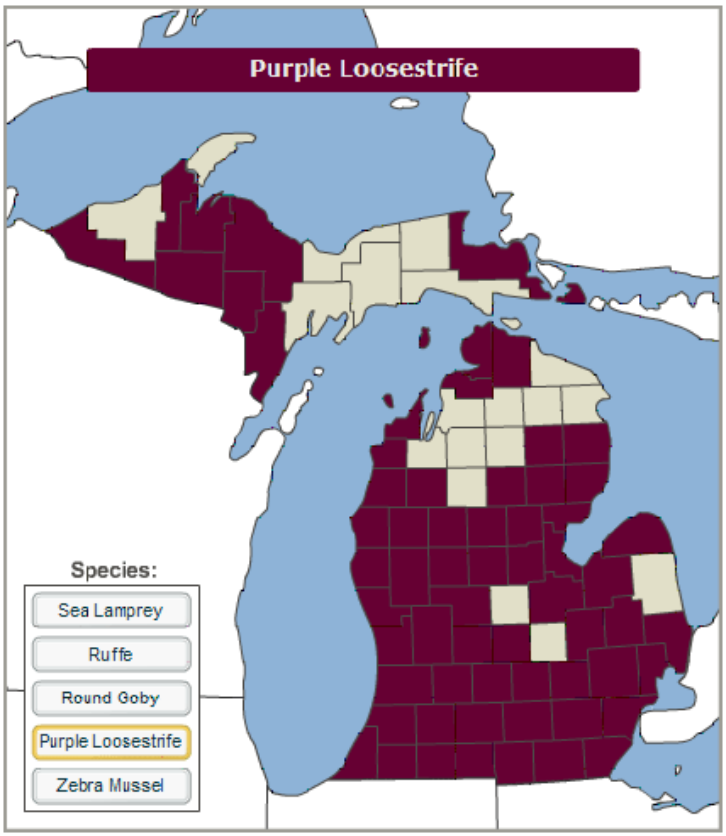
A Model GIS Assessment of Nonindigenous Invasive Species in Michigan Waters

FINAL REPORT



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Executive Summary

Aquatic invasive species (AIS) pose significant risks to the ecological and economic integrity of the Great Lakes-St. Lawrence system. The Great Lakes Commission (GLC) in association with the Michigan Office of the Great Lakes has developed an Internet-based spatial database of AIS invasions for the State of Michigan in an effort to improve coordination among resource managers and thereby enhance prevention and control measures. This work builds upon current AIS prevention and control work being conducted in the state, bringing together information from local, state, federal, academic and non-governmental organizations (NGO) sources. In doing so, the database provides timely, valid, reliable and practical information to assist managers and decision makers in implementing AIS prevention and control efforts. Further, it identifies unmet data and information needs that enhance the validity, detail and utility of the spatial database.

Spatial data for major AIS of concern within Michigan waters were collected. These species include round goby (*Neogobius melanostomus*), ruffe (*Gymnocephalus cernuus*), purple loosestrife, (*Lythrum salicaria*), sea lamprey (*Petromyzon marinus*), zebra mussel (*Dreissena polymorpha*), quagga mussel (*Dreissena bugensis*), spiny waterflea (*Bythotrephes cederstroemi*) and eurasian watermilfoil (*Myriophyllum spicatum*).

Time series maps are provided showing the spread of each species and/or accumulation of data over time from earliest dates available to the most recent field season of data collection. Local AIS information specific to either county or watershed for six species (sea lamprey, ruffe, round goby, purple loosestrife, zebra mussel, and quagga mussel) are available showing the year of data collection and waterbody/location of the occurrence. "Quick facts" about each species of concern were developed to provide pertinent introductory information. Lastly, direct data downloads are provided to users of GIS for their own use and manipulation.

Introduction

AIS pose significant risks to the ecological and economic integrity of the Great Lakes basin. Nationwide, control efforts for zebra mussels, purple loosestrife and sea lamprey alone are estimated to cost $365 million/year. The problem of AIS is second only to habitat loss as a factor causing significant declines in biodiversity. The GLC developed an Internet-based spatial database of AIS invasions for the State of Michigan to enhance prevention and control measures, advance information and education activities and improve coordination among resource managers. The project builds on current AIS management and control work being conducted in the state and the region, bringing together information from local, state, federal, academic and NGO sources. In doing so, the data provides timely, valid, reliable and practical information to assist managers and decision makers in implementing AIS prevention and control efforts.

