Great Lakes Water Quality Agreement
2009–2011 Priority Cycle Report
International Joint Commission

AQUATIC INVASIVE SPECIES

RAPID RESPONSE

2009–2011 Priority Cycle Report on

BINATIONAL AQUATIC INVASIVE SPECIES RAPID RESPONSE

Prepared by the
BINATIONAL AQUATIC INVASIVE SPECIES RAPID RESPONSE
WORK GROUP

For the
INTERNATIONAL JOINT COMMISSION
Canada and United States

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Aquatic Invasive Species Rapid Response Work Group
to the International Joint Commission (IJC), 2011.
Great Lakes Water Quality Agreement Priorities 2009–11 Series.
2009–2011 Priority Cycle Report of the Binational Aquatic Invasive Species Rapid Response, 2011.
IJC, Special Publication 2011–06, Windsor, Ontario, Canada.

ISBN 978-1-927336-06-9

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This report is available for downloading at: http://meeting.ijc.org/workgroups/ais

Cover photo credit, with thanks: Ted Lawrence, Great Lakes Fishery Commission

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BACKGROUND AND METHODS

Description of Issue

Aquatic Invasive Species (AIS) are plants, animals and microscopic organisms that have been introduced into new aquatic ecosystems. AIS have harmful impacts on these ecosystems, on human use of ecosystem resources and, often, directly to human health. Scientists, policymakers and resource managers agree that invasion by non-native species is one of the most challenging environmental issues facing the Great Lakes basin today, because of the large number of AIS already present, the complexity of interactions among AIS and the Great Lakes ecosystem, and the variety of vectors by which they can be introduced[1]. Controlling a population of AIS once it has become established is resource intensive and eradication is virtually impossible. The 23.6 million dollars required for sea lamprey control in the Great Lakes in 2010[2] clearly illustrates that population control of established AIS is expensive and therefore not feasible for a large number of newly introduced AIS. An alternative solution in needed.

The best way to deal with the issue of AIS is to prevent introductions in the first place; consequently, the focus in recent years has been on preventative action with an array of initiatives developed at the state/provincial, federal and international levels. If, however, preventative measures are unsuccessful, an early detection and rapid response program is often suggested as the "second line of defense." [3]

"Rapid response" to a discovery of an AIS as discussed in this report is the timely assessment of the incident at hand, the rapid selection from among pre-planned actions for eradicating and/or stopping the spread of the AIS and the execution of the planned action in a manner that best utilizes the resources available in what is likely to be a multi-jurisdictional and binational landscape.

Rapid Response Planning as it Relates to Prevention

Rapid response is often described as the "second line of defense" beyond prevention. AIS rapid response has also often been criticized for potentially wasting resources that would be better used for AIS, prevention.[4] However, the purpose of rapid response is not to reduce the need for preventative action but instead to enhance prevention. As observed with the U.S. Army Corps of Engineers' (USACE's) Great Lakes and Mississippi River Interbasin Study (GLMRIS) pathways assessment, successful rapid response planning efforts may help to identify effective pre-emptive measures that could support prevention.[5] In fact, early detection and rapid response could be considered a form of prevention because its purpose is to prevent AIS establishment.

[1]A more detailed overview of the impacts of AIS in the Great Lakes is in the International Joint Commission's 2007–09 Priorities Series report, *Work Group Report on Binational Aquatic Invasive Species Rapid Response Policy Framework*.

[2]Great Lakes Fishery Commission. 2008. *Program Requirements and Cost Estimates for Fiscal Year 2010*. Retrieved June 2011 from http://www.glfc.org/aboutus/budget.php

[3]This approach has been accepted by the Great Lakes Regional Collaboration, the Great Lakes Panel and the Mississippi River Basin Panel of the U.S. Aquatic Nuisance Species (ANS) task force and other regional ANS panels, all representing a myriad of federal, state/provincial, and local agencies/organizations.

[4]Horns WH 2011. Early Detection and Rapid Response May Not be Smart. Wisconsin Department of Natural Resources. Presentation at the International Association for Great Lakes Research Conference, Duluth, Minnesota, June 2, 2011.

[5]The GLMRIS pathways assessment uncovered high-risk flood water connections that were subsequently blocked with physical barriers, greatly reducing the risk of adult Asian carp circumventing the electrical barrier near Chicago and emphasizing the risk of Asian carp migrating to the Great Lakes via other tributaries. This served to underscore the need to evaluate risks associated with potential invasion pathways and the importance of prevention in rapid response.

Regardless of how it is described, the feasibility of AIS rapid response is debated and is clearly not an option in all cases. However, the time for debate is not when an emergency occurs. It is critical to assess *potential* invasions of high-risk AIS in order to identify where action is likely to succeed well in advance of the threat and to work through likely scenarios. Unlike the straightforward process that can be followed when developing a rapid response plan for a forest fire emergency, where fire will be a common threat, developing an AIS response plan is problematic. It has to cope with a range of threats and potential responses that can vary greatly depending on the organism invading.

This uncertainty has been coupled with doubts raised by well publicized but failed rapid response efforts for species such as northern snakehead (Crofton Pond, MD 2002) and the round goby in Pefferlaw Brook (Ontario, 2004). This has led many to subscribe to the view that AIS populations can rarely be eradicated, only controlled. Others might say that we have won battles only to lose the war. However, there are notable cases where rapid response has proven highly effective. Chemical eradication of invasive aquatic weeds such as *Hydrilla* and Eurasian water milfoil has been successful on many occasions and there has been some successful eradication of fish species such as the Asian carps.[6] With a strong emphasis on risk assessment and early detection, rapid response planning efforts will serve to underscore prevention as the most effective option for AIS control. Better communication with regard to the value of having a comprehensive, binational plan in place for AIS rapid response will help build greater public awareness and support for both prevention and rapid response.

