Report on the Peer Review Workshop for Great Lakes Fish Monitoring Program— Quality Management Plan and Historical Database

Chicago, IL
December 11–12, 2007

Submitted to:

Great Lakes National Program Office
U.S. Environmental Protection Agency
Chicago, IL 60604

Submitted by:

Eastern Research Group, Inc.
110 Hartwell Avenue
Lexington, MA 02421

Notice

This report was prepared by Eastern Research Group, Inc. (ERG), an EPA contractor, as a general record of discussion during the Peer Review Workshop for Great Lakes Fish Monitoring Program—Quality Management Plan and Historical Database, held December 11–12, 2007, in Chicago, Illinois. This report captures the main points and highlights of the meeting. It is not a complete record of all details discussed, nor does it embellish, interpret, or enlarge upon matters that were incomplete or unclear. Statements represent the views of meeting participants.

Contents

This page intentionally left blank.

Executive Summary

Since 1977, the U.S. Environmental Protection Agency's (EPA's) Great Lakes National Program Office (GLNPO) has engaged in efforts to measure the levels of various contaminants in fish in the Great Lakes ecosystem. This effort is currently known as the Great Lakes Fish Monitoring Program (GLFMP), and it represents a collaboration with state and federal agencies and Native American tribes, overseen by GLNPO.

EPA seeks to enhance the quality and validity of the GLFMP to ensure that the data generated under the program are statistically sound and representative of today's environment, and that any future decisions based on this program have a credible basis. To this end, Eastern Research Group, Inc. (ERG), an EPA contractor, convened an independent panel of six experts on December 11 and 12, 2007, to review and evaluate the GLFMP's Quality Management Plan and historical database. EPA asked the reviewers to assist in identifying appropriate data quality objectives and to recommend future changes to the design of the GLFMP.

During the workshop, the peer reviewers had an opportunity to ask EPA for more details about the GLFMP, then they discussed the program in depth. Their review covered three major aspects of the program: Element 1, an effort to monitor trends in top predator fish in open waters; Element 2, a sport fish fillet monitoring effort; and strategies to address newly identified or emerging contaminants. At the end of the workshop, the panel provided EPA with several specific recommendations.

Element 1 (Open Lake Trend Monitoring)

GLFMP Element 1 involves collecting top predator fish in the open waters of the five Great Lakes, then analyzing whole body tissue for contaminants. EPA generally views Element 1 as a tool for ecological assessment, using species that are thought to incorporate large portions of the Great Lakes, such as lake trout and walleye.

The peer reviewers had generally positive impressions of Element 1, noting that it reflects a long and consistent time series and it provides data that are useful to the scientific community. They felt that the design provides a solid foundation for the program; nonetheless, they identified several ways to enhance the design further, and they cautioned that the true "appropriateness" of the design lies in how well it meets the needs of those who use the data. Reviewers also expressed an interest in learning more about the statistical power of the results.

Reviewers urged EPA to define the objectives of Element 1 more clearly. In their opinion, establishing data quality objectives requires a clearer vision of what the program aims to do, along with a better understanding of the needs of various data users. At the same time, reviewers encouraged EPA to be realistic, focusing on what the program can actually do well—provide basic "ecosystem monitoring" data—while acknowledging that this program alone cannot answer more complex questions about ecosystem health or the ecological effects of toxicants. Rather, the reviewers encouraged EPA to view GLFMP Element 1 as an effort that can inform others and serve as a starting point for more detailed ecological assessments.

In their discussion, the reviewers provided the following recommendations for Element 1:

1. Focus on long-term "ecosystem monitoring."
2. Explicitly state the program objectives, questions, and uses of data.
3. Document how this program relates to other agencies' efforts.
4. Pursue cooperative agreements with the states.
5. Conduct an in-depth statistical analysis of past data.
6. Compare GLFMP biannual data with Canadian annual results to determine how sample frequency might impact variability.
7. Follow a graduated sampling program (i.e., maintain the essential elements of the current sampling design but with possible enhancements such as annual sampling at each station).
8. Continue to archive composite samples. Archive a subset of samples as individuals, too.
9. Catch fish of a desired age, based on lake-specific age-length relationships.
10. If possible, pre-age fish before compositing.
11. Add a few supplemental stations to test spatial comparability.
12. Consider augmenting the data by collecting lake trout from the eastern basin of Lake Erie (in addition to walleye).
13. Consider adding stable isotope analyses to help understand food web dynamics.
14. Examine the literature comparing native versus hatchery-reared trout for differences in exposure and age-size relationships.
15. Calculate toxic equivalency quotients (TEQs) where appropriate, but continue to report individual congener concentrations as well.
16. Establish an appropriate data quality objective (DQO).

Element 2 (Sport Fish Fillet Monitoring)

GLFMP Element 2 involves collecting samples of sport fish (salmon and rainbow trout) and analyzing the fillets to determine whether contaminants are present at levels that could pose risks to human health. After learning about the program design, reviewers explored how the data are used, particularly with respect to the process of setting fish consumption advisories. They observed that Element 2 is complicated because it borders on the domain of the Food and Drug Administration (FDA)—which regulates the quality of commercial fish—and the domain of the states, which issue fish consumption advisories for sport caught species. Although Element 2 is intended to support state efforts, reviewers noted that the states have not expressed a need for the data, despite the fact that EPA is several years behind in publishing results. Thus, the reviewers expressed concern about the extent to which EPA's data serve a unique purpose, rather than duplicating existing state efforts. Reviewers also discussed several aspects of the sample design that could limit the utility of the data.

Ultimately, the majority of the panel felt that instead of trying to improve Element 2's design, EPA would be better served by eliminating this program and using the funding for other purposes. They recommended reallocating Element 2 resources to augment Element 1 and to bolster efforts to learn about emerging contaminants.

Emerging Contaminants

In its charge to reviewers, EPA asked them to consider how the GLFMP can stay up-to-date with respect to new or emerging contaminants. Under the current program design, EPA periodically will conduct an "extended program year" to scan samples for contaminants that are not part of the standard list of analytes. Reviewers supported this idea, noting that once EPA identifies a new contaminant, the Agency can also revisit archived samples to learn more about the history of that contaminant in Great Lakes fish. To provide the best value to the scientific community, the reviewers generally felt that EPA should focus on detecting new contaminants in open water samples (i.e., Element 1), thereby complementing the efforts of other groups that track emerging contaminants near point sources along the shore.

The panel developed five specific recommendations regarding the design of the program and the use of data:

1. Continue to archive samples from Element 1. Archive multiple subsamples from each composite.

2. Every few years, conduct a workshop to discuss current knowledge regarding emerging contaminants.

3. Every few years, conduct a complete scan to identify new contaminants. Once new contaminants are identified, analyze historical samples to determine trends.

4. Develop protocols for taking action on newly identified contaminants, including interactions with other agencies and offices.

