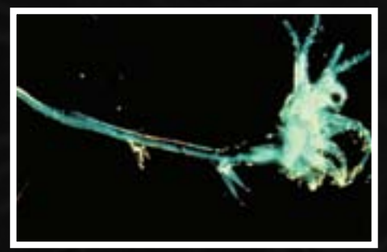
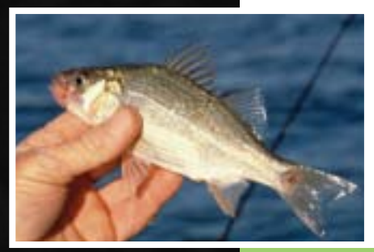
# Great Lakes Aquatic Invasions

**Aquatic Invasive Species (AIS) are non-native plants, animals and pathogens that cause or potentially cause economic loss, environmental damage, or harm to human health.**






Aquatic Invasive Species Prevention and Control:
Outreach, Research, Management and Policy



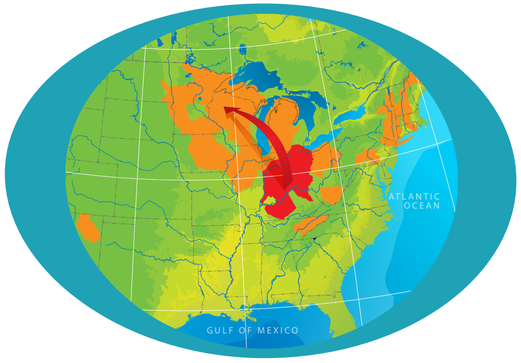
**Cover Photo Credits**

**Top row, left to right**:
Water chestnut (*Trapa natans*), U.S. Fish and Wildlife Service, Lower Great Lakes Fishery Research Office;
Spiny waterflea (*Bythotrephes longimanus*), U.S. Fish and Wildlife Service;
Zebra mussels (*Dreissena polymorpha*), David Jude, Center for Great Lakes Aquatic Sciences;
Purple loosestrife (*Lythrum salicaria*), Michigan Sea Grant;
White perch (*Morone americana*), Jeff Gunderson, Minnesota Sea Grant;
Rusty crayfish (*Orconectes rusticus*), Jeff Gunderson, Minnesota Sea Grant

**Bottom row, left to right**:
Sea lamprey (*Petromyzon marinus*), Great Lakes Sea Grant Network Exotic Species Graphics Library;
Round goby (*Apollonia melanostomus*), Matt Vardy, Ontario Federation of Anglers and Hunters;
Hydrilla (*Hydrilla verticillata*, potential Great Lakes invader), Center for Aquatic and Invasive Plants;
Quagga mussel (*Dreissena bugensis*), Michigan Sea Grant;
Eurasian ruffe (*Gymnocephalus cernuus*), Gary Cholwek, National Biological Service;
Bloody red shrimp (*Hemimysis anomala*), NOAA, Great Lakes Environmental Research Laboratory


Asian Carp

Native range of bighead and silver carp  Range of bighead and silver carp in the United States




Rusty Crayfish

Native range of rusty crayfish  Current invaded range


Zebra Mussel and Round Goby

Zebra mussel invaded range  Round goby, confirmed sightings



# Great Lakes Aquatic Invasions

Zebra mussels on beach. Photo courtesy Michigan Sea Grant

## Global Movement of Aquatic Invasive Species and Policy Developments

**1800s** — Purple loosestrife introduced into North America; sea lamprey observed in Lake Ontario

**1921** — Sea lamprey expand into the upper Great Lakes due to alterations to the Welland Canal

**1955** — Great Lakes Commission established by the Great Lakes states to help protect and manage water and other natural resources; Great Lakes Fishery Commission (GLFC) established by an international treaty between the U.S. and Canada to control sea lamprey

**1958** — The GLFC begins application of the selective lampricide TFM to suppress sea lamprey populations in the Great Lakes

**1959** — St. Lawrence Seaway opens, allowing ocean-going vessels access to the Great Lakes

**1982** — Spiny waterflea detected in Lake Ontario; Asian carp (silver and bighead; potential Great Lakes invaders) reported in the upper Mississippi River

**1987** — Eurasian ruffe identified in Duluth Harbor, Lake Superior

1987 amendments to the Great Lakes Water Quality Agreement (first adopted by the United States and Canada in 1972) call for the Coast Guards of the two countries to study ballast water as a vector of AIS introduction and spread

**1988** — Zebra mussels identified in Lake St. Clair

**1990** — Round goby first reported in St. Clair River

*Nonindigenous Aquatic Nuisance Prevention and Control Act* (NANPCA) enacted by U.S. Congress, establishing the Aquatic Nuisance Species Task Force (ANSTF) and the Great Lakes Panel on Aquatic Nuisance Species (Great Lakes Panel)

Great Lakes Panel convened by the Great Lakes Commission; United States and Canada issue *Voluntary Guidelines for Control of Ballast Water Discharge from Ships in the Great Lakes*; Minnesota establishes first state exotic species program

