Inventory of Available Controls for Aquatic Nuisance Species of Concern

Chicago Area Waterway System

April 2012

Product of the GLMRIS Team

The Great Lakes and Mississippi River Interbasin Study Team consists of a regional, collaborative effort led by the U.S. Army Corps of Engineers, including various District and Division offices, as well as Corps Centers of Expertise and Research Laboratories. Products of the GLMRIS Team are also made possible in collaboration with various Federal, state, local, and nongovernmental stakeholders.

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Acronyms

ANS – Aquatic Nuisance Species
CAWS – Chicago Area Waterway System
GL – Great Lakes
GLMRIS – Great Lakes and Mississippi River Interbasin Study
MR – Mississippi River
USACE – U.S. Army Corps of Engineers

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Chicago Area Waterway System

1. Introduction

The U.S. Army Corps of Engineers (USACE), in conducting the Great Lakes and Mississippi River Interbasin Study (GLMRIS), will explore options and technologies that could be applied to prevent aquatic nuisance species (ANS) transfer through aquatic pathways within the United States between the Great Lakes (GL) and Mississippi River (MR) basins (Figure 1). The USACE authorization, Section 3061(d) of the Water Resource and Development Act of 2007, for GLMRIS states as follows:

> . . . [USACE] in consultation with appropriate Federal, State, local, and nongovernmental entities, shall conduct, at Federal expense, a feasibility study of the range of options and technologies available to prevent the spread of aquatic nuisance species between the Great Lakes and Mississippi River Basins through the Chicago Sanitary and Ship Canal and other aquatic pathways.

This paper is an inventory of available options and technologies (called "Controls" or "ANS Controls") that may be applied to prevent ANS transfer via aquatic pathways. These Controls serve as management measures[1] for the Chicago Area Waterway System (CAWS) portion of GLMRIS, also referred to as Focus Area I (Figure 2). The ANS may also transfer between the basins via terrestrial and airborne means, including human assistance; however, these pathways fall outside of the scope of the GLMRIS authority. Options and technologies that address these pathways are not included in this paper.

[1] Measures are the building blocks of alternative plans (USACE 2000).

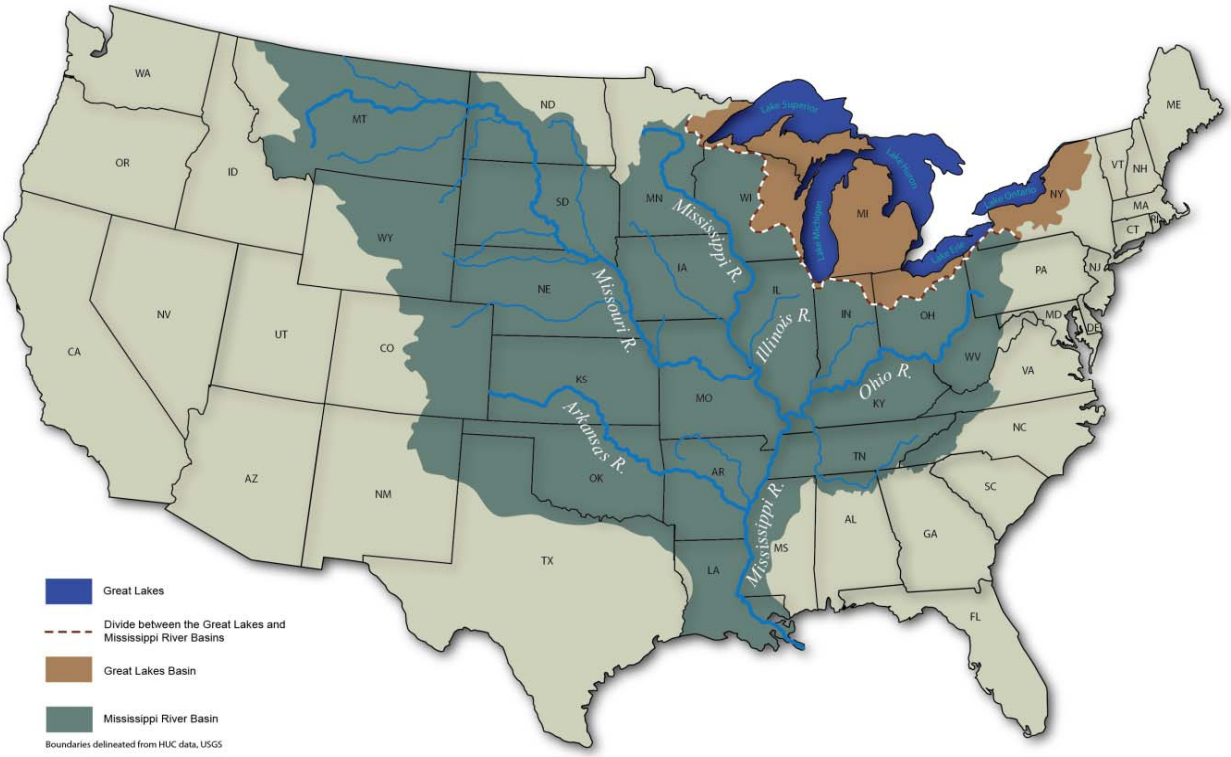


Figure 1. Great Lakes and Mississippi River Basins Within the United States

The following terms, also defined in Section 2, *Definitions*, are emphasized due to their integral significance in this paper.

- ***ANS*** is a nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters. See Section 1003(2) of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, 16 U.S.C. §4702(1) (2010).
- ***Prevent*** includes the reduction of risk to the maximum extent possible, because it may not be technologically feasible to achieve an absolute solution.
- ***ANS Controls*** or ***Controls*** are technologies or options that can be applied to prevent the transfer of ANS via aquatic pathways.
- ***Aquatic pathways*** are natural or manmade hydraulic connections between the GL and MR basins, and include intermittent hydraulic connections formed as a result of rain events.

For this inventory, the GLMRIS Technology Team (Technology Team) did not thoroughly evaluate a Control's application constraints, regulatory requirements, technological feasibility, or impacts due to application. These evaluations will be completed as part of the plan formulation phase, later in the study. During formulation, the GLMRIS Team will develop screening criteria consistent with study objectives, and will screen the identified Controls to determine which warrant further consideration. The USACE will formulate plans, comprised

of one or more of the screened Controls, in consideration of four criteria the U.S. Water Resource Council established in its *Economic and Environmental Principles for Water and Related Land Resources Implementation Studies* (P&G): completeness, effectiveness, efficiency, and acceptability. The formulation and evaluation of plans will be based on site-specific requirements; not all screened Controls will be appropriate for a specific location or situation. In formulating and evaluating alternatives, the GLMRIS Team will evaluate and consider each screened Control's constraints and conditions for application, regulatory requirements, and technological feasibility.

Though the Controls identified in this paper were selected for the CAWS, the information presented in this document may be more broadly applied to formulate alternatives for aquatic pathways outside the CAWS, as long as the Organisms of Concern are identical to those identified for the CAWS (Figure 2) or are also responsive to the Controls. If additional ANS of Concern are identified for aquatic pathways outside of the CAWS and these ANS are not responsive to the inventoried Controls, then additional research may be required to identify appropriate Controls for these species.

Figure 2. Focus Area I – Chicago Area Waterway System and Select Tributaries

2. Definitions

The following are definitions for terms used in this paper:

An ***aquatic nuisance species (ANS)*** is a nonindigenous species that threaten the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters. See Section 1003(2) of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, 16 U.S.C. § 4702(1) (2010).

ANS Controls or ***Controls*** are options or technologies that could be applied to prevent the transfer of ANS through an aquatic pathway.

Aquatic pathways are natural or manmade hydraulic connections between the GL and MR basins, and include intermittent hydraulic connections occurring during rain events.

ANS of Concern – CAWS are ANS that the GLMRIS Natural Resources Team identified as species that pose a threat for transferring from one basin to another through the CAWS (Figure 2). Through a screening process, these ANS of Concern have been predicted to pose a moderate to severe threat of impacting the invaded ecosystem (Veraldi et al. 2011).

The ***Chicago Area Waterway System (CAWS)*** is the system of canals and rivers within the Chicagoland area that forms continuous aquatic pathways between the GL and MR basins (Figure 2).

Focus Area I is a portion of GLMRIS focused on the aquatic pathways within the CAWS (Figure 2).

Focus Area II is a portion of GLMRIS focused on the aquatic pathways between the MR and GL basins that are outside of the CAWS.

The ***GLMRIS Chicago Area Waterway System Team (CAWS Team or Focus Area I Team)*** is composed of staff representing USACE and partner governmental agencies and consultants, tasked with completing GLMRIS for the CAWS. The CAWS Team is composed of the following teams: Communications, Environmental Quality, Hydrology and Hydraulics, Natural Resources, Navigation and Economics, Plan Formulation, and Technology.

> The ***Communications Team*** is responsible for developing a communication plan that will enhance stakeholder involvement through key strategic messages and relevant products for the project, serve as a central clearinghouse for communications products, and act as communication advisors to the other teams.
>
> The ***Environmental Quality Team*** is responsible for addressing issues related to water quality in the CAWS. The team shall identify and quantify impacts of alternative plans on water quality and waterway point source dischargers. This analysis will consider applicable water quality and discharge standards and regulations. The team shall also address air

quality and Hazardous Toxic and Radioactive Waste investigations issues related to specific project alternatives.

The ***Hydrology and Hydraulics Team*** is composed of technical personnel, including USACE hydraulic engineers and contractors, United States Geological Survey (USGS) hydrologists, and independent consulting members. The team is responsible for data collection, analysis, and modeling support for stage, velocity and discharge in the rivers and lakes, and potential basement flooding in urban drainage areas.

The ***Natural Resources Team*** is tasked with work associated with the natural, cultural and social resources of the study area, and is responsible for the project's environmental compliance, including compliance with the requirements of the National Environmental Policy Act. This team was responsible for completing a screening-level assessment to identify the ANS of Concern – CAWS.

The ***Navigation and Economics Team*** is composed of USACE economists, navigation experts and consultants, and is responsible for identifying the current conditions for commercial, commercial passenger (tour boats) and recreational navigation in the CAWS. Additionally, the team is tasked with completing an economic and navigational impacts analysis of GLMRIS alternatives.

