THE ADVERSE EFFECTS OF AQUATIC INVASIVE SPECIES ON NATIVE COMMERCIAL AND RECREATIONAL FISHERIES OF THE GREAT LAKES AND THE EXACERBATION OF THE PROBLEM BY JUDICIAL RELUCTANCE TO ACT

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I. INTRODUCTION

By the shores of Gitche Gumee,
By the shining Big-Sea-Water,
Stood the wigwam of Nokomis,
Daughter of the Moon, Nokomis.
Dark behind it rose the forest,
Rose the black and gloomy pine-trees,
Rose the firs with cones upon them;
Bright before it beat the water,
Beat the clear and sunny water,
Beat the shining Big-Sea-Water.[1]

Oft used backdrops to literary works,[2] the Great Lakes seem to captivate authors and readers alike with their august sense of majesty. Beneath their surfaces, the Great Lakes are complex ecological wonders whose apparent tranquility mask significant biological and commercial value. We must delve into their waters to truly understand the Great Lakes and the threats posed by invasive species. With but a single brief exception,[3] the entity of the Great Lakes is composed of five freshwater

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[1] HENRY WADSWORTH LONGFELLOW, THE SONG OF HIAWATHA (n.p. 1855), *available at* http://www.gutenberg.org/ebooks/19.

[2] *See* Wisconsin Historical Society, Lake Superior [Origin of Place Name], http://www.wisconsinhistory.org/dictionary/index.asp?action=view&term_id=3740&keyword=origin+name (last visited Feb. 15, 2011). (Indeed, Longfellow's reference to "Gitche Gumee" is his phonetic spelling of "kitchigami," the name used by the indigenous Ojibwe tribe of his time to refer to Lake Superior. Longfellow also alludes to the spectacular ecological biodiversity characteristic of the Great Lakes which becomes the primary reason for curbing the spread of invasive species).

[3] Katharine Q. Seelye, *Superior Is Great. Could Champlain Be Too?*, N.Y. TIMES, March 4, 1998, at A18, *available at* http://query.nytimes.com/gst/fullpage.html?res=9E01E1D61231F937A35750C0A96E958260; *Champlain is Designated a Great Lake*, L.A. TIMES, March 7, 1998, *available at* http://articles.latimes.com/1998/mar/07/news/mn-26409; *Champlain Loses Great Lake Title*, CHICAGO TRIBUNE, available at http://articles.chicagotribune.com/1998-03-24/news/9803250386_1_lake-champlain-great-lakes-national-sea-grant-program (Lake Champlain in Vermont was briefly designated a Great Lake from the period between March 6, 1998 and

lakes located in northeastern North America; these member lakes are Lakes Superior, Michigan, Huron, Erie, and Ontario.[4] Collectively, the Great Lakes are the largest surface freshwater system on the planet and contain over one fifth of the Earth's surface fresh water.[5]

Members of the scientific community are in general consensus that "[t]he origins of the [Great Lakes] watershed are a product of multiple glaciations during the late Cenozoic as well as redirected drainage, particularly during retreat of the last ice sheet."[6] In essence, the Great Lakes started forming about 20,000 years ago and attained their modern level and surface area approximately 3,500-4,000 years ago.[7] Currently, the Great Lakes "occupy basins carved and deepened by the most recent ice sheets and were once filled with glacial meltwater as the ice sheets retreated."[8] As time passed, a plethora of organisms populated the lakes and created their unique ecosystem, which will be discussed subsequently. At this juncture, it suffices to say that there is a great deal of biodiversity contained within the Great Lakes system, and that aquatic invasive species pose a grave risk to the continued survival of a great number of indigenous species.

This Note first touches upon the geological history of the Great Lakes and some relevant background information. Section II provides a more detailed analysis of the unique features of the Great Lakes ecosystem that are at risk. Section III of this Note discusses means by which invasive species spread and harm indigenous species. Section IV examines the National Invasive Species Act of 1996[9] and prior legislation. This section also includes brief case studies of representative members of the following classifications of aquatic invasive species: invertebrate fauna, vertebrate fauna and flora. Section V details the deleterious effects that present aquatic invasive species have or are likely to have on the Great Lakes. It also speculates as to the probable impact of Asian Carp on the Great Lakes, and Lake Michigan in particular. Section VI elaborates on the above discussion of potential consequences of Asian Carp migration into the Great Lakes and contains a cost-benefits analysis to weigh the harms and advantages of regulating waterways through which migrating Asian Carp would travel to reach the Great Lakes. Finally, Section VII attempts to

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March 24, 1998. However, this categorization was rescinded, due in part to public opposition.).

[4] *Great Lakes*, United States Environmental Protection Agency, http://www.epa.gov/glnpo/basicinfo.html (last visited Feb. 15, 2011) [Hereinafter "Great Lakes"].

[5] *Id.*

[6] Grahame Larson & Randall Schaetzl, *Origin and Evolution of the Great Lakes*, 27 (4) J. of Great Lakes Research 518, 518 (2001), *available at* http://www.geo.msu.edu/schaetzl/PDFs/Larson-Great_lakes.pdf.

[7] *About Our Great Lakes – Background*, NOAA Great Lakes Environmental Research Lab, http://www.glerl.noaa.gov/pr/ourlakes/background.html (last visited Feb. 15, 2011).

[8] Carla W. Montgomery, ENVIRONMENTAL GEOLOGY 200 (7th ed. 2006).

[9] The National Invasive Species Act of 1996, 16 U.S.C.S. § 4701 (West 2011).

rationalize the general reluctance of the American judiciary to act regarding Asian Carp.

II. GREAT LAKES ECOLOGY

Although a comprehensive study of the Great Lakes Basin necessarily includes nearby woodlands and other terrestrial biomes located on the flood plain, the coniferous and northern hardwood forests, prairies, and grasslands[10] are not the primary focus of this piece. Because aquatic invasive species are the primary topic of discussion, the biomes most relevant are open water ecosystems and wetland ecosystems.[11] Open water ecosystems are typically located centrally on a body of water while wetland ecosystems are located primarily along the periphery. Among the open water systems recognized by the United States Environmental Protection Agency are "open lake," "coastal shore," and "tributary/ connecting channel."[12] More specific classifications of open water ecosystems include the various strata within the water system. Benthic or pelagic are two such classifications.[13] Among the benthic systems exist further distinctions based on substrate and feeding types.[14]

The Environmental Protection Agency defines wetlands as "areas where the water table occurs above or near the land surface for at least part of the year. When open water is present, it must be less than two metres deep (seven feet), and stagnant or slow moving."[15] All Great Lakes wetlands fall into one of four categories: swamps, marshes, bogs, or fens.[16] Each of these categories of wetlands has unique hydrological and chemical properties that allow for different types of flora and fauna inhabitants.[17]

Swamps are "wet, organically rich mineral soils that are flooded for part or all of the year"[18] and provide suitable habitat for conifers,

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[10] NOAA Great Lakes Environmental Research Lab, *About Out Great Lakes – Ecology*, http://www.glerl.noaa.gov/pr/ourlakes/ecology.html (last visited Feb. 15, 2011).

[11] Henceforth, any reference to the "Great Lakes" refers solely to the aquatic ecosystems within the Great Lake Basin. When speaking of the Great Lakes Basin, "Great Lakes Basin" or "Great Lakes region" will be used.

[12] United States Environmental Protection Agency, Globally Significant Elements of Biodiversity in the Great Lakes Basin, http://www.epa.gov/glnpo/ecopage/glbd/issues/table1.pdf (last visited Feb. 15, 2011).

[13] See *The Aquatic Biome*, University of California Musuem of Paleontology, http://www.ucmp.berkeley.edu/exhibits/biomes/aquatic.php.

[14] See *The Living Element*, Benthos, http://www.aqualex.org/elearning/marine_environment/english/chap3/chap3-2.html.

[15] United States Environmental Protection Agency, The Great Lakes: An Environmental Atlas and Resource Book, http://www.epa.gov/glnpo/atlas/glat-ch2.html (last visited Feb. 7, 2012). [Hereinafter "Environmental Atlas and Resource Book"].

[16] *Id.* ; Great Lakes Information Network, Wetlands in the Great Lakes Region, http://www.great-lakes.net/envt/air-land/wetlands.html (last visited Feb. 7, 2012). [Hereinafter "Wetlands in the Great Lakes Region"].

[17] Environmental Atlas and Resource Book, *supra*, note 15.