Any response to the AIS threat to the shared resource of the Great Lakes needs to be coordinated between the U.S. and Canada. A Binational Rapid Response Plan for the Great Lakes basin will prevent wasted effort on the part of agencies charged with protecting native species and habitat so they do not waste time and resources on partial responses that are doomed to fail. If rapid response planning is carried out binationally and across jurisdictional boundaries, then AIS managers can conserve resources for cases that have a high probability of success. Time will be saved by identifying jurisdictions that are able to provide assistance with vital assets. Effective risk communication and advanced planning could make the difference between having enough time to implement a successful rapid response and reacting too slowly to prevent the establishment of an invader. The importance of quick decision-making and rapid implementation of response actions following the discovery of a new invasion cannot be overemphasized for, without this, rapid response is highly unlikely to succeed. Fisheries and Oceans Canada (DFO) completed a peer-reviewed National Framework for Rapid Response in 2010 and the 2007–2009 International Joint Commission's Binational AIS Rapid Response Work Group recently identified an overall rapid response framework for the Great Lakes—St. Lawrence River basin. These resources can serve as over-arching frameworks from which more specific plans can be developed.

[6]The discussion of Operation Silver Screen provides footnote discussion of the Indiana DNR eradication of *Hydrilla*, and other references as necessary.

Work Group Approach and Activities

The Commission's commitment to the AIS issue is long standing; it was again designated as one of the IJC's top five priorities for review during the 2009–2011 priority cycle. The Commission charged a collaborative Work Group comprised of members from the Water Quality Board, the Science Advisory Board and the Council of Great Lakes Research Managers with investigating Binational Aquatic Invasive Species Rapid Response. Their work built on the Binational Aquatic Invasive Species Rapid Response Policy Framework developed by the Work Group during the previous priority cycle.

The 2007–2009 Work Group report identified an overall binational rapid response framework for the Great Lakes—St. Lawrence River basin. It highlighted the organizational complexity associated with rapid response in the binational Great Lakes region as well as the need for regional and national species-specific plans such as the Asian carp rapid response plan. Although site and species-specific details of AIS rapid response planning may differ in each situation, the scoping process and many of the rapid response mechanisms used in each area will remain the same. The framework report recognized the need for each nation and/or jurisdiction to officially designate a lead agency to assure appropriate action is taken in collaboration with their counterparts in the other nation. This framework recognized the need to respect both sovereign rights and responsibilities and the necessity to act without delay. It emphasized the need for effective coordination and removal of barriers to action before an emergency arises.

In 2009–2011 the Work Group took the process a step further towards developing a Binational Rapid Response Plan for the Great Lakes by completing some of the groundwork for a binational pilot response plan that will focus on a specific region and a list of higher-risk AIS. Producing and testing this pilot plan will answer many of the outstanding questions regarding implementation of rapid response and serve as a model for binational plans in other boundary regions.

Over the past two years the Binational AIS Rapid Response Work Group conducted research on several topics related to rapid response to build on the policy framework, and to serve as both a foundation and a more detailed guide for further planning efforts. Information was gathered from a wide variety of sources and included a review of scientific and grey literature, a series of personal interviews with key AIS managers including Work Group members, and correspondence with key AIS personnel in various jurisdictions.

This summary report communicates the findings and recommendations of the Binational AIS Rapid Response Work Group members as informed by the appended background reports as well as their personal and professional experiences. This report consolidates and summarizes the background work, findings and recommendations and serves as an executive summary of Work Group activities over the past two years. The Work Group reports, together with public input gathered at the Commission's Biennial Meeting being held at Wayne State University in October 2011, are intended to transmit advice to the Commission for the purpose of informing the Commission's advice to the governments of the U.S. and Canada.

The contributions of the 2009–2011 Work Group members are greatly appreciated, these members include: William Taylor *University of Waterloo* (Co-chair), Chris Wiley *Transport Canada and Fisheries and Oceans Canada* (Co-chair), Eugene Braig *Ohio Sea Grant*, Suzanne Hanson *Minnesota Pollution Control Agency*, Joseph Koonce *Case Western Reserve University*, John Dettmers *Great Lakes Fishery Commission*, Roger Eberhardt *Michigan Department of Environmental Quality,* Mike Bohm *Ontario Ministry of Natural Resources,* Scott Millard and Becky *Cudmore Fisheries and Oceans Canada.*

The Work Group gratefully recognizes the support of three contractors in gathering this information and developing its background reports which are included in the appendices to this work group report: Appendix A—G*ap Analysis: Asian Carp Rapid Response Planning and Implementation* by Michael Donahue: *Appendix B—Aquatic Invasive Species Early Detection and Rapid Response—An Assessment of Chemical Response Tools* by Sommer Abdel-Fattah; and *Appendix C—An Assessment of Risk Assessments and Early Detection Monitoring for Aquatic Invasive Species in the Great Lakes Basin* by Samantha Dupre. Their dedicated work over the past two years in assembling a wealth of material related to U.S. and Canadian early detection and rapid response efforts and for providing a disciplined, thoughtful analysis is much appreciated.

Lessons Learned from Operation Silver Screen —the 2009 Binational Asian Carp Response

The major Asian carp multi-agency eradication effort (Operation Silver Screen) that took place in the Chicago Sanitary and Ship Canal (CSSC) in December 2009 offered an ideal case study for the Work Group to aid in the development of a binational AIS rapid response plan, particularly since both U.S. and Canadian agencies were involved in this effort. The project methodology centered on several primary tasks that included data gathering and analysis, a selective review of the rapid response literature; assessment of the planning and execution of Operation Silver Screen, interviews with multiple parties involved in the planning and execution of that operation and an analysis of outcomes to generate findings and recommendations. The findings from this case study can strengthen regional Asian carp rapid response planning and inform the development and implementation of a binational AIS rapid response plan.

Operation Silver Screen was conducted in response to the discovery of bighead and silver carp eDNA[7] within the Lockport Pool as well as within a mile of the electric dispersal barrier by the USACE. Coinciding with scheduled maintenance of the electric dispersal barrier by USACE, the operation involved chemical treatment within a targeted area of the CSSC as well as a netting operation on the Grand Calumet River in proximity of the T.J. O'Brian Lock. Objectives included successful multi-agency collaborative treatment of the target area, utilization of a new rotenone delivery system, barrier maintenance and subsequent restoration of operation, implementation of the Incident Command System (ICS), and netting at a second target area. Overall, the operation involved more than 400 responders drawn from over 20 local, state/provincial, U.S./Canadian federal and binational agencies, as well as over 20 contractors responsible for some aspect of the operation. Personnel appearing in leadership roles on the organizational chart for the response operation were drawn from the Illinois Department of Natural Resources (overall lead), USACE's Chicago District, U.S. Environmental Protection Agency's (USEPA's) Great Lakes National Program Office, U.S. Fish and Wildlife Service (USFWS), and the U.S. Department of Agriculture (USDA). Multiple other agencies *e.g.*, U.S. Coast Guard, DFO and the Great Lakes Fishery Commission had critical roles as well.