Further, the project identifies unmet data and information needs that enhance the validity, detail and utility of the spatial data. All of this helps limit the spread of established populations of AIS into un-infested waters, an objective outlined in Michigan's management plan.

A spatial data layer for each of the major AIS species of concern within Michigan waters was developed or is under development. Species include round goby (*Neogobius melanostomus*), ruffe (*Gymnocephalus cernuus*), purple loosestrife, (*Lythrum salicaria*), sea lamprey (*Petromyzon marinus*), zebra mussel (*Dreissena polymorpha*), quagga mussel (*Dreissena bugensis*), spiny waterflea (*Bythotrephes cederstroemi*) and Eurasian watermilfoil (*Myriophyllum spicatum*). The data were contributed by various specialized agencies and organizations active within the region.

The GLC recognized that data quality varied by agency and topic. Several prospective issues were identified and addressed to ensure the validity and consistency of project outcomes. These considerations were:

- *Spatial accuracy* – Species data varies significantly in the accuracy of its spatial coordinates; detailed comparisons between data from different sources or data for different species is qualified.

- *Vintage of the data* – Collection intervals for some species data may at times make cross-species comparisons difficult. In addition, certain spatial reference layers are based on older paper maps.

- *Completeness of coverage* – The intensity of species data collection efforts varies across the state. Therefore, it is must be emphasized that the absence of data does not necessarily imply the absence of invasive species.

To assist users in making informed decisions about any data quality issues that arise, metadata was developed for each of the AIS layers, meeting the standards of the Federal Geographic Data Committee (FGDC). The metadata is packaged with the spatial data and provided to the user at the time of download.

The GLC worked closely with the data source collaborators to develop the most appropriate approach to presenting the data online. It was determined that absence/presence data based upon high quality and verifiable sampling data was to be the basis of the presentation. In most cases data was georeferenced by the data provider. In some cases, the GLC digitized the data for project collaborators.

The data were standardized and matched to a set of reference map features based upon the U.S. Geological Survey's (USGS's) 7.5 minute topographic quadrangles with a scale of 1:24,000. These data layers were incorporated into the Internet-mapping application. The original intent of the project was to serve the data through an Internet mapping system (IMS) package providing the user with tools for zooming and panning, for turning reference features on or off as desired, and for choosing which AIS layers are displayed. These types of applications allow the user to emphasize and view a single species, selected species together or all species at the same time.

However, once data was received in-house at the GLC, a review showed that the data density and species coverage did not necessarily support an IMS platform and that such a tool may actually hinder access and use. Therefore, the GLC developed a Macromedia Flashed-based tool to serve the data that is highly user friendly and intuitive. The original geospatial data is being served in conjunction to the higher end user.

The project provides resource managers, decision makers and others access to valuable AIS mapping and analysis tools. The data developed for this mapping tool provides a baseline of current and historic AIS invasions, allowing managers to identify priority areas for prevention and control efforts. For example, by merging AIS data layers with state and regional data, managers will be able to view ports, marinas, and harbors where AIS infestations exist or may be under pressure from commercial and recreational vectors. These areas can then be targeted for increased outreach efforts aimed at limiting the spread of AIS from these facilities via recreational and commercial users. From another angle, the mapping tool is able to highlight locations where monitoring activity has shown an absence of AIS infestations. These areas, particularly those of pristine quality, can benefit from increased efforts to prevent the introduction and further spread of AIS. The data also help identify gaps and determine where future monitoring efforts are needed, as well as highlighting redundant monitoring efforts. Finally, maps showing the presence of AIS at specific locations can be used in the development of strategies focused on removing new and isolated infestations and containing the spread.

In addition to the technical aspects of the project, the project tasks also address two broader goals. The first is to foster local, state/provincial and regional cooperation and collaboration regarding prevention and control of invasive species, pursuits already being advanced by numerous regional projects. A single online GIS database for priority AIS infestations improves data sharing among agencies and organizations and reduces redundant data collection. The second is the development of a predictive tool through the integration of data from multiple spatial and temporal zones across the entire Great Lakes region. The capacity to view a particular species throughout the region on a spatial and temporal level provides resource managers with information on invasion patterns and the basis for predicting future AIS infestations. This information enhances the formulation of timely responses to eradicate or control invasions in new areas. The data should also allow for the evaluation of the AIS management effectiveness efforts.