[18] *Id.*

hardwoods, and woody shrubs.[19] Marshes form in shallow bodies of standing water[20] and contain semi-aquatic flora such as "rushes, reeds, cattails, and lily pads."[21] Characterized by stagnant pools of water[22] and highly acidic soil,[23] bogs are inhospitable to many species of flora and fauna.[24] For this reason, bogs primarily house Sphagnum moss, black spruce, blueberries, cranberries, orchids, and insectivorous plants.[25] Fens are similar to bogs, but have increased water circulation and are therefore less acidic;[26] the underlying soil is nutrient poor and supports primarily sedges and grasses.[27] While swamps and marshes are typically found in the southern and eastern parts of the Great Lakes Basin, bogs and fens are located in the northern and northwestern regions of the basin.[28]

Due in large part to the variety of natural habitats within the Great Lakes region, over 3,500 discrete species of flora and fauna reside within the Great Lakes Basin.[29] Included among these species are mammals, amphibians, reptiles, birds, and fish unique to the Great Lakes region.[30] A survey performed by the Fish and Wildlife Service "identified 130 globally endangered or rare plant and animal species which inhabit the Great Lakes ecosystem."[31] Undoubtedly, activities such as overfishing, deforestation, and development along water ways are to blame for the plight of some of these animals.[32] Invasive species that threaten to displace and otherwise adversely affect indigenous organisms also complicate the ecological situation.[33] Even absent any outside interference, natural conditions such as food scarcity and varying weather patterns have the potential to disrupt the natural balance. This precious balance must be maintained, for the slightest disturbance to the food chain – particularly in the form of newly

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[19] Wetlands in the Great Lakes Region, *supra*, note 16.

[20] Environmental Atlas and Resource Book, *supra*, note 15.

[21] Wetlands in the Great Lakes Region, *supra*, note 16.

[22] Environmental Atlas and Resource Book, *supra*, note 15.

[23] Wetlands in the Great Lakes Region, *supra*, note 16.

[24] Environmental Atlas and Resource Book, *supra* note 15.

[25] Wetlands in the Great Lakes Region, *supra*, note 16; *Carnivorous and Insectivorous Plants*, Botanical Society of America, http://www.botany.org/Carnivorous_Plants/ (last visited Feb. 7, 2012). (The native Sphagnum moss is harvested and sold commercially as peat moss. Insectivorous plants must prey upon insects because they are unable to derive all of their necessary nutrition from photosynthesis and soil nutrients alone.).

[26] *Id.*

[27] Environmental Atlas and Resource Book, *supra*, note 15.

[28] *Id.*

[29] *About Our Great Lakes – Ecology*, NOAA Great Lakes Environmental Research Lab, http://www.glerl.noaa.gov/pr/ourlakes/ecology.html (last visited Jan. 16, 2011).

[30] *Id.*

[31] *Great Lakes Basin Ecosystem Team - Endangered Species*, United States Fish & Wildlife Service, http://www.fws.gov/midwest/greatlakes/endangeredsp.htm (last visited Jan. 16, 2011).

[32] *Species at Risk*, USGS Great Lakes Science Center, http://www.glsc.usgs.gov/main.php?content=research_risk&title=Species%20at%20Risk0&menu=research (last visited Jan. 17, 2011).

[33] *Id.*

introduced species – is sufficient to wreak havoc within the Great Lakes Basin ecosystem.

III. INVASIVE SPECIES GENERALLY

After developing a primitive understanding of Great Lakes Basin ecosystems, it is possible to understand how external factors exert an influence that alters the status quo. Among the forces that act on an ecosystem are invasive species. Popular misconception adheres to a technically incorrect understanding of what constitutes an invasive species. The layman's definition of an invasive species is likely one that is non-native to the area which it occupies. This description is more apropos of a nonindigenous species, which is properly defined as "an organism (plant, animal, or microbe) found living beyond its historic range, which is usually taken as the area where it evolved to its present form."[34] On the other hand, an invasive species is a "[nonindigenous] species whose introduction does or is likely to cause economic or environmental harm or harm to human health."[35] While all invasive species are nonindigenous, it does not necessarily follow that all nonindigenous species are invasive.[36]

Invasive species are noted for forcibly ejecting indigenous species and filling the newly vacated niche.[37] The primary means by which invasive species effect the displacement of endemic species are: directly preying upon native species, competing with native species for a static amount of resources, causing the loss of genetic uniqueness through hybridization, and serving as a vector for transmittable diseases.[38] The introduction of the Nile Perch (*Lates niloticus*) into African rift lakes

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[34] NOAA Great Lakes Environmental Research Lab, "*Exotic, Invasive, Alien, Nonindigenous, or Nuisance Species: No Matter What You Call Them, They're a Growing Problem*," *available at* http://www.glerl.noaa.gov/pubs/brochures/invasive/ansprimer.pdf. [Hereinafter "Exotic, Invasive, Alien, Nonindigenous, or Nuisance Species."]

[35] *Id.*

[36] For example, aquaculture in Southeast Asia produces tilapia, a cichlid species endemic to Africa, for human consumption. *Oreochromis niloticu niloticus, Nile Tilapia : fisheries, aquaculture*, FishBase, http://fishbase.org/Summary/SpeciesSummary.php?ID=2&genusname=Oreochromis&speciesname=niloticus%20niloticus (last visited Jan. 17, 2011). Thus, the farmed tilapia are nonindigenous species whilst growing, but do not rise to the level of an invasive species unless individuals escape from growing ponds into other bodies of water and adversely affect the local ecosystem. *See* Exotic, Invasive, Alien, Nonindigenous, or Nuisance Species, *supra*, note 34. On the other hand, the distinction is not always so clear. Accepting an evolution based approach to life on the planet, humans no longer residing in the African "cradle of civilization" are necessarily nonindigenous to the regions in which they currently reside. Given the adverse impact that human industrialization and technological advances have had on the environment, it is also possible to consider *Homo sapiens* an invasive species. Although it is not necessary to the subject matter of this paper, I posit that mankind is an invasive species and has had the most widespread deleterious impact on the planet of any invasive species.

[37] *See NatureServe: Invasive Species*, NatureServe, http://www.natureserve.org/consIssues/invasivespecies.jsp (last visited Jan. 17, 2011). [Hereinafter "NatureServe: Invasive Species."]

[38] *Id.*

demonstrates the significant harm caused through direct predation.[39] Brought into the region by the aquaculture industry, *L. niloticus* has caused the extinction of over one hundred species of native cichlids.[40] Invasive North American gray squirrels are displacing red squirrels endemic to Britain by virtue of their ability to better forage for nuts and other food items.[41] Genetic distillation can be seen in the aftermath of the introduction of North American mallard ducks to the Hawaiian Islands.[42] Mallards, which were introduced to create a commercial hunting industry, interbred with endangered endemic Hawaiian ducks, thereby creating genetically impure hybrids.[43] Although a widely publicized example of disease transmission by an invasive species has not occurred recently, the Bubonic Plague that affected Europe thrice in the past centuries is among the most prominent examples of such harm.[44] Similar outbreaks of plague occurring in Uganda have been attributed to the accidental introduction of roof rats by freighter and cargo ships.[45] These invasive rats carried fleas, which in turn carried the Bubonic Plague bacterium that inflicted humans in the area.[46]

Invasive species are able to thrive due in large part to the fact that they are often conveyed in isolation from other organisms in their natural food chain.[47] Species adopted to prey upon invasive species in their native habitat are often absent from the invaded environment, resulting in decreased pressure on invasive species from the higher tiers of the food chain. On a related note, prey species differ between the native and invaded environments, and the most prolific invasive species are able to adapt to this change. Further limiting factors are natural fluctuations in season temperatures and conditions which are present in native environments but at

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39 Daniel Simberloff, *Introduced Species: The Threat to Biodiversity & What Can Be Done*, ACTIONBIOSCIENCE, *available at* http://www.actionbioscience.org/biodiversity/simberloff.html. [Hereinafter "Simberloff"].

[40] *Id.*; Frank J. Rahel, *Homogenization of Freshwater Faunas*, 33 ANN. REV. OF ECOLOGY & SYSTEMATICS 291, 291-2 (2002), *available at* http://limnology.wisc.edu/courses/zoo510/jvz%20readings/Rahel%20Ann%20Rev02.pdf. (In the case of the Nile Perch, "extinction" of the endemic cichlid species is more accurately characterized as the extirpation of the species from their native environments. Due to the ornamental nature of some of these cichlids, domestic individuals exist in home and public aquaria).

[41] Simberloff, *supra*, note 39.

[42] *Id.*

[43] *Id.* Scientists have also suggested that *Homo sapiens* is responsible for the extinction of Neanderthals, and brought about their extinction by interbreeding that eventually caused the loss of genetic identity. Ewen Callaway, *Neanderthal genome reveals interbreeding with humans*, NewsScientist (May 6, 2010, 19:00 PM), http://www.newscientist.com/article/dn18869-neanderthal-genome-reveals-interbreeding-with-humans.html.

[44] Jeff N. Borchert, et al., *Invasive Rats and Bubonic Plague in Northwest Uganda*, *in* MANAGING VERTEBRATE INVASIVE SPECIES (2007), *available at* http://digitalcommons.unl.edu/nwrcinvasive/3/.

[45] *Id.*

[46] *Id.* Interestingly, nearly all of the aforementioned species were brought to the areas in which they are invasive either intentionally or accidentally by human activity, further bolstering my assertion that humans are the worst invasive species known to man.

