Great Lakes Panel on Aquatic Nuisance Species
Policy Coordination Committee Priorities
December 2013

Introduction

Aquatic invasive species (AIS) pose serious threats to the economic and ecological stability of the binational Great Lakes region.[1] To date, over 180 nonindigenous aquatic species have entered the basin via direct or indirect pathways, including ballast water discharge, canals and waterways, transport via recreational boating equipment, escape from aquaculture facilities and water gardens, releases of aquarium plants and pets, the live bait trade, and others. Be it the fouling of commercial and industrial infrastructure by zebra mussels, the ongoing toll on key predator and sport fish by the parasitic sea lamprey, or the alteration of food webs by species such as the quagga mussel and fishhook water flea, the damages from AIS are substantial. Indeed, the median annual cost in the US from non-native species introduced into the Great Lakes through ballast-water discharges from ocean-going vessels is estimated to be over $138 million.[2] Considering the potential for further environmental impacts, the costs to alleviate these impacts and the unique transboundary nature of the basin, strong and effective inter-jurisdictional policies – in particular among U.S. states and Canadian provinces and between the two federal governments – are necessary to enhance regional AIS prevention and control.

The Great Lakes Panel on Aquatic Nuisance Species (GLP) was established under the auspices of the federal interagency Aquatic Nuisance Species Task Force (ANSTF) in 1991, as directed by Section 1203 of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990. The GLP has worked for over two decades to advance prevention and control of AIS through regional coordination, with the Great Lakes Commission (GLC) serving as administrator. The mission of the Policy Coordination Committee (PCC) of the GLP is to "promote consistent and effective policy and programs to prevent and control aquatic invasive species (AIS) in the Great Lakes region."[3] The PCC offers this document as a resource guide to parties involved in AIS policy and program activities in the Great Lakes region, including the ANSTF, states, provinces, tribes, the International Joint Commission, the Great Lakes Water Quality Agreement (GLWQA) Annex VI Subcommittee, the Council of Great Lakes Governor's AIS Task Force, other advisory and decision-making bodies, and nongovernmental and private sector stakeholders.

In this document, the PCC has identified priorities for policy and program aspects of AIS management in the Great Lakes region. Priorities are organized under five "General Issues:" Prevention; Regional Coordination, Education, Information Management; Control and Management of AIS; Future Issues; and Impact Studies. The priorities have been identified to address issues of longstanding concern in the region, as identified in reports such as the Great Lakes Regional Collaboration *Strategy to Protect and Restore the Great Lakes* and the binational *Lake Superior Aquatic Invasive Species Complete Prevention Plan*, the commitments made by the U.S. and Canada in Annex VI of the 2012 GLWQA, and previous GLP efforts. This document also draws upon the ANSTF 2013-2017 Strategic Plan, publications in the peer-reviewed literature and other reports, and PCC member and staff recommendations, among others (see reference list).

The priorities presented in this document complement priorities in similar documents developed by the two other GLP standing committees – the Research Coordination Committee and the Information and Education Committee.[4] For each priority, this document states a relevant goal, outlines the justification, and proposes key action items. Action items have been numbered for ease of reference and the sequence in which they are listed is not meant to reflect a priority order or relative importance. The PCC recognizes that each of the general issues is complex, and that many details of implementing individual recommendations will require significant collaborative work among relevant and interested parties.

Note: St. Lawrence Seaway Development Corporation, At-large member of the Great Lakes Panel, abstained from endorsing the document.

Priorities

I. Prevention

Early Detection and Rapid Response
Goal: A consistent framework, with associated protocols, that delineates a system for early detection of – and rapid response to – new AIS and the spread of existing AIS to new areas within the Great Lakes basin.