5. Track emerging approaches for characterizing contaminants.

This page intentionally left blank.

1. Introduction

Since 1977, the U.S. Environmental Protection Agency's (EPA's) Great Lakes National Program Office (GLNPO) has engaged in efforts to measure the levels of various contaminants in fish in the Great Lakes ecosystem. This effort is currently known as the Great Lakes Fish Monitoring Program (GLFMP), and it represents a collaboration with state and federal agencies and Native American tribes, overseen by GLNPO.

Ultimately, the mission of the GLFMP is to support GLNPO's goals of assessing the ecological health of the Great Lakes ecosystem and understanding trends in the condition of the ecosystem. The GLFMP has the following stated objectives:

- Monitoring temporal trends in bioaccumulative organic chemicals in the Great Lakes using top predator fish as biomonitors;
- Assessing potential human exposure to organic contaminants found in these fish; and
- Providing information on new compounds of concern entering the lakes ecosystem.

The GLFMP consists of two program elements:

- Element 1: Open Lake Trend Monitoring. Element 1 aims to monitor contaminant trends in the open water of the Great Lakes and assist in evaluating the impacts of contaminants on fish and fish-consuming wildlife. EPA annually collects and composites samples of top predator fish—walleye in Lake Erie and lake trout in the other Great Lakes—at two sites per lake on an alternating schedule. A grantee (currently Clarkson University; formerly the University of Minnesota) analyzes chemical concentrations in whole body tissue.

- Element 2: Sport Fish Fillet Monitoring. Element 2 aims to monitor potential human exposure to contaminants through consumption of popular sport species. Sport fish samples—rainbow trout in Lake Erie; coho and chinook salmon in the other Great Lakes—are collected by the eight states surrounding the Great Lakes (Ohio, Illinois, Michigan, New York, Pennsylvania, Wisconsin, Minnesota, and Indiana). Samples are collected annually at one to eight sites per lake. The laboratory analysis measures chemical concentrations in fillets. Until 1997, Element 2 was a cooperative effort with the U.S. Food and Drug Administration (FDA), which has statutory authority over the safety of commercial fish. Since then, EPA has assumed responsibility for the program.

Over the life of the GLFMP, the list of analytes has changed in response to both budgetary constraints and information about new and emerging contaminants. Accordingly, GLNPO is working on revising its data quality objectives (DQOs) to be more representative of present day contaminant concentrations in Element 1. GLNPO is also working to create a DQO for Element 2. The revision and creation of DQOs will lead to changes in both elements of the GLFMP for the future.

On December 11 and 12, 2007, Eastern Research Group, Inc. (ERG), an EPA contractor, convened an independent panel of six experts (Appendix A) in a workshop to review and evaluate the GLFMP's Quality Management Plan (QMP) and historical database. The overall goals of the peer review were to enhance the quality and validity of the program, ensure that the data generated under the program are statistically sound and representative of today's environment, and ensure that any future decisions based on this program have a credible basis. In its charge to the reviewers (Appendix B), EPA asked them to assist in identifying present day DQOs and to recommend future changes to both elements of the GLFMP. Prior to the meeting, each panelist submitted individual comments (Appendix C), which the panel chair summarized in Appendix D. Appendix E contains the agenda for the workshop.

This report summarizes the presentations and discussions that took place at the workshop. For organizational efficiency, this report groups many of the discussions by topic, rather than strictly chronologically.

2. Opening Session

Kate Schalk of ERG opened the workshop by welcoming the reviewers and observers. She then reviewed the meeting agenda.

Schalk introduced Paul Horvatin, Program Manager of GLNPO's Monitoring, Indicators, and Reporting Branch, who presented an overview of the GLFMP (Appendix F). Horvatin explained the history and goals of the program, noting that the GLFMP is one way that GLNPO analyzes long-term trends. The GLFMP may also represent an opportunity for greater collaboration with Canada, following the Integrated Atmospheric Deposition Network (IADN) as a model. Horvatin summarized the peer review charge, emphasizing that EPA would like to:

- Enhance the quality and validity of the GLFMP;
- Ensure that data meet stakeholder needs; and
- Ensure a credible scientific basis for future program decisions.

Horvatin asked the reviewers to consider the validity of both the sample design and the current reporting standards. He also asked them to consider the financial feasibility of their recommendations. Elizabeth Murphy, the GLFMP manager, noted that the program has an annual budget of approximately $350,000 for analysis, $90,000 for contractor support (e.g., quality assurance/quality control [QA/QC], sample shipment, homogenization support), and $10,000 for sample collection.

Additional remarks were provided by Louis Blume, the Quality Assurance Manager for GLNPO. Blume explained that the GLFMP has not historically had extensive QA procedures due to its origins as a collaborative program. Existing QA elements include historical documentation, standard operating procedures, and laboratory audits. Recent milestones include a program review in 2005, awarding of a new primary investigator (PI) grant to three university researchers (a collaborative partnership administered by Clarkson University) in 2006, and development of a QMP in 2007, which is still under review. In general, GLNPO aims to make sure the information it collects is of adequate quality for the intended use. With this goal in mind, Blume urged reviewers to consider what the end uses of GLFMP data truly are, and to recommend a sample design that supports these endpoints. He also asked the panel to think about aspects such as representativeness (i.e., whether the results are representative of an entire lake), sample size, the statistical ramifications of using composite samples, and the validity of current age-versus-length assumptions.

Following EPA's opening remarks, the reviewers introduced themselves. Panel chair Kent Thornton then opened the discussion with some general observations gleaned from the panel's pre-meeting comments, which he summarized in a written handout (Appendix D). Thornton commended EPA for its long history with the GLFMP and its interest in ensuring data quality. He also raised the following overarching questions and concerns:

- Reviewers feel that they need more information on the GLFMP's primary questions and objectives. Several reviewers commented that they were unable to glean this information from the QMP, which they found difficult to understand, perhaps due to its constrained organizational structure.

- Proper sampling approaches depend on the program's objectives. For example, if the GLFMP aims to assess ecosystem health, then it might be more appropriate to sample prey species instead of top predators. Some objectives might be accomplished by nesting intensive studies within the overall design.

- The reviewers need to know more about program goals before they can determine what constitutes an appropriate DQO for Element 1.

- By some indications, there are relatively few end users of data from Element 2, which might present an opportunity to refocus the sport fish program or curtail the program and spend the money to enhance Element 1 instead.

- In both program elements, many of the reviewers would like to see a greater emphasis on mercury contamination.

- Based on pre-meeting comments, reviewers feel that the current approach of archiving samples and scanning for other compounds every five years is generally a good way to stay abreast of trends in emerging contaminants, although reviewers provided some specific suggestions for improvement.

Following the chair's summary of major issues, several panelists elaborated on their overarching concerns. Some spoke about the need for a clear purpose, with one suggesting that the current stated goals (examining ecological health and human health within the Great Lakes Basin) are too broad. As others noted, publishing data in a timely fashion is important, but without a clear scientific use of the data within the Agency, monitoring programs might persist simply "to collect data." Another panelist pointed out that EPA will need to be aware of political objectives as well.

