



GREAT LAKES PROTECTION FUND

**A WORKING PAPER:**

**STOPPING INVASIVE SPECIES**  
*(version 3.1)*

DECEMBER, 2005

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*The Fund expects to launch new projects in this area within the next year. We want feedback on the concepts presented, new ideas to consider, and to build a cadre of potential project team members. This paper is a work in progress. It will be continuously revised as ideas and comments are received. Please check our site ([www.glpf.org](http://www.glpf.org)) frequently for updated versions.*

The [Great Lakes Protection Fund](#) is interested in supporting efforts to prevent the introduction of invasive species into the waters of the Great Lakes Ecosystem. The Fund seeks nominations for project team members and ideas for the best set of next investments.

The Opportunity:

The Great Lakes need a man-made immune system. That system needs to be able to sense foreign bodies and activate a response to those foreign bodies that are a threat. Roads, canals, and other transportation systems have breached the Great Lakes natural watershed. These breaches have allowed over 180 previously exotic species to invade and become established in the watershed. Invasions continue at the rate of one new invader about every six months. This march of invading plants, animals, and microorganisms remains perhaps the biggest threat to the ecological integrity of the Great Lakes. Primary vectors for these species include shipping, the canals themselves, and unintentional releases of organisms in commerce.

The Governors of the States that border the Great Lakes have made clear [their priority](#) to “Stop the introduction and spread of invasive species.” Stop means stop—not reduce, slow down or accommodate new invasions. While this goal is ambitious, the question is when and how it will be met, not whether it will be met. The State of Michigan has adopted a law requiring that all ships be “clean” by 2007 and other Great Lakes states are considering measures of their own.

In their [final recommendations](#), the President’s [Great Lakes Regional Collaboration](#) identifies [priority government actions](#) (pdf file) that are estimated to cost basin governments over \$138 million in each of five years. The Collaboration emphasizes regulatory efforts to stop ballast-mediated invasions, enhanced government programs to manage canals and waterways, new laws and funding to address the risks presented by trade in live organisms, establishing a rapid response program to contain new invasions, and expanded education and outreach efforts.

The Fund wishes to support efforts that help frame these governmental responses, provide new tools to enhance their effectiveness, and complement the focus on regulation and rapid response with activities that can immediately anticipate and prevent problems. The Fund will not attempt to take on activities that are identified as government responsibilities.

Several activities could help create a preventative dimension to these elements. First, tools can be further developed to better identify the risks of those species likely to become invaders, better characterize the trade and transportation systems that they contaminate, and the likely sensitivities of potential receiving areas in the basin. Next, new tools and potential actions to minimize those risks can be identified and described. Such tools and actions might include criteria for lock operation, requirements for insurance or performance bonds, codes of practices, and performance criteria for vessels traveling from ports of “high risk” to the Great Lakes. Third, a prevention network can be designed and deployed. This network will be a new way for shippers, carriers, port officials, drinking water suppliers, canal operators and others to use their current positions and authorities to anticipate and prevent new introductions. It is unlikely that any one act or actor can eliminate these invasions. Like the human immune system, a network of agents, acting in a coordinated fashion, is likely to produce the best results.

The Fund is interested in supporting the design and field-testing of new prevention tools that can be used to help reach the Governors' goal of stopping invasions. The Fund is not interested in supporting academic or advocacy research that results in papers or reports that highlight what others might do in a perfect world. Nor is the Fund interested in supporting the risk assessment work as a stand-alone product, preferring that risk assessment and tool development happen in the context of an action-oriented project. Our emphasis is on financing action-oriented teams who will try new approaches and lead by doing. As illustrations the following kind of projects build part of a prevention network:

- A project team could develop and deploy the first ever, real-time information system that identifies invasion risks associated with ships about to enter the Great Lakes. The system would rely upon available information, and most likely be driven by a data-mining system that pulls from existing public and private data sources. Canal operators, insurance companies, and others to identify would manage invasion risks using this information.
- A team of scientists, citizen volunteers, shipping industry experts, port officials, and drinking water suppliers could monitor high priority vectors that might be transporting invasive species, assesses their risks, communicates those risks to public and private sector officials, and acts to minimize threats. This effort could focus on the movements of exotic species within the basin and link to rapid response networks contemplated by the President's Regional Collaboration.
- A project team could create the consumer's guide to Clean Shipping in the Great Lakes. Businesses that ship goods into or out of the Lakes, the ship-brokers and cargo intermediaries that arrange shipment, and their corporate officers and directors could receive information related to the invasive species management practices of the carriers that regularly operate international routes into the basin. The team would develop metrics to evaluate the practices and provide that analysis to the carriers' customers.

#### The Need:

Pioneering, committed leaders are needed to design and carry out this work. Project ideas that are more workable than the above examples are particularly welcome.

The Fund is positioned to support one or more teams of such leaders to test promising approaches. Project teams generally include all of the interests affected by a problem and involved in its resolution. Typically, a Fund-supported team has a dozen or more active members. Team members are experts in one or more of the areas that the project is addressing. In this case, the Fund expects that teams will have members with solid engineering and scientific expertise, legal expertise, commercial shipping or transportation experience, and solid experience with the various communities where the work needs to occur.

While, the exact composition of the project team depends on the exact nature of the work undertaken, the most critical position is that of project manager. This individual manages the

work of the team. She (or he) is the “face” of the project, should be people-oriented in their style, outcome-oriented by nature and committed to building products that are both new and tangible. Leading a project of this nature requires an exceptional individual who is comfortable with business leaders, research scientists, government officials and citizen activists.

Next Steps:

If you are interested in participating in the world’s first effort to create a man-made immune system for an ecosystem—nominate yourself as a team member. If you know of someone else who can play an important role in this work—nominate him or her. Please send your resume and a short description of what you’d like to do (one or two pages please) to [invasives@glpf.org](mailto:invasives@glpf.org)

If you have a specific project idea, please send a summary to the above address. We are particularly interested in what prevention activity you expect to create, who will use it, a sense of your approach, the team you will use, the resources you lack, and an estimate of the financing you require. We are also interested in your reactions to this working paper, especially constructive criticism. Use whatever format you feel best conveys your idea, but keep your concept paper to five pages or less.

Team member nominations and project concepts are welcome at any time, but will be most useful if received by February 15, 2006. The Fund will begin to review them upon receipt.

The Fund expects to support a number of projects related to this idea in 2006. As a general guideline, a typical Fund project: involves a team of 10 to 12 experts usually from a range of organizations (private sector, non-governmental organizations, academics, and governmental organizations); produces results in the first few months and wraps up work in 24 to 36 months; and requires \$275,000 to \$500,000 in financial support. Smaller projects are sometimes supported, but most small requests reflect ideas that are not ready to be deployed at the scale required.

Timeline:

Idea generation, team member nominations, project concepts	through February 06
Team building, project design	through April 06
Proposal development	through June 06
Review and modification	through July 06
Project launch	September 06

## APPENDIX I: Resource Guide

The following resource guide is not an exhaustive summary of aquatic invasive species research. The information provided is meant to serve as representative of the vast amounts of research on invasive species history, characteristics, modeling, risk assessment, transmission, and legislation. It is intended as a dynamic collection. Should you see fit, please provide feedback on additional relevant information to include in this guide.

### General Background Resources

The following list of links is offered to provide an idea of the current resources that exist for cataloging invasive species on multiple levels (i.e. regional, national, global). Additionally, the links provide information on well-established groups of individuals and organizations that have been working with aquatic invasive species issues.

A distributed database system for NIS designed by the Smithsonian Environmental Research Center and the USGS.