Assessment of Related Plans and Strategies

Three documents related to the response were reviewed in the context of Operation Silver Screen and in terms of binational response: *Asian Carp Control Strategy Framework* (February 2010), prepared by the member agencies of the Asian Carp Regional Coordinating Committee; *Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (November 2007), prepared by the Asian Carp Working Group of the Aquatic Nuisance Species Task Force; and *Asian Carp Rapid Response Plan* (November 2009), prepared by the Asian Carp Rapid Response Work Group, a 13-member body drawn from federal, state, local, binational and nongovernmental entities.

These three documents provided additional information in developing recommendations for strengthening AIS rapid response planning. All three documents lacked detailed reference to the involvement of Canadian agencies or the binational dimension of the Asian carp issue (or AIS in general). Although the Asian Carp Rapid Response plan did identify a "support, coordination, and involvement role" for the Canadian and binational entities, there was no direct Canadian government input into the plan. All documents touched on the need to identify the roles of entities involved, formalize communications, and establish a coordination structure

[7]Environmental Deoxyribonucleic acid (eDNA) monitoring is a surveillance method for AIS that collects water samples containing DNA from sloughed tissues that are shed into the water from aquatic organisms. The DNA is then analyzed to identify which species have recently been in a particular water body.

Planning for Operation Silver Screen highlighted the challenges of a complex, multi-agency response with a binational dimension. These challenges included securing the involvement of multiple parties in the planning process, focusing on the geographic scope of the response operation, coping with varying degrees or lack of ICS planning experience, working with differing agency authorities/capabilities, accommodating resource constraints, and addressing logistical challenges in moving and staging personnel and materials in a binational setting.

Assessment of AIS Monitoring and Risk Assessments in the Great Lakes Basin

Accurate risk assessments and effective early detection monitoring are essential components of successful AIS rapid response. As newly introduced invasive species go undetected in ecosystems for longer periods of time, the probability of successful intervention decreases drastically[8]. In view of this, an assessment was performed of risk assessments and potential gaps in early detection coverage within the Great Lakes—St. Lawrence River basin. A list of risk assessments and ongoing active (AIS-targeted) and passive (incidental biomonitoring) programs was compiled and a geographic analysis conducted by overlaying locations of monitoring programs with high-risk invasion areas (Figure 1). Determining gaps in early detection monitoring depends on two factors: evaluating the effectiveness of various types of monitoring activities and identification of high-risk species and areas. Understanding the potential risk-posed by an invasive species and high-risk areas for invasion will shape the scale and geographic focus of a rapid response.

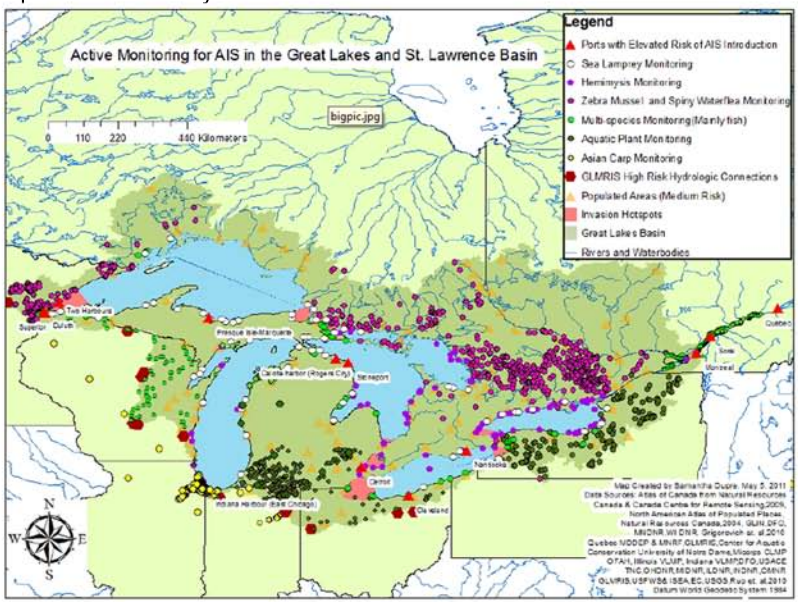

Figure 1. *Active Monitoring Programs in the Great Lakes Basin*
Note: Ports with elevated risk of AIS introduction were determined from Rup, 2010; invasion hotspots were determined from Griogorovich, 2003; urban areas were determined from the North American Atlas published by Natural Resources Canada; and the High Risk Hydrologic Connections were determined from the USACE's GLMRIS-Other Pathways Preliminary Risk Characterization Report. Figure adapted from "An Assessment of Risk Assessments and Early Detection Monitoring for Aquatic Invasive Species in the Great Lakes Basin" by Samantha Dupre (Appendix C).

[8] Vander Zanden J, Hansen G, Higgins S, and Kornis M (2010) A pound of prevention, plus a pound of cure: Early detection and eradication of invasive species in the Laurentian Great Lakes. *Journal of Great Lakes Research*, 36, 199–205.

Effectiveness of Monitoring

The intensity and effectiveness of early detection monitoring varies greatly throughout the basin. Some areas, like the western tip of Lake Superior, benefit from cutting-edge research on AIS-targeted sampling techniques and binational cooperation among several jurisdictions, while others have no active monitoring coverage at all (Figure 1).

Evaluating the effectiveness of monitoring is further complicated by the fact that most ongoing monitoring and research activities being carried out by agencies, academics, industries and citizen-groups are passive; they can detect AIS, but only incidentally and they often lack the taxonomic expertise to identify new or less well known AIS.[9] All jurisdictions have either fisheries or water quality monitoring programs in place that can serve as useful AIS detection mechanisms. Government agencies from all jurisdictions along with academics, industries and citizens groups invest public and private resources in monitoring to understand the status of aquatic resources and the functioning of the communities of organisms and ecosystems that support those resources. Staffs in these programs are trained professionals but often lack the specialized training to monitor or identify AIS. These long-term and regular assessments may be critical to assessing the temporal and spatial extent of an invasion. However, these monitoring programs are often diminished in spatial or temporal scale because of limited resources and variable funding, and their effectiveness in AIS early detection is limited. These passive monitoring efforts will not always be sufficient to fully identify invasions. Targeted active AIS monitoring is needed.