**1991** — The Ruffe Control Committee of the ANSTF begins development of a control plan

**1992** — Asian carp (bighead and silver) escaped from aquaculture ponds into the lower Mississippi River due to floods

**1993** — International Maritime Organization (IMO) establishes a working group to develop a legally binding document on ballast water management

U.S. Coast Guard (USCG) issues final rule, *Ballast Water Management for Vessels Entering the Great Lakes*; New York's ANS State Management Plan approved by ANSTF

**1994** — NANPCA reauthorized as the *National Invasive Species Act* (NISA); Michigan's ANS State Management Plan approved by ANSTF

**1996** — Fishhook waterflea (*Cercopagis pengoi*) identified in Lake Ontario

**1997** — Ohio's ANS State Management Plan approved by ANSTF

National Invasive Species Council (NISC) established by Executive Order; Illinois' ANS State Management Plan approved by ANSTF

**1998** — Asian carp discovered 50 miles from Lake Michigan in the Illinois River and 21 miles downstream of the demonstration ANS electrical dispersal barrier

**1999** — USCG issues *Voluntary Guidelines of Recreational Activities to Control the Spread of Zebra Mussels and other Aquatic Nuisance Species*

NISC management plan *Meeting the Invasive Species Challenge* published; Michigan Public Act 114 establishes Michigan Dept. of Environmental Quality *Ballast Water Reporting Program*

**2000** — Demonstration ANS electrical dispersal barrier completed in Chicago Sanitary and Ship Canal; all 28 snakehead species are listed as injurious under the Lacey Act; NISA expires, *National Aquatic Invasive Species Act* (NAISA) introduced in House, fails to pass

**2001** — The North American strain of the Viral Hemorrhagic Septicemia (VHS) virus was isolated from freshwater drum caught in Lake St. Clair in Michigan

**2002** — ANS State Management Plans of Indiana and Wisconsin approved by ANSTF; NAISA introduced in Senate and again in House, fails to pass

USCG issues final rules *Penalties for Non-submission of Ballast Water Management Reports* and *Mandatory Ballast Water Management Program for U.S. Waters*; IMO adopts *International Convention for the Management of Ships' Ballast Water and Sediment*; no action taken on NAISA by Congress; Canada completes a *Canadian Action Plan to Address the Threat of Aquatic Invasive Species*

**2003** — Great Lakes Regional Collaboration AIS Action Plan submitted to the U.S. Administration; National Oceanic and Atmospheric Administration (NOAA) and University of Michigan complete No Ballast on Board (NOBOB) assessment identifying risks of AIS introduction via NOBOB vessels; USCG issues voluntary guidelines *No Ballast on Board Best Management Practices*; NAISA introduced again in both House and Senate, with no vote taken

**2004** — Hydrilla (potential Great Lakes invader) detected in northern Indiana's Lake Manitou; Bloody red shrimp detected in samples collected by NOAA in Muskegon, Mich.

**2005** — Canada enacts *Ballast Water Control and Management Regulations* on both ballasted and NOBOB vessels; construction begins on permanent ANS electrical dispersal barrier in Chicago Sanitary and Ship Canal; no action taken on NAISA by Congress, requiring reintroduction of the legislation

