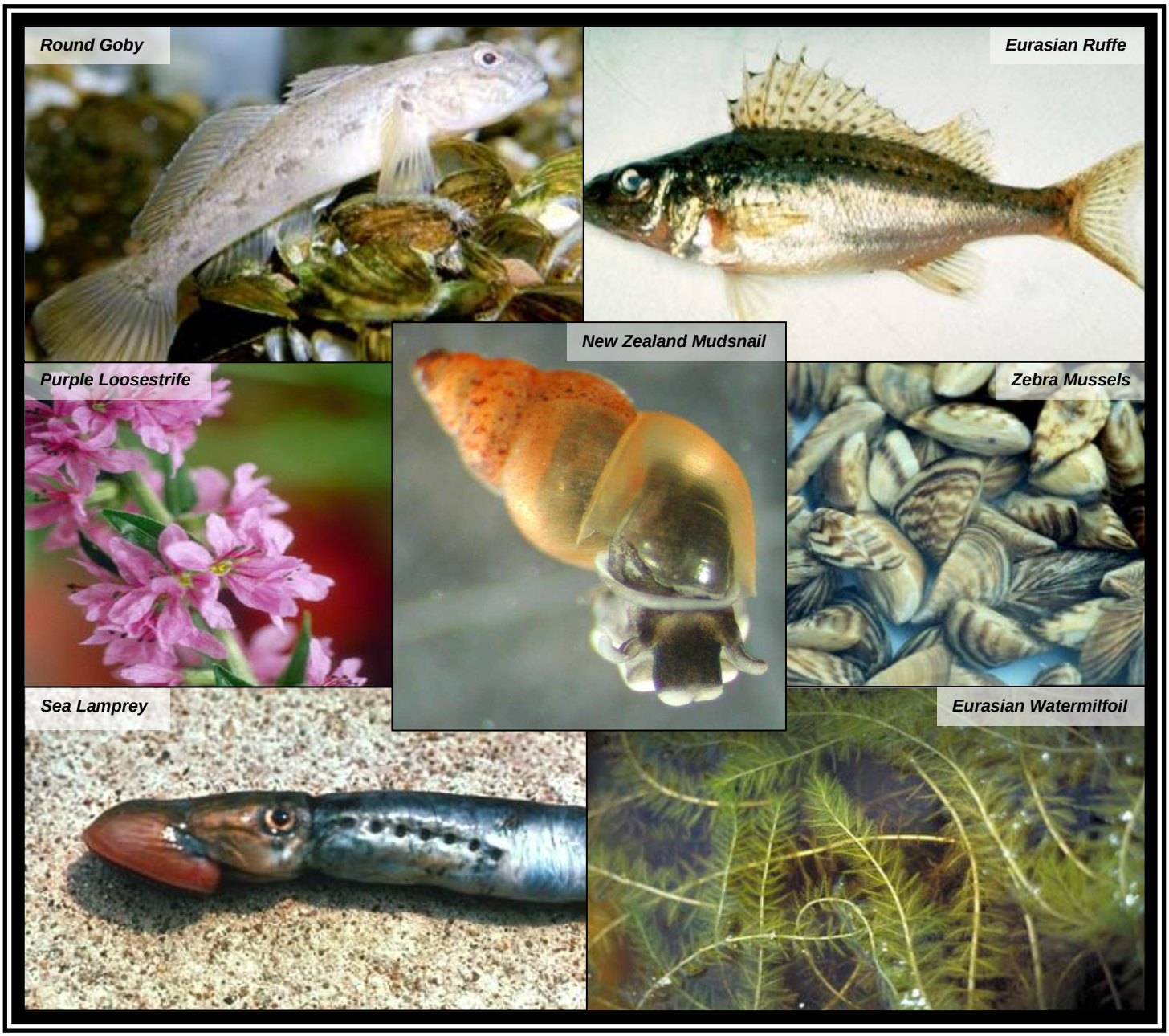
Lake Superior
Binational Program

Lake Superior
Aquatic Invasive Species
Complete Prevention Plan



Prepared by
The Lake Superior Work Group of the
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Lake Superior Aquatic Invasive Species Complete Prevention Plan
Note to Reader
January 2014

The Lake Superior Aquatic Invasive Species Complete Prevention Plan (the Plan) is an expression of the best professional judgment of the members of the Lake Superior Task Force as to what is necessary to protect Lake Superior from new aquatic invasive species. The Plan is based on sound science and underwent extensive reviews, including an expert technical review involving external and agency experts, an agency review by agencies involved with Lake Superior, and a broad Great Lakes stakeholder review. The reviews generated a significant number of comments, which were taken under advisement and incorporated into the Plan, as appropriate.

The Plan identifies recommended actions to prevent new aquatic invasive species from entering Lake Superior. We agree with these recommendations and encourage all stakeholders to pursue implementation actions as well as to report progress. A commitment to seek implementation of the Plan's recommendations does not signify a commitment of resources to any specific action by any agency. Rather, it signifies a commitment to promote coordinated actions that will protect Lake Superior from the devastating effects of additional aquatic invasive species that can irrevocably harm the ecosystem.

The role of the Lake Superior Lakewide Action and Management Plan and Program will be to: set common goals consistent with the Great Lakes Water Quality Agreement; support local implementation; support public outreach and education; and report on current conditions, trends and progress. The success of the Plan and, thus, the protection of Lake Superior, will depend on the commitment from U.S. and Canadian agencies, organizations, stakeholders and jurisdictions.

A draft of the Plan has been available since 2010, and implementation of the recommended actions has been ongoing. While not all parts of the Plan have been updated since the draft was published, the pathways for introduction and the recommendations for preventing invasions remain relevant. The Plan is now considered finalized.

EXECUTIVE SUMMARY

Situated at the head of the Great Lakes St. Lawrence Seaway system, a 2,342 mile long (3,700 km) water navigation system connected to global trade, Lake Superior is at risk for continued invasion by aquatic invasive species (AIS), including plants, animals, and microscopic organisms. As of April 2010, 89 non-native aquatic species have been found in Lake Superior. These include Eurasian watermilfoil, sea lamprey, and most recently, the fish disease Viral Hemorrhagic Septicemia (VHS). AIS have caused devastating economic and ecosystem effects that impart significant losses to the region in the form of damage and control costs, degraded water quality, job losses, declining property values, compromised native species, decreased biodiversity, and other negative impacts.

This *Lake Superior Aquatic Invasive Species Complete Prevention Plan* **outlines recommended actions that need to be newly implemented, in addition to existing efforts, to prevent new aquatic invasive species from entering and becoming established in the Lake Superior ecosystem**.

Through the process of developing this plan, Canadian and U.S. government agencies involved in the Lake Superior Lakewide Action and Management Plan (LAMP) have consulted broadly and have developed recommendations for consideration by each jurisdiction. However, citizens, organizations and government agencies in both Canada and the United States need to work together to implement the recommended actions and ensure that protecting Lake Superior from new invasive species is a top priority for all. The Lake Superior LAMP will utilize an adaptive management approach to monitoring implementation progress and overall effectiveness of this prevention plan.

Key recommended actions for the United States and Canada include:

- Implement compatible, federal regulatory regimes for ballast water discharge that are protective of the Great Lakes for both the U.S. and Canada.
- Support the development, testing and implementation of effective ballast treatment systems that meet the operational characteristics of Great Lakes ships.
- Establish federal screening processes for organisms in trade to classify species into three lists: prohibited, permitted, and conditionally prohibited/permitted.
    - Establish an immediate moratorium on the trade of prohibited species.
    - Consider the concept of a "Certified Pathogen-Free through Raising from Seed" category for plants sold through garden centers and nurseries.
    - Expand or implement education programs to increase consumer awareness of the risk of AIS.
- Require permits for shoreline restoration projects, which identify AIS introduction issues and include best management practices and restrictions that minimize the potential for introducing invasive species.
    - Implement education programs to raise awareness of the issue and promote compliance with prevention actions among contractors and residents.
- Ensure that existing laws prohibiting the sale of invasive species are enforced for on-line and mail order purchases of aquatic plants.

- To prevent the illegal transport of bait across the U.S./Canadian border and on shared waters, ensure effective education and prevention efforts at border crossings and at retail bait shops, and conduct monitoring to gauge the effectiveness of such efforts.
- Make AIS prevention education, regulation, and enforcement a priority in all Lake Superior jurisdictions, and implement prevention approaches that target specific audiences (e.g., boaters, anglers, professional fishing guides, plant nurseries).
- Build capacity for education and enforcement efforts within local communities by providing outreach products that can be tailored for local use, and coordinate consistent messaging across jurisdictions.
- Explore options for a broad range of prevention measures at public boat launches.
- Review and adjust policies for the operation of the locks at Sault Ste. Marie to include best management practices that effectively prevent fish from passing through the locks, including closing the upper and lower gates when not in use and the use of in-stream barriers or deterrent technologies, if necessary.
- Investigate options to achieve ecological separation of the Great Lakes and Mississippi River watersheds to protect the Great Lakes from the invasion of Asian carp.
    - Until ecological separation is achieved, maintain the electric barriers in the Chicago Sanitary and Ship Canal at optimum conditions and ensure their continued operation.
    - Establish structural measures to prevent the inadvertent introduction of Asian carp from floodwaters of the Des Plaines River into the Chicago Sanitary and Ship Canal.
- Adapt invasive species management to the challenge of a changing climate – monitor ecosystem changes, coordinate information resources, and engage in further research.

ACKNOWLEDGEMENTS

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LIST OF ACRONYMS

AIS	Aquatic Invasive Species
AIS-HACCP	Aquatic Invasive Species-Hazard Analysis and Critical Control Point program
ANS	Aquatic Nuisance Species
APHIS	Animal and Plant Health Inspection Service
BMP	Best Management Practice
BOB	Ballast on Board
BWE	Ballast Water Exchange
BWM	Ballast Water Management
BWMS	Ballast Water Management Systems
BWWG	Ballast Water Working Group
CAISN	Canadian Aquatic Invasive Species Network
Cal-IPC	California Invasive Plant Council
CEARA	Centre of Expertise for Aquatic Risk Assessment
CEC	North American Commission for Environmental Cooperation
CFIA	Canadian Food Inspection Agency
COA	Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem
COTP	Captain of the Port
CWA	Clean Water Act
DNR	Department of Natural Resources
DOD	Department of Defense
DPEIS	Draft Programmatic Environmental Impact Statement
EEZ	Exclusive Economic Zone
GLANSIS	Great Lakes Aquatic Nonindigenous Species Information System
GLERL	Great Lakes Environmental Research Laboratory
GLIFWC	Great Lakes Indian Fish and Wildlife Commission
GLRC	Great Lakes Regional Collaboration
GLRI	Great Lakes Restoration Initiative
GLFC	Great Lakes Fishery Commission
GLWQA	Great Lakes Water Quality Agreement
IJC	International Joint Commission
IMO	International Maritime Organization
IN	Indiana
LAMP	Lakewide Action and Management Plan
MERC	Maryland Environmental Resource Center
MI	Michigan
MN	Minnesota
MN DNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
NANPCA	Nonindigenous Aquatic Nuisance Prevention and Control Act
NAS	National Academy of Sciences
NISA	National Invasive Species Act
NIOZ	Royal Netherlands Institute for Sea Research
NIVA	Norwegian Institute for Water Research

NOAA	National Oceanic and Atmospheric Administration
NOBOB	No Ballast on Board
NPDES	National Pollution Discharge Elimination System
NPRM	Notice of Proposed Rulemaking
OFAH	Ontario Federation of Anglers and Hunters
OMNR	Ontario Ministry of Natural Resources
SAC	Superior Aggregates Company
SOLEC	State of the Lakes Ecosystem Conference
TBT	Tributyl tin
UNDS	Uniform National Discharge Standards
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Service
VGP	Vessel General Permit
VHS	Viral Hemorrhagic Septicemia
WDNR	Wisconsin Department of Natural Resources
WI	Wisconsin

1.0 INTRODUCTION

The invasion of aquatic habitats by non-indigenous species, also known as non-native and exotic species, in the Lake Superior Basin can cause negative ecological and economic impacts and may cause harm to human health. A non-native species that becomes established, spreads widely and causes harm to an ecosystem is considered invasive. Aquatic invasive species (AIS) compete with native species for food and habitat, and can directly or indirectly kill native species, degrade habitat, and alter food webs. AIS can also have significant economic effects on waterfront property values, tourism, utilities, and other industries.

AIS may enter the lake through various human-assisted vectors[1] such as maritime commerce (e.g., ship ballast water and hull fouling), fishing and aquaculture, canals and diversions, the trade of live organisms, and tourism and development activities (CAISN 2009). Shipping has resulted in high levels of invasion in global temperate regions, including Lake Superior (Molner et al. 2008). A changing climate is likely to increase opportunities for non-native species to invade Lake Superior as warmer temperatures accelerate reproductive cycles and increase the likelihood of non-native species becoming established.

Actions taken to date to prevent the introduction of new AIS include regulatory and voluntary efforts at all levels. Many activities serve as models using innovative, strategic approaches. These include best management practices for the exchange of ballast water, followed more recently by ballast water regulations, and educational programs to increase awareness of the pathways to prevent new AIS associated with recreational activities and with aquatic invasive organisms in trade. Government agencies and others engaged in biological research perform ad hoc monitoring for existing and new AIS, and provide assessments of AIS management efforts. However, much remains to be done to protect Lake Superior from new introductions of AIS from around the world and from the other Great Lakes. This complete prevention plan proposes a comprehensive program of education, monitoring, and regulation (including inspection and enforcement) that integrates and augments previous prevention efforts while recognizing the importance of shipping, port operations, and trade and commerce to both the Lake Superior region and the American and Canadian economies.

Scope of Organisms Covered Under this Plan

This aquatic invasive species prevention plan for Lake Superior considers non-native, aquatic biological organisms including pathogens, parasites, and algae that may become invasive in Lake Superior and cause harm to the ecosystem, environment, economy, or human health. Although this plan initially focuses on aquatic species, the vector/pathway closure approach can be applied to terrestrial species, and in fact, many of the prevention actions for aquatic species also work well for terrestrial species.

1.1 PURPOSE OF THE PLAN

Canada and the U.S. share responsibility for protecting Lake Superior from the introduction of new AIS. This *Lake Superior Aquatic Invasive Species Complete Prevention Plan* **outlines**

[1] **Vectors** are the modes of transmission, and pathways are the routes taken.

actions recommended by the Lake Superior Work Group that need to be implemented, in addition to existing efforts, in order to close existing pathways on both sides of the border and prevent new aquatic invasive species from entering and becoming established in the Lake Superior ecosystem. The plan aims to prevent both primary introductions and the secondary spread of AIS to Lake Superior. Similar to the Lake Superior Binational Program's[2] designation of Lake Superior as a zero discharge demonstration area for toxic substances, this prevention plan adopts a goal of zero invasions of new AIS in Lake Superior. Commitment and coordination between Canada (Ontario) and the U.S. are needed to effectively implement the provisions of the plan and ensure coordinated, commensurate action on both sides of the border.

While the main objective of the plan is to prevent the introduction and spread of AIS to Lake Superior, it is important to emphasize the importance of protecting inland waterways in the Lake Superior Basin. Recent research has demonstrated that preventing the spread of invasive organisms away from invaded sites (i.e., containment) is the most effective way to reduce the likelihood of new invasions at the landscape scale (Drury and Rothlisberger, 2008). The prevention actions recommended in this plan should be effective in preventing both the entry of organisms into Lake Superior and the transfer of organisms out of Lake Superior into inland waterways.

In addition to protecting Lake Superior and waterways in the basin, the plan supports related invasive species efforts by the U.S. and Canadian federal governments. The plan assists Canada in complying with internal obligations, such as implementing an *Invasive Alien Species Strategy for Canada,* which aims to minimize the risk of invasive species to the environment, economy, and society, and to protect environmental values such as biodiversity and sustainability. In addition, the Canadian Council of Fisheries and Aquaculture Ministers developed an action plan and task force to address the threat of AIS through the *Canadian Action Plan to Address the Threat of Aquatic Invasive Species.* The Canadian action plan recognizes that one of the most effective ways of controlling AIS is preventing new species from being introduced and outlines a national approach for managing AIS in Canada (Canadian Council of Fisheries and Aquaculture Ministers 2004). Fisheries and Oceans Canada is the lead agency for managing AIS in Canada. In the U.S., the plan supports efforts to address invasive species under the federal interagency Great Lakes Restoration Initiative (GLRI) led by the United States Environmental Protection Agency (USEPA).[3]

1.2 HISTORY OF THE PLAN

Lake Superior has been the focus of special protection and restoration initiatives for many years, in recognition of its unique status among freshwater lakes in the world. This special status has been emphasized in the Lake Superior Lakewide Action and Management Plan (LAMP) and the

[2] A *Binational Program to Restore and Protect the Lake Superior Basin* began in 1991 through an agreement among the federal governments of Canada and the United States, tribal governments, the Province of Ontario, and the States of Michigan, Minnesota, and Wisconsin. The administrative framework through which these jurisdictions jointly act on the commitments identified in the agreement is known as the Lake Superior Binational Program, which is implemented through the Lake Superior LaMP. The Program identifies two major areas of activity: A Zero Discharge Demonstration Project and the broader ecosystem program.

[3] USEPA. Great Lakes Restoration Initiative. 2010 Great Lakes Restoration Initiative Summary of Proposed Programs and Projects. Available at http://www.epa.gov/greatlakes/glri/.

Lake Superior Binational Program since their inception. The Lake Superior Task Force[4] conceived the idea of a *Lake Superior Aquatic Invasive Species Complete Prevention Plan* in 2006 and formed a Prevention Plan Project Team that included state, provincial, and federal agencies. The project team established the use of a vector/pathway approach for the prevention of new AIS in Lake Superior. In 2007, the project team developed a concept map and outline to guide the drafting of the plan, which began in January 2008 with contractor support.

The *Lake Superior Aquatic Invasive Species Complete Prevention Plan* builds on a number of existing AIS prevention and control plans, as well as regulatory programs in the Great Lakes states, Canadian provinces, and U.S. and Canadian federal governments. These include programs documented in previous Lake Superior LaMP reports; the Great Lakes Regional Collaboration (GLRC) *Strategy to Restore and Protect the Great Lakes*; state, provincial, federal, and tribal management plans; and international, national, state, provincial, and local regulations.

In particular, the GLRC *Strategy to Restore and Protect the Great Lakes* was the culmination of a comprehensive effort to characterize environmental issues affecting the Great Lakes and to recommend options for restoring and protecting the Great Lakes. The efforts that went into the Strategy's recommendations for AIS laid the groundwork for the development of this AIS prevention plan for Lake Superior.

The GLRC emanated from Executive Order 13340 signed by President Bush in May 2004. The Order called for the USEPA to convene a "regional collaboration of national significance for the Great Lakes." A group comprised of the Great Lakes states, local communities, tribes, non-governmental organizations, and other stakeholders in the Great Lakes region was convened to form the GLRC. The GLRC developed a *Strategy to Restore and Protect the Great Lakes,* which was released on December 12, 2005 (GLRC 2005). The Strategy was developed by eight teams of subject-matter experts organized around priorities identified by the Council of Great Lakes Governors. The Strategy teams developed recommendations for action focusing on each priority area.

AIS is one priority area addressed in the December 2005 GLRC Strategy. The AIS Strategy Team developed recommendations for the highest priority actions that would achieve the greatest results within five years. Key recommendations for AIS in the GLRC Strategy include:

- Prevent AIS introductions by ships through ballast water and other means;
- Stop invasions of species through canals and waterways;
- Restrict trade in live organisms;
- Pass comprehensive federal AIS legislation;
- Implement a system of enhanced monitoring and ecological surveys to identify AIS invasions in the Great Lakes;[5]
- Establish a program for rapid response and management; and

[4] The Lake Superior Task Force is a steering committee comprised of senior Canadian and U.S. federal, provincial, tribal, and state representatives who make management decisions related to Lake Superior.

[5] Although monitoring for AIS invasions is a key recommendation of the GLRC Strategy, it is not included as a recommended action in the present prevention plan (see Section 5.3).

- Emphasize education and outreach on AIS introduction and prevention.

Canada has established the Centre of Expertise for Aquatic Risk Assessment (CEARA) through Fisheries and Oceans Canada. There is a great deal of uncertainty associated with AIS and the risk that each species has on overall ecosystem health. The primary role of CEARA is to help develop standards to be used in investigating these risks, and provide guidance based on the findings. The primary objectives and deliverables of CEARA are to (Fisheries and Oceans Canada 2008):

- Develop a national standard for conducting biological risk assessments of AIS;
- Educate practitioners on the risk assessment process;
- Develop a process for prioritizing risk assessment needs;
- Provide advice to headquarters on national priorities for risk assessments; and
- Coordinate and track progress of national risk assessments and ensure that deliverables are met.

In Canada, national policy direction is provided by *An Invasive Alien Species Strategy for Canada* to prevent new invasions, detect and respond to new invasive species, and manage established invasive species through eradication, containment and control. The Canadian Wildlife Service leads a national Invasive Alien Species Partnership Program to reduce the risk of invasive alien species and conserve ecosystems. Partnership projects are funded to empower grass roots-level work, engage multiple stakeholders and inform Canadians, thus also improving Canadians' understanding and awareness of invasive species.

The *Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem* (COA) was drafted by the Canadian federal and Ontario provincial governments to restore, protect and conserve the Great Lakes Basin ecosystem in order to assist in achieving the vision of a healthy, prosperous, and sustainable basin ecosystem for present and future generations (Environment Canada 2007). In order to achieve this vision, the COA established a number of goals and commitments that focus on protecting and improving the quality of the Great Lakes Basin ecosystem through sustainable and preventative actions. Specifically, the COA established 11 commitments that are being implemented to reduce the threat of AIS to Great Lakes aquatic ecosystems and species (Annex 3, Goal 4). One of the commitments requires Canada to take actions aimed at 100% compliance with the Canadian Ballast Water Control and Management Regulations that came into effect in July 2007. The COA coordinates implementation of the *Canadian Action Plan to Address the Threat of Aquatic Invasive Species*, in cooperation with the government of Ontario, for actions specific to the Great Lakes. Completion of the *Lake Superior Aquatic Invasive Species Complete Prevention Plan* is a priority for COA in 2010-2011.

The Great Lakes Water Quality Agreement (GLWQA) is a binational agreement that expresses Canada and the United States' commitment to restore and maintain the chemical, physical and biological integrity of the Great Lakes Basin ecosystem. On February 12, 2013, the Governments of Canada and the United States ratified the GLWQA of 2012. Annex 6 of the GLWQA calls for a binational prevention-based approach to eliminating new introductions of AIS. Although development of this AIS prevention plan for Lake Superior preceded the revised GLWQA of 2012, the plan is consistent with the intentions of the GLWQA AIS Annex.

2.0 BACKGROUND ON AIS IN LAKE SUPERIOR

The impacts of AIS on ecosystems and society are wide-ranging, pervasive, and irreversible. As of April 2010, the list of known non-native aquatic species in Lake Superior had reached 89 species, according to Minnesota Sea Grant (Jensen 2010). Some of these species and their effects on the ecosystem and economy of the Lake Superior Basin are discussed in the following sections.

2.1 SPECIES

Included in the 89 non-native aquatic species that threaten the integrity of the Lake Superior ecosystem are fish, aquatic invertebrates, aquatic plants, and pathogens and parasites (Minnesota Sea Grant 2007). Several examples of AIS that have been introduced into the Lake Superior ecosystem are presented below.