The ***Plan Formulation Team*** will utilize data gathered by the Hydrology and Hydraulics, Natural Resources, Environmental Quality, Technology, and Navigation and Economics Teams to formulate alternative plans to address the identified problems and opportunities. This team will evaluate plans by comparing the forecasted conditions within the MR and GL basins assuming no federal project is implemented (future without-project conditions) with the forecasted conditions, assuming Controls are implemented through GLMRIS (future with-project conditions). The Plan Formulation Team will evaluate the plans using the P&G criteria of completeness, effectiveness, efficiency and acceptability.

The ***Technology Team*** is composed of technical staff tasked with identifying all available options and technologies that may prevent the transfer of ANS via aquatic pathways.

The ***GLMRIS Other Aquatic Pathways Team (Focus Area II Team)*** is composed of USACE staff, staff from other governmental agencies, and consultants, and is tasked with completing the Focus Area II portion of this study. The Other Aquatic Pathways Team is comprised of sub-teams organized around each of the aquatic pathways identified outside of the CAWS.

Mitigation is provided to protect the Nation's environment from adverse effects of alternative plans. Mitigation to address other adverse effects should be determined in accordance with applicable laws, regulations, and Executive Orders. See USACE's Engineering Regulation 1105-2-100, Planning Guidance Notebook, page 2-5.

Organisms of Concern – CAWS are organism types into which the ANS of Concern – CAWS may be grouped. Organism types considered in this paper include algae, annelid, bryozoan, crustacean, fish, mollusk, plant, and protozoan.

Prevent is defined as the reduction of risk to the maximum extent possible, as it may not be technologically feasible to achieve an absolute solution.

3. Limitations

The following limitations acknowledge the confines of identifying available Controls and preventing ANS transfer between the GL and MR basins:

1. The probable effectiveness of a single ANS Control or a combination of ANS Controls to prevent the transfer of ANS through aquatic pathways will be based on scientific analyses and best professional judgment, due to the limited number of projects that have been implemented to address aquatic nuisance species;

2. ANS Controls identified within the paper have been included based on their current scientific understanding of their possible effectiveness on the 39 ANS of Concern – CAWS (Table 1);

3. ANS Controls are effective only if they are properly implemented, operated and maintained;

4. Currently, the scientific community cannot predict the identity of all future ANS that may be introduced to GL or MR basins;

5. Additional research on the behavior and life-history of some ANS for all life stages is needed;

6. ANS may transfer between the basins through means other than aquatic pathways (terrestrial, human, etc.); and

7. The transfer of ANS between the GL and MR basins through all available pathways – aquatic, terrestrial, human, etc. is regulated by many different agencies, including the U.S. Fish and Wildlife Service, the U.S. Coast Guard and others. The GLMRIS will address aquatic pathways, and will consider the other pathways in general, but will not develop measures or alternatives to prevent transfer through these other pathways, as this would be outside the scope of the study's authorization.

4. Focus Areas

The USACE is conducting GLMRIS along two concurrent tracks: Focus Area I, the *CAWS Study*, and Focus Area II, the *Other Aquatic Pathways Study*, and has staffed both tracks with dedicated project teams. Focus Area I encompasses the CAWS, which includes the Chicago Sanitary and Ship Canal. Focus Area I contains up to five continuous aquatic pathways between the GL and MR basins and, consequently, poses the greatest threat of potential ANS transfer between these basins (Figure 2).

Focus Area II covers the remaining portion of the study area along the almost 1,500-mile basin divide between the GL and MR basins within the United States. The GLMRIS Other Aquatic Pathways Team (Focus Area II Team) has identified potential aquatic pathways along this basin divide and is conducting a detailed characterization of these potential pathways.

5. Technology Team and Scope of Paper

The CAWS Team is composed of the following technical teams that are responsible for a specific portion of the study: Communications, Environmental Quality, Hydrology and Hydraulics, Natural Resources, Navigation and Economics, Plan Formulation, and Technology. The Technology Team includes staff from multiple USACE divisions, with backgrounds in research, biology, and field application of Controls and is responsible, in part, for identifying Controls that are available to prevent ANS transfer through aquatic pathways in the CAWS.

Identified Controls will serve as the planning measures for Focus Area I. This paper includes a brief description of each Control and citations from which additional information may be gathered. This paper is not intended to describe the steps, procedures, or permitting and regulatory requirements necessary to implement the Controls or to rank their effectiveness. Instead, the CAWS Team will first develop screening criteria consistent with study objectives and will screen the identified ANS Controls to determine which warrant further consideration. The USACE will formulate alternative plans, comprised of one or more of the screened Controls, in consideration of the following criteria established by the U.S. Water Resources Council's P&G: completeness, effectiveness, efficiency, and acceptability.

The Technology Team included Controls based on a literature review of options and technologies that could be used to prevent the transfer of the 39 ANS of Concern – CAWS (Table 1). These ANS of Concern are identified in the Natural Resources Team's *Non-Native Species of Concern and Dispersal Risk for the Great Lakes and Mississippi River Interbasin Study* (Veraldi et al. 2011).

The Controls listed in this paper are specific to the CAWS, but this information may also be applicable to Focus Area II. If, however, additional ANS of Concern for a Focus Area II pathway are identified, then the GLMRIS Other Aquatic Pathways Team must review the included Controls to determine whether they remain effective management measures or if additional investigation is required.

Table 1: ANS of Concern – CAWS
Grouped by Organism Type

Organism Type	Scientific Name	USGS Fact Sheet Common Name[1]	Basin[2]
algae	*Bangia atropurpurea*	red macro-algae	GL
	Cyclotella cryptica	cryptic algae (diatom)	
	Cyclotella pseudostelligera	cylindrical algae (diatom)	
	Enteromorpha flexuosa	grass kelp	
	Stephanodiscus binderanus	diatom	
annelid	*Branchiura sowerbyi*	tubificid worm	GL
bryozoan	*Lophopodella carteri*	bryozoans	GL
crustacean	*Bythotrephes longimanus*	spiny water flea	GL
	Cercopagis pengoi	fish-hook water flea	
	Daphnia galeata galeata	water flea	
	Echinogammarus ischnus	European amphipod	
	Hemimysis anomala	bloody red shrimp	
	Neoergasilus japonicas	parasitic copepod	
	Schizopera borutzkyi	harpacticoid copepod	
	Apocorophium lacustre	scud	MR
fish	*Alosa aestivalis*	blueback herring	GL
	Alosa psuedoharengus	alewife	
	Gasterosteus aculeatus	threespine stickleback	
	Gymnochephalus cernuus	ruffe	
	Proterorhinus semilunaris	tubenose goby	
	Petromyzon marinus	sea lamprey	
	Alosa chrysochloris	skipjack herring	MR
	Channa argus	northern snakehead	
	Hypophthalmichthys molitrix	silver carp	
	Hypophthalmichthys nobilis	bighead carp	
	Menidia beryllina	inland silverside	
	Mylopharyngodon piceus	black carp	
mollusk	*Pisidium amnicum*	greater European pea clam	GL
	Sphaerium corneum	European fingernail clam	
	Valvata piscinalis	European stream valvata	
plant	*Carex acutiformis*	swamp sedge	GL
	Glyceria maxima	reed sweetgrass	
	Trapa natans	water chestnut	
	Landoltia (Spirodela) punctata	dotted duckweed	MR
	Murdannia keisak	marsh dewflower	
	Oxycaryum cubense	Cuban bulrush	
protozoan	*Psammonobiotus communis*	testate amoeba	GL
	Psammonobiotus dziwnowi	testate amoeba	
	Psammonobiotus linearis	testate amoeba	

[1] The ANS common names were taken from the Nonindigenous Aquatic Species information resource for the USGS http://nas.er.usgs.gov
[2] 'Basin' indentifies the basin in which the species has established, either the Mississippi River (MR) or the Great Lakes (GL) basin.

6. Methodology

Before identifying available Controls, it is important to identify which ANS are most likely to transfer between the GL and MR basins. This work was completed by the Natural Resources Team. Informed by an extensive literature search, the Natural Resources Team conducted a screening-level assessment to identify which ANS are of concern in GLMRIS and may transfer between the GL and MR basins. Figure 4 shows a flowchart that in part, depicts the ANS of Concern screening process. This team first identified a total of 254 ANS that either occurred in both basins, solely the GL basin or MR basin, or had a threat of infiltrating either basin (Veraldi et al. 2011; Appendix I). Of these 254 species, the team identified 135 as currently established in both basins, not yet located in either basin, could bypass a Control through terrestrial movement, or had no potential to cause adverse impacts to the invaded ecosystem. The team removed these 135 species from further consideration. A total of 119 species moved to the next level of screening (Veraldi et al. 2011; Appendix II).

Using information gathered from the literature search, such as species proximity to the CAWS, ecological tolerances and needs, and ability to disperse, the Natural Resources Team continued to screen the list of species and identified 39 species as ANS of Concern – CAWS (Veraldi et al. 2011). The team identified these ANS as being a potential threat for interbasin transfer, and if transfer occurred, having a likelihood of moderately to severely impacting the invaded ecosystem. For a photo reference of the 39 species of ANS of Concern – CAWS please see Appendix A.

Of these 39 species, 10 are currently located in the MR Basin and were screened as being a concern for transferring to and impacting the GL Basin (Figure 3). These 10 ANS are grouped within three organism types: crustacean, fish, and plant. The remaining 29 species are currently located in the GL Basin and were screened as having a concern of transferring to and impacting the MR Basin. These 29 ANS are grouped within the following eight organism types: algae, annelid, bryozoan, crustacean, fish, mollusk, plant and protozoan.