Justification: The Great Lakes region has experienced the negative impact of AIS for decades, and the region's ecology and economy continue to face threats from new aquatic invaders. It has been estimated that AIS cost the region over $100 million annually.[5] Moreover, it is important to prevent future introductions of AIS that could compromise ongoing ecological restoration work. There is need for a high level of preparedness to prevent the introduction of species entirely new to the Great Lakes and the spread of existing AIS to new areas. A regionally-coordinated framework for early detection and rapid response to AIS is vital to achieving this objective, as previous experience has shown that once new invasive species are established, our ability to manage and/or eradicate their populations diminishes considerably and is often expensive. Due to the interconnectedness of the Great Lakes and St. Lawrence River systems, an early detection and rapid response framework must be regional in scope and must provide a consistent and integrated approach to preventing further AIS establishment and spread. Recent developments are leading to some progress on this priority. In 2013, the Council of Great Lakes Governors and Premiers committed to developing a "mutual aid" agreement to enable cooperative rapid response actions to new AIS in the basin. In addition, the 2012 GLWQA Annex VI includes near-term binational commitments on early detection and rapid response.

Action items:

1. Establish and implement a consistent, coordinated framework for early detection and monitoring for new invaders across the Great Lakes region
2. Expand efforts to incorporate non-professional efforts (*e.g.*, citizen monitoring programs, recreational user reporting systems) into agency-led early detection and monitoring systems
3. Establish a memorandum of understanding among key jurisdictions (including states, provinces and federal governments) that facilitates the development and implementation of a coordinated rapid response protocol among the jurisdictions involved
4. Conduct a series of rapid response workshops that include mock tabletop exercises featuring species-specific examples from different taxonomic groups to develop options for jurisdictional coordination
5. Assess the status of jurisdictional requirements and develop permitting procedures to facilitate a rapid response to newly detected invasions in each of the Great Lakes states and provinces (*e.g.,* for treatment methods and protocols, consistent with laws such as the Endangered Species Act, Clean Water Act, and Federal Insecticide, Fungicide and Rodenticide Act)

Risk Assessment
Goal: Consistent AIS risk assessments across the Great Lakes region.

Justification: Numerous AIS have the potential to invade the Great Lakes and prevention resources are finite. As a result, it is essential to focus prevention efforts on priority high risk species as determined by risk assessments. One approach to assessing the risk of AIS is identifying, for a given species, the probabilities of introduction, establishment, spread, and impacts, including potential severity. Organisms that are imported and/or traded for a variety of purposes are of particular concern as there is often no mandatory requirement for assessing the risk of these species. At the U.S. federal level, the National Management Plan has called for the U.S. Department of Agriculture, the Department of Interior, and U.S. EPA to work jointly to establish risk assessment screening protocols for new invasive species. Although limited progress has been made on a national scale,[6] the U.S. FWS is in the process of developing and implementing a screening tool based primarily on climate matching. The

Department of Fisheries and Oceans Canada Centre of Expertise for Aquatic Risk Assessment has developed guidelines for risk assessment and is working on screening tools and other related efforts for Canada. Within the Great Lakes, there have been several related efforts aimed at identifying AIS of concern, including the Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS),[7] the Great Lakes and Mississippi River Interbasin Study (GLMRIS),[8] and a U.S. EPA effort.[9] Regional AIS prevention programs can be improved by ensuring that the AIS risk assessment process, and the risk assessments that result for individual species or AIS vectors, are scientifically robust and are consistent across the region.

Action items:

1. Support scientifically robust risk assessments for individual AIS and AIS vectors, with particular attention to live organisms in trade to determine if they are safe for importation and/or commercial use and related transport
2. Create a clearinghouse for existing AIS risk assessments that have been conducted for the Great Lakes region, with fully integrated results (*e.g.,* indicating species identified in more than one assessment)
3. Coordinate risk assessment findings among relevant agencies, facilitating the flow of this information to decision makers for consideration in establishing programs and coordinating strategies for addressing high-risk vectors and species

Ballast Water

Goal: Regional agreement on policies that protect the Great Lakes from AIS introduced via ballast water and increase regulatory certainty and consistency for the shipping industry.