Methods

1) Project Infrastructure and Scoping: A multifaceted team comprised of GLC staff, the AIS prevention and control community (*e.g.*, Michigan Department. of Environmental Quality's Office of the Great Lakes, Michigan Sea Grant and Michigan's Aquatic Nuisance Species Action Team) and selected individuals from the Great Lakes Panel on Aquatic Nuisance Species who offer a regional perspective provided project oversight.

2) Map and Data Library: The data library developed for the project consists of specialized data sets for each species (round goby, ruffe, purple loosestrife, sea lamprey, spiny water flea, quagga mussel, zebra mussel, and eurasian watermilfoil). Project staff acquired the majority of the data

sets for the project through partnerships developed within the Great Lakes Panel on Aquatic Nuisance Species and the larger community of relevant agencies and organizations. Data sharing partnerships were developed to ensure the long-term continuity of data exchange and dissemination.

3) Interface Design and Programming: The web interface was designed to be comfortable, intuitive and readily accessed while allowing users from a variety of backgrounds to quickly download information on AIS infestations of interest. The interface itself is on the Great Lakes Information Network (GLIN) site at: http://www.glin.net/envt/flora-fauna/invasive/mapping.html (**Figure 1**).

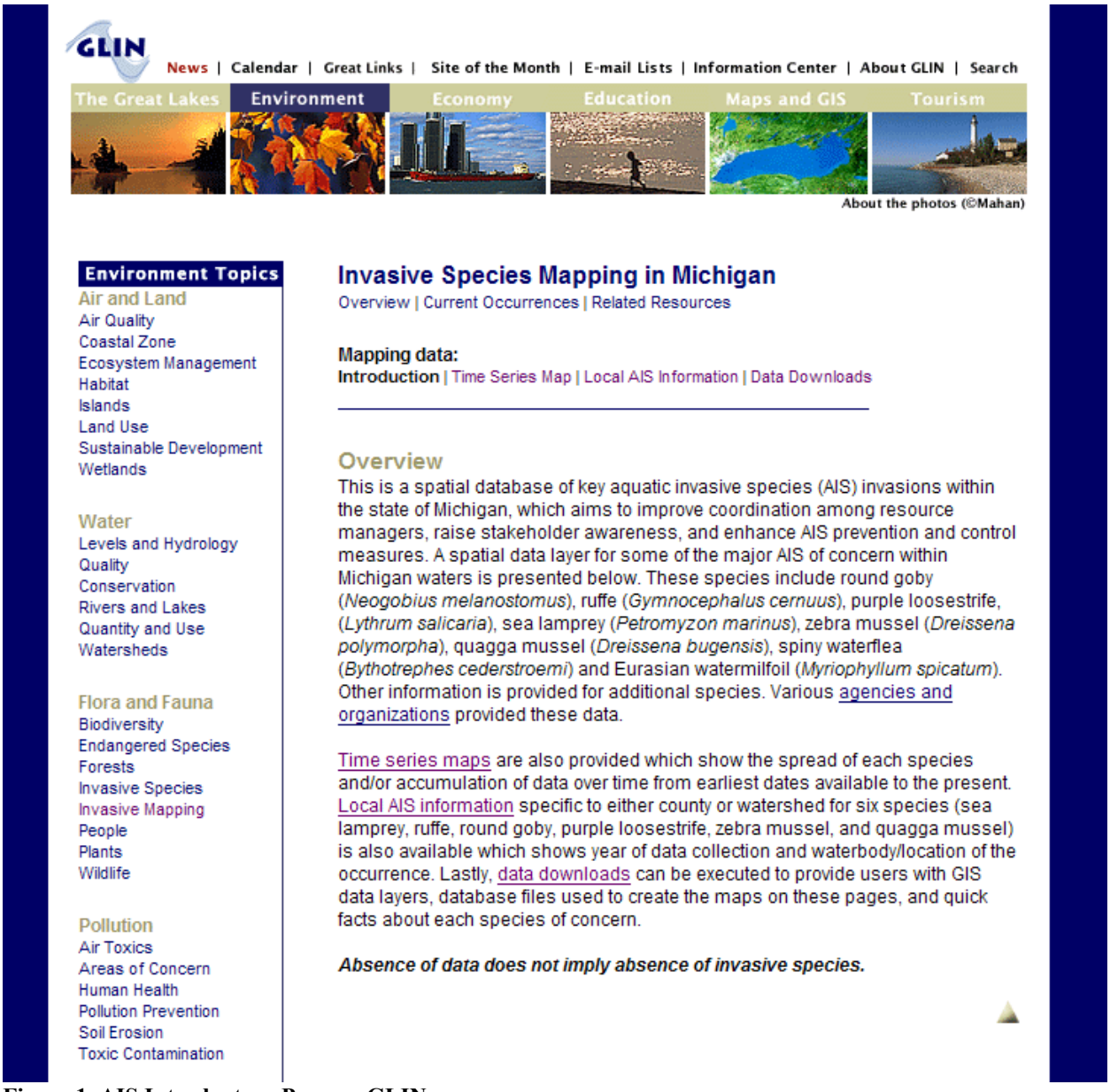

Figure 1, AIS Introductory Page on GLIN.

4) Internet Map Presentation: The original intent of the project work was to develop an IMS-based data display. When project staff sat down and re-addressed project needs, the intended audience, data density and "message conveyance" it was decided that an IMS was excessive and awkward. Instead, project staff in consultation with partners and collaborators defined the specific needs and function of the web site. Priority questions that arose were:

- Where are the current known infestations?
- What is the historic migratory pattern of each species?
- Where specifically are each species within my county or watershed?
- Is the actual data available for my own use?
- What are the "take home" messages for each species?

Building on supplying answers to these questions, the project staff focused on specifically and simply answering each of these in a straight forward manner. A graphical manner to access and serve the data was paramount to usability. The GLC has previously developed a Macromedia Flash-based tool to geographically access metadata for an FGDC companion site (www.glin.net/gis/glide/). This was modified to return data to the user on local infestations of AIS. In addition, simple displays were developed to present the current known presence of AIS, a time series of each species throughout their span on sampling, a series of "Quick Facts" about each species and downloads of the actual data itself by species.