**2006** — Pennsylvania's ANS State Management Plan approved by the ANS Task Force

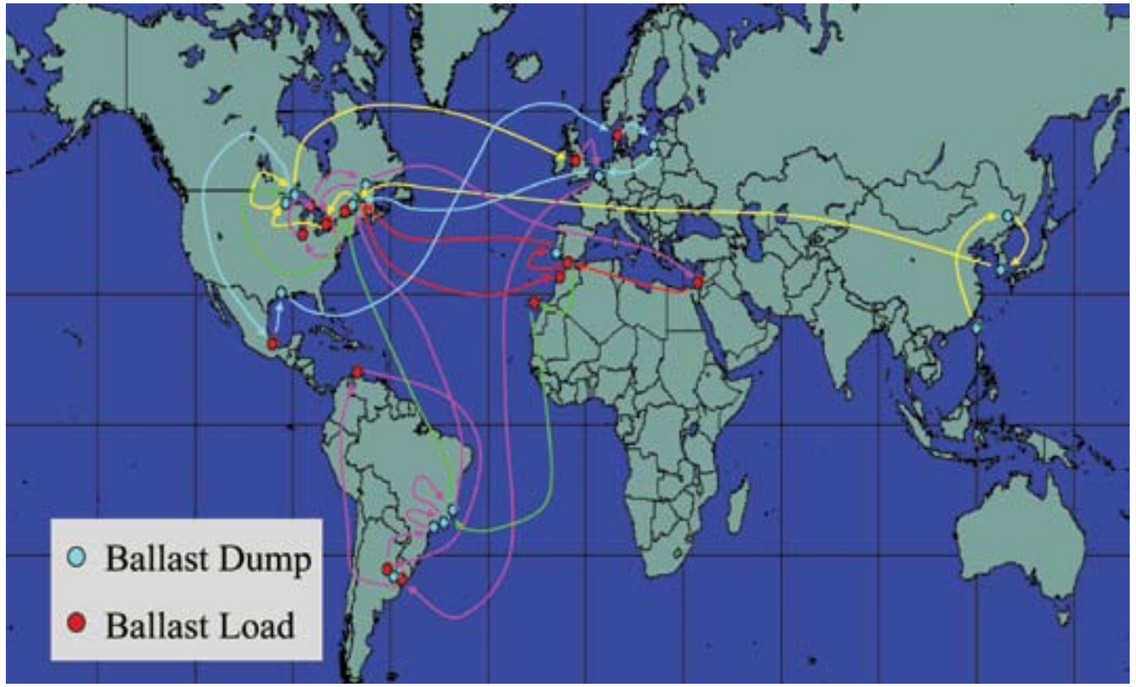
**2007**

Throughout history, human settlement and trade have caused the introduction of non-native aquatic invasive species (AIS), often to the detriment of native ecosystems. As of 2006, at least 200 non-native aquatic species have become established in the Great Lakes.* This number continues to grow through vectors (mechanisms of AIS introduction and spread) such as maritime commerce, canals and waterways, organisms in trade, recreational activities, and public and private aquaculture. In one study, the economic and environmental losses caused by AIS in the Great Lakes have been estimated to be as much as $5.7 billion annually. There is an urgent need to take action in halting the devastating and often permanent damage caused by Great Lakes aquatic invasions. AIS prevention and control is fundamental in sustaining the ecological and economic health as well as recreational benefits of the Great Lakes, protecting a precious legacy for future generations.

Impacts caused by AIS are far reaching and extensive. Of special concern in the Great Lakes region are recreational impacts caused by AIS, such as degradation to beaches and swimming areas due to weed infestations and deposits of zebra mussel shells that litter beaches and shorelines. AIS threaten Great Lakes fisheries in a variety of ways including changing water quality and clarity, competing with native species for food and habitat and altering complex food-webs that support the aquatic ecosystem. AIS impacts can also add significant costs to industry by clogging water intake/discharge pipes and damaging other submerged structures and equipment. In the Great Lakes region and around the globe, AIS are introduced and spread through multiple pathways and, once present, are extremely difficult to eradicate or control. Life history characteristics of aquatic invaders provide an opportunity for these species to dominate native populations, leading to permanent displacement of native species and, ultimately, threatening biodiversity of native ecosystems. Characteristics commonly found among invasive species, contributing to their competitive edge, include:

- **Reproduction:** Occurs early, frequently and in large numbers
- **Adaptability:** Tolerant of a wide range of environmental conditions such as light, temperature, turbidity, nutrient levels and pH
- **Diet:** Prey upon a variety of native species that can be economically or recreationally valuable or key species in the native food web
- **Predator pressure:** Limited (in their new environment)

*References for the information presented in this booklet can be found online at www.glc.org/ans/aquatic-invasions




Global activity of a single transoceanic vessel over a 14-month period. Circles indicate sites where ballast water was loaded (red) or discharged (light blue). Colors demonstrate individual voyages. Graphic courtesy MacIsaac et al. October, 2004 (BioScience).

## Protecting the Great Lakes from Global AIS Risks

The Great Lakes basin is a unique ecosystem formed by a glacial process that began approximately 100,000 years ago. The basin holds 90 percent of North America's surface freshwater and supports more than 172 native fish species. The Great Lakes offer recreational enjoyment to more than 4 million registered boaters and 2 million anglers which, along with commercial fishing, contribute to a fishery valued at over $4 billion annually. The region faces steep challenges in its efforts to protect valuable natural resources and beneficial uses of the Great Lakes. Expansion of global trade, demographic shifts, land-use changes, transportation practices and other trends all pose risks for AIS introduction and spread. In meeting this challenge, AIS prevention and control demands a comprehensive approach in collaboration with multiple entities and programs across the Great Lakes region.

## Binational Programs

In 1955, the United States and Canada established the binational Great Lakes Fishery Commission to control sea lamprey. In the 1990s a binational approach was taken in the development of U.S. and Canadian guidelines for ballast water management to help prevent the spread of zebra mussels and other new AIS introductions.

## Federal Programs and Legislation

In 1990, Congress passed the *Nonindigenous Aquatic Nuisance Prevention and Control Act* (NANPCA), prompted largely by the damage caused by the introduction and spread of zebra mussels. This legislation called for the establishment of a national ANS Task Force and regional Aquatic Nuisance Species (ANS) panels. NANPCA created an effective way to build strong state, tribal, nongovernmental, federal and binational partnerships to battle Great Lakes aquatic invasions. As part of this regional effort the federal Canadian government completed a *Canadian Action Plan to Address the Threat of Aquatic Invasive Species* in 2004.

**Aquatic Nuisance Species Task Force:** The ANS Task Force is the intergovernmental agency charged with implementing NANPCA. The Task Force is comprised of representatives from 10 federal agencies and 12 ex-officio members. It is co-chaired by representatives of the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA).