- The **Eurasian ruffe** (*Gymnocephalus cernuus)* is a well-known example of a fish species that was first accidentally introduced via ballast water to the Great Lakes (and North America) in Duluth in 1986. It has subsequently spread to many parts of Lake Superior's southern and northern nearshore waters between Thunder Bay, Ontario, and the Tahquamenon River mouth in Whitefish Bay.
- The **round goby** (*Apollonia melanostomus*), a non-native fish thought to have been introduced through the ballast water of transoceanic vessels, displaces native fish and continues its range expansion. In 2008, round gobies were found at Marquette, as well as in three other places in Lake Superior.
- First introduced into Lake Erie in 1986, the **zebra mussel** (*Dreissena polymorpha*) quickly spread to all of the Great Lakes (Hebert et al. 1989). Zebra mussels were found in the Duluth-Superior Harbor in 1989, likely transported in ship ballast water.
- One **quagga mussel** (*Dreissena bugensis*), related to the zebra mussel, was found in the Duluth-Superior Harbor during 2005. Since then, quagga mussels appear to be thriving in the Duluth-Superior Harbor.
- **Rusty crayfish** (*Orconectes rusticus*) were discovered in the early 1990s in the lower Pigeon River, south of Thunder Bay, and have since spread along the shoreline to nearby neighboring tributaries. They were found in the Duluth-Superior Harbor in 1999. In 2007, they were found in the lower St. Marys River, the connecting channel between Lakes Superior and Huron.
- A substantial population of the **New Zealand mudsnail** (*Potamopyrgus antipodarum*) was discovered in Duluth-Superior Harbor in May 2006, a first for waters of Wisconsin and Minnesota. Mudsnails were found in the lower Great Lakes over a decade before their discovery in Lake Superior.

Rusty crayfish, Lake Superior. Photo credit: Minnesota Sea Grant, Jeff Gunderson. Courtesy of US EPA Great Lakes National Program Office

- **Eurasian watermilfoil** (*Myriophyllum spicatum)* is a submerged aquatic plant. Since being discovered in North America in the 1940s, it has invaded nearly every U.S. state and at least three Canadian provinces. Records from the Minnesota Department of Natural Resources indicate its presence in Lake Superior (Cook County, MN) beginning in 2006 (MN DNR 2007).
- The **spiny waterflea** (*Bythotrephes longimanus)*, a small predacious crustacean, was first discovered in Lake Huron in 1984 and gradually spread to other Great Lakes, reaching Lake Superior in 1987 (IN DNR 2005).
- After introduction into the U.S. in the 1800s in solid ballast, **purple loosestrife** (*Lythrum salicaria*) has spread to nearly every U.S. state and most Canadian provinces. The invasive perennial plant thrives in wetlands and shorelines throughout North America (GLIFWC 2008) and was intentionally introduced in Duluth, Minnesota, in 1907 as an ornamental plant (Minnesota Sea Grant 2008a).
- Native to the Atlantic Ocean, the **sea lamprey** (*Petromyzon marinus*), a jawless parasitic fish, was first observed in Lake Ontario in the 1830s and invaded Lake Erie in 1921, after modifications were made to the Welland Canal which altered drainage patterns (Mills et al. 1993). Sea lampreys subsequently spread throughout the Great Lakes, appearing in Lake Superior in 1938 (GLFC 2000).

Sea lamprey. Photo credit: Lee Emery, U.S. Fish and Wildlife Service

- The **alewife** (*Alosa pseudoharengus*), a fish native to the Atlantic coast, was discovered in Lake Ontario in 1873 and expanded into Lake Erie after improvements were made to the Welland Canal (Mills et al. 1993). Alewives reached Lake Superior by 1954 (IN DNR 2006).
- **Rainbow smelt** (*Osmerus mordax)* expanded into Lake Superior by 1930, 18 years after being introduced into Michigan's Crystal Lake as a food source for stocked salmon (WDNR 2004). The fish species was unintentionally spread to Lake Superior at Whitefish Bay through the locks at Sault St. Marie.

Non-native species continue to be introduced into Lake Superior from multiple pathways. In January 2010, Cornell University reported that investigators had positively identified the presence of Viral Hemorrhagic Septicemia (VHS, *Novirhabdovirus sp.*) in fish from four sites in Lake Superior.[6] The pathway of introduction is not clear, but possibilities include commercial ships and recreational boats from the lower Great Lakes, where VHS is known to have infected fish (Cornell University, 2010).

Recent research by the Mid-Continent Ecology Division of USEPA's National Health and Environmental Effects Research Laboratory in Duluth is demonstrating that species new to Lake Superior continue to be discovered in its tributaries and harbors. Prior to the institution of strict

[6] Fish from Superior Bay and St. Louis Bay, as well as Paradise and Skanee Bays in Michigan, tested positive for VHS.

ballast water management regulations in July 2006 (see Section 4.1.1), a new non-indigenous species was being discovered in the Great Lakes, on average, once every 28 weeks (Riccardi 2006; GLERL 2009).

2.2 ECOSYSTEM EFFECTS

Many Great Lakes researchers and managers consider AIS the single most important and immediate threat to Great Lakes ecosystems and their food webs (Lake Superior LaMP 2006). USEPA asserts that invasive species are the second-highest contributing factor to species extinction in aquatic environments worldwide (USEPA 2008a). The effects of AIS on an ecosystem can be devastating. Invasive species increase competition for food resources and living space, can physically and chemically modify aquatic habitats, can hybridize with native species and decrease biodiversity by crowding out native species. In fact, researchers consider AIS one of the primary threats to native biodiversity (Sala et al. 2000; Dextrase and Mandrak 2005). AIS thrive due to a lack of natural predators and high reproductive rates compared with native species, resulting in a shift in native species distribution and transformation of ecosystem structure and function (Office of Technology Assessment 1993).

Examples of the detrimental effects of AIS are prevalent among established species in Lake Superior. One of the most troubling examples is that of the sea lamprey, a parasitic jawless fish that has devastated native fish populations. The sea lamprey contributed to the collapse of Lake Superior lake trout populations in the mid-twentieth century, which had a dramatic effect on both the fish community and fisheries. Due to its successful predatory behavior—only one out of every seven fish attacked survive—the sea lamprey continues to have adverse effects on large fish species in the Great Lakes (GLFC 2000). While the control of sea lamprey through various means has resulted in positive results in Lake Superior, control efforts are not without negative impacts, such as killing native lamprey species (Great Lakes Wiki 2006).

Lampricide treatment, St. Louis River (near Duluth, Minnesota). Photo credit: US EPA Great Lakes National Program Office

An overabundance of AIS disrupts an ecosystem's balance through competition for limited resources, often resulting in reduced populations of native species. At one time Eurasian ruffe, an invasive fish species now found in river mouth and embayment habitats along the south shore of Lake Superior, outnumbered all other fish species combined in the Duluth-Superior Harbor (ANS Task Force 2005). Ruffe populations in the Duluth-Superior Harbor declined from a peak of approximately 8.5 million in 1995 to 2.5 million in 2004 (USGS unpublished data). The U.S. Geological Survey has not surveyed ruffe populations in the Duluth-Superior Harbor since 2004, but casual observations suggest that ruffe populations have increased in some areas of Lake Superior, notably Chequamegon Bay (Czypinski 2009). Ruffe displace native fish by competing for food and feeding on juvenile native species, such as yellow perch and walleye, in addition to being less favored by predators than their native counterparts (NOAA 2007).

Displacement of native species by invasive species adversely affects other organisms reliant upon native species for survival. Loss of native species results in a disproportionate abundance of AIS that can trigger a chain or cascade of events leading to significant changes in the abundance, distribution, and health of species supporting the food web (NWF 2004).

The spiny waterflea was first noted in Lake Superior in 1987. It competes with native zooplankton and juvenile fish for native zooplankton such as *Daphnia*. Due to its high reproductive rates and seasonal explosions in numbers, the spiny waterflea may alter the zooplankton community such that food resources for juvenile fish are reduced (Ontario Federation of Anglers & Hunters 2009). Smaller fishes have trouble feeding on the spiny waterflea because of the long tail spine. As a result, growth and survival rates of native fish species are affected (IN DNR 2005). The spiny waterflea has also had a significant impact on zooplankton biodiversity. Boudreau and Yan (2003) found a 30% decrease in biodiversity in Canadian Boreal Shield lakes invaded by the spiny waterflea.

Increased growth of weeds and algae is another negative impact of AIS facilitated by invasive zebra and quagga mussels. The mussels' filter feeding increases water clarity and light penetration, allowing aquatic plants and algae such as *Cladophora* to grow at greater depths (SOLEC 2008). Algal growths present aesthetic and odor problems when the algae and organisms trapped within wash up on the beach and begin to decay, generating a sewage-like smell and creating adequate conditions for bacterial growth (WDNR 2009a).

Scientists have hypothesized that zebra and quagga mussels also contribute to environmental conditions that prompt avian botulism outbreaks in the Great Lakes. Increased algal growth facilitated by the mussels' filtration of water may lead to anaerobic conditions necessary for the production of the bacterium that causes botulism (*Clostridium botulinum*) in the food eaten by fish. Quagga mussels may also filter the botulism toxin and transfer it up the food chain to predator fish. Outbreaks of avian botulism occur when birds and waterfowl consume poisoned fish, leading to significant losses of wildlife (Michigan Sea Grant 2007).

AIS also include bacteria and viruses, which can increase fish mortality. Recently, Great Lakes fisheries managers have expressed concern over the spread of VHS, a pathogen that infects a broad range of fish species, causing hemorrhage, anemia, and death (Cornell University, 2010). Agencies have instituted emergency regulations and management plans to retard the spread of the virus in the Great Lakes and inland. Lake Superior's Isle Royale National Park put emergency regulations in place regarding transport of fish bait into park waters and the cleaning of boats. Together, the U.S. National Park Service 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 instituted emergency restrictions to prevent the spread of VHS due to the imminent threat to park fishery resources (NPS 2008b).

2.3 ECONOMIC EFFECTS

In addition to the ecological effects, the economic impacts of AIS in Lake Superior include loss of recreational and commercial fishing opportunities, damage to infrastructure, and damage to boats and equipment. AIS can also have significant economic effects on waterfront property

values, tourism, utilities, and other industries. These economic losses are difficult to quantify in the Great Lakes. However, such losses have been estimated to be as high as $5 billion per year in 2005 (USD, representing both U.S. and Canadian waters); the commercial and sport fishing industries were the hardest hit, and damages and control costs were projected at an estimated $4.5 billion per year (USD; Pimentel 2005). Such impacts are attributable to the reduction of native fish populations, directly caused by competition for resources with invasive species.

Lodge and Finnoff (2008) estimated the impact of losses to the Great Lakes region from invasive species introduced through shipping. The authors estimated that over $200 million (USD) in lost economic benefit to the Great Lakes economy may result from reductions in commercial fishing, sport fishing, wildlife watching, and increased costs for raw water users.

The economics associated with AIS prevention and control can be staggering. For example, the Great Lakes Fishery Commission currently spends in excess of $20 million (USD) per year for control of the sea lamprey. The Canadian and U.S. governments have financially supported the Great Lakes Fishery Commission's sea lamprey control efforts for over 30 years (Fisheries and Oceans Canada 2008).

Zebra and quagga mussels, related invasive species found throughout the Great Lakes Basin, interfere with commercial fishing, recreational boating, sport fishing, and shipping by adhering to the hulls and motors of watercraft. The cost of removing the mussels from watercraft in the Great Lakes was estimated to be $19.5 million per year in 2005 (USD; Pimentel 2005). Moreover, zebra and quagga mussels clog intake pipes at electric power plants and water supply facilities, costing an additional estimated $480 million per year in expenditures related to damage and control. Great Lakes tourism suffered an estimated $500,000 annual loss in 2005 from the infestation of zebra and quagga mussels. For all activities combined, the result was an estimated total impact of $500 million per year in 2005 from zebra and quagga mussels alone within the Great Lakes Basin (both U.S. and Canadian waters; Pimentel 2005).

Zebra mussels have had a significant economic impact on the Great Lakes Basin. Photo credit: Amy Benson, U.S. Geological Survey

Invasive aquatic plants also impact the economic health of the Great Lakes Basin. Invasive plants such as the Eurasian watermilfoil, a vine-like submerged aquatic plant, form thick mats that interfere with recreational activities such as swimming, boating, fishing, and hunting (Minnesota Sea Grant 2009). The annual control cost of these types of invasive aquatic plants in U.S. and Canadian waters of the Great Lakes Basin was estimated to be $29 million in 2005 (USD; Pimentel 2005). Invasive plants can also negatively affect waterfront property values. A study completed by the University of New Hampshire in 2003 revealed that the invasion of watermilfoil along a shoreline may cause waterfront property values to decrease as much as 20 – 40% (Halstead et al. 2003). Corroborating the New Hampshire study, an analysis performed in

Vermont suggests that property values may decrease as much as $12,000 along shorelines infested with aquatic invasive plants (Varney 2004).

The cost of AIS reaches far beyond damage and control costs. Of particular concern is the effect of AIS on tribes and First Nations due to the risk to culturally significant subsistence species. Non-native species may contribute to the loss of tribal food sources or a reduction in native plants used in a variety of traditional life ways or medicinal and cultural practices. Decreasing fish harvests may impact market price and result in diminished consumer demand and job loss among commercial fisheries. Also, water quality is degraded in areas infested with invasive plants due to increased nutrient loading from excessive amounts of decaying organic matter, which can interfere with water treatment technology in drinking water supply areas. The decaying organic matter also causes depletion of oxygen and further degrades water quality. AIS, particularly zebra and quagga mussels, attach themselves to piers and other structures, compromising structural integrity and leading to costly removal or repair (State of Maine Land and Water Resources Council 2002).

3.0 VECTORS AND PATHWAYS FOR AIS IN LAKE SUPERIOR

The Lake Superior ecosystem and economy have been profoundly impacted by AIS (such as sea lamprey (*Petromyzon marinus*), rainbow smelt (*Osmerus mordax*), spiny waterflea (*Bythotrephes longimanus*), and Eurasian ruffe (*Gymnocephalus cernuus*)). The basin remains at risk for the introduction of new aquatic species through a number of open pathways (Figure 1). Lake Superior is somewhat isolated from new AIS spreading from the lower Great Lakes. This is primarily due to the constructed physical barriers (e.g., locks) between the lower Great Lakes and Lake Superior and the velocity of water flowing from Lake Superior into the St. Marys River at Sault Ste. Marie. These barriers consist of ship locks, hydropower stations and associated berms, and lift gates in the compensating works at the head of the St. Marys rapids. While these barriers impede the movement of mobile organisms from traveling upstream into Lake Superior, they are not complete barriers. Fish are commonly observed swimming in and out of the locks when lock doors are open. Two to five of the compensating gates are always open partway to supply water to the St. Marys rapids. Only the hydropower stations' outflows through elevated turbines are an effective barrier to upriver movement.

In addition, the cold, nutrient- and mineral-poor waters of Lake Superior inhibit survival and reproduction of many AIS; only the hardiest species survive (Grigorovich et al. 2003). However, the relatively richer, warmer waters of the ports and embayments around the lake provide environments conducive to AIS survival. It is in these areas where the effect of AIS can be devastating, especially to native species that utilize such areas as spawning and nursery habitats.

AIS may be introduced to Lake Superior through a number of different vectors and pathways. The most important pathway by which AIS have been introduced to Lake Superior was the shipping ballast water pathway, which continues to be a pathway of concern. A discussion of potential vectors and pathways for AIS in Lake Superior follows.

3.1 VECTOR AND PATHWAY DEFINITION

A vector is the physical means by which a non-indigenous species is transported to a new region, primarily by humans, whether deliberate or accidental. Within a vector, one or more pathways or routes of transfer exist by which an invasive species is transferred from one ecosystem to another.

Various vectors provide a mechanism through which AIS may enter the Lake Superior Basin. This prevention plan addresses potential AIS invasion into Lake Superior through eight vectors: maritime commerce; agency activities; organisms in trade; illegal activities; fishing and aquaculture; canals and water diversions; tourism and development; and water recreation. Figure 1 presents a concept map for various pathways of potential entry of AIS into Lake Superior. The following sections describe each pathway in detail. Other miscellaneous pathways that have the potential to introduce AIS to Lake Superior are not discussed here (such as commercial transportation (trucking) or reuse of equipment (e.g., discharge pipes) used in other aquatic environments).

The vectors and pathways presented in the following sections do not have risk ratings at this time.[7] While much is known about past introductions of AIS into Lake Superior, new regulations, educational programs, and other actions have had a positive effect on blocking some of those pathways. Risk, 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. The purpose of this plan is not to assign risk to pathways or to identify the most damaging species that may arrive. Rather, the plan'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 Lake Superior from new AIS.

Climate change is neither a vector nor a pathway of AIS introduction, but is considered a stressor that impacts the ability of a new species to become established (or survive) and expand its range. Climate change is altering ecosystem conditions, causing increased atmospheric carbon dioxide, modified precipitation patterns, increased water and atmospheric temperatures, and altered nitrogen distribution. Increased rainfall and flooding, for example, may facilitate the dispersal of invasive plant seeds by flotation. Increased water temperatures can provide more favorable conditions for 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 2007). For example, increasing water temperatures in Lake Superior have increased the breeding and feeding cycles of sea lampreys, resulting in larger lampreys that are more effective predators for a longer period of time each year (New York Times, 2010). This plan recommends actions that a) increase awareness of the increased risks of AIS introductions due to climate change and b) attempt to mitigate those risks.

[7] 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.

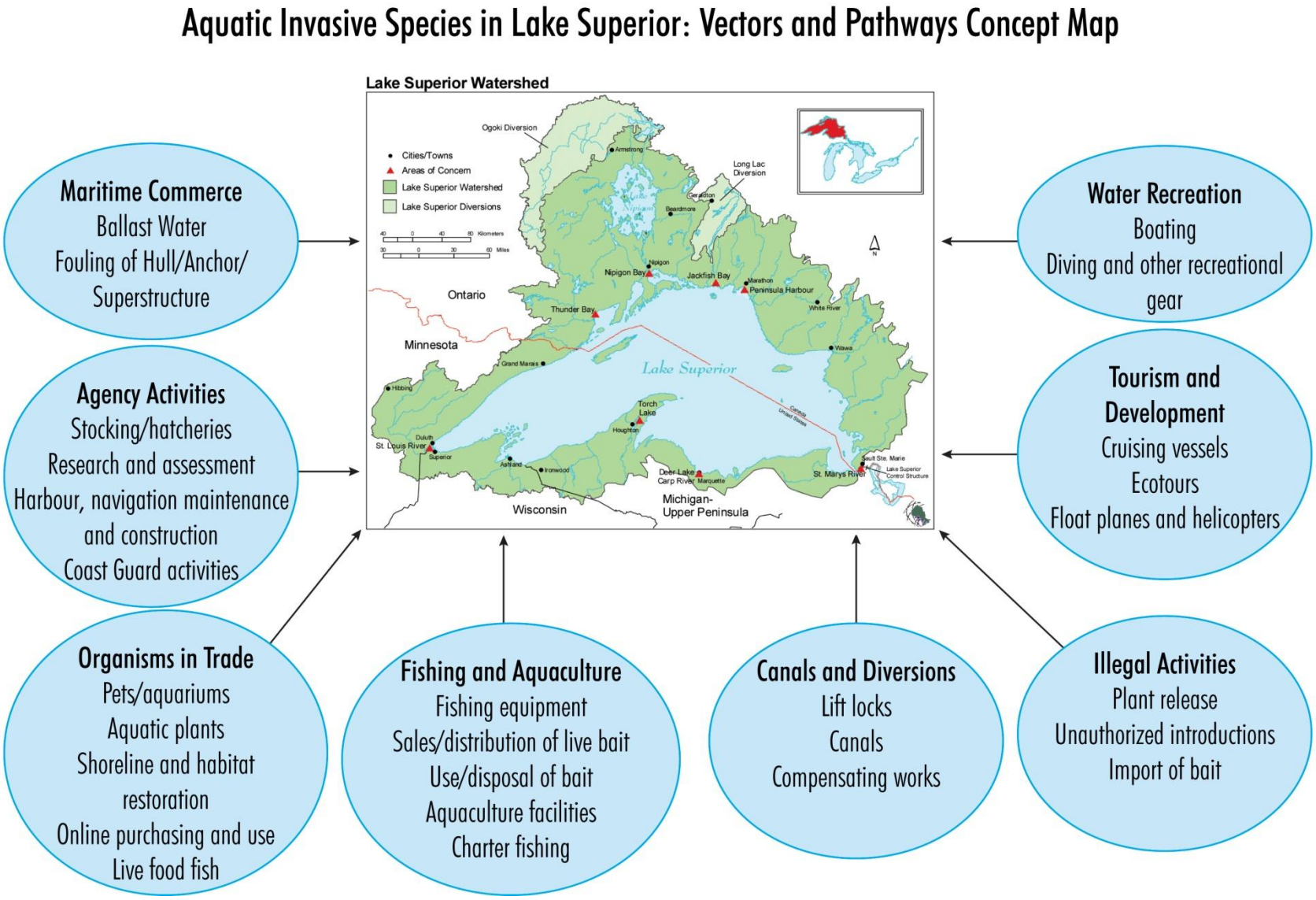


Figure 1. Aquatic Invasive Species in Lake Superior: Vectors and Pathways Concept Map

3.1.1 Maritime Commerce Vector

Ballast Water Pathway

The primary pathway for transport of new AIS to the Great Lakes is in the ballast tanks of ships (National Academy of Sciences 2008). Approximately 35% of non-native species found in Lake Superior were likely introduced via ballast water discharge (Minnesota Sea Grant 2008a). Eurasian ruffe, round goby, and zebra mussels are examples of organisms transported to Lake Superior via ballast water.

Ship arriving in Duluth ship canal, Duluth, Minnesota. Photo credit: Jerry Bielicki, US Army Corps of Engineers. Courtesy of US EPA Great Lakes National Program Office

Ballast water is used on cargo vessels to maintain stability as vessels travel from port to port. Once ships reach their destination and cargo is loaded, the ballast water is no longer needed and may be released into the port. Some vessels enter Duluth (and other Lake Superior ports) with ballast water on board (BOB) and load cargo after discharging ballast into the harbor. Some vessels enter the Great Lakes loaded with cargo and with no pumpable ballast on board (NOBOB). Ships typically have several ballast tanks, and at times may have a combination of BOB and NOBOB tanks.

When ships discharge cargo at a port in the lower lakes, they take on ballast which mixes with the sediments and residual water in the ballast tanks, and then go to a Lake Superior port, where the mixed ballast water is discharged and cargo is loaded. Duluth-Superior Harbor handles more cargo by volume than any other port on the Great Lakes, with 1,100 vessel calls per year (Duluth Seaway Port Authority 2008). The pattern of shipping on the Great Lakes is such that more ballast water is discharged in Lake Superior than all other Great Lakes combined.

Lakers vs. Salties

There are two types of shipping vessels that carry trade on the Great Lakes. "Salties" are oceangoing vessels that reach the Great Lakes through the St. Lawrence Seaway. Vessels that trade only on the Great Lakes are called "lakers". The operational requirements of the two types of vessels are different. Lakers carry very large amounts of cargo and spend very short periods of time in port. To support their operations, lakers carry large amounts of ballast (when they are not carrying cargo), and they pump ballast at fast rates. The largest lake vessels can hold as much as 16.4 million gallons of ballast and pump it at a rate of nearly 80,000 gallons per minute (Great Lakes Maritime Task Force, 2010).