Justification: Ballast water has been responsible for over 60 percent of new introductions of nonindigenous species to the Great Lakes since the opening of the St. Lawrence Seaway in 1959.[10] A number of policy initiatives and regulations have been adopted in the past two decades to minimize the introduction of non-native species through ballast water, including a mandatory ballast water management program, saltwater flushing requirements and the establishment of technology-based commercial vessel discharge standards. [11] The U.S. Coast Guard through a rule-making process (March 2012), and the U.S. EPA through its 2013 Vessel General Permit (VGP), establish numeric discharge limits based on the International Maritime Organization (IMO) (D-2) standards, covering ocean-going ships, but not "lakers" (i.e. ships staying within the Great Lakes). Canada's *Ballast Water Control and Management Regulations* are harmonized to the maximum extent possible with current U.S. and international provisions, including the *International Convention for the Control and Management of Ships' Ballast Water and Sediments*.[12] Great Lakes states have enacted their own permits and have imposed state specific conditions on the U.S. EPA VGP through Section 401 of the Clean Water Act. Vessel operators now face varying requirements from state to state which make achieving compliance more challenging. More work is needed to coordinate ballast water policies in the region.

Action items:

1. Develop a more formal process to coordinate state ballast water policies, including considering development of an interstate agreement
2. Support continued formal coordination between the states as part of the U.S. EPA VGP process for ballast water discharge and facilitate coordination in future VGP iterations
3. Continue to use the Great Lakes Ballast Water Collaborative and other mechanisms to increase coordination between the U.S. and Canada on ballast water policy that addresses ocean-going vessels, lakers, and "no ballast on board" (NOBOB) vessels
4. Facilitate and review research on technical and logistical aspects of ballast water treatment methods with the potential for greater efficacy within the Great Lakes freshwater ecosystem to support policy decisions

Organisms in Trade
Goal: Regionally consistent polices to prevent the introduction and spread of invasive species through the high-volume trade in non-native plants and animals, including programs for screening imported species for their potential to become invasive.

Justification: Significant concern exists over the risks posed by the trade of live organisms as a vector for AIS introduction and spread in the Great Lakes. Pathways for organisms in trade (OIT) include the live bait industry, pet and aquarium trade, horticulture and water garden businesses, and live seafood markets, among others. OIT may be introduced for beneficial uses, but over time, some imported plant and animal species have established wild populations and caused harmful impacts. Inconsistent OIT policies among states and provinces in the Great Lakes region and the lack of a strong pre-import screening process at the federal level, have undermined the effectiveness of OIT polices. As a result, existing policies may allow the importation or movement of problem species, including those known to be invasive, that some jurisdictions are attempting to prevent.

Action items:
1. Develop management practices and policies to address the mechanisms of AIS introduction and spread associated with known OIT pathways
2. Develop model legislation as part of a framework for regional consistency on laws and regulations needed for the OIT vector
3. Develop and implement a regionally consistent pre-import risk assessment process

Aquaculture
Goal: A consistent and comprehensive framework for aquaculture management to prevent the introduction and spread of AIS in the Great Lakes basin through aquaculture activities.

Justification: The aquaculture industry is beneficial in terms of providing bait fish, food for human consumption, stocking to release natural populations from harvest pressure, and contributing to regional economic development. Aquaculture is also a vector of concern for AIS introductions in the Great Lakes region. Intentional stocking or unintentional escape of non-native, target species, and incidental transport of non-target species (*e.g.,* equipment-fouling organisms; contamination of site water with microscopic species such as viral hemorrhagic septicemia (VHS) or spiny waterfleas) via harvesting equipment may present serious threats to local waterways. With over 1200 aquaculture facilities in the Great Lakes basin, each working under varying jurisdictions and operational protocols, significant gaps may exist in their abilities to prevent release or escape of non-native species to the Great Lakes environment.