<http://www.nisbase.org/nisbase/index.jsp>

Global Invasive Species Program

<http://www.gisp.org/>

National Invasive Species Database

<http://www.invasivespeciesinfo.gov/>

USGS Nonindigenous Aquatic Species Database

<http://nas.er.usgs.gov/>

International Conference on Aquatic Invasive Species

<http://www.icaiss.org/>

Invasives in the Great Lakes

<http://www.glerl.noaa.gov/res/Programs/invasive/>

Sea Grant Program on Invasive Species

<http://www.sgnis.org/>

Great Lakes Panel on Aquatic Nuisance Species

<http://www.glc.org/ans/anspanel.html>

Northeast Midwest Institute – Biological Pollution

<http://www.nemw.org/biopollute.htm>

Review of Fish Species Introduced into the Great Lakes, 1819 – 1975

Great Lakes Fishery Commission Technical Report No. 45, Available at:

[http://www.glfc.org/pubs/pub.htm#tech\\_reports](http://www.glfc.org/pubs/pub.htm#tech_reports)

## Legislation and Policy

The information listed below provides a framework of past, current, and future legislative issues related to invasive species.

Ballast Legislation in Michigan

[http://www.michigan.gov/deq/0,1607,7-135-3307\\_3667\\_8278---,00.html](http://www.michigan.gov/deq/0,1607,7-135-3307_3667_8278---,00.html)

Firestone, Jeremy and J.J. Corbett. (2005) “Coastal and Port Environments: International Legal and Policy Responses to Reduce Ballast Water Introductions of Potentially Invasive Species”. *Ocean Development and International Law*, 36:291-316.

The first several pages of this article provide a solid background of the international legal history and current standards in the shipping industry for ballast water. The final four pages describe a policy support model that draws on a number of variables including ship characteristics, port qualities and ballast treatment technologies employed by a particular vessel.

Commission for Environmental Cooperation. (2003) Closing the Pathways of Aquatic Invasive Species across North America: Overview and Resource Guide.

[http://www.cec.org/pubs\\_docs/documents/index.cfm?varlan=english&ID=51](http://www.cec.org/pubs_docs/documents/index.cfm?varlan=english&ID=51)

Carlton, JT (2001) Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Pew Oceans Commission, Arlington, VA, USA.

National Ballast Water Information Clearinghouse

<http://invasions.si.edu/ballast.htm>

## Biological Invasions – Overview

The articles and reports posted below contain an overview of the biological invasion process in both aquatic and terrestrial ecosystems. This issue has been under study for many years. The information contained below is meant serve as a resource of general invasion biology terms and variables.

Ann K. Sakai,<sup>1</sup> Fred W. Allendorf,<sup>2</sup> Jodie S. Holt,<sup>3</sup> David M. Lodge,<sup>4</sup> Jane Molofsky,<sup>5</sup> Kimberly A. With,<sup>6</sup> Syndallas Baughman,<sup>1</sup> Robert J. Cabin,<sup>7</sup> Joel E. Cohen,<sup>8</sup> Norman C. Ellstrand,<sup>3</sup> David E. McCauley,<sup>9</sup> Pamela O'Neil,<sup>10</sup> Ingrid M. Parker,<sup>11</sup> John N. Thompson,<sup>11</sup> and Stephen G. Weller<sup>1</sup>. “The Population Biology of Invasive Species”. *Annual Review of Ecology and Systematics*. 32:305-332.

Tina Heger, L. Trepl. (2003) “Predicting Biological Invasions”, *Biological Invasions*, 5: 313-21.

This work offers an overview of methodologies to predict biological invasions. They distinguish between four different methods: (1) focus on the invading organism, (2) studying the ecosystem under invasion threat, (3) the relationship between these two factors (key-lock model), or (4) the stages of the invasion process. The organism only model denotes an ideal invader in that none of the characteristics is held by every invader and none of the species has all of the characteristics listed. The researchers found that high ecosystem diversity and lack of disturbances were important factors in identifying invasion susceptible ecosystems. They find key-lock models aid in

examining post invasion rather than predicting, while evaluating the steps and stages of the ecosystem process is more accurate at predicting the likelihood of invasion.