Two reviewers applauded EPA for revisiting the GLFMP because the program now operates in an environment that is very different from when the program was initially conceived. Originally, the GLFMP examined the effects of "turning off the pipe," helping scientists observe how Great Lakes ecosystems would respond once major pollution sources were curtailed. In its early days, the program observed large declines in contaminant concentrations, but contaminants are now behaving differently, raising new questions about ecosystem dynamics.

Based on the charge and the pre-meeting comments, the panel agreed to organize their subsequent discussion around three major topic areas:

- Element 1 (Open Lake Trend Monitoring)
- Element 2 (Sport Fish Fillet Monitoring)
- Emerging contaminants

3. Element 1 (Open Lake Trend Monitoring)

3.1 General Discussion

Murphy opened the discussion by providing additional background information on Element 1; her presentation can be found in Appendix H. She explained that the program uses fish as indicators to monitor contaminant trends in the open waters of the Great Lakes. Element 1 also represents an opportunity to examine the effects of toxicants on fish and fish-consuming wildlife, using top predator fish as a surrogate. Murphy emphasized that the GLFMP is a "big picture" program and not intended to drive regulatory actions. Samples are collected from two designated sites in each lake on an alternating schedule; one site is sampled in odd years and the other in even years. From each site, EPA analyzes five composite whole-body samples of 10 fish each (a total of 50 fish). Composite samples are archived; since 2003, additional composite samples have been stored for perfluorinated chemical analysis.

Several reviewers inquired about site selection, with one noting that sites should ideally be selected with input from wildlife biologists. Murphy explained that each lake has two sites—one in a rural setting, the other in an area with more urban influences. Sites were chosen with biological considerations in mind (e.g., near reefs and shoals where the target species are known to occur).

Reviewers also expressed concern that the GLFMP has not released data for many years. Murphy acknowledged that the previous grantee, the University of Minnesota, has had equipment problems that have delayed reporting. She expects 2001-2003 data to be released in early 2008, however, and she also expressed hope that the new grantee—Clarkson University—will report future results in a timely fashion. In general, she explained, data collected in the fall should be released in spring of the following year.

Murphy explained that polychlorinated biphenyls (PCBs) receive the most attention in the GLFMP literature because they are the contaminant most responsible for consumption advisories in the region, but the program also analyzes for other organics. A reviewer inquired about mercury, noting that levels seen in the Great Lakes would be sufficient to trigger consumption advisories in most states. Murphy explained that mercury was added to the routine analyte list in 1999. Dioxins and furans were added to the list more recently; the new grantee (Clarkson) has equipment with sufficient sensitivity to detect these compounds.

PCBs are also the focus of EPA's current DQO, which dictates that EPA must be able to report changes in PCB concentrations to a certain level of precision: specifically, the program must be able to detect an average annual decline of 5 percent in total PCB concentrations in whole fish between 1990 and the present on a basin-wide scale. As Murphy and Blume explained, this DQO evolved in a policy arena. While the GLFMP's funding is contingent upon meeting the DQO, EPA can change this DQO in the future if it has a legitimate justification for doing so.

In the ensuing discussion, reviewers provided numerous recommendations to help EPA enhance Element 1. These recommendations are described in Section 3.2. In supplemental comments, at least one reviewer suggested that for future reviews, EPA should try to compile relevant information into one comprehensive program document, rather than the current mosaic of separate documents.

3.2 Panel Recommendations

3.2.1 Focus on long-term "ecosystem monitoring."

Before discussing specific aspects of program design, panelists outlined their fundamental vision for GLFMP Element 1. In their view, EPA should consider leading the program in the following direction:

- Treat the program as an "ecosystem monitoring" effort, and collect data in a way that facilitates their use by others.
- Focus on long-term trends, not year-to-year change.
- Use wildlife criteria where appropriate.

Ecosystem monitoring

Reviewers debated whether Element 1 can truly measure the ecological effects of contaminants, which is a complex endeavor. As one reviewer explained, programs like GLFMP Element 1 originated as ways to measure contaminants in the water, using top predator fish as a surrogate for measuring levels of toxic chemicals present in the Great Lakes. Now that concentrations in the water have declined, however, contaminant trends in top predator fish reflect a more complex array of factors such as atmospheric deposition, trends in abundance of forage fish populations, and broader ecosystem change. At the same time, people have become less concerned about human health impacts from drinking the water, and more concerned with human health and ecological impacts through consumption of fish tissue—leading to more complicated questions about ecosystem dynamics.

Panelists debated the program's emphasis on top predators. As one reviewer observed, an assessment of ecological health would ideally consider a range of populations. Another noted that lake trout and walleye are not food sources for other fish, nor are they typically consumed by birds or other piscivorous wildlife. Because lake trout have the same food source as piscivorous birds, however (i.e., forage fish), panelists noted that lake trout data might prove to be a useful surrogate for wildlife body burdens. Top predator fish are also useful tools for contaminant monitoring because they have typically accumulated these chemicals at concentrations that can be detected and quantified—particularly large, fatty lake trout—while fish from lower trophic levels might not. With these arguments in mind, the reviewers generally agreed that top predators can at least serve as one indicator of ecological condition.

Still, the reviewers emphasized that GLFMP Element 1 cannot realistically be expected to address a wide range of ecosystem and food web questions by itself. For example, if contaminants are present in fish but below levels that produce obvious health effects in the individual (e.g., an LD_{50}), further study would be needed to determine the nature of more subtle effects to the individual—as well as potential effects elsewhere in the food web. In an ideal scenario, two panelists suggested, scientists might wish to translate the findings of Element 1 through the food web and learn which links are most vulnerable to toxic effects. Given the inherent limitations of a single study of top predators, however, panelists urged EPA to view GLFMP Element 1 as an important part of the answer, rather than the whole answer (i.e., a basis for other studies and a program that can help support more in-depth assessment when combined with data from other programs such as herring gull egg studies).

Following the discussion above, one reviewer suggested that EPA define its objective as "ecosystem monitoring" rather than assessing "ecological health," which is not an operational definition. The panel generally agreed, suggesting that EPA treat Element 1 as a basic ecosystem monitoring program and a stepping stone to more detailed research by others. Accordingly, reviewers encouraged EPA to collect the data in a manner that will maximize their utility and versatility:

- To support ecological assessment, EPA should continue to collect whole fish.
- EPA should record other parameters that can facilitate interpretation, such as lipid content.

In response to a question from EPA, reviewers agreed that the Agency should not attempt to use Element 1 to answer questions about impacts to human consumers. Human health effects depend on contaminant concentrations in fillets, and while it is possible to correlate whole-body measurements with fillet concentrations, reviewers cautioned that these relationships vary by location, species, age, size, and contaminant. Thus, human health advisories are better informed by fillet studies.