Historically, all types of vessels that use and discharge ballast water pose risks of introducing new AIS to Lake Superior. NOBOB tanks represent a risk for AIS introductions because, while the tanks carry no ballast, they may have organisms that remain and survive in the residual material left in the ballast tanks. Organisms surviving in the residual material can be discharged into Lake Superior ports along with ballast water that NOBOB tanks took on at a lower Great Lakes port (Bailey et

al. 2005). New ballast water regulations for transoceanic NOBOB vessels effectively reduce the risk of introduction of new AIS transported to the Great Lakes by foreign vessels (salties) (Wiley 2009). Mid-ocean exchange required by the new regulations results in less sediment accumulation in ballast tanks and less chance of organisms surviving in residual material.

However, interlake transfer of ballast water by vessels that do not leave the Great Lakes (lakers) could facilitate the spread of existing AIS due to lakers' high volume of ballast discharges and high frequency of visits to Lake Superior ports (Bailey et al. 2005). In the Great Lakes-St. Lawrence River system, nearly 90% of commercial shipping operations are domestic, and the short distances travelled increase the likelihood of non-indigenous species' survival. The Duluth-Superior Harbor, in particular, receives 40% of ballast water discharged by lakers (Rup et al., 2010). Bloody red shrimp (*Hemimysis anomala*) is an example of AIS at risk of being transferred to Lake Superior from the lower Great Lakes via the ballast water of interlake vessel movement. As of May 2010, bloody red shrimp had not been found in Lake Superior.

Coastal vessels that load ballast water in the Gulf of St. Lawrence, St. Lawrence River (many are freshwater ports), or northern coastal ports also pose a risk for the transfer of AIS through ballast water that is transferred to the Great Lakes. The similarity of biological communities increases the risk of invasion in a Great Lakes port. Several non-indigenous species found in the Great Lakes were first recorded in the St. Lawrence River (Rup et al., 2010).

Shipping patterns on the Great Lakes and Lake Superior are not static. New port development may be considered as communities along the shoreline seek means to develop and diversify their economies (e.g., aggregate extraction, mining, wood products, tourist vessels), and the option of shipping is always explored. The impending risk of AIS transfer through the use of vessels related to new ports and shipping routes adds to the imperative for action.

An Imminent Threat: Bloody Red Shrimp

Photo credit: NOAA, Great Lakes Environmental Research Laboratory

The bloody red shrimp, a mysid native to the Ponto-Caspian region of Europe, has invaded the lower Great Lakes and presents an imminent threat to Lake Superior. The shrimp was first reported in the Great Lakes in Muskegon, Michigan, in November 2006. Bloody red shrimp have also been found in the nearshore zone of Lake Ontario. In 2008, several hundred of these mysids were found on the Ontario side of Lake Huron at Goderich. The shrimp are thought to have been transported to Goderich—a busy commercial shipping port—via ship ballast water. The long-term impact of the bloody red shrimp is uncertain. It has the potential to affect both zooplankton and phytoplankton populations, but it may serve as prey for some larger fish. Its reproductive capabilities suggest a high expansion potential.

Hull/Anchor/Superstructure Fouling Pathway

AIS can also be introduced by attaching themselves to hulls, anchors and other exterior surfaces, fouling shipping vessels or barges. Freshwater snails, mussels, sponges, algae and other organisms can be transported in this manner. Once a vessel is at port, the organisms release their larvae into the water or attach themselves to port infrastructure, establishing residence as an aquatic invasive species (Smithsonian Environmental Research Center 2004). Foreign organisms attached to exterior surfaces can also be dislodged and released into Lake Superior waters when a ship is in dry dock for repairs or painting (when vessel hulls are cleaned, for example) and when vessels are tied dock side (due to rubbing against the dock). Zebra mussels are reported to have been introduced to Lake Superior through ships' ballast water (Minnesota Sea Grant 2008a); however, hull fouling may have been another pathway of introduction.[8]

Recent research has investigated the potential risk of hull fouling as a pathway of AIS. A study completed in Lake Ontario quantified the risks of hull fouling 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 (Drake and Lodge 2007). As part of current research to determine the risk of hull fouling as a pathway for the introduction of AIS, the Canadian Aquatic Invasive Species Network (CAISN) sampled 20 transoceanic ships; one freshwater species that is not native to the Great Lakes was found. Nearly all species attached to the hulls of the 20 ships sampled were marine (e.g., barnacles) or freshwater species that are already in the Great Lakes. The study authors concluded that hull fouling appears to pose a low risk of introductions of new AIS to the Great Lakes from transoceanic vessels (Sylvester and MacIsaac 2010).

Metal hulls and anti-fouling paints are used on many vessels as a deterrent. In the past, tributyltin (TBT) compounds were commonly used as an anti-fouling agent but have been phased out due to their harmful effects (TBT is currently banned in new applications). Developing alternative anti-fouling systems that are as effective as TBT is proving to be a challenge.

3.1.2 Agency Activities Vector

Stocking/Hatcheries Pathway

To enhance sport and commercial fishing, public, private and tribal agencies stock lakes with additional fish from hatcheries in an effort to improve fishing opportunities, meet fisheries management objectives, stimulate growth of the economy, and aid in species recovery. However, this practice is not without potential risk. AIS may inadvertently be introduced to an ecosystem if preventative measures are not employed. Approximately 12 non-native species have been intentionally introduced to Lake Superior through the fish stocking pathway (Minnesota Sea Grant 2008a). AIS may hitch a ride on contaminated gear, in stocking water, or in the stomachs of stocked fish that may have ingested invasive species prior to transfer from a hatchery. Fish may also be infected with 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 stock transfer, are also a concern.

[8] Species may be introduced via multiple pathways.

To mitigate damaging effects on the environment, public, private and tribal stocking of fish is regulated in the Great Lakes. The states regulate fish stocked in public waters through various state stocking permits for public waters. State, provincial, and tribal agencies are restricted by the Great Lakes Fishery Commission - Great Lakes Model Fish Health Program, which ensures that the same rules apply in all Great Lakes jurisdictions. 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.*

Hatchery load out, Duluth, Minnesota. Photo credit: Steve Geving, Minnesota Department of Natural Resources. Courtesy of US EPA Great Lakes National Program Office

Harbor, Navigation Maintenance and Construction Pathway

Federal agencies[9] in both the United States and Canada have responsibilities for development and maintenance of waterways, harbors, navigation aids and other marine installations. In carrying out these responsibilities, federal agencies need to include AIS prevention practices as an integral part of their operations and those of private agents with whom they contract or whose proposals they review and permit.

Routine maintenance is required to retain the integrity of harbor structures and to maintain channel size. Harbor maintenance and water construction activities may require using equipment and tools that were used in other marine or freshwater environments and could be contaminated with AIS. Dredging may also be required for channel widening/deepening or removal of contaminated sediment. Vessels and equipment associated with dredging operations, or aids to navigation,[10] and construction (e.g., offshore wind power development) may also inadvertently introduce non-native species to Lake Superior via contaminated equipment, construction materials, or fill. As required for chemically contaminated dredged sediments, all permits should clearly state that sediments must be checked for the presence of AIS and, if present, dredged material must be disposed of such that AIS are not reintroduced to Lake Superior or its watershed (e.g., no shoreland or open water disposal).

Evidence of this pathway as a mechanism for AIS introduction occurred in 2001. Two zebra-mussel-infested barges from the lower lakes traveled though Marquette and moored in the Duluth-Superior Harbor (J. Nichols, pers. comm.). The barges traveled to Isle Royale to serve as

[9] These agencies include Coast Guard Canada, Transport Canada, Fisheries and Oceans Canada (Small Craft & Harbours), U.S. Coast Guard, and U.S. Army Corps of Engineers.
[10] Every spring and fall federal vessels tour the Great Lakes deploying and retrieving aids to navigation.

construction platforms to repair docks. Upon discovery, the infested barges returned to Duluth for decontamination and were redeployed.

Coast Guard Activities Pathway

The U.S. and Canadian Coast Guards perform several services in support of search and rescue, maritime safety and security, environmental protection, maritime law enforcement, aids to navigation, and icebreaking. These services involve a multitude of equipment that may provide an opportunity for AIS to be transported to Lake Superior from the lower Great Lakes or from other regions of the U.S. and Canada. To date, Coast Guard activities have not been documented as a mechanism for AIS transport to Lake Superior.

Research and Assessment Pathway

Agencies use field assessments to collect information on the status of the Lake Superior fish community and its habitat. Large and small vessel surveys may use capture equipment such as gill nets, trawls, and traps, or they may employ onboard or in-water remote sensing equipment to collect information. Equipment, including boats, used in multiple Great Lake environments by an agency or organization with responsibilities or interest in several Great Lakes could result in cross-contamination and accidental introduction of AIS from one lake to another, if precautions are not taken.

AIS can be introduced through aquatic research activities, for example, when unwanted organisms hidden within a sample are improperly disposed. Photo credit: Battelle

Research, testing, and educational facilities may introduce AIS to Lake Superior waters through specimen shipment or disposal (including via the sanitary wastewater system). A mishandled shipment may result in the escape of specimens during transit. A shipment may also contain unwanted hidden organisms within the packaging or holding water. Improper disposal of such packaging material may inadvertently introduce 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 to the environment.

AIS may also escape into open waters from a facility via plumbing or by hitching a ride on previously used sampling equipment, vessels, scuba gear, or other research equipment that was not adequately decontaminated (Olson et al. 2000). To date, agency research activities have not been identified as a source of AIS in Lake Superior.

3.1.3 Organisms in Trade Vector

Pets/Aquariums Pathway

The vast majority of species found at pet stores and nurseries are non-native to the region in which they are sold. Depending on the education efforts of the retailer, consumers may be

unaware that they have purchased a non-native species and be unaware of the consequences of improper disposal. Many believe it is humane to release unwanted species to a nearby stream, lake or river. However, this practice can result in the introduction of AIS to the environment, including viruses and other pathogens associated with ornamental fish. In addition, aquarium water may contain invasive plants and species, including pathogens, and if flushed to a sewer system or otherwise disposed of improperly, can release AIS into waterways (USFWS 2006). Four non-native species (5% of all non-native species in Lake Superior) are reported to have been introduced to Lake Superior through aquarium releases (Minnesota Sea Grant 2008a).

Aquatic Plants Pathway

Water gardening is a popular hobby, but one in which the introduction of AIS is possible. Many aquatic gardening enthusiasts introduce exotic plants, fish, reptiles and invertebrates to enhance the beauty of their garden or natural landscape. Some of these non-native species can escape into the natural environment. Seeds from non-native plants can be carried off by wind, flood, or wildlife to sprout in nearby waterways. Water gardens in flood-prone areas present a higher risk of AIS introductions because non-native species are more likely to be released if flooding occurs. Nineteen species have been introduced into Lake Superior by the accidental escape of cultivated plants from ornamental or backyard gardens (Minnesota Sea Grant 2008a).

Unwanted organisms may also hitchhike with purchased products (e.g., in soil, water, packing materials, or growing medium). Mislabeling or inconsistencies in the use of species names by retailers can lead to the accidental purchase of AIS (Maki and Galatowitsch 2004). Improper disposal of unwanted species into storm sewers, ditches or local waters can result in establishment of AIS in the local natural environment (Cal-IPC 2007).

One aquatic invertebrate (Gammarid amphipod, *Echinogammarus ischuus*) is reported to have been unintentionally released in Lake Superior through packaging material (Minnesota Sea Grant 2008a).

Shoreline and Habitat Restoration Pathway

It is important to prevent the spread of invasive species during shoreline restoration projects, as invasive species thrive in disturbed areas. Road development and bridge construction projects, in particular, may be vulnerable to AIS introductions. Invasive species should never be planted as part of a shoreline restoration project, and care must be taken to ensure that they are not unintentionally established. Equipment should be cleaned between projects to remove potential hitchhikers in mud, dirt, sand, water, plants, or other materials where species can hide.

If care is not taken to ensure native species are planted, the results can be detrimental to the local ecosystem. Seed mix packaged for slope or shoreline stabilization may not have had sufficient quality control to ensure the absence of invasive seeds. Earth transported as clean fill may be contaminated by common invasives such as common reed or purple loosestrife. No new AIS are known to have been introduced to Lake Superior via the shoreline and habitat restoration pathway.

Live Food Fish Pathway

The import and sale of fish or other organisms for human consumption may result in the introduction of AIS if care is not taken to ensure proper handling and disposal. Live fish are sold in markets in large urban centers. Some people release the fish live for spiritual and cultural reasons. The release of non-indigenous fish, as well as pathogens and other hitchhikers present in the shipping material used to transport live food fish, is illegal in the Lake Superior Basin. Shipments of marine organisms to freshwater market areas present less of a threat due to the change in salinity of the water. No AIS are known to have been introduced to Lake Superior via live food fish.

On-line Purchasing and Use Pathway

On-line commerce has exploded as an avenue for consumers to purchase aquatic plants, fish, and invertebrates from around the globe for use in home aquariums and water gardens. Research shows that most on-line orders received by consumers contain additional unwanted algae, plants, fungi, or other non-native organisms (Zhuikov 2004). These unwanted species may include AIS and, when improperly disposed of, they are introduced to the environment. While on-line purchasing and use has not been documented as a mechanism of AIS introductions in Lake Superior, on-line sales of aquatic plants are escalating.

3.1.4 Illegal Activities Vector[11]

Plant Release Pathway

To curb illegal plantings, most states and provinces prohibit the introduction of plants and animals into public waters without a permit. They also maintain lists of prohibited species that are illegal to purchase, possess or plant. However, prohibited plants are sometimes introduced by hobbyists or shoreline restorers who may not have a thorough understanding of regulations or the species they purchased based on compatibility or use. Purple loosestrife is an example of an aquatic plant that was intentionally introduced to Lake Superior (Minnesota Sea Grant 2008a).

Although it is illegal to sell prohibited invasive species in certain areas, mail order and on-line sales can elude such regulations. Current consumer trends show an increased interest in exotic species for the enhancement of water gardens and home aquariums. The internet provides easy access to prohibited invasive species from around the globe (Global Invasive Species Programme 2008). University of Minnesota researchers found that prohibited aquatic nuisance plants could be purchased by mail order, despite current regulations prohibiting their sale and use (Zhuikov 2004).

Unauthorized Introductions Pathway

Unauthorized fish stocking is the introduction or transfer of fish that is not performed or authorized by a federal or state/provincial/tribal fisheries management agency. Unauthorized

[11] Unlike other vectors in which the introduction of AIS may be inadvertent, this vector includes activities that intentionally transport or release AIS illegally into the Lake Superior Basin.

stocking is typically conducted for the purpose of creating new recreational or commercial fisheries or manipulating existing fish stocks to introduce food into stunted fish lakes. Such practices are usually illegal due to their harmful nature and negative effect on existing recreational, commercial, and bait fisheries (USFWS 2006). The number of species introduced to Lake Superior through unauthorized releases is uncertain. As one example, pink salmon were intentionally introduced into Thunder Bay due to unauthorized release.

Other types of unauthorized introductions, such as the release of aquarium fish/plants and live food fish, are discussed under the Organisms in Trade vector and Fishing and Aquaculture vector.

Import of Bait

It is illegal to bring into Ontario crayfish or salamanders, or live fish or live leeches for use as bait. Despite this restriction, U.S. residents continue to attempt to smuggle live baitfish into Ontario. Conservation officers regularly confiscate live baitfish from U.S. residents during border crossings, resulting in significant fines (OMNR 2009).

The U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS) issued a Federal Order in October 2006 prohibiting the importation of 37 species of live fish (susceptible to VHS) from two Canadian provinces (Ontario, Quebec) into the U.S. and the interstate movement of the same species from the eight states bordering the Great Lakes. An interim rule was published in the Federal Register on September 9, 2008, to provide a regulatory framework for the interstate movement and importation into the U.S. of live fish that are susceptible to VHS. The rule establishes certain requirements to prevent the spread of VHS by interstate movement of live VHS-regulated fish from states where VHS has been detected or that are at immediate risk of being affected (includes Michigan, Minnesota, and Wisconsin). The effective date of the interim rule has been delayed indefinitely to provide APHIS with time to make adjustments to the rule that are necessary for the rule to be successfully implemented (USDA 2008a).

Regulations pertaining to the interstate movement of bait vary by state. For instance, Michigan does not allow the export of bait, while Minnesota restricts imports of live bait. Bait such as leeches, worms, and grubs can carry the VHS virus and provide a mechanism for spreading the virus in fish (WDNR 2008a).[12] No AIS have been reported in Lake Superior as a result of the illegal import of bait.

3.1.5 Fishing and Aquaculture Vector

Fishing Equipment

Anglers and commercial harvesters have the potential to transport AIS associated with or on their fishing equipment or boats. AIS can accumulate on both commercial and recreational fishing nets, waders, lures, anchors, boat hulls, motors, and other equipment. For example, some

[12] Bait such as leeches, worms, and grubs cannot be infected with VHS but can carry and transmit the virus if it has been in contact with infected waters or fish.

invasive species can survive for long periods inside boat livewells. Draining livewell water from one water body into another waterway or a launch ramp may result in the release of AIS that have been accidentally transported in the livewell. Inadequate drying of livewells also increases the risk of introducing AIS. The felt soles of waders have been blamed for the spread of *Didymosphenia geminata*, commonly known as didymo or rock snot, an invasive species that multiplies rapidly, reduces fish populations, and grows into dense sludge-like material that can clog water intakes and pipes.

To date, fishing equipment has not been identified as a source of AIS in Lake Superior. However, spiny waterfleas are known to be spread overland on fish lines and downrigger cables (see sidebar at right). Thorough inspection and cleaning of fishing equipment is of paramount importance to prevent the transport of AIS in or on fishing equipment.

AIS Impact on Recreational Fishing

Spiny waterfleas are an example of AIS that negatively impact recreational fishing. Spiny waterfleas can accumulate on fishing equipment and foul fishing lines and nets. Specific information on how to prevent the introduction of AIS by anglers can be found at http://www.protectyourwaters.net/prevention/user_anglers.php.

Photo above: Spiny waterfleas fouling a fishing line. Photo credit: Jeff Gunderson, Minnesota Sea Grant.

Sale and Distribution of Live Bait Pathway

The sale and distribution of live bait presents a risk of introducing AIS through contaminated gear used to harvest and transport fish, fish that may carry disease, and fellow travelers that may be present with fish in the transport medium. Commercial harvesting of baitfish does not occur routinely in Lake Superior, although it may occur in the basin. Each jurisdiction in the Lake Superior Basin addresses the sale and distribution of live bait through its own regulations. In the states, for example, bait may be certified for sale at the wholesaler level (i.e., certified free of VHS). Most bait retailers prefer to sell certified bait (Whelan 2009).

No new AIS are known to have been introduced to Lake Superior through the wholesale or retail sale and transport of live bait. However, the pathway remains a potential avenue for new AIS introductions.

Use and Disposal of Bait Pathway

Improper disposal of baitfish into waters may exacerbate the spread of AIS by introducing potentially invasive plants, invertebrate species, and pathogens hitchhiking in bait wells or buckets. Live bait may be infected with pathogens (e.g., VHS) or parasites, which when improperly disposed of, can adversely affect populations of native aquatic species. In the Lake Superior Basin, releasing unused live bait is illegal. It is also illegal to empty the contents of a

bait bucket or other baitfish container into Ontario waters. Unwanted bait, live or dead, should always be disposed of properly (in a trashcan or on the land, far away from the water). Illegal use of non-native fish as bait can also result in the introduction of invasive species. Three non-native species have been reported in Lake Superior, most likely due to live bait releases by anglers (Minnesota Sea Grant 2008a).

Aquaculture Facilities Pathway

Aquaculture is the farming of fish and aquatic plants, which can lead to unwanted introductions of AIS. Although cultured species may be commercially valuable, they are usually not native to the area or waters in which they are bred. Escapes from aquaculture facilities in the U.S. have resulted in the introduction of non-native species of fish (e.g., rainbow trout (*Oncorhynchus mykiss*) and pink salmon (*Oncorhynchus gorbuscha*)) and pathogens that may negatively impact native fish populations, such as brook trout (*Salvelinus fontinalis*) (Naylor et al. 2001).

Aquaculture is strictly regulated by Ontario and the U.S. states in the basin, and no commercial aquaculture currently occurs in Lake Superior.

Charter Fishing Pathway

Chartered boats and guide services offer anglers the opportunity to fish without investing in a boat and fishing equipment. If charter boats are transported in and out of the basin, proper equipment management must be undertaken by charter companies and their clients to ensure AIS do not hitch a ride on fishing lines, boat hulls, or other associated equipment. Improper disposal of baitfish from charter fishing may also result in the introduction of AIS.

At present, the charter fishing business in Lake Superior is small and largely confined to the basin. However, guide boats may frequently move between Lake Superior and inland water bodies or between Lake Superior and Lake Huron or Lake Michigan. No AIS have been reported in Lake Superior as a result of charter fishing operations or professional guide services.

3.1.6 Canals and Diversions Vector

This vector includes canals, lift locks, water diversions, and compensating works as pathways of potential AIS introductions into Lake Superior. These pathways are discussed in further detail below. Six non-native species are thought to have entered Lake Superior through canals and diversions, likely through the Poe Lock at Sault Ste. Marie (Minnesota Sea Grant 2008a).

Canals Pathway

Canals are man-made waterways used for transporting goods and commodities and for recreation. Canals often connect lakes or rivers and allow the transport of AIS within and across previously unconnected watersheds. For example, the Portage Canal, or Portage Lake Canal, is part of the Keweenaw Waterway connecting to Lake Superior on the Keweenaw Peninsula of Michigan. It is thought that Eurasian ruffe employed this pathway in its eastern expansion along the south shore of Lake Superior (USFWS 2007).

The Chicago Sanitary and Ship Canal links the Great Lakes to the Mississippi River and exposes the Great Lakes to species invasion from the Mississippi River. Some of these potential AIS species found in the Mississippi River Basin, such as Asian carp, are adapted to cold water environments like Lake Superior. Asian carp populations (bighead, silver and grass carp) present a serious threat for range expansion into the lower Great Lakes through the Chicago Sanitary and Ship Canal (USEPA 2008b), and subsequently into Lake Superior.

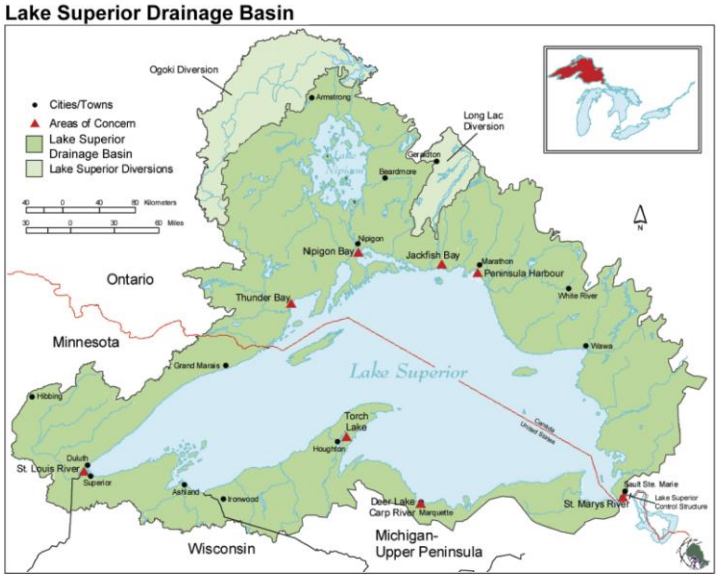
Lift Locks Pathway

Lift locks are a mechanism for transporting commercial ships and boats between waterways of different water levels. Inside the chamber of a lock, the water level can be raised or lowered, to move vessels up or down the waterway system. The lift locks at Sault Ste. Marie allow vessels to bypass the 6.1 metre drop at the St. Marys River rapids and travel between Lake Superior and the lower Great Lakes.