AIS monitoring programs include both volunteer and agency-run programs. Most active volunteer monitoring initiatives in the Great Lakes basin focus mainly on a small subset of well known invasive species: zebra and quagga mussels, spiny waterflea, or invasive aquatic plants. The programs run by staff scientists also mainly focus on a limited set of species (mainly invasive fishes and plants) and occur over limited geographic ranges (Figure 1). Agency-run programs also focus on specific high-risk pathways or geographic areas of concern for invasion.

More noticeable invasive species are more often the focus of monitoring. Few programs actively look for invasive algae, zooplankton or invertebrates. Asian carps have been a large focus of monitoring in the U.S., and new monitoring methodologies like eDNA are being developed for Asian carps and other species.

[9]Evidence for the lack of effectiveness of incidental monitoring when compared with active monitoring for rare (newly introduced) invasive species is widespread in the scientific literature. References include: Trebitz, A., Kelly, J., Hoffman, J., Peterson, G. and West, C. 2009. Exploiting habitat and gear patterns for efficient detection of rare and non-native benthos and fish in Great Lakes coastal ecosystems. Aquatic Invasions,V. 4:4, p. 651-667.environmental DNA. Conservation Letters, V.4, p. 150–157.
Magnuson, J. Benson, B., and McLain, A.1994. Insights on Species Richness and Turnover from Long-Term Ecological Research: Fishes in North Temperate Lakes, American Zoologist, V. 34:3, p. 437–451.
Gu, W., and Swihart, R. 2004. Absent or undetected? Effects of non-detection of species occurrence on wildlife–habitat models. Biological Conservation, V. 116:2, p. 195–203.
Hoffman, J., Kelly, J., Trebitz, A. and Peterson, G., West, C. (2011. Manuscript submitted for journal review by USEPA). Effort and potential efficiencies for aquatic non-native species early detection.

Determining High-Risk Species and High-Risk Areas

Thorough species-focused risk assessments have been completed in both Canada and the U.S. Most species-level assessments have looked broadly and qualitatively at the risks associated with invasion of that species to the Great Lakes basin and have been criticized because of their lack of usefulness to AIS managers. These risk assessments allow an evaluation of the level of concern and investment that AIS managers and agencies should have about the potential entry of a given organism, but these assessments lack geographic specificity to provide useful advice to direct detection monitoring or to aid in design of rapid response. The DFO and USFWS are currently implementing a new strategy for risk assessment that includes quick, high-level risk screening for aquatic organisms in trade that have the potential to become AIS. These screening-type assessments complement more quantitative type risk assessments being developed for species perceived as presenting the greatest risk. Agencies developing these more detailed and thorough assessments include the DFO and a binational team at the University of Notre Dame funded by the Great Lakes Restoration Initiative (GLRI). The Canadian Aquatic Invasive Species Network is also working on research to inform aspects of these quantitative risk assessments. One example of this new type of risk assessment is the currently underway Binational Risk Assessment for Asian Carps in the Great Lakes which will be conducted jointly by scientists in Canada and the United States. This work will provide advice for monitoring, early detection and rapid response of Asian carps before the end of 2011.

Assessment of Chemical Response Tools

Although it is critical that AIS research and management actions focus on methods of prevention, research and development of tools for responding to AIS is also needed for successful rapid response. There are several tools with which to respond to invading non-native species, but the Work Group limited its assessment to one key method, chemical control.[10]

Management Considerations for Chemical Control Selection and Use

New scientific evidence concerning the potential impacts that certain toxic substances may have on human and aquatic life has increased public concern regarding the intentional introduction of toxic substances to surface waters. AIS managers considering the application of any chemical to surface waters must determine if that chemical has toxic effects on humans or other biota (particularly endangered or protected species) and whether those toxic effects are significant enough to outweigh the benefits of removing AIS. Additionally, before considering any control tool, the local ecosystems need to be thoroughly understood.

The first consideration for AIS managers in conducting any chemical application should be public safety, health, and the protection of drinking water sources. Consideration of a chemical control tool should also include an assessment to determine if the chemical may have acute or long-term negative effects on other biota.

[10]This assessment examined the use and registration process for chemical controls with target species on the high-priority species list of the Aquatic Nuisance Species Task Force's (ANSTF's) Great Lakes Panel. A list of specific priority species, associated chemical controls, and their water quality and non-target impacts as well as their regulatory status was compiled (Table 1).