[47] NatureServe: Invasive Species, *supra*, note 37.

times absent in the invaded environment. For example, when a plant with a growing cycle limited by the onset of winter in its natural environment is introduced to a locale that has a warm climate year round, the invasive species can be expected to have no neatly delineated growing season. Scientific studies summarize these factors succinctly: "[u]nchecked by natural controls, invasive species are spreading across our lands and through our waterways, and wreaking havoc with already fragile native species and ecosystems."[48]

For the most part, invasive species are condemned for their adverse impacts on agriculture, ranching, forestry, and industry, but they also pose a dire threat to biodiversity and ecological stability within the areas in which they supplant local species.[49] Peer reviewed scientific studies have established that invasive species are the second-leading threat to imperiled indigenous species, second only to habitat destruction caused by human activity.[50] Furthermore, "introduced species are a greater threat to native biodiversity than pollution, harvest, and disease combined."[51] Collectively, invasive species are estimated to inflict damages in excess of $137 billion to the United States economy alone,[52] and more than $1.4 trillion globally – roughly equivalent to five percent of the global economy.[53]

IV. THE NATIONAL INVASIVE SPECIES ACT

Because of the tremendous capacity for environmental and economic harm by invasive species, Congress passed the Nonindigenous Aquatic Nuisance Prevention and Control Act ("NANPCA") in 1990.[54] Although the act purported to apply to aquatic invasive species generally, the primary focus of the act seemed to rest on the zebra mussel (*Dreissena polymorpha*), which had already been introduced into waters of the United States by ballast water collected in Russia.[55] The stated purposes of the Act were: (1) "to prevent unintentional introduction and dispersal of nonindigenous species into waters of the United States";[56] (2) "to

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[48] *Id.*

[49] *Id.*

[50] *Id.*; *Simberloff, supra*, note 39.

[51] *Simberloff, supra*, note 39.

[52] *Id.*

[53] *Invasive Species – Invasive Species Initiative, Invasive Species Education and biodiversity*, The Nature Conservancy, http://www.nature.org/initiatives/invasivespecies/ (last visited Jan. 17, 2011).

[54] The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, 16 U.S.C.A. § 4701 (1990). [Hereinafter "NANPCA."]

[55] 16 U.S.C.A. § 4701(b)(5) (1990) (This emphasis is evident in the fifth enumerated purpose of the act: "to establish a program of research and technology development and assistance to States in the management and removal of zebra mussels." All of the other stated purposes refer generally to nonindigenous aquatic nuisance species, but this purpose relates only to zebra mussels.); *see generally* Ronald W. Griffiths, et al., *Distribution and Dispersal of the Zebra Mussel (Dreissena polymorpha) in the Great Lakes Region*, 48 CANADIAN J. OF FISHERIES & AQUATIC SCI. 1381 (1991).

[56] 16 U.S.C.A. § 4701(b)(1) (1990).

coordinate... research, prevention[,] control, information dissemination and other activities regarding...aquatic nuisance species";[57] (3) "to develop and carry out environmentally sound control methods to prevent, monitor and control unintentional introductions of nonindigenous species. . . .";[58] and (4) "to understand and minimize economic and ecological impacts of nonindigenous aquatic nuisance species that become established. . . ."[59]

Pathways to achieving these goals include federal oversight and support for the individual states in the effort to deter and curb further spread of zebra mussels.[60] In response to the finding that "the discharge of untreated water in the ballast tanks of vessels... results in unintentional introductions of nonindigenous species to fresh, brackish, and saltwater environments,"[61] private actors within the shipping industry and independent scientists sought to develop technology to curb the spread of invasive species through ballast discharge.[62] While technology has developed rather slowly in the two decades since the passage of NANPCA, several feasible methods of preventing unintentional introduction of invasive species through ballast water have emerged. These methods include UV filtration of ballast water, heating ballast water prior to discharge to kill any biotic organisms, and increasing salinity of ballast water to the same ends, among others.[63] At present, these methods are scientifically feasible, but cost prohibitive, and thus unlikely to be voluntarily implemented by industry actors.[64]

In 1996, Congress enacted the National Invasive Species Act ("NISA"),[65] which sets forth scientific findings made subsequent to the passage of NANPCA and broadens the scope of the legislation to include more aquatic invasive species. NISA tracked the progression of zebra mussels through the freshwater systems of North America from their 1988[66] introduction until the time of NISA's enactment.[67] Congress found that *D.*

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[57] 16 U.S.C.A. § 4701(b)(2) (1990).

[58] 16 U.S.C.A. § 4701(b)(3) (1990).

[59] 16 U.S.C.A. § 4701(b)(4) (1990).

[60] *See* 16 U.S.C.A. § 4701(b)(2) (1990).

[61] 16 U.S.C.A. § 4701(a)(1) (1990).

[62] *See generally* Corrina Chase, Christine Reilly, and Judith Pederson, "MARINE BIOINVASIONS FACT SHEET: Ballast Water Treatment Options," *available at* http://massbay.mit.edu/resources/pdf/ballast-treat.pdf.

[63] *Id.*

[64] *Id.*; N. Dobroski, L. Takata, C. Scianni, and M. Falkner, "Assessment of the Efficiency, Availability and Environmental Impacts of Ballast Water Treatment Systems for Use in California Waters," December 2007, *available at* http://groups.ucanr.org/Ballast_Outreach/files/49504.doc.

[65] The National Invasive Species Act of 1996, 16 U.S.C.A. § 4701 (West 2011). [Hereinafter "NISA."]

[66] 58 Fed.Reg. 18330, 18330 (Apr. 8, 1993) ("In June 1988, this small bivalve mollusk, native to the Black, Azov, and Caspian Seas in [E]astern Europe, was discovered on the Canadian side of Lake Saint Clair in the Great Lakes.")

[67] 16 U.S.C.A. § 4701(a) (West 2011).

polymorpha had spread through the Great Lakes and adjacent waters,[68] into Lake Champlain,[69] and into the Chesapeake Bay watershed.[70] NISA also reiterated NANPCA's earlier finding that the amount of damages expected nationally from the zebra mussel infestation between 1990 and 2000 was estimated to be $5,000,000,000.[71]

In addition to reiterating NANPCA's focus on zebra mussels, NISA discussed aquatic invasive species in more generalized terms. Congress set forth an expanded finding that nonindigenous species "may compete with or prey upon native species of plants, fish, and wildlife, [and] may carry diseases or parasites that affect native species. . . ."[72] To this end, NISA mentioned other invertebrate invasive species,[73] invasive species of vertebrate fauna,[74] and invasive flora species[75] of particular concern. These organisms are discussed briefly below.

A. Invertebrate Fauna

As noted above, both NANPCA and NISA place emphasis on the adverse impact of invasive zebra mussels on the nation's freshwater ecosystem. Zebra mussels are filter feeders and harm native species by virtue of their ability to filter water at a rate faster than that of native species.[76] Native species in competition with zebra mussels for plankton suspended in the water column include native bivalve species and filter feeding fishes.[77] Decreased plankton levels in bodies of water also decreases turbidity and allows for deeper sunlight penetration, thereby permitting more abundant vegetative growth, which in turn can decrease the amount of dilute oxygen in the water.[78] Zebra mussels secrete byssal threads, which are used to anchor the mussel to objects.[79] This permits zebra mussels to colonize any submerged object and becomes especially troublesome when water intake pipes are the surface upon which mussels

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[68] 16 U.S.C.A. § 4701(a)(3)(A)-(C) (West 2011) (The bodies of water listed include the Mississippi River drainage, the Arkansas River in Oklahoma, and the Hudson River.)

[69] 16 U.S.C.A. § 4701(a)(5) (West 2011).

[70] 16 U.S.C.A. § 4701(a)(6) (West 2011).

[71] 16 U.S.C.A. § 4701(a)(4) (West 2011).

[72] 16 U.S.C.A. § 4701(a)(2) (West 2011).

[73] 16 U.S.C.A. § 4701(a)(11)(A)-(D) (West 2011).

[74] *See* 16 U.S.C.A. § 4701(a)(4) (West 2011).

[75] *See* 16 U.S.C.A. § 4701(a)(12) (West 2011).

[76] *Zebra mussel Invasive species: Minnesota DNR*, Minnesota Department of Natural Resources, http://www.dnr.state.mn.us/invasives/aquaticanimals/zebramussel/index.html (last visited Jan. 17, 2011). [Hereinafter "*Zebra mussel - Invasive species.*"]

[77] *See* Simberloff, *supra,* note 39 ("At least thirty freshwater mussel species are threatened with extinction by the zebra mussel."); Hugh J. MacIsaac, *Potential Abiotic and Biotic Impacts of Zebra Mussels on the Inland Waters of North America*, 36 AM. ZOOLOGIST 287, 288 & 293 (1996), *available at* http://icb.oxfordjournals.org/content/36/3/287.abstract.