5) Testing and Revisions: The presentation and mapping tools, web interface and data library were fully tested prior to publication of the project on the Internet, both internally and externally. The web site and data library is housed on a fully equipped server maintained by the GLC.

6) Dissemination and User Community Awareness: The targeted audience needs to be made aware of the presence and application of the final product. Promotional efforts are being led by the GLC in collaboration with the Great Lakes Panel on Aquatic Nuisance Species, the Michigan Department of Environmental Quality, Michigan Sea Grant and other relevant agencies and organizations. These efforts include the use of target listserv announcements, paper presentations at relevant venues, a feature on GLIN's "What's New" page, an article in the GLC's *Advisor* newsletter and incorporation of the data and products into other GLC activities, including the Great Lakes Monitoring Inventory. In addition, the AIS data is currently being incorporated by Michigan Department of Natural Resources into its online mapping effort for boat access sites (http://www.mcgi.state.mi.us/mapmichigan/home.asp).

Results

The GLC produced 9,465 records for six invasive species. Abstracts were developed for eight invasive species. A total of four web pages were developed on GLIN to share these data as the most recent known infestations, time series, local county/watershed searches and direct data downloads (**Figures 2-5**). Data are available to the user down to the detail of which specific waterbody was sampled and the most recent year for which data is available. Each principal partner has agreed to act as a point of contact for further data sharing activities.

To serve the data, GLC staff utilized Macromedia Flash and a customized, in-house designed database program. Macromedia Flash is authoring software used for creating the scalable, interactive animation. The backend database, attached to the Flash, is a group of related tables containing information on those invasive species found in the Great Lakes region. It answers queries such as:

- Where in Michigan can certain invasive species be found?
- What is the time span of species invasions?
- What counties/watersheds have certain invasive species?

The first presentation of aquatic invasive species data on the web pages represents the known current state of infestations from the most recent year data was available – generally this is from the summer 2003 field season (**Figure 2**). Data is presented to the user in broad terms of occurrences in each Michigan County. The user can "toggle" between the individual species for an overview of impacts statewide. This page is online at: http://www.glin.net/envt/flora-fauna/invasive/mapping.html.