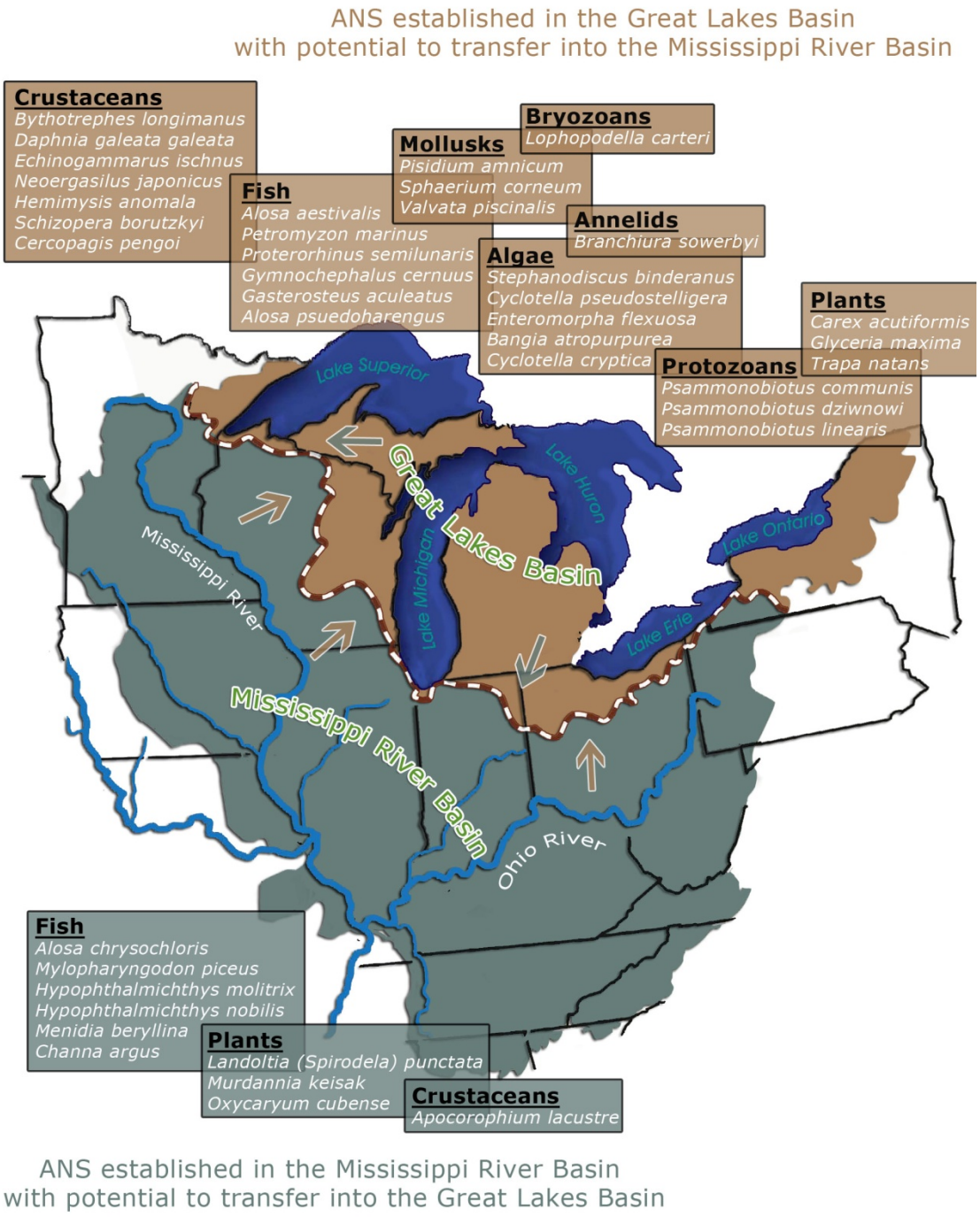


Figure 3. ANS of Concern – CAWS and Basin Where Established

Initially, the Technology Team researched the life histories of the ANS of Concern – CAWS and available Controls that could be applied to prevent the transfer of these species via aquatic pathways. The Technology Team found that even though extensive research has been conducted on a variety of ANS issues and concerns, comparatively little research has been completed on many of the 39 ANS of Concern – CAWS.

The 39 ANS of Concern – CAWS were categorized into eight organism types. The team identified these eight organism type as the "Organisms of Concern – CAWS" and expanded its research to include Controls effective for these groups of species. The Technology Team gathered its information from peer-reviewed journal articles, books, governmental, academic and industry literature, meeting symposia, conference abstracts, scientific databases, manufacturer product labeling and personal observation and communication.

Per the GLMRIS authorization and USACE planning guidance, the Technology Team used the following criteria to determine whether a Control should be included as an available Control:

1. The Control is possibly effective at preventing the transfer of the ANS of Concern – CAWS via aquatic pathways;
2. The Control, if used according to specified conditions, will pose minimal risk to human health and safety; and
3. The Control is currently available or is under research and development.

While performing its literature research, the team removed certain Controls from consideration. Examples of removed Controls include herbicides that are not approved for use in or around an aquatic environment, pathogens not approved for use, oil-based sprays, and barley straw. The team removed these herbicides and pathogens in light of Criterion 1 listed above. Oil-based sprays can be used to control mollusk eggs that are laid outside of the aquatic zone; however, the mollusks identified as ANS of Concern – CAWS lay their eggs inside the aquatic zone. Consequently, this Control would be ineffective and was removed from consideration in accordance with Criterion 1. As for barley straw, which has been used to control algae, further investigation revealed that the barley straw is an ineffective Control and is not currently approved by the U.S. Environmental Protection Agency (USEPA); consequently, the team removed barley straw from consideration in light of Criteria 1 and 3.

7. Results

The Technology Team identified over 90 available Controls that may be applied to prevent the transfer of Organisms of Concern – CAWS between the GL and MR basins via aquatic pathways. These Controls are grouped into 27 categories (Table 2) and described in fact sheets..

Table 2. ANS Controls Categories

ANS Control Categories		
Accelerated Water Velocity	Acoustic Fish Deterrents	Algaecides
Alteration of Water Quality	Aquatic Herbicides	Benthic Barriers
Biocides for Industrial Use	Biological Controls	Controlled Harvest and Overfishing
Deleterious Gene Spread	Dredging and Diver Dredging	Electron Beam Radiation
Hydrologic Separation	Irrigation Water Chemicals	Lethal Water Temperature
Light Attenuating Dyes	Manual Harvest	Mechanical Control Methods
Molluscicides	Pheromones	Piscicides
Screens	Sensory Deterrent Systems	Ultrasound
Ultraviolet Light	Vertical Drop Barrier	Williams Cage

The Technology Team included a particular ANS Control (Appendix B), based on the Team's expertise and the documented use of the Control on the Organisms of Concern – CAWS in an aquatic pathway. However, the Controls indentified in Appendix B may not be effective at preventing all growth forms or life stages of a particular organism. For example, a herbicide may be effective against a mature plant to which it is applied, but may not impact seeds already present in the soil. Similarly, algaecides may kill algal cells present in water, but not impact algal spore viability, and piscicides (such as rotenone) kill juvenile and adult fish but do not impact fish eggs.

In addition to listing the Controls, Appendix B identifies for each Control which Organism of Concern – CAWS the Control is targeting. It also summarizes inforon from the fact sheets that related to whether a Control is selective. Out of over 90 Controls, the team identified only five Controls that are most likely selective. Out of these five Controls, four are in research and development. The only selective Control that is not in research and development is manual harvest, which targets plants.

The identified Controls range from those that are currently used to manage ANS, such as aquatic herbicides, algaecides, benthic barriers, irrigation water chemicals, light attenuating dyes, molluscicides, piscicides and introduced predatory fish species (biological control) to Controls that are currently in research and development. For those currently in use, information regarding the targeted use, proper application and operating constraints impacting their effectiveness are generally known. These Controls could be used to target ANS populations where ANS are currently found instead of targeting an ANS when it arrives or is newly detected at an interbasin transfer location.

Other Controls prevent ANS transfer by modifying the flow conditions of a water body. Examples of these include vertical drop barrier (prevents upstream transfer by requiring upstream movement through a waterfall), accelerated water velocity (water traveling at high velocities prevents upstream swimming or migration) and hydrologic separation (prevents the flow of water within a channel or contains water within an enclosure). Though site-specific application of the identified Controls has not been investigated, technologies such as

ultrasound, ultraviolet light, and electron beam irradiation would require water to be routed through or come in contact with a treatment system.

Other Controls may physically remove ANS from a target water body. These Controls are mechanical harvesting (using machinery to remove plant ANS); manual harvesting (using manual labor to remove plant ANS); dredging and diver dredging; controlled harvest/overfishing (fishing or netting of fish); and a variety of non-mechanical and mechanical screens. Mechanical and manual harvesting, dredging and diver dredging, controlled harvest/overfishing are additional examples of Controls that can be implemented to reduce or eliminate the ANS populations where ANS are currently established versus targeting an ANS that is first detected at an interbasin transfer point.

Another set of Controls calls for modifying the water quality of a water body as means of preventing ANS transfer. These Controls include altering the water quality with chemicals such as alum (removes phosphorus from water, inhibiting algae growth and reproduction); gases such as carbon dioxide, ozone, or nitrogen; oxygen-depleting chemicals; and lethal temperature (raising the water temperature to lethal levels).

Another group of Controls are biocides for industrial uses. Certain biocides are currently used in wastewater and drinking water treatment processes, antifouling and disinfection, and are classified as experimental for application as a means of preventing the transfer of ANS.

Controls under research and development are also indentified. These controls include sensory deterrent systems (underwater strobe lights and sound and acoustic air bubble curtains); pheromones; acoustic fish deterrents (chronic sonic deterrents and seismic deterrents); biological controls (introduced predatory insect species, introduced predatory fish species, *Pseudomonas fluorescens* CL 145A, and targeted disease agents); deleterious gene spread; and Williams' Cage (trap for jumping fish).

8. Fact Sheets

The Technology Team developed a fact sheet for each available Control based on the results of its literature research (Appendix C). Each fact sheet contains the following information, if available:

ANS Control lists the name of the control technology, as well as specific subcategories to the technology, that will be described in the given fact sheet.

Targeted Species lists specific ANS of Concern – CAWS that may be prevented from transferring via aquatic pathways using this technology. The terminology for common names in this section follows "NAS - Nonindigenous Aquatic Species" information resource for the USGS http://nas.er.usgs.gov as found on the chart of ANS of Concern – CAWS (Table 1).

Selectivity outlines whether or not the technology is capable of being applied specifically to one or more ANS of Concern – CAWS, without affecting non-target species.

Developer/Manufacturer/Researcher includes specific examples of developers, manufacturers or researchers of the technology, if applicable. Manufacturers and products mentioned are examples only. Nothing contained herein constitutes an endorsement of a non-Federal entity, event, product, service, or enterprise by USACE or its employees.

