The Effectiveness of the Great Lakes Water Quality Agreement

Yellow Jackets

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Abstract:

The Great Lakes system contains 20% of the world's fresh water, and is shared by the United States and Canada. In the 1970s, the Great Lakes were heavily polluted and lacked a legislative framework for environmental protection. In response to the dismal state of the Great Lakes, the most important piece of legislation passed was the Great Lakes Water Quality Agreement, most recently updated in 2012.

Our goal is to analyze the GLWQA's effectiveness in protecting the Great Lakes ecosystem. We will identify areas of the Agreement that are lacking/ineffective, and propose practical solutions. Afterwards, we will contact local congressional representatives and propose our findings.

Our research focuses on 5 main policy areas: Chemical pollution, Nutrient influx, Invasive Species, Discharge from Vessels, and Climate Change. Our investigations of invasive species and discharge revolved around identifying gaps in legislation that prevent effective regulation. Our investigations of pollution focused primarily on identifying major causes of pollutant influx into the lakes and finding potential solutions to pollution/runoff. Our investigation of climate change focused mainly on the impact it has on the Great Lakes ecosystem, as well as potential local and national solutions to address both the symptoms and the underlying cause.

Background:

The Great Lakes Water Quality Agreement (GLWQA) is an intergovernmental agreement between the governments of the United States and Canada with the goal of ensuring effective preservation and stewardship of the Great Lakes as a material and ecological resource. The agreement was first signed in 1972 by Canadian prime minister Pierre Trudeau and US President Richard Nixon; subsequently, it was updated in 1978, 1987, and 2012. The agreement covers several issues of water quality and environmental protection throughout the Great Lakes (Lakes Superior, Michigan, Huron, Erie, and Ontario) as well as much of the St. Lawrence river basin.[1]

The bulk of the GLWQA consists of individual sections, or annexes, each of which addresses a specific issue related to water quality in the Great Lakes. The current iteration of the GLWQA consists of the following 10 annexes[2]:

1. Areas of Concern: Annex 1 focuses on the identification and restoration of severely contaminated or degraded sites in the Great Lakes basin
2. Lakewide Management: Annex 2 focuses on broad issues of policy management and water quality, especially on a lake-by-lake basis
3. Chemicals of Mutual Concern: Annex 3 focuses on chemical pollutants identified by the IJC as posing a significant threat to water quality in the Great Lakes
4. Nutrient pollution: Annex 4 focuses on nutrients, specifically nitrate and phosphate, and their impact on the Great Lakes
5. Discharge from Vessels: Annex 5 focuses on the impact of discharged ballast water from ships, particularly in relation to the introduction of exotic or invasive species to the Great Lakes ecosystem or the discharge of harmful substances
6. Aquatic Invasive Species: Annex 6 focuses on the threat of invasive species, such as Asian Carp or Garlic Mustard, to the Great Lakes ecosystem
7. Habitat and Species: Annex 7 focuses on the protection and preservation of native species and habitats
8. Groundwater: Annex 8 focuses on the protection and sustainable use of groundwater resources and the coordination and management of groundwater science
9. Climate Change: Annex 9 focuses on studying and preventing the impacts of climate change on the Great Lakes
10. Science: Annex 10 focuses on the international coordination and integration of scientific study of the Great Lakes

[1] "Great Lakes Water Quality," *Ijc.org*. International Joint Commission, 2018, Web, Accessed 11 Feb. 2018. <http://www.ijc.org/en_/Great_Lakes_Quality>

[2] "GLWQA Annexes," US Environmental Protection Agency: EPA.gov, June 26 2015, Web. <<https://www.epa.gov/glwqa/glwqa-annexes>>

Keywords:

1. (Laurentian) Great Lakes
2. GLWQA
3. CMC
4. IJC: International Joint Commission, an international regulatory body created within the GLWQA with the goal of protecting the Great Lakes
5. EPA: US Environmental Protection Agency, the federal agency responsible for creating and enforcing environmental regulations

Purpose of the research:

The purpose of this research is to gain a deeper understanding of the treaties and agreements concerning the management of the Great Lakes, especially the 2012 Great Lakes Water Quality Agreement (GLWQA). The Great Lakes are in a unique position where it is shared by two countries and its various states and municipalities; there are countless laws, rules, and regulations set forth by each individual actor, but the GLWQA provides the broadest framework under which the two countries as a whole have agreed to work under. In understanding more about GLWQA, this paper will provide insights into where the agreement is effective, where it is lacking, and make subsequent recommendations for improving the efficiency of this agreement. This research will also serve as an example of how best to manage a body of water and identify various areas of concerns.

Method of the research:

The research was conducted by dividing up key sections of the GLWQA amongst the team members. The primary focus was to split up the annexes of the GLWQA, which outlines the key issues the GLWQA seeks to address. After dividing up the areas of research, each team member conducted their own research, utilizing various published papers and official resources to create a background and draw conclusions about the current effectiveness of the GLWQA in addressing various issues and what recommendations can be made. During the independent research period, team members met up occasionally to check on each other's progress and to ensure that the research can be combined into a final report. After each member had completed his/her research, it was compiled into a shared document, where edits were made and additional information was added in order to create a seamless report and generate policy recommendations incorporating our research in order to develop strategies to address the problems identified by the GLWQA. Our final goal is to share our research findings with politicians, educators, industry leaders, and others who play a role in improving and maintaining the health of the Great Lakes ecosystem.

Results of the research:

International Joint Commission:

Part of the efforts to manage the Great Lakes, the International Joint Commission (IJC) was formed to coordinate the management of the lakes between the United States and Canada. Its primary duty is to regulate the water usage in the Great Lakes as well as giving approval for building various structures such as dams, bridges, diversions etc. that could affect the Great Lakes. The IJC also has the power to appoint a board of experts to conduct studies and issue recommendations when prompted by either the US or Canada. However, the recommendations are non-binding, although the IJC notes that the two countries have generally accepted recommendations made by the IJC.[3]