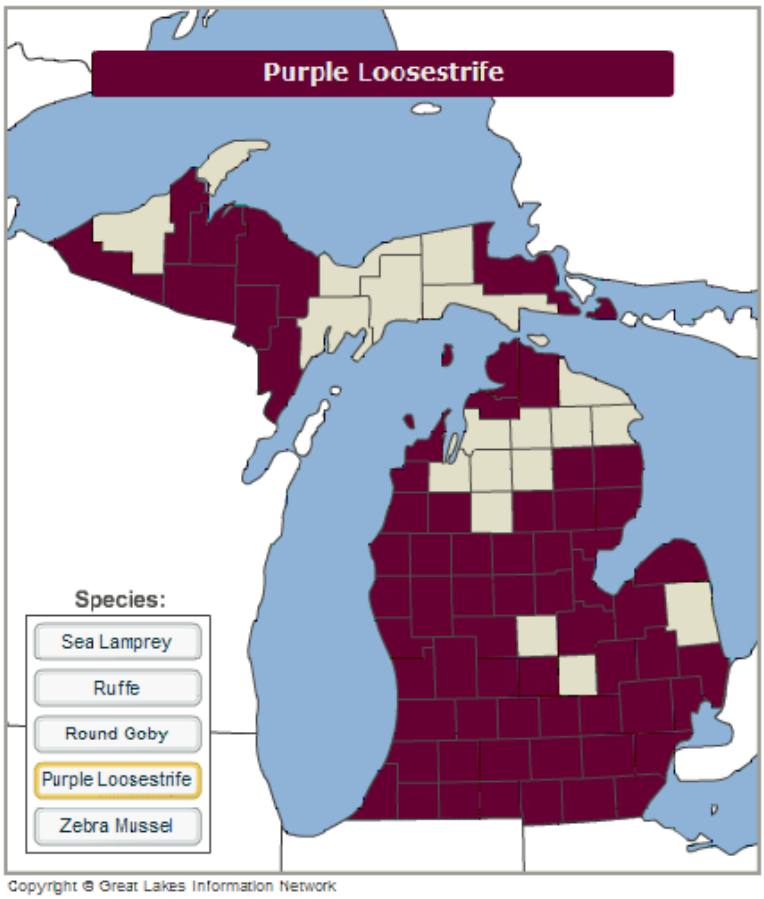

Figure 2, Current Infestations - Purple Loosestrife.

The second web page (http://www.glin.net/envt/flora-fauna/invasive/timeseries.html) is a "time series" map for species where multiple sampling years were available (**Figure 3**). This allows the user to view patterns of spread, spatially and temporally.

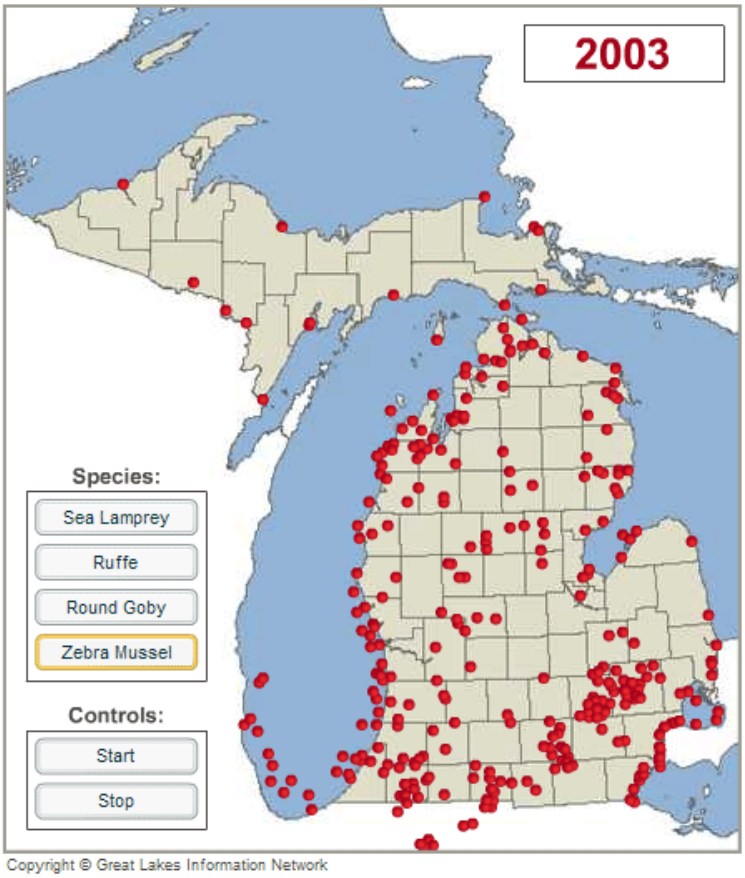

Figure 3, Time Series - Zebra Mussel.