Action items:
1. Implement an improved screening process based on species-specific risk models that seek to minimize the risk of ecological damage resulting from the escapement of fish from aquaculture facilities.
2. Support the use of detailed procedures such as HACCP (Hazard Analysis and Critical Control Point) to develop a uniform system of prevention throughout the diverse range of facilities across the region

Canals and Waterways
Goal: Management of hydrologic connections (*e.g.*, canals) between watersheds to prevent AIS movement across basin boundaries and prevention of AIS movement within the Great Lakes basin as infrastructure is removed or replaced.

Justification: The extensive canal and waterway system in the Great Lakes region, while used beneficially as a transportation corridor for commercial and recreational activities, establishes connections between watersheds and provides pathways for aquatic species movement. One of the first known AIS to have had a significant negative impact on the Great Lakes–the sea lamprey–was introduced via these waterways. The Chicago Sanitary

and Ship Canal, an engineered waterway that connects the Mississippi River and Great Lakes watersheds, has provided an interbasin pathway for AIS such as the round goby. Of significant concern currently is the northward migration of certain Asian carp species through the Chicago waterway system. The process of repairing and/or replacing aging water infrastructure presents additional risk of AIS movement between and within watersheds. Many restoration efforts across the Great Lakes basin involve the removal or repair of dams and other water infrastructure, which could inadvertently facilitate the spread of AIS by opening up previously inaccessible waterway segments. Activities should be undertaken to prevent AIS movement across basin boundaries through canals and waterways and when water infrastructure is repaired or replaced.

Action items:

1. Implement actions to prevent AIS movement in the Chicago Area Waterway System, while addressing other problems such as water quality and flooding, drawing on studies such as *Restoring the Natural Divide* and *Evaluation of Physical Separation Alternatives for the Great Lakes and Mississippi River Basins in the Chicago Area Waterway System* (www.glc.org/caws)
2. Identify and fully assess potential AIS risks associated with other canal systems linking the Great Lakes and other basins, including the costs and benefits of efforts to mitigate risks
3. Close or modify canals that have fallen into disuse or disrepair; incorporate AIS prevention measures in cases of canals subject to repair; fully consider benefits to native species and impacts from AIS when evaluating cost-benefits of proposed dam removal and/or fish passage projects
4. Advance polices that fully consider risk of AIS transfer if new inter-basin hydrologic connections in the Great Lakes basin are proposed
5. Support the development of fish passage policies that incorporate risk analysis into decision-making and seek to prevent the range expansion of AIS.
6. Advance efforts to close "other pathways" identified between the Great Lakes and Mississippi River basins, including intermittent flood-related connections, building on work underway through the U.S. Army Corps of Engineers (Corps) through the Great Lakes Mississippi River Interbasin Study (GLMRIS)

Recreational Activities

Policy: A robust framework that provides consistent guidance for preventing the introduction and spread of AIS through recreational activities, including programs that promote widespread action by recreational users.

Justification: Combating the spread of AIS by recreational activities requires a comprehensive approach focused on prevention, containment and controlling spread. A number of education and outreach efforts addressing this pathway are underway. The *Stop Aquatic Hitchhikers!*™ *(SAH!)* campaign, established under the ANSTF and sponsored by the U.S. FWS and USCG, raises awareness among boaters, anglers, scuba divers, waterfowl hunters and other recreationists aimed at encouraging each group to take the appropriate actions at water accesses to prevent the spread of AIS. The *Habitatitude* campaign, another campaign of the ANSTF and sponsored by U.S. FWS, provides education and outreach on AIS issues to aquarium hobbyists, water gardeners, and backyard pond owners. The *Nab the Aquatic Invader!* campaign, led by the NOAA Sea Grant program, provides educational material for K-12 students and teachers. Guidelines (or best management practices) for recreationalists, including boaters and anglers, waterfowl hunters, and personal watercraft users, are being revised by the Recreational Activities Committee of the ANSTF to improve outreach communication and education. Along with AIS outreach, policy plays a vital role in prevention. Widespread and coordinated implementation of these programs is critical to their success due to the transient nature of many recreationists.