Grouping	Tier	Name	Taxon	Species	Chemical Control Tools
Fish	1	sea lamprey	Petromyzontidae	*Petromyzon marinus*	TFM, Bayer 73, Rotenone, Antimycin and Bayluscide®
	2	bighead carp	Cyprinidae	*Hypophthalmichthys nobilis*	Rotenone and Antimycin
	2	black carp	Cyprinidae	*Mylopharyngodon piceus*	Rotenone and Antimycin
	2	grass carp	Cyprinidae	*Ctenopharyngodon idella*	Rotenone-laced bait such as Prentox®
	1	rudd	Cyprinidae	*Scardinius erythrophthalmus*	Rotenone and Lime
	2	tench	Cyprinidae	*Tinca tinca*	Rotenone and Antimycin
	2	roach	Cyprinidae	*Rutilus rutilus*	Rotenone and Antimycin
	1	white perch	Moronidae	*Morone americana*	Rotenone
	1	european perch	Percidae	*Perca fluviatilis*	Rotenone
	1	Eurasian ruffe	Percidae	*Gymnocephalus cernus*	Rotenone, antimycin, TFM and Bayluscide®
	2	monkey goby	Gobiidae	*Neogobius fluviatilis*	Rotenone
	1	round goby	Gobiidae	*Neogobius melanostomus*	Rotenone
	1	tubenose goby	Gobiidae	*Proterorhinus semilunaris*	Rotenone
	1	northern snakehead	Channidae	*Channa argus*	Rotenone
Zooplankton	1	fish-hook waterflea	Cladocera	*Cercopagis pengoi*	Chlorine
	1	spiny waterflea	Cladocera	*Bythotrephes longimanus*	Chlorine
Aquatic Plants	2	brazilian elodea	Hydrocharitaceae	*Egeria densa*	Diquat (Reward®), Fluridone
	1	curly-leaf pondweed	Potamogetonaceae	*Potamogeton crispus*	Diquat, copper with diquat, endothall, fluridone, imazamox
	1	eurasian water milfoil	Haloragaceae	*Myriophyllum spicatum*	Copper complexes, 2,4-D, diquat, fluridone, imazamox, penoxsulam, endothall, triclopyr
	1	common reed	Phragmites	*Phragmites australis*	
	1	water soldier	Hydrocharitaceae	*Stratiotes aloides*	Glyphosate (Roundup, Rodeo), Imazapyr (Habitat) Diquat (Reward®)
	1	european frog-bit	Hydrocharitaceae	*Hydrocharis morsusranae*	2,4-D, diquat, imazamox and imazapyr
	2	hydrilla	Hydrocharitaceae	*Hydrilla verticillata*	Copper complexes, diquat, copper with diquat, endothall, fluridone, imazamox and penoxsulam
	1	purple loostrife	Lythraceae	*Lythrum salicaria*	Glyphodsate, Triclopyr-TEA
	1	water chestnut	Trapaceae	*Trapa natans*	2,4-D
Macro invertebrates	1	Echinogammarus	Amphipoda	*Echinogammarus ischnus*	No known chemical, biocides can aid
	2	killer shrimp	Amphipoda	*Dikerogammarus villosus*	No current method known, can be killed by biocides
	1	New Zealand mud snail	Gastropoda	*Potamopyrgus antipodarum*	Copper sulphate, Hyamine and hydrogen peroxide, TFM, Bayluscide®
	1	quagga mussel	Dreissenidae	*Dreissena rostriformis bugensis*	Zequanox, chlorine
	1	zebra mussel	Dreissenidae	*Dreissena polymorpha*	Zequanox, chlorine
Pathogens	1	Microsporidia	Microsporidia	*Heterosporis* spp.	Fumagillin DCH
	1	Myxosporidian	Myxozoa	*Sphaeromyxa sevastopoli*	No current method known
	1	Salmonid whirling disease	Protozoa	*Myxobolus cerebralis*	Calcium Cyanide, Quicklime (CaO), Calcium cyanamide with Chlorine gas
	1	Viral hemorrhagic septicemia (VHS)	Rhabdoviridae	*Viral hemorrhagic septicemia virus*	Virkon Aquatic, hypochlorite with some slaked lime (at high concentrations), Iodophor
Phytoplankton	1	cylindro blue-green algae or Cylindrospermopsis	Cyanobacteria	*Cylindrospermopsis raciborskii*	Endothall (Hydrothol 191®), copper sulphate or complexed copper products

Table 1. *Priority Invasive Species and Associated Chemical Control Tools Adapted from Background report Aquatic Invasive Species Early Detection and Rapid Response—An Assessment of Chemical Response Tools by Sommer Abdelfattah*
Tier 1=established, harmful, non-native species
Tier 2=potential invader to the Greal Lakes Basin

Accordingly, one of the most important tools for decision making with regard to chemical control use is the results of toxicological studies for aquatic species (both native and threatened) including long-term environmental impacts regarding the persistence of chemical tools. Studies of human health and safety central to pesticide registration processes will also be critical inputs to the evaluation of chemical use. Having a variety of registered chemical options available for control can provide the flexibility necessary to control nuisance populations while still maintaining other beneficial water uses, especially when economic resources play a role in the decision-making process. When possible, it is best to choose a selective pesticide.

Only registered chemical pesticides and herbicides will be available for consideration for use in rapid response. A wide variety of registered chemical controls are available for aquatic plants. Only two main general-use piscicides are registered for use by AIS managers-rotenone and antimycin. There are also a variety of molluscicides and two common lampricides (TFM and Bayluscide). In addition, several non-specific treatments are available. However, there are currently limited treatments for pathogens and small invertebrates even though biocide treatment might help prevent their spread.

Development and Registration of Pesticides in Canada and the U.S.

In order to get a new product registered with the U.S. and Canadian governments, there are strict guidelines for tests and research that need to be conducted before a product can be labelled and sold. The time and costs required for development and registration of new chemicals to control organisms in aquatic environments are too great to have new compounds easily considered for rapid response.

In Canada and the U.S., adding new species to a registered pesticide label can also be time-consuming; however, in Canada there are provisions to enable use of a pesticide for a species not on the label in an emergency stiutation. It should be noted the TFM and Bayluscide are labelled specifically for sea lamprey control in both Canada and the U.S. but may not be ideal for general use because there is a need to avoid using these chemicals in any way that might jeopardize sea lamprey control.

Pesticides are carefully regulated in both countries through a program of scientific assessment, enforcement, and information dissemination. Enforcement activities are shared among all levels of government. In Canada, all pesticides must be federally registered by Health Canada's Pest Management Regulatory Agency (PMRA) and provincially classified. USEPA and the states (usually through the state agriculture department) register or license pesticides for use in the U.S. and pesticides must be registered both by USEPA and the state before distribution.

Currently, Canada and the U.S. have separate registration of pesticides and herbicides. There have been efforts by PMRA and USEPA to harmonize the environmental data requirements under North American Free Trade Agreement (NAFTA) for registration of Chemical Pesticides, to create a joint review process. Harmonization reduces costs to applicants and facilitates simultaneous registration of pesticides in Canada and the U.S. Some changes have been made to harmonize requirements; for example, PMRA has deleted the requirement to conduct toxicity studies on soil microorganisms. These changes have aided in simplifying the application process. However, impediments still remain to optimum work-sharing of environmental reviews; these are currently being addressed by the NAFTA Technical Working Group on Pesticides.[11]

[11]The North American Free Trade Agreement (NAFTA) Technical Working Group on pesticides works to address trade issues, national regulatory and scientific capacity, governmental review burden, and industry burden; and to coordinate regulatory decision-making in Canada, Mexico and the U.S. It was established in 1997, to streamline certain pesticide shipments among the three countries. For more information please visit http://www.epa.gov/oppfead1/international/naftatwg/

Science and Policy Gaps That Need to Be Addressed

Science and policy gaps related to rapid response were identified in all background reports.