Locks can also be a mechanism for facilitating the spread of AIS along and between waterways because they may connect water bodies that were once naturally or now artificially separated from one another. Development of navigation and water power infrastructure has removed most of the St. Marys 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 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) or by accompanying a vessel in the lock as it is lifted up to Lake Superior.

Water Diversions

Two separate water diversions are present in the Lake Superior Basin. Both the Long Lac and Ogoki diversions add water to Lake Superior from James Bay in Canada. Together, the Long Lac and Ogoki diversions comprise 6% of the water that refreshes Lake Superior each year. The diversions are used to generate hydroelectric power and transport pulpwood logs. The rate of water flow varies between 2,500 and 8,000 cubic feet per second (Rankin, 2002).



The Ogoki and Long Lac Diversions in Ontario add water to Lake Superior. Photo credit: Environment Canada

Compensating Works Pathway

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 rapids, allowing water to be diverted from the rapids to the three 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 induce growth of invasive species (Conger et al. 2002). Two to five of the compensating gates are always open part way to supply water to the St. Marys rapids. During a period of flow measurements and gate operation testing in the mid 1990s, all the gates were open for significant periods of time. During 1997, Sea Lamprey Control staff monitoring a lamprey trap in the Big Carp River approximately 8 kilometers upriver from the rapids noticed 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 surmised that the increased flow in the rapids overwhelmed the discharge from the four power-generating 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. The trap catch at the power generation facilities during 1997 was 40% of the usual catch in years when the gates were at normal settings (Steeves 2009).

3.1.7 Tourism and Development Vector

Potential pathways for the introduction of AIS in Lake Superior through tourism and development include cruising vessels, ecotours, and float planes and helicopters. No new AIS are reported to have been introduced to Lake Superior through tourism and development.

Cruising Vessels

Each year, tourists aboard recreational vessels of various sizes travel from the lower Great Lakes to Lake Superior.[13] These vessels may carry AIS along with them. The focus of this pathway is vessel hulls, anchors, bilge water, or other means of transporting unwanted organisms that would expose Lake Superior to non-native species that had previously been confined to the lower lakes.

Ecotours Pathway

Ecotours are trips to fragile, pristine, and usually protected areas with a goal of educating the traveler, minimizing impacts on the local community while benefiting the local economy, providing funds for conservation, and fostering respect for different cultures. Ecotourism can add stress to the local environment and create additional opportunities for the infiltration of AIS. As the popularity of Lake Superior ecotours increases, so does the likelihood of AIS introduction. This is a current issue in Antarctica, where the increased presence of ecotourism is credited with the transport of plant seeds on clothing and footwear that are not native to the archipelago (e.g., species used on golf courses) (National Geographic News 2006).

[13] Commercial cruise ships are included in the maritime commerce vector.

Float Planes and Helicopters Pathway

Float planes or sea planes are a popular activity allowing tourists to see the sights from the air. Some operators take off and land on the surface of lakes. In Ontario, float planes and helicopters are important for transportation, fire suppression, and remote rescue. Equipment used by helicopters for fire suppression is transported among lakes and watersheds (e.g., bucket transports). Air charter companies operate in the Lake Superior Basin and from the St. Marys River, transporting recreationalists and business interests into remote lakes. Because it is difficult for floats to be cleaned between lake landings, float planes provide an opportunity for AIS to travel between watersheds when planes land on multiple lakes (Bayfield County Lakes Forum 2008). Standard precautions have been developed for this pathway and are accepted and promoted throughout the Great Lakes Basin. For instance, ANS Task Force recreational guidelines provide cleaning provisions for before and after landing in new waters.

3.1.8 Water Recreation Vector

Boating Equipment Pathway

Water recreation activities involve many types of equipment in addition to boats, including water skis, wake boards, pull ropes, and flotation devices. AIS can hide in equipment and become entangled on boat motors, propellers, anchors, hulls, and trailers. If not properly cleaned, boats and related equipment may spread AIS, especially when boats are transported between water bodies. Boat motors and trailers with multiple angles in their frames that can snare plant material are a common pathway. Two non-native species are reported to have been introduced to Lake Superior by recreational boaters (Minnesota Sea Grant 2008a).

Diving and Other Recreation Gear Pathway

Equipment and clothing (wet or dry suits) associated with scuba diving are often used in different water bodies by divers. The equipment and clothing may contain AIS, such as larvae or algae, and if not cleaned properly or dried thoroughly prior to reuse, may serve as a pathway for the introduction of AIS to waters. For example, adult and juvenile zebra mussels have been found impinged in the folds of wet or dry suits and between suits and equipment. Prevention procedures have been developed for divers and are promoted through outreach campaigns (see Section 4.4).

Diving and other recreation gear has not been identified to date as a mechanism for AIS introductions in Lake Superior.

3.2 PRIORITIZATION OF AIS PATHWAYS INTO LAKE SUPERIOR

The identification of pathways specific to the Lake Superior Basin is crucial in the development of preventative measures. Based on the history of AIS introductions in Lake Superior, the ballast water pathway is most significant. Table 1 presents a list of AIS that were first introduced into the Great Lakes in Lake Superior. Half of these non-indigenous invasions were introduced via ships' ballast (USEPA 2008c). According to Minnesota Sea Grant, more AIS have been

introduced to Lake Superior via the ballast water pathway than any other pathway. Table 2 lists the mechanisms of entry for non-native species found in Lake Superior.

Lake Superior may be at risk of new invasions via ballast water. According to a recent report by the USEPA that predicted the potential for several invasive species to invade the Great Lakes, Duluth, Minnesota, and Superior, Wisconsin, were among the Great Lakes ports at greatest risk for invasion by AIS from ballast water discharges (USEPA 2008c). Of all Great Lakes ports, Duluth received the greatest volume of ballast water from vessels with ballast on board and from NOBOB vessels in 2006–2007. This high volume of ballast water increases the risk of AIS invasions at the Duluth port via domestic or foreign trade. Many of the potential AIS on a Watch List published by NOAA's Great Lakes Environmental Research Laboratory involve shipping or ballast water as a possible pathway of introduction (GLERL 2011).

As discussed in Section 3.1.1, the risk of invasion from the ballast water of transoceanic vessels is expected to have been reduced due to new regulations that require mid-ocean exchange of ballast water. Lakers, coastal vessels, and transoceanic vessels which take on ballast water in the lower lakes have ballast water that has not undergone exchange. These vessels are thought to present the greatest risk of spreading AIS through ballast water from the lower lakes.

Table 1. AIS Introductions into the Great Lakes that First Occurred in Lake Superior[14]

Year of Invasion	Species	Common Name	Type	Vector or Pathway of Introduction
1884	*Agrostis gigantean*	Redtop	Plant	Release (deliberate)
1895	*Pisidium moitessierianum*	Pea clam	Mollusk	Shipping, Solid Ballast
1901	*Rumex longifolius*	Yard dock	Plant	Release (deliberate)
1936	*Sparganium glomeratum*	Bur reed	Plant	Unknown
1950	*Cirsium palustre*	Marsh thistle	Plant	Unknown
1956	*Oncorhynchus gorbuscha*	Pink salmon	Fish	Release (unintentional)
1972	*Cyclops strenuous*	Copepod	Zooplankton (crustacean)	Canals (water diversion)
1975	*Renibacterium (Corynebacterium) salmoninarum*	Bacterial kidney disease	Bacteria	Release (unintentional)
1985	*Salmincola lotae*	Copepod	Zooplankton (crustacean)	Unknown
1986	*Gymnocephalus cernuus*	Eurasian ruffe	Fish	Shipping, Ballast Water
1986	*Apeltes quadracus*	Fourspine stickleback	Fish	Shipping, Ballast Water
1992	*Acanthostomum sp.*	Digenean fluke*	Other invertebrate	Shipping, Ballast Water
1992	*Ichthyocotylurus pileatus*	Digenean fluke*	Other invertebrate	Shipping, Ballast Water
1992	*Neascus brevicaudatus*	Digenean fluke*	Other invertebrate	Shipping, Ballast Water
1992	*Trypanosoma acerinae*	Flagellate*	Other invertebrate	Shipping, Ballast Water

[14] Adapted from USEPA 2008c.

Year of Invasion	Species	Common Name	Type	Vector or Pathway of Introduction
1992	*Dactylogyrus amphibothrium*	Monogenetic fluke*	Other invertebrate	Shipping, Ballast Water
1992	*Dactylogyrus hemiamphibothrium*	Monogenetic fluke*	Other invertebrate	Shipping, Ballast Water
2001	*Gammarus tigrinus*	Amphipod	Benthic Crustacean	Shipping, Ballast Water

* These species were present in the bodies of ruffe and round goby (as parasites) during their introduction.

Table 2. Mechanisms of Non-native Species Found in Lake Superior since 1883

Mechanism	Number of Species	Percent*
Ballast Water Discharge	30	35
Cultivation†	19	22
Stocked Fish	12	13
Unknown	9	10
Diseases and Parasites with Fish	9	10
Canals and Diversions	6	7
Aquarium Releases	4	5
Live Bait Releases by Anglers	3	3
Recreational Boaters	2	2
Railroads and Highways	1	1
Packaging Hitchhikers	1	1
Other Release	1	1

† Cultivation generally refers to escape from backyard gardens, in a similar context as Mills et al. 1993.
* The sum exceeds 100% because six species arrived via multiple pathways.
Source: Minnesota Sea Grant. 2008. Non-native Species Found in Lake Superior since 1883. Available at http://www.seagrant.umn.edu/ais/superior_nonnatives.

Table 2 lists the most important pathways of AIS introduction to Lake Superior based on historical records. Priority pathways for preventive actions may differ from the above list and may change as a result of regulations, guidelines, education/outreach efforts, and other management strategies that have been developed to halt new introductions. Improved understanding of the existing and future risks of each vector is needed to optimize the allocation of resources for prevention actions. However, conducting a full risk assessment takes time and should not preclude implementation of the recommended actions to prevent new introductions presented in Section 5.0.

4.0 MANAGEMENT STRATEGIES FOR INTERRUPTING THE PATHWAYS

This plan addresses the many vectors by which AIS may enter Lake Superior specifically, and the Great Lakes ecosystem in general. This section presents existing federal, state, and provincial rules and regulations, collaborative efforts, education, guidance, and other management efforts aimed at stopping the spread and introduction of AIS. The large geographic area covered by the Lake Superior watershed and larger Great Lakes ecosystem results in varied and complex regulations. There is no uniform policy or regulating agency for either watershed. This section describes the assortment of regulations in place by the various regulatory entities with jurisdiction in the Lake Superior Basin.

4.1 LAWS, REGULATIONS, AND AGREEMENTS

It is widely reported in the literature that the primary vector for the introduction of new, and spread of existing, AIS in the Great Lakes ecosystem is ballast water (USEPA 2008c; Batabyal 2006; Rup et al., 2010). As such, regulations and agreements related to ballast water management are presented first below, followed by federal (U.S. and Canada), state/provincial, and tribal statutes intended to protect against the spread and introduction of AIS. Although a thorough search for regulations was conducted, this section may not contain all pertinent regulations. In addition, some regulations may not apply directly to the Great Lakes ecosystem, but to invasive species in general that could by virtue of proximity (e.g., maritime east coast) reach the Great Lakes.

4.1.1 Ballast Water Rules and Regulations

Efforts to control the spread of AIS through ballast water have been developing since the late 1980s. Through multi-agency and collaborative efforts, several steps or best management practices (BMPs) for ballast water have been developed. In some cases, voluntary efforts or guidelines developed in the late 1980s or early 1990s for ballast water management have become mandatory for vessels operating in the Great Lakes ecosystem. These regulations are enforced by the U.S. and Canadian federal governments and the Joint Seaways Authority. Ballast water management requirements in the Great Lakes St. Lawrence Seaway System are presented in Table 3 and discussed further below. Appendix A contains ballast water requirements for various vessels under shipping conditions in the Great Lakes St. Lawrence Seaway System.

Table 3. History of Ballast Water Requirements in the Great Lakes St. Lawrence Seaway System

Year	Requirement	Description
1989	Voluntary Canadian guidelines	Ships entering the Seaway requested to conduct ballast water exchange (BWE)
1993	U.S. Coast Guard regulations for BWE by BOB ships	Oceangoing BOB ships entering the Great Lakes must conduct BWE at sea. Enforced through inspections and testing of ballast water salinity (at least 30 ppt)
1993	Great Lakes Maritime Industry Voluntary Ballast Water Management Plan for the Control of Ruffe in Lake Superior Ports	Voluntary plan to maximize loads out of western Lake Superior ports and minimize the need for ballast water. Ships taking on ballast from ruffe-inhabited ports should exchange ballast water within a specified zone in the open waters of Lake Superior.
2002	St. Lawrence Seaway Requirement	All foreign flag ships entering the Seaway must comply with BMPs, and lakers must comply with voluntary management practices
2004	U.S. Coast Guard National Mandatory Ballast Management Requirements	A national mandatory ballast water management program required all vessels equipped with ballast water tanks (BOB ships) that enter or operate within U.S. waters to maintain a ballast water management plan*
2004	International Maritime Organization (IMO) International Convention for the Control and Management of Ships' Ballast Water and Sediment	Proposed that all ships: implement a Ballast Water and Sediments Management Plan, carry a Ballast Water Record Book, and perform ballast water exchange or meet ballast water performance standards.
2005	U.S. Coast Guard NOBOB BMPs	U.S. Coast Guard and Transport Canada inspect NOBOB vessels and recommend that NOBOB ships conduct mid-ocean exchange whenever possible and if not possible, to conduct mid-ocean salt water flushing, to raise the salinity level of residual, unpumpable ballast above 30 ppt.
2006	Canadian Ballast Water Control and Management Regulations	All vessels (BOB and NOBOB) entering waters under Canadian jurisdiction must follow the International Maritime Organization D1 BWE standard.
2008	St. Lawrence Seaway NOBOB Requirement	All transoceanic ships (BOB and NOBOB) must conduct saltwater flushing 200 nautical miles from any shore before entering the St. Lawrence Seaway. Final salinities in each ballast tank must be at least 30 ppt.
2008	USEPA Vessel General Permit (VGP)	USEPA finalized the VGP, which requires several ballast water management practices for all waters and includes numeric discharge limits for certain states.
2009	U.S. Coast Guard Proposed Ballast Water Discharge Standard Rulemaking	The Coast Guard proposed a phase-two standard for the allowable concentration of living organisms in ships' ballast water discharged in U.S. waters.
2012	U.S. Coast Guard Standards for Living Organisms in Ships' Ballast	The Coast Guard issued the Ballast Water Final Rule, which does not include the previously proposed

Year	Requirement	Description
	Water Discharged in U.S. Waters	phase-two standard. The discharge standard in the Final Rule is the same as the IMO's performance standard.

Source: Great Lakes BWWG 2009; ANS Task Force 1996

*The ballast water management plan includes reporting and recordkeeping requirements and requires that ships either conduct a mid-ocean BWE, retain ballast water onboard, or use an alternative environmentally sound ballast water management method approved by the U.S. Coast Guard.

Ballast water exchange involves replacing a vessel's ballast water from a source harbor with ocean water. It removes organisms from a ship's ballast tanks and exposes remaining freshwater organisms to salt water, thereby killing most of them by osmotic shock. The August 28, 2009 Notice of Proposed Rulemaking (NPRM) and the Draft Programmatic Environmental Impact Statement (DPEIS) for the U.S. Coast Guard rulemaking entitled "Standards for Living Organisms in Ships' Ballast Water" summarize ballast water exchange studies and identify important variables in the efficacy of ballast water exchange. Ballast water regulations have evolved over the years, leading up to the U.S. Coast Guard rulemaking in 2012. The history of ballast water regulations in the Great Lakes St. Lawrence Seaway System is outlined below.

Canada first initiated voluntary guidelines in 1989 for ships entering the Great Lakes St. Lawrence Seaway to exchange their ballast. The U.S. Coast Guard began testing BOB ships on a voluntary basis in 1991. The voluntary guidelines became mandatory in 1993, when the U.S. Coast Guard required oceangoing vessels containing ballast on board that enter the Great Lakes from beyond the U.S. 200-mile EEZ to exchange ballast water on the high seas, or take other action to prevent the introduction of AIS via ballast water. Compliance is monitored through inspections and testing the salinity of ballast tanks to ensure salinity levels of at least 30 parts per thousand (ppt), which is considered a reasonably harsh environment to kill remaining organisms and evidence that the tanks have been adequately exchanged with seawater.

In 1993, the Great Lakes maritime industry introduced the voluntary guidelines for shippers to prevent the spread of ruffe from western Lake Superior ports. A voluntary ballast water management plan advised that ships should maximize loads out of ruffe-inhabited ports and minimize the need for ballast water. Ships that do take on ballast from ruffe-inhabited ports should exchange ballast water in the open waters of Lake Superior west of a demarcation line drawn between Grand Portage, Minnesota, and a point one mile east of the Ontonagon River, Michigan. If ships cannot exchange ballast in that zone, it should be completed in deep water (at least 240 ft) and 15 miles from shore. The U.S. and Canadian Coast Guards monitored compliance with the plan through shipping companies' ballast water records (ANS Task Force 1996).

Eurasian ruffe. Photo credit: Gary Cholwek, National Biological Service. Courtesy of USEPA Great Lakes National Program Office

Following Transport Canada guidance, in 2002, the U.S. and Canadian Seaway Corporations instituted two separate requirements for oceangoing vessels and lake carriers (lakers). Foreign flag ships entering the Great Lakes St. Lawrence Seaway System must comply with the *Code of Best Practices for Ballast Water Management* endorsed by the Shipping Federation of Canada. This code commits vessels entering into the Great Lakes to follow, among other practices, record keeping, reporting, and ballast water exchange procedures enforced through U.S. Coast Guard regulations.[15] Lakers that operate within the Great Lakes and St. Lawrence Seaway were required to comply with the *Voluntary Management Practices to Reduce the Transfer of Aquatic Nuisance Species within the Great Lakes* provided by the Lake Carriers' Association and the Canadian Shipowners' Association, dated January 26, 2001. These voluntary management practices require ships to agree to regular inspections of ballast tanks and regular removal of sediment accumulated in ballast tanks.[16]

In 2004, the U.S. Coast Guard issued a final rule requiring all vessels equipped with ballast water on board (BOB) and bound for ports or places of the United States to conduct ballast water exchange at sea, retain ballast water onboard, or use an alternative environmentally sound ballast water management method approved by the U.S. Coast Guard. The rule also established penalties for failure to submit a ballast water management reporting form or comply with mandatory ballast water management requirements. Under the U.S. Coast Guard's National Mandatory Ballast Water Management Program, all vessels equipped with ballast water tanks that enter or operate within U.S. waters must maintain a ballast water management plan specifically for that vessel and must assign responsibility for its implementation.

In 2004, the International Maritime Organization (IMO) adopted an International Convention for the Control and Management of Ships' Ballast Water and Sediment (IMO 2004). The IMO 2004 convention proposed that all ships:

- Implement a Ballast Water and Sediments Management Plan;
- Carry a Ballast Water Record Book; and
- Perform ballast water management procedures that meet the IMO's ballast water exchange standards or ballast water performance standards.

The IMO's Ballast Water Exchange Standard (Regulation D-1) states that:

> *Ships performing Ballast Water exchange shall do so with an efficiency of 95 per cent volumetric exchange of Ballast Water. For ships exchanging ballast water by the pumping-through method, pumping through three times the volume of each ballast water tank shall be considered to meet the standard described. Pumping through less than three times the volume may be accepted provided the ship can demonstrate that at least 95 percent volumetric exchange is met.*

[15] For the full Code of Best Practices for Ballast Water Management, see http://www.shipfed.ca/eng/library/other_subjects/ballats_water/BallastWaterBestPractices.html.
[16] For the full list of voluntary management practices, see http://www.michigan.gov/deq/0,1607,7-135-3313_3677_8278-16312--,00.html.

Ballast water exchange can be used to meet the IMO Ballast Water Performance Standard (Regulation D-2), which states that:

> *Ships conducting ballast water management shall discharge less than 10 viable organisms per cubic metre greater than or equal to 50 micrometres in minimum dimension and less than 10 viable organisms per milliliter less than 50 micrometres in minimum dimension and greater than or equal to 10 micrometres in minimum dimension; and discharge of the indicator microbes shall not exceed the specified concentrations.*[17]

In 2005, the U.S. Coast Guard issued voluntary BMPs for NOBOB vessels. The policy recommends ballast water exchange at sea whenever possible and, if not possible, salt water flushing of ballast tanks at sea. The practices are intended to raise the salinity level of residual, unpumpable ballast in NOBOB tanks above 30 ppt, and reduce the risk of transferring salinity-tolerant invasive species that might survive in NOBOB tanks (Bailey et al. 2005). Due to concerns over the risks of NOBOB vessels, the U.S. Coast Guard and Transport Canada began inspecting NOBOB vessels in 2005.

Saltwater flushing is the procedure used for vessels with no ballast on board (NOBOB). This process is accomplished by allowing a limited amount of salt water to slosh around in an individual ballast tank as a result of the ship's rolling and pitching motion during passage. This agitation re-suspends trapped sediments and provides a salinity shock to biota, which can then be discharged into the open ocean (National Academy of Sciences 2008).

Ballast water management became mandatory and enforceable by Canada beginning in 2006 by implementing ballast water management practices through regulation (Transport Canada 2006).[18] All vessels entering waters under Canadian jurisdiction are required to follow the IMO ballast water exchange standard (Regulation D-1).

At the beginning of the 2008 navigation season, all transoceanic ships entering the St. Lawrence Seaway (including NOBOB ships) were required to conduct saltwater flushing of their ballast tanks before entering the St. Lawrence Seaway, regardless of whether their destination is a Canadian or U.S. port. Ships must also maintain the ability to measure salinity levels in each tank onboard so that final salinities of at least 30 ppt can be ensured. A joint U.S./Canadian inspection program has been an important monitoring tool for ensuring compliance with ballast water regulations in the Great Lakes (see Section 4.3 of this plan).

The U.S. Coast Guard ballast water requirements, in combination with USEPA's Vessel General Permit (VGP), are the primary way in which ballast water discharges are regulated by the U.S. The U.S. Coast Guard oversees a Ballast Water Management (BWM) Program, which details mandatory practices for all vessels entering U.S. waters. The requirements 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 "salties," and training vessel personnel on appropriate ballast water

[17] The indicator microbes, as a human health standard, include but are not limited to: Toxicogenic Vibrio cholerae, *Escherichia coli*, and Intestinal *Enterococci*.
[18] Ballast water management in Canada falls under federal, rather than provincial, jurisdiction.

management procedures (USCG 2008). A study conducted by Bailey et al. (2011) shows that the risk of ship-mediated AIS introductions has been substantially reduced since the Great Lakes BWM Program was instituted. Ballast water exchange and tank flushing are typically 99.993% effective at preventing the transfer of freshwater zooplankton.

The USEPA regulates ballast water discharges under the National Pollution Discharge Elimination System (NPDES) Program, usually through the VGP. In addition to generally reflecting U.S. Coast Guard requirements, the VGP, which became effective in 2008, requires that all vessels entering any U.S. waters from outside the U.S. Exclusive Economic Zone (EEZ) conduct saltwater flushing and that vessel discharges must be controlled as necessary to meet any applicable water quality standards (Albert et al., 2010). The 2008 VGP provides mandatory and suggested ballast water management practices applicable to inland waters and within 3 nautical miles (nm) of shore. The VGP includes general effluent limits applicable to all discharges; effluent limits applicable to 26 specific discharge streams; narrative water-quality based effluent limits; inspection, monitoring, recordkeeping, and reporting requirements; and additional requirements applicable to certain vessel types. Recreational vessels, non-recreational vessels less than 79 feet (24.1 meters) in length (with the exception of ballast water discharges), and all commercial fishing vessels, regardless of length, are not subject to the VGP (USEPA 2008d).