Comparatively, the IJC has significantly less power now than it did before. From the 1950s to late 1970s, the governments placed their faith the ability of the IJC which led to joint cooperation on various large-scale projects to improve the quality of the Great Lakes. For its efforts, the IJC was "highly respected", and was recognized for its independence and impartiality.[4] However, several incidents in the 1970s spelled the downfall of the IJC; the IJC overstepped its bounds by trying to be more active and increase its responsibilities. In one incident, the IJC tried to assert that they must be consulted regarding the Garrison Diversion Project in the St. Mary's River; the governments rejected the IJC's intrusion. In another incident, the IJC tried to build a regional office in Windsor, Ontario despite being against the Canadian government's wishes; it was viewed as a power grab by the IJC and lowered its credibility and status in the eyes of both governments. In the end, the IJC was seen as a threat to the sovereignty of both the US and especially Canada, who thought the IJC was insufficiently protecting Canadian interests, which led to a decreased reliance on the IJC. Often times, the IJC was completely bypassed regarding matters in the Great Lakes and has become increasing marginalized and ignored by both governments.[5]

Success of the IJC is heavily dependent on the support the two governments and a common goal to preserve the Great Lakes. Given that the IJC has been marginalized to non-crucial matters and its recommendations being ignored, the IJC cannot properly regulate the usage of the Great Lakes.[6] Despite its marginalization, the concept of the IJC has plenty of merits. The IJC is a novel concept to settle transnational disputes over the Great Lakes where Canada and the United States are on equal footing and allows for the possibility of a non-partisan forum to resolve Great Lakes issues. In an era increasingly beset by environmental problems such as global warming and increasing pollution, it is crucial to maintain whatever natural resources we have left. An intergovernmental organization like the IJC can more effectively recommend solutions that are impartial to either

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[3] "Role of the IJC," International Joint Commission, www.ijc.org/.

[4] Austen L Parrish, "Mixed Blessings: The Great Lakes Compact and Agreement, the IJC, and International Dispute Resolution," Michigan State Law Review, 2006, www.repository.law.indiana.edu/.

[5] Parrish 1311-1314

[6] Murray Clamen and Daniel Macfarlane, "The International Joint Commission, Water Levels, and Transboundary Governance in the Great Lakes," Review of Policy Research, PDF ed., vol. 32, no. 1, 2015, pp. 40-59.

government and present an outside perspective not influenced by national politics. While it would be unrealistic to ask the two countries to cede power over to a third party in regard to the management of the Great Lakes, having a reliable, independent commission would be a substantial improvement to policies that are colored by national interests.

Recommendations:

1. Grant the IJC the power to issue binding decisions regarding Great Lakes disputes and issues

2. Elect committee members based on their scholarship and not their political/national affiliation

3. Grant the IJC sufficient funding to improve data gathering and analysis of the Great Lakes

Nutrient pollution:

Nutrient pollution in the Great Lakes is a major contributor to major issues of water quality and environmental degradation throughout the region. Nutrient pollution generally consists primarily of nitrate (NO3-) and phosphate (PO43-) ions which can enter waterways either through direct dumping/discharge (point sources) or through more indirect runoff (nonpoint sources). Nutrient influx into the Great Lakes is the central subject of Annex 4 of the Great Lakes Water Quality Agreement; accordingly, nutrient levels and influx into the Great Lakes - especially insofar as nitrates and phosphates are concerned - are central to water quality and the health of the Great Lakes ecosystem, and they must be similarly central to any regulatory or policy strategy for the proper stewardship and ecological well-being of the Great Lakes basin.

One of the most important impacts of elevated nutrient influx into surface water is eutrophication. Every body of surface water exists within a spectrum of Trophic State values, which measures the amount of biologically available nutrients; eutrophication, an elevated trophic state which results from high nutrient levels, is a global problem with serious ramifications for surface water and aquatic ecosystems worldwide.[7] Eutrophication as a result of nutrient inflow is most prevalent in Lake Erie and, to a lesser extent, Lake Ontario, but all five of the lakes are impacted by some degree of nutrient-related eutrophication. The eutrophication observed in Lake Erie is “cultural eutrophication,” meaning that it is an anthropogenic phenomenon resulting from man-made nutrient spikes from runoff, rather than natural hydrological cycles.[8] Especially in Lake Erie, eutrophication has reached record levels in recent years, highlighting the urgent need to control nutrient runoff in the Great Lakes basin.

Perhaps the most prominent outcome of eutrophication is the phenomenon of “algae blooms.” These occur when a large amount of an ecosystem’s limiting nutrient - usually phosphorus - is introduced, leading to an explosion in the algal biomass. Algal blooms are often followed by mass algal die-offs, leading to a spike in BOD (Biochemical Oxygen Demand) that can kill off most life in an area and

[7] Val H. Smith, "Eutrophication of freshwater and coastal marine ecosystems a global problem," *Environmental Science and Pollution Research* 10.2 (2003): 126-139.

[8] Anna M. Michalak, et al. "Record-setting algal bloom in Lake Erie caused by agricultural and meteorological trends consistent with expected future conditions," *Proceedings of the National Academy of Sciences* 110.16 (2013): 6448-6452. <http://www.pnas.org/content/110/16/6448.short>

create a dead zone; further, algal blooms often contain algae such as *Microcystis* and *Anabaena* that produce dangerous toxins (microcystin and anatoxin, respectively.[9] In addition to the immediate harmful effects on humans and the environment (including mass fish die-offs, water shortages, and beach closures), evidence from Lake Erie blooms in 2014 suggests that algal blooms can have a long-term negative impact on the microbial life in an aquatic ecosystem.[10] Algal blooms thus further highlight the very real impact of nutrient contamination on both the environment and communities in the Great Lakes basin.

Although both nitrate and phosphate play an important role in eutrophication and algal blooms, phosphate is typically the ecological limiting factor and is thus more important in determining the environmental impact of nutrient pollution. As a result, one of the most successful methods of combating eutrophication in surface water ecosystems has been limiting phosphorus inflow into bodies of water. Evidence from numerous bodies of surface water around the world, including all five Great Lakes, indicates that reducing phosphorus leads to some improvement in overall levels of lake eutrophication, particularly in contrast with (relatively unsuccessful) attempts to reduce nitrate input.[11] Policy strategies for combating nutrient inflow into the Great Lakes should therefore focus on limiting the influx of phosphates and phosphorus.

By far, the largest anthropogenic contributor to nutrients in the Great Lakes is nonpoint runoff from agriculture. Both nitrates and phosphates are widely used in fertilizers, since they are necessary for plant growth. Due to this near-ubiquitous usage, the IJC has declared industrial manure and fertilizer to be the primary source of nutrient pollution, particularly in the algal bloom-plagued western part of Lake Erie.[12] Historically, efforts to combat nutrient pollution in Michigan have focused elsewhere, with mixed success. These measures have included limits on phosphate discharge from wastewater treatment plants and restrictions on phosphates in detergents.[13] While this focus on point-source phosphate pollution was effective in reducing these (admittedly significant) sources of phosphate, these strategies largely overlooked the broader problem of nonpoint runoff from agriculture, storm drains, etc. Any future strategies to limit eutrophication in the Great Lakes must take such nonpoint sources of pollution into account.