Science and Policy Gaps Identified in the December 2009 Asian Carp Response

In assessing the outcome and process of the December 2009 Asian carp response, several areas where policy gaps limited the efficiency and effectiveness of rapid response became apparent. Operation Silver Screen encountered many challenges including an evolving command structure, insufficient communication protocols, uneven political commitment, differences in jurisdictional authorities, and funding uncertainties.

An effective AIS rapid response process requires official sanction at the highest levels, a firm basis in law backed by a consistent regulatory framework, "on the shelf" response protocols and a well developed organizational structure with adequately funded and trained responders ready for immediate deployment. Legal issues posing potential obstacles to rapid response must be fully identified and addressed. Regulatory differences among jurisdictions are problematic; efforts to "harmonize" them must continue over the long term while, in the short term, efforts must be made to work around them.

At the basin-wide binational level, a Rapid Response Plan is needed to present the overall organizational structure for a site- and/or species-specific response. In the interest of cost efficiency, effectiveness and timeliness, leaders should rely upon existing Great Lakes institutions, to the extent possible, as the foundation for a Binational Great Lakes AIS Rapid Response Program. Some form of binational authority (*e.g.*, new treaty, or an amended Great Lakes Water Quality Agreement) should be established to coordinate development and implementation of a binational Rapid Response Plan. Additionally an "Area Committee" approach to rapid response is advisable in the interest of ensuring a local presence and understanding in a response operation. Selection of a lead agency (or agencies) for any given rapid response scenario should be a case-by-case determination depending upon which agency can respond most effectively (*e.g.*, because of site familiarity or access to resources).

Overall, a need for policies that address three key areas has been identified: the need for an initial and/or continued training program for different levels of the Incident Command System (ICS) for all potential responders, the development of formalized and centralized communication protocols and rapid response Standard Operating Procedures and, finally, better planning of facilities and technologies for use during rapid response. When identified and addressed prior to the response operation, such considerations can greatly reduce uncertainties that might otherwise compromise success.

To implement the above recommendations it was suggested that a "pilot test" of a rapid response protocol under a Binational Great Lakes AIS Rapid Response Program be conducted by the Work Group, based upon presently available risk assessment data, at a specific binational location (*e.g.* Detroit River). On March 11, 2011, officials in Ontario worked with partners from the U.S and the DFO to conduct a tabletop response exercise aimed at identifying vulnerabilities and needed response actions in the event of an Asian carp invasion of the Thames River. There is a clear opportunity for the lessons learned in this exercise to be linked with the Commission's pilot test. Exercises like the Ontario Ministry of Natural Resources (OMNR) table top exercise will serve as an important resource in developing the Commission's pilot plan as well as an overall Binational Great Lakes Rapid Response Plan.

Risk Assessment Science and Policy Gaps

Risk assessments, like science experiments, require the scientist to set the scope of the assessment at the outset. This allows the assessment to be completed with either a fine or coarse level of detail. Research conducted for the background report, *An Assessment of Risk Assessments and Early Detection Monitoring for Aquatic Invasive Species in the Great Lakes Basin*, included a brief survey of geographic risk assessments available in the scientific literature, in the public domain and to AIS managers.[12] This survey found that most geographically based assessments focus on broad geographic regions and determine overall invasion "hotspots", but do not examine and predict risks at finer levels of spatial detail (*eg.* county, municipality, or region of a stream).

Researchers leading risk assessment science note an overall lack of detailed aquatic environmental data as well as data about new AIS occurrences. This makes it difficult to conduct spatially explicit and quantitative modeling for risk assessments. This in turn makes it a challenge for AIS managers to plan effective early detection strategies. Therefore, research such as the projects being completed by the Canadian Centre of Expertise for Aquatic Risk Assessment (CEARA), the Canadian Aquatic Invasive Species Network (CAISIN), USEPA, and the team researching AIS at the University of Notre Dame needs to be encouraged. CEARA is currently conducting risk assessments on all pathways of AIS introduction. The USACE's GLMRIS has looked at hydrologic connections as vectors. However, in the past there has been a lack of risk assessments that focus on non-ballast water human-mediated vectors of AIS introduction and spread; this may become increasingly important as new regulations reduce threats from ballast water introduction. CEARA is now conducting risk assessments that focus on a variety of human-mediated vectors in Canada; future risk assessments in both countries may benefit from following this example and continuing to look at all other vectors.

The scope of organisms that are potential invaders may need to be explicitly defined in rapid response policy. Different AIS fall into different regulatory categories which may or may not create inconsistencies in risk assessment approaches. For example, pathogens and internal parasites (*e.g.* tapeworms or viral hemorrhagic septicemia virus and aquatic invasive plants that might be imported in trade fall under the jurisdiction of the Canadian Food Inspection Agency in Canada, and in the U.S., imported aquatic plants may also be regulated by USDA. These agencies develop pest risk assessments for the import of these species. However, other federal agencies are the main leads in AIS risk assessments and, thus, policy direction could become confused. Communication among these agencies will be critical in any comprehensive AIS response planning efforts.

[12] Refer to background report *An Assessment of Risk Assessments and Early Detection Monitoring for Aquatic Invasive Species in the Great Lakes Basin* (Appendix C).

Early Detection Monitoring Science and Policy Gaps

Overall, there is insufficient active monitoring coverage within the Great Lakes basin to constitute a truly effective early detection program. New AIS monitoring methodologies such as eDNA are not yet implemented consistently throughout the basin. Many agencies perform passive monitoring, but AIS management is not their primary purpose. Agencies are given minimal funds for monitoring work and most do not have additional funding available for AIS monitoring. Ongoing aquatic ecosystem, fisheries, and water quality monitoring efforts need to be consistently supported to provide critical background assessments to compare and evaluate targeted monitoring.

Formal mechanisms to encourage dialogue between scientists and managers whose programs include (or could include) AIS early detection could enhance rapid response effectiveness with minimal increases in cost. A good example of this type of mechanism is the collaborative AIS survey effort between U.S and Canadian agencies in Lake Superior, where all agencies involved cooperated to develop and use standardized AIS-specific monitoring protocols and new monitoring methodologies. In this case, the USFWS provides the taxonomic expertise necessary; the establishment of a network of experts would assist other regions.