[78] *See Zebra mussel - Invasive species*, *supra*, note 76.

[79] *Id.*

grow.[80] Further increasing the risk of damage is the exceptional fecundity of the zebra mussel – females are capable of spawning 100,000 to 500,000 eggs per year.[81]

NISA also mentions several coastal invasive species "that have the potential for causing adverse economic and ecological effects":[82] "the brown mussel (*Perna perna*) that has become established along the Gulf of Mexico";[83] "the mitten crab (*Eriocher sinensis*) that has become established on the Pacific Coast";[84] and "the green crab (*Carcinus maenas*) that has become established in the coastal waters of the Atlantic Ocean."[85] The brown mussel, although a member of the same taxonomic class, is fundamentally different from the zebra mussel in its adverse effects on native species and the environment.[86] As a marine species, competition with endemic organisms for plankton is a lesser concern, as transoceanic currents transport suspended matter across significant distances.[87] The primary adverse effect of brown mussels is via uncontrolled growth on man-made structures – the Gulf States Marine Fisheries Commission determined that brown mussels accumulate in concentrations sufficient to sink navigation buoys.[88]

While occupying different regions of the coast, mitten crabs and green crabs have similar effects upon indigenous wildlife. Mitten crabs are a food species from Asia whose means of transmission to North American waters is unknown.[89] *E. sinensis* is a non-swimming benthic species with a propensity to burrow into the substrate, thereby accelerating bank erosion and instability.[90] Furthermore, mitten crabs are an omnivorous species that feed indiscriminately on a wide range of organisms, allowing them to out-

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[80] *Id.*

[81] *Id.*

[82] 16 U.S.C.A. § 4701(a)(11) (2011).

[83] 16 U.S.C.A. § 4701(a)(11)(C) (2011).

[84] 16 U.S.C.A. § 4701(a)(11)(A) (2011).

[85] 16 U.S.C.A. § 4701(a)(11)(B) (2011).

[86] *ITIS Standard Report Page: Dreissena polymorpha*, Integrated Taxonomic Information System, http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=81339 (last visited Feb. 9, 2012); *ITIS Standard Report Page: Perna perna*, Integrated Taxonomic Information System, http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=568077 (last visited Feb. 9, 2012).

[87] Philip F. Sexton and Richard D. Norris, *Dispersal and biogeography of marine plankton: Long-distance dispersal of the foraminifer Truncorotalia truncatulinoides*, 36(11) GEOLOGY 899 (2008).

[88] Daniel J. Sheehy and Susan F. Vik, *The Role of Constructed Reefs in Non-indigenous Species Introductions and Range Expansions*, 36(1) ECOLOGICAL ENGINEERING 1, 4-5 (2010).

[89] *Guide to Marine Invaders in the Gulf of Maine: Eriocher sinensis*, Salem Sound Coastwatch, http://www.salemsound.org/mis/MISEriocheir.pdf (last visited Feb. 18, 2011) [Hereinafter "Guide to Marine Invaders in the Gulf of Maine: Eriocher sinensis"]; *see* Amy J. Benson and Pam L. Fuller, *Nonindigenous Crustaceans in the United States*, USGS Great Lakes Science Center, http://fl.biology.usgs.gov/posters/Nonindigenous/Nonindigenous_Crustaceans/nonindigenous_crustaceans.html (last modified Jan. 7, 2011).

[90] Guide to Marine Invaders in the Gulf of Maine: Eriocher sinensis, *supra*, note 89.

compete native crab species for a finite amount of resources.[91] Green crabs, native to the North Atlantic coast of Europe and the North African coast, are believed to have arrived in North American as early as 1817.[92] *C. maenas* "is one of New England's dominant benthic predators, feeding on clams, oysters, crabs and mollusks [and] is often blamed for the collapse of Maine's soft shell clam industry."[93]

B. Vertebrate Fauna

NISA references two invasive fish species, the round goby (*Neogobius melanostomus*) and Eurasian Ruffe (*Gymnocephalus cernuus*).[94] The round goby is a benthic species indigenous to the Black and Caspian Sea area of Eastern Europe and were first observed in the Great Lakes waterways in 1990.[95] *N. melanostomus* are capable of occupying shallow and quick-moving bodies of water unsuitable for other piscine species.[96] It is a predatory fish that competes with native species for the same food sources, but its diet also includes the zebra mussel, which would not otherwise be preyed upon.[97] While this may seem like a redeeming quality, round gobies are largely ineffective at stopping or retarding the spread of zebra mussels.[98] Instead, *N. melanostomus* serves simply as a mechanism by which the bioaccumulation of toxins is expedited; fish that prey primarily upon round gobies consume a higher concentration of contaminants than do predators that target other fish species.[99]

The Eurasian Ruffe is a "small but aggressive exotic percid species native to Eurasia"[100] that was first introduced "in the early 1980's in ballast water discharges."[101] Due to their rapid rate of population growth and minimal population doubling time, *G. cernuus* competes successfully with

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[91] *Id.*

[92] *Guide to Marine Invaders in the Gulf of Maine: Carcinus maenas*, Salem Sound Coastwatch, http://www.salemsound.org/mis/MISCarcinus.pdf (last visited Feb. 18, 2011).

[93] *Id.*

[94] 16 U.S.C.A. § 4701(a)(4) (West 2011).

[95] *Invasive Fish: Round Goby*, USGS Great Lakes Science Center, http://www.glsc.usgs.gov/main.php?content=research_invasive_goby&title=Invasive%20Fish0&menu=research_invasive_fish (last visited Jan. 17, 2011) [Hereinafter "Invasive Fish: Round Goby"].

[96] *Id.* at 1; *See* Danielle M. Crosier, et al., *Round Goby - Neogobius melanostomus*, USACE Engineer Research and Development Center, 5-6, http://el.erdc.usace.army.mil/ansrp/neogobius_melanostomus.pdf.

[97] *Invasive Fish: Round Goby*, *supra*, note 95.

[98] *Id.* at 2; *Harmful Aquatic Hitchhikers: Fish: Round-Goby*, Protect Your Waters, http://www.protectyourwaters.net/hitchhikers/fish_round_goby.php, (last visited Feb. 18, 2011).

[99] *Invasive Fish: Round Goby*, *supra,* note 95.

[100] *Invasive Fish: Eurasian Ruffe*, USGS Great Lakes Science Center, 1, http://www.glsc.usgs.gov/main.php?content=research_invasive_ruffe&title=Invasive%20Fish0&menu=research_invasive_fish (last visited Jan. 17, 2011) [Hereinafter "Invasive Fish: Eurasian Ruffe."].

[101] 16 U.S.C.A. § 4701(a)(10) (West 2011).

endemic species with similar diets and feeding habits.[102] Eurasian Ruffe are blamed for "caus[ing] severe declines in populations of other species of fish in Duluth Harbor (in Minnesota and Wisconsin)."[103]

C. Aquatic Flora

The aquatic flora species mentioned as being of special concern in NISA are Eurasian watermilfoil (*Myriophyllum spicatum*), hydrilla (*Hydrilla verticillata*), water hyacinth (*Eichhoria crassipes*), and water chestnut (*Trapa natans*).[104] Eurasian watermilfoil, a plant of Eurasian origin, was commonly used as an aquarium plant.[105] Like *M. spicatum*, hydrilla was intentionally imported to the country through the aquarium trade.[106] Water hyacinth is a South American plant that became widely used in water gardens; it has since become invasive in many Southern states.[107] Water chestnuts are an Asian food crop, likely introduced for aquaculture but subsequently escaped cultivation; it is found primarily in the northeastern states.[108]

All four named invasive plant species cause similar problems for both the natural and human environment. All are floating plants characterized by extremely rapid growth, often prolific to the point of occupying a majority of a waterway's surface.[109] This allows for the invasive flora to gain solar priority over submerged plant species, thereby displacing the endemic flora.[110] Their rapid growth drastically depletes the levels of dissolved oxygen in the water column, leading to the asphyxiation of fishes.[111] The combination of surface coverage and rapid oxygen usage creates stagnant bodies of water low in oxygen[112] – the ideal breeding

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[102] *Invasive Fish: Eurasian Ruffe*, *supra* note 100, at 1.

[103] 16 U.S.C.A. § 4701(a)(10)(A) (West 2011).

[104] 16 U.S.C.A. § 4701(a)(12) (West 2011).

[105] *General Information about Eurasian Watermilfoil*, State of Washington Department of Ecology, http://www.ecy.wa.gov/programs/wq/plants/weeds/milfoil.html (last visited Feb. 20, 2011) [Hereinafter "Eurasian Watermilfoil"].

[106] *Non-native Invasive Freshwater Plants Hydrilla (Hydrilla verticillata)*, State of Washington Department of Ecology, http://www.ecy.wa.gov/programs/wq/plants/weeds/hydrilla.html (last visited Feb. 20, 2011) [Hereinafter "Hydrilla"].