**Great Lakes Panel on Aquatic Nuisance Species:** The Great Lakes Panel was the first regional panel to be established under NANPCA, and convened by the Great Lakes Commission in 1991. The Panel is comprised of representatives from U.S. and Canadian governmental agencies on the state, provincial and federal level; environmental groups; universities; and recreational and commercial user groups. Members work toward the coordination of AIS prevention and control on a multijurisdictional level for the shared waters of the Great Lakes. The role and potential contributions of the Great Lakes Panel were reinforced and enhanced by reauthorization of NANPCA through the *National Invasive Species Act of 1996* (NISA).

**National Invasive Species Council (NISC):** The NISC was established under Executive Order (EO13112, 1999) to better coordinate federal efforts and mobilize AIS prevention and control at the local, state, regional, national and international levels. NISC has since developed a national invasive species management plan.



An illustration of water discharge from a maritime vessel. Photo courtesy Marine Invasions Laboratory, Smithsonian Environmental Research Center.

## Future Directions of AIS Management in the Great Lakes

- Public education: Specific user groups are being targeted with outreach methods such as regulation booklets, signs at water accesses and advertising for recreational boaters. National voluntary guidelines help to deliver consistent messages on AIS prevention and control.
- Policy, regulations and enforcement: Mechanisms are being created to ensure compliance with AIS prevention and control measures at a state, tribal and federal level. Examples include prohibition of the possession, sale or transport of live aquatic invasive species.
- Watercraft inspection: Educational programs conducted by agency inspectors and volunteers provide a valuable resource reaching potentially thousands of boaters and anglers with prevention messages.
- Early detection, monitoring and rapid response: Innovative management strategies enhance the capacity to anticipate, prevent and respond to new aquatic invasions before they become established as reproducing populations.
- Predictive modeling: Use of life history analysis and computer modeling helps to identify potential new invaders and forecast their possible range of infestation.
- Pathway and vector analysis: Research is providing valuable information on the relative risk of geographic routes of introduction or spread and mechanisms of spread, such as ballast water.
- Risk assessment: Analysis on a quantitative basis is helping managers determine the "invasiveness" of verified new species and identify their potential impacts on local industry, ecosystem and human health.

# Vector

## Maritime Commerce

Transoceanic shipping has operated in the Great Lakes since the opening of the St. Lawrence Seaway in 1959. Ship ballast has been recognized as a leading vector of AIS introductions since the discovery of zebra mussels in Lake St. Clair in 1988. The zebra mussel and a host of other species introduced by ballast have quickly spread throughout the Great Lakes via intrabasin ballast exchange and other vectors. As of 2007, Canada has implemented mandatory ballast water control and management regulations for both ballast and No Ballast on Board (NOBOB) vessels. The U.S. has instituted mandatory ballast water requirements for ballast vessels and voluntary management guidelines for NOBOBs. The development of a ballast water management discharge standard to define the maximum permissible concentration of organisms at all life stages per volume of ballast water has been a regional priority. New innovations for ship design are also being investigated to diminish the potential for AIS transport through ballast water and the ship itself, such as surface fouling.

Photo courtesy Michigan Sea Grant.

## Case Study: Zebra Mussel

### (*Dreissena polymorpha*)

The zebra mussel, native to eastern Europe, was most likely discharged into the Great Lakes from the ballast water of ships while in their free-swimming larval stage of their life, called veligers. Rapidly spread by a variety of vectors, this non-native mollusk attaches to hard surfaces, including pipes and other submerged structures. Maintenance to clean infested pipes costs industry millions of dollars each year. Biodiversity of the Great Lakes ecosystem has been devastated by zebra mussel colonization as evidenced by declines in native clam populations and the loss of spawning habitat for some native fish species. Zebra mussels are efficient filter feeders and are linked to contaminant cycling and the collapse of forage populations, such as the shrimp-like amphipod *Diporeia*. By depleting the base of the food web, zebra mussels can impact important fish species such as trout and salmon. Costly recreational impacts associated with zebra mussels include the sharp shells littering Great Lakes beaches and the proliferation of the often toxic blooms of the blue-green algae *Microcystis*.

## Canals and Waterways

Canals and waterways in the Great Lakes basin, used as transportation corridors for commercial and recreational activities, also establish interconnections between watersheds, which make them more susceptible to aquatic invasions. A prime example is the Chicago Sanitary and Ship Canal which has opened passage for AIS, such as the round goby, between the Mississippi River and the Great Lakes, historically disconnected watersheds. To address this AIS vector, there is a need for construction of dispersal barriers, flood control barriers, physical barriers and other separation mechanisms in these canals and waterways. An electrical dispersal barrier is being established on the Chicago Waterway in efforts to obstruct the movement of AIS between the Mississippi River and Great Lakes.

Photo courtesy Michigan Sea Grant.