Pesticide Registration/Application (only appears in pesticide-related fact sheets) includes general USEPA guidelines for the application of pesticides.

Brief Description gives general background information on what a technology is and how it functions as a control technique. Subheadings of specific Controls are included where applicable.

Prior Applications includes further details on how the Control has been applied through research or industry.

General Effectiveness explains the general effectiveness of prior applications of the Control in research and in field application, if available; however, the information does not necessarily pertain to the effectiveness of the Control on the ANS of Concern – CAWS.

Operating Constraints outlines the parameters necessary for proper and effective use of the Control.

Cost Considerations describes general details on the costs associated with each Control, broken down into implementation, operations and maintenance, and mitigation factors.

Citations lists cited sources; please refer to these references for more information on the given Control.

The fact sheets do not contain exhaustive research on the particular Controls or specific guidelines for their implementation. Instead, they provide a brief description of the Control and serve to inform the CAWS Team as to which Controls are available for use in the plan formulation phase of this study.

9. Next Steps

The available Controls identified in this paper are measures the CAWS Team will use to formulate alternatives. In part, the evaluation of alternative plans will be based on the Control's relative effectiveness to prevent the transfer of the ANS of Concern – CAWS via aquatic pathways.

The direction of movement of individual species across the GL and MR basin boundary is also an important factor when determining which Controls are effective. Table 1 and Figure 3 indicate in which basin the ANS of Concern – CAWS are currently present and therefore, which direction they must move to transfer to the currently unaffected basin. A number of identified Controls, such as accelerated water velocity, vertical drop barrier, and screens may

only be effective at controlling ANS movement in the upstream direction. Both the target species and the direction of movement across the boundary between MS and GL basins must be considered prior to identifying a potentially effective Control.

Before determining the potential effectiveness of a given Control or combination of Controls, it is important to closely examine the biology, ecology and distribution of the ANS of Concern – CAWS for a particular project location. These environmental factors include key characteristics of each ANS of Concern or Organism grouping; including: life cycle, sizes of their life stages, eco-tolerance of the species throughout their life cycle, and species dispersal mechanisms.

With this information, the CAWS Team will be better able to assess the effectiveness of various Controls on particular species. Additionally, this data may provide the team with insight as to the best location for a potential control mechanism. Subsequent plan formulation will further refine the risk associated with ANS transfer and establishment. The assessment will be based on the Aquatic Nuisance Species Task Force's *Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process* (1996) and in part, will be used to assess Control effectiveness. See Figure 4 for a flowchart that depicts the ANS of Concern screening process and how it feeds into the risk assessment. Risk assessment will be a key component of the plan formulation and alternatives evaluation processes for GLMRIS.

The GLMRIS Team will develop screening criteria consistent with the study objectives and will screen the identified Controls to determine which warrant further consideration. Utilizing data gathered throughout the study, the team will formulate plans comprised of one or more of the screened Controls (integrated pest management) to address the identified problems and opportunities. The team will evaluate the plans in consideration of the criteria established by the U.S. Water Resource Council's P&G: completeness, effectiveness, efficiency, and acceptability. Acceptability includes compliance with applicable laws and policies. The GLMRIS Team will then compare the alternative plans.

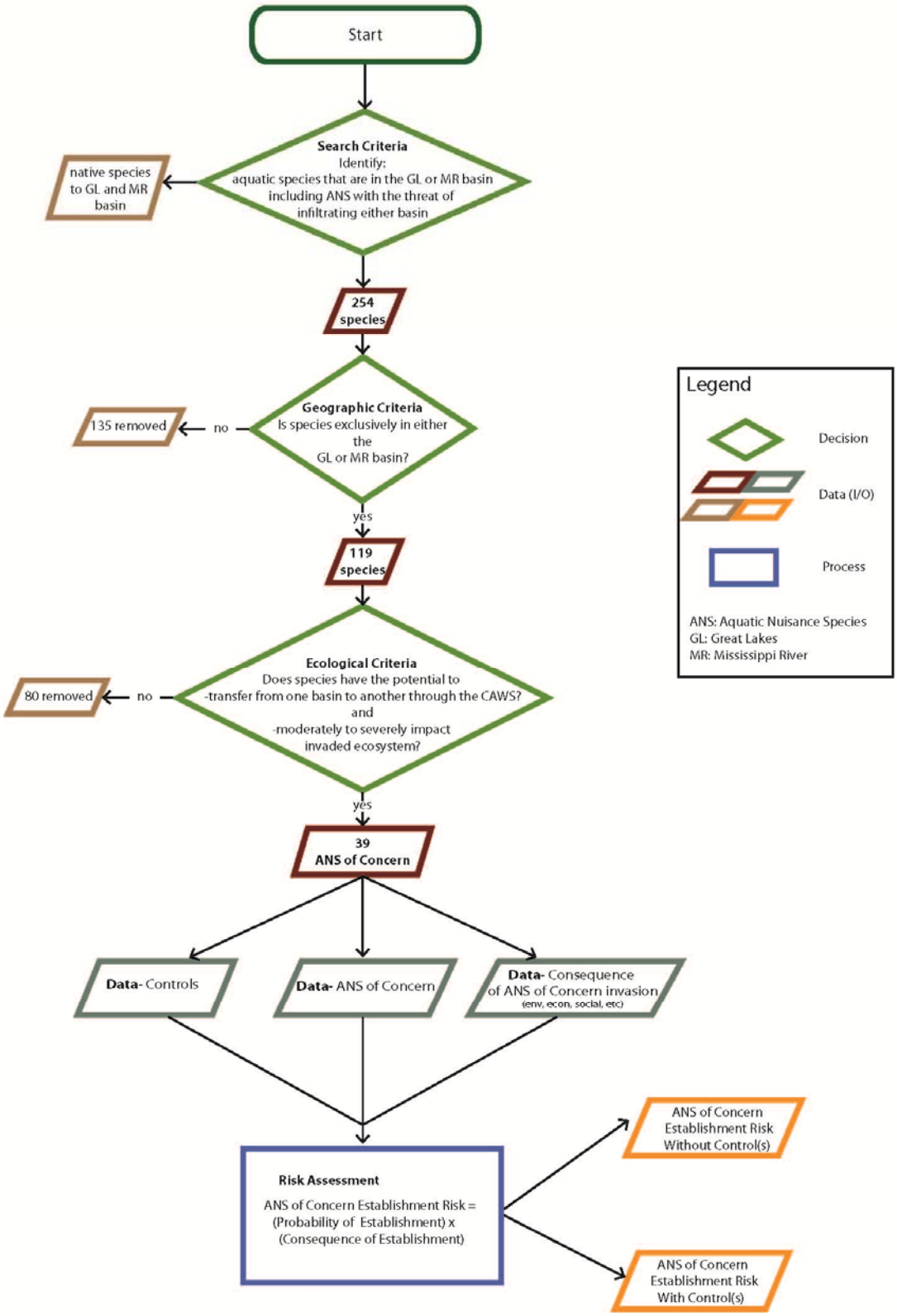


Figure 4. Flowchart of Screening Process for ANS of Concern – CAWS Continuing to Assessment of Established Risk

10. Citations

Aquatic Nuisance Species Task Force. 1996. *Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process (For Estimating Risk Associated with the Introduction of Nonindigenous Aquatic Organisms and How to Manage for that Risk*). Aquatic Nuisance Species Task Force's Risk Assessment and Management Committee

U.S. Army Corps of Engineers. 2000. Engineering Regulation No. 1105-2-100, *Planning Guidance Notebook*. Washington, D.C.

Veraldi, F., K. Baerwaldt, B. Herman, S. Herleth-King, M. Shanks, L. Kring, & A. Hannes. 2011. *Non-Native Species of Concern and Dispersal Risk for the Great Lakes and Mississippi River Interbasin Study*

Appendix A – Photo Reference for the 39 ANS of Concern – Chicago Area Waterway System (CAWS)

Algae

Great Lakes Basin

red macro-algae
Bangia atropurpurea

1

microscopic image
spore diameter- 15.5µm
filament diameter- 75 µm

2

red macro-algae colony

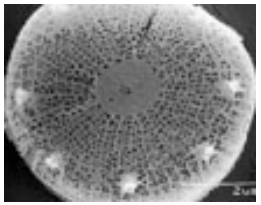
cryptic algae
Cyclotella cryptica

3

microscopic image
diameter range- 8 to 16µ

cylindrical algae
Cyclotella pseudostelligera

4



microscopic image
diameter range- 5 to 9µ

grass kelp
Enteromorpha flexuosa

5

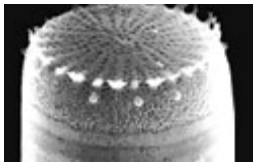
size (diameter):
flexousa flexousa- 0.16 µm
flexousa paradoxa- 3.6mm

6

grass kelp growing on rock

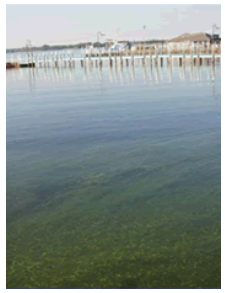
a diatom
Stephanodiscus binderanus

7



microscopic image
volume- 830µ^3

8



diatom bloom

Annelid

Great Lakes Basin

tubificid worm
Branchiura sowerbyi

9

length- 20 to 185mm

10

tubificid worms in sediment

Bryozoan

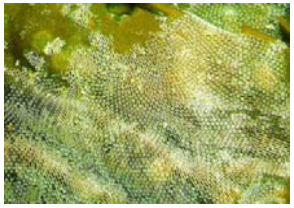
Great Lakes Basin

bryozoans
Lophopodella carteri

11

microscopic image
colonies are not usually greater than 1 cm in diameter

12



lacy-crust bryozoans colony on kelp bed

Appendix A – Photo Reference for the 39 ANS of Concern – Chicago Area Waterway System (CAWS)

Crustacean

Great Lakes Basin

spiny water flea
Bythotrephes longimanus

13

microscopic image
length- up to 15mm

14

cluster of spiny water fleas

fish-hook water flea
Cercopagis pengoi

15

microscopic image
length- 6 to 13 mm with tail

16

cluster of fish-hook water fleas on a boat line

water flea
Daphnia galeata galeata

17

microscopic image
length- 1.2 to 2mm

18

water fleas cluster on a fishing line

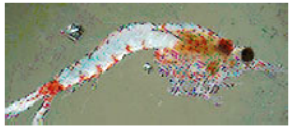
European amphipod
Echinogammarus ischnus

