Great Lakes Panel on Aquatic Nuisance Species

Aquatic Invasive Species Research Priorities for the Great Lakes – 2014/2015

Updated: January 2015

Background

Aquatic invasive species (AIS) substantially affect the ecologic and economic integrity of the Great Lakes-St. Lawrence region. The Great Lakes Aquatic Nuisance Species Information System (GLANSIS) documents 180 aquatic nonindigenous species in the region as of 2012, including well-known species, such as dreissenid mussels, sea lamprey, purple loosestrife, Eurasian watermilfoil, round goby, ruffe, spiny water flea, and rusty crayfish, among others. Preventing new introductions remains the most effective approach to reducing impacts of AIS and must be a top priority.

This research priorities document is organized around the following (bolded) themes presented below. The Research Coordination Committee of the Great Lakes Panel on Aquatic Nuisance Species (hereafter the Research Committee) has compiled this document to serve as a resource for, and provide guidance to, private foundations and local, state/provincial, and federal agencies that provide funds for research on AIS prevention and control in the Great Lakes, as well as those involved in the conduct of AIS research, management, and control initiatives.

AIS prevention requires the identification of introduction pathways, which include: **Maritime Shipping** (primarily through ballast-water discharge), **Canals and Connectivity** that enable of passage of AIS into around or out of the Great Lakes or within basin watersheds (e.g., the Erie Canal, the Chicago Sanitary and Ship Canal, dam removal and fish passage restoration efforts), movement of **Trailered Boats** and other equipment and vessels between water bodies, and **Trade in Live Organisms** (e.g. fish stocking, fish industries, the aquarium and water garden trades, biological control, live bait, and horticultural practices).

Information and research must be pursued and accelerated to prevent future AIS introductions, both unintentional and unauthorized intentional, to detect and respond to new introductions (**Early detection and Rapid Response,** (EDRR)) and to **Control and Manage** established invasive species populations. Within each thematic area there is a subset of AIS species that owing to either the imminent threat of introduction, recent detection (in the basin) or magnitude of impacts scale where species specific knowledge or solutions is more urgently needed. A list of priority species and associated research priorities are also appended to this document to provide guidance on species specific research needs within the three thematic areas (Prevention, EDRR, Management and Control).

State and regional research and management plans, research articles and briefing papers and conference proceedings support the development of these priorities. Research on some of these priorities is underway or completed where further work is deemed to be required on others to resolve evolving policy and management concerns. Topics/items for which progress has been made, but still require support have been identified in the background sections of this document. These research priorities were identified as important for the Great Lakes region, but in many instances they can be applied to inland waters of the basin and elsewhere in North America. The list is intended to be dynamic to allow additions and deletions as our knowledge expands and our focus changes.

Prevention - Maritime shipping

Transoceanic shipping has been a primary vector for AIS introductions in the Great Lakes-St. Lawrence River system. No ballast-mediated introductions have been reported since 2006, possibly indicating that regulatory requirements for ballast-water exchange and tank flushing of transoceanic vessels have reduced actual introduction. While ballast-water management practices have significantly improved, some coastal vessels and "Lakers" (ships that do not leave the Great Lakes) that are currently exempted from U.S. federal ballast water regulations may facilitate the secondary spread of AIS within the Great Lakes-St. Lawrence River system. Continued support is necessary to maintain progress being made by various organizations to reduce the likelihood of species transfers by evaluating the relative risks of the different shipping pathways (transoceanic, coastal, Laker, recreational); developing methods and standards for treatment of ballast water and sediment; and, evaluating the risk of other non-ballast shipping vectors. Also, until shipboard treatment technologies are verified for use in the Great Lakes (i.e., effective in temperate, freshwater systems), and are in widespread operational use with a consistent record of long-term reliability, research efforts should continue to help advance and evaluate the efficacy and applicability of various ballast water treatment technologies and practices for both main and residual (no ballast on board (NOBOB)) ballast waters. Emerging research priorities identified include:

<u>Shipping vector risk-assessments</u>

- Evaluate the risk of introduction and/or secondary spread of AIS by small vessels, including small commercial vessels not subject to federal ballast management regulations and larger recreational vessels that cannot be trailered.
- Develop a research program to identify, assess, and address potential high-risk AIS present in foreign fresh and brackish water systems associated with shipping vectors. This should include the development of rapid screening methods, such as genomics or eDNA, to quickly detect these high-risk species.