## Case Study: Sea Lamprey (*Petromyzon marinus*)

Native to the North Atlantic Ocean and, first observed in Lake Ontario in the 1800s, the sea lamprey's spread to the Upper Great Lakes was accelerated with changes to the Welland Canal in 1921. A parasitic fish species, sea lamprey feed on the fluids of fish by attaching themselves to the body of large fish with their oral disks and using their rasping tongue to penetrate the host's body. By the late 1940s sea lamprey had contributed to the decline of several fish species including lake trout, with catch decreasing from 15 million pounds in the upper Great Lakes to only 300,000 pounds by the 1960s. Sea lamprey infestations have caused hundreds of millions of dollars in damage to the $4 billion Great Lakes commercial and recreational fisheries. Led by the Great Lakes Fishery Commission, the United States and Canada conduct a joint sea lamprey control program, spending more than $18 million annually and reducing sea lamprey populations by 90 percent in many areas. Control techniques include lampricides, barriers, trapping and the release of sterile males. Ongoing control programs will be necessary to prevent a resurgence of lamprey populations. Current research is focused on trapping sea lamprey populations with applications of sea lamprey pheromones. Also under investigation is use of these hormones to disrupt normal sea lamprey spawning.



Phragmites (*Phragmites australis*) in winter. Photo courtesy Michigan Sea Grant.

# Model Strategies to Advance AIS Prevention and Control

Successful public education and outreach campaigns to prevent and slow the spread of AIS are being implemented at local, state, regional and national levels. The following programs have been found to effectively promote practices that reduce the risk of AIS introduction and spread among public and private user groups. Education programs that encourage the adoption of preventative practices are fundamental to establishing long-term protection from the harmful impacts caused by aquatic invasions in the Great Lakes and beyond.

## Stop Aquatic Hitchhikers!™

is a national campaign designed to educate recreational water resource users on AIS issues and provide targeted advice on voluntary guidelines for AIS prevention and control. The campaign has been established by the USFWS in conjunction with the national ANS Task Force and U.S. Coast Guard. Partners have joined this initiative from the public, private and nonprofit sectors to help promote a unified conservation message of the Stop Aquatic Hitchhikers!™ campaign.

The campaign also maintains a website (www.protectyourwaters.net) that provides information on voluntary recreational guidelines such as the following:

» Remove visible mud, plants fish or animals and drain all water before transporting equipment
» Clean and dry everything having contact with the water before moving
» Do not release any plants fish or animals into a waterbody unless the organism was found in the waterbody

## Habitattitude™

is a national campaign targeting aquarists and water gardeners to promote responsible consumer behaviors. The campaign is a cooperative venture between the Pet Industry Joint Advisory Council, USFWS and the NOAA National Sea Grant College Program.

Habitattitude™ is designed to prevent the release of unwanted aquarium plants and fish by aquarists and water gardeners. All phases of the industry are targeted, including wholesalers, manufacturers, retailers and the media.

Habitattitude™ provides consumers and retailers with clear, consistent AIS prevention messages combined with beneficial guidelines for release. Methods used to deliver the campaign message include brochures, stickers, posters, public service ads, banners, tip cards, displays at aquarist and water garden shows, and a website (www.habitattitude.net) that provides access to educational material.



## Recreational Activities

Many aquatic invaders hitchhike on recreational vehicles and equipment. With more than 4 million registered boats in the Great Lakes, recreational vectors pose a significant risk for aquatic invasions. It is critical that recreational users are educated on the importance of adopting preventative behaviors and for policy makers to develop effective, uniform regulations. The national recreational activities guidelines (www.protectyourwaters.net) have been developed to encourage stewardship of the Great Lakes for today and future generations.

Photo courtesy Don Schmitz, Florida Department of Environmental Protection.

## Case Study: Hydrilla (*Hydrilla verticillata*)

Hydrilla, a potential Great Lakes invader, was first introduced into U.S. waters as an aquarium plant in Florida during the 1950s. Native to the warm waters of Asia, this submerged perennial herb has infested the southern regions of the country, found as far north as Maine and Indiana. Hydrilla has not yet been detected in the Great Lakes; however significant concern exists over the risk of future introductions. Hydrilla fragments can hitchhike on recreational vehicles and equipment used in infested waters and transported from one water body to another. With each fragment capable of growing up to one inch per day, dense mats of hydrilla can quickly form, shading out beneficial native species. This invasive plant also clogs drainage and irrigation canals, prevents boating access for water recreation and also impedes commercial navigation. Prevention, early detection and monitoring coupled with rapid response are priority management strategies since hydrilla is virtually impossible to control once introduced. As seen in Florida, control costs are staggering. During the period from 1980 to1993, hydrilla management in public lakes and rivers cost $38.5 million. Given the 2006 discovery of hydrilla in Lake Manitou in northern Indiana (55 miles south of Michigan), outreach programs coupled with watercraft inspections are being implemented in efforts to prevent the invasion of hydrilla into the Great Lakes.

## Aquaculture

Aquaculture, conducted at public and private facilities, involves the cultivation of both native and non-native species for commercial purposes. Examples include raising fish for aquariums, water gardens, biological control, bait and food industries. A significant risk associated with aquaculture is the escape of non-native species from facilities which can result in wide-spread invasions throughout interconnected waterways, such as the case of Asian carp. These incidences can be further damaging if the cultivated species harbor disease. Another risk is posed when cultivated native species are purposely or accidentally released, potentially diminishing the overall genetic variability of wild populations.