Focusing on long-term trends

Given the many factors that can influence contaminant concentrations in fish, the reviewers agreed that EPA should emphasize long-term trends rather than year-to-year change. As two reviewers explained, year-to-year variability is expected, and might reflect the influence of climate patterns or other factors. This is not to say that EPA should not *watch* the data year-to-year; as one panelist noted, EPA would want to know sooner rather than later about a large jump that might signal a release from a historical contaminant sink (e.g., a dioxin dumpsite along the lakeshore). Nonetheless, panelists agreed that EPA should focus on identifying a time scale that is appropriate for reporting meaningful long-term trends, then determining the statistical significance of these trends.

Using wildlife criteria where appropriate

Another value of GLFMP Element 1 is as an indicator for the public, providing a general picture of whether trends in contaminant concentrations are going up or going down. Yet the next logical question the public might ask is: "Do we have a problem?" As one reviewer noted, comparing measured concentrations with established, peer-reviewed wildlife criteria can help address this question. Another reviewer cautioned that some wildlife criteria may be set at "unrealistically" low levels (e.g., the Great Lakes Water Quality Agreement criterion of 0.1 micrograms per gram [µg/g] total PCB in whole fish), although a third member of the panel countered that just because the vast majority of fish exceed a criterion does not automatically mean the criterion is overprotective.

3.2.2 Explicitly state the program objectives, questions, and uses of data.

As a starting point for enhancing the GLFMP's design, panelists advised EPA to define the program's objectives and the questions it aims to answer. They also advised EPA to consider the needs of various groups who use the data. EPA explained that several groups use the data produced by Element 1:

- The PI has received a competitive grant from EPA to analyze the homogenate and provide quality-assured data. In return, the PI retains a one-year exclusive right to publish the data in a peer-reviewed journal, which they generally do. The PI also must produce an annual report for EPA.
- EPA uses the data internally for the binational State of the Lakes Ecosystem Conference (SOLEC), reports to the Government Accountability Office (GAO) and the Office of Management and Budget (OMB), and other users.
- EPA makes the full dataset available to researchers. Most interest comes from universities; other potential users could include the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Fish and Wildlife Service.

As far as user needs are concerned, Blume explained that many users are looking for data to make statements on a lakewide basis—for example, EPA's *Report on the Environment*. Thus, it will be particularly important to determine the extent to which the GLFMP data are representative of entire lakes (see Section 3.2.11). One reviewer suggested that the pending release of several years' worth of data could provide a good opportunity for EPA to renew interest among partners and to survey their needs.

3.2.3 Document how this program relates to other agencies' efforts.

At several points in the discussion, reviewers noted the potential for overlap with efforts by the states, other federal agencies, or Canadian groups. For example, the Environment Canada fish monitoring program (previously operated by Fisheries & Oceans Canada) has measured contaminants in smelt, alewife, and sculpin. One reviewer suggested that EPA develop a matrix to document other agencies' efforts. Another noted that learning about other efforts—including efforts that may use data from the GLFMP—could serve as a starting point for an improved Element 1 DQO.

3.2.4 Pursue cooperative agreements with the states.

Noting that EPA already relies on states to collect samples for Element 2, one reviewer inquired whether EPA could extend these cooperative agreements to cover analysis for Element 1. Panelists discussed several benefits and drawbacks of this approach. Ultimately they did not endorse the idea as a group, but recommended that EPA at least consider it.

One panelist suggested that having states perform the analysis could save EPA money, perhaps allowing EPA to devote more resources to studying emerging contaminants. However, another reviewer cautioned that for analytes like PCBs, there can be considerable variation among different laboratories using the same method. Further, different states use different analytical methods, which can make quality assurance more complicated and potentially nullify any cost savings. A third reviewer suggested following the example of the U.S. Geological Survey (USGS), which has reportedly moved away from requiring specific methods and towards performance-based accuracy and precision standards.

3.2.5 Conduct an in-depth statistical analysis of past data.[1]

As several panelists noted, the statistical power of the data determines the strength of the conclusions that can be drawn—both in terms of contaminant concentrations and in terms of other questions about ecosystem dynamics, trophic stressors, and so on. More specifically, devising an optimal sampling plan requires an understanding of the components of variance. For example, one panelist explained how Canada's herring gull egg sampling program was able to analyze a single composite sample per site (thereby reducing analysis costs) after a statistical analysis showed consistent coefficients of variation. Accordingly, the panel recommended that EPA review historical data in depth in order to learn more about the sources of variability and their effects on trend detection, and ultimately partition the overall variance among these sources. Reviewers listed several sources of variability that EPA can analyze, including the following:

- Sampling frequency (annual and inter-annual variance)
- Number and size of composites

---

[1] In post-meeting comments, one reviewer (Don Stevens) suggested that EPA consult the following references for guidance on this type of statistical analysis:

Larsen, D.P., N.S. Urquhart, and D.L. Kugler. 1995. Regional-scale trend monitoring of indicators of trophic conditions of lakes. Water Resources Bulletin 31:117–140.

Larsen, D.P., P.R. Kaufmann, T.M. Kincaid, and N.S. Urquhart. 2004. Detecting persistent change in the habitat of salmon-bearing streams in the Pacific Northwest. Can. J. Fish. Aquat. Sci. 61:283–291.

Urquhart, N.S., S.G. Paulsen, and D.P. Larsen. 1998. Monitoring for policy-relevant regional trends over time. Ecol. Appl. 8:246–257.

- Variability among sites in a given lake
- Variability among lakes
- Age
- Lipid content

Several of these sources of variability are described in further detail under other recommendations. One aspect not discussed elsewhere is lipid content. One reviewer stated that lipid adjustments are more important when dealing with muscle tissue contaminant data, and suggested that lipid content is probably not a large source of variability for whole fish samples within systems (e.g., within each lake). However, another reviewer suggested that lipid variability might be larger *between* systems, especially given that lake trout in Lake Superior might represent a leaner subspecies. Ultimately, several reviewers agreed that EPA does not need to lipid-normalize the results, but should at least report lipid concentrations so other users can normalize the data if they wish. One panelist also reminded EPA not to mix the two subspecies of Lake Superior lake trout in the composites.

Several reviewers pointed out that overall, a statistical analysis should not be particularly costly. EPA could further reduce the scale of the effort by examining only a subset of samples (e.g., three composites from each year, rather than 10), as one panelist suggested.