The third page is the main page for individuals to search by either their county or watershed and locate infestations for specific waterbodies or in the case of purple loosestrife, township (**Figure 4**). Reports are returned to the individual in a new window and provide the user with the county and watershed chosen, species name, specific location as reported and the year it was discovered (**Figure 5**). This page is online at: http://www.glin.net/envt/flora-fauna/invasive/miloc.html.

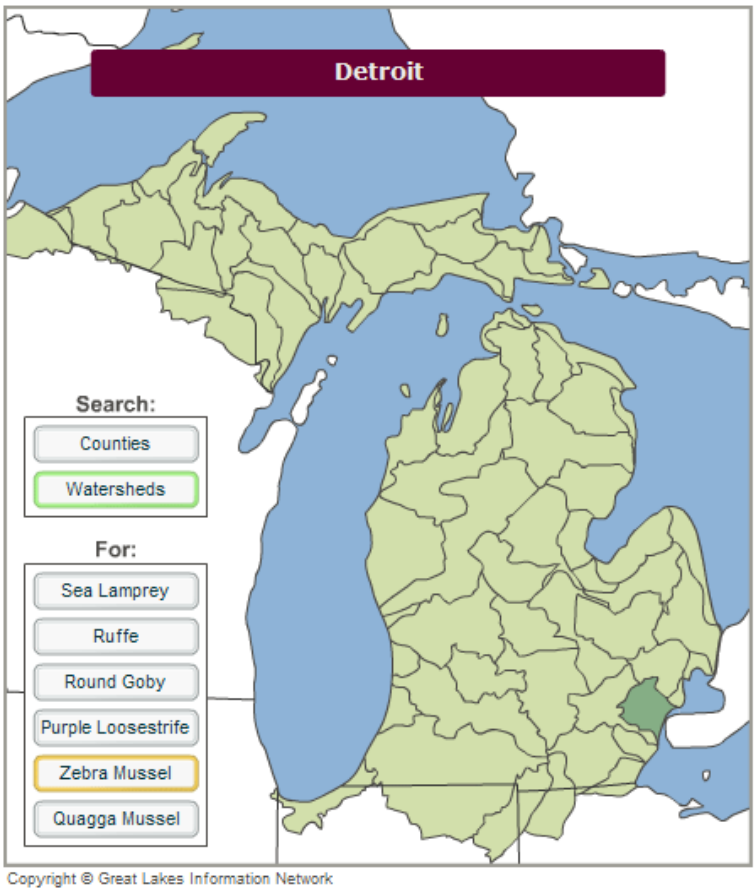

Figure 4, Local Infestations by Watershed.

Search results

Absence of data does not imply absence of invasive species.

County: *Wayne*
Species: *Zebra Mussel*
3 match(es) returned.

Watershed :	Huron River
Location :	Belleville Lake (west of Detroit MI)
Year Disc. :	1993
Watershed :	Detroit River
Location :	Detroit River at Detroit Belle Isle Water Plant, on an island in the Detroit River, Michigan
Year Disc. :	1989
Watershed :	Detroit River
Location :	Detroit River at Belle Isle, Detroit, MI
Year Disc. :	1992

Figure 5, Data Results of Local Infestation Search.

The final status of data availability and incorporation into the final product for the project species is presented below:

Invasive Species	Data Contact	Data Completeness	Data Maintenance	Notes
Round Goby	David Jude, University of Michigan	Some Michigan, Ohio and Indiana sample sites	GLC will be placed on their regular distribution list for future updates	Data digitized by GLC in cooperation with D. Jude.
Ruffe	Mark Dryer and Gary Czypinski, U.S. Fish and Wildlife Service	Great Lakes, Upper Mississippi River, and Ohio River Basins	GLC will be placed on their regular distribution list for future updates	Data is current to last field season
Purple Loosestrife	Mike Klepinger, Michigan Sea Grant	State of Michigan	GLC will be placed on their regular distribution list for future updates	Data is current to last field season
Zebra Mussel (inland waters)	Mike Klepinger, Michigan Sea Grant Mark Dryer and Gary Czypinski, U.S. FWS	State of Michigan, Great Lakes, Upper Mississippi River, and Ohio River Basins	GLC will be placed on their regular distribution list for future updates	Data is current to last field season. GLC digitized roughly 300 additional records.
Zebra Mussel (coastal waters)	Thomas Nalepa (NOAA GLERL) Mark Dryer and Gary Czypinski, U.S. FWS	Southern Basin of Lake Michigan, Great Lakes, Upper Mississippi River, and Ohio River Basins	GLC will be placed on their regular distribution list for future updates	Data only covers SB of Lake Michigan, additional data will be required
Quagga Mussel	Thomas Nalepa, NOAA GLERL	Southern basin of Lake Michigan	GLC will be placed on their regular distribution list for future updates	Data only covers SB of Lake Michigan, additional data will be required
Eurasian Watermilfoil	Dennis Zimmerman, Michigan Lake and Stream Association	No data received	No update cycle determined.	GLC building its own data set
Spiny Waterflea	Hank Vanderploeg, NOAA GLERL	No data received	No update cycle determined.	Data to first be published and then will be shared