Science and Policy Gaps in the Development and Utilization of Chemical Response Tools

The limited suite of registered pesticides and herbicides for application to waters for control of AIS will constrain rapid response. Investment in continued registration and research to support the human health and environmental safety of these current pesticides will be critical to having any chemical tools for rapid response. Research, development, and registration of new chemical tools might also be necessary to improve the suite of chemical tools available. Before chemical tools can be used in rapid response they must be registered. Although a joint review process for registration of chemicals between Canada and the U.S has been developed, further alignment of PMRA and USEPA standards is still needed, and should be encouraged, to reduce costs and streamline the pesticide registration process. Implementation of complete joint-registration for chemicals would be one way of accomplishing this.

AIS managers operating in boundary waters and applying chemicals to shared waters will need to meet both Canadian and U.S. guidelines and state and provincial restrictions for the use of chemical response tools. While complicated, working in adjacent waters is possible as illustrated by the application of Bayluscide to control sea lampreys in the shared St. Mary's River. Establishing a clear and formalized set of binational chemical response standards, rather than requiring managers to conform to two sets of regulatory guidelines, would greatly improve the efficiency of the use of chemical tools in rapid response. When used by licensed personnel in accordance with the label guidelines, chemical response tools present minimal risk.[13] All managers and practitioners involved in rapid response need to be educated about the regulatory and label constraints on using any chemical tool in the specific area under consideration. State and provincial restrictions may not always be clear or publicly accessible to individuals at the ICS level who are involved in a rapid response effort. These restrictions need to be clearly detailed to ensure that all relevant statutes are being followed.

[13]Refer to background report, *Aquatic Invasive Species Early Detection and Rapid Response An Assessment of Chemical Response Tools* (Appendix B).

Research, Monitoring and Coordination Needs

The Work Group has identified several areas that would benefit from enhanced research, monitoring and coordination, to improve rapid response planning in the Great Lakes basin.

Research, Monitoring and Coordination Needs for AIS Early Detection Monitoring

The need for a systematic program for targeted active early detection of a wide variety of AIS in the Great Lakes region has been identified. USEPA has plans to implement a basin-wide program with GLRI funding; however, since there is currently no corresponding plan on the Canadian side of the border, USEPA's planned early detection program will not be truly basin-wide. Similarly GLMRIS will create aquatic habitat maps of the Great Lakes and Mississippi River basins and forecast the potential spread of AIS; however, like the USEPA program, this initiative concentrates on the U.S side of the basin only. Accordingly, there is a clear need for stable support for a binational active monitoring program, and funding is required to support AIS detection monitoring in Canada. OMNR does cooperate with the USFWS to sample ports in Lake Superior; however, there is no current ongoing basin-wide effort for binational cooperation on active sampling and information sharing. There is also no basin-wide coordination with First Nation groups related to AIS detection. The DFO and OMNR do invest in targeted AIS monitoring on the other Great Lakes, but this investment provides only limited coverage. The pilot project for Asian carp eDNA sampling (occurring in higher risk areas across the U.S side of the Great Lakes basin) should be funded to become an ongoing program in all jurisdictions and should continue to grow to include other AIS.

All regions have public education programs for AIS reporting in place, but such programs are insufficient on their own, and a more active form of early detection is needed. Experts have identified species identification as one major challenge in active and passive monitoring programs in the Great Lakes. Implementing active surveys in all jurisdictions may not always be economically feasible. Therefore, enhancing the capacity of passive biomonitoring and volunteer monitoring programs by providing funding for AIS identification training, and developing and coordinating standardized AIS specific monitoring protocols, are important and cost-effective ways to fill gaps in both geographic coverage and the scope of species moni tored. Improved sharing of information among all groups involved in AIS detection is needed. These groups include but are not limited to government agencies, First Nations, companies conducting surveys, NGOs, and educators.

Research, Monitoring and Coordination Needs for Chemical Response Tools

When using chemical tools for rapid response, AIS managers need to carefully consider and select specific pesticides for each situation in order to ensure human health and safety and to limit non-target impacts. The broad temporal and spatial separation of AIS rapid response incidents does not suggest a high risk of cumulative impacts from chemical response tools. However, support is needed to ensure that research and registration studies provide sufficient detailed information relating to the impacts of these potential tools on ecosystems and public health.

Although label information is provided online by PMRA and USEPA[14], more detailed information on chemicals, safety, water quality and labels should be provided and compiled into an easy online resource. Making studies

[14]Refer to http://npic.orst.edu/ for further information (referenced by USEPA).

and findings readily available online for public viewing can help alleviate public concerns about rapid response as well as better inform the decisions of AIS managers. Additionally, regionally available ecosystem databases should be established and used by AIS managers to rapidly predict the effects of chemical usage in a rapid response situation. Such a database would also be of use to experts in performing detailed risk assessments and in planning early detection monitoring. The GLMRIS study and the U.S. and Canadian risk assessments may develop much of these data; however, additional research and monitoring will be required to keep these data up to date.

Research, Monitoring and Coordination Needs Identified in the December 2009 Asian Carp Response

A careful analysis of the December 2009 Asian carp response program revealed that there is clearly a need for some form of technical, science-based entity on site to provide responders with the requisite scientific expertise to guide actions in rapid response. Additionally, it was learned that the success of a rapid response is determined largely by the extent and quality of "up front" planning, including risk assessment, modeling, monitoring and ICS training. This echoes the findings of research needs for chemical response tools, monitoring and risk assessments in the other two background reports and reinforces the need for support of such research.

Recommendations for the International Joint Commission to Transmit to the Governments of the United States and Canada

Primary Recommendation

1. Develop and implement a formal Binational Great Lakes AIS Rapid Response Plan in cooperation with AIS management agencies to harmonize response actions and to promote mutual cooperation among U.S. and Canadian Great Lakes institutions.