[107] *Non-native Invasive Freshwater Plants - Water Hyacinth (Eishornia crasspipes)*, State of Washington Department of Ecology, http://www.ecy.wa.gov/programs/wq/plants/weeds/hyacinth.html (last visited Feb. 20, 2011) [Hereinafter "Water Hyacinth"].

[108] Charles R. O'Neill, Jr., *Water Chestnut (Trapa natans) in the Northeast*, 2, New York Sea Grant, *available at* http://www.waterchestnut.org/Assets/PDF/wcfactsheet.pdf; *Water Chestnut: An Exotic Invasive Aquatic Plant*, Massachusetts Department of Conservation and Recreation, http://www.mass.gov/dcr/watersupply/lakepond/factsheet/Water%20Chestnut.pdf [Hereinafter "Water Chestnut"].

[109] *Eurasian Watermilfoil, supra*, note 105; *Hydrilla, supra*, note 106; *Water Hyacinth, supra*, note 107; *Water Chestnut, supra*, note 108.

[110] *See id.*

[111] *Id.*

[112] Eurasian Watermilfoil, *supra*, note 105; Water Chestnut, *supra*, note 108.

habitat for mosquitoes capable of serving as vectors for malaria and West Nile disease. Finally, dense mats of aquatic foliage on the water surface decreases the number of recreational uses to which the waterway is suited and detracts from the landscape aesthetically, decreasing the property value of adjacent parcels.[113]

V. IMPACT OF AQUATIC INVASIVE SPECIES ON THE GREAT LAKES

Although, as of 2007, over 180 invasive species are estimated to have permeated the Great Lakes ecosystem,[114] two groups received the most publicity due to the increased risk and propensity for successful colonization posed by these organisms. The first group are invasive mussels. Invasive mussels are already well established within the Great Lakes, so the current focus is on how to exterminate the current infestations and prevent their spread to adjacent waterways.

The second group of aquatic invasive species garnering nationwide concern is that of the Asian carp. Although Asian carp are the cause of grave concern, there is not yet definitive proof that they have breached the boundaries of the Great Lakes; what has been proven is that there exists breeding populations in adjoining waterways. Scientists are most interested in developing methods to prevent the spread of Asian carp into the Great Lakes ecosystem. Both groups of aquatic invasive species are discussed below.

A. Invasive Mussel Species

The dominant species of invasive mussels contained within the Great Lakes are the previously mentioned zebra mussel, and the quagga mussel (*Dreissena rostriformis bugensis*). Quagga mussels are believed to have been introduced into the Great Lakes via ballast water in 1989 and are similar to zebra mussels, as both are members of the same genus.[115] The body of scientific evidence, however, suggests that the quagga mussel may be even better suited to spread throughout the Great Lakes than are zebra

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[113] Eurasian Watermilfoil, *supra*, note 105; Hydrilla, *supra*, note 106; Water Chestnut, *supra*, note 108.

[114] *NOAA Great Lakes Aquatic Nonindigenous Species Information System*, National Oceanographic and Atmospheric Administration, http://www.glerl.noaa.gov/res/Programs/glansis/glansis.html (last visited Feb. 20, 2011). (Although the source states that "over 180 nonindigenous species" can be found within the Lakes, the statement that reproducing populations are found strongly suggest that the proper characterization of the aforementioned 180 species is as invasive – and not merely nonindigenous – species).

[115] *Quagga Mussels*, Michigan Sea Grant, http://www.miseagrant.umich.edu/downloads/ais/fs_quagga_mussel.pdf [Hereinafter "MiSG Quagga Mussels"]; *Quagga Mussel (Dreissena rostriformis)*, United States Geological Survey, http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=95 (last visited Jan. 18, 2011) [Hereinafter "USGS Quagga Mussels"].

mussels, which are already quite prolific.[116] Quagga mussels are able to survive at depths of up to ninety feet, while zebra mussels are typically found at depths of fifty feet or shallower.[117] *D. r. bugensis* are also able to survive and reproduce in cooler waters than are zebra mussels.[118] While zebra mussels typically use byssal threads to adhere to a solid surface,[119] quagga mussels are capable of colonizing and thriving on sandy or silty substrates that would be inhospitable to zebra mussels.[120]

The sole biological advantage zebra mussels have is their ability "to produce more byssal threads than quagga mussels, enabling them to attach more securely to underlying material."[121] However, this distinction makes little difference as far as colonization of the Great Lakes is concerned, as there typically are not high velocity water currents within the Lakes.[122] Although scientific consensus suggests that quagga mussels will eventually supplant zebra mussels as the dominant invasive mussel species in the Great Lakes,[123] this eventuality has not yet occurred, and quagga and zebra mussels currently act in tandem towards a common end.

Quagga mussels act on the Great Lakes ecosystem in a manner similar to that of zebra mussels: "[q]uaggas are prodigious water filterers, removing substantial amounts of phytoplankton and suspended particulate from the water."[124] Collectively, the invasive mussel species of the Great Lakes are able to severely diminish the level of phytoplankton in the water column, having the dual effect of increasing water clarity and depleting food sources for endemic animals.[125] As turbidity is decreased, vegetative growth is able to extend into the deeper reaches of the Great Lakes, potentially overwhelming the ecological balance through an increased demand for oxygen.[126]

As noted above, zebra and quagga mussels are both capable of secreting byssal threads, which allow them to attach to submerged structures. This becomes especially problematic when the invasive mussels colonize on water intake pipes used by Great Lakes industry and local municipalities to draw cooling and drinking water, respectively.[127] Mussel

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[116] *See* MiSg Quagga Mussels, *supra*, note 115.

[117] MiSG Quagga Mussels, *supra*, note 115.

[118] *Id.*

[119] Zebra mussels - Invasive species, *supra*, note 76.

[120] MiSG Quagga Mussels, *supra*, note 115.

[121] *Zebra Mussels Hang on While Quagga Mussels Take Over*, SCIENCE DAILY, June 14, 2009, *available at* http://www.sciencedaily.com/releases/2009/06/090612092733.htm [Hereinafter "Zebra Mussels Hang on While Quagga Mussels Take Over"].

[122] *See Id.*

[123] *Id.*

[124] USGS Quagga Mussels, *supra*, note 115.

[125] *Id.*

[126] *See generally Eurasian Watermilfoil, supra*, note 105; *Hydrilla, supra*, note 106; *Water Hyacinth, supra*, note 107; *Water Chestnut, supra*, note 108.

[127] Daniel J. Sheehy and Susan F. Vik, *supra,* note 88 at 1, 4-5.

colonization is also troublesome when the structures colonized are piers and boat launches – this severely curtails the number of the Lakes' recreational uses.[128]

Studies that predict quagga dominance of the Great Lakes suggest that "[q]uagga mussels may be the reason Diporea, a small shrimp-like species that serves as a food source for larger fish, is no longer abundant. The whitefish that feed on Diporea are growing to less than half of their expected size."[129] The ability of invasive mussel species to outcompete endemic organisms of the same trophic level causes a decrease in the abundance of not only those organisms, but of any species of higher trophic levels that feed primarily upon the outcompeted species.[130] This could have unpredictable effects on tertiary and quaternary predators within the Great Lakes food chain, as predator-prey relationships can rarely be neatly delineated.

As filter feeders, zebra and quagga mussels are essentially vessels through which rapid bioacccumulation of dilute toxins occur.[131] Studies suggest "quagga mussels accumulate organic pollutants within their tissues to levels more than 300,000 times greater than concentrations in the environment."[132] When the invasive mussels are preyed upon – typically by the invasive round goby – the predator ingests all of the contained contaminants and further concentrates the toxins in its own flesh.[133] Any tertiary predators, such as native perch, that prey upon round gobies that feed primarily on invasive mussels are at an increased risk of succumbing to poisoning.[134] Recent studies show that invasive mussels and round gobies combine to form a conduit to transfer contaminants to Great Lakes fish species of commercial and recreational value.[135] A similar effect has been observed in aquatic birds that prey upon round gobies; the mussel-goby pairing is blamed for the death of over 100,000 birds – including hundreds of common loons, a threatened species in Michigan – over the

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[128] *Id.*

[129] Zebra Mussels Hang on While Quagga Mussels Take Over, *supra*, note 121.

[130] *Changes in Lake Huron's Ecosystem and Foodweb Cause Chinook Salmon Collapse*, Michigan Department of Natural Resources, (2010), http://www.michigan.gov/documents/LakeHuronNewEcosystem-foodweb_122463_7.pdf. (Invasive mussel species are able to outcompete alewife for a finite amount of plankton in Lake Huron, leading to drastic decreases in alewife population size. The loss of alewifes, a primary food species for Chinook salmon, led to the collapse of the Chinook salmon population in Lake Huron).

[131] USGS Quagga Mussels, *supra*, note 115; *see also* J.M. Roper, et al., *Bioaccumulation of toxicants in the zebra mussel, Dreissena polymorpha, at the Times Beach Confined Disposal Facility, Buffalo, New York*, 94(2) ENVTL. POLLUTION 117 (1996).