Silver carp. Photo courtesy Ted Lawrence, Great Lakes Fishery Commission

## Case Study: Bighead (*Aristichthys nobilis*) and Silver carp (*Hypophthalmichthys molitrix*)

Bighead and silver carp, potential Great Lakes invaders, were imported into the United States in the early 1970s for the purpose of controlling weeds in public and private aquaculture ponds in the lower Mississippi River. Flooding in the early 1990s led to the escape of thousands of Asian carp into the Mississippi River, allowing a northward migration toward the Great Lakes. With fast growth and voracious consumption habits, these carp could wreak havoc on the Great Lakes ecosystem if introduced. Silver carp also cause a safety hazard to boaters, as adults weighing up to 20 pounds can leap out of water when startled by passing watercraft. To stop AIS from passing between the Mississippi River and Great Lakes, an electrically charged barrier was constructed in the Chicago Sanitary and Ship Canal, beginning operation in 2002. As this demonstration barrier nears the end of its life, a new barrier is being constructed 800 feet downstream which is larger, more powerful and longer lasting. This is a cooperative project between the U.S. Army Corps of Engineers, the state of Illinois and the other Great Lakes states. For updates, see www.seagrant.wisc.edu/ais.



# Model Strategies to Advance AIS Prevention and Control

A U.S. Fish and Wildlife Service employee rinses a mesh "sock" that filters reservoir water entering the Inks Dam National Fish Hatchery, Texas. The sock keeps debris, fish eggs and fry from contaminating the hatchery's water supply and is an example of a "critical control point" designed to control aquatic invasive species introductions. Photo and description courtesy of the U.S. Fish and Wildlife Service, Inks Dam National Fish Hatchery and Minnesota Sea Grant.

## AIS HACCP (Hazard Analysis and Critical Control Point)

This quality control process was originally designed to manage the safety of foods taken on space flights in the 1960s, then adapted to address seafood regulations in 1997. State Sea Grant programs have translated this program for resource agencies and resource-dependent businesses while the USFWS has helped to spread and promote use of the process. HACCP enables agencies and businesses to target potential points of AIS introduction or spread associated with aquaculture, fish stocking, wild baitfish harvesting, aquatic plant harvesting and field research activities, among others. By minimizing these AIS risks the program also helps commercial businesses avoid regulatory violations. AIS HACCP facility plans are being implemented by state, federal and tribal hatchery managers, private baitfish and aquaculture producers, as well as state and private veterinarians. For more information, visit these sites: www.haccp-nrm.org/ and http://nsgd.gso.uri.edu/haccp.html.

## Regional Partnerships

The Great Lakes Panel has worked since 1991 to promote information and education, research and policy responses to AIS problems in the region and nationally. The commitment is high in the Great Lakes region to coordinate efforts on AIS prevention and control on a state, provincial, tribal and federal level.

## Provincial

The Invading Species Awareness Program, operating since 1992, is a cooperative venture of the Ontario Ministry of Natural Resources and the Ontario Federation of Anglers and Hunters. The program mission is to raise public awareness on AIS and encourage public participation in prevention, monitoring and control activities. Key AIS vectors addressed are the live bait industry, recreational watercraft, aquarium and water garden trades, and unauthorized fish introductions. Program initiatives include the Invading Species Hotline which encourages citizen- and agency-reporting of AIS, volunteer monitoring programs, displays at boating and fishing shows, industry workshops, outreach materials and school curricula.

## State Government Programs

States are encouraged, in part through federal legislation (NANPCA, 1990), to develop and implement a state-specific management plan on AIS prevention and control. Upon approval of the plan by the ANS Task Force, states become eligible for federal funding, on a cost share basis, to assist plan implementation. High priorities for state plans include public education, early detection and monitoring, rapid response and control programs. Examples of popular outreach products include invasive species hotlines, fact sheets, boat launch signs, displays at boating and fishing shows, identification cards, handbooks, newsletters, websites and videos. Watercraft inspection programs demonstrate how outreach can be coupled with monitoring to actively promote AIS prevention and control in the Great Lakes and inland waters. Regulatory action is another tool being implemented to increase the level of protection from aquatic invasions.

Volunteers with the Dickinson Conservation District and Michigan Clean Boats/ Clean Waters program are shown cleaning aquatic plant life off a boat motor. Photo courtesy Ann Hruska and Dickinson Conservation District Volunteers.



## Organisms in Trade

Non-native aquatic species marketed for commercial purposes are classified as organisms in trade. Examples include baitfish, live food fish and stocked fish, as sold in the aquarium and water gardening trade. Consumer lack of awareness as well as certain cultural traditions and practices, have resulted in accidental and intentional release of these organisms. Currently, there is not an effective screening process in place to identify high-risk species before they are introduced through importation, interstate commerce or trade. The ecological or economic impacts of these species are frequently unknown until the species becomes established as a reproducing population.

Photo courtesy Michigan Sea Grant.