The final web page (http://www.glin.net/envt/flora-fauna/invasive/data.html) provides the user access to the georeferenced data as ESRI shapefiles, the database files and abstracted species information. In addition, the project partners/primary contacts for data have been provided.

Summary

GLC staff will continue to maintain and update the project web site in accordance with the work plan and our intentions to keep the site current. As additional species data are available (*i.e.*, water milfoil) it will be integrated into the online products. The GLC is also pursuing funding options to expand the project beyond the borders of the State of Michigan. Our hope is that the site will evolve into a binational, basin-wide clearinghouse for data acquisition and tool for data dissemination.

Integrating known and new sources of data into this online tool will continue to provide expansive advantages in data sharing and public outreach. As previously mentioned, the GLC is continuing to look for potential project partners to heighten the detail on the existing species, provide data on other species, and geographically expand the project beyond the State of Michigan. Linking this project to other ongoing regional initiatives is critical to the long-term success of both this product and the integrated approach of invasive species management. In addition, invasive species data collection has been included in the overall scope and survey efforts of the Great Lakes Basin Monitoring Inventory: www.glc.org/monitoring/greatlakes/

Working with U.S. and Canadian federal, state/provincial and local agencies the GLC is developing a comprehensive inventory of environmental monitoring programs in the Great Lakes Basin. The inventory will provide a much-needed mechanism for information sharing throughout the region. The Great Lakes Basin Monitoring Inventory is a web-based searchable database that provides users with program descriptions as well as contact information. This "monitoring portal" is designed to improve coordination, collaboration and data sharing throughout the Great Lakes basin including among agencies and across borders.

Making data widely available is another way to ensure the overall success of any management program. With many ongoing national and regional initiatives such as the Great Lakes and Central States Ecological Observatory Network (GLACEO), a National Science Foundation (NSF) funded project, and the Great Lakes Observing System (GLOS), a NOAA-funded effort; invasive species are integral to their overall goals and data acquisition efforts.

GLACEO is the regional node of the National Ecological Observatory Network (NEON). NEON will be a continental scale research instrument consisting of geographically distributed infrastructure, networked via state-of-the-art communications. Cutting-edge lab and field instrumentation, site-based experimental infrastructure, natural history archive facilities and/or computational, analytical and modeling capabilities, linked via a computational network will comprise NEON.

NEON will transform ecological research by enabling studies on major environmental challenges, including invasive species, at regional to continental scales. Scientists and engineers will use NEON to conduct real-time ecological studies spanning all levels of biological organization and temporal and geographical scales. NSF disciplinary and multi-disciplinary programs will support NEON research projects and educational activities. Data from standard measurements made using NEON will be publicly available. Additional information is available online at: http://www.glaceo.org/

GLOS will provide access to information on the climate, meteorology, chemistry, geology, biology and human activities that affect the Great Lakes, their interconnecting waterways and the St. Lawrence River. Data, information and knowledge about the system will be drawn from numerous sources, consolidated, and then made available to meet the needs of many communities, including resource managers, researchers, educators, commercial shippers, recreational boaters, beach users and homeland security interests.

A regional node of the U.S. national Integrated Ocean Observing System (IOOS) initiative, GLOS is a cooperative activity of many U.S. federal and state agencies as well as academic institutions, non-governmental organizations and commercial interests across the region. The development of GLOS will continue to engage Canadian federal agencies and provincial ministries. Additional information is available online at: http://www.glc.org/glos/

The GLC will continue to present and highlight the aquatic invasive species mapping effort at appropriate venues and work to incorporate the data sharing process into the collective regional psyche.