Our policy recommendations for control of nutrient pollution in the Great Lakes would focus primarily on phosphate reduction, which has been shown to be an effective means of combating eutrophication.[14] We would recommend focusing on nonpoint sources of nutrients, especially agriculture, and

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[9] Michalak et al.

[10] Michelle A. Berry, et al. "Cyanobacterial harmful algal blooms are a biological disturbance to western Lake Erie bacterial communitie," *Environmental microbiology* 19.3 (2017): 1149-1162. <http://onlinelibrary.wiley.com/doi/10.1111/1462-2920.13640/full>

[11] David W. Schindler, et al. "Reducing phosphorus to curb lake eutrophication is a success," (2016): 8923-8929. <https://pubs.acs.org/doi/full/10.1021/acs.est.6b02204>

[12] "Report: Fertilizer, manure top Lake Erie phosphorus sources," The Associated Press: February 14, 2018,Web. <https://phys.org/news/2018-02-fertilizer-manure-lake-erie-phosphorus.html>

[13] "Nutrients in Michigan – Overview," *Nutrient Framework to Reduce Phosphorus and Nitrogen Pollution,* State of Michigan: Department of Environmental Quality, August 10 2013, Web. <https://www.michigan.gov/documents/deq/wrd-nutrient-framework-overview_429129_7.pdf>

[14] Schindler et al. 16.

we would propose regulations such as limiting the amount of phosphate fertilizers used, especially in areas near bodies of water. We would also recommend strengthening and broadening limits on the application of fertilizers to frozen or snow-covered ground to limit unnecessary runoff. Lastly, an abundance of evidence indicates that wetlands and planted riparian zones are effective means of nutrient removal from runoff water. Wetlands in particular have been shown to be critical in the fight against eutrophication; however, wetlands are under intense pressure from human development and habitat destruction, and more than 50% of the world's wetlands have already been destroyed.[15] Studies indicate that restoring 40,000 hectares of wetlands in the Great Lakes region would have a significant impact on reducing eutrophication and algal blooms.[16] Therefore, we would recommend a significant increase in funding for wetland restoration throughout the Great Lakes basin.

Chemical Pollution:

As with many ecosystems across the globe, the threat of chemical pollution continues to menace the Great Lakes. Throughout the 1900s, rapid industrial growth in major urban areas like Detroit, MI and Chicago, IL led to incredible influxes of industrial waste, in turn causing a massive decline in water quality throughout the Great Lakes basin. The pollution of the Great Lakes grew so severe that some rivers were consistently covered with an oil sheen; some, including the Cuyahoga in 1969, even caught fire.[17] Although there has been significant progress in recent decades, especially with the creation of the EPA and the passage of laws like the Clean Water act, the Great Lakes remain under constant threat of pollution and chemical degradation.

Within the framework of the GLWQA, the IJC has thus far identified 8 specific chemicals of mutual concern which pose an immediate threat to the Great Lakes. The chemicals identified are[18]:

- Hexabromocyclododecane (HBCD)
- Long-Chain Perfluorinated carboxylic acids (LC-PFCAs)
- Mercury
- Perfluorooctanoic acid (PFOA)
- Perfluorooctane sulfonate (PFOS)
- Polybrominated Diphenyl Ethers (PBDEs)
- Polychlorinated Biphenyls (PCBs), and
- Short-Chain Chlorinated Paraffins (SCCPs)

The main pollution threats to the Great Lakes can be roughly divided into 5 groups[19]:

- Biomagnifying toxic metals

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[15] William J. Mitsch, "Solving Lake Erie's harmful algal blooms by restoring the Great Black Swamp in Ohio," *Ecological Engineering* 108 (2017): 406-413.

[16] Mitsch 17.

[17] "Cuyahoga River Fire," *Encyclopedia of Cleveland History*, Case Western Reserve, Feb. 1 2001 <https://case.edu/ech/articles/c/cuyahoga-river-fire/>

[18] "Canada and the United States Designate the First Set of Chemicals of Mutual Concern," International Joint Commission: Binational.net, May 31 2016. Web. <https://binational.net/2016/05/31/cmcdesig-pcpmdesig/>

[19] "Toxic Chemicals," *Lake Stressors.* GLEAM (Great Lakes Environmental Assessment And Mapping Project), December 7 2012, Web. <http://greatlakesmapping.org/great_lake_stressors/1>

- Non-biomagnifying toxic metals
- Biomagnifying toxic organics
- Non-biomagnifying toxic organics
- Agricultural pesticides

The biomagnifying pollutants, including substances such as mercury or PCBs, increase in concentration as they travel up the food chain within the Great Lakes ecosystem. As a result, they can reach dangerous concentrations in larger, higher trophic-level organisms such as fish, birds, or mammals, and they can even pose a significant danger to humans who consume fish from the Great Lakes[20].

Hexabromocyclododecanes (HBCD), the first of these CMCs, are a class of manmade, biomagnifying pollutants. These brominated flame retardants are widely used on textiles, buildings, electronics, etc.; the primary use is foam insulation for construction. Due to this widespread use, HBCDs are practically omnipresent environmental pollutants.[21] However, there has been relatively little data collected on HBCD contamination in the Great Lakes on a broad scale. Some localized research has found significantly elevated levels of α- and β-HBCDs in Great Lakes basin sediments, particularly from the Detroit River.[22] The primary use of HBCDs is in polystyrene foam boards for construction and insulation. Although there is no real substitute for HBCD in polystyrene, since alternatives can impact the foam's structural stability, there are promising alternatives to polystyrene foam itself, such as blanket, loose-fill, or reflective insulation and/or butadiene styrene brominated copolymer.[23] Our policy recommendations for HCBDs would include funding research into alternatives for HCBDs and polystyrene in construction/insulation, and phasing out HCBD use, with the eventual goal of ending all HCBD use (especially in construction) and achieving zero-discharge.