## Case Study: Purple loosestrife (*Lythrum salicaria*)

Purple loosestrife is an emergent aquatic plant of Eurasian origin. Transported in the dry ballast of European ships, the seeds of this invasive plant were first introduced to North America in the early 19th century. The spread of purple loosestrife has been accelerated by human activities such as gardening. It is valued as a medicinal herb, an ornamental and a nectar plant in honey production. Infestations of purple loosestrife form dense, monotypic stands, impacting the habitat of wetland species. An estimated 190,000 hectares of wetland, marshes, pastures and riparian meadows are invaded by purple loosestrife in North America each year, replacing native plant communities and compromising the biodiversity of these ecosystems. An integrated approach is used to manage this highly invasive plant, combining biological control (one organism is used to control another) and herbicide eradication. The most efficient and economical approach to deal with extensive purple loosestrife infestations is biological control through the release of the natural predator, the European beetles *Galerucella sp*. Herbicide treatment is applied in cases of localized infestations. Early detection of purple loosestrife is critical to preventing its spread and minimizing damage to the native plant community.

Floating mats of European frogbit (*Hydrocharis morsus-ranae*). Photo courtesy Michigan Sea Grant.

# Model Strategies to Advance AIS Prevention and Control

## First Nations

The Chippewa Ottawa Resource Authority (CORA), an intertribal regulatory and management body, works on fisheries and seafood safety issues for the five tribes involved with treaty fishing rights in the upper Great Lakes. CORA provides biological services that ensure proper regulation of tribal fisheries and cooperative management with federal and state agencies including the Great Lakes Fishery Commission, the USFWS, the Canadian Dept. of Fisheries and Oceans and the state of Michigan. The Inter-Tribal Fisheries and Assessment Program represents CORA on AIS research projects including an assessment of sea lamprey impact on fish populations in Lake Superior.

The Great Lakes Indian Fish & Wildlife Commission (GLIFWC) is an intertribal agency committed to the implementation of off-reservation treaty rights on behalf of its 11 Ojibwe member tribes. GLIFWC has compiled and published regional AIS distribution and control data via an interactive GIS database (www.glifwc-maps.org).

Dickinson Conservation District volunteer hand pulling purple loosestrife. Photo courtesy Ann Hruska and Dickinson Conservation District Volunteers.

## Nonprofit/Lake Associations

Many nonprofit groups and lake associations throughout the Great Lakes region recognize aquatic invasions as a priority environmental problem. These organizations are eligible for grants through state and provincial natural resource agencies which encourage public participation in AIS prevention and control initiatives. Examples include the collection of AIS data, development of outreach material tailored to the needs of specific user groups and waterbodies, and the implementation of control activities. Public involvement provides state natural resource agencies with valuable information on state waters and builds capacity to protect these waters from aquatic invaders through stewardship efforts.

## A Model of Regional Collaboration

The Great Lakes Regional Collaboration (GLRC), established through Executive Order 13340 issued in May 2004, is a model of collaboration representing more than 1,500 individual stakeholders and providing a framework for the future of Great Lakes protection and restoration. Aquatic invasions are recognized by the GLRC as a priority environmental issue threatening the health of the Great Lakes ecosystem. An AIS Strategy Team, lead by agency staff and composed of regional stakeholders, developed a set of recommended near-term actions to stop AIS introduction and spread in the Great Lakes basin. Primary vectors identified include maritime commerce, canals and waterways, aquaculture, organisms in trade, and recreational activities. Key issue area recommendations were integrated into a comprehensive strategy and action plan, the *Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes*, and submitted to the President in December 2005. A priority recommendation of the GLRC strategy is to prevent further AIS introductions through comprehensive legislation.



# Aquatic Invasive Species Websites

## Binational/Regional

Council of Great Lakes Governors: **www.cglg.org**
Great Lakes Commission: **www.glc.org; www.glc.org/ans**
Great Lakes Fishery Commission: **www.glfc.org**
Great Lakes United: **www.glu.org**
IAGLR: **www.iaglr.org/scipolicy/issues/ais.php**
International Joint Commission: **www.ijc.org**

## U.S. National Interagency Groups

ANS Task Force: **www.anstaskforce.gov**
National Invasive Species Council: **www.invasivespecies.gov**
North American Lake Management Society: **www.nalms.org**