In addition, USEPA, in partnership with the Coast Guard, commissioned two scientific studies to better inform the U.S. government's understanding of ballast water discharges. The first study, led by the National Academy of Sciences National Research Council (NAS), assessed the risk associated with ballast water discharges (NAS 2010). The second study, led by USEPA's Science Advisory board, evaluated the status of ballast water treatment technologies (Boornazian 2010). These studies were designed to assist USEPA in deriving environmentally protective numeric ballast water discharge standards for the development of the next VGP. The 2008 VGP expired on December 19, 2013 (USEPA 2008d).

The St. Lawrence Seaway Development Corporation (a federal agency within the U.S. Department of Transportation) also has requirements to reduce the impact of ballast water discharges to the Great Lakes. The St. Lawrence Seaway Development Corporation, in partnership with their Canadian counterparts in the St. Lawrence Seaway Management Corporation, require ballast water exchange and saltwater flushing for all vessels that arrive from outside the EEZ and enter the Great Lakes through the St. Lawrence Seaway and plan to discharge ballast water.

Vessels of the U.S. Armed Forces are exempt from the Coast Guard's BWM Program (as stated in 33 CFR 151.2010) and VGP permit requirements. The various branches of the Armed Forces have their own policies and management practices regarding ballast water, mostly based on IMO guidelines. To further standardize discharges, the USEPA and Department of Defense (DOD) are developing Uniform National Discharge Standards to initiate additional control practices for a variety of other discharges in addition to ballast water. The standards are being developed through a three-phase program, which is currently in the second phase (UNDS 2008). In the first phase, USEPA and the DOD jointly determined the types of vessel discharges requiring control,

which included ballast discharges from Armed Forces vessels.[19] In phase 2, USEPA and DOD will establish performance standards for control devices or management practices. In the final phase, DOD will issue regulations that specify the design, construction, installation, and use of control devices or practices to meet the published performance standards.

U.S. and Canadian Navy vessels typically visit the Great Lakes only to provide goodwill tours. The size of the locks that the vessels must pass through limits the size of Navy vessel that can traverse the Great Lakes. Canadian naval vessels do not carry ballast; they have essentially converted their ballast tanks to freshwater tanks that are filled by on-board reverse osmosis technology (Wiley 2009). Canadian Coast Guard vessels meet or exceed Canadian requirements for ballast water management.

In August 2009, the U.S. Coast Guard proposed the establishment of ballast water discharge standards that would be used to approve alternative ballast water management systems (BWMS) that are at least as effective as ballast water exchange in preventing or reducing the introduction of non-indigenous species via discharged ballast water. The rulemaking proposed a phase-two standard for the allowable concentration of living organisms in ships' ballast water discharged in U.S. waters. The phase-one standard was based upon the IMO Regulation D-2 standard. The phase-two standard was based on the most stringent proposed U.S. state regulations that were based on quantitative limits (CFR 2009).

The U.S. Final Ballast Water Rule was published on March 23, 2012, and went into effect on June 21, 2012 (USGPO 2012). The rule covers the U.S. territorial sea (12 nautical miles), and applies to sea-going vessels previously required to conduct ballast water exchange and coastwise vessels that do not operate outside EEZ but are greater than 1,600 gross tons and transit between Captain of the Port (COTP) Zones. Within the Great Lakes region, the rule applies to vessels that depart the Great Lakes, transit beyond the EEZ, and return and pass upstream of Snell Lock ("Salties").

In the Final Rule, BWM Plans now require the inclusion of training and safety procedures for the crew, and fouling maintenance and sediment removal procedures. Also new to the Final Rule, ship owners can request an extension of compliance implementation if compliance is not possible. Non-indigenous species reduction practices (formerly called BWM Practices) and ballast water reporting and recordkeeping requirements have not changed from the previous rule. The Final Rule did not adopt the phase-two standard previously proposed; instead, the discharge standard is the same as the IMO's performance standard (USCG 2013; USGPO 2012).

Many Great Lakes states have developed ballast water management regulations for their respective jurisdictions. Whenever the federal government issues a license or permit for a discharge into waters of the U.S., the Clean Water Act Section 401 requires certification for that discharge stating that any such discharge complies with the applicable provisions of Sections 301, 302, 303, 306, and 307 of the Clean Water Act (i.e., applicable effluent limitation, standard, or other limitation). Before USEPA issued the VGP in December 2008, it sought Section 401 certification from all of the Great Lakes states. These states were responsible for granting or

[19] USEPA promulgated regulations identifying those Armed Forces vessel discharges requiring control, and those which do not, in May 1999 at 40 CFR part 1700.

denying Section 401 certification for vessel discharges into navigable waters for which they had jurisdiction (at the point where the discharge originates). When a discharge may affect the quality of waters, a state may attach conditions to the license or permit (see http://www.epa.gov/OWOW/wetlands/regs/sec401.html). Many of the Great Lakes states included ballast water and other requirements as conditions in the VGP (USEPA 2008d). Table A-2 in Appendix A lists ballast water treatment permit requirements for the U.S. states in the Lake Superior Basin.

The states' involvement with ballast water regulations is complex and involves numerous aspects of state and federal laws, as well as international agreements. Current state regulations for ballast water management in the Lake Superior Basin are described below.

Minnesota requires existing oceangoing ships and commercial vessels that move only among Great Lakes ports, known as "lakers," to meet the proposed IMO ballast water performance standard by 2016 using treatment technology that meets Minnesota Pollution Control Agency (MPCA) approval. New ships, both oceangoing and lakers, launched after 2012 will be required to meet the IMO standard. Vessels must obtain a state permit demonstrating compliance with the above requirements.

Wisconsin requires existing oceangoing ships to meet the IMO performance standard by January 2014. New oceangoing ships are required to meet the IMO performance standard for ships launched after January 2012. Great Lakes carriers are exempt from Wisconsin's treatment standards but must implement BMPs to prevent the spread of AIS in the Great Lakes. Lakers are also required to maintain a sediment management plan that conforms to U.S. Coast Guard standards (WDNR 2009b).

Michigan requires a state permit verifying that vessels meet their state requirements. Michigan also provided 401 certification conditions, which are contained within USEPA's VGP. Discharge from oceangoing vessels is prohibited in Michigan waters unless an approved treatment system to prevent AIS is in place (sodium hypochlorite, chlorine dioxide, ultraviolet light radiation treatment preceded by suspended solids removal, or de-oxygenation). Since Michigan's State law was implemented in 2007, approximately 100 vessels have obtained a ballast water control general permit for port operations. However, none have discharged ballast water, likely because Michigan imports goods, and ships arrive at Michigan ports loaded with cargo and no ballast water on board (USEPA 2008c). Michigan currently has no requirements for discharge from lakers but has reserved the right to modify the state's requirements if it is determined that ballast water treatment on lakers is necessary, available, and cost-effective.

Ontario has not set forth any statutes pertaining to ballast water exchange or treatment, as federal regulations apply.

Ballast Water Treatment Systems

Shipboard treatment to kill organisms in ballast water is widely viewed as offering greater operational flexibility than ballast water exchange or saltwater flushing, as well as the potential for greater effectiveness. A variety of ballast water treatment technologies have proven effective

on a small scale (e.g., filtration, ultraviolet light, ultrasound, biocides), but implementing new systems on-ship or on-site at ports presents major challenges.

In response to the ballast water standards proposed by the IMO in 2004, significant progress has been made in developing effective ballast water treatment systems. Several commercial treatment systems have received IMO approval for demonstrating compliance with the 2004 IMO performance standard and are available for sale (IMO 2008). However, scientific methods to assess the concentration of viable organisms present in ballast water discharge, and thus compliance with ballast water performance standards, have not been fully developed. The water quality impacts of discharging chemically treated effluent is another issue that must be resolved (Dobroski et al. 2009).

To accelerate the research, development and implementation of effective ballast treatment systems for ships entering the Great Lakes, the Great Ships Initiative was launched. The Great Ships Initiative operates a ballast treatment testing facility in the Duluth/Superior Harbor for testing various ballast treatment technologies designed to clean ballast waters. The facility offers both land-based and shipboard testing to assess the performance and toxicity of treatment systems in freshwater (Northeast-Midwest Institute 2007). Other treatment testing facilities exist both in the U.S. and abroad. These testing facilities include the Maryland Environmental Resource Center (MERC), facilities aboard the training ship Golden Bear, the Royal Netherlands Institute for Sea Research (NIOZ), and the Norwegian Institute for Water Research (NIVA). Not all of these facilities have the ability to test systems in freshwater that would be appropriate for the Great Lakes.

Additional ballast treatment testing programs are operated by the U.S. Coast Guard and USEPA. The Coast Guard's Shipboard Technology Evaluation Program provides an incentive for foreign and domestic vessels to install and operate an experimental treatment system by granting an equivalency to future ballast water discharge standard regulations, for up to the life of the vessel or system. Under the Environmental Technology Verification Program, the U.S. Coast Guard and USEPA have collaboratively developed protocols for ballast water treatment systems. The most recent protocol for the verification of ballast water treatment technology was finalized in September 2010 (USEPA 2010). The Naval Research Laboratory Ballast Water Treatment Testing Facilities in Key West, Florida, were responsible for developing and validating many of these protocols, in partnership with the U.S. Coast Guard and USEPA.

Shore-based ballast water treatment avoids some of the challenges associated with shipboard application of water treatment methods. There are currently no shore-based ballast water treatment facilities available to vessels operating in the Great Lakes St. Lawrence Seaway system.

A report prepared for the Wisconsin Department of Natural Resources (WDNR) evaluated the feasibility of developing an off-ship ballast water treatment system for use in port areas (Brown and Caldwell 2008). The treatment system would be housed on a barge, allowing it to be transported and used at other ports. The report recommended further research and testing to determine the impact of requiring ballast water treatment in Wisconsin waters, including the

effectiveness of the proposed treatment (cloth filter followed by UV radiation). It remains to be seen whether shore-based treatment systems will be feasible.

Retention of ballast water on ship ensures that no AIS present in ballast water are released into non-native waters. However, depending on the trading pattern of the vessel, retention of ballast water may not be possible or practical.

4.1.2 U.S. Federal Statutes

Several statutes are aimed at preventing the introduction and spread of AIS in the U.S. Several regulations stipulate ballast water management to prevent the introduction and spread of AIS, including the Nonindigenous Aquatic Species Prevention and Control Act (NANPCA), National Invasive Species Act of 1996, and the Clean Water Act (CWA). The Lacey Act and its amendments govern the importation or shipment of injurious organisms covering a range of fish, wildlife, plants and plant products. The Alien Species Prevention and Enforcement Act of 1992 addresses the shipment through the U.S. mail of prohibited fish, wildlife, and plants covered under the Lacey Act. The Plant Protection Act (2000) regulates the prevention and spread of noxious weeds, including foreign aquatic plants. Appendix B presents selected U.S. statutes governing AIS.

Several bills related to AIS have recently been introduced into Congress. For example, U.S. House bills H.R.260, Aquatic Invasive Species Research Act, and H.R.1350, Great Lakes Collaboration Implementation Act, point to the need for continued research to protect against AIS. The Aquatic Invasive Species Research Act is intended to establish marine and freshwater research, development, and demonstration programs to support efforts to prevent, control, and eradicate invasive species, as well as to educate citizens and stakeholders and restore ecosystems. The Great Lakes Collaboration Implementation Act is intended to establish a collaborative program to protect the Great Lakes by authorizing funding for key recommendations from the Great Lakes Regional Collaboration.

4.1.3 Canadian Federal Codes and Statutes

Appendix B presents selected Canadian codes and statutes governing AIS. In summary, the following Canadian regulations help prevent the introduction of AIS in Lake Superior:

1. No harmful substances of any type may be deposited (i.e., from ships, sewers, run-off, etc.) in waters frequented by fish. (*Fisheries Act*)
2. Ballast water control and management are mandated for Canadian vessels everywhere and for foreign vessels in Canadian waters. An inspection and enforcement program is in place to monitor compliance. (*Canada Shipping Act*)
3. The direct discharge of sanitary wastes into certain bodies of water is prohibited. The discharge of galley or washing wastes is not prohibited. (*Canada Shipping Act*)
4. Permits are required for dumping contaminated and harmful substances (including dredged sediments) into Canadian waters. (*Canadian Environmental Protection Act*)
5. The discharge of any waste or material that would impair navigation in navigable waters is prohibited. Certain material—such as rock, gravel, soil, or ash—can be discharged where water depth exceeds 20 fathoms. (*Navigable Water Protection A*ct)

6. Petroleum storage tanks on federal lands must be registered. (*Canadian Environmental Protection Act*)
7. All necessary precautions to avoid accidental spills should be taken; in the event of a spill, an emergency spill response should proceed. A list of hazardous substances that are used on site and that are likely to contaminate the environment if spilled should be created. The release of a toxic substance to the environment must be reported. (*Canadian Environmental Protection Act*).
8. Ships in waters under Canadian jurisdiction or in the United States waters of the Great Lakes Basin must manage ballast water through the following management processes, either separately or in combination:
    a. the exchange of ballast water;
    b. the treatment of ballast water;
    c. the discharge of ballast water to a reception facility; and
    d. the retention of ballast water on board the ship. (Canadian Ballast Water Management and Control Regulation 2006, under authority of *Canada Shipping Act*).

4.1.4 State and Provincial Administrative Codes and Statutes

The states (Michigan, Minnesota, and Wisconsin) and province (Ontario) in the Lake Superior Basin have promulgated administrative codes and statutes to control AIS that are introduced through various pathways. These statutes address various pathways of AIS introduction, including ballast water, import of bait, boating, plant release, unauthorized introductions, aquatic plants that are purchased and sold, fishing equipment, float planes, and use and disposal of live bait. Appendix C presents relevant codes and statutes for each state/province. In addition, ballast water treatment permit requirements for the U.S. states in the Lake Superior Basin are presented in Table A-2 of Appendix A.

4.1.5 Tribal Regulations

A number of tribes have reservations and/or treaty-reserved hunting, fishing, and gathering rights in the Lake Superior Basin. On the U.S. side, tribes regulate their members in the exercise of these rights, with the help of intertribal agencies like the Great Lakes Indian Fish and Wildlife Commission, the 1854 Treaty Authority, and the Chippewa-Ottawa Resource Authority. Tribes have promulgated regulations to control AIS that could be introduced when tribal members are exercising these rights. In some but not all cases, these regulations parallel the regulations in place in the state where the rights are being exercised.

4.2 INTERAGENCY COLLABORATION

Section 4.1 listed the state, provincial, federal, and international requirements aimed at reducing the spread and introduction of AIS. Working toward the same goal, and within their respective jurisdictions, various agencies have worked collaboratively to develop these rules. One of the most widespread invasions of AIS in the Great Lakes region, the zebra mussel, has focused many collaborative efforts on the management and control of ballast water. This section highlights current interagency collaboration aimed at stemming the spread of AIS through ballast water.

The primary U.S. and Canadian federal agencies that have helped shape AIS control efforts in the Great Lakes are:

- United States Coast Guard
- United States Environmental Protection Agency
- United States Fish and Wildlife Service
- United States Army Corps of Engineers
- National Oceanographic and Atmospheric Administration
- Transport Canada
- Environment Canada
- Fisheries and Oceans Canada
- Canadian Food Inspection Agency

The U.S. agencies were brought together in 1990 to implement the newly enacted NANPCA through the establishment of the Aquatic Nuisance Species (ANS) Task Force. The ANS Task Force was commissioned to conduct studies to identify areas where ballast water could be discharged and loaded to ships where no environmental damage would occur, and to determine the need for additional control on vessels. The results of these studies were to be reported to Congress. The collaboration of agencies and task force resulted in the development of the Great Lakes Ballast Water Management Program in 2004, directed by the U.S. Coast Guard.

Under NANPCA, mandatory requirements for ballast water management in the Great Lakes (for both ballasted and non-ballasted vessels) have been enforced since 1993. Currently, all vessels entering the Great Lakes ecosystem must report ballast water data to one of three check points (Captain of the Port in Buffalo, Coast Guard's Marine Safety Detachment in Massena, or via the U.S. Saint Lawrence Seaway Development Corporation to the Marine Safety Detachment in Massena). This data is tracked and stored in the National Ballast Information Clearinghouse, which is maintained jointly by the U.S. Coast Guard and the U.S. Smithsonian Environmental Research Center.

In addition to the ANS Task Force and requirements established under NANPCA and the CWA, multiple efforts in the U.S., Canada, and internationally have been initiated to prevent the introduction of AIS in the Great Lakes ecosystem and beyond. In 2004, the IMO convened an international convention to stop the spread of AIS. As a result of the convention, 30 nations (representing 35% of the world merchant shipping tonnage) adopted rules and regulations for the control and management of ballast water and sediments. However, the convention only comes into force once 30 nations or 35% of the world shipping tonnage have ratified it. As of July 2010, 24 nations had ratified the convention, representing 25% of worldwide shipping tonnage. Canada ratified the IMO convention as of April 9, 2010. Current Canadian ballast water regulations are consistent with the requirements of the IMO convention, except for the convention's application dates for fitting ballast water technology on ships.

The U.S. and Canada are cooperating through the North American Commission for Environmental Cooperation (CEC), the Great Lakes Commission, and the International Joint Commission (IJC) to better understand, coordinate, and address ballast water management concerns. The CEC promotes research and development related to AIS. Recognizing the

potential risk of transfer of non-native species through international commerce, the CEC recently developed Trinational Risk Assessment Guidelines for Aquatic Alien Invasive Species. The AIS issue is a priority for the Great Lakes Commission, which has supported the Great Lakes Panel on Aquatic Nuisance Species since 1991 and which implements several projects related to AIS issues. Due to potential water quality concerns posed by AIS, the IJC has supported government actions to protect the Great Lakes from the threat of invasive species, including federal U.S. legislation for ballast water treatment, and ratification of the 2004 IMO convention (IJC 2004).

The U.S./Canadian Ballast Water Working Group (BWWG) was established in January of 2006. This binational group consists of representatives from Transport Canada - Marine Safety, U.S. Coast Guard, the U.S. Saint Lawrence Seaway Development Corporation, and the Canadian St. Lawrence Seaway Management Corporation. The mission of the group is to coordinate regulatory compliance and research efforts for reducing AIS introductions through ballast water into the Great Lakes. All four agencies committed resources to aggressively increase ballast tank inspections during 2008.

Most recently, the Great Ships Initiative was formed collaboratively with U.S. and Canadian participation to focus resources and expertise on developing solutions to AIS problems from maritime commerce in the Great Lakes St. Lawrence Seaway System. The current focus of the Great Ships Initiative is research, development and implementation of effective ballast treatment systems for ships entering the Great Lakes from overseas. The initiative brings together experts from the Northeast-Midwest Institute, the American Great Lakes Ports Association, the National Fish and Wildlife Foundation, the University of Wisconsin-Superior, Minnesota Sea Grant, and other federal, state and interested carriers.

In 2009, the Saint Lawrence Seaway Development Corporation (SLSDC) and the International Joint Commission initiated the Great Lakes Ballast Water Collaborative to bring together industry and state and federal regulators on the issue of ballast water and invasive species in the Great Lakes region. One of the primary goals of the Collaborative is to share relevant, useful, and accurate information and to foster better communication and collaboration among key stakeholders engaged in the effort to reduce the risk of introduction and spread of AIS (SLSDC 2010).

The International Conference on Aquatic Invasive Species is an important catalyst for collaboration among researchers, practitioners, resource managers and educators who are addressing the issue of non-native species in marine and freshwater environments. Held every 18 months, the international forum provides a review of scientific knowledge, presents current research, introduces new technological developments for control and mitigation of non-native species, promotes outreach and education initiatives, discusses policy and legislation, and considers ballast water and other shipping-related issues.

In 2006 the Canadian Aquatic Invasive Species Network (CAISN) was established at the University of Windsor. This is a multi-million dollar research initiative that involves 20 universities across Canada as well as five federal laboratories, the shipping and aquaculture industries, and the Ontario Federation of Anglers and Hunters. This program brings together academia, government, industry, and non-government organizations to work on and advance the

technology, science, and policy needed to address invasive species introductions (CAISN 2009). The program and its research are directed at three theme areas (CAISN 2006-2007):

- Identification and quantification of vectors and pathways that transmit AIS to and within Canada
- Assessment of factors that affect establishment success of AIS
- Risk assessment modeling of AIS

In Ontario, several federal and provincial government agencies collaborate to implement the specific goals related to invasive species that are outlined in COA. For example, to reduce the entry and spread of non-native invasive species in the Great Lakes, Canada developed a *Canadian Action Plan to Address the Threat of Aquatic Invasive Species* through the collaboration of federal, provincial and territorial governments. Both government and non-government organizations are working together to deliver invasive species monitoring, risk assessment, control, reporting, research and outreach initiatives as part of the Ontario Ministry of Natural Resources (OMNR) and Ontario Federation of Anglers and Hunters Invading Species Awareness Program. Risk assessments for AIS of national importance are conducted by Fisheries and Oceans Canada.

Most of the discussion on interagency collaboration has focused on international and federal efforts regarding ballast water. There is also much collaboration among state, local, and tribal organizations in an effort to stop the spread of AIS. For example, in December 2004, the U.S. Great Lakes Regional Collaboration (GLRC) was launched, creating a unique partnership of key members from federal, state, and local governments, tribes, and other stakeholders for the purpose of developing a strategic plan. Due to the large number of potential organizations, not all local, inter- and intra-state, intertribal, and agency collaborations are described in the present plan. This is primarily due to the limited documentation of such collaborative efforts. However, in the following sections, several state, provincial, and tribal initiatives promoting voluntary actions for other vectors are included. These initiatives require the collaborative efforts of many resource management agencies and organizations.

4.3 MANAGEMENT, MONITORING AND GUIDANCE

Because ballast water has historically been the primary vector for the introduction of AIS in the Great Lakes ecosystem, this section briefly describes management and monitoring efforts related to ballast water and then discusses voluntary and mandatory efforts (BMPs, monitoring and general guidance) that focus on other vectors of AIS.

4.3.1 Ballast Water Management and Monitoring

In 1997, Transport Canada, the U.S. Coast Guard, and the U.S. and Canadian Seaway Corporations began conducting joint inspections of vessels entering the St. Lawrence Seaway System to ensure compliance with ballast water management requirements.[20] Ships are inspected before entering the Great Lakes, at a central point in Montreal. Inspections of vessels include review of ballast water reports, logs, records and ballast water management plans.

[20] Great Lakes ballast water exams are conducted and reported by the Great Lakes Ballast Water Working Group.

Additionally, ballast water tanks are routinely sampled for salinity as part of Transport Canada's inspection and enforcement regime. All data are recorded and reported annually. This monitoring allows agencies to identify areas where additional regulation and enforcement are required and to evaluate the effectiveness of current regulations.

In 2009, 100% of vessels bound for the Great Lakes Seaway were inspected, a 26% increase over the number of inspections conduced in 2007. Ships' compliance with ballast water management requirements remains high. In 2008, 98.6% of 6,704 ballast tanks sampled were compliant, compared to 95% compliance in 2007 (Great Lakes BWWG 2009). In 2009, 97.9% of 5,450 ballast tanks sampled were compliant. Most non-compliant vessels chose to retain non-compliant ballast water on board in 2009; one vessel chose to conduct an exchange in an approved alternate zone (Great Lakes BWWG 2010). Non-compliance is addressed on a case-by-case basis,[21] and civil penalties may be incurred for violations.