Perfluorinated compounds (PFCs, including LC-PFCAs, PFOA, and PFOS) are also of both economic and ecological significance. These chemicals are of particular danger to children and infants, and they have been identified at elevated levels in blood and breast milk.[24] The most economically and ecologically important long-chain perfluorinated compounds (LC-PFCs) are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), as well as other long-chain perfluorinated carboxylic acids (LC-PFCAs). PFOA and PFOS do not biodegrade to any appreciable extent, and thus can remain in the environment practically indefinitely. Further, since PFCAs are non-polar and lipophilic, they can easily bioaccumulate in aquatic organisms; elevated levels of PFOA have been observed in minnows, frogs, and rainbow trout under both laboratory and

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[20] "Toxic Chemicals"

[21] Adrian Covaci, et al. "Hexabromocyclododecanes (HBCDs) in the environment and humans: a review," *Environmental science & technology* 40.12 (2006): 3679-3688. <http://dare.ubvu.vu.nl/bitstream/handle/1871/32095/192859.pdf?sequence=1>

[22] Robert J. Letcher, et al. "Hexabromocyclododecane flame retardant isomers in sediments from Detroit River and Lake Erie of the Laurentian Great Lakes of North America," Bulletin of environmental contamination and toxicology 95.1 (2015): 31-36. <https://link.springer.com/article/10.1007/s00128-015-1491-y>

[23] "Hexabromocyclododecane (HBCD) Action Plan," *Assessing and Managing Chemicals under TSCA.* EPA, August 2010. <https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/hexabromocyclododecane-hbcd-action-plan>

[24] "Long-Chain Perfluorinated Chemicals (PFCs) Action Plan," US Environmental Protection Agency, December 30 2009, Web. <https://www.epa.gov/sites/production/files/2016-01/documents/pfcs_action_plan1230_09.pdf>

field study.[25] Polyfluorinated compounds are primarily used for their ability to resist water, grease, soil, etc., so the primary economic use of PFCAs is in nonstick coatings.[26] The greatest concern is that PFCAs are not removed by conventional water treatment techniques; not nearly enough research has been done concerning the removal of PFCs from drinking water or surface water in the environment, and preliminary evidence indicates that water purification plants are not adequately removing PFCs from drinking water at several sites throughout Michigan.[27] Our recommendations for PFCs would include limiting the use of LC-PFCAs, especially PFOS, and funding research into substitutes and removal/remediation techniques for both drinking water purification and environmental cleanup.

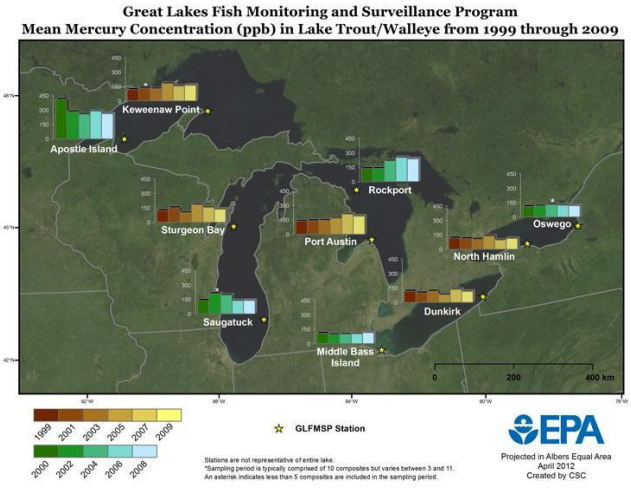

Figure 1: Trends in Mercury level if Great Lakes fish, 1999-2009. Source: Great Lakes Open Trend Monitoring program

Mercury (Hg) is a toxic metal and a widespread contaminant in Great Lakes sediments and organisms. Although some mercury arises from natural sources, the majority of environmental mercury contamination is anthropogenic, and most of the man-made mercury pollution (57%) comes from the burning of coal in power plants.[28] Mercury (and other heavy metals) in the environment does not degrade over time; instead, it bioaccumulates and builds up in organisms and sediments, leading to increasingly harmful impacts on the ecosystem over time. Although mercury levels in Great Lakes fish declined in the 1990s, levels have since stagnated and, in some areas, begun to increase. Like PCB and PAH, mercury is an ASEP (Atmosphere-Surface Exchangeable Pollutant), allowing it to travel great distances through the air; as a result, recent modelling indicates that even with rigorous policy changes to reduce emissions, mercury will likely remain at elevated levels in the Great Lakes basin through 2050.[29] Our policy recommendations for mercury would include regulations requiring scrubbing of mercury from coal power plant emissions, increased financial incentives for cleaner fuel sources (such as natural gas or renewable energy), and statewide or interstate cooperation on reducing the broader problem of atmospheric mercury emissions through sensible federal and/or state level environmental regulations.

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[25] J. P. Giesy, et al. "Perfluorinated compounds in the Great Lakes," *Persistent organic pollutants in the Great Lakes*, Springer, Berlin, Heidelberg, 2006. 391-438. <http://www.jlakes.org/ch/web/698_5_046.pdf>

[26] "Long-Chain Perfluorinated Chemicals (PFCs) Action Plan."

[27] Joy Taylor Morgan, et al. "Perfluorinated Compounds in Michigan," Michigan DEQ: Toxics Steering Group, September 1 2001. Web. <https://www.michigan.gov/documents/deq/deq-aqd-tox-pfc_report_2001_560091_7.pdf>

[28] "Mercury in Great Lakes Sediments," *Lake Stressors: Toxic Chemicals*, GLEAM: December 7, 2012 <http://greatlakesmapping.org/great_lake_stressors/1/mercury-great-lakes-sediments>

[29] Allison Mills; citing study by Judith Perlinger and Noel Urban. "The Big Picture of Great Lakes Mercury Pollution," Michigan Technical University, January 23 2018. Web. <https://www.mtu.edu/news/stories/2018/january/the-big-picture-of-great-lakes-mercury-pollution.html>

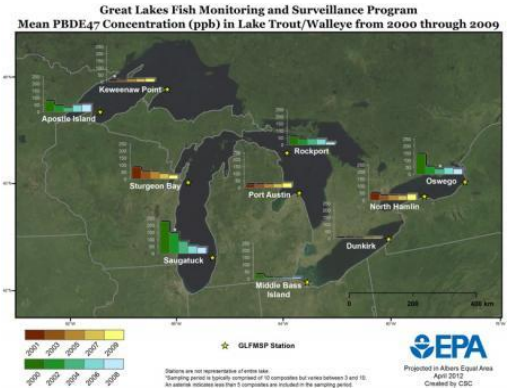

Figure 2: Trends in PBDE levels in Great Lakes fish, 1999-2009. Source: Great Lakes Open Trend Monitoring program

Polybrominated diphenyl ethers (PBDEs), like HBCDs, are brominated hydrocarbons widely used as flame retardants in a variety of products. Both globally and within the US, the most widely used is decabromodiphenyl ether (decaBDE); the production of octaBDE and pentaBDE, the other economically relevant PBDEs, ceased in the US in 2004.[30] Additionally, the main producers of decaBDE have agreed to voluntarily phase-out production in favor of safer alternatives; despite the near-end of new PBDE production, the compounds persist in the environment, so they are still a threat to the Great Lakes basin.[31] Our policy recommendations for PBDEs would include funding for research into removal/remediation of PBDEs, especially decaBDE, from the environment.