### **Characteristics of Invasive Species**

Since Elton's seminal work on invasives in 1958, biologists have been working to elucidate the 'ideal invader' characteristics. Several studies have found that while there is no magic bullet for all invasions particular variables help to indicate which species are more likely to persist in a foreign environment. The research papers described below provide systematic approaches to deriving such invasability characteristics.

Ricciardi, Anthony and S.K. Atkinson. (2004) "Distinctiveness Magnifies the Impact of Biologic Invaders in Aquatic Ecosystems". *Ecology Letters*, 7: 781-4.

[www.redpath-staff.mcgill.ca/~ricciardi/Ricciardi&Atkinson.pdf](http://www.redpath-staff.mcgill.ca/~ricciardi/Ricciardi&Atkinson.pdf)

This article analyzes the taxonomic relationship between hi- / low-impact invaders and aquatic ecosystems.

Marchetti, Michael P., P.B. Moyle, and R. Levine. (2004) "Invasive Species Profiling? Exploring the Characteristics of Non-native Fishes Across Invasion Stages in California". *Freshwater Biology* 49: 646-61.

The researchers collected data from invasive fish in California to identify social and biologic variables that are predictive of invasion success. This study also distinguishes among the different stages – establishment, spread, and integration – identifying the important characteristics at each phase. The study finds that species with a narrow range of physiological tolerance do not successfully establish as often as ones that are more tolerant. Additionally, analysis of life history characteristics demonstrates that fishes with a prior invasion success are also likely to successfully invade California's aquatic systems (study area).

### **Models: Invasion Probability/Risk**

The following literature attempts to model invasions in the Great Lakes looking at mainly biotic factors. The first two articles focus on how to identify potential invaders. The remaining three papers look at management decisions and the invasion process using zebra mussels to test their model.

Kolar, Cynthia S., and Lodge, David. (2001) "Progress in Invasion Biology: Predicting Invaders". *Trends in Ecology and Evolution* 16: 199-204.

This research develops a variety of predictive invasion models for fish in the Great Lakes. Uses the models to identify the next generation of Great Lakes fish to invade and their likely success. They also note the importance of evaluating the potential invaders at various transitions throughout the invasion process (i.e. transport v. establishment v. spread).

Kolar, Cynthia S. (2004) "Risk Assessment and Screening for Potentially Invasive Fishes". *New Zealand Journal of Marine and Freshwater Research* 38: 391-7.

Review article analyzing screening tools to identify potential invaders.

Bossenbroek, Jonathan M., C.E. Kraft, and J.C. Nekola. (2001) “Prediction of Long-Distance Dispersal Using Gravity Models: Zebra Mussel Invasion of Inland Lakes”. *Ecological Applications* 11: 1778-88.

Develops a model for overland dispersal of invasive species where recreational boaters are the main vector. The study accurately models the migration/infestation of inland lakes by the zebra mussel via recreational boater traffic from Lake Michigan.

Moore, Rebecca, A.M. Macpherson, and B. Provencher. (2005) “A Dynamic Principal-Agent Model of Human-Mediated Aquatic Species Invasions”. *University of Wisconsin – Madison Agricultural and Applied Economics Staff Paper Series*. Paper No. 485.

The team models lake management decisions and subsequent recreational boater choices to describe the likelihood of water milfoil invasion. The paper investigates the optimal management strategies under two different objectives: maximizing boater welfare and minimizing milfoil spread.

Buchan, Lucy A., and D.K. Padilla. (1999) “Estimating the Probability of Long-Distance Overland Dispersal of Invading Aquatic Species”. *Ecological Applications*, 9: 254-65.

The researchers look at the impact of recreational boaters on the transmission of zebra mussels overland and into inland lakes.

### **Invasive Species Modeling: Economic Factors**

While most research focuses on the biological factors of the potential invaders and/or the ecosystem under study, the following papers take an alternative route by analyzing the economic factors that may be involved in facilitating nuisance species invasion.