<u>Ballast treatment and management</u>

- Develop and evaluate, for possible immediate implementation, interim ballast water management technologies or practices for reducing the risk of inter/intra-lake transfer of AIS by Lakers.
- Conduct full-scale testing of ballast water treatment technologies on shore or ship over the range of environmental conditions (e.g., temperature, transparency, salinity) typical for the Great Lakes ballast discharges during the shipping season, considering physical and operational limitations of saltwater and domestic vessels, in order to prevent new AIS introductions from foreign or domestic freshwater or estuarine ports and/or prevent secondary spread of AIS between Great Lakes ports by all vessels.
- Advance the understanding of aquatic invasion biology, particularly numeric thresholds for successful/unsuccessful invasions, which can be used to refine ballast water discharge standards.
- Develop physical/chemical methodology to enable compliance monitoring with regulatory ballast water discharge standards.

Prevention - Canals and connectivity

Canals and waterways facilitate the conveyance of bulk goods and commodities and are used for recreational activities, but they also facilitate the spread of AIS by allowing cross-basin transfer between watersheds. Closing canals and waterways can re-establish the natural geographic separation of the Great Lakes from other drainage basins. Existing canals and waterways in the Great Lakes - St. Lawrence River basin should be equipped with dispersal barriers, flood control barriers, physical barriers, and other provisions to ensure hydrologic separation of historically disconnected watersheds. Wherever possible, canals that are no longer in use should not be improved and, in fact, should be physically sealed to prevent the free-flow of aquatic organisms. Also, restoration of native fish passage to inland waters by the removal of dams or culvert barriers needs to be considered against the risk that this may open up previously uninvaded waters to AIS colonization. The U.S. Army Corps of Engineers (USACE) Great Lakes and Mississippi River Interbasin Study (GLMRIS) identified technologies that could be used to prevent AIS movement through canals and waterways and associated research gaps. The GLMRIS report also identified options for hydrological, ecological and/or biological separation of the Great Lakes and Mississippi River systems at 18 connection points including the Chicago area waterway system (CAWS). While the GLMRIS report advances the region's knowledge and understanding regarding the transfer of AIS between the Great Lakes and Mississippi River through aquatic pathways there are still additional emerging and unmet research needs which include:

- Develop effective lock or approach channel treatment technologies that enable vessel movement and prevent AIS transfer through lock structures.
    - Evaluate the effectiveness and ecological and structural impacts of lock or approach channel treatment methods and technologies.
    - Conduct scale testing of the effectiveness of artificial canals that would be used to treat barges and other vessels for AIS (e.g., heat, CO_2, water guns, acoustics, vacuum system).
    - Test and evaluate the effectiveness of technologies designed to repel or deter organism from entering locks or channels (e.g. fish deterrents like acoustic barriers, heat, CO_2).
    - Develop tools for trapping/attracting fish in locks/canals.
- Evaluate and reduce the risks of creating new and unintentional AIS habitat and spread pathways as a result of barriers removal. Specifically,
    - What AIS species are likely to spread upstream of barriers to be removed
    - Socio-economic cost/benefit analysis of barriers removals factoring in the increased threat of AIS spread and establishment
- Examine health and human safety issues surrounding both barriers and locks and dams treatment methods.
- Identify and assess the risk of AIS transfer from canals and rivers to the Great Lakes from basins other than the Mississippi River.
- Identify ways to mitigate the risk of AIS transfer when barges move through electric barriers not in single file (e.g., four barge configuration creating a "duck pond").

Prevention – Trade in live organisms

Introductions arising from the trade in live organisms are the second-most significant source of new invasions into the Great Lakes. The 2005 Great Lakes Regional Collaboration Strategy to Restore and

Protect the Great Lakes reported “Importation, interstate commerce and trade are among the most dangerous pathways for introduction of invasive species in the Great Lakes ecosystem.” A 2005 study of the invasion risks to the Great Lakes posed by the aquarium and live food trades found that a variety of nonindigenous species not yet in the Great Lakes, but possessing “invasive” attributes, were available in the marketplace, including Brazilian elodea and the bighead and grass carp. The live organism trade has also been linked to the escape of some of the most problematic aquatic weeds in other regions of the U.S., including Brazilian elodea and hydrilla. Non-native aquatic vegetation in the U.S. is estimated to cost $10 million in losses and damages and $100 million in control costs each year. A small number of species are prohibited from sale and possession, but there is little consistency across jurisdictions within the basin regarding restricted and prohibited species. This allows the importation, interstate commerce, and widespread dispersal of numerous problem species including known invasive species, increasing the potential that some will eventually be either accidentally or deliberately released and become established in natural waterways. Internet commerce further facilitates the sale of live organisms and presents unique management challenges. Continued support is necessary to further the significant progress being made by various organizations to develop screening tools and risk assessments, and to create and verify models to identify vulnerable waters. A more comprehensive and consistent approach to regulating the live trades is required and needs to be supported by robust science. Emerging research needs include:

- Quantify species, trade volume, economic values, and the cost/benefits of organisms in trade.
- Develop a suite of risk assessment tools for fishes, plants, mollusks, amphibians, reptiles and crustaceans to identify a list of high and low risk species. This includes:
    - Supporting research to advance the understanding of aquatic invasion biology, particularly characteristics of successful/unsuccessful invasions and invaders.
    - Quantifying the life history characteristics that lead to successful invasions (e.g., propagule pressure and trophic disruption).
    - Researching species attributes to complement the development of risk assessment tools.
    - Develop future models that account for changes associated with climate change and variability.
    - Continue to review the state of risk assessment globally to identify the most accurate and cost effective methods.
- Research the behavior of the end user and the motivation behind releasing organisms in trade into the wild, quantifying release rates, and identifying areas where releases are most likely to occur.
- Expand the development and application of genetic tools to identify relationships among source communities and newly established AIS populations to identify high risk trade pathways and routes and activities.
- Quantify the invasion risk of least well known aspects of the movement or trades in live organisms
    - Fish and bait haulers
    - Biological supplies
    - Live fish
    - Internet trade

Prevention - Trailered boats and equipment

Boats or equipment used in water that is capable of being trailered and moved across natural watershed boundaries can be an important vector of introduction and secondary spread of AIS into, and around, the Great Lakes basin. These boats can also transport AIS within waterbodies during operation. The problem is potentially large, with millions of boaters and tens of thousands of lakes and waterbodies that could be invaded and act as stepping stones for the invasion of the Great Lakes or neighboring watersheds. Currently, large amounts of operational and voluntary resources are expended by agencies and other organizations on this invasion pathway with a strong emphasis placed upon boater education. Continued research is necessary to support the significant progress being made to develop more accurate predictive models based on vessel type, boater movement patterns, and spread patterns; to estimate the volume of risky versus benign boating trips; and to measure the effectiveness of boater AIS education programs. For the identified priorities below, a niche area is a physical place on a boat, trailer or other structure that should be investigated as a source of biofouling. The emerging research priorities identified include:

- Quantify per-vessel estimates of propagule abundance in relation to key niche on the vessel and trailer.
- Investigating the efficacy of strategies to reduce the risk of AIS contamination within key boat and trailer niche areas.
- Quantify the relationship between propagule pressure and invasion risk, especially at the levels of propagule introduction anticipated through various types and lengths of recreational boating trips.
- Examine the physical, social and economic feasibility of mandatory AIS prevention regulations for recreational boaters, especially for outbound trips from high-risk source regions.
- Develop an easy to dose, environmentally-friendly treatment for bilge and live well waters to prevent the spread of AIS via recreational boaters and anglers.
- Determine the temperatures and associated contact times required to induce mortality on various post settlement life stages/sizes of dreissenid mussels that may be found on boat surfaces and in compartments. Determine the physical effects of pressure washing and the pressures required to induce mortality and removal of various life stages of dreissenid mussels on boat surfaces.

Early Detection, Monitoring and Rapid Response

Effective early detection and rapid response (EDRR) requires that new introductions of AIS be detected in the early phases of establishment when management actions are more likely to be successful. It also requires that effective containment, control, and eradication tools are immediately available for implementation once founding populations are detected. EDRR is vital for the Great Lakes – St. Lawrence River region. Significant progress has been made to advance EDRR efforts including the creation of a “hot list” list of highly invasive species, risk assessments of potential AIS, and the development of genetic markers for screening. Also, a binational rapid response plan, supported by the International Joint Commission, has been completed to help state, provincial and federal jurisdictions in their efforts to respond quickly, effectively and in a coordinated manner when AIS are detected. These efforts are supported by databases such as the Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS) and the National Aquatic Species (NAS) system managed by NOAA and USGS respectively. Also, the 2012 amendments to the Great Lakes Water Quality Agreement established an Annex on AIS (Annex 6) which calls for effective and coordinated binational response actions. These

important efforts require continued support. However, research is still necessary to develop effective rapid response tools (chemical and physical) and effective communication and coordination is required to ensure that the appropriate legal mandates are in place to allow their application. EDRR requires effective monitoring tools that can detect species at low abundances with known detection limits. Effective EDRR will also require regionally coordinated surveillance monitoring programs undertaken over appropriate time scales. Emerging research priorities identified include:

- Identify policy and management barriers to effective assessment or response and developing better ways to optimize informed management decisions following the discovery of new AIS
- Review and develop standardized surveillance monitoring techniques for high risk invasive species (see below), quantifying detection limits, sources or errors, result interpretation and appropriate sampling periodicity.
- Expand development of genetic markers for high risk invasive species predicted to invade the Great Lakes including by vectors other than ballast water.
- Establish relative detection sensitivity of next generation genomic tools.
- Review availability (legal, specificity, toxicity) and effectiveness of existing control tools for the range of taxonomic groups and species that may invade the Great Lakes.
- Develop environmentally acceptable chemical (e.g. selective biocides) and physical control and eradication tools for localized rapid response for those taxonomic groups (e.g., crustacean) for which no tools exist.
- Establish coordinated monitoring programs focusing on the identification and prioritization of high risk sites for surveillance (early detection) for new introductions.
- Spatially quantify the risk of introduction by all invasion pathways across the Great Lakes to identify priority sites for surveillance to detect new AIS introductions.
- Verify and expand the "hot list" of high risk species, potential source locations, and probable impacts (Appendix A).
- Establish eDNA production and degradation rates, collection methods, detection limits and error rates of molecular (genetic) methods; including research to improve the ability of these methods to detect rare, non-native species within large assemblages of abundant native species.
- Improve and apply ecological forecast methods that identify areas vulnerable to newly introduced species and predict likely dispersal pathways and potential natural barriers that might impede or slow dispersal.
- Pilot small-scale sampling/surveillance projects to optimize sampling design and to help decide what species, where, how and how often monitoring should occur.

Control and Management of Established Species

Maintenance and recovery of Great Lakes fisheries, biodiversity, ecosystem functions, and services ultimately will require the management of established AIS. As efforts to prevent new introductions begin to take effect, research to improve control and management options must also be pursued and accelerated. Management and, if possible, containment of existing AIS populations will help provide researchers time to develop new methods to eradicate and better control invasive species. Sea lamprey control for example, remains a high priority. Recent developments in pheromone research are expected

to augment lamprey control efforts, but the rising abundance of lamprey in Lake Michigan underscores the need for additional control efforts. Environmentally acceptable chemical, physical, and biological control methods including attractant and repellents need to be developed to address other established invasive species. A priority list of established species has been identified (Appendix A) and where appropriate species specific research agendas developed (Appendix B). Emerging research priorities for control and management can be summarized to include:

- Develop environmentally acceptable chemical and physical control and eradication tools for priority established invasive species (Appendix A).
- Develop and refine containment systems for established but localized invasive species to slow or prevent ongoing spread and anthropogenic dispersal.
- Conduct life history and basic biology studies of established invasive species to identify behaviors, life history traits or physiologies that might make them responsive to management.
    - Include studies across native and introduced ranges (within and outside Great Lakes basin) to both identify potential species- specific biological control agents (predators, pathogens or parasites) and quantify non-target risks.
- Develop decision support tools to quantify the efficacy of different eradication, control or containment approaches to identify strategies that have greatest impact on rates of spread and establishment to minimize economic and ecological impacts.
- Develop tools to measure the effectiveness and/or difference that AIS management strategies are making.

Threats and Impacts to Ecosystems, Human Health and Socio - Economic Values

A stronger understanding of the ecosystem and economic impacts of invasive species is required by decision and policy makers to inform public and private investment in research to support AIS management, as well as to justify increased investment in AIS prevention and control. There is a need to understand what species have caused the greatest changes to Great Lakes ecology, how ecosystems have responded to invasive species and the potential for resisting or facilitating invasion by introduced species. Challenges for threat identification are significant when dealing with AIS, because AIS-related damage to ecosystems and natural resources is not immediately recognized, or may not be a priority, until resources have been significantly affected. Emerging research priorities include:

<u>Biological impacts:</u>

- Quantify community and species patterns at high risk invasion sites to provide baseline reference measurements that will (1) enable ecological change to be measured if new AIS become established; (2) aid identification of new invasive species; and (3) help quantify differences resulting from management efforts.
- Determine biological impacts of AIS on native species and aquatic biodiversity, including the prevalence of cumulative impacts involving AIS to aquatic ecosystems. A priority list of established species or predicted imminent invaders where data on impacts is lacking or inconclusive is provided in Appendix A.
- Expand food web disruption studies to include a broader array of invasive species, mechanistic processes and impacts at all trophic levels.

Human health impacts:

- Examine potential human health and ecosystem issues from pathogens and parasites (e.g., Type E botulism, VHSv).

Socio - economic impacts:

- Develop and validate approaches for assessing economic impacts of AIS within the Great Lakes ecosystem. Conduct cost-benefit analyses of various management scenarios including control and eradication of individual species.
- Evaluate current and historical costs (e.g., physical, biological, chemical, economic, recreational, societal) to the Great Lakes ecosystem caused by AIS.
- Conduct cost/benefit studies on all potential vectors for AIS introduction and spread, including hydrologic and ecological separation of canals and waterways.
- Examine the motivations of stakeholders relating to AIS movement and release in order to better focus outreach, regulatory, and legislative efforts.