4.3.2 Other AIS Vectors

The Province of Ontario and several states have implemented BMPs and management plans aimed at AIS vectors other than ballast water. These programs are primarily aimed at the water recreation, fishing, and tourism vectors. Programs in the states and Ontario incorporate public education and monitoring to prevent the introduction and spread of AIS. For instance, during the summer months, trained individuals monitor recreational boats as they are removed from the lake and trailered. The inspectors inform boaters of the laws regarding restrictions on transport of AIS, and demonstrate how to inspect and remove AIS from their boating equipment. Education and outreach programs are described further in Section 4.4 below.

Michigan, Minnesota, and Wisconsin have developed state AIS management plans and maintain active programs to manage AIS. Since 1996, Michigan has maintained a management plan to address AIS through legislation and policy, information and education, and research and monitoring. Minnesota established an invasive species program in 1991 that involves outreach, education, regulation, watercraft inspections, monitoring and active management of established AIS. Wisconsin's program includes watercraft inspections, monitoring for AIS, education and outreach efforts, control of established species, and training for volunteers to help inspect boats and equipment and monitor for aquatic invasives.

In addition to state invasive species programs, the Great Lakes Sea Grant Network, a network of Great Lakes universities funded by the National Oceanic and Atmospheric Administration (NOAA), funds research, supports public outreach and education, and maintains AIS resources to address aquatic invasive species prevention and control. The Michigan, Minnesota, and Wisconsin Sea Grant programs are instrumental partners in the states' efforts to prevent the introduction of new aquatic species to Lake Superior. Resources such as NOAA's Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS), which maintains a database of aquatic non-indigenous species in the Great Lakes, are additional tools that have proven useful in informing invasive species management decisions.

[21] Ships with non-compliant ballast tanks are required to perform one of three options: (1) Retain the ballast water and residuals on board, (2) Treat the ballast water in an environmentally sound and approved manner, or (3) Return to sea and conduct a full ballast water exchange.

The Canadian Food Inspection Agency, Fisheries and Oceans Canada, Transport Canada, and OMNR, in partnership with the Ontario Federation of Anglers and Hunters, have developed invasive species programs and strategies that include guidelines and other actions to prevent the introduction of new invasive species (e.g., steps for recreational boaters regarding boat cleaning).

AIS are one of the top concerns of the Chippewa-Ottawa Resource Authority, an intertribal agency that has been involved with many initiatives and efforts for the prevention of AIS through involvement with the ANS Task Force, Great Lakes Panel on Aquatic Nuisance Species, Great Lakes Fishery Commission and sea lamprey control efforts. The Great Lakes Indian Fish and Wildlife Commission, another intertribal agency, has also been involved in AIS efforts, with an extensive control and mapping program for aquatic and terrestrial invasive species.

4.4 EDUCATION AND INFORMATION

Current AIS management programs inform and educate individuals regarding the threat of invasive species and steps that can be taken to prevent the introduction of AIS. In addition to state/provincial or federal programs, non-profit and grassroots organizations can play an important role in education and the dissemination of information. For example, the Ontario Federation of Anglers and Hunters has thousands of members and hundreds of member clubs spread across Ontario. Similar organizations represented in both countries include Ducks Unlimited, Trout Unlimited, and the Nature Conservancy. The efforts of these groups to educate the public and influence the drafting of rules and regulations on issues such as AIS have a significant impact on reducing their impacts.

In 1992, the Ontario Federation of Anglers and Hunters, in partnership with OMNR, established the Invading Species Awareness Program. The program seeks to raise public awareness of invasive species and encourage participation in preventing their spread, monitor and track the spread of invading species in Ontario waters, and conduct research on the impacts and control of invasive species.[22] For example, the Ontario Federation of Anglers and Hunters and OMNR have installed roadside signs with educational messages for boaters and anglers in the Lake Superior Basin.

Minnesota Sea Grant has successfully implemented AIS education and outreach efforts by targeting segmented Lake Superior audiences and integrating prevention through education, inspection (legal or voluntary), monitoring, and enforcement. Minnesota Sea Grant also supports and participates in scientific research that focuses on Lake Superior. Three programs that have been effective at increasing public awareness and changing behavior to prevent the introduction of AIS include: Stop Aquatic Hitchhikers!™, Habitattitude, and Aquatic Invasive Species-Hazard Analysis and Critical Control Point program (AIS-HACCP) (Minnesota Sea Grant 2008b).

[22] For more information about the Invading Species Awareness program, see http://www.invadingspecies.com/indexen.cfm.

Drying a gill net, North Shore Lake Superior. Photo credit: Minnesota Sea Grant, Jeff Gunderson. Courtesy of US EPA Great Lakes National Program Office

Stop Aquatic Hitchhikers! is a multi-media campaign aimed at recreational water users. Specific AIS prevention measures have been developed for the following recreational users of the lake: anglers, aquarium or pet owners, bait harvesters/users, boaters, dog owners, hunters, scuba divers/snorkelers, seaplane pilots, surfers, swimmers, and tourists. The program is based on over 10 years of experience and the application of human dimension research to understand awareness, knowledge, attitudes, beliefs, insight into values, and behaviors of target audiences. In states like Minnesota and other jurisdictions that have made the campaign a priority, the program has effectively influenced boaters and anglers to inspect and clean their equipment. Results of surveys conducted in 2007 show that 99% and 97% of Minnesota and Wisconsin boaters, respectively, report taking action at water accesses to prevent the spread of AIS. The success of past efforts suggests that other jurisdictions can interrupt this potential pathway of spread by fully implementing Stop Aquatic Hitchhikers!.

Habitattitude is a successful partnership of the pet industry, U.S. Fish and Wildlife Service, and the Great Lakes Sea Grant Network. Through consumer education, the program aims to prevent the release or escape of aquarium fish, plants, crayfish, snails, and turtles by providing alternatives for the release of unwanted aquarium fish and plants into the environment.

Led by Michigan and Minnesota Sea Grant, AIS-HACCP is a program aimed at preventing the spread of AIS by the aquaculture and baitfish industries. AIS-HACCP works with businesses and agencies in the U.S. states and Ontario to identify and address points in the fish and bait handling business that are critical for AIS contamination or release. As a result of AIS-HACCP, an estimated 1,035 plans have been implemented by businesses and agencies to address critical points for AIS contamination or release. By 2010, all commercial bait operators in Ontario, Canada (consisting of approximately 1600 licenses), will be required to have AIS-HACCP plans in place. Bait harvesters need to complete mandatory training as well. The requirements for AIS-HACCP plans were implemented by OMNR starting in 2006.

Michigan Sea Grant has been involved with the development of AIS-HACCP training materials, and early training was targeted at the private aquaculture and baitfish industries in Michigan. Later training focused on State of Michigan fish hatchery and natural resources personnel, including Tribes. Recent activities have focused on preventing the spread of VHS, and a series of Biosecurity/AIS-HACCP Workshops have been conducted in the region (Gunderson and Kinnunen 2002; Gunderson and Kinnunen 2004).

Minnesota Department of Natural Resources (MN DNR) has used a multi-pronged approach to educate boaters, anglers, and others. Since 1992, the DNR's Invasive Species Program has made substantial efforts to create and maintain a high level of public awareness and understanding about invasive species. Key components of annual education efforts include television and radio

public service announcements, printed materials, press releases, media contacts, newspaper ads, billboards, information on DNR's website, staffing at sports shows and other major events, educational displays and exhibits, informational signs at public water accesses, and training.

4.5 SOURCES OF SUPPORT FOR AIS PROGRAMS

Although the need for efforts to prevent the introduction of AIS is evident, actions cannot be realized without appropriate funding. There are several government agencies and non-government organizations that actively provide funding for research and enforcement of regulations related to AIS. A few examples are presented below.

The OMNR funds programs delivered through the Invading Species Awareness Program run by its partner, the Ontario Federation of Anglers and Hunters. The program includes control, monitoring, and prevention programs, public participation, demonstrations, and education campaigns to raise awareness about the ecological impacts associated with AIS.

Education and outreach efforts implemented by Minnesota Sea Grant (described above) are funded by Sea Grant (NOAA) in cooperation with several partners: AIS-HACCP in partnership with the Great Lakes Protection Fund; Habitattitude in partnership with the U.S. Fish and Wildlife Service and the Pet Industry Joint Advisory Council; Stop Aquatic Hitchhikers! in partnership with the U.S. Fish and Wildlife Service and Minnesota and Wisconsin Departments of Natural Resources.

NOAA has also funded the National Sea Grant program and Great Lakes Ballast Water Technology Demonstration program to investigate alternatives to ballast water exchange methods and provide leadership assistance to the Great Lakes NOBOB and Ballast Exchange research program. NOAA also funds AIS research and outreach in all Great Lakes states through the Sea Grant program.

Since 2005, funding for the Great Ships Initiative has been provided primarily by Congress, with additional funds or in-kind contributions from several partners. In March 2009, Congress awarded the Great Ships Initiative $1 million in new funding to continue efforts to prevent ship-mediated introductions of AIS.

Research surrounding complex issues such as AIS is key to preventing the introduction of new invasive species. Advanced research labs such as NOAA's Great Lakes Environmental Research Lab, the Smithsonian Environmental Research Center in the U.S., as well as the Great Lakes Institute for Environmental Research, and the Canadian labs that have partnered under CAISN are crucial to fully understanding AIS. The Natural Sciences and Engineering Research Council of Canada is funding much of the research undertaken by CAISN partners, including the building and testing of tools for studying vectors, pathways, the factors that affect the success of species establishment, and the development of risk assessment models related to future AIS invasion. Additional CAISN funding partners include Transport Canada, Fisheries and Oceans Canada, and OMNR.

Minnesota established an Invasive Species Program in 1991 within MN DNR. It has grown into a $4.7 million per year program to prevent the introduction and spread of invasive species within

Minnesota and to reduce the impacts caused by invasive species. Funding for program activities is provided through a surcharge on watercraft licenses, a surcharge on non-resident fishing licenses, and the state's general fund. Additional funding, primarily for specific research efforts, is provided by the Environment and Natural Resources Trust Fund and Minnesota Future Resources Fund. Federal grants are also sought to help fund program efforts.[23]

MN DNR has provided grants to extend its Invasive Species Program efforts on a local scale. Invasive Species Prevention Grant funds totaling $100,000 was offered in 2009 for community-based prevention efforts such as public awareness campaigns and watercraft inspections. Eligible applicants include various non-profit type groups (e.g., lake associations, conservation districts, watershed groups).

Established by the Convention on Great Lakes Fisheries, a binational agreement signed by Canada and the U.S. in 1954, the Great Lakes Fishery Commission is a joint U.S.-Canadian organization with two major responsibilities related to AIS in the Great Lakes: 1) Develop coordinated research programs and recommend measures that permit the maximum sustained productivity of fish stocks, and 2) maintain a sea lamprey control program to eradicate or minimize sea lamprey populations in the Great Lakes.

The Great Lakes Fishery Commission and the Great Lakes Fishery Trust recently provided funding for a three-year study that investigated eliminating the transfer of invasive species between the Great Lakes and Mississippi River systems. The results of the research indicated that, while an electrical dispersal barrier currently provides some control on the Chicago Sanitary and Ship Canal, long-term solutions are needed to further reduce the risk of invasions (U.S. Water News 2008).

On April 8, 2009, the U.S. Army Corps of Engineers announced the activation of a new electric barrier (Barrier IIA) in the Chicago Sanitary and Ship Canal to prevent the spread of AIS (e.g., Asian carp) into the Great Lakes. Barrier IIA now operates in addition to a smaller demonstration barrier that the U.S. Army Corps has operated in the canal since 2002. Both barriers operate at an electric field strength of 1 volt per inch to block the passage of fish between the Great Lakes and Mississippi River basins. The Army Corps is continuing efforts to determine the optimum combination of voltage, pulse duration and frequency required to repel all sizes of fish, including smaller juveniles, which are more likely to swim through lower voltage fields. As with the sea lamprey control program, the barrier system must operate continuously, in perpetuity, to prevent the passage of AIS, unless measures are taken to completely separate the Great Lakes ecosystem from the Mississippi River drainage area.

The U.S. Army Corps of Engineers continues to investigate technologies that may enhance the efficacy of dispersal barriers in the Chicago Sanitary and Ship Canal system (e.g., additional

[23] More information about the Minnesota DNR's Invasive Species Program is available at http://www.dnr.state.mn.us/eco/invasives/index.html.

technologies such as acoustic deterrents, air bubble curtains, and strobe lights used both individually and in combination).[24]

The National Invasive Species Act (NISA) in 1996 authorizes the appropriation of funding to U.S. states for prevention, education, monitoring, control and research. Under the auspices of the ANS Task Force, the U.S. Fish and Wildlife Service distributes approximately $1 million annually to states that have an approved state management plan addressing AIS. Under this authority, each state receives about $48,000.

5.0 SUMMARY AND CONCLUSIONS

5.1 RECOMMENDED STRATEGIES

Action is needed to prevent the introduction of new AIS in the Lake Superior ecosystem. Table 4 identifies current gaps in existing rules, regulations, practices, and programs that may lead to the introduction of AIS in Lake Superior. Organizations to lead implementation of each of the recommended actions will be identified in an implementation plan, which will be developed upon final approval of the plan. Recommended actions are discussed further following the table. As new information arises, the identified gaps and need for action may change. For example, in the next few years, an overall study of the relative risk of each vector of AIS introduction in Canada will be conducted under the guidance of CEARA (Fisheries and Oceans Canada). The results of this study may provide new information that changes the need and approach for preventive actions.

Table 4. Recommended AIS Prevention Activities for Lake Superior, by Vector and Pathway

Pathway	Gap	Recommended Action	Jurisdiction
Maritime Commerce			
Ballast water	- Ballast water standards for maritime and lake vessels vary among Lake Superior jurisdictions	- Implement compatible, federal regulatory regimes for ballast water discharge that are protective of the Great Lakes for both the U.S. and Canada.	- Federal U.S. - Federal Canada
	- New technologies for ballast water treatment are not widely available. The development, testing, approval and commercial availability of treatment systems suited for the operational characteristics of the Great Lakes is a significant technology gap.	- Work with appropriate federal agencies and the Great Ships Initiative to support development, testing and implementation of effective ballast treatment systems for the Great Lakes - Provide incentives for proving technology effective in freshwater environments	- Federal U.S. - Federal Canada
Hull/anchor/ superstructure	- Lack of regulations and programs to prevent deck	- Identify programs and determine an effective management approach that	- Federal U.S. - Federal Canada

[24] Federal Register: March 15, 2010 (Volume 75, Number 49). Notice of Availability for Comments Regarding the Planned Environmental Assessment Interim Report IIIa Fish Deterrent Barriers, Illinois and Chicago Area Waterways

Pathway	Gap	Recommended Action	Jurisdiction
fouling	and superstructure fouling as a pathway - Research needed into alternative anti-fouling agents to TBT	will prevent the transfer of AIS to Lake Superior	
Agency Activities			
Stocking/ Hatcheries		- No new actions	
Harbor, navigation maintenance and construction	- Activities may require using equipment and tools in the basin that were previously used in other marine or freshwater environments and may be contaminated with AIS - AIS may be contained in dredged material, and its reuse may result in AIS introductions	- Ensure that government agencies and their contractors establish and perform BMPs to prevent AIS introductions during dredging operations, construction, and other maintenance activities - Implement an education campaign	- Federal U.S. - Federal Canada
Research and assessment	- All research vessels (government, contracted, academic, Tribal, and First Nation) need to be able to perform due diligence in preventing transfers of invasive species - Lack of education, planning and reporting new species or infestations	- Ensure that operating budgets allow for due diligence (e.g., adequate time and resources to take preventive measures) - Apply AIS-HACCP to operations and products - Encourage all agencies who issue permits for research and assessment in Lake Superior to include AIS precautions in the permit conditions	- State/Provincial / Tribal - Federal U.S. - Federal Canada
Coast Guard activities	- Coast Guard vessel practices, such as relocating navigation buoys, may spread AIS	- The Coast Guards should review practices to ensure AIS are not transferred to Lake Superior from lower lakes	- USCG - Canadian Coast Guard
Organisms in Trade			
Live food fish, pets/aquariums, aquatic plants	- Regulatory gaps - Lack of inspection for prohibited state , provincial and federal species - Lack of consumer awareness/education - Lack of consistency in use and labeling of names - Contamination of products sold	- Establish federal screening processes to classify species proposed for trade into three lists: prohibited, permitted, and conditionally prohibited/permitted - Establish an immediate moratorium on the trade of prohibited species - Consider the concept of a “Certified Pathogen-Free through raising from seed” category for plants sold through garden centers and nurseries - Expand or implement education programs	- State/ Provincial - Federal U.S. - Federal Canada
Shoreline and habitat restoration	- Regulatory gaps - Lack of education and enforcement	- Require permits for shore land work, which identify AIS introduction issues and establish BMPs and restrictions - Implement education and enforcement efforts addressing shoreline and habitat	- State/ Provincial - Federal Canada - USACE

Pathway	Gap	Recommended Action	Jurisdiction
		restoration - Identify ecosystems that may be more vulnerable to invasion under changing environmental conditions, and restore ecosystems to become less vulnerable	
Illegal Activities			
Plant release	- On-line and mail order purchases evade regulations prohibiting the sale of invasive species.	- Ensure that existing laws prohibiting the sale of invasive species are enforced for on-line and mail order purchases - Work with plant nurseries or the industry to educate retailers about regulations pertaining to the sale of invasive plants	- State/ Provincial - Federal U.S. - Federal Canada
Unauthorized introductions	- Fish are transported between jurisdictions and watersheds and released. - Lack of education	- Create or initiate educational campaigns at, e.g., sportsman shows, bait shops, aquaria trade fairs, schools - Implement proven education campaigns appropriate for each audience	- State/ Provincial - Tribes - First Nations
Import of bait	- Live bait is illegally transported across the U.S./Canadian border and on shared waters - Lack of education	- Ensure effective education and prevention efforts at border crossings and retail bait shops - Monitor for effectiveness - Alert inspection and border control agencies to new invasive threats due to climate changes, and re-assess inspection priorities	- Federal U.S. - Federal Canada
Fishing and Aquaculture			
Fishing equipment including boats and vessels	- Lack of uniform regulations, enforcement, and inspection capacity across the Lake Superior Basin. - Additional resources are needed in some jurisdictions to support effective education and enforcement efforts	- Make regulations consistent basinwide re: cleaning fishing equipment - Make AIS prevention education, regulation, and enforcement a priority in all Lake Superior jurisdictions - Use community-based social marketing to identify the best methods or prevention approaches for reaching target audiences (e.g., boaters, anglers) and adapt for audiences not currently being reached - Fully implement Stop Aquatic Hitchhikers! - Build capacity for education and enforcement efforts within local communities by providing outreach products that can be tailored for local use - Provide community grants for education and enforcement efforts - Monitor programs for effectiveness	- Federal U.S. - Federal Canada - State/ Provincial - Communities (e.g., lake associations)
Sale and distribution of live bait, Use and disposal of bait	- Additional resources are needed in some jurisdictions to support effective education and	- Make AIS prevention education, regulation, and enforcement a priority in all Lake Superior jurisdictions - Ensure that current regulations are	- State/ Provincial

Pathway	Gap	Recommended Action	Jurisdiction
	enforcement efforts	updated as needed - Adequately enforce baitfish regulations - Maintain or expand education and outreach programs - Revise import/ introduction/release standards based on risk assessments that account for how changing climate conditions will affect the threat of new species	
Aquaculture facilities		- No new actions at this time	
Charter fishing/ Professional fishing guides	- Research suggests high risk due to number of waterways frequented and lack of effective boater hygiene practices	- Target outreach/ education to identify and communicate with fishing guides to improve boater inspection and cleaning	- State/ Provincial
Canals and Diversions			
Lift locks	- Despite operational procedures that keep the lock gates closed when not in use, fish are able to pass through the locks at Sault Ste. Marie	- Review and adjust policies regarding operation of the locks at Sault Ste. Marie to include best management practices that effectively prevent fish from passing through the lock, including closing the upper and lower gates when not in use and the use of in-stream barriers or deterrent technologies, if necessary	- USACE - City of Sault St. Marie
Chicago Sanitary and Ship Canal	- The electric barrier in the Chicago Sanitary and Ship Canal may not be sufficient to prevent the passage of fish (e.g., Asian carp) through the canal	- Investigate options to achieve ecological separation of the Great Lakes and Mississippi River watersheds - Until ecological separation is achieved, maintain the electric barrier at optimum conditions and ensure its continued operation - Establish structural measures to prevent the inadvertent introduction of Asian carp from floodwaters of the Des Plaines River into the canal	- USACE - Federal U.S. - State
Tourism and Development			
Cruising vessels	- Potential gap with cruising vessels from lower lakes	- Increase education efforts targeting cruise vessel operators	- State/ Provincial
Ecotours	- Unregulated	- Support educational campaigns	- State/ Provincial
Float planes and helicopters	- Potential routes of introduction through float planes, equipment used for fire fighting, and transport of goods for development (e.g., construction materials, baitfish)	- Liaison with plane charter companies, agencies, pilot associations - Promote BMPs for pilots	- State/ Provincial - Federal licensing agencies
Water Recreation			
Boating equipment, Diving and other	- Lack of uniform education, regulations, enforcement, and inspection capacity	- Make AIS prevention education, regulation, and enforcement a priority in all Lake Superior jurisdictions	- Federal U.S. - Federal Canada - State/ Provincial

Pathway	Gap	Recommended Action	Jurisdiction
recreation gear	across the Lake Superior Basin - Additional resources are needed in some jurisdictions to support effective education and enforcement efforts - Inconsistent messaging - Lack of adaption or adoption of strategies and methods that work	- Utilize existing outreach/education efforts to educate the public about increased risks of invasive species introductions (and their vectors/ pathways) due to climate change - Explore options for a broad range of solutions at public boat launches - Identify the best methods or prevention approaches for reaching target audiences (e.g., boaters, anglers) and adapt for audiences not currently being reached (e.g., scuba divers) - Fully implement Stop Aquatic Hitchhikers! - Use appropriate terminology and messages, and coordinate consistent messaging across jurisdictions - Build capacity for education efforts within local communities by providing outreach products that can be tailored for local use - Provide community grants for education efforts	- Tribal - Communities (e.g., lake associations)

Maritime Commerce

Ballast Water

The risk of new AIS introductions via ballast water is relative to enforcement activities (e.g., budgets for enforcement of saltwater flushing). Under the current enforcement regime, the risk of AIS introductions via ballast water is lower than in the past, but enforcement actions are subject to political commitment and capacity (availability of resources). Ricciardi (2006) suggested that non-native species continue to be introduced into Lake Superior through the maritime commerce vector (e.g., Chinese mitten crab (*Eriocheir sinensis*) in December 2005).

While Lake Superior remains at risk of new species invading through the ballast water pathway, recent ballast water management requirements, combined with increased inspections, have vastly reduced the risk for new foreign species. Lakers likely pose the greatest risks for introducing existing AIS from the lower Great Lakes into Lake Superior. Lakers are managed to varying degrees by Canada and the U.S. states (see Appendix A). It is recommended that the U.S. and Canada continue to work together to implement compatible, federal ballast water treatment and exchange standards that are protective of the Great Lakes for both the U.S. and Canada.

