Great Lakes Nearshore and Human Health

Assessment
Ecosystem Condition: Mixed
Ecosystem Trend: Undetermined

State of the Ecosystem
The variation in statuses and trends among the Great Lakes public health indicator topics create a challenge in assigning a specific ecosystem assessment that would accurately represent all indicators. Levels of polychlorinated biphenyls (PCBs) continue to decrease, but still drive advisories for limiting consumption of Great Lakes sport fish. Air quality in the region is generally improving throughout the basin. Beach advisories, postings and closures suggest a combination of trends ranging from deterioration to improvement and drinking water quality status remains good.

Contaminants in Sport Fish.
Concentrations of organochlorine contaminants in Great Lakes sport fish are generally decreasing. However, in the U.S., PCBs still drive advisories for limiting consumption of Great Lakes sport fish. In Ontario, most of the consumption advisories are driven by PCBs, mercury, and dioxins and furans. Toxaphene also contributes to a small proportion of consumption advisories for sport fish from Lake Superior and Lake Huron, according to the Ontario Ministry of the Environment (OMOE). In addition to an indicator of human health, contaminants in fish are an important indicator of contaminant levels in an aquatic ecosystem. Contaminants that are often undetectable in water can be detected in fish because of the bioaccumulation of organochlorine chemicals in their tissues.

Both the United States and Canada (Ontario) collect and analyze sport fish to determine contaminant concentrations to relate those concentrations to health protection values and / or to develop consumption advice to protect human health. The Great Lakes Fish Monitoring Program (U.S. EPA Great Lakes National Program Office (GLNPO)) and the Sport Fish Contaminant Monitoring Program (Ontario Ministry of the Environment (OMOE)) have been monitoring contaminant levels in Great Lakes fish for over three decades.

Consumption advice for sport fish varies throughout the Great Lakes Basin depending upon the agency or government responsible for issuing consumption advice. In the United States, the Federal Government does not issue consumption advice. Rather, individual States and Tribes are responsible for this task. In Canada, OMOE is responsible for advising Canadians on the recommended frequency and meal size for fish consumption from sport fish collected in their waters. U. S. EPA's Great Lakes National Program Office (GLNPO) does collect and analyze contaminants in sport fish fillets and compares those concentrations to the categories set by the *Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory* that was developed by the Great Lakes States.

According to OMOE data, the level of total PCBs in lake trout has continued to decrease since the early 1990s. In Lake Superior the data demonstrate fluctuations over time but with an overall decline. The most recent data collected in 2006 indicate a maximum consumption level of two meals per month while GLNPO data fall into the one meal per week category. OMOE advice to sensitive populations for sport fish from Lake Erie is for two meals per month, while GLNPO data fall into the one meal per month category. Current PCB concentrations in Lake Huron OMOE lake trout allow for the safe consumption of a maximum of two meals per month, while current GLNPO data hover around the one meal per week consumption advice category. Historically, the highest concentrations of PCBs in sport fish have been found in Lake Ontario. From the late 1970s to 1999, PCBs in OMOE lake trout from Lake Ontario exceeded the "do not eat" consumption limit. Substantially lower concentrations have been found in the most recent samples in 2006 and 2007, and the current levels would permit consumption of two meals per month for the general population. Current GLNPO data for PCB concentrations in sport fish fall into the one meal per week category. GLNPO data for PCB concentrations in sport fish from Lake Michigan can be used to discern general trends due to multiple collection sites. These data display a general decline in PCB concentrations in coho and Chinook salmon fillets. The majority of current concentrations fall into the one meal month consumption advice category with one site falling into the one meal per week category. No OMOE samples were collected from Lake Michigan.