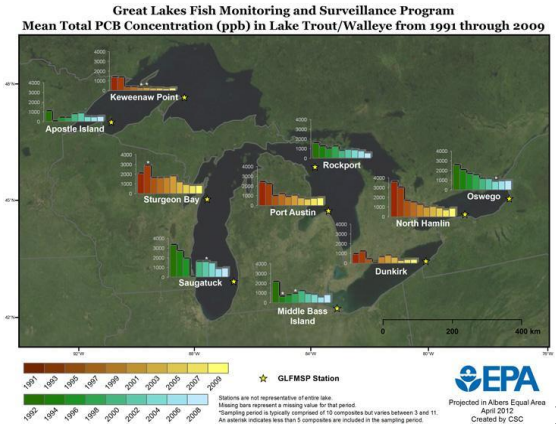

Figure 3: Trends in PCB concentration in Great Lakes fish, 1999-2009. Source: Great Lakes Open Trend Monitoring program

Similarly, polychlorinated biphenyls (PCBs) are no longer produced or used on an industrial scale in either the US or Canada, but they remain in the Great Lakes ecosystem as persistent contaminants. The production of PCBs in the US was banned in 1977; in the years since, concentrations of PCBs in the environment and in aquatic organisms have declined significantly and continue to drop, demonstrating the effectiveness of regulatory policy in preventing pollutant inputs into the Great Lakes.[32] However, since PCBs are extremely slow to biodegrade, they continue to persist in the Great Lakes environment. Our policy recommendations for PCBs include continued funding for PCB monitoring and a focus on developing environmental remediation techniques to remove PCB from the lakes.

Lastly, Short-Chain Chlorinated Paraffins (SCCPs) are potentially carcinogenic, bioaccumulating compounds used

[30] "Technical Fact Sheet – PBDEs," US EPA: Office of Land and Emergency Management, November 2017. <https://www.epa.gov/sites/production/files/2014-03/documents/ffrrofactsheet_contaminant_perchlorate_january2014_final_0.pdf>

[31] "Great Lakes Open Lakes Trend Monitoring Program: Polybrominated Diphenyl Ethers (PBDEs)," US EPA, May 9 2017, Web. <https://www.epa.gov/great-lakes-monitoring/great-lakes-open-lakes-trend-monitoring-program-polybrominated-diphenyl>

[32] Paul W. Rasmussen, et al."Trends of PCB concentrations in Lake Michigan coho and chinook salmon, 1975–2010," *Journal of Great Lakes Research* 40.3 (2014): 748-754. <https://ac.els-cdn.com/S0380133014001373/1-s2.0-S0380133014001373-main.pdf?_tid=3586d726-164b-11e8-8eaa-00000aab0f6b&acdnat=1519137471_5a96b1b0f2a62db3c27571881a90131e>

as additives in lubricants, metal cutting fluids, flame retardants, and other industrial applications. Since SCCPs are hydrophobic and lipophilic, they can easily bioaccumulate in aquatic organisms (esp. Large fish), and they have been detected in all parts of the Great Lakes environment.[33] Like many other CMCs, current regulations are implemented under a Significant New Use Rule (SNUR), which allows the EPA to regulate the production and use of SCCPs under TSCA authority. The EPA has already taken legal action to enforce the SNUR and limit the use and potential future impact of SCCPs.[34] Our policy proposals for SCCPs, as with other currently-regulated CMCs, include strengthening of SNUR enforcement and funding research into environmental remediation and ecologically sound substitutes.

Beyond the chemicals already identified as CMCs by the IJC, there are several other pollutants of potential concern for the Great Lakes region. One such pollutant is Atrazine, a chemical pesticide widely used in agriculture. Although Atrazine does not exhibit bioaccumulation, it is water soluble and thus can leach from soil into surface water, potentially contaminating drinking water.[35] As a result, it has been banned in Europe, but little regulatory action has been taken in the United States to prevent it from contaminating surface water in the Great Lakes basin. Another class of pesticides, Neonicotinoids, also pose a risk for the Great Lakes. These compounds are widely used as agricultural insecticides, and they have been implicated in colony collapse disorder in bees. A recent study found year-round elevated levels of neonicotinoids, specifically clothianidin, imidacloprid, thiamethoxam, in all water samples taken throughout the Great Lakes basin.[36] Even at low concentrations, neonicotinoids have been observed to significantly increase mortality and reduce responsiveness in populations of invertebrate predators, leading to a disruptive top-down cascade through an aquatic ecosystem.[37] Our recommendations for policy action on Atrazine and Neonicotinoids would include classifying them as chemicals of mutual concern under annex 3 of the GLWQA and regulating them domestically under the TSCA; we would also recommend promoting a voluntary production/consumption phase-out, or an outright ban if necessary, as well as research into less ecologically harmful substitutes.

The IJC report's conclusion was largely consistent with the fact that despite declared regulatory priorities and goals, not nearly enough progress has been made regarding chemical pollution in the Great Lakes.[38] The two main areas of

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[33] Libia Saborido Basconcillo, et al. "Current status of short-and medium chain polychlorinated n-alkanes in top predatory fish across Canada," *Chemosphere* 127 (2015): 93-100. <https://www.sciencedirect.com/science/article/pii/S0045653515000569>

[34] "Risk Management for Short-Chain Chlorinated Paraffins," US EPA: June 22, 2017, Web. <https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-management-short-chain-chlorinated-paraffins>

[35] Jiehong Guo, et al. "Occurrence of atrazine and related compounds in sediments of upper Great Lakes," *Environmental science & technology* 50.14 (2016): 7335-7343. <http://ir.rcees.ac.cn/bitstream/311016/35910/1/Occurrence%20of%20Atrazine%20and%20Related%20Compounds%20in%20Sediments%20of%20Upper%20Great%20Lakes.pdf>

[36] Michelle L. Hladik, et al. "Year-round presence of neonicotinoid insecticides in tributaries to the Great Lakes, USA," *Environmental Pollution* (2018), <https://www.sciencedirect.com/science/article/pii/S0269749117344962>

[37] Jesse C. Miles, et al. "Effects of clothianidin on aquatic communities: Evaluating the impacts of lethal and sublethal exposure to neonicotinoids," *PloS one* 12.3 (2017): e0174171.