Action items:

1. Support partnerships and provide adequate funding and staff resources to key entities with the capacity to reach the maximum number of recreationalists through education and outreach work, including the aforementioned campaigns and other programs
2. Develop consistent regulations and policies among the states and provinces, including concerning personal watercraft, bait fish, and other avenues of potential AIS transfer

3. Conduct assessments of the effectiveness of both mandatory and voluntary AIS prevention and control measures covering recreational activities

II. Regional Coordination, Education and Information Management

Funding for AIS Programs
Goal: Adequate funding to support the activities of the ANSTF and other federal AIS programs, and thus the activities of regional, state and local programs, to ensure sustained progress on AIS issues in the Great Lakes region and nationwide.

Justification: The ANSTF is an intergovernmental organization that was created to advance the prevention and control of AIS on a national level through implementation of the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990 (later reauthorized as the National Invasive Species Act (NISA) of 1996). Co-chaired by the U.S. FWS and NOAA, the ANSTF coordinates federal AIS management through the work of issue-specific committees, species-specific control plans and regional AIS panels. As a regional AIS panel created under NANPCA, the Great Lakes Panel historically has received funding from the U.S. FWS through the NANPCA/NISA authorization. State management plans (SMPs) for the prevention and control of AIS are also authorized under this program and funded through the U.S. FWS. Resource constraints due to inadequate Congressional appropriations make it increasingly difficult for the panels and states to fully address ongoing AIS priorities. Specifically, the overall appropriated funding level for the regional panels and SMPs has remained flat, while the number of panels and SMPs has increased.

Action Items:
1. Support Congressional authorization of adequate funding to the U.S. FWS, NOAA and other agencies, under NANPCA/NISA to fully implement activities of the ANSTF, regional AIS panels and state management plans
2. Encourage the ANSTF to provide formal consultation opportunities to regional panels during interagency AIS budget development discussions between U.S. FWS and NOAA
3. Educate and inform stakeholder groups regarding the funding needed to sustain AIS prevention and control programs in efforts to effectively reach Congressional decisionmakers
4. Support funding for important AIS work and initiatives, including activities such as risk assessments for species in trade, research on AIS prevention and control measures (including advanced ballast water treatment technologies), and education and outreach to user groups and the public
5. Support continued and/or enhanced funding of regional programs such as the Great Lakes Restoration Initiative (GLRI) (including its invasive species component) that can fund a diverse array of efforts

III. Control and Management of AIS

Viral Hemorrhagic Septicemia (VHS)
Goal: Prevent further spread of VHS, in particular to unexposed Great Lakes water bodies.

Justification: As of 2009, VHS, an invasive fish pathogen, has been documented in each of the Great Lakes. In many cases, the presence of the virus has resulted in large-scale die-offs of native fishes. VHS is microscopic in size, a feature that not only makes the virus difficult to detect, but also makes it readily transportable via ballast water, recreational equipment, bait water, and a suite of additional vectors.

Action items:

1. Incorporate the phased-in analysis of VHS as part of routine fish or water monitoring programs (or both) in the Great Lakes
2. Conduct an assessment of bait fish VHS screening and transfer policies in the states and provinces, with consideration of efforts to harmonize screening approaches and regulations governing transfer.

Asian Carp

Goal: Permanent measures to prevent Asian Carp from entering the Great Lakes, along with monitoring and rapid response.