[132] USGS Quagga Mussels, *supra*, note 115.

[133] *Invasive Fish: Round Goby*, *supra*, note 95.

[134] *Id.*

[135] *Invasive fish and mussels team up to transfer toxic substances into Great Lakes walleyes*, SCIENCE DAILY (April 9, 2010) http://www.sciencedaily.com/releases/2010/04/100409162726.htm. (Specifically, the study shows that zebra mussels and round gobies combine to transfer PCBs to Saginaw Bay walleyes).

past fifteen years.[136]

There is little doubt that invasive mussel species have had a resounding impact on the Great Lakes ecosystem. Although these species have devastated some species within the Lakes, they have not yet caused extinctions.[137] The spread of zebra and quagga mussels throughout the Lakes and into connected waterways must be stopped before irreversible damage does occur.

B. Asian Carp

While the spread of "Asian carp" is decried as the next significant invasive species disaster to affect the Great Lakes, the term refers not to a single species, but to bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*) collectively. Both species were imported by catfish farmers in the 1970's to remove algae and other vegetation from their ponds but subsequently dispersed in the 1990's during regional floods.[138] After their escape, Asian carp established breeding populations in the Mississippi River and Illinois River, which connects the Mississippi to Lake Michigan.[139] The steady northward progression of *H. nobilis* and *H. molitrix* is troublesome, as their inevitable destination would seem to be the Great Lakes system.

Measures taken to curb the migration of Asian carp into the Great Lakes include the construction of electric fences in the Chicago Sanitary and Ship Canal at the cost of approximately $20 million.[140] However, these drastic measures have proved largely ineffective, as Asian carp have demonstrated they are capable of passing through the electric barriers on their journey towards the Great Lakes.[141] A press release issued by the Asian Carp Regional Coordination Committee announced that a bighead carp was caught in Lake Calumet, above the U.S. Army Corps of Engineers' Electric Barrier System and a mere six miles from Lake Michigan.[142]

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[136] Joel Hood, *Lake invaders may be killing birds*, CHI. TRIB., November 27, 2010, *available at* http://articles.chicagotribune.com/2010-11-27/news/ct-met-lake-michigan-bird-deaths-20101127_1_zebra-and-quagga-mussels-common-coast-research-invasive-species.

[137] Jessica Gurevitch and Dianna K. Padilla, *Are invasive species a major cause of extinctions?*, 19(9) TRENDS IN ECOLOGY & EVOLUTION 470, 471 (2004). ("[T]o date, no species have gone extinct as a result of the introduction of zebra mussels.")

[138] United States Environmental Protection Agency, *Asian Carp and the Great Lakes*, http://www.epa.gov/greatlakes/invasive/asiancarp/ (last visited Jan. 18, 2011). [Hereinafter "Asian Carp and the Great Lakes."]

[139] *Id.*

[140] Monica Davey, *Be Careful What You Fish For*, N.Y. TIMES, December 13, 2009, at WK3, *available at* http://www.nytimes.com/2009/12/13/weekinreview/13davey.html. [Hereinafter "Be Careful What You Fish For."]

[141] Monica Davey, *Asian Carp Found Near Great Lakes*, N.Y. TIMES, June 24, 2010, at A17, *available at* http://www.nytimes.com/2010/06/24/us/24carp.html.

[142] Chris McCloud and Katie Steiger-Meister, *"Bighead Asian Carp Found in Chicago Area Waterway System,"* Asian Carp Regional Coordination Committee, June 23, 2010, at 1, *available at*

Although Asian carp have not yet been spotted within the Great Lakes themselves, their spread seems inevitable, so analysis of the impacts of Asian carp upon the Great Lakes ecosystem will be performed under the assumption that bighead carp, silver carp, or both will gain entry into the Great Lakes.

Because bighead and silver carp are biologically similar – they are members of the same genus – their impact on the Great Lakes ecosystem will be nearly identical. Both are filter feeders that have evolved the means to feed continuously while swimming; as water is forced across the gills, surface capillaries capture dissolved oxygen and gill rakes capture plankton.[143] Asian carp attain large sizes – with maximum weights of over 100 pounds and maximum lengths approaching five feet[144] – due to their ability to consume up to 40% of their body weight each day.[145] Depletion of plankton by bighead and silver carp "can lead to reductions in populations of native species that rely on plankton for food, including all larval fishes, some adult fishes, and native mussels."[146]

Furthermore, both species exhibit dietary overlap with gizzard shad, bigmouth buffalo, and some with paddlefish (*Polyodon spathula*).[147] Juvenile gizzard shad are an important prey animal in the Great Lakes ecosystem,[148] and decreases in the number of shad available to tertiary predators will adversely affect the population of such predators. Although dietary overlap with paddlefish is minimal,[149] any competition with *P. spathula* has the potential to cause irreversible ecological loss, as the paddlefish is considered endangered, threatened, or of special concern in half of the states within its species range.[150]

In addition to being in direct competition with indigenous species of Great Lakes fishes, Asian carp, like the mussels that invaded before them, are adept at removing plankton and suspended particulates from the

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http://www.asiancarp.org/documents/FINALRCCCarpDiscoveryLakeCalumetJune232010.pdf.

[143] *See Hypophthalmichthys nobilis, Bighead carp*, FishBase, http://fishbase.org/Summary/SpeciesSummary.php?ID=275&AT=bighead+carp (last visited Jan. 18, 2011) (citation omitted); *Hypophthalmichthys molitrix, Silver carp*, FishBase, http://fishbase.org/Summary/SpeciesSummary.php?ID=274&AT=silver+carp (last visited Jan. 18, 2011) (citation omitted).

[144] *Id.*

[145] Gerald A Barnhart, *The Threat Posed to the Great Lakes Basin by Asian Carp: Before the House Subcommittee on Fisheries and Oceans,* Great Lakes Fishery Commission, (November 3, 2005), at 2, *available at* http://www.glfc.org/fishmgmt/testimony_AsianCarp.pdf.

[146] United States Geological Survey, *bighead carp (Hypophthalmichthys nobilis)*, http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=551 (last visited Jan. 18, 2011). [Hereinafter "*USGS Bighead Carp.*"].

[147] *Id.*; *silver carp (Hypophthalmichthys molitrix)*, United States Geological Survey, http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=549 (last visited Jan. 18, 2011). [Hereinafter "*USGS Silver Carp.*"]

[148] Dan O'Keefe, *Gizzard Shad Species Profile*, Michigan Sea Grant, http://www.miseagrant.umich.edu/species/fish/gizzard-shad.html (last visited Jan. 18, 2011).

[149] USGS Bighead Carp, *supra*, note 146; USGS Silver Carp, *supra*, note 147.

[150] *Paddlefish Introduction*, USGS Upper Midwest Environmental Sciences Center, http://www.umesc.usgs.gov/aquatic/fish/paddlefish/introduction.html (last visited Jan. 18, 2011).

water column.[151] It is possible that Asian carp can do more harm due to their capacity to filter greater volumes of water and their mobile nature. While mussel species are sedentary, Asian carp are capable of relocating when one area becomes devoid of plankton and other edible matter. Excessive removal of plankton by Asian carp promise to cause the same ecological calamities precipitated by zebra and quagga mussels: decreased food for endemic species and the encroachment of vegetation into the depths.

In addition to their projected impact on the ecosystem, Asian carp infestation of the Great Lakes will limit potential recreational uses of the Lakes. As some unfortunate boaters have discovered, Asian carp "are very excitable, and disturbance[s] such as boat motor noise can cause them to jump as high as 10 feet out of the water. They have been known to injure boaters and water-skiers, and even knock people off of their boats. . . ."[152] Stretches of the Illinois River infested by silver carp are of little recreational value, and scientists conducting research in those areas must customize their boats to shield themselves and their equipment from piscine projectiles.[153] If an infestation of a similar magnitude occurred in the Great Lakes, most forms of boat traffic would be impossible, and potentially dangerous. Reduced to fishing from the shoreline or non-motorized watercraft, recreational anglers would likely seek bodies of water free of Asian carp and be less likely to bring tourism dollars into the Great Lakes region.

The ecological impact of a full scale Asian carp invasion of the Great Lakes would be disastrous. Asian carp could quickly become the dominant species in the Lakes, and constitute the majority of the ecosystem's biomass.[154] As is the case with many invasive species, Asian carp entered American waterways independent of food web relationships that encumber uncontrolled growth and population spread in their native habitat.[155] While some endemic species may prey upon carp fry and

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[151] *Species at a Glance: Asian Carps*, Oregon Sea Grant, Oregon State University, http://seagrant.oregonstate.edu/themes/invasives/toolkit/asian-carp-factsheet.html

[152] *Asian Carp Species*, United States Environmental Protection Agency, http://yosemite.epa.gov/r10/ECOCOMM.NSF/B724CA698F6054798825705700693650/19CF2902BD8485508825741600 56CDD1?OpenDocument (last visited Jan. 18, 2011).