19

microscopic image
length- 8 to 11mm

bloody red shrimp
Hemimysis anomala

20



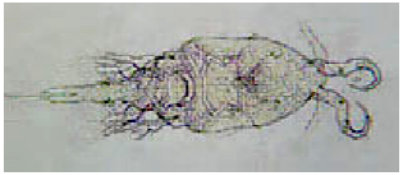
microscopic image
length- 6 to 13 mm

21

actual size of bloody red shrimp in a petri dish

parasitic copepod
Neoergasilus japonicus

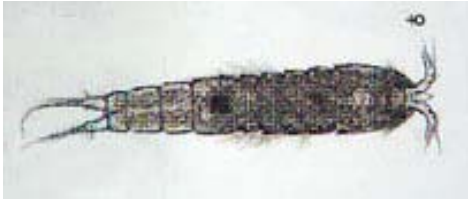
22



microscopic image
length- 0.6 to 0.76 mm

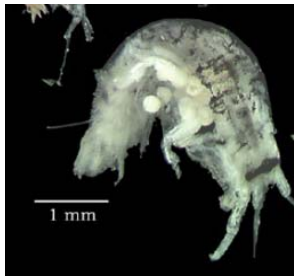
harpacticoid copepod
Schizopera borutzkyi

23



microscopic image
Adult length- 0.5 to 0.6 mm

Appendix A – Photo Reference for the 39 ANS of Concern – Chicago Area Waterway System (CAWS)

Mississippi River Basin		
scud *Apocorophium lacustre*		
24  actual size		
Fish		
Great Lakes Basin		
blueback herring *Alosa aestivalis*	alewife *Alosa pseudoharengus*	threespine stickleback *Gasterosteus aculeatus*
25  adult length- 40cm	26  adult length- 38 cm (max), 25 cm (landlocked populations)	27  adult length- 10 cm (max)
ruffe *Gymnocephalus cernuus*	tubenose goby *Proterorhinus semilunaris*	sea lamprey *Petromyzon marinus*
28  adult length- 10.2 to 15.2 cm	29  adult length- 11cm	30  adult length- 64 cm (landlocked), 120 cm (ocean)

Appendix A – Photo Reference for the 39 ANS of Concern – Chicago Area Waterway System (CAWS)

Mississippi River Basin		
skipjack herring *Alosa chrysochloris*	northern snakehead *Channa argus*	silver carp *Hypophthalmichthys molitrix*
31  adult length- 53 cm (max)	32  adult length- 85 cm	33  adult length- 1 m (max)
bighead carp *Hypophthalmichthys nobilis*	inland silverside *Menidia beryllina*	black carp *Mylopharyngodon piceus*
34  adult length- 1.4 m (max)	35  adult length- 15 cm (max)	36  adult length- 1.5 m (max)

Mollusk

Great Lakes Basin			
greater European pea clam *Pisidium amnicum*	European fingernail clam *Sphaerium corneum*		European stream valvata *Valvata piscinalis*
37  length- 8.8 to 11.9 mm	38  length- 9 to 14 mm	39  two fingernail clams on a leaf	40  adult length- 7 mm (max)

Appendix A – Photo Reference for the 39 ANS of Concern – Chicago Area Waterway System (CAWS)

Plant

Great Lakes Basin

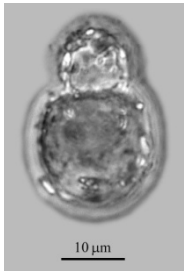
swamp sedge *Carex acutiformis*		reed sweetgrass *Glyceria maxima*	water chestnut *Trapa natans*	
41  leaf length- 55 to 130 cm	42  swamp sedge growth in river	43  stem length- 2.5 m high (max)	44  stem length- up to 16 ft	45  water chestnut growth in a river

Mississippi River Basin

dotted duckweed *Landoltia (Spirodela) punctata*		marsh dewflower *Murdannia keisak*	Cuban Bulrush *Oxycaryum cubense*	
46  individual width- 1.5 to 8 mm	47  actual size of individual plant	48 	49  height- 33 to 110 cm	50  dense stand of Cuban Bulrush

Protozoan

Great Lakes Basin

testate amoeba *Psammonobiotus communis, Psammonobiotus dziwnowi, Psammonobiotus linearis*
51  length- 34mm (average for Great Lakes species)

Citations

red macro-algae

[1]**Kipp, Rebekah.** *Bangia atropurpurea.* USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011 http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=1700

[2]*The ingredient that makes it easier to spread peanut butter comes from the ocean.* NOAA Ocean Facts. Jpeg. Accessed Dec 2, 2011. http://oceanservice.noaa.gov/facts/peanutbutter.html

cryptic algae

[3]*Great Lakes Water Life Photo Gallery, Algae, Diatoms, Cyclotella spp.* NOAA Great Lakes Sea Grant Extension Office. Jpeg. Accessed Dec 2, 2011. http://www.glerl.noaa.gov/seagrant/GLWL/Algae/Diatoms/Cards/Cyclotella.html

cylindrical algae

[4]Kipp, Rebekah**.** *Cyclotella pseudostelligera.* USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=1672

grass kelp

[5]Sturtevant, Rochelle. *Enteromorpha flexuosa subsp. flexuosa and flexuosa subsp. paradoxa*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=2726

[6]Kipp, Rebekah. *Enteromorpha prolifera*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://www.google.com/imgres?imgurl=http://nas.er.usgs.gov/XIMAGESERVERX/2009/20090611112615.jpg&imgrefurl=http://nas.er.usgs.gov/queries/FactSheet.aspx%3FspeciesID%3D2714&usg= OFRnQ9p-1ecPfAO6FH-jof01zh8=&h=350&w=226&sz=72&hl=en&start=1&sig2=mRTzukAJ1ybI5O-PIiPosw&zoom=1&tbnid=FtvqFExwytZ7aM:&tbnh=120&tbnw=77&ei=YvvYTuGMFpPBtgfPz4TtAQ&prev=/search%3Fq%3Dgrass%2Bkelp%26um%3D1%26hl%3Den%26sa%3DN%26gbv%3D2%26tbm%3Disch&um=1&itbs=1

diatom

[7]Kipp, Rebekah. *Stephanodiscus binderanus.* USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=1687

[8]*Great Lakes Water Life Photo Gallery, Algae, Division Chrysophyta, Diatoms.* NOAA Great Lakes Sea Grant Extension Office. Jpeg. Accessed Dec 2, 2011. http://www.glerl.noaa.gov/seagrant/GLWL/Algae/Diatoms/Diatoms.html

tubificid worm

[9, 10]Liebig, Jim. *Branchiura sowerbyi*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=1151 (for both pictures)

byrozoans

[11]Fuller, Pam. *Lophopodella carteri*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=278

[12]O'Connell, Danny. *Conopeum tenuissimum*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=270

spiny water flea

[13]Liebig, Jim. *Bythotrephes longimanus.* USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. *http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=162*

[14]Great *Lakes Water Life Phot Gallery, Zooplankton, Waterfleas Gallery, Family Cercopagidae.* NOAA Great Lakes Sea Grant Extension Office. Jpeg. Accessed Dec 2, 2011. http://www.google.com/imgres?imgurl=http://www.glerl.noaa.gov/seagrant/GLWL/Zooplankton/Cladocera/Images/DBBythotrephes-

03.jpg&imgrefurl=http://www.glerl.noaa.gov/seagrant/GLWL/Zooplankton/Cladocera/CladoceraGallery3.html&usg=__q9SAKYbAnmFDL7G6uAGvdKXfJhM=&h=449&w=600&sz=62&hl=en&start=41&sig2=uXz6jsmyxE2JinL7IsGKHQ&zoom=1&tbnid=KrWKUeEfAz5DxM:&tbnh=101&tbnw=135&ei=lwXZTrepFc6atwfyhvnsAQ&prev=/search%3Fq%3Dspiny%2Bwater%2Bflea%2Bsite:*.gov%26start%3D21%26hl%3Den%26sa%3DN%26gbv%3D2%26tbm%3Disch&itbs=1

fish-hook water flea

[15]Benson, Amy. *Cercopagis pengoi.* USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. *http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=163*

[16]*Water flea Confirmed in First Non-border Water*. New York State Department of Environmental Conservation. Jpeg. Accessed Dec 2, 2011. http://www.google.com/imgres?imgurl=http://www.dec.ny.gov/images/environmentdec_images/spinywatflea2.jpg&imgrefurl=http://www.dec.ny.gov/environmentdec/49080.html&usg=__ruDE8c4XNUKpKS-vvI5HW8ir7CY=&h=169&w=225&sz=13&hl=en&start=11&sig2=034eNclSmUzBlPqiF5ayDw&zoom=1&tbnid=DVC6MA0lTCT3YM:&tbnh=81&tbnw=108&ei=hQfZTr2BE4m5tgfX-73sAQ&prev=/images%3Fq%3Dfish-hook%2Bwater%2Bfleas%2Bsite:*.gov%26hl%3Den%26gbv%3D2%26tbm%3Disch&itbs=1

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[17]Kipp, Rebekah. *Daphnia galeata galeata*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=2732

[18]*Water flea alert.* Massachusetts Department of Conservation and Recreation. Jpeg. Accessed Dec 2, 2011. http://www.mass.gov/dcr/watersupply/watershed/spinywaterflea.htm

European amphipod

[19]Benson, Amy. *Echinogammarus ischnus*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=23

bloody red shrimp

[20, 21]Kipp, Rebekah. *Hemimysis anomala*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=2627 (for both pictures)

parasitic copepod

[22]Kipp, Rebekah. *Neoergasilus japonicus*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=2595

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[23]Kipp, Rebekah. *Schizopera borutzkyi*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=2374

scud

[24]*Apocorophium lacustre*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=2315

blueback herring

[25]Fuller, P. *Alosa aestivalis*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=488

alewife

[26]Fuller, P. *Alosa pseudoharengus*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=490

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[27]Fuller, Pam. *Gasterosteus aculeatus*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=702