Mercury in sport fish is another contaminant of concern due to the detrimental effects of methylmercury on neurological function and development. The OMOE found that concentration measurements of walleye and lake trout in Lake Erie demonstrate a considerable decline in mercury levels from 0.76 ppm in 1970 to 0.14 ppm in 2006. As a result, OMOE does not have a consumption advisory for this lake. However, GLNPO data fall into the two meals per week advice category. Similarly, in Lake Huron, mercury levels have declined over the last few decades falling below the first level of concentration restriction for sensitive populations in Canada. Currently, GLNPO data fall into the one meal per week category for Lake Huron. The other lakes have also experienced declines in mercury concentrations in fish. According to GLNPO data, Lake Michigan sport fish fall into the one meal per month category. Based upon the most recent data available, Lake Ontario sport fish fall into the four meals per month category for OMOE fish and the one meal per week category for GLNPO data. The OMOE has set the advisory for Lake Superior sport fish at four to eight meals per month for sensitive populations due to consistency in mercury levels since 2000. GLNPO data fall into the two meals per week category.

Since the 1970s, there have been declines in the levels of many PBT chemicals in the Great Lakes basin due to bans on the use and/or production of harmful substances and restrictions on emissions. However, because of their ability to bioaccumulate and persist in the environment, PBT chemicals continue to be a significant concern. Historically, PCBs have been the contaminant that most frequently limited the consumption of Great Lakes sport fish. In some areas, dioxins/furans, toxaphene (Lake Superior) or mirex/photomirex (Lake Ontario) have been the consumption-limiting contaminants. OMOE has found concentrations in Lake Superior lake trout ranging from 0.810 to 0.346 ppm between 1984 and 2006. According to these levels, consumption of up to four meals per month is permissible. Additionally, Health Canada recently has revised downward its TDIs for PCBs and dioxins, which has increased the frequency of consumption restrictions caused by PCBs and dioxins/furans and decreased the relative frequency for toxaphene and mirex/photomirex.

Air Quality

There have been significant improvements in air quality within the Great Lakes basin. For over a decade, there has been considerable progress in reducing urban or local pollutants, though somewhat less in recent years, with just a few remaining problem districts. Of these pollutants, ambient concentrations of carbon dioxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), lead and PM10 as well as emissions of CO have all shown reductions in the Great Lakes basin at nearly the same rate as the nation. Emissions in the basin of NOx, SO2, and PM10 have all decreased at rates faster than national reductions, demonstrating the successes of instituting more stringent transportation emission standards; establishing regulations for fuel combustion, transportation, electric and other industry; as well as efforts like U.S. EPA's Acid Rain Program.

Air toxics also fall under the urban or local pollutant category and include a large number of pollutants that, based on toxicity and likelihood of exposure, have the potential to harm human health or adverse environmental and ecological effects. The U.S. Clean Air Act targets a 75% reduction in cancer "incidence" and a "substantial" reduction in non-cancer risks. At the same time, the Maximum Available Control Technology (MACT) program has established standards to reduce emissions in the industrial sector. These standards will in turn have a significant impact on the future of the Great Lakes basin, which is home to many high pollution-potential industries.

In February 2006, U.S. EPA released the results of its National Assessment of Air Toxics (NATA) using 1999 emissions. The purpose of the national-scale assessment is to identify and prioritize air toxics, emission source types and locations which are of greatest potential concern in terms of contributing to population risk. Since 2003, the United States has been monitoring ambient concentrations of high-risk air toxics such benzene, formaldehyde, 1,3-butadiene, acrolein, and chromium through a National Air Toxics Trend Site (NATTS) network. There are four NATTS monitoring sites in the Great Lakes region including Chicago, IL, Detroit, MI, Rochester, NY and Mayville, WI. Most sites indicate that concentrations of benzene show a statistically significant decreasing trend for any five-year period from 1990 to 2005. While some sites show an increase over this time period, no site shows a statistically significant increase.

Manganese compounds are another hazardous air pollutant of special concern in the region. NATA results show that among the 50 counties with the highest ambient concentrations nation-wide, 20 are located in the U.S. EPA's Region 5. Also, according to the 1999 U.S. National Emissions Inventory (NEI), Region 5 had the highest manganese emissions of all U.S. EPA Regions, contributing 36.6% of all manganese compounds emitted nation-wide. Over time, however, the median average annual ambient concentration of manganese at 21 trend sites showed

a 28% decline between 2000 and 2006. It may then be assumed that ambient concentrations as well as emissions of manganese compounds are decreasing in the region, however, additional years of data may be needed to confirm this apparent trend.