[38] Lana Pollack, et al. "First Triennial Assessment on Great Lakes Water Quality," International Joint Commission,

insufficiency identified in the report are a lack of zero-discharge policies and a greater need for extended producer responsibility. In addition, some specific chemical pollutants remain understudied; as a result, more EPA funding for Great Lakes pollution research is needed to get data on specific chemicals.

Recommendations:

Our overall recommendations for regulatory changes addressing chemical pollution of the Great Lakes are as follows:

1. Increase funding for studies of the type and amount of specific chemical pollutants in the Great Lakes
2. Classify Atrazine as a CMC and regulate it under the TSCA
3. Classify Neonicotinoids as CMCs and regulate them under the TSCA
4. Establish and implement specific plans for zero-emission regulations of all CMCs
5. Implement Extended Producer Responsibility strategies for pollutants entering the Great Lakes

Discharge from Vessels and Aquatic Invasive Species (Annex 5 & 6):

Since 2011 the overall status of the Great Lakes has remained unchanging, as issues with invasive species are still pertinent. Although the introduction of nonnative species has declined, aquatic and terrestrial invasive species still harm the Great Lakes ecosystem, and cause more than $100 million in economic impacts in the United States alone.[39] The overall economic impact includes direct operating costs, decreased productivity, reduced demand of sport and commercial fishing, power generation, industrial facilities, tourism and recreation, water treatment, and households.[40]

Over 180 species of invasive species have become established in the Great Lakes, but due to regulation of ballast water only one new invasive species has been discovered since 2006. All 5 Great Lakes are experiencing a deteriorating condition with the impacts of aquatic invasive species including the Sea Lamprey and Dreissenid mussels, more commonly known as Zebra and Quagga Mussels. In addition, all 5 lakes are also experiencing a deteriorating condition in terrestrial invasive species, from invasives such as Phragmites, purple loosestrife, garlic mustard, emerald ash borer, and Asian long-horned beetle.

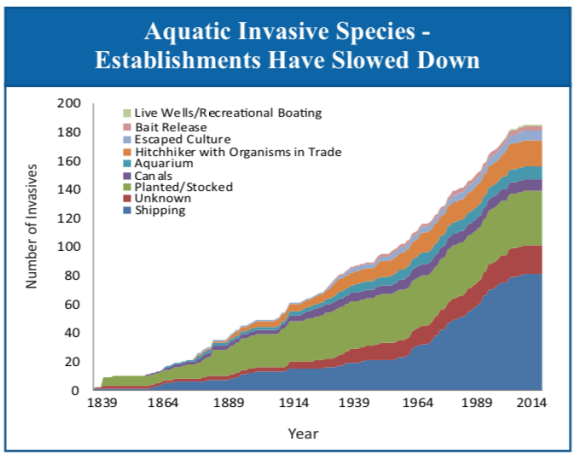

Figure 4: Aquatic Invasive Species by Vector

November 28 2017. <http://ijc.org/files/tinymce/uploaded/GLWQA/TAP.pdf>

[39] Environment and Climate Change Canada, and U.S. Environmental Protection Agency, "State of the Great Lakes 2017 Technical Report," PDF file, 2017.

[40] Environment and Climate Change 353.

Source: Great Lakes Aquatic Nonindigenous Species Information System

A current problem in the Great Lakes Basin is the issue of containment- invasive species spreading across the basin and into different lakes. The Great Lakes Aquatic Nonindigenous Species Information (GLANSIS) keeps track of species in new locations in the last decade. In Lake Superior, GLANSIS has found 19 new invasive species introduced in the last decade, and 67 species in the Superior basin in the same period. In lake Michigan, more than 30 new invasive species have been reported in the past decade, and 86 new species in the Lake Michigan basin in the same amount of time. In Lake Huron, 23 new invasive species have been reported in the past decade, such as the Chain Pickerel and Tubenose Goby, and 54 new species in the Lake Huron basin in the same period. In Lake Erie, 29 new invasive species have been reported in the past decade, and 76 species in the Lake Erie basin in the same period. In Lake Ontario, 19 new invasive species have been reported in the last decade, and 79 species in the Lake Ontario including the Niagara River basin in the same period. In addition to the 5 Great Lakes, Lake St-Clair and St.

Clair Rivers have reported 26 new invasive species in the past decade, with 48 new species in the Lake St. Clair corridor in the same period. Many of these organisms being spread across the basin are high impact species which pose serious threat to the ecological well-being of the lakes. **Article 3 Clause 1 Subclause A Sub Sub Clause 7 (General Objective #7) of The Great Lakes Water Quality Agreement states that the Great Lakes should be free from the both the introduction and spread of aquatic invasive species and terrestrial species. Although the problem of the introduction of invasive species has been alleviated, the problem of the spread of aquatic and invasive species has not been resolved, as many invasive are spreading across the Great Lakes Basin. A potential reason why invasive species are spreading across the Great Lakes Basin is because ballast water movement within the basin is not regulating. The GLWQA must begin to add regulations and restrictions on interbasin movement to regulate ballast water movement and the spread of aquatic and terrestrial invasives throughout the Great Lakes Basin.**[41]

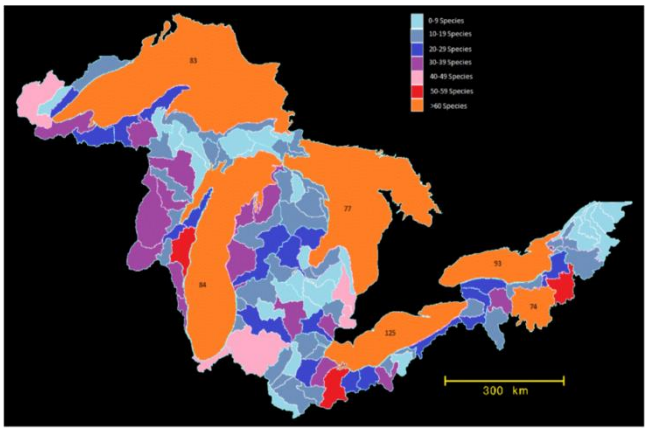

Figure 5: Number of AIS Present in the Great Lakes Basin for each lake Source: Great Lakes Aquatic Nonindigenous Species Information System