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[28]Fuller, P. *Gymnocephalus cernuus*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=7

tubenose Goby

[29]Fuller, P. *Proterorhinus semilunaris*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=714

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[30]Fuller, Pam. *Petromyzon marinus*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2010. http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=836

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[31]Fuller, Pam. *Alosa chrysochloris*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=489

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[32]Fuller, P. *Channa argus*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=2265

silver carp

[33]Nico, Leo. *Hypophthalmichthys molitrix*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 2, 2011. http://nas.er.usgs.gov/queries/factsheet.aspx?speciesID=549

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[34]Nico, Leo. *Hypophthalmichthys nobilis*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 4, 2011.

inland silverside

[35]Fuller, Pam. *Menidia beryllina*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 4, 2011. http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=321

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[36]Nico, L. *Mylopharyngodon piceus*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 4, 2011. http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=573

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[37]Kipp, Rebekah. *Pisidium amnicum*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 4, 2011. http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=129

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[38]Kipp, Rebekah. *Sphaerium corneum*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 4, 2011. http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=131

[39]*The Kuenzler Wildlife Habitat Preserve: A story of Farmland Protection and wetland Restoration*. US Fish and Wildlife service. Jpeg. Accessed Dec 4, 2011 http://www.fws.gov/nc-es/es/partners/Clams2.jpg

European Stream valvata

[40]Kipp, Rebekah. *Valvata piscinalis*. USGS Nonindigenous Aquatic

Species Database. Jpeg. Accessed Dec 4, 2011.
http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=1043

swamp sedge

[41]Coa, Ling. *Carex acutiformis*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 4, 2011.
http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=2704

[42]Flemming, Gary. The Natural Communities of Virginia: Classification of Ecological Community Groups, Second Approximation. Virginia Department of Conservation and Recreation. Jpeg. Accessed Dec 4, 2011.
http://www.dcr.virginia.gov/natural_heritage/ncPIIIa.shtml

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[43]VM Howard. *Glyceria maxima*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 4, 2011.
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[44]Coa, Ling. *Trapa natans*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 4, 2011.
http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=263

[45]Mehrhoff, Leslie. *Aquatic Plants*. National Park Service. Jpeg. Accessed Dec 4, 2011. http://www.nps.gov/plants/alien/pubs/midatlantic/trna.htm

dotted duckweed

[46]Jacono, C.C. *Landoltia (Spirodela) punctata*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 4, 2011.
http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=1116

[47]Outdoor Alabama: Share the Wonder. Alabama Department of Conservation and Natural Resources. Jpeg. Accessed Dec 4, 2011.
http://www.google.com/imgres?imgurl=http://www.dcnr.state.al.us/images/Image/ap/Spirodela_polyrhiza_2.JPG&imgrefurl=http://www.dcnr.state.al.us/fishing/freshwater/where/ponds/p/ap/guide/floating/spirodelap.cfm&usg=__FKTd8Z3IHR8kn0hyHp594vYXkNY=&h=374&w=499&sz=105&hl=en&start=8&zoom=1&tbnid=9bEL-gxFZ5aUmM:&tbnh=97&tbnw=130&ei=8CXdTrHXEZKXtweT8PXtAQ&prev=/search%3Fq%3Ddotted%2Bduckweed%2Bsite:*.gov%26um%3D1%26hl%3Den%26gbv%3D2%26tbm%3Disch&um=1&itbs=1

marsh dewflower

[48]Morgan, Howard V. *Murdannia keisak*. USGS Nonindigenous Aquatic Species Database. Jpeg. Accessed Dec 4, 2011.
http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=1102

Cuban bulrush

[49, 50]Mc Laurin, C.S. *Oxycaryum cubense*. USGS Nonindigenous Aquatic Species Database. pdf. Accessed Dec 4, 2011.
http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=2819
(both pictures)

testate amoeba

[51]Nicholls, K. *Psammonobiotus communis.* N shore Lake Erie (Long Point). Jpeg. June 2002. Provided Dec 14, 2011.

Appendix B - Available Controls for the ANS of Concern – Chicago Area Waterway System (CAWS) - This table contains a comprehensive list of available options and technologies to prevent the transfer of ANS via aquatic pathways. No analysis of constraints, impacts, regulatory requirements, or technological feasibility has been conducted at this time, and a particular Control may not be suitable for a specific location or situation.

Fact Sheet	ANS Control	Selective for ANS of Concern – CAWS	Status [2]	Targeted Organisms of Concern – CAWS								Comments Refer to fact sheets for additional information on each Control
				algae	annelid	bryozoan	crustacean	fish	mollusk	plant	protozoan	
Accelerated Water Velocity	Accelerated Water Velocity	N	**Available**	X	X	X	X	X	X	X	X	• Not effective in preventing downstream ANS movement • Must have a length and speed of flow greater than the organism's leaping ability and swimming endurance
Acoustic Fish Deterrents	Continuous Wave	N	**Experimental**					X				• Under development for control of fish • May not be effective on all fish species
	Pulsed Pressure Wave	N	**Experimental**					X				• Not lethal unless an organism is very close to sound source
Algaecides [§]	Copper Sulfate and Chelated Copper Formulations (ethanolamines, ethylene diamines, triethanolamines, triethanolamine+ethylene diamine, and copper citrate/gluconate)	N	**Available, Registered**	X								• May be effective on diatoms (*Cyclotella cryptica, C. pseudostelligera* and *Stephanodiscus binderanus*) and grass kelp (*Enteromorpha flexuosa*) • Chelated copper formulations may be effective on red macro-algae (*Bangia atropupurea*) • Reduced efficacy in waters with high pH and water temperatures < 15 °C
	Endothall (as the mono(N,N-dimethylalkylamine) salt) CAS #: 66330-88-9	N	**Available, Registered**	X								• May be effective on red macro-algae (*B. atropupurea*) and diatoms (*C. cryptica, C. pseudostelligera and S. binderanus*) • Can be harmful to fish
	Algaecides containing Sodium Carbonate Peroxyhydrate CAS #: 15630-89-4	N	**Available, Registered**	X								• May be effective on diatoms (*C. cryptica, C. pseudostelligera and S. binderanus*), and grass kelp (*E. flexuosa*)

[§] Pesticides must be applied in accordance with the USEPA-approved product label guidelines. Users must confirm pesticide registration status prior to application. The registration status, trade name, and availability of pesticides are subject to change.

[2] Status

Available - An option or technology that has been implemented in the field.

Experimental - A novel option or technology, or a chemical that is not a U.S. Environmental Protection Agency (USEPA)-registered pesticide under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

Registered - A chemical that is a USEPA-registered pesticide under FIFRA for the fact sheet use in compliance with the USEPA-approved product label.

When Not Registered for a Use - A product can only be used for the control of ANS, if the product is labeled for ANS Control. Under FIFRA section 2(ee), where an ANS is not listed on the pesticide label, the product may still be used to control those species so long as the site, where the pesticide is to be used, is on the label. If the use site is not listed on the pesticide label, the proposed new use must be submitted to the USEPA for a "new use assessment" which may require the USEPA to conduct human health and ecological risk assessments.

Fact Sheet		ANS Control [1]	Selective for ANS of Concern – CAWS	Status [2]	Targeted Organisms of Concern – CAWS								Comments Refer to fact sheets for additional information on each Control
					algae	annelid	bryozoan	crustacean	fish	mollusk	plant	protozoan	
Alteration of Water Quality [§] The status of these chemicals is in part based on results of a Pesticide Product Information System (PPIS) index query at http://ppis.ceris.purdue.edu/ run on 11/10/2011. The Chemical Abstracts Service (CAS) numbers were used to enter the query and for convenience have been provided.	Gases	Carbon Dioxide (CO_2)	N	**Available, When Not Registered for a Use**		X	X	X	X	X		X	• May repel fish at sub-lethal levels • Lowers pH • Creates irreversible cell damage and death
		Ozone	N	**Available**	X	X	X	X	X			X	• Rendered ineffective in the presence of organic matter • Used commercially to decontaminate water • Ozone oxidation is toxic to most small waterborne organisms • Destroys the epithelium covering the gill lamella in fish
		Nitrogen	N	**Available**		X	X	X	X	X		X	• Adult fish are more tolerant than young fish • Nitrogen supersaturation is a cause of gas bubble disease in fish
	Solids	Alum	N	**Available**	X								• Creates a solid precipitate from suspended solids within the water column which settles • Alum is not classified as a pesticide, therefore does not require FIFRA registration
		Sodium Thiosulfate CAS #: 7772-98-7	N	**Experimental**		X	X	X	X	X		X	• Deoxygenated compound

[1] This table contains a comprehensive list of available options and technologies to prevent the transfer of ANS via aquatic pathways. No analysis of constraints, impacts, regulatory requirements, or technological feasibility has been conducted at this time, and a particular Control may not be suitable for a specific location or situation.

[§] Pesticides must be applied in accordance with the USEPA-approved product label guidelines. Users must confirm pesticide registration status prior to application. The registration status, trade name, and availability of pesticides are subject to change.

[2] Status

Available - An option or technology that has been implemented in the field.