While there is a uniform standard for ballast water exchange for both BOB and NOBOB vessels entering the Great Lakes, there are no uniform standards for ballast water *treatment* in the Great Lakes. There is a need for standardization across all Lake Superior jurisdictions.

Several organizations support federal standards for ballast water treatment, including the U.S. Coast Guard, USEPA, and the IJC (see the IJC 2007 Annual Report). According to Rear Admiral P. Neffenger, "… a single federal, bi-national standard is the best approach to ensure consistency and uniformity throughout the Great Lakes system" (USCG 2009).

The U.S. Coast Guard finalized federal ballast water discharge standards for vessels discharging ballast water into U.S. waters. The standards are discussed in Section 4.1.1 of this plan. The Lake Superior Work Group supports the U.S. federal ballast water discharge standards and encourages Canada to adopt compatible federal standards that would provide uniform protection for the Great Lakes. The IMO Regulation D-2 standard is the same as the U.S. Coast Guard's phase-one Ballast Water Discharge Standard. The Coast Guard maintains that this standard is practicable to achieve in the near term and will provide considerable environmental protection over ballast water exchange.[25]

New technologies for ballast water treatment continue to be developed but are not widely available. However, new technologies continue to be researched, developed, and tested that provide alternative treatment systems and economic technology options. For example, the Great Ships Initiative is testing freshwater systems designed to operate on lake carriers. It is recommended that Canada and the U.S. support the Great Ships Initiative in the testing and implementation of effective ballast water treatment systems that meet the operational characteristics of the fresh, cold waters of the Great Lakes. The goal should be to develop ballast water treatment technology to reach the greatest effect possible, and not be limited to the goal of meeting a specific standard. This work may also help in developing capabilities to evaluate whether ships are in compliance with ballast water treatment requirements. In addition, the governments of the U.S. and Canada should consider incentives to further develop and prove treatment technologies in freshwater environments (e.g., reward treatments that move beyond current standards).

Hull/Anchor/Superstructure Fouling

As TBT compounds are phased out as an anti-fouling agent, an effective alternative is needed to protect against the transport of AIS on ships' hulls. It is recommended that the U.S., Canada, and the states/province, in cooperation with state Sea Grants programs, determine an effective management approach and implement programs that will prevent the transfer of AIS attached to the hulls or anchors of recreational, agency and commercial vessels traveling into Lake Superior. This is particularly important at points of entry into Lake Superior such as the Soo Locks. The IMO is compiling voluntary guidance for commercial and recreational vessels for the control and management of biofouling, to minimize the transfer of AIS. The IMO *Draft Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species* provide measures or practices to control and manage bio-fouling, including hull cleaning and the proper selection, use, and maintenance of anti-fouling paint. Implementation of the IMO

[25] Code of Federal Regulations (CFR). 2009. Notice of Proposed Rulemaking: Standards for Living Organisms in Ships' Ballast Water Discharged in U.S. Waters. 33 CFR 151; 46 CFR Part 162. Docket No. USCG-2001-10486. Available at http://www.regulations.gov/search/Regs/contentStreamer?objectId=0900006480a16b14&disposition=attachment&contentType=pdf.

guidelines would provide an internationally consistent approach to preventing the transfer of AIS through hull fouling.

Agency Activities

Stocking/Hatcheries

No new actions are recommended to prevent escapement of invasive species into the Lake Superior watershed from hatcheries. Fish species, facility security and other concerns are adequately addressed by existing policy and regulations. In Ontario, fish stocking is restricted to native or naturalized species. Likewise, species of fish stocked throughout Lake Superior are limited.

Harbor, Navigation Maintenance and Construction

Two actions are recommended to prevent AIS introductions as a result of harbor and navigation maintenance and water construction activities. First, it is recommended that government agencies responsible for harbor and navigation maintenance and water construction establish and ensure that appropriate procedures are taken to prevent AIS introductions during dredging operations, construction, and other maintenance activities. BMPs should be developed (e.g., cleaning dredging equipment before moving between lakes, removing visible plant material) and required as part of permits issued for dredging, construction, or other maintenance activities. Also, AIS prevention plans should be a requirement for any bid submitted by an independent private company for dredging, construction, or other maintenance activities.

Second, an education campaign targeting federal agencies, private contractors, and local harbor authorities would help to raise awareness of the issue and promote compliance with prevention actions. Sea Grant and state/provincial agencies who are experienced in conducting AIS outreach campaigns may be the appropriate leads to implement an education campaign that addresses the harbor, navigation maintenance and construction pathway.

Research and Assessment

All research and assessment activities should follow due diligence in ensuring that vessels and equipment do not provide an opportunity for transfer of AIS to Lake Superior (including federal, state/provincial, and academic vessels/equipment, both government and contracted, as well as Canadian Coast Guard vessels that are operated and maintained on behalf of other agencies). Operating budgets should allow for adequate time and resources needed for researchers and agency staff to learn and follow appropriate procedures for preventing the transfer of invasive species (e.g., cleaning and drying equipment including gill nets, properly disposing of research specimens). The AIS-HACCP education and training program has been applied to research, monitoring and assessment operations to help staff prevent AIS contamination or release. Research staff must also report new species or infestations of AIS to the appropriate state or provincial authorities.

State and provincial agencies that issue permits for research, monitoring and assessment in Lake Superior should include AIS precautions in the permit conditions.

Coast Guard Activities

The U.S. and Canadian Coast Guards should review management practices to ensure AIS are not transferred to Lake Superior from lower lakes as a result of Coast Guard activities [e.g., search and rescue missions (divers and helicopters might be used on more than one lake), icebreaking, maintenance, training activities, and navigational aide deployment and retrieval].

Organisms in Trade

Live Food Fish, Pets/Aquariums, Aquatic Plants

Several factors contribute to the risk of AIS introductions from live food fish, pets/aquariums, and aquatic plants. These include regulatory gaps that permit the sale of non-native species at pet stores and nurseries, a lack of inspection for prohibited species offered for sale, inconsistencies in the use and labeling of species names, product contamination, and a lack of consumer awareness. For instance, the ornamental fish industry in the Lake Superior region is largely unregulated, and consumers often release ornamental fish to lakes or streams (Whelan, 2009). Provincial and state agencies, in cooperation with state Sea Grant programs, should implement or expand, as appropriate, education programs aimed at targeted audiences: implement Habitattitude for aquarium hobbyists, backyard pond owners, and water gardeners; and expand AIS-HACCP to include live food fish and aquatic plant vendors in the basin.

To establish a consistent and comprehensive classification and regulatory system for AIS, it is recommended that the U.S. and Canada establish federal screening processes for each country to classify species proposed for trade into three lists: prohibited, permitted, and conditionally prohibited/permitted. An immediate moratorium should be established on the trade of prohibited species. While some states have begun to implement screening processes of their own, a federal classification system would provide more comprehensive and consistent protection against AIS across the Lake Superior Basin. The process of establishing a federal prohibited list would require that risk assessments be conducted to determine whether species pose a threat for becoming invasive and causing economic or ecological damage. The process must also consider relevant existing and proposed legislation. For example, in March 2010, the State of New York proposed a four-tier regulatory system for preventing the importation and/or release of non-native animal and plant species. The proposed system includes (i) a list of prohibited species; (ii) a list of regulated species; (iii) a list of unregulated species; and (iv) a procedure for the review of a non-native species that is not on any of the above lists before the use, distribution or release of such non-native species. New York's proposed system and others provide examples of efforts to develop effective screening processes.

A bill has been introduced in the U.S. House of Representatives (H.R. 669) that would establish a clean list of approved species and criteria that must be met for new importations. However, the proposed bill pertains to wildlife species only and does not include plant species. A federal

screening and approval process is needed for both plants and animals. A similar rule is needed to establish a classification and regulatory system for AIS in trade in Canada.

In addition, to address potential introductions of AIS in the packaging material of plants sold through garden centers and nurseries, the governments are encouraged to consider the concept of a "Certified Pathogen-Free through Raising from Seed" category. Such a category would provide certification for non-native and native plants that were not harvested from the environment but were grown from seeds in containers free of non-native organisms.

Shoreline and Habitat Restoration

AIS may be introduced during shoreline and habitat restoration projects due to a lack of awareness of non-native species or contamination of materials (e.g., seed mix, fill dirt, equipment). Permits to work on shorelines can be an effective means of providing education and ensuring conditions that will prevent AIS from being established during the course of a shoreline project. It is recommended that permits for shoreland work be required, identify AIS introduction issues, and establish BMPs and restrictions that residents and contractors must follow. The states and province should also implement education programs addressing the potential for AIS introductions during shoreline and habitat restoration projects.

Illegal Activities

Plant Release

Invasive species can be purchased from vendors on the internet or through mail-order catalogs. Federal and state/provincial agencies should work with plant nurseries or the industry to educate retailers about regulations pertaining to the sale of invasive plants, and ensure that existing laws prohibiting the sale of invasive species are enforced for on-line and mail-order purchases.

Unauthorized Introductions

Fish continue to be transported between jurisdictions and released due to a lack of education and possibly enforcement of rules prohibiting such actions. Education campaigns in Minnesota and Wisconsin have been effective in reaching target audiences such as anglers and aquarists. It is recommended that the states, province, and Tribes, in cooperation with Sea Grant and industry (e.g., angling industry), implement proven education campaigns, such as Habitattitude, and Stop Aquatic Hitchhikers!. Additional educational campaigns should be initiated at sportsman shows, bait shops, aquaria trade fairs, schools, or other conventions for appropriate audiences to increase awareness of prevention procedures.

Import of Bait

Greater support for educational campaigns is needed to prevent the transport of bait across state boundaries, the U.S.-Canadian border, and on shared waters of Lake Superior. The transport of commercial and non-commercial bait poses risks of new introductions of organisms and pathogens that may be carried in bait containers. Efforts should be made to increase inspection,

education and prevention efforts to encourage the purchase of bait locally and to ensure that fishermen are aware of restrictions on the transport and possession of bait from another jurisdiction. Education and prevention efforts should target anglers at border crossings, retail bait outlets, and other key locations.

Fishing and Aquaculture

Fishing Equipment

There is a lack of uniform regulations, enforcement, and inspection capacity across the Lake Superior Basin. It is recommended that regulations concerning fishing equipment, including boats, be made consistent basinwide. For example, rules requiring anglers to drain all containers and fishing equipment before leaving any lake or shore should apply to waters throughout the Lake Superior Basin. Likewise, anglers should not be permitted to transport live fish from any waters in the Lake Superior Basin. The Great Lakes Fishery Commission has performed a review of regulations basinwide related to VHS prevention and may be able to assist individual jurisdictions in developing regulations that are consistent with other jurisdictions.

Informing anglers of effective prevention procedures is another way to prevent new introductions of AIS. Minnesota and Wisconsin have taken the lead in implementing effective education and outreach campaigns targeted to specific audiences, such as AIS-HACCP and Stop Aquatic Hitchhikers!. However, similar campaigns are not as aggressively implemented in Michigan and Ontario due to a lack of resources. AIS prevention education, regulation, watercraft inspection, and enforcement must be made a priority in all Lake Superior jurisdictions.

State and provincial agencies can take the lead in using community-based social marketing to identify the best methods or prevention approaches for reaching target audiences (e.g., boaters, anglers) and utilize those approaches for audiences that are not currently being reached. Surveys of boaters and anglers in Minnesota and Wisconsin have demonstrated the effectiveness of the Stop Aquatic Hitchhikers! campaign when sufficient resources are dedicated to the program (Jensen 2009). The states and province should fully implement Stop Aquatic Hitchhikers! to reach all anglers in the Lake Superior Basin.

State/provincial agencies can also build capacity for education and enforcement efforts within local communities by providing outreach products that can be tailored for local use, such as public service announcements and boat ramp signs (models are provided through the Stop Aquatic Hitchhikers! campaign). Community grants can support AIS education and enforcement efforts on a local scale.

Sale and Distribution of Live Bait, Use and Disposal of Bait

Each jurisdiction in the Lake Superior Basin (state, province, tribes) has its own regulations governing the import/export of live bait, certification of bait species, and use of bait. While the regulations differ between jurisdictions, most Lake Superior agencies have established regulations that effectively address these issues. Enforcement of baitfish regulations plays an important role in ensuring that the regulations are effective. Not all Lake Superior agencies have

sufficient staffing capabilities to adequately enforce current regulations aimed at preventing AIS introductions through live bait. Each jurisdiction should seek additional resources, as needed, to provide adequate enforcement of baitfish regulations.

Combined with enforcement efforts, outreach and education programs can be used to inform anglers of relevant baitfish regulations and deter unwanted behaviors. Additional resources are needed in some jurisdictions to support effective outreach and education efforts. Education and outreach programs targeting anglers are ongoing to minimize the risk of AIS introductions from live bait. However, stronger education efforts warning anglers of the risks of transporting live bait are needed in some cases. For example, in the Chicago area, there is potential for juvenile Asian carp caught for bait in the Mississippi drainage basin to be used and released into Lake Michigan. The fishing tackle and boating industries could be engaged to enlist their marketing capabilities to help educate anglers and to advance prevention efforts. Approaches to most effectively reach anglers about the risk of AIS from baitfish could be shared among jurisdictions.

All Lake Superior jurisdictions should make AIS prevention education, regulation, and enforcement a priority. This means ensuring that current regulations are updated as needed to address new AIS threats (e.g., require certification of bait as pathogen-free[26] at the wholesale level), adequately enforcing baitfish regulations, and maintaining or expanding education and outreach programs so that all anglers in the Lake Superior Basin are aware of the risk of AIS and do their part to prevent new introductions.

Aquaculture Facilities

No new actions are recommended at this time. Very few aquaculture research facilities exist, and there are no net pen operations. However, the release of non-native species from aquaculture facilities has been perceived as a risk in other jurisdictions, and this pathway should be monitored for the development of potential new risks.

Canals and Diversions

The Chicago Sanitary and Ship Canal continues to pose a threat of new invasions to the Great Lakes. While the activation of a second electrical barrier in the canal improves protection against the transfer of fish, the level of protection provided by the barrier has yet to be determined. The U.S. Army Corps of Engineers continues to adjust the voltage and determine the effectiveness of barrier operation.

In 2009, the inadequacy of the electrical barrier in providing full protection against invasive species became apparent. In December 2009, the electrical barrier was shut down for scheduled maintenance, and preventive measures were taken to stop the passage of fish during the maintenance operation. A physical specimen of Asian carp was retrieved 500 feet north of the Lockport Lock and Dam in the Chicago Sanitary and Ship Canal, much closer to the electrical barrier than previously found. The U.S. Army Corps of Engineers also reported positive results

[26] Specific pathogens are not defined but include any pathogen identified as posing a risk to native species in Lake Superior.

on carp eDNA in water samples taken in the Calumet Harbor of Lake Michigan and a number of other locations upstream of the barrier. [27]

In a resolution passed by the Great Lakes Commission on February 23, 2010, eight Great Lakes states, along with the Canadian provinces of Ontario and Quebec, asked Congress and the U.S. Army Corps of Engineers to adopt a goal of ecological separation of the Great Lakes and Mississippi River watersheds as a means of protecting the Great Lakes from the invasion of Asian carp. The resolution also called for the U.S. Army Corps of Engineers to accelerate the timetable for full operation of the electrical barrier system and to establish structural measures to prevent the inadvertent introduction of Asian carp from floodwaters of the Des Plaines River into the canal.[28] Support for these efforts is encouraged, and it is recommended that ecological separation be attained as soon as possible.

Ocean vessel at the Soo Locks, Sault Ste. Marie, Michigan. Photo credit: Jerry Bielicki, US Army Corps of Engineers. Courtesy of US EPA Great Lakes National Program Office

The use of an electric barrier in the Soo Locks and recreational lock would prevent the passage of fish into Lake Superior, but it would not prevent the spread of other invasive species (e.g., aquatic invertebrates). The U.S. Army Corps of Engineers' routine practice of closing the lock gates and chambers after a vessel has passed through helps to reduce the opportunity for fish and other mobile organisms to enter the lock and gain access to Lake Superior. However, it is recommended that the U.S. Army Corps of Engineers ensure that best management practices are employed to most effectively prevent fish from passing through the lock, including the use of in-stream barriers or deterrent technologies, if necessary. This recommendation is consistent with the Corps' Invasive Species Policy, adopted in 2009, to prevent or reduce the establishment of invasive and non-native species.[29] Likewise, operating procedures for the recreational canal lock at Sault St. Marie should include closing lock gates when not in use and other best management practices that effectively prevent the passage of fish (electric barrier or alternative options, as necessary).[30]

Tourism and Development

There is potential for AIS to enter Lake Superior from cruising vessels and ecotour boats traveling from the lower lakes. Professional fishing guides, who frequent a greater number of

[27] Great Lakes Commission. 2010. Resolution: Actions to Address the Threat to the Great Lakes from Asian Carp. Adopted on February 23, 2010. Available at http://www.glc.org/about/resolutions/10/asiancarp.html. Accessed: April 2010.
[28] Ibid.
[29] U.S. Department of the Army, U.S. Army Corps of Engineers. 2009. Memorandum: U.S. Army Corps of Engineers Invasive Species Policy. Available at http://www.nae.usace.army.mil/reg/invasivespeciespolicy.pdf.
[30] The recreational lock is currently operated by the City of Sault St. Marie under an operating agreement with Parks Canada.

waterways and are less likely to inspect and clean their boats than other small-craft boaters, pose a relatively high risk of AIS transfer (Rothlisberger et al., 2010). Float planes and helicopters represent a potential route of introduction through the movement of aquatic plants and animals on floats or in water tanks (of fire suppression planes) and the transport of goods for development (e.g., construction materials). Potential AIS introductions from all tourism and development pathways could be mitigated through increased education efforts targeted to the public, cruising vessel owners, professional fishing guides, boat clubs, and the ecotour industry. It is also recommended that state/provincial agencies and federal licensing agencies liaison with plane charter companies, agencies, pilot associations, and recreational flying clubs to promote BMPs for pilots to prevent transfers of AIS.

Water Recreation

AIS can be introduced when boating, diving, and other recreational equipment is moved between lakes without being cleaned or dried properly. A lack of uniform education, regulations, enforcement, and inspection capacity across the Lake Superior Basin leaves an open pathway for the introduction of AIS by recreational boaters and divers. Additional resources are needed in some jurisdictions to support effective education and enforcement efforts. .

It is recommended that state/provincial/tribal agencies and communities (e.g., lake associations) ensure that AIS prevention education, regulation, and enforcement are a priority in all Lake Superior jurisdictions. This will require continued implementation of AIS prevention efforts, including:

- Identifying the best methods or prevention approaches for reaching target audiences (e.g., boaters, anglers) and adapting those methods for audiences that are not currently being reached (e.g., scuba divers).
- Using appropriate terminology and messages.
- Coordinating consistent messaging across jurisdictions.
- Building capacity for education efforts within local communities by providing outreach products that can be tailored for local use.

One way to achieve the above objectives is to fully implement the Stop Aquatic Hitchhikers! campaign across the Lake Superior Basin. Surveys used to evaluate the program have shown that Stop Aquatic Hitchhikers! is effective in influencing boaters and anglers to inspect and clean their equipment. The program also provides resources (e.g., campaign logo with prevention tips) for partners to use in local outreach efforts.

To help build capacity for outreach and education efforts on the local level, state/provincial and federal agencies can offer community grants for prevention efforts. MN DNR, for example, provides community grants to local entities, such as lake associations, local citizen groups, and local units of government (e.g., conservation districts, counties) for watercraft inspections at local water accesses and for public awareness projects.

In addition to outreach and education efforts, state/provincial/tribal agencies should explore options for a broad range of solutions to prevent AIS from being transferred on boats, trailers,

and equipment at public boat launches. Recent research indicates that visual inspection of boats and hand removal of plants at boat landings is effective for removing macrophytes from boats and trailers; however, high-pressure washing is highly effective for removing small-bodied organisms (e.g., spiny waterflea) from boats and trailers (Rothlisberger et al., 2010). High-pressure washing at targeted locations, for example where VHS is known to occur, would be an effective method of managing the risk of transfer within the region, as well as introductions of new organisms.

5.2 REPORTING

Progress in implementing this prevention plan will be reported through the Lake Superior LaMP. Annual LaMP updates and full Lake Superior LaMP reports (prepared every 5 years) will include the status of new invasions and will describe new AIS as they are discovered (e.g., location, pathway of introduction), including prevention efforts, or the lack of, which failed to prevent the species from being introduced into Lake Superior.

5.3 FURTHER EFFORTS

Several agencies are currently conducting limited early detection surveys as resources allow, including OMNR, Fisheries and Oceans Canada, and the USEPA Mid-Continent Ecology Division in Duluth. Additional monitoring and coordination of such monitoring are needed to detect the presence of new AIS in Lake Superior and respond quickly to the threat of new invasions. Several organizations are responding to this need. For example, the IJC is planning an international framework for rapid response. The Binational Aquatic Invasive Species Rapid-Response Framework would position the IJC to address the effectiveness of rapid response policy in shared watersheds on a periodic basis (IJC 2009). The National Park Service is developing an emergency response guide that identifies options for handling ships with high-risk ballast water to control the release of non-indigenous species (Glosten Associates 2009).

In addition, new technology for detecting AIS genetic material in water samples is currently being developed and field tested. This shows great promise and may provide an "early warning system" for species threatening to enter the Great Lakes, such as Asian carp moving upstream toward the Chicago Sanitary and Ship Canal.

Changing climate conditions suggest the need for further early detection and rapid response efforts. Additional actions are recommended to prevent the introduction of new AIS into Lake Superior as a result of climate change:

- Collect and monitor data on species movement and establishment, and information on ecosystem conditions (e.g., water temperature, salinity levels, and water chemistry), to evaluate invasive species threats in the context of climate change.
- Modify pathway analysis and species prediction models to include climate change parameters.
- Take advantage of state/provincial invasive species councils to:
    - Share climate-related concerns, data, and projections
    - Create lists of potential invaders and share with neighboring jurisdictions
    - Coordinate cross-jurisdiction integration of prevention strategies/tasks.

Early detection surveys and monitoring results would provide a means of evaluating the effect of prevention actions, such as those recommended in this prevention plan. However, the primary purpose of this plan is the prevention of new AIS, and it is recommended that the limited resources for AIS be directed at the strategies outlined above in Section 5.1.

None of the recommendations outlined in Section 5.1 could be implemented without being adequately resourced with appropriate expertise. Although the Great Lakes states, Ontario, public and private agencies, and organizations currently support efforts to prevent the introduction of new AIS, further work is needed. All relevant agencies should take advantage of every opportunity to prevent AIS introductions in Lake Superior. In addition, in the creation or changing of legislation, policy, or regulation, governments should ensure that the new measure does not ignore AIS introduction risks, provide loop holes that create AIS introduction risks, or remove existing protective requirements. That is, one legislative requirement should not neuter a protective element of another. The need to make AIS prevention a priority for all agencies with regulatory or intervention mandates is critical.

A bi-partisan effort is needed to overcome differences and support this environmentally and economically pressing issue. The recommended actions in this plan call for cooperative, binational efforts to prevent AIS introductions in Lake Superior. As a binational forum for maintaining and restoring the physical, chemical and biological integrity of the lake, the Lake Superior LaMP is coordinating and facilitating implementation of the recommended actions in this plan. Finally, as a product of the Lake Superior LaMP, the goal of this plan is to achieve zero introductions of new AIS into Lake Superior—just as the Lake Superior Binational Program seeks zero discharge of toxic chemicals into Lake Superior.