[153] Dan Barry, *On an Infested River, Battling Invaders Eye to Eye*, N.Y. TIMES, September 15, 2008, at A13, *available at* http://www.nytimes.com/2008/09/15/us/15land.html.

[154] *See* Matthew Berger, *Invasive species threaten US biodiversity*, Guardian Env't Network, Jan. 5, 2010, *available at* http://www.guardian.co.uk/environment/2010/jan/05/invasive-species-us-waterways. ("In terms of damage to biodiversity, Asian carp crowd out other species by simply eating and reproducing more and faster. They make up 95% of the biomass in some stretches of the Illinois River.").

[155] Joel Hood, *Asian Carp Forces Troubleshooters to Dream Big*, CHI. TRIB., June 27, 2010, *available at* http://articles.chicagotribune.com/2010-06-27/news/ct-met-0627-asian-carp-20100626_1_carp-lake-michigan-chicago-river. [Hereinafter "Asian Carp Forces Troubleshooters to Dream Big."]

juveniles, Asian carp lack predators upon attainment of adulthood.[156] Theoretically limited only by the amount of phytoplankton available, the carp would likely switch to consuming detritus in times of plankton scarcity, only to resume normal feeding when plankton stocks recovered. In addition to their environmental impact, bighead and silver carp have the potential to transform a region with high ecotourism potential into an aquatic wasteland with few recreational uses.

VI. NECESSITY OF ASIAN CARP REGULATION

In the wake of numerous sensationalized news reports decrying the inevitable spread of Asian carp into the Great Lakes system, different parties proposed dramatic measures to curb such migration. Among the more outlandish suggestions are that Americans should exercise their rights as apex predators and eat Asian carp into extinction[157] and the solution of harvesting the carp and shipping them to China, as some Chinese have developed a taste for Asian carp.[158] Two other drastic proposals that merit closer consideration involve measures that would effectively sever the connection between Lake Michigan and the Mississippi River.[159] Proposed means by which this separation would occur include closure of the canal locks within the Chicago Area Waterway System[160] (CAWS) and permanent separation of the bodies of water effected by filling in sections of the CAWS.[161] Assessing the propriety of regulation entails the performance of a cost-benefits analysis regarding a disruption in the waterways connecting Lake Michigan to the Des Plaines River, and subsequently the Illinois and Mississippi Rivers.

A. Benefits of Interrupting the Lake Michigan-Mississippi River Connection

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[156] *See id.*

[157] *See* James Gorman, *A Diet for an Invaded Planet: Invasive Species*, N.Y. TIMES, December 31, 2010, at WK3, *available at* http://www.nytimes.com/2011/01/02/weekinreview/02gorman.html?r=1&partner=rss&emc=rss. (Suggesting that Asian carp be rebranded "Kentucky tuna" to increase its appeal to would-be customers.)

[158] Joel Hood, *Quinn: Catch Asian carp, send them to China*, CHI. TRIB., July 13, 2010, *available at* http://archive.chicagobreakingnews.com/2010/07/quinn-catch-asian-carp-send-them-to-china.html.(The governor of Illinois recently entered into a contract under which the state of Illinois would catch and export up to 30 tons of Asian carp per year; this deal includes the marketing of Asian carp as "Wild Mississippi River Fish.")

[159] *The Sanitary and Ship Canal*, Encyclopedia of Chicago, http://www.encyclopedia.chicagohistory.org/pages/300018.html (last visited Jan. 18, 2011). (The Chicago Sanitary and Ship Canal (CSSC) was constructed in 1900 to provide a pathway by which Chicago's sewage could be directed away from the city. In 1907, the CSSC was extended to the Des Plaines River, creating a conduit into the Illinois – and subsequently, Mississippi – Rivers systems.)

[160] Michigan v. U.S. Army Corps of Engineers, No. 10-CV-4457, 2010 WL 5018559 (N.D. Ill. Dec. 2, 2010). (Plaintiffs sought an injunction mandating "temporarily closing and ceasing operation of the locks at the O'Brien Lock and Dam and the Chicago River Controlling Works except as needed to protect public health and safety.")

[161] Asian Carp Forces Troubleshooters to Dream Big, *supra* note 155.

As delineated above, the primary benefits of implementing an impassable barrier on the Chicago Area Waterway System are ecological and environmental. The abundance of desirable aquatic biodiversity within the Great Lakes permits for robust commercial and recreational fisheries. Recreational anglers fishing the Great Lakes can pursue numerous species of salmon, trout, and bass, northern pike, muskellunge, walleye, and lake sturgeon.[162] Notably, most of the major sport fishes occupy higher trophic levels as tertiary predators, and would experience decreased levels of prey fish availability were Asian carp established in their environments.[163] Collectively, recreational fishing activities on the Great Lakes account for a $7 billion per year industry.[164]

Although the commercial fisheries of the Great Lakes are greatly diminished from their peak decades ago, fish are still harvested commercially.[165] Commercial fisheries of the United States and Canada on the Great Lakes generate approximately $1 billion per year.[166] The three species that account for the bulk of commercial fishing's profits – lake whitefish, yellow perch, and walleye – are all tertiary predators whose existence would be threatened by the introduction of Asian carp.[167]

In addition to fishing, the Great Lakes provide hunters with opportunities to pursue a wide range of waterfowl species, including both native and migratory fowl. Hunting in the Great Lakes region generates approximately $2.6 billion per year.[168] Most waterfowl are omnivorous, and Asian carp would be in direct competition with these birds for aquatic vegetation common to the diets of both, such as pondweed.[169] Furthermore, Asian carp would be in direct competition with crustaceans and zooplankton for phytoplankton; crustaceans and larger zooplankton are also important food sources for waterfowl.[170] Therefore, if Asian carp

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[162] *Fish of the Great Lakes*, Wisconsin Sea Grant, http://seagrant.wisc.edu/greatlakesfish/framefish.html (last visited Jan. 18, 2011). (Because lake sturgeon are considered endangered or threatened by several states within the species range, anglers may be limited to catch-and-release fishing for this species.)

[163] *See* Michigan v. U.S. Army Corps of Engineers, 2010 WL 5018559, at *4 n.8 (N.D. Ill. Dec. 2, 2010).

[164] *Id.*

[165] *About Our Great Lakes – Economy*, NOAA Great Lakes Environmental Research Lab, http://www.glerl.noaa.gov/pr/ourlakes/economy.html (last visited Jan. 18, 2011).

[166] *Id.*

[167] Ronald E. Kinnunen, *Great Lakes Commercial Fisheries*, 2 (August 2003), *available at* http://www.miseagrant.umich.edu/downloads/fisheries/GLCommercialFinal.pdf.

[168] U.S. Fish & Wildlife Service, *Asian Carp - Aquatic Invasive Species*, 2 (March 2006), *available at* http://www.asiancarp.org/Documents/Asiancarp.pdf.

[169] Becky Cudmore and Nicholas E. Mandrak, *Biological Synopsis of Grass Carp (Ctenopharyngodon idella)*, CAN. MANUSCRIPT REP. OF FISHERIES & AQUATIC SCI. 2705: v + 44p (2004) at 21, *available at* http://publications.gc.ca/collections/collection_2007/dfo-mpo/Fs97-4-2705E.pdf.

[170] *See* Drew YoungeDyke, *Against the Current: The Attempt to Keep Asian Carp Out of the Great Lakes*, Animal Legal and Historical Center, Michigan State University, available at

successfully colonize the Great Lakes, migratory waterfowl may be forced to find alternative bodies of water with more reliable food sources.[171]

The Great Lakes also support other recreational aquatic uses, such as waterskiing, sailing, and recreational boating.[172] Marinas on Lake Michigan that cater to recreational boaters generate approximately $2 billion per year for the state of Michigan alone.[173] Infestation of the Great Lakes by bighead and silver carp prone to being spooked and launching themselves out of the water would greatly decrease the number of individuals choosing to engage in recreational water sports on the Great Lakes.

As becomes evident from the above discussion, preventing Asian carp infestation of the Great Lakes will preserve multi-billion dollar industries. Disrupting the channels by which water travels from Lake Michigan to the Mississippi River is sure to prevent the northward migration of Asian carp from the Mississippi River watershed into the Great Lakes.

B. Costs of Interrupting the Lake Michigan-Mississippi River Connection

In the face of what has been declared to be impending ecological doom if the waterways tying Lake Michigan to the Mississippi River are not severed, it would seem that there could be few costs that outweigh the purported benefits. However, the CAWS plays important roles in the shipping industry and the insurance of municipal safety.