Discussion

Each nation should officially designate a lead agency to assure appropriate action is taken in collaboration with their counterpart in the other nation while respecting sovereign rights and responsibilities and the necessity to act without delay. Federal expertise and ability should be used to convene larger groups to develop a suite of guidelines or a framework for action that can be implemented by the most appropriate lead agency in each sub-region. Lead agencies may be provincial, state or federal. A rapid response plan will aid the lead agency by identifying other jurisdictions impacted by a particular incident and agencies that can provide assistance. It ensures that all parties involved have sufficient technical expertise and resources, as well as the appropriate legislative and regulatory authority. This is especially important with respect to applying chemical pesticides into shared waters where joint approval and permitting must be completed well in advance. The focus of the plan should be on addressing coordination, technical gaps and barriers to action that need to be removed before an emergency arises. Well-targeted, pre-emptive actions such as those being taken by the Asian Carp Regional Coordinating Committee in the Chicago Area Waterways System are a critical complement to rapid response.

Removing Barriers to Rapid Response Action: Four Key Sub-Recommendations

2. Implement an aggressive prevention program as an essential component of a successful Binational Great Lakes AIS Rapid Response Plan.

Discussion

It becomes less likely that an intervention will be successful the longer AIS go undetected. Two actions provide a foundation for rapid response planning:

- Risk Assessments: *Encourage and support* formalized and effective risk communication between scientists and managers by ensuring that AIS managers are part of the risk assessment scoping process. This will ensure research is conducted that focuses on increasing the usefulness of risk assessments to AIS managers, by implementing newer methodologies like ecological niche modeling to develop *species-and-location-specific assessments* that prioritize AIS and associated vectors (especially non-ballast water mediated vectors) that pose a significant threat. Risk assessments are essential because they support the development of regulations for pesticide use and AIS import as well as AIS monitoring plans.
- Early Detection Monitoring: *Implement* a long-term and stable binational basin-wide AIS early detection monitoring plan. *Prioritize* species for which monitoring action is most urgently needed using risk assessments. Such a plan needs to incorporate new AIS-specific monitoring techniques as they are developed for high risk AIS and at-risk habitats.

3. Build on existing local, national and binational AIS early detection and response programs and institutions in the Great Lakes basin as a foundation for successful AIS rapid response.

Discussion

AIS managers in local, regional and binational agencies are already involved in many activities that provide a foundation for formal rapid response planning. A binational AIS response plan can be implemented in a cost effective manner by building on these activities to achieve a high level of collaborative mutual assistance. Examples of activities where such investment would yield significant results include:

- *Expand* the current U.S.—Canada joint-review process for pesticide response tools to include joint registration of pesticides and clearer formal, harmonized binational pesticide regulations.
- *Augment* the capacity of established agency biomonitoring programs that are currently not focused on AIS detection. Enhance citizen volunteer monitoring programs by providing funding for training on the detection of a wide range of high-risk AIS, and by developing and coordinating AIS monitoring protocols.
- *Build* on the cooperative actions of U.S. and Canadian agencies in Lake Superior for AIS prevention. These could serve as a model for active early detection monitoring programs in other jurisdictions where gaps exist in the Great Lakes basin.
- *Continue* ongoing training programs for AIS responders, ICS exercises, drills and actions.
- *Ensure* support for registration and studies into the human health and environmental safety of existing pesticides and herbicides with potential use in AIS rapid response.

4. Provide for and encourage swift and effective information sharing and communication between U.S and Canadian Great Lakes agencies as well as with the public.

Discussion

Streamlined communication among AIS response agencies (including agencies at multiple levels) in Canada and the U.S. and with the public in both countries will aid in identifying jurisdictional inconsistencies, gaps in the response network and opportunities to garner public support. An effective ongoing training program for responders, ICS exercises, and actions to increase public awareness by publicizing these activities are all important parts of this process.

Examples of areas where increased information sharing should be encouraged include: information on chemical response tools and their relationship to eco-

system and human health; formalized data sharing agreements among agencies maintaining AIS occurrence databases; development of management techniques, technology and resources needed to coordinate AIS monitoring and response—especially citizen monitoring and First Nation involvement; and formalized sharing of risk assessment information among jurisdictions.[15]

5. Implement a pilot rapid response plan for the Huron—Erie corridor as a proof-of-concept and model for other site-specific binational AIS rapid response plans in the Great Lakes—St. Lawrence River basin.

Discussion

During the next twelve months, in partnership with responsible agencies and ANSTF's Great Lakes Panel, the Work Group will complete its work to develop a pilot rapid response plan for the connecting waters of Lakes Huron and Erie. This plan, funded by GLRI, must serve as a nexus of collaborative activity and binational communications as well as a model for similar plans in other sites. The large-scale overall framework for the Great Lakes—St. Lawrence River basin has been addressed in the Work Group's report for the 2007–2009 priority cycle, as well as in regional and national species-specific plans such as the Asian carp rapid response plan. As discussed previously, effective plans must address site-specific and species-specific concerns. Some of the main barriers to implementing a successful AIS rapid response plan in the Great Lakes basin are institutional rather than scientific or technical. Accordingly, the binational pilot plan under development is meant to guide implementation of on-the-ground activities in a specific boundary region for a given set of AIS that are considered to be high risk. In order to be effective, this plan will need to be exercised, continuously improved and supported. This will not come without cost; however, any investment in this area will fuel an aggressive institutional mind-set about prevention and help avoid future high costs associated with controlling a destructive established invasive species.

[15]In Canada all risk assessments are publicly available via government websites. The main website is the CEARA website: http://www.dfo-mpo.gc.ca/science/coe-cde/ceara/index-eng.htm

Information Sharing to Encourage on-the-Ground Action for Enhanced Early Detection and Rapid Response

The Binational Aquatic Invasive Species Rapid Response Work Group will work with its partners to share the information from this report and in the Work Group's background reports with AIS program managers at all levels of government. The findings of these reports can be used to influence current funding sources so that they are in alignment and fill the needs and gaps identified in this report. The four sub-recommendations must serve as a guide for AIS mangers, allowing them to build on existing frameworks in the most effective and efficient manner.

Developing a Pilot Binational AIS Rapid Response Plan

The Binational Aquatic Invasive Species Rapid Response Work Group plans to work with its partners to develop a pilot rapid response plan for the connecting waters of Lake Huron and Lake Erie, by the end of May 2012. The completed plan will include an analysis of jurisdictional roles in the Great Lakes basin. This will include information on how responsibilities and capabilities vary in relation to location and type of high-risk species. The plan will also include an analysis of regional high-risk species, alternative approaches, and a description of how U.S and Canada would and should organize in response to the discovery of a potential AIS.

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