Regional pollutants such as ground-level ozone and fine particulates remain a concern in the Great Lakes basin, especially in the Detroit-Windsor-Ottawa corridor, the Lake Michigan basin, and the Buffalo-Niagara area. Ground-level ozone levels may be augmented in the region due to local onshore circulations that can trap pollutants for days below a maritime/marine inversion. Consistently high levels are found in provincial parks near Lake Huron and Lake Erie, and western Michigan is impacted by transport across the lake from Chicago. Ozone levels in the U.S. have shown continued improvement since 2002, however, the Great Lakes region has experienced smaller decreases than nationwide averages and many of those recorded improvements are the result of local emission reductions in urban areas.

Weather can also play a factor in concentrations levels. In 2005, the industrial Midwest (including WI, IL, IN, MI, OH, KY, and parts of WV, PA, and NY) had a temporary increase in PM2.5 concentrations, likely the result of the colder-than-normal winter and the hotter-than-normal summer, which elevated nitrate and sulfate levels. In the U.S., annual average PM2.5 concentrations have declined nationally by 14% and daily PM2.5 concentrations by 15% between 2000 and 2006. The rate of decrease in the Great Lakes basin is roughly in line with the national averages. However, there are three areas in the Great Lakes region that are designated as non-attainment for the PM2.5 standard (Chicago-Gary-Lake Co, IL-IN metropolitan area; Detroit-Ann Arbor, MI metro area; and the Cleveland-Akron-Lorain, OH metro area). In general, the status of the Great Lakes basin is mixed, but the trends show an overall improvement in air quality.

Beach Advisories, Posting and Closures

Health-related postings for beaches are based upon elevated levels of E. coli, or other indicator organisms, as reported by county health departments (U.S.), Public Health Units (Ontario), or municipal health departments in the Great Lakes basin. The bacteria criteria recommendations for E. coli from the U.S. EPA are a single sample maximum value of 235 cfu per 100 ml. The state of Michigan, as permitted by U.S. EPA, uses 300 cfu per 100ml. For *Enterococci*, another indicator bacterium, the U.S. EPA recommended criterion is a single sample maximum value of 62 bacteria per 100 ml. If the levels of any indicator organisms exceed the recommended criteria, then swimming is either prohibited or advisories are placed to warn beachgoers and swimmers of the possible risk.

The percentage of Great Lakes beaches open the entire season remained nearly constant in the United States between 1998 and 2007 at an average 74%. Although it should be noted that the number of reporting beaches more than doubled between 2002 and 2004, and almost doubled again between 2004 and the past two years. In Canada, the percentage of beaches open the entire season averaged at around 49% from 1998 to 2007. During the 2006 and 2007 seasons, the percentage of beaches posting more than 10% of the time averaged 9% in the U.S. and 42% in Canada. For consistent comparison, calculations derived from posting data are based on the months of June, July and August.

According to Great Lakes data for 2006 and 2007, the number of beach reports has increased significantly in the U.S. and slightly more than in previous years for Canada. The data illustrate that conditions have improved since 2004 and 2005, but have deteriorated in comparison to the data from 1998 to 2003. Affecting this data may be the fact that some beaches that were not directly situated on the Great Lakes were included in the Canadian dataset prior to 2004, but were excised from the data set in 2004. Also the United States included significantly more beach reports in this data, thus adding to trend analysis uncertainty.

The United States *Great Lakes Strategy 2002* has set a goal that by 2010 all Great Lakes beaches should be swimmable, which would require that 90% of all monitored, high priority Great Lakes beaches meet bacteria standards more than 95% of the swimming season. Using the strategy goal as a tool for assessment, it appears that only Lake Superior and Lake Huron met the goal on the U.S. side. For lakes Michigan, Erie and Ontario, many groups are in the process of collaborating to identify and remediate sources in an effort to reduce beach contamination. Unfortunately on the Canadian side none of the lakes satisfied the key objective of the *Great Lakes Strategy*, and while there has been some deterioration, there have also been improvements in comparison to data from 2004 and 2005. Overall, the indicator is assessed as having a mixed status and an unchanging trend.