Justification: Four species of Asian carp–bighead, silver, grass, and black– are a current invasion concern for the Great Lakes region. They were first introduced to the U.S. for algae control in aquaculture ponds and other purposes in the southern U.S. in the 1960s and 1970s. Bighead and silver carp are a particular threat to the Great Lakes, as large planktivores with the potential to outcompete other planktivorous native fish, and potentially further damage food webs already altered by other invasive species, and recent research has shown there is potential suitable habitat in parts of the Great Lakes (including western Lake Erie). A primary pathway of concern for Asian carp entry into the Great Lakes is via the Chicago Area Waterway System (CAWS) (see discussion above in Canals and Waterways). Although an electric barrier is in place on the Chicago Sanitary and Ship Canal to deter movement of the invasive Asian carp towards the Great Lakes, there are ongoing concerns about its effectiveness (primarily due to power outages). These concerns have spurred additional study and initiatives, including the U.S. Army Corps of Engineers GLMRIS and Restoring the *Natural Divide: Separating the Great Lakes and Mississippi River Basins in the Chicago Area Waterway System*, prepared under the leadership of the Great Lakes Commission (GLC) and Great Lakes St. Lawrence Cities Initiative (GLSLCI).

Action items:

1. Consistent with action items under Canals and Waterways above, implement actions that prevent the movement of Asian carp into the Great Lakes via the CAWS, including potentially through hydrological separation as described in the GLC/GLSLCI study
2. Consistent with action items under Canals and Waterways above, implement more permanent measures to prevent Asian carp movement into the Great Lakes via other hydrologic pathways, including priority areas (such as the Eagle Marsh wetlands area near Fort Wayne, IN) identified through GLMRIS and from other basins
3. Assess the risk of Asian carp introduction and establishment in the Great Lakes that may be posed by other vectors, such as organisms in trade (*e.g.,* live bait and live food fish)
4. Increase monitoring, including environmental DNA monitoring, of priority water bodies in the region
5. Consistent with action items under Early Detection and Rapid Response above, expand early detection and rapid response capacity specifically for Asian carps, and increase coordination between state, provincial, federal and tribal agencies in the region

IV. Emerging Issues

Climate Change and AIS

Goal: Management efforts that respond to climate change in order to prevent invasive species from gaining a competitive advantage over native species.

Justification: Evidence continues to indicate that manifestations of climate change—such as warming air and water temperatures, changes in precipitation patterns and intensification of storm events—are emerging on a global basis, as well as in the Great Lakes. This evidence raises concern over the potential for these changes in abiotic conditions to exacerbate invasive species problems. For example, concern exists that warming trends will

facilitate the introduction, establishment and spread of invasive species into habitats where temperature was a limiting factor before climatic conditions began to change. To help prepare for climate change impacts in the Great Lakes, there is a need for resource managers to consider the best ways to integrate adaptation strategies into invasive species prevention and control efforts.

Action items:

1. Consider species with increased risk of introduction/movement into the Great Lakes based on climate change projections when implementing early detection and monitoring programs
2. Establish best management practices for addressing the specific aspects of AIS prevention and control relevant to changing climatic conditions and incorporate them into state AIS management plans
3. Implement habitat restoration activities that strengthen ecosystem resiliency and help prevent establishment of new AIS that may be facilitated by climate change

V. Impact Studies

Economics of AIS

Goal: A better understanding of the economic consequences of AIS and decision support tools based on this information to help identify cost-effective strategies for addressing AIS.

Justification: History has shown that AIS can have significant economic consequences in invaded areas. These consequences can include, among others, losses associated with damage to economically valuable resources and societal infrastructure (*e.g.*, fisheries and power plant intake/discharge pipes), and costs associated with implementation of control measures (*e.g.*, herbicide application). For example, approximately $20 million per year is spent to control sea lamprey populations that prey on fish species that have commercial and recreational value (e.g., lake trout, whitefish and walleye). Annual damages and costs associated with controlling AIS (primarily invasive mussels) at raw water intakes (*e.g.*, for power plants, municipal water supply plants, and industries) have been estimated at $27 million.[13] Evaluating costs associated with AIS, whether it be costs avoided as a result of preventing an invasion or resources expended to control an existing invasion, is a valuable decision support exercise. Estimating these costs, however, is inherently challenging as they often are species-specific, wide-ranging and subject to significant uncertainties. Strengthening public awareness and understanding of the economic impacts caused by AIS is critical in building the political will to invest funding in AIS prevention and control.