3.2.6 Compare GLFMP biannual data with Canadian annual results to determine how sample frequency may impact variability.

Reviewers noted that Canada has collected samples annually from some of its own sites in the Great Lakes (sites in Lake Erie and Lake Ontario), while GLFMP Element 1 has sampled each of its sites every two years. Along with the in-depth statistical analysis described above, some members of the panel suggested that EPA compare trends and variability from the U.S. and Canadian programs to determine which approach—annual or alternating years—does a better job of providing useful long-term trends. However, they disagreed as to whether EPA should compare actual results or just compare variability. Results could be compared in terms of correlations or regressions, but one reviewer cautioned that different results might reflect the use of different sampling sites, if it turns out that each site is not representative of lake-wide trends. For some comparisons, EPA might need to adjust for Canada's use of individual samples, versus the GLFMP's composites of 10. Accordingly, one reviewer noted that EPA could make mathematical composites of the Canadian data (i.e., groups of 10 samples) before comparing the two programs.

One reviewer felt that instead of a separate analysis, it would make more sense to consider sampling frequency as part of the broader statistical analysis recommended in Section 3.2.5, which should examine all relevant components of variance. Two others noted that U.S. and Canadian programs have already been compared in various studies.

3.2.7 Follow a graduated sampling program.

The reviewers discussed several aspects of sample design, recommending specific approaches with respect to the frequency of sampling and the frequency of analysis. As several reviewers pointed out, EPA should avoid radical changes to the sample design in order to maintain comparability with past data and preserve the ability to track long-term trends. Nonetheless, reviewers identified a few opportunities for EPA to enhance its sampling program.

Reviewers debated whether EPA should collect samples annually rather than in alternating years. Annual resolution would help support sentinel monitoring, as skipping years could cause EPA to miss important events (e.g., regime shifts). Some external data users might also desire annual resolution. Reviewers inquired about financial constraints, however, to which Murphy responded that sample collection is a relatively small cost, while analysis is more expensive. Accordingly, two reviewers suggested that EPA collect samples annually from each site, but prioritize only certain samples for analysis. One approach might be to analyze samples every year for lakes with the highest contamination, and analyze less frequently (e.g., every three years) for lakes where contamination is lower and year-to-year change is smaller. Another approach might be to use smaller pools for annual analysis.

In a related discussion, reviewers disagreed about whether annual data are necessary for tracking long-term trends. One reviewer argued that from a statistical perspective, it is best to calculate long-term trends using a cluster of points at the beginning and another cluster at the end, but fewer points in the middle. Others disagreed, asserting that a reliance on end points can introduce bias and mask the true shape of the curve. One reviewer pointed to a case study with graphs showing what happens when one tries to determine long-term trends using data at three-year intervals: over the same time period, apparent trends vary widely depending on which set of years (e.g., years 1, 4, 7, 10 versus years 2, 5, 8, 11) one chooses. The proponent of fewer points countered that if trends can vary so widely depending on the choice of three-year intervals, it suggests a great deal of inter-annual variability; thus, the observed trends actually have very little statistical power. This reviewer noted that in general, the power of a trend is inversely proportional to the variance. It is necessary to conduct annual sampling for a sufficient length of time to obtain a good estimate of inter-annual variability, but once that estimate is available, annual sampling is no longer required for long-term trend analysis.

Although the reviewers did not reach consensus about the need for annual data in long-term trend analysis, they generally agreed that there are other benefits to collecting data with annual resolution, such as examining ecosystem dynamics.

3.2.8 Continue to archive composite samples. Archive a subset of samples as individuals, too.

Regardless of how the monitoring design is modified, reviewers agreed that EPA should continue to archive composite samples. They noted that archived samples can help EPA address status and trend questions, deal with emerging contaminants, and provide information to others.

Reviewers also suggested that EPA archive individual samples to allow for the analysis of variability. They suggested the following approach:

- Given the expense of archiving and analysis, retain only a subset of the samples as individuals.[2]

- For the chosen subset, homogenize each individual. Save a portion of this individual homogenate, and use the remainder to create composite samples per the overall sampling design.

- Analyze individual samples as needed to assess variability.[3]

3.2.9 Catch fish of a desired age, based on lake-specific age-length relationships.

Differences in length, weight, and age represent possible sources of variability. Panelists agreed that the GLFMP's objectives are best served by collecting fish of similar age, which will enable EPA to make more statistically meaningful statements about trends over time and space. EPA should not apply a uniform length or weight criterion across the entire study, as this criterion could correlate to different ages in different lakes, due to differences in productivity and growth rates. Further, age-length relationships might change within the same lake over time, as ecosystem dynamics change. Thus, the panel agreed that EPA should aim to collect fish from 6 to 8 years old—comparable to the current design—and should consult fisheries biologists to determine the corresponding size range for each lake. EPA might be able to utilize existing databases; for example, one reviewer reported that USGS fisheries assessment units have already developed some age-length relationships for specific fish communities in each of the Great Lakes. Once EPA knows what size range to pursue in each lake, the Agency can ask collectors to utilize optimal sampling equipment (e.g., gill net mesh size) to target that size of fish.

3.2.10 If possible, pre-age fish before compositing.

Reviewers also discussed the overall value of using composite samples. One reviewer suggested that individual samples could yield results with greater statistical strength, while another noted that composites smooth out inter-fish variability. If composites must be used for financial reasons, several reviewers suggested that EPA pre-age each individual before creating composites. Doing so could allow EPA to improve its understanding of the influence of age on variability. Knowing the average age of each composite sample would enable EPA to report age-adjusted body burdens if it so chooses and also would allow EPA to create composites of similar age (as opposed to similar length or weight), thereby reducing age-related uncertainty.

---

[2] In post-meeting comments, two reviewers (Don Stevens and Ross Norstrom) suggested archiving 10 individual samples from each site—i.e., before creating one of the composites, archive the 10 individual homogenates. Norstrom recommended archiving equal weight proportions of the 10 individual homogenates, perhaps 100 g per fish, divided into aliquots as described in recommendation 5.2.1. Another reviewer (Mike Whittle) stated that if not all individuals can be archived, the subset chosen should represent the range of fish (e.g., size and age) collected at the site.

[3] In post-meeting comments, reviewers disagreed on how often the variability needs to be reassessed. As a rough estimate, several reviewers suggested analyzing the individual samples every 5 years.

A few members of the panel raised concerns about the cost of pre-aging each individual. Of the various methods of aging fish (otoliths, scales, microtags, and age-length relationships), otoliths would probably be the most reliable method for the GLFMP, as scales are difficult to read accurately in slow-growing fish (e.g., Superior lake trout), and microtags are present only in stocked fish from certain agencies. However, one reviewer suggested that aging 250 fish per year (50 individuals per lake)—the current sample design—should not be a particularly difficult task.

Reviewers also recommended that composites be uniform (i.e., created using the same amount of sample from each individual) to avoid biasing the composite in favor of larger individual fish.