The CAWS is a key passage for cargo ships transporting goods from the Great Lakes region.[174] Individuals and interest groups opposed to obstructing the canals are quick to note that:

> Each year, millions of tons of steel, petroleum and other cargo pass through the twisting man-made corridors that feed from Lake Michigan to the Illinois River and on to the Mississippi River and, ultimately, the Gulf of Mexico. Critics say placing physical barriers would restrict cargo vessels, increase costs, slow down delivery and force many

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http://www.animallaw.info/articles/arusasiancarp.htm.

[171] *See generally id.*

[172] *Id.*

[173] Office of the Great Lakes & Michigan Department of Environmental Quality, *MI Great Lakes Plan*, 1 (January 2009), *available at* http://www.michigan.gov/documents/deq/MI-GLPlan_262388_7.pdf. (While there is no direct information on the amount recreational boating on all five Great Lakes generates, it must be higher than the $2 billion per year generated on Lake Michigan.)

[174] *See Michigan v. U.S. Army Corps of Engineers*, 2010 WL 8018559, at *3 (N.D. Ill. Dec. 2, 2010) (The court sets forth factual findings that seven million tons of cargo pass through the canals each year.)

> Chicago businesses to move elsewhere.[175]

While the economic impact of shutting the locks to commercial and recreational boat traffic cannot be known with certainty, some estimates suggest that forcing vessels to seek alternative routes will cost approximately $90 million per year.[176] Industry actors respond that alternative water routes might not be feasible and "assert that 1.3 million more trucks would be needed each year to handle what the barges carry."[177] A related concern raised by industry actors is the probable increase in air pollution due to putting over a million trucks on the road.[178]

Other costs associated with severing the CAWS connection between Lake Michigan and the westerly tributaries are related to safety concerns. "The locks also are used by the Coast Guard stations on the Lake Michigan side of the locks in responding to safety emergencies on the canal and in patrolling infrastructure facilities in the river system."[179] Barriers to transportation on the canals would force the Coast Guard to find other routes to emergency sites. At times, these alternative routes would delay response time, potentially allowing for the emergency situation to escalate. Proponents of shutting the locks suggest that these problems could be avoided if the Coast Guard establishes stations on the riverward side of the locks, but have not accounted for the additional costs inherent in construction and staffing of additional facilities.[180]

In addition to expediting Coast Guard responses to emergencies and calls for assistance, the canal system is pivotal in preventing widespread flooding in the city of Chicago during instances of heavy precipitation.

> Both the Chicago Lock and Controlling Works and the O'Brien Lock are used for flood control purposes and water diversion, pursuant to agreements between the Corps and the District. During severe rain events, the locks and the sluice gates are opened to abate the risk of flooding by drawing water from the canal system into Lake Michigan.[181]

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[175] Asian Carp Forces Troubleshooters to Dream Big, *supra*, note 155; *Id.*

[176] Andrew Stern, *U.S. Asian Carp Remedies Unsatisfactory- Governors*, REUTERS, February 8, 2010, *available at* http://www.reuters.com/article/idUSTRE61801020100209.

[177] Be Careful What You Fish For, *supra*, note 140.

[178] *Id.* (Interestingly enough, representatives of the shipping industry speak in absolute value terms when alluding to the problem of air pollution, but fail to offer a comparison as to the increase or decrease in the net amount of air pollution caused as compared that caused by barge traffic).

[179] Michigan v. U.S. Army Corps of Engineers, 2010 WL 5018559, at *3 (N.D. Ill. Dec. 2, 2010).

[180] *Id.*, at *32 n.30.

[181] *Id.*, at *3.

The relatively flat topography of area around the Chicago metropolitan area makes it prone to widespread flooding, as there is no natural route through which water can pass.[182] Substantial amounts of water are able to pass through the sluice gates into Lake Michigan as necessary.[183]

C. Cost-Benefits Analysis

In terms of an exclusively economic comparison, the cost of interrupting the waterway is far less significant than the benefit. The shipping industry's extra $90 million expense per year is far outweighed by the benefits to ecological and environmental based industries, which stand to maintain profits in excess of approximately $13 billion per year.[184] When the economic benefit of taking a certain action is approximately 144 times the expected cost, the correct decision seems obvious.

On the other hand, the economic values ascribed to some of the costs were either unquantified or unquantifiable. Although property damage due to flooding as a result of static locks and sluice gates is measurable, no economic cost was assigned. The cost of slower Coast Guard response times is a factor that, at times, cannot be measured strictly in economic terms. Operating within the Department of Homeland Security, the Coast Guard can be called to respond to issues of national security.[185] In the event of a national emergency, a delayed response leading to the loss of life can cause loss of morale, which cannot be measured in dollars. In performing the cost-benefit analysis, it is important to weigh each cost and benefit fairly.

The costs and benefits of interrupting the Lake Michigan-Mississippi River connection are both compelling. A more thorough analysis can be performed only when the cost of implementing other flood control measures and the cost of building a secondary Coast Guard base are calculated. As it stands, the benefits of severing the CAWS to ensure that Asian carp do not migrate into the Great Lakes seem to outweigh the costs.

VII. JUDICIAL RELUCTANCE TO ACT

The overarching response of the judiciary in invasive species actions has been inaction. In the span of four months, the Supreme Court

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[182] *Id.*

[183] *Id.*, at *3 n.5. ("The Chicago lock and sluice gates recently were opened for flood control purposes in July 2010, to allow approximately 5.7 billion gallons of storm water to flow into Lake Michigan.")

[184] This is the approximate per annum value of nature related industries on the Great Lakes. (Recreational fishing- $7 billion; commercial fishing- $1 billion; hunting- $2.6 billion; recreational boating- $2 billion.) See *supra*, Section VI.A. for an in depth discussion.

[185] *See U.S. Coast Guard Home Page*, UNITED STATES COAST GUARD, http://www.uscg.mil/ (last visited Jan. 18, 2011).

has thrice refused to hear a suit brought by the state of Michigan seeking an injunction ordering Illinois to close the Chicago Lock and O'Brien Lock, which aquatic organisms may use to transverse from the Mississippi River to Lake Michigan.[186] The Court's decisions were rendered without opinion, so it is difficult to ascertain the reasoning behind the rulings.[187]

Having found little success in the High Court, Michigan and her co-plaintiffs filed suit in the Northern District of Illinois.[188] Plaintiffs sought "declaratory judgment that Defendants [were] maintaining a public nuisance and that the Corps ha[d] acted unlawfully, as well as injunctive relief."[189] Although the court found against plaintiffs, it issued a written opinion stating its rationale. Plaintiff's motion for a preliminary injunction was denied, as the court found that plaintiffs failed to "carr[y] their burden of showing that the balance of the harms weigh[ed] in their favor."[190] Essentially, the court performed the same costs-benefits test featured above, but found that the costs of severing the canal connection and the dangers of flooding were greater than the benefits.[191] Variability in the end result is to be expected when the adjudicator is presented with highly technical knowledge without his domain of expertise. Unless greater deference is given to acknowledged expert witnesses, the judiciary may continue to act erratically in rendering environmental decisions.

The judicial proceedings in these groups of cases epitomize the reluctance of courts to act. As time elapses, the courts may decline to take action to curb the spread of invasive species, yet invasive species show no similar restraint. While it is unlikely that a single instance of inaction will cause a deluge of Asian carp into the Great Lakes, collective delays permit for a steady stream of individuals to migrate until a breeding population is established.

VIII. CONCLUSION

Because of the extraordinary amount of biodiversity contained within the Great Lakes Basin and the tremendous capacity of invasive

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[186] Dan Egan, *Asian carp DNA found as closure rejected*, MILWAUKEE WIS. J. SENTINEL, January 19, 2010, *available at* http://www.jsonline.com/news/wisconsin/82058727.html; Gabriel Nelso, *Supreme Court Again Rejects Injunction in Asian Carp Case*, N.Y. TIMES, March 22, 2010, *available at* http://www.nytimes.com/gwire/2010/03/22/22greenwire-supreme-court-again-rejects-injunction-in-asia-55113.html; Kristen Mack, *Supreme Court declines Asian carp case*, CHI. TRIB., April 26, 2010, *available at* http://articles.chicagotribune.com/2010-04-26/news/ct-met-asian-carp-supreme-court-20100426_1_lake-michigan-carp-great-lakes.

[187] *Id.*

[188] Complaint, Michigan v. U.S. Army Corps of Engineers, 2010 WL 5018559, (N.D. Ill. Dec. 2, 2010) (No.1:10-cv-04457).

[189] *Id.*, at 2.

[190] Michigan v. U.S. Army Corps of Engineers, 2010 WL 5018559, at *33 (N.D. Ill. Dec. 2, 2010).

[191] *Id.*

species to throw the ecosystem into turmoil, the spread of invasive species into and throughout the Great Lakes must be curbed. Further intrusions by nonindigenous species have the potential both to cause grave harm to the ecological aspects of the Great Lakes and to drastically limit recreational uses for the region. It is important for courts to act expeditiously to limit the opportunities invasive species have to multiply and spread. No longer can courts maintain the status quo of inaction in invasive species actions.