Drinking Water Quality

The purpose of this indicator is to evaluate chemical and microbial contaminant levels, assess the potential for human exposure to these drinking water contaminants, and review the effectiveness of policies and technologies to ensure safe drinking water. In the U.S. information is drawn from Water Treatment Plants (WTPs), which produce annual Consumer Confidence / Water Quality reports. This information is then verified and further supplemented using the Safe Drinking Water Information System (SDWIS). For Canada, the Ontario Ministry of the Environment (OMOE) produces annual reports from the Drinking Water Systems (DWSs) and other sources. Data for the 2007 operational year (2006 when available) were collected from 43 different WTPs in the U.S., and in Canada data were collected from 74 different DWSs from January to June of 2004. It should also be noted that the U.S. focuses mainly on finished or treated drinking water, whereas Canada tests both raw and treated water.

The status of drinking water in the Great Lakes basin is best assessed through the use of 10 drinking water parameters, which include several chemical parameters, microbiological parameters, and other indicators of potential health hazard. An established standard then regulates these parameters. The U.S. Environmental Protection Agency (U.S. EPA) defines this standard as the Maximum Contaminant Level (MCL) and in Ontario the standard is defined as the Maximum Acceptable Concentration (MAC). Canada also has in place the Interim Maximum Acceptable Concentration (IMAC) with the purpose of managing parameters with insufficient toxicological data or when it is purely not feasible to establish a MAC.

The chemical contaminants atrazine, nitrate and nitrite were assessed in the report according to the standards set by the U.S. and Canada. In the Great Lakes basin, WTP levels of atrazine did not exceed the standard for finished water and no violations were reported. The same was true of Ontario with somewhat higher levels only being detected in raw water sources. For nitrate, detected levels never exceeded the contamination standards of either country, thus no health complications are likely to occur. There were only two violations in the U.S. between January 2006 and December 2006: the Erie Water Works and the Green Bay Water Utility. In the U.S., nitrite was rarely detected and where detected it was only in finished water for WTPs using rivers, small lakes or reservoirs as source water. No violations were reported for nitrite. Ontario had no nitrite contaminant levels exceeding MAC standards and no violations were reported.

Microbiological parameters evaluated include total coliform, *Escherichia coli* (*E. coli*), *Giardia*, and *Cryptosporidium*. In the U.S., two WTPs had health based violations for total coliform bacteria: the City of Rochester in September 2006, and the Michigan International Speedway Water Tower in July 2006. There were also two monitoring and reporting violations for total coliform bacteria: City of Syracuse's Department of Water in July 2007, and in Milwaukee Water Works in September 2007. In the U.S., there was only one monitoring and reporting violation for *E. coli*, the Erie County Water Authority in March 2007. No WTP has any health based violations for *E. coli*. Ontario did not find the presence of *E. coli* in any finished water samples, however small amounts were present in raw water samples. Ontario also detected total coliform in a few treated water samples and in many raw water samples.

Ontario adopted removal/inactivation regulations for *Giardia* and *Cryptosporidium*, but there are no data to report at this time. Neither *Giardia* nor *Cryptosporidium* were detected in finished water supplies from any of the WTPs on the U.S. side, however Consumer Confidence and Water Quality reports discussed the presence of these microorganisms in the source waters (Lake Erie, Lake Huron, Lake Michigan, Lake Ontario, small lakes/reservoirs). The reports illustrate the effectiveness of the WTPs at removing these microbial contaminants, but also the need for continued research on raw water in the Great Lakes basin. At this time it is not likely that any of the aforementioned microbial contaminants will lead to any serious health complications.