## U.S. Federal

National Park Service:
**http://science.nature.nps.gov/im/monitor/invasives**
National Sea Grant Office (NOAA): **www.nsgo.seagrant.org**
U.S. Coast Guard: **www.uscg.mil/hq/g-m/mso/ans.htm**; **www.uscg.mil/hq/g-m/mso/vrag.htm**
U.S. Department of Agriculture: **www.invasivespeciesinfo.gov**; APHIS-Aquaculture, **www.aphis.usda.gov/vs/aqua**
USDA-Forest Service Eastern Region:
**www.fs.fed.us/invasivespecies**; **www.fs.fed.us/r9/wildlife/nnis**
U.S. Dept of Commerce (National Oceanic and Atmospheric Administration):
Great Lakes Environmental Research Laboratory:
**www.glerl.noaa.gov/res/Programs/ais**
National Sea Grant Office:
**www.seagrant.noaa.gov/themesnpa/aquaticinvasivespecies.html**
NOAA National Center for Research on Aquatic Invasive Species:
**www.glerl.noaa.gov/res/Programs/ncrais/ncrais.html**
Great Lakes Aquatic Nonindigenous Species Information System:
**www.glerl.noaa.gov/res/Programs/invasive**
U.S. Environmental Protection Agency:
**www.epa.gov/owow/invasive_species**
U.S. Fish and Wildlife Service:
**www.fws.gov/contaminants/Issues/InvasiveSpecies.cfm**;
**www.fws.gov/midwest/Fisheries/topic-ans.htm**
U.S. Geological Survey: **http://nas.er.usgs.gov**

## Canadian Agencies

Department of Fisheries and Oceans Canada: **www.dfo-mpo.gc.ca**
Environment Canada: **www.ec.gc.ca**
Ontario Federation of Anglers and Hunters: **www.invadingspecies.com**
Ontario Ministry of Natural Resources: **www.mnr.gov.on.ca**
Transport Canada: **www.tc.gc.ca**

## Regional ANS Panels

Great Lakes Panel: **www.glc.org/ans**
Gulf and South Atlantic Panel: **http://nis.gsmfc.org**
Mid-Atlantic Regional Panel: **www.chesapeakebay.net/marp.htm**
Mississippi River Basin Panel:
**http://wwwaux.cerc.cr.usgs.gov/MICRA**
Northeastern Panel: **www.northeastans.org**
Western Panel: **http://answest.fws.gov**

## Tribal/First Nations

Chippewa Ottawa Resource Authority: **www.1836cora.org**
Great Lakes Indian Fish & Wildlife Commission: **www.glifwc.org**

## State Government

Illinois: **http://dnr.state.il.us** (IL DNR); **www.iisgcp.org/il-ans**
Indiana: **www.in.gov/dnr** (IN DNR)
Michigan: **www.michigan.gov/deqaquaticinvasives** (MI DEQ)
Minnesota: **www.dnr.state.mn.us/ecological_services/invasives.html** (MN DNR); **www.mda.state.mn.us/misac** (Minnesota Invasive Species Advisory Council)
New York: **www.dec.state.ny.us/website/site/programs.html** (NY DEC); **www.dec.state.ny.us/website/dfwmr/habitat/istf** (NY Invasive Species Task Force, plant and aquatic invasives)
Ohio: **www.ohiodnr.com/wildlife/wildresources/dealingwithwildlife/nuisance**
Pennsylvania: **www.dep.state.pa.us** (PA DEP)
Wisconsin: **http://dnr.wi.gov/invasives** (WI DNR)

## State Sea Grant Programs

Illinois/Indiana: **www.iisgcp.org**
Michigan: **www.miseagrant.umich.edu**
Minnesota: **www.seagrant.umn.edu**
New York: **www.seagrant.sunysb.edu**
Ohio: **www.sg.ohio-state.edu**
Pennsylvania: **www.pserie.psu.edu/seagrant**
Wisconsin: **www.seagrant.wisc.edu**

## International, National and Regional Initiatives

Great Lakes Aquatic Invasive Species Information System (GLANSIS):
**www.glerl.noaa.gov/res/Programs/invasive**
Great Lakes Information Network (GLIN): **www.great-lakes.net**
Great Lakes Regional Collaboration (GLRC): **www.glrc.us**; AIS Strategy Team: **www.aisstrategyteam.org;** Great Lakes Regional Collaboration Strategy: **www.glrc.us/strategy**
International Joint Commission's Great Lakes-St. Lawrence Research Inventory: **http://ri.ijc.org**
International Nonindigenous Species Database Network (NISbase):
**www.nisbase.org**
National Sea Grant and Sea Grant clearinghouse: **www.nsgo.seagrant.org**; **www.aquaticinvaders.org**; **www.sgnis.org**
Smithsonian Environmental Research Center:
**http://invasions.si.edu/aird**
USGS Nonindigenous Aquatic Species: **http://nas.er.usgs.gov**

## What can you do?

Stop Aquatic Hitchhikers! ™: **www.protectyourwaters.net**
Habitattitude™: **www.habitattitude.net**
Wisconsin DNR: Take Action to Stop Invasive Species:
**http://dnr.wi.gov/invasives/action.htm**

Pass this booklet on to your friends:
**www.glc.org/ans/aquatic-invasions**

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**Photo Credits:**

Clockwise from left: Fanwort (*Cabomba caroliniana*), Heather Smith, Ontario Federation of Anglers and Hunters; Phragmites (*Phragmites australis*), Michigan Sea Grant; Eurasion ruffe (*Gymnocephalus cernuus*), Michigan Sea Grant; Yellow Iris (*Iris pseudacorus*), Dawn Sucee, Ontario Federation of Anglers and Hunters; and European frogbit (*Hydrocharis morsus-ranae*), Michigan Sea Grant.

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