3.2.11 Add a few supplemental stations to test spatial comparability.

In the interest of thoroughness, the panel revisited the assumption that results represent lake-wide conditions rather than local phenomena. The representativeness of the results depends in part on the extent to which lake trout and walleye migrate throughout a given lake. Addressing this issue, one reviewer who was familiar with Canada's open lake monitoring program explained that lake trout tend to move around, dispersing through the lake before returning to reefs to spawn in the fall. Studies of tagged fish have shown large spatial variation between the point of release and the eventual point of capture, particularly in older fish like the 6- to 8-year-olds targeted by Element 1. To illustrate this point, the reviewer provided maps that illustrate migration patterns in Lakes Huron and Ontario, which are attached in Appendix J. In addition, he noted that water masses circulate throughout each of the Great Lakes—another potential integrating factor. Together, these lines of evidence suggest that observed contamination in fish represents a summation of insults from throughout the lake—or, in the case of Lakes Michigan and Erie, insults throughout a basin.

To test the degree of representativeness, reviewers suggested that EPA's in-depth statistical analysis include a comparison of data from the two or more sites in each lake. For additional confirmation, one reviewer suggested analyzing fish from a few additional sites. Other reviewers agreed, noting that expanding the number of sites would be a better use of resources than increasing sample density at existing sites. One approach might be to identify a set of additional reef or shoal sites—perhaps along a transect—and randomly select a few of these supplemental sites to sample each year. Panelists recommended that EPA use the same measurement protocols at supplemental sites that it uses at its regular sites. The required sample size might depend on how much variability is present in a typical composite, per the in-depth statistical analysis recommended in Section 3.2.5.

3.2.12 Consider augmenting the data by collecting lake trout from the eastern basin of Lake Erie (in addition to walleye).

Several reviewers discussed the relative merits of collecting lake trout versus walleye:

- Lake trout are found in all five Great Lakes, but in Lake Erie they are limited to the eastern basin. One reviewer noted that lake trout data correlate well with the results of herring gull egg studies, which suggests that lake trout can be a valuable ecological indicator.

- Walleye are present in all five Great Lakes, but in Lake Superior, these warm-water fish are generally limited to embayments. While ecologically important in Lake Erie, they might not be as important as lake trout in the other four lakes. Walleye are probably more important than lake trout from a recreational (sport) fishing perspective, however.

Given these constraints, one reviewer suggested that EPA continue to collect walleye from Lake Erie, but consider adding lake trout from the eastern basin. Among other issues, adding Lake Erie lake trout to the program could facilitate more consistent inter-lake comparisons.

3.2.13 Consider adding stable isotope analyses to help understand food web dynamics.

The reviewers suggested that EPA consider adding stable isotope analyses—primarily nitrogen—to help understand food web dynamics. As one reviewer explained, heavier isotopes of nitrogen are enhanced as one moves up the food chain due to fractionation during protein metabolism. Another reviewer suggested that sulfur isotopes can also provide useful information.

Going a step further, one reviewer suggested that nitrogen isotope analysis can be a relatively inexpensive way to adjust data for variations in food source and trophic level. This type of adjustment could be useful because, as another reviewer explained, lake trout might change their food source depending on the changing availability of prey fish species.

3.2.14 Examine the literature comparing native versus hatchery-reared trout for differences in exposure and age-size relationships.

Noting that the fish analyzed in GLFMP Element 1 might be either native or stocked, one reviewer inquired whether contaminant burdens have been observed to differ depending on fish origin. For context, panelists noted that behavioral differences have been observed between wild and hatchery-reared Pacific salmon, and genetic differences could potentially affect contaminant retention. One reviewer responded that based on his experience with fish monitoring in Canada, body burdens in stocked and native lake trout are similar after three years; another spoke of the importance of mechanisms, noting that because chemicals like highly chlorinated PCBs are not excreted, all genetic strains of fish will accumulate them. EPA could still consider separating tagged (stocked) and untagged (native) individuals for compositing and analysis; however, the panel suggested reviewing the literature before incorporating such elements in the survey design. As one reviewer noted, some published literature on the behavior of hatchery-raised fish might be available from the period when biologists were determining the best strains of fish for successfully stocking the Great Lakes. In its literature review, EPA might also want to examine any known differences in age-length relationships between native and hatchery-reared lake trout.

3.2.15 Calculate TEQs where appropriate, but continue to report individual congener concentrations as well.

In response to questions from reviewers, Murphy explained that the new grantee (Clarkson University) will analyze samples for dioxins, furans, and coplanar PCBs. Two panelists suggested that EPA calculate toxic equivalency quotients (TEQs) from these data. However, they also noted that human health TEQs might not be appropriate for certain uses of the data; for example, wildlife assessments use different toxic equivalency factors (TEFs). Thus, they recommended that EPA continue to report individual congener concentrations in addition to TEQs.

In addition, one reviewer suggested that EPA use a TEF accounting method for polycyclic aromatic hydrocarbons (PAHs), which appear on the list of analytes for the extended scan that occurs every five years. Although another reviewer noted that PAHs are generally metabolized quickly, the proponent asserted that PAH residues might still be of interest if EPA's goal is to assess wildlife health in general, rather than just the health of individual fish.

3.2.16 Establish an appropriate DQO.

Overall, the panel felt that they would need more information about objectives, data users, and variability before establishing a specific DQO. Nonetheless, they tried to outline some general principles for EPA to consider.

Reviewers noted several shortcomings inherent in the current DQO, which requires EPA to be able to detect a 5 percent change in PCB concentrations. First, the DQO is restricted to PCBs, and says nothing about EPA's ability to measure other analytes. Further, as concentrations decline over time, a 5 percent change will become harder to measure using available technology, and it might also become less statistically meaningful.

Reviewers debated the best way to avoid relying on a single fixed increment (e.g., 5 percent). Below a certain threshold, EPA could define a different increment (e.g., a certain fraction of a wildlife criterion). However, as one reviewer cautioned, when measured values approach the criterion, determining whether the actual values are below or above the criterion might require an exponential increase in the number of samples. Instead, several reviewers suggested defining the DQO in terms of statistical power (e.g., a specific alpha level or percentage of the standard deviation). If the results are close to the relevant threshold or criteria level, EPA may simply have to acknowledge that it is not possible to determine with statistical significance whether the mean is above or below the criterion.

As far as the magnitude of the DQO, reviewers agreed that it should be realistic and should ensure that the data are of sufficient quality to meet the needs of a variety of actual end users. These endpoints might be loads, or they might be biological endpoints such as wildlife criteria.

Reviewers debated whether the DQO should be concerned with year-to-year change, long-term trends, or both. One reviewer argued that long-term trends are most important, given the overall objectives of the program. Another recommended that EPA's DQOs consider three different scales: inter-annual change, longer-term trends, and change-point regressions. A third reviewer suggested that the DQO be based on rolling 10-year trends, which would account for annual data and maintain a consistent window size.

With these points in mind, reviewers suggested several elements to include in the DQO:

- It should explicitly state the program objectives and target sample. For GLFMP Element 1, one way to define the target sample is: "top predator fish, including lake trout and walleye, from ages 6 to 8." "Surrogate" might be a useful word when explaining the purpose of analyzing top predator fish.