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Aquatic Herbicides [§] The status of these chemicals is in part based on results of a Pesticide Product Information System (PPIS) index query at http://ppis.ceris.purdue.edu/ run on 11/13/2011. The Chemical Abstracts Service (CAS) numbers were used to enter the query and for convenience have been provided.	2,4-D (both the amine and butoxy-ethyl ester formulations) CAS #: 94-75-7	N	**Available, Registered**							X		• May be effective on Cuban bulrush (*Oxycaryum cubense*) and water chestnut (*Trapa natans*) • Tank mixing with other herbicides improves plant control
	Diquat CAS #: 85-00-7	N	**Available, Registered**							X		• Effective on Cuban bulrush (*O. cubense*) when tank mixed with 2,4-D or glyphosate • May be effective on dotted duckweed (*Landoltia* (*Spirodela*) *punctata*)
	Fluridone CAS #: 59756-60-4	N	**Available, Registered**							X		• May be effective on dotted duckweed (*L.* (*S.*) *punctata*) • Plants must be exposed to a lethal dose for a minimum of 45 days for optimal results
	Glyphosate CAS #: 1071-83-6	N	**Available, Registered**							X		• Effective on Cuban bulrush (*O. cubense*) when tank mixed with 2,4-D • May be effective on swamp sedge (*Carex acutiformis*), reed sweetgrass (*Glyceria maxima*), and marsh dewflower (*Murdannia keisak*)
	Imazapyr CAS #: 81334-34-1	N	**Available, Registered**							X		• May be effective on swamp sedge (*C. acutiformis*), reed sweetgrass (*G. maxima*), and Cuban bulrush (*O. cubense*)
	Triclopyr CAS #: 55335-06-3	N	**Available, Registered**							X		• May be effective on water chestnut (*T. natans*)
Benthic Barriers	Textile or Plastic	N	**Available**							X		• Not effective for floating plants such as dotted duckweed (*L. (S.) punctata*) • Ongoing research investigating effectiveness on mollusks
	Silt	N	**Available**					X				• Created by applying excessive silt/sand to smother bottom-dwelling organism • Application to control aquatic nuisance species has not been widely studied

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Biocides for Industrial Use [§] Unless noted by [B,GS], information was obtained from (U.S. Coast Guard Research and Development Center. *Evaluation of Biocides for Potential Treatment of Ballast Water: Final Report.* (Report No. CG-D-01-05) Washington, DC, 2004) The status of these chemicals is based on results of a Pesticide Product Information System (PPIS) index query at http://ppis.ceris.purdue.edu/ run on 9/28/2011. The Chemical Abstracts Service (CAS) numbers were used to enter the query and for convenience have been provided. Manufacturers and products mentioned are examples only. Nothing contained herein constitutes an endorsement of a non-Federal entity, event, product, service, or enterprise by the U.S. Army Corps of Engineers or its employees.	Isothiazolone (Sea-Nine®) CAS #: 64359-81-5	N	When Not Registered for a Use	X	X		X		X			• Antifouling agent used in hull coatings
	2-(thiocyanomethylthio) benzothiazole (TCMTB) CAS #: 21564-17-0	N	When Not Registered for a Use		X		X	X	X			• Antifouling agent • Disinfection of industrial water systems
	Benzalkonium Chloride CAS #: 8001-54-5	N	When Not Registered for a Use		X		X	X	X			• Corrosive • Disinfection of industrial water systems
	Bromine CAS #: 7726-95-6	N	When Not Registered for a Use		X			X	X			• Purification of drinking water, cooling systems, and surfaces • Corrosive • Requires a controlled application; reacts quickly • Presence of organic matter limits effectiveness • Residuals remain in water after treatment • Requires frequent applications
	Chlorine (free chlorine, hypochlorous acid, hypochlorite salts) CAS #: 7782-50-5	N	When Not Registered for a Use	X	X		X	X	X			
	Chlorine Dioxide CAS #: 10049-04-4	N	When Not Registered for a Use		X			X	X			
	Chlorothalonil CAS #: 1897-45-6	N	When Not Registered for a Use				X					• Registered under FIFRA as a fungicide
	Dibromonitrilopropionamide (DBNPA) CAS #: 10222-01-2	N	When Not Registered for a Use	X			X					• Pulp and paper water treatment systems • Disinfection of industrial water systems
	Dichlofluanid CAS #: 1085-98-9	N	Experimental		X			X	X			• Antifouling agent
	N-(3-Chloroallyl) Hexamethylenetetrmine chloroallyl chloride (Dowicil® 75) CAS #: 4080-31-3	N	When Not Registered for a Use				X					• Not persistent and degrades rapidly under acidic conditions
	Glutaraldehyde CAS #: 111-30-8	N	When Not Registered for a Use	X	X				X			• Slight to moderate efficiency in presence of organic matter • Some residuals remain in water after treatment

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	Iodine CAS #: 7553-56-2	N	**When Not Registered for a Use**				X	X				• Disinfection of drinking water, cooling systems and surfaces • Requires a controlled application and reacts quickly • Corrosive • Presence of organic matter limits effectiveness • Residuals remain in water after treatment • Requires frequent applications
	2-methylthio-4-tertbutylamino-6-cyclo-propylamino-striazine (Irgarol®) CAS #: 28159-98-0	N	**When Not Registered for a Use**					X				• Antifouling agent
	Fatty Amines (Mexel® 432)	N	**Experimental**		X				X			• Rapid degradation in the environment • Scale dispersant & corrosion inhibitor
	Peracetic Acid (Peraclean®) CAS #: 79-21-0 CAS #: 7722-84-1	N	**When Not Registered for a Use**					X				• No known toxic residual; more potent than hydrogen peroxide • Rapidly active at low concentrations against a wide range of microorganisms • Corrosive • Highly efficient in presence of organic matter • Wastewater treatment
	Phenol CAS #: 108-95-2	N	**When Not Registered for a Use**		X			X	X			• Disinfectant & low corrosivity • Little or no residuals remain in water after treatment

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	Potassium Permanganate CAS #: 7722-64-7	N	**Experimental**	X	X		X		X			• Organic matter limits effectiveness & moderately corrosive • Some residuals remain in water after treatment
	Vitamin K (SeaKleen®) CAS #: 11032-49-8	N	**Experimental**	X	X		X	X	X			• Ballast water treatment • Toxic to a broad spectrum of marine and freshwater organisms (fish larvae and eggs, planktonic crustaceans, bivalve larvae, *Vibrio* bacteria, and dinoflagellates)
	Silver (Ionic or Salts) Ions CAS #: 15046-91-0	N	**Experimental**	X								• Disinfection of industrial water systems • Limited applications of metal ions or salts • Not generally used due to human side effect risk
	Sodium Chlorite CAS #: 7758-19-2	N	**When Not Registered for a Use**	X	X		X	X				• Disinfection of drinking water, cooling systems and surfaces • Presence of organic matter limits effectiveness • Residuals remain in water after treatment • Requires frequent applications and corrosive
	Sodium Hydroxide [B, GS] CAS #: 1310-73-2	N	**When Not Registered for a Use**	X	X		X	X	X			• Under consideration for use in ballast water treatment • Mollusk mortality following 17 to 31 day exposure to NaOH-adjusted pH of 9.3 to 9.6.[B] [B]Bowman, M.F. and R.C. Bailey. 1998. Upper pH tolerance limit of the zebra mussel (*Dreissena polymorpha*). *Canadian Journal of Zoology*, vol. 76, pp. 2119-2123. • <1% survival of test organisms including algae, annelids, crustaceans and fish with 48-hr exposure to pH adjustments of 11.5 to 12.5 using NaOH [GS] [GS] TenEyek, M. 2009. Great Ships Initiative Bench-Scale Test Findings, Technical Report – Public, Sodium Hydroxide (NaOH). GSI/BS/5.
	Triclosan CAS #: 3380-34-5	N	**When Not Registered for a Use**					X				• Stable and incompatible with strong oxidizing agents • Wastewater treatment
	Zineb (Thiocarbamate) CAS #: 12122-67-7	N	**Experimental**					X				• Antifouling agent & disinfection of industrial water systems

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Biological Controls [§] Manufacturers and products mentioned are examples only. Nothing contained herein constitutes an endorsement of a non-Federal entity, event, product, service, or enterprise by the U.S. Army Corps of Engineers or its employees.	Introduced Predatory Fish Species	N	**Available**					X	X	X		• Includes both carnivorous, herbivorous and molluscivorous fish species • Best used in waters with no outflows • Predatory fish are non-selective feeders
	Introduced Predatory Insect Species	N	**Experimental**							X		• United States Department of Agriculture (USDA) has not approved of any insects for use as biological controls of plants identified as ANS of Concern – CAWS • Although a leaf beetle (*Galerucella birmanica*) was found to cause complete defoliation of water chestnut (*T. natans*), research was suspended in 2002
	Pseudomonas fluorescens CL 145A	N	**Registered**						X			• May be effective on European fingernail clam (*Sphaerium corneum*), the European pea clam (*Pisidium amnicum*), and the European stream valvata (*Valvata piscinalis*) • Active ingredient (*Pseudomonas fluorescens* CL 145A) approved by the United States Environmental Protection Agency (USEPA) in July 2011(Reg. No. 84059-4) • Formulation of commercial product as Zequanox™ is pending review by USEPA as of October 2010; Section 3 registration expected in March 2012 • Ongoing research to assess impacts to non-target mollusks
	Targeted Disease Agents	N	**Experimental**					X				• Under consideration for carp species

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Controlled Harvest and Overfishing	Controlled Harvest and Overfishing	N	**Available**					X				• Requires sorting and returning of native fish species • Requires continual capture over a long period of time, or intensive harvest during critical periods of concentration and reproduction (e.g., migration and spawning season) • Once harvesters, processors, and communities become economically dependent on harvesting nuisance fish, pressure to manage a sustainable population of these fish may conflict with the original purpose of removing them from the environment
Deleterious Gene Spread	Daughterless Gene	Y	**Experimental**					X				• Researched as a Control for silver carp (*H. molitrix*), bighead carp (*H. nobilis*), black carp (*Mylopharyngodon piceus*), and sea lamprey (*Petromyzon marinus*) • Researched as a Control for common carp • Manipulation of genes can manifest unforeseen and significant undesirable side effects and would require extensive research before being accepted as a Control • The Food and Drug Administration regulates genetically engineered animals
	Trojan Y Chromosome	Y	**Experimental**					X				
Dredging and Diver Dredging	Dredging and Diver Dredging	N	**Available**							X		• Not effective on dotted duckweed (*L. (S.) punctata*) • Requires careful disposal or reuse of dredged material to prevent the transfer of ANS to a new location • May remove other ANS of Concern – CAWS and non-target organisms that reside in sediment