In addition to the assessment parameters of chemical and microbial contaminants, treatment techniques including turbidity, total organic carbon (TOC) in the U.S. and dissolved organic carbon (DOC) in Canada, also influence the safety of drinking water. Turbidity data in the United States is difficult to assess due to the different requirements and regulations for WTPs depending on the source water and treatment technique implemented. There were no health violations, but there were two monitoring and reporting violations from the City of Ann Arbor Water Utilities, which occurred in June and July of 2007. In Ontario, the 2003-2004 Drinking Water Surveillance Program (DWSP) report indicated that 78 raw water samples, many of which originated from Lake St. Clair and the Detroit River, exceeded the aesthetic objective.

The U.S. EPA only had one monitoring and reporting violation for total organic carbon, which occurred at the Erie Water Works in January 2007 and continued through until March 2007. For dissolved organic carbon, Ontario found that there were 110 violations identified from raw water samples based on their 2003-2004 data. Most of the high DOC results came from raw water originating from small rivers and lakes. There were a few other drinking water quality parameters that were not mentioned above, but did receive health based violations.

Pressures

Contaminants in Sport Fish:

In the U.S., state and tribal governments currently provide information to consumers regarding the consumption of sport-caught fish. The guidance and advice offered by these governments are not regulatory, though some states use federal commercial fish guidelines for the acceptable level of contaminants. Each state or tribe is responsible for the development of fish consumption advisories and tailoring the advice to meet the health needs of its citizens. As a result, advice may vary between state and tribal programs for the same lake and species. Ontario does maintain federally regulated advice and guidelines, and the data suggest that concentrations of PBT contaminants such as PCBs have declined in lake trout throughout the Great Lakes basin. However, concentrations still exceed current consumption limits thereby stressing the necessity for regular monitoring. The focus should also turn to PBT contaminants of emerging concern and other toxic chemicals.

Air Quality:

Air quality is in a complicated state as continued economic growth, population growth, and the associated urban sprawl threaten to offset emission reductions achieved by policies currently in place. Climate change may also bring about meteorological changes that are more conducive to increased ambient concentrations of many pollutants. There is also increasing evidence of changes to the atmosphere as a whole. Continuing health research is also producing evidence that existing standards may need to be lowered and that multi-pollutant effects may need to be addressed.

Beach advisories, postings and closures:

Beach advisories, postings and closures all rely upon laboratory analysis of samples that may take 18 to 24 hours before processing is completed. Due to the time lag, the efficiency of posting and later lifting restrictions is reduced. The delay in developing a rapid test protocol for bacteriological indicators, as well as the costs, training, and collection times associated with rapid methods, is lending support to the use of predictive models to estimate when bacterial levels may exceed water quality standards. For instance, assuming contaminant sources remain consistent in the Great Lakes, past sample data may be used to forecast when elevated bacterial counts may occur (such as poor recreational water quality after a specific meteorological event).

Additional point and non-point source pollution at coastal areas due to population growth and increased land use may result in additional beach postings, particularly during wet weather conditions. In the U.S., all coastal states (including those along the Great Lakes) have criteria as protective as U.S. EPA's recommended bacteriological criteria (use of *E. coli* or *Enterococci* indicators) applied to their coastal waters. Conditions required to post Ontario beaches as unsafe have become more standardized due to the 1998 Beach Management Protocol, but the conditions required to remove the postings remain variable.

Drinking Water Quality:

The greatest pressure to the quality of drinking water within the Great Lakes basin is degraded runoff. Several causes for a reduction in quality include the increasing rate of industrial development on or near water bodies, low-density urban sprawl, and agriculture (both crop and livestock operations). Point source pollution, from wastewater treatment plants for example, can also contribute to the contamination of raw water supplies and can be considered an important pressure. Additionally, there is an emerging set of pressures derived from newly introduced chemicals and chemicals of emerging concern (i.e., pharmaceuticals and personal care products, endocrine disruptors, antibiotics and antibacterial agents). Invasive species might also affect water quality, but to what extent is still unknown.