In addition to the lack of regulation of ballast water movement within the basin, there are several flaws in the regulation of distribution of exotic live fish in the Great Lakes, Mississippi River states, Quebec, and Ontario. These flaws include exemptions for pet trade, exemptions for live food fish trade, inability to enforce shipping bans, lack of inspections at aquaculture facilities, allowing aquaculture in public waters, inadequate sterilization requirements, and

[41] Environment and Climate Change 349-352.

failure to regulate transport.[42] **Article 3 Clause 1 Subclause A Sub Sub Clause 7 (General Objective #7) of The Great Lakes Water Quality Agreement states that the Great Lakes should be free from the both the introduction and spread of aquatic invasive species and terrestrial species. The lack of regulation in private transaction in activities such as shipping bans may prove ruinous if more exotic fish are introduced to the Great Lakes region.**

Dreissenid Mussels populations in lakes Michigan, Huron, and Ontario are currently at a poor status with a deteriorating trend. Populations have stabilized or decreased at depths less than 90m, but are increasing offshore at depths greater than 90m. Lake Superior is currently at a good status with respect to dreissenid populations, and had an unchanging trend. It is believed that calcium concentrations in Lake Superior are too low to support mussels in high numbers. Lake Erie has a fair status but is currently improving. Mussel populations are limited in Lake Erie due to food limitation, poor food quality, and season hypoxia. Zebra and Quagga Mussels are high impact species that alter nutrient and energy cycles, promote algal blooms and benthic algae, and impact species of invertebrates and fish.

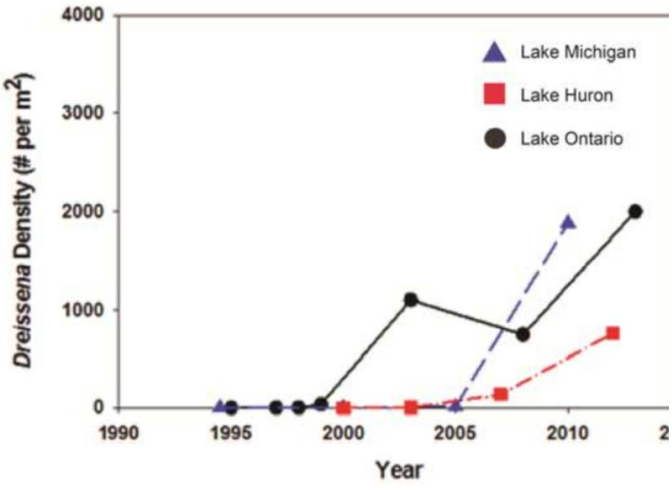

Figure: Mean densities of Dreissena from sites below 90 meters in Lakes Michigan, Huron, and Ontario. Source: Watkins et al. 2007; Birkett et al. 2015; Great Lakes Environmental Research Lab, NOAA

Dreissenid mussels are also linked to an abundance in the benthic community (Benthos), *Cladophora, Diporeia*, and a change in abundance and composition of phytoplankton. **Article 3 Clause 1 Subclause A Sub Sub Clause 7 (General Objective #7) of The Great Lakes Water Quality Agreement states that the Great Lakes should be free from the both the introduction and spread of aquatic invasive species and terrestrial species. Despite this accomplishment General Objective, dreissenid mussels continue to have ecological damage.**[43] Newly invading species benefit from previous invades. One invasive species may help establish the growth of another. For example, the round goby and amphipod may have thrived in the presence of zebra and quagga mussels. Zebra and quagga mussels have been linked to several facilitations of other invasive species, therefore **more attention, effort, and energy must be spent in the eradication of zebra and quagga mussels,**

[42] Environment and Climate Change 353.

[43] Environment and Climate Change 360-362.

which are the root and establishers to many other invasive species.[44]

The sea lamprey is an aquatic invasive species that impacts many fish in the Great Lakes region. Sea Lampreys kill fish such as trout, salmon, whitefish, Lake Sturgeon, cisco, Walleye, and perch. Sea Lamprey control activities have been successful, as the population has been suppressed as much as 90%. Lakes Huron and Michigan hit their target, and populations of adult Sea Lamprey are declining. Lake Ontario has hit its population target; however, the current populations of Sea Lamprey are holding steady. Lake Superior and Lake Erie have no met their target level, however, populations of adult Sea Lamprey have declined since 2010. Despite the immense progress made in controlling the Sea Lamprey population, more work and control is needed especially in Lake Superior and Erie to maintain the fish communities and ecosystem. **Locating new sources of Sea Lampreys must be researched. In addition, Sea Lamprey interactions, and population dynamics of those that survive lampricide treatment must be studied. Even further, research into even more control methods is necessary.**[45]

Garlic Mustard was introduced from Europe in the late 1800s for the culinary or medicinal purposes. Garlic Mustard disrupts natural understory growth and makes germination for tree seedlings difficult. In addition, Garlic Mustard is toxic to butterfly larvae, which results in a reduction in pollination. Garlic Mustard is in all eight Great Lakes states and in all five Great Lakes. Garlic Mustard is predicted to spread across North America due to its high adaptability and ability to grow in numerous ecosystems. Unique management is required to deal with specific instances in each state and basin. Phragmites are invasives that form dense stands along the water's edge and in wetlands, reducing biodiversity by choking out native plants.