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Electron Beam Irradiation	Electron Beam Irradiation	N	**Available**				X				X	• Used in irradiation of food, environmental waste, medical sterilization, and water treatment • Requires a closed system and not appropriate for open water application • May require pretreatment to remove suspended solids • Used in irradiation of food, environmental waste, medical sterilization, and water treatment
Hydrologic Separation	Physical Barriers	N	**Available**	X	X	X	X	X	X	X	X	• Modifies flow within waterway, including stormwater and combined sewer overflow discharge, and conveyance and commercial water dischargers and withdrawal of water
Irrigation Water Chemicals [§] *A product, or its uses, classified as "Restricted Use" may only be applied by a certified pesticide applicator or under the direct supervision of a certified applicator. Information on restriction of use of a pesticide is found in the Code of Federal Regulations (Chapter 40, Part 152.160-175)	Acrolein CAS #: 107-02-8	N	**Available, Registered, Restricted Use Product***	X						X		• For control of submersed and floating weeds and algae only in irrigation canal systems in western states, provided the appropriate state registrations are also in place • Toxic to fish and other aquatic organisms at labeled use rates
	Xylene CAS #: 1330-20-7	N	**Registered**	X						X		• For use only in irrigation and drainage canals designated by the Bureau of Reclamation and cooperating water user organizations • For use in Programs of the Bureau of Reclamation and Cooperating Water User Organizations within the following states, provided that the appropriate state registrations are also in place: AZ, CA, CO, ID, KS, MT, NE, NM, NV, ND, OK, OR, SD, TX, UT, WA, and WY • For control of submerged weeds in irrigation and drainage canals • Toxic to fish and other aquatic organisms at labeled use rates

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Lethal Temperature	Pressurized Hot Water/Steam Treatment	N	**Available**	X	X	X	X	X	X	X	X	• Hot water has been used to kill zebra and quagga mussels at municipal and industrial facilities, and high pressure hot water is used to clean ANS off of recreational boats
	Hot Water Thermal Barrier	N	**Available**	X	X	X	X	X	X	X	X	• Difficult to manage in open water system, must be completely mixed throughout the water column • During cold weather conditions, warm water temperatures may attract fish
	Freezing	N	**Available**	X	X	X	X	X	X	X	X	• Freezing is often combined with winter water level drawdowns to expose the ANS to freezing air temperatures • Cluster mussels are more tolerant of reduced air temperatures than individual organisms
	Carbon Dioxide ($CO_{2)}$ Pellet (dry ice) Blasting	N	**Available**	X	X	X	X	X	X	X	X	• Method used extensively to remove organics from aircrafts producing no deterioration of surfaces • CO_2 pellets convert to a gas at ambient temperatures, leaving no residue.
	Desiccation	N	**Available**	X	X	X	X	X	X	X	X	• Desiccation can only be achieved in areas where water levels can be controlled • Exposure to air quickly leads to death for active water-breathing organism—mollusks and plants are more tolerant and require longer drying period
Light Attenuating Dyes [§]	Light Attenuating Dyes	N	**Registered**	X						X		• May suppress growth of water chestnut (*T. natans*) if applied prior to plant germination (pre-emergence) • Not effective for suppressing growth of floating aquatic plants or emergent shoreline vegetation identified as ANS of Concern – CAWS • Not effective on floating algal mats • May suppress the growth of non-target plants and algae • Only for use in contained waterbodies with little or no outflow • Do not apply to waters used for human consumption

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				algae	annelid	bryozoan	crustacean	fish	mollusk	plant	protozoan	
Manual Harvest	Manual Harvest	Y	**Available**							X		• Labor-intensive • Selectively dependent upon training and skill of staff
Mechanical Control Methods	Mechanical Harvesting	N	**Available**							X		
	Shredding	N	**Available**							X		
	Mowing	N	**Available**							X		• Not effective on dotted duckweed (*L. (S.) punctata*) • May disturb non-target organisms in equipment path
	Chaining	N	**Available**							X		
	Roto-tilling	N	**Available**							X		
	Rotovating	N	**Available**							X		• Used for submersed vegetation rooted in the substrate • May have applications on emergent plants • Not effective on dotted duckweed (*L. (S.) punctata*) • May disturb non-target organisms in equipment path

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Molluscicides [§] The status of these chemicals is based on results of a Pesticide Product Information System (PPIS) index query at http://ppis.ceris.purdue.edu/ run on 9/28/2011. The Chemical Abstracts Service (CAS) numbers were used to enter the query and for convenience have been provided. *A product, or its uses, classified as "Restricted Use" may only be applied by a certified pesticide applicator or under the direct supervision of a certified applicator. Information on restriction of use of a pesticide is found in the Code of Federal Regulations (Chapter 40, Part 152.160-175)	Quaternary and Polyquaternary Ammonium Compounds; Aromatic Hydrocarbons; Endothall as the Mono (N,N-imethylalkylamine) Salt (TD2335 Industrial Biocide-Molluscicide) CAS #: 145-73-3	N	**Registered**						X			• Used for recirculating and once-through cooling water systems • For control of established populations of freshwater and saltwater mollusks in closed systems • Is non-selective at use rates to control mollusks
	Metals and their salts (Copper Sulfate and Chelated Copper Formulations)	N	**Registered**						X			• Can be used to control mollusks in open water systems • Is non-selective at use rates to control mollusks
	Niclosamide CAS #: 1420-04-8	N	**Available, Registered, Restricted Use Product***						X			• First developed as a lampricide • Used for control of snails in aquaculture ponds • Toxic to fish and aquatic invertebrates at recommended use rates for control of snails in aquaculture ponds
Pheromones	Repellant and Attractant Pheromones	Y	**Experimental**					X				• Under investigation as an attractant and/or deterrent for silver carp (*H. molitrix*), bighead carp (*H. nobilis*), black carp (*M. piceus*), and sea lamprey (*P. marinus*)

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Piscicides [§] The status of these chemicals is based on results of a Pesticide Product Information System (PPIS) index query at http://ppis.ceris.purdue.edu/ run on 9/28/2011. The Chemical Abstracts Service (CAS) numbers were used to enter the query and for convenience have been provided. *A product, or its uses, classified as "Restricted Use" may only be applied by a certified pesticide applicator or under the direct supervision of a certified applicator. Information on restriction of use of a pesticide is found in the Code of Federal Regulations (Chapter 40, Part 152.160-175)	Antimycin A CAS #: 1397-94-0	N	**Available, Registered, Restricted Use Product***					X				• Effectiveness can vary with the surfactant used. • Requires approximately 8 to 32 hours to kill cyprinid species such as bighead carp (*H. nobilis*) and silver carp (*H. molitrix*) • Restricted use pesticide due to aquatic toxicity and need for highly specialized applicator training
	Niclosamide CAS #: 1420-04-8	N	**Available, Registered, Restricted Use Product***					X				• First developed as a lampricide • Used for control of snails in aquaculture ponds • Toxic to aquatic invertebrates; non-target organisms may be killed at rates recommended for sea lamprey control • Limited geographically to the Great Lakes Basin, the Lake Champlain system and the Finger Lakes • For use only by United States Department of Interior, United States Fish & Wildlife Service (USFWS), state fish and game, Fisheries and Oceans Canada, and Provincial Certified Applicators trained in sea lamprey control
	Rotenone (Both Standard Application and Via Oral Delivery Platforms) CAS #: 83-79-4	N	**Available, Registered, Restricted Use Product***					X				• Kills bighead (*H. nobilis*) carp and silver carp (*H. molitrix*) within approximately 4 hours • May be toxic to other aquatic organisms
	TFM (3-Trifluoromethyl-4-nitrophenol) CAS #: 88-30-2	N	**Available, Registered, Restricted Use Product***					X				• Designed only to control sea lamprey (*P. marinus*) • Limited geographically to the Great Lakes Basin, the Lake Champlain system and the Finger Lakes • For use only by certified applicators of USFWS, Fisheries and Oceans Canada, and provincial and state fish and game employees • Non-target organisms may be killed at labeled use rates

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Screens	Non-Mechanical Screens	Fences	N	Available					X		X		• May not prevent aquatic organism movement downstream • Effectiveness is dictated by the size of mesh or bar spacing • Screens may prevent movement of non-target organisms, depending on their size
		Bar Screens	N	Available					X		X		
		Trash Racks	N	Available					X		X		
		Curtains	N	Available					X		X		
	Mechanical Screens	Chain Bar Screens	N	Available					X		X		• May not prevent aquatic organism movement downstream • Effectiveness is dictated by the size of mesh or bar spacing • Screens may prevent the movement of non-target organisms, depending on their size
		Reciprocating Rake Bar Screens	N	Available					X		X		
		Catenary Bar Screens	N	Available					X		X		
		Continuous Belt Bar Screens	N	Available					X		X		
		Rotating Drum Screens (Paddle Wheel Or Power)	N	Available					X		X		
		Wedge-Wire Cylinders	N	Available					X		X		
		Louvered Screens	N	Available					X				
		Mechanical Climber Screens	N	Available					X		X		
	Filters		N	Available	X	X	X	X	X	X	X	X	• Generally used to treat small volumes of water • Constrained by resistance through filter membrane and filter fouling • Filters may prevent the movement of non-target organisms, depending on their size

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Sensory Deterrent Systems	Underwater Strobe lights	N	Experimental					X				• Used to prevent upstream movement of fish • May not prevent downstream movement of aquatic organisms
	Underwater Sound	N	Experimental					X				
	Acoustic Air Bubble Curtain	N	Experimental					X				
	Electric Barrier	N	Available					X				• Must be configured to stop upstream and downstream movement of fish • May impact non-target aquatic organisms
Ultrasound	Ultrasound	N	Available	X								• Used in small water bodies and water treatment plants • Ultrasound may be effective on diatoms (*C. cryptica*, *C. pseudostelligera* and *S. binderanus*) • Most effective on enclosed bodies of water • Additional research may be needed to investigate potential impacts on non-target organisms • Under investigation for use against aquatic vascular plants (non-algae)
Ultraviolet Light	Ultraviolet (UV) Light	N	Available	X			X				X	• Used in fish hatcheries and water treatment facilities • Used to treat contained flowing systems • Best used after suspended solids, iron and manganese have been filtered from water • May impact non-target aquatic organisms
Vertical Drop Barrier	Vertical Drop Barrier	N	Available		X	X	X	X	X		X	• Does not prevent aquatic organism movement downstream • May impact upstream movement of non-target organisms
Williams' Cage Manufacturers and products mentioned are examples only. Nothing contained herein constitutes an endorsement of a non-Federal entity, event, product, service, or enterprise by the U.S. Army Corps of Engineers or its employees.	Williams' Cage	Y	Experimental					X				• May be effective on silver carp *(H. molitrix)* and sea lamprey *(P. marinus)* • Does not prevent aquatic organism movement downstream

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Appendix C –

Please see ANS Control Fact Sheets on the GLMRIS Web site at http://glmris.anl.gov/documents/docs/anscontrol/All27ANSControlFactSheets.pdf