- It should define how the data are used.
- It should establish precision and power requirements to ensure that the data can support end uses, be they load measurements or comparisons with biological criteria.
- It should consider multiple analytes, not just PCBs.
- It should clearly state whether the DQO applies to change or longer-term trends, and whether it is based on mean concentrations, specific percentiles, or other parameters.

Given the many aspects to consider, one reviewer suggested that EPA divide its objectives into two separate DQOs: a programmatic objective and a reporting objective. The program objective would describe what Element 1 fundamentally aims to do (e.g., program objectives, target sample), while the reporting objective would be a statement of precision or power. Another reviewer added that the reporting objective should be determined following an in-depth statistical analysis of the data, and should be set at a conservative level.

Reviewers also discussed ways to build flexibility into the reporting DQO—for example, if the variance changes in the future. The DQO could be defined with respect to the variance; however, Murphy cautioned that the DQO's language must remain simple enough to be accessible to policy-oriented people. Alternatively, the panel noted that EPA can modify the DQO as needed in the future, as long as the Agency provides sufficient justification.

4. Element 2 (Sport Fish Fillet Monitoring)

4.1 General Discussion

Opening the discussion on Element 2, Murphy explained the history and current status of the program; her presentation can be found in Appendix I. As Murphy explained, Element 2 began as an FDA effort. GLNPO joined the program in the 1980s, working with FDA, USGS, and other partners. Since then, FDA and USGS have both dropped out of the program, leaving EPA as the sole source of federal funding.

For Element 2, partner states collect samples of common sport fish: rainbow trout in Lake Erie and coho and chinook salmon in the other four Great Lakes. Fish are collected at one to eight tributary sites per lake (i.e., near the mouths of rivers) and are collected in the fall when they return to spawn. The states collect 15 fish per site, catching fish of three sizes (small, medium, and large) and sending them to EPA for analysis. EPA's laboratories use skin-on fillets, analyzing three composites of five fish for each site.

Reviewers asked Murphy how the data are used. She explained that contaminant concentrations are presented in GLNPO's annual report on the Great Lakes. EPA also assigns each lake an index score from 1 to 5 based on a uniform protocol for fish consumption advisories. Reviewers noted that even with a uniform protocol for deriving advisories, the states and tribes in the Great Lakes region still have different ways of collecting, processing, and analyzing samples for their fish advisories; however, they felt that as a blunt risk assessment tool, the broad categories in the protocol are appropriate. Murphy reported that in the future, EPA hopes to examine emerging contaminants in sport fish through an "extended program year," which is scheduled to occur in 2008. Element 2 currently has no DQO.

In their discussion, reviewers raised several concerns about Element 2:

- Limited use of data for fish advisories. Reviewers agreed that ideally, states would use data from Element 2 to augment their fish advisory programs. However, they noted that each state already analyzes its own samples, and states have not been clamoring for EPA's data even though the program is several years behind in reporting results. Still, one reviewer argued that just because states are not asking for data does not mean they already possess sufficient data to make well-informed decisions about the risks of consuming fish caught in the Great Lakes. Rather, the reviewer suggested that EPA consult with the states to determine what use they have made of the data, if any, and whether they are anticipating uses for data not yet received.

- Data do not address the needs of anglers and communities. As one reviewer argued, the data collected by Element 2 are not relevant to the vast majority of anglers and communities because they largely reflect Pacific salmon species captured at an abnormal part of their life cycle. Another reviewer explained that if EPA wants to support fish consumption advisories, the Agency should ideally start by considering which fish people actually eat, where they are caught, how often they are consumed, and whether sensitive human populations are involved.

- Bias in sample collection. One reviewer explained that salmon are generally good integrators, and their age at the time of spawning is consistent, at 3 or 4 years old. Nonetheless, collecting fish during their spawning season can introduce several forms of bias. One reviewer warned that sex can be a source of variability in spawning salmon; another noted that the maturity of gravid females can vary widely at this stage. If EPA continues to support Element 2, these reviewers recommended sampling at a different time.

- Possibly outside of EPA mandate. One reviewer argued that Element 2 falls outside of EPA's mandate because commercial fish are the purview of FDA, while fish advisories are the domain of states and tribes, which already collect and analyze their own samples. However, another reviewer argued that it is appropriate for EPA to be concerned with recreational fishing.

Upon further discussion, the panel arrived at two recommendations for the future of Element 2, which are described in Section 4.2.

4.2 Panel Recommendations

4.2.1 Eliminate Element 2.

As described above, reviewers identified numerous problems with the current design of Element 2, including design flaws and what appears to be a lack of interest from potential data users (the states). As one reviewer summarized, the program does not appear to be contributing to states' efforts, and it may not fit with other EPA efforts either.

At this point the panel faced two options for Element 2: 1) end the program or 2) redesign it. One reviewer argued that more data are needed before making this decision, and recommended that EPA conduct an angler survey to determine whether state advisory programs are already satisfying anglers' needs. However, the rest of the panel generally felt confident in recommending that EPA should eliminate Element 2, considering the limitations of the program, the overlap with state efforts, and potentially better uses for the money.

4.2.2 Use the resources to augment Element 1 and/or efforts to learn about emerging contaminants.

Reviewers agreed that the EPA resources currently used for Element 2 can be better spent in other areas. They suggested using the money for two other aspects of the GLFMP: 1) improving EPA's sentinel analysis for emerging contaminants, and 2) augmenting other aspects of Element 1 (e.g., sample design).

5. Emerging Contaminants

5.1 General Discussion

In its charge to reviewers, EPA asked them to consider how the GLFMP can stay up-to-date with respect to new or emerging contaminants. Murphy described current efforts in this area. Under the current grant arrangement for Element 1, Clarkson University agreed to conduct an "extended program year" in 2008—something EPA hopes to do every five years in the future. In this extended analysis, Clarkson agreed to analyze samples for an expanded list of target compounds. Murphy noted that if Clarkson lacks the capability to analyze for a particular contaminant, the PI will outsource the analysis to another laboratory that has the necessary equipment. EPA's analysis might also include some screening of historical samples.

The panel discussed whether EPA should strictly limit its emerging contaminants analysis to Element 1 (i.e., limiting the analysis to open lake samples) or should expand to include near-shore samples. As several reviewers explained, new contaminants often originate from localized point sources such as sewage treatment plants, so the best early warning samples may come from fish inhabiting sites near the source. However, one reviewer noted that point sources are the domain of the states, not EPA. Another mentioned that the International Joint Commission (IJC) has already embarked on a more intensive examination of 43 "Areas of Concern" throughout the Great Lakes, most of which are embayments or connecting channels. Thus, a third reviewer recommended that EPA complement these state efforts by continuing to focus the GLFMP emerging contaminant analysis on open water sites.

One reviewer noted that "emerging" might not be the most appropriate word to describe all the contaminants of potential interest. As an alternative, another reviewer suggested using the term "recently identified."

Collectively, the panel identified five key recommendations for studying emerging contaminants, which are described in Section 5.2.