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APPENDIX A – BALLAST WATER MANAGEMENT REGULATIONS IN THE GREAT LAKES ST. LAWRENCE SEAWAY SYSTEM

TABLE A-1. Ballast Water Management Requirements for Vessels Entering the Great Lakes St. Lawrence Seaway System

Vessel Origin	Vessel Destination	Ballast Status	Ballast Water Management Requirements
Transoceanic Vessels			
Outside Canadian and U.S. EEZ	Canadian Great Lakes ports	BOB	BWE, treatment, discharge to reception facility, or retention Code of Best Practices[a]
		NOBOB	Saltwater flushing, treatment, discharge to reception facility, or retention Code of Best Practices[a]
	U.S. Great Lakes ports	BOB	BWE, retention, or alternative preapproved environmentally sound method Code of Best Practices[a] Regulated Management Practices[b]
		NOBOB	Saltwater flushing mandatory from beginning of 2008 seaway navigation season Code of Best Practices[a] Regulated Management Practices[b]
Coastal Vessels			
Within Canadian EEZ	Canadian Great Lakes ports	BOB or NOBOB	Voluntary Management Practices[c]
	U.S. Great Lakes ports	BOB	BWE, retention, or alternative preapproved environmentally sound method Regulated[b] and Voluntary Management Practices[c]
		NOBOB	Regulated[b] and Voluntary Management Practices[c]
Within U.S. EEZ	Canadian Great Lakes ports	BOB	BWE, treatment, discharge to reception facility, or retention Voluntary Management Practices[c]

Vessel Origin	Vessel Destination	Ballast Status	Ballast Water Management Requirements
		NOBOB	Saltwater flushing, treatment, discharge to reception facility, or retention Voluntary Management Practices[c]
	U.S. Great Lakes ports	BOB or NOBOB	Regulated[b] and Voluntary Management Practices[c]
Inland Vessels			
Inland waters of GLSLS system	Canadian ports	BOB and NOBOB	Voluntary Management Practices[c]
	U.S. ports	BOB and NOBOB	Regulated[b] and Voluntary Management Practices[c]

Source: Transportation Research Board. 2008. Transportation Research Board Special Report 291: Great Lakes Shipping, Trade, and Aquatic Invasive Species. Available at http://onlinepubs.trb.org/Onlinepubs/sr/sr291.pdf. Accessed: January 2009.

[a] *Code of Best Practices for Ballast Water Management*, Shipping Federation of Canada, Sept. 28, 2000.

[b] 33 CFR 151.2035, Subpart D.

[c] *Voluntary Management Practices to Reduce the Transfer of Aquatic Nuisance Species Within the Great Lakes by U.S. and Canadian Domestic Shipping,* Lake Carriers' Association and Canadian Shipowners Association, Jan. 26, 2001.

TABLE A-2. Summary of Key Elements of States' Ballast Water Requirements for States in the Lake Superior Basin

State	Regulatory Vehicle	Existing Oceangoing	New Oceangoing	Existing Lakers	New Lakers	Comments
MI	State permit; 401 Certification	Discharge prohibited unless approved treatment to prevent AIS in place	Discharge prohibited unless approved treatment in place	---	---	Rights reserved to modify 401 Cert. if it is determined that ballast treatment on lakers is necessary, available and cost effective
MN	State permit; 401 Certification	IMO by Jan. 2016	IMO for ships launched after Jan 2012	IMO by Jan. 2016	IMO for ships launched after Jan 2012	MPCA approval of treatment technology
WI	State permit; No finding on 401 Certification	IMO by Jan 2014	IMO for ships launched after Jan 2012	BMPs and sediment management plan, may have discharge standard in future	BMPs and sediment management plan	No technology was available to support stricter standards

Source: Great Lakes Commission, January 2010.

APPENDIX B – U.S. AND CANADIAN FEDERAL STATUTES RELATED TO AIS

TABLE B-1. Selected U.S. Statutes Related to AIS[31]

Statute	Summary	Affected Vectors
P.L. 101-646, Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990	Aims to prevent the unintentional introduction of non-indigenous species into waters of the U.S. and control the spread of species already introduced. Requires 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 U.S. Also authorizes a number of studies and monitoring programs to assess the spread of AIS and develop methods for controlling them.	Maritime commerce
P.L. 102-393, Alien Species Prevention and Enforcement Act of 1992	Makes it illegal to ship prohibited fish, wildlife and plants covered under the Lacey Act through the U.S. mail.	Illegal activities
P.L. 104-332, National Invasive Species Act of 1996	Amends NANPCA to require voluntary guidelines to become law if voluntary compliance is inadequate.	Maritime commerce
Executive Order 13112 (1999)	Created an interagency Invasive Species Council, consisting of 13 agencies to prevent the introduction of invasive species, provide for their control, and minimize their economic, ecological, and human health impacts. Also defined invasive species.	Agency activities
33 CFR 151 Subparts C and D, Ballast Water Management (1999)	Subpart C describes the ballast water management requirements for the control of non-indigenous species for vessels operating in the Great Lakes and Hudson River. Subpart D presents penalties for violations, exemptions for vessels, and additional requirements.	Maritime commerce
40 CFR Part 9 and Chapter VII, Uniform National Discharge Standards for Vessels of the Armed Forces (1999)	The rule identifies ballast discharges, among other discharges of Armed Forces vessels (including Coast Guard vessels), that require control. Discharge standards will be promulgated in the future.	Maritime commerce
P.L. 106-53, Water Resources Development Act of 1999	Provides for the conservation and development of water and related resources, to authorize the United States Army Corps of Engineers to construct various projects for improvements to rivers and harbors of the United States, and for other purposes.	Agency activities
33 CFR 401, Seaway (St. Lawrence) Regulations and	Describes the rules, regulations, practices, and procedures for vessels operating in the St. Lawrence Seaway.	Maritime commerce, Fishing and aquaculture

[31] In addition to the regulations listed here, ballast water management regulations are discussed in Section 4.1.1.

Statute	Summary	Affected Vectors
Rules (2000)		
7 U.S.C. Chapter 104, Plant Protection Act (2000)	Provides regulations for the detection, control, eradication, suppression, prevention, or retardation of the spread of plant pests or noxious weeds. Determines that this is necessary for the protection of the agriculture, environment, and economy of the U.S.	Organisms in trade, Illegal activities
16 U.S.C. Chapter 67, Aquatic Nuisance Prevention and Control (2002)	Intended to prevent unintentional introduction and dispersal of non-indigenous species into waters of the United States through ballast water management and other requirements; coordinate research on prevention and control, carry out control methods, monitor vector pathways other than ballast water, investigate economic and ecological impacts of AIS.	Maritime commerce, Fishing and aquaculture
16 U.S.C. Chapter 15A, Great Lakes Fisheries (2004)	Provides the Great Lakes Fishery Commission with authority for Sea Lamprey protection and prevention.	Agency activities, Fishing and aquaculture
7 CFR 300-388, Animal and Plant Health Inspection Service (APHIS), U.S. Department of Agriculture (2005)	Parts 300-388 present the activities and responsibilities for the APHIS program within the USDA. Example activities include quarantines, regulations, export certification, and National Environmental Policy Act procedures.	Agency activities
33 CFR 273, Aquatic Plant Control (2005)	This regulation prescribes policies, procedures, and guidelines for research, planning, and operations for the Aquatic Plant Control Program under authority of Section 302 of the Rivers and Harbors Act of 1965.	Agency activities, Canals and diversions
50 CFR 216, Regulations Governing the Taking and Importing of Marine Mammals (2005)	The regulations in this part implement the Marine Mammal Protection Act of 1972, which among other things, restricts the taking, possession, transportation, selling, offering for sale, and importing of marine mammals.	Organisms in trade, Illegal activities, Fishing and aquaculture
50 CFR 24, Importation and Exportation of Plants (2005)	Sets regulations for the purpose of establishing ports for the importation, exportation, and re-exportation of plants. Provisions are in addition to regulations set forth in the same Chapter (USFWS regulations on the taking, possession, transportation, sale, purchase, barter, exportation, and importation of wildlife).	Organisms in trade, Illegal activities
50 CFR 300, International Fisheries Regulations (2005)	Implements the fishery conservation and management measures provided for in the international treaties, conventions, or agreements specified in each subpart, as well as certain provisions of the Lacey Act Amendments of 1981. Applies to all persons and all places subject to the jurisdiction of the United States.	Illegal activities, Fishing and aquaculture
18 U.S.C. Chapter 3 and 16 U.S.C. Chapter 53, Control of Illegally Taken Fish and Wildlife – "Lacey Act" (2006)	The Lacey Act and its amendments govern the importation or shipment of injurious mammals, birds, fish (including mollusks and crustacea), amphibia, and reptiles.	Illegal activities

Statute	Summary	Affected Vectors
P.L. 109-326, Great Lakes Fish and Wildlife Restoration Act of 2006	Amends the Great Lakes Fish and Wildlife Restoration Act of 1990 to provide for implementation of recommendations of the United States Fish and Wildlife Service contained in the Great Lakes Fishery Resources Restoration Study.	Agency activities
Compendium for Isle Royale National Park (2007)	Adds an Emergency Restriction to the Superintendent's Compendium that prohibits the discharge of untreated ballast water within Isle Royale National Park waters and within the boundaries of Isle Royale National Park.	Maritime commerce
P.L. 110-288, Clean Boating Act of 2008	Amends the Federal Water Pollution Control Act to address certain discharges incidental to the normal operation of a recreational vessel.	Fishing and aquaculture, Water recreation, Tourism
Interim Rule amending 9 CFR 71, 83, 93. 73 FR 52173-52189: Viral Hemorrhagic Septicemia; Interstate Movement and Import Restrictions on Certain Live Fish (2008)	Restricts the interstate movement and importation into the United States of live fish that are susceptible to viral hemorrhagic septicemia or VHS, a highly contagious disease of certain freshwater and saltwater fish.	Organisms in trade, Illegal activities

TABLE B-2. Recently Introduced U.S. Congressional Bills Related to AIS

Bill	Summary	Affected Vectors
H.R.260, Aquatic Invasive Species Research Act	Aims to establish marine and freshwater research, development, and demonstration programs to support efforts to prevent, control, and eradicate invasive species, as well as to educate citizens and stakeholders and restore ecosystems.	Agency activities
H.R.553; S.336, Great Lakes Asian Carp Barrier Act (Barrier Project Consolidation and Construction Act of 2007)	Aims to require the Secretary of the Army to operate and maintain as a system the Chicago Sanitary and Ship Canal dispersal barriers.	Canals and diversions
H.R.801, Great Lakes Invasive Species Control Act	Aims to amend the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 to require application to all vessels equipped with ballast water tanks, including vessels that are not carrying ballast water, the requirement to carry out exchange of ballast water or alternative ballast water management methods prior to entry into any port within the Great Lakes, and for other purposes.	Maritime commerce, Fishing and aquaculture
H.R.889, Prevention of Aquatic Invasive Species Act of 2007	Aims to amend the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 to establish vessel ballast water management requirements, and	Maritime commerce, Fishing and aquaculture

Bill	Summary	Affected Vectors
	for other purposes.	
H.R.1350; S.791, Great Lakes Collaboration Implementation Act	A bill intended to establish a collaborative program to protect the Great Lakes, and for other purposes.	Maritime commerce, Fishing and aquaculture
H.R.2423; S.1578, Ballast Water Management Act of 2007	Aims to provide for the management and treatment of ballast water to prevent the introduction of non-indigenous aquatic species into coastal and inland waters of the United States, and for other purposes.	Maritime commerce
H.R.2830, Coast Guard Authorization Act of 2007	To authorize appropriations for the Coast Guard for fiscal year 2008, and for other purposes. (Prevention of invasive species into and within the United States from vessels).	Maritime commerce
S.725, National Aquatic Invasive Species Act of 2007	A bill introduced to amend the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 to reauthorize and improve that Act.	Maritime commerce, Fishing and aquaculture
S.726, Asian Carp Prevention and Control Act	A bill introduced to amend Section 42 of Title 18, United States Code, to prohibit the importation and shipment of certain species of carp.	Organisms in trade, Illegal activities

Source: USDA. 2008b. National Agricultural Library, Laws and Regulations. Available at http://www.invasivespeciesinfo.gov/laws/bills.shtml. Modified: December 2008. Accessed: 12-09-2008.

TABLE B-3. Selected Canadian Codes and Statutes Related to AIS[32]

Statute[+]	Summary	Affected Vectors
R.S.Q. 1984, c. P-9.01, Commercial fishing and commercial harvesting of aquatic plants	Provides rules, regulations, and enforcement power related to commercial fishing and commercial harvesting of aquatic plants.	Fishing and aquaculture, Organisms in trade
R.S.C. 1985, c. F-15, Fisheries Act	Establishes the Department of Fisheries and gives oversight regarding sea coast and inland fisheries; fishing and recreational harbours; hydrography and marine sciences; and the coordination of the policies and programs of the Government of Canada respecting oceans.	Fishing and aquaculture, Illegal activities
R.S.C. 1985, c. F-17, Great Lakes Fisheries Convention Act	Establishes collaboration between Canada and the United States through the Great Lakes Convention and creation of the Great Lakes Fishery Commission.	Agency activities
R.S.C. 1985, c. N-19, Navigable Waters Protection Act	Protects the public right of navigation by prohibiting the building or placement of any “work” in, upon, over, under, through, or across a navigable water without the authorization of Transport Canada. “Works”	Agency activities, Canals and diversions, Fishing and aquaculture, Tourism

[32] In addition to the regulations listed here, ballast water management regulations are discussed in Section 4.1.1.

Statute[+]	Summary	Affected Vectors
	may include bridges, tunnels, aquaculture facilities, and dumping of dredged material.	and development
Health of Animals Act (1990, c.21) Health of Animals Regulation	Establishes rules and regulations related to animal import and disease such as VHS.	Organisms in trade
Plant Protection Act, S.C. 1990, c. 22	Protects plant life and the agricultural and forestry sectors by preventing the import, export and spread of pests and by controlling or eradicating pests.	Organisms in trade, Illegal activities
Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act (1992, c. 52)	Regulates the import and cross-province border movement of harmful species. This Act has not been used traditionally for invasive species, but it is an available tool.	Organisms in trade, Illegal activities
National Parks Act (2000)	Provides authority for the management and regulation of fishing, among other activities, in national parks.	Fishing and aquaculture
SOR/2006-129, Canada Shipping Act 2001	Ballast water control and management regulations.	Maritime commerce
National Code on the Introductions and Transfers of Aquatic Organisms (2001)	Establishes standards for assessing introductions and transfers, including a risk assessment process that can be applied to introductions and transfers of new aquatic organisms between and within regions and jurisdictions.	Agency activities, Fishing and aquaculture
R.R.S. c. E-10.21 Reg. 1, Water Regulations, 2002	Provides all water regulations under the Environmental Management and Protection Act 2002.	Agency activities
2007, S.O. 2007, c. 6, Canadian Endangered Species Act	Establishes rules and regulations aimed at the identification and protection of Canadian endangered species.	All vectors associated with the potential capture of wildlife species, aquatic or terrestrial.
R.Q. c. A-20.2, r.1, Commercial Aquaculture Regulations (2008)	This Act applies to aquaculture carried on for commercial purposes and, in the waters in the domain of the State, to aquaculture carried on for research or experimentation purposes. It also applies to the operation of fishing ponds for commercial purposes.	Agency activities, Fishing and aquaculture
Ballast Water Control and Management Regulations (SOR/2006-129) Enabling Statute: Canada Shipping Act, 2001*	Requires the management of ballast water taken on board ships in waters under Canadian jurisdiction or in the United States waters of the Great Lakes Basin.	Maritime Commerce

[+]Source: Canadian Legal Information Institute. Available at http://www.canlii.org/en/index.php. Accessed: December 2008

*Source: Government of Canada Justice Laws Website. Available at http://laws-lois.justice.gc.ca/eng/regulations/SOR-2006-129/. Accessed: September 2013.

APPENDIX C – STATE AND PROVINCIAL CODES AND STATUTES RELATED TO AIS

Minnesota Rules and Regulations

TABLE C-1. Selected Minnesota Administrative Codes and Statutes Related to AIS

Title	Summary	Affected Vectors
Invasive Species Statute Chapter 84D	Invasive species management for aquatic plants and wild animals, including restricted activities such as launching a boat, trailer, or other equipment if there are potentially invasive species attached.	Fishing and aquaculture, Illegal activities, Tourism, Water recreation
Minnesota Noxious Weed Law, Minnesota Statutes, Sections 18.76 – 18.91 (MDA)	A person owning land, a person occupying land, or a person responsible for the maintenance of public land shall control or eradicate all noxious weeds on the land at a time and in a manner ordered by the county agricultural inspector or a local weed inspector.	Organisms in trade
Invasive Species Management and Investigation Statute Chapter 18G.12 (MDA)	Conduct research and prepare management plan to prevent the introduction and the spread of harmful plant pest and terrestrial invasive species.	Agency activities, Organisms in trade
Aquatic Plants and Nuisances Rule Chapter 6280 (MN DNR)	Standards and practices for aquatic plant management and control.	Organisms in trade
Invasive Species Rule Chapter 6216 (MN DNR)	Prevent the spread of invasive species, including prohibited and regulated invasive aquatic plants and wild animals, into and within the state as authorized by Minnesota Statutes.	Canals and diversions, Fishing and aquaculture, Illegal activities, Organisms in trade, Tourism, Water recreation
Minnesota Statutes 115 (MPCA)	Requirements for vessels using ballast water in Minnesota waters of Lake Superior, including ballast water management plan and record book of operations involving ballast water or sediment discharge.	Maritime commerce

Source: USDA National Agricultural Library, Laws and Regulations. Available at http://www.invasivespeciesinfo.gov/laws/statelaws.shtml. Modified: 12-02-2008. Accessed: 01-23-09.

Wisconsin Rules and Regulations

TABLE C-2. Selected Wisconsin Administrative Codes and Statutes Related to AIS

Title	Summary	Affected Vectors
Conservation Statute Chapter 23	Conservation, including the control of invasive species, nuisance weeds, and aquatic plants.	Agency activities, Water recreation, Tourism, Fishing and aquaculture
Plant Inspection and Pest Control Authority Statute Chapter 94.01	Quarantines or other restrictions on the importation into or movement of plants or other material within this state to prevent or control the dissemination or spread of injurious pests.	Organisms in trade, Agency activities, Illegal activities
Abatement of Pests Statute Chapter 94.02	Abatement of pest-harboring materials or plants infected with pests.	Organisms in trade, Agency activities, Illegal activities
Plant Inspection and Pest Control ATCP 21	Plant inspection and pest control.	Organisms in trade, Agency activities, Tourism, Water recreation
Aquatic Plant Management NR 107	Establish procedures for the management of aquatic plants and control of other aquatic organisms.	Organisms in trade, Water recreation
Aquatic Plants: Introduction, Manual Removal, and Mechanical Control Regulations NR 109	Procedures and requirements for issuing aquatic plant management permits for introduction of aquatic plants or control of aquatic plants by manual removal, burning, use of mechanical means or plant inhibitors. Introduction and control of aquatic plants shall be allowed in a manner consistent with sound ecosystem management, shall consider cumulative impacts, and shall minimize the loss of ecological values in the body of water. The purpose of this chapter is also to prevent the spread of invasive and non-native aquatic organisms by prohibiting the launching of watercraft or equipment that has any aquatic plants or zebra mussels attached.	Water recreation, Tourism, Fishing and aquaculture
Viral Hemorrhagic Septicemia Revised Rule Emergency Order	The Wisconsin Natural Resources Board proposes an emergency order to amend NR 20.05 (6) and (7) and 20.20 (73) (h) and create NR 19.05 (3) (e) and (f), 19.055 (5) and 20.14 (9) and (10), relating to control of fish diseases and invasive species. This emergency rule amends the emergency measures put into effect November 2, 2007 by Order No. FH-40-07(E) for the control and prevention of VHS in fish in state waters.	Water recreation, Fishing and aquaculture
Wisconsin Act 16, Section 30.175	Makes it illegal to launch or operate a vehicle, seaplane, watercraft, or other object of any kind in a navigable water if it has any aquatic plants or aquatic animals attached.	Water recreation, Tourism, Fishing and aquaculture

The WDNR is proposing a new rule to address invasive species identification, classification and control (WDNR 2008b). The proposed rule is intended to bridge the gap between federal and state laws pertaining to invasive species and set specific restrictions on actions involving invasive species. The new rule would allow WDNR to systematically regulate listed invasive species and facilitate working with local government and landowners.

Michigan Rules and Regulations

TABLE C-3. Selected Michigan Administrative Codes and Statutes Related to AIS

Title	Summary	Affected Vectors
The Insect Pest and Plant Disease Act Act 189 of 1931, Section 286.201 - 286.228	Regulate the sale and distribution of nursery stock, plants, and plant products; to prevent the introduction into and the dissemination within this state of insect pests and plant diseases; to provide for the destruction and control of insect pests and plant diseases; to provide for the destruction or treatment of certain plants or plant products; to provide for the licensure and inspection of certain persons and activities under certain circumstances; to impose certain powers and duties on the director of agriculture; to create certain restricted funds for certain department activities and to allow allocation of those funds throughout the department; to provide for the promulgation of rules; to prescribe penalties and civil sanctions; and to provide remedies.	Agency activities, Organisms in trade, Illegal activities
Natural Resources and Environmental Protection Act Act 451, Part 413, Section 324.41301 - 324.41323	Transgenic and non-native organisms.	Agency activities, Water recreation, Tourism, Fishing and aquaculture
Natural Resources and Environmental Protection Act Act 451, Part 31, Section 3103a	Ballast water reporting and permitting legislation.	Maritime commerce (oceangoing and non-oceangoing vessels)
Public Health Code Act 368 of 1978	Suppression of aquatic nuisance-producing organisms and plants.	Water recreation

Ontario Rules and Regulations

TABLE C-4. Selected Ontario Administrative Codes and Statutes Related to AIS

Title	Summary	Affected Vectors
S.O.R./2007-237, Ontario Fishery Regulations, 2007	Establishes rules and regulations related to Ontario fisheries. Includes items related to AIS such as invasive fish, bringing bait into the fisheries, overland transport of crayfish, live bait white list (permitted bait species), live holdings and transport.	Agency activities, Fishing and aquaculture, Illegal activities, Organisms in trade
Ontario Fish and Wildlife Conservation Act, 1997 S.O. 1997, c. 41	Establish rules and regulations for bait and commercial fishing licenses. The Act also authorizes enforcement and outlines penalties.	Fishing and aquaculture
Ontario Regulation 664/98 Fish Licensing	Defines the rules and regulations related to Ontario fishing and aquaculture licenses. Includes items related to AIS such as regulations on the sale of species and bait species.	Fishing and aquaculture, Organisms in trade
S.O. 2007, c. 6, Ontario Endangered Species Act	Establishes rules and regulations aimed at the identification and protection of Canadian endangered species.	Illegal activities
Provincial Parks and Conservation Reserves Act, 2006, S.O. 2006, c. 12	Establishes rules and regulations for the planning and management of a system of provincial protected areas. Includes provisions for the maintenance of ecological integrity, including healthy and viable populations of native species.	Water recreation, Tourism, Agency activities, Fishing and aquaculture, Organisms in trade
Plant Diseases Act, R.S.O. 1990, c. P.14	Defines the rules and regulations related to trade in diseased plants.	Organisms in trade, Illegal activities
Animals for Research Act, R.S.O. 1990, c. A.22	Establishes rules and regulations related to the disposal of organisms.	Agency activities, Organisms in trade
Fish Inspection Act, 2001, c.20, s.58	Establishes rules against the sale or possession of fish species under a misleading name.	Organisms in trade, Illegal activities