Action items:

1. Clarify the costs and benefits of AIS policy options through better estimates of the value of sectors that may be impacted, *e.g.,* the size and characteristics on the sport fishing sector
2. Develop a clearinghouse for economic tools to assist resource managers and other stakeholders in evaluating the impacts associated with invasive species prevention and control[14]

References

[1] Regarding terminology, both the authorizing federal legislation (Nonindigenous Aquatic Nuisance Prevention and Control Act) and the panel name reference "aquatic nuisance species". Except when referencing legislation, this document uses the term *aquatic invasive species* (AIS), the term often used by resource managers, researchers, and others involved in work addressing harmful nonindigenous species. An invasive species has been defined in Executive Order 13112 as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." Characterizing nonindigenous species is challenging, in that to some extent value judgments are inherent; these issues have been discussed in other forums, including by the National Invasive Species Council (NISC 2006, Invasive Species Definition Clarification and Guidance White Paper, Submitted by the Definitions Subcomittee of the Invasive Species Advisory Committee, available from http://www.invasivespeciesinfo.gov/docs/council/isacdef.pdf).

[2] Rothlisberger, J.D., Finnoff, D.C., Cooke, R.M., Lodge, D.M. 2012. Ship-borne nonindigenous species diminish Great Lakes ecosystem services, *Ecosystems*, Published online, Feb. 29, 2012.

[3] Great Lakes Panel on Aquatic Nuisance Species, Policy Coordination Committee Mission Statement and Guidelines, May 3, 2011. Available from http://glc.org/ans/panel.html#committees.

[4] Priority documents are available on the Great Lakes Panel on Aquatic Nuisance Species Web site, available from http://glc.org/ans/panel.html#committees.

[5] Anderson Economic Group, LLC. 2012. The Costs of Aquatic Invasive Species to Great Lakes States.

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

[7] National Oceanic and Atmospheric Administration, Great Lakes Aquatic Nonindigenous Species Information System, Watchlist of Potential Great Lakes Aquatic Invasive Species, available from http://www.glerl.noaa.gov/res/Programs/glansis/glansis.html

[8] Non-Native Species of Concern and Dispersal Risk for the Great Lakes and Mississippi River Interbasin Study, available from http://glmris.anl.gov/documents/docs/Non-Native_Species.pdf

[9] U.S. Environmental Protection Agency. 2008. Predicting future introductions of nonindigenous species to the Great Lakes. National Center for Environmental Assessment, Washington, DC; EPA/600/R-08/066F. Available from the National Technical Information Service, Springfield, VA, and http://www.epa.gov/ncea.

[10] Ricciardi, A. 2006. Patterns of invasion in the Laurentian Great Lakes in relation to changes in vector activity. *Diversity and Distributions* 12(4): 425-433

[11] A mandatory ballast water management program was administered by the U.S. Coast Guard (USCG) beginning in 1993 which included reporting and no discharge requirement for vessels declaring ballast on board for ballast water originating within 200 miles of any shore. A 2008 rule published by the St. Lawrence Seaway Development Corporation required saltwater flushing for all vessels declared no ballast on board (NOBOB) that operate outside the Exclusive Economic Zone. Following litigation, U.S. EPA in 2008 issued a Vessel General Permit (VGP) addressing discharges (including ballast water) of commercial vessels, establishing technology-based standards relying on best management practices. Independent state actions have included, passage of legislation in Michigan regulating ocean-going ships in 2005 (with a general permit subsequently issued), and more stringent certification requirements issued by New York for the U.S. EPA 2008 VGP under Section 401 of the Clean Water Act.

[12] Transport Canada. 2007. A Guide to Canada's Ballast Water Control and Management Regulations.

[13] Rothlisberger et al. 2012, *Op. Cit.*

[14] Minnesota Sea Grant compiled a bibliography of economic impact studies which is available upon request.