Management Implications

Contaminants in Sport Fish:

Health risk communication and cooperation among national, state, and tribal governments is essential to develop and distribute the same message regarding safe fish consumption. Currently, only PCBs, mercury and chlordane (draft)

have uniform advisory protocols across the U.S. Great Lakes basin. Additional uniform PBT advisories may be necessary in order to limit public confusion. Increased monitoring and reduction of PBT chemicals is also needed. Furthermore, potential negative health effects from exposure to PBT chemicals and the monitoring of contaminant levels in environmental media and bio-monitoring of human tissues should be addressed and/or improved upon.

Air Quality:
In Canada, new ambient standards for particulate matter and ozone have been endorsed, with an achievement date of 2010. New, more protective ambient air standards for ozone and particulate matter have been promulgated in the U.S. Also, U.S. MACT standards continue to be promulgated for sources of toxic air pollution. U.S. EPA has also begun looking at the risk remaining after emissions reductions for industrial sources take effect. In December of 2000, both Canada and the U.S. signed the Ozone Annex to the Air Quality Agreement, which commits both countries to reducing emissions of NOx and VOCs. The U.S. and Canada have also undertaken cooperative modeling, monitoring, and data analysis as well as developed a work plan to address transboundary particulate matter issues. Efforts to reduce toxic pollutants will also continue under the North American Free Trade Agreement and through United Nations-Economic Commission for Europe protocols. The U.S. continues its deployment of a national air toxics monitoring network.

Beach advisories, postings and closures:
States, provinces, and municipalities are continuing to identify point and non-point sources of pollution in recreational waters. Potentially harmful sources include combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), malfunctioning septic systems, and poor livestock management practices, which can become exacerbated after heavy rainfall. In an effort to address these concerns, in 2007 U.S EPA issued grants to nine parties to participate in a pilot beach sanitary survey project at 61 Great Lakes beaches in the U.S. and Canada. The goal is to identify sources of pollution and evaluate the beaches and surrounding watersheds. Additionally, the Great Lakes Regional Collaboration Strategy's Coastal Health Chapter laid out goals: to achieve a 90-95% reduction in bacterial, algal and chemical contamination at all local beaches; and at the local level, individual contamination events will occur no more than 5% of available days per bathing season. Sources of these contamination events will be identified through standardized sanitary surveys, and remediation measures will be in place to address these events.

Ontario health units participate in beach management programs such as enhanced beach grooming, in-water and land debris clean-up, waterfowl and gull deterrent and public campaigns to encourage proper disposal of food (City of Toronto, 2006). Also, the Blue Flag program is becoming well-known and is an effective way of promoting clean beaches in Canada. It is an eco-label that is internationally recognized and only awarded to beaches that achieve high standards in areas such as water quality, education, environmental management and safety (Environmental Defense, 2008). In 2007, Ontario already had nine awarded Blue Flag beaches, and 5 candidate beaches.

Drinking Water:
A more standardized and extensive monitoring program is needed to address newer parameters of concern that might not be listed by the U.S. EPA due to availability of resources or technology. Implementing a more extensive program should also successfully demonstrate a correlation between drinking water quality and the status of the Great Lakes basin. At this time, the finished drinking water data merely depict the efficiency of the WTPs rather than the overall water quality in the region. Source water data need to be reviewed to properly assess the state of the ecosystem.

Acknowledgments
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List of Tables

Table 1. Human Health Indicators Assessment for 2009

HUMAN HEALTH

ID #	Indicator Name	2009 Assessment (Status, Direction)				
		Lake				
		SU	MI	HU	ER	ON
4175	Drinking Water Quality	◆				
4177	Biological Markers of Human Exposure to Persistent Chemicals	?				
4200	Beach Advisories, Postings and Closures	◆→	→	◆→	←	◆←
4201	Contaminants in Sport Fish	◆	→	→	◆	→
4202	Air Quality	→				

Status					Trend			
					➡	◆	⬅	?
Not Assessed	Good	Fair	Poor	Mixed	Improving	Unchanging	Deteriorating	Undetermined
Note: Progress Reports and some Reports from previous years have no assessment of Status or Trend								