Perrings, C., M. Willimanson, E.B. Barbier, D. Delfino, S. Dalmazzone, J. Shogren, P. Simmons, and A. Watkinson. (2002) “Biological Invasion Risks and the Public Good: An Economic Perspective”. *Conservation Ecology*, 6: <http://www.consecol.org/vol6/iss1/art1>

This article considers biological invasions as an economic problem in the sense of a weakest-link public good. The researchers suggest an economic solution with two components: incentives to change human behaviors and institutions that support the weakest-links to mitigate the threat of invasion.

Dalmazzone, Silvana. (1999) “Economic Factors Affecting Vulnerability to Biological Invasions”. Draft to the EAERE 2000 Annual Conference.

This draft investigates the role of economic activities in determining a country’s vulnerability to biologic invasions.

Integrated Systems for Invasive Species – Ecological forecasting and risk analysis of nonindigenous species.

<http://www.math.ualberta.ca/~mathbio/ISIS/index.html>

### **Models: Policy Support**

Firestone, Jeremy and J.J. Corbett. (2005) “Coastal and Port Environments: International Legal and Policy Responses to Reduce Ballast Water Introductions of Potentially Invasive Species”. *Ocean Development and International Law*, 36:291-316.



The first several pages of this article provide a solid background of the international legal history and current standards in the shipping industry for ballast water. The final four pages describe a policy support model that draws on a number of variables including ship characteristics, port qualities and ballast treatment technologies employed by a particular vessel.

## Vectors

Transportation vectors are a critical link in the chain of invasion biology. In order to appropriately model and assess invasion risk it is necessary to understand how the species reach the Great Lakes. The following literature resources provide information on these vectors along with advancements to minimize their invasion potential.

Cangelosi A & Mays N. (2005) Summary and Findings of the Ballast Discharge Monitoring Device Workshop. Marrowstone Island Marine Field Station, Olympic Peninsula, Washington, August 12-16, 2002.

<http://www.nemw.org/MarrowstoneReport.pdf>

Carlton JT & Geller JB (1993) Ecological Roulette: The Global Transport of Non-Indigenous Marine Organisms. *Science* 261:78-82.

Carlton JT, Reid DM & van Leeuwen H. (1995) Shipping Study. The Role of Shipping in the Introduction of Non-Indigenous Aquatic Organisms to the Coastal Waters of the United States (other than the Great Lakes) and an Analysis of Control Options. The National Sea Grant College Program/Connecticut Sea Grant Project R/ES-6. Department of Transportation, United States Coast Guard, Washington, DC and Groton, Connecticut. Report Number CG-D-11-95.

GloBallast (2005) GEF/UNDP/IMO Global Ballast Water Management Programme (GloBallast).

<http://globallast.imo.org/>

Colautti, Robert I., A.J. Niimi, C.D.A. van Overdijk, E.L. Mills, K. Holeck, and H.J. MacIsaac. (2001) "Spatial and Temporal Analysis of Transoceanic Shipping Vectors in the Great Lakes". *Proceedings of the Second International Conference on Marine Bioinvasions*, New Orleans, La., April 9-11, 2001, p. 92.

<http://sgnis.org/publicat/macisaac.htm>

Firestone, Jeremy and Corbett, James. (2003) "Maritime Transportation: A Third Way for Port and Environmental Security". *Widener Law Symposium Journal*, 9:419-437.

<http://www.ocean.udel.edu/cms/jfirestone/CorbettFirestonePublication.pdf>

Worldwide Ship Traffic

<http://www.sailwx.info/shiptrack/shiplocations.phtml>

Great Lakes and St. Lawrence Seaway Shipping Network

<http://www.boatnerd.com/default.htm>

## **Warning Systems**

NCCOS, USGS, the Smithsonian Museum, the Bishop Museum. (2005) “A US – Canadian Aquatic Species Inventory and Invasive Species Early Warning System”.

<http://www8.nos.noaa.gov/nccos/npe/projectdetail.aspx?id=69&fy=2005>

<http://trb.org/Conferences/MTS/4B%20Turgeon.pdf>