Phragmites have changed the hydrologic cycle, altered the nutrient cycle, and contribute to loss of habitat. Phragmites grow at rapid rates of 4 cm vertically a day, and their roots can grow up to several meters long. Phragmites can also spread quickly through water or birds. Currently Phragmites are in five of the eight Great Lakes States. Phragmites are unique to their ability to rapidly colonize and multiple management controls are required to eliminate it. Purple Loosestrife is a plant native to Asia and Europe. The plant has spread to wetlands and impacted quality of habitat for birds, insects, and other plants. In addition, the plant threatens ecosystems by altering water levels and reducing food sources. The Purple Loosestrife is in all eight Great Lakes States and is on the shorelines of all give Great Lakes. One effective method of control is using their natural predators, *Galerucella calmariensis and G. pusilla* beetles. However, these beetles can only reduce the loosestrife to manageable populations and cannot eradicate it. More research must be done to find newer methods of eradication other than using their natural predators, as that will not eliminate the Purple Loosestrife completely.[46] **Although the Great Lakes Water Quality Agreement states that the Great Lakes should be free from the introduction and spread of terrestrial invasive species, the agreement does little to provide solutions for terrestrial invasives, as the**

[44] Environment and Climate Change 353.
[45] Environment and Climate Change 370-373.
[46] Environment and Climate Change 378-382.

solutions under Annex 6 are solely for aquatic invasives. The GLWQA needs to build put more into the research of not only aquatic invasives, but also terrestrial invasives, as they are both equally important.

Climate Change:

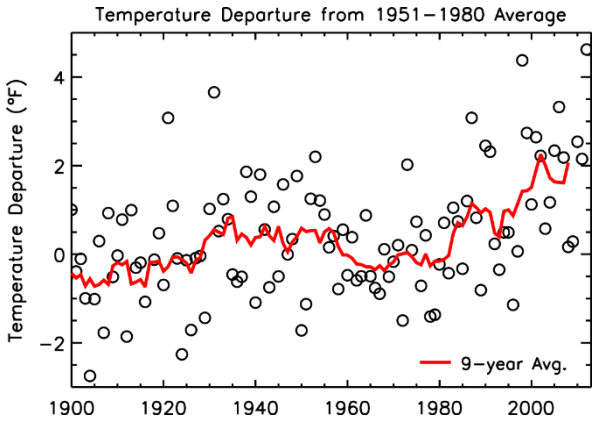

Figure 7: Temperature increase in the Great Lakes region since 1900. Source: GLISA, "Temperature"

Annex 9 of the GLWQA concerns the impact of climate change on the Great Lakes. Overall, average air temperatures have been rising rapidly over the past century, leading to a 2°C increase since 1900 throughout the region.[47] This increase has been significantly higher than the national average. Additionally, ice coverage throughout the Great Lakes has decreased dramatically, leading to a 71% decline since 1973.[48] These changes have been closely linked to anthropogenic greenhouse gas emissions; models predict that if these emissions can be reduced, much of the projected warming in the latter half of the century could be averted.[49]

The primary impacts of climate change on the Great Lakes region will likely be a magnification of the impacts of other issues threatening the Great Lakes, rather than a significant impact from warming itself. Several models predict a significant increase in seasonal precipitation in the Great Lakes region; these increases could lead to an increase in runoff, in turn impacting the amount of nutrients and chemical pollutants entering the lakes.[50] Similarly, higher temperatures significantly increase the risk and rate of lake eutrophication, leading to a rise in the severity and frequency of algal blooms and the subsequent creation of aquatic "dead zones."[51] These problems are compounded by the projected increase in nutrient-laden runoff from extreme precipitation events. Lastly, the environmental shifts brought by climate change will likely lead to an increase in invasive species, since the changes in temperature will have a significant and negative impact on native wildlife populations.[52] Climate change thus serves as a threat magnifier that increases the severity of the other issues addressed within the GLWQA.

Our recommendations for policy approaches to climate change would include significantly increasing funding for studies of climate change and its impact on the Great Lakes region. Further, we would recommend policies that encourage renewable energy in place of fossil fuels, in order to reduce the emission of greenhouse gases. Finally, we

[47] "Temperature," U of Michigan School for Environment and Sustainability: GLISA, Dec. 4 2014. Web. <http://glisa.umich.edu/climate/temperature>

[48] "Great Lakes Ice Coverage," U of Michigan School for Environment and Sustainability: GLISA, Dec. 4 2014. Web. <http://glisa.umich.edu/climate/great-lakes-ice-coverage>

[49] "Temperature."

[50] "Precipitation," U of Michigan School for Environment and Sustainability: GLISA, Dec. 4 2014. Web. <http://glisa.umich.edu/climate/precipitation>

[51] "Algal Blooms," U of Michigan School for Environment and Sustainability: GLISA, Dec. 4 2014. Web. <http://glisa.umich.edu/climate/algal-blooms>

[52] "Fish and Wildlife," U of Michigan School for Environment and Sustainability: GLISA, Dec. 4 2014. Web. <http://glisa.umich.edu/climate/fish-and-wildlife>

would recommend updating regulations concerning runoff, pollution, and other aspects of water quality in order to meet the more stringent demands posed by the threat of global warming in the Great Lakes basin.

Conclusion:

Although the GLWQA serves as a great starting point for cooperation between the US and Canada to tackle issues pertaining to the Great Lakes, it is still lacking in a variety of areas. There are still many unknowns, meaning that increasing funding for the management and research of the Great Lakes is critical to maintaining its health. At the core of everything, the IJC, which is supposed to coordinate the management of the Great Lakes, is underutilized and neglected, leading to partisan decisions rather than environmentally positive decisions. By increasing the authority of the IJC and the funding it receives, the Great Lakes will be better able to meet future environmental needs and maintain its quality for future generations.

Our policy recommendations are as follows:

1. Nutrient Pollution

a. Provide funding for studies of phosphate reduction methods, especially improvements in agriculture and agricultural technology

b. Regulate the amount of phosphate fertilizer use, especially near waterways

c. Strengthen and broaden limits on the application of fertilizers to frozen or snow-covered ground to limit unnecessary runoff.

d. Significantly increase funding/support for wetland restoration throughout the Great Lakes basin

2. Chemical Pollution

a. Increase funding for studies of the type and amount of specific chemical pollutants in the Great Lakes

b. Classify Atrazine as a CMC and regulate it under the TSCA

c. Classify Neonicotinoids as CMCs and regulate them under the TSCA

d. Establish and implement specific plans for zero-emission regulations of all CMCs

e. Implement Extended Producer Responsibility strategies for pollutants entering the Great Lakes

3. Climate Change

a. Increase funding for research into climate change impacts in the Great Lake region

b. Implement policies that favor an increase of renewable energy sources over fossil fuels

c. Update water quality regulations to account for climate change impacts

Acknowledgements:

We would like to thank our adviser, Mr. Drougel, for his help during our work on this project. We would also like to thank our school and its administration for give us the opportunity to submit this report.

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