5.2 Panel Recommendations

5.2.1 Continue to archive samples from Element 1. Archive multiple subsamples from each composite.

Reviewers agreed that EPA should continue to use samples from Element 1 for emerging contaminant analysis. As one reviewer explained, whole body samples are generally better than fillet samples for identifying the presence of emerging contaminants. Because one of the steps in the proposed program is to analyze archived samples to determine if newly identified contaminants were present in the past (see recommendation 5.2.3), the panel agreed that EPA should continue to archive samples.

When archiving, reviewers suggested that EPA retain multiple subsamples of each composite. As two reviewers explained, retrospective analysis of frozen samples is difficult because material becomes locked in micelles, and once a frozen sample has been opened and material has been extracted, the sample cannot be used again. By dividing each composite (or at least one composite per site) into several containers for archiving, EPA can avoid destroying an entire sample as a result of a single retrospective analysis.

Alternatively, one panelist asked whether EPA's contractor could archive the solvent extract. Two others explained that it can be more difficult to store solvent samples because of evaporation issues and the like. One reviewer inquired about variability among subsamples from the same composite. Murphy explained that the ongoing QA audit of the program's laboratories will examine the homogeneity of the composites.

5.2.2 Every few years, conduct a workshop to discuss current knowledge regarding emerging contaminants.

Several reviewers spoke about the importance of collaborating with other groups that are studying emerging contaminants. For example, one reviewer noted that USGS and other agencies are working on trace organics and other new contaminants; another mentioned Canadian programs. Accordingly, the panel recommended that EPA conduct a workshop every few years to discuss current knowledge regarding emerging contaminants. This workshop could serve as a starting point for the extended analysis every five years, and could serve to facilitate knowledge sharing across EPA workgroups and with other agencies. One reviewer added that it would be particularly interesting to find out what USGS might know about emerging contaminants in the Great Lakes.

In addition to consulting with other groups, one reviewer suggested that EPA consult databases and other sources to determine potential compounds of interest. EPA could consider lists developed as part of the Binational Toxics Strategy, for example, or could review the Toxics Release Inventory (TRI) for recent trends. Developing a list of possible contaminants could help EPA approach the extended program year with a set of "educated guesses."

5.2.3 Every few years, conduct a complete scan to identify new contaminants. Once new contaminants are identified, analyze historical samples to determine trends.

Reviewers generally endorsed the idea of conducting an "extended program year" every few years. They recommended a two-pronged approach:

- Conduct a full scan of the samples. Identify any new "peaks" that are not part of the standard analyte list.

- When extra peaks are identified as new contaminants, analyze archived samples to determine if the same contaminants were present in the past, and to determine trends over time.

The panel discussed several specific details related to analytical methodology. For example, two reviewers suggested combining the five composite samples from each site into one large composite for analysis. Reviewers described at least two reasons for doing so: 1) scanning for a wide range of contaminants with multiple methods can require a large volume of sample; and 2) because emerging contaminants might not have had a chance to become uniformly distributed across a given fish population.

Detecting and identifying compounds with a wide range of sizes, structures, and polarity will require multiple analytical steps. As an initial step, one reviewer suggested screening samples with liquid chromatography/mass spectrometry (LC/MS) and gas chromatography/mass spectrometry (GC/MS). This broad scan will require several analytical streams (e.g., using different ions) but ultimately will produce a series of peaks that can be reviewed to determine whether or not they reflect chemicals on the standard analyte list. New compounds of interest can then be divided into approximately four or five general classes for further analysis. The reviewer added that most lipid artifacts can be removed. Another reviewer described seeing a similar process used on drinking water samples; the analysis resulted in the detection of several pharmaceutical residues and other new industrial chemicals. A third reviewer noted that research labs generally have lower detection limits than commercial labs, so EPA should rely on research labs to screen samples for emerging contaminants.

Once new contaminants have been identified, reviewers recommended that EPA analyze archived samples to determine whether these contaminants were present in the past, and to calculate trends over time. They urged EPA to be cautious in its use of historical samples, however. As two reviewers explained, retrospective analysis of frozen samples is difficult and can effectively destroy the sample. Thus, the panel recommended that EPA archive multiple subsamples (see recommendation 5.2.1), and open archived samples only when a new contaminant has been identified with some degree of certainty in current samples. One reviewer also urged EPA to take a close look at sample history, including temperature, duration, processing equipment, and the use of containers with Teflon-lined lids.

5.2.4 Develop protocols for taking action on newly identified contaminants, including interactions with other agencies and offices.

Once EPA identifies new contaminants, what steps should the Agency take next? One next step could be alerting states and tribes about chemicals that they might want to begin looking for in their own sampling and analytical efforts. Identifying new contaminants in whole body samples could also trigger analysis of fillet samples to get a better idea of potential risks to human health, as one reviewer suggested. Ultimately, when new contaminants have been detected in the environment, agencies charged with protecting human and ecological health should have an interest in studying potential risks and—if necessary—establishing protective guidelines.

In response to reviewers' questions, Murphy and Horvatin explained that GLNPO has historically engaged USGS and other EPA offices upon discovering new contaminants in Great Lakes fish, but no formalized action plan is in place. One reviewer recommended that GLNPO develop a more formal protocol to address the scientific and regulatory implications of discovering new contaminants, including a plan for communicating with other offices and agencies. The other reviewers generally agreed with this recommendation.

5.2.5 Track emerging approaches for characterizing contaminants.

Panelists recommended that EPA stay abreast of emerging approaches for characterizing or accounting for contaminants. For example, one panelist noted that work is underway to develop methods of aggregating dose-response data for endocrine disruptors with similar modes of action.

Appendix A

Peer Reviewers

This page intentionally left blank.

Review Workshop for Great Lakes Fish Monitoring Program—Quality Management Plan and Historical Database

U.S. Environmental Protection Agency
Great Lakes National Program Office
December 11-12, 2007

Peer Reviewers

Ellen Bentzen
Biology Department
Trent University
Peterborough, ON
K9J 7B8 Canada
Ph: 705-748-101, ext 7751
E-mail: ebentzen@trentu.ca
Mailing Address:
227 Antrim Street
Peterborough, ON
K9H 3G5 Canada

Ross Norstrom
Consultant
1481 Forest Valley Drive
Ottawa, ON
K1C 5P5 Canada
Cell: 613-325-4123
Ph: 613-834-6160
E-mail: ross.norstrom@sympatico.ca

Alan Stern
Adjunct Associate Professor
University of Medicine & Dentistry of New Jersey
School of Public Health Section
Mailing Address:
321 Grove Avenue
Metuchen, NJ08840
Ph: 609-633-2374
Fax: 609-777-2852
E-mail: ahstern1@verizon.net

Don L. Stevens, Jr.
Stevens Environmental Statistics
2394 Chapel Drive
Corvallis, OR 97333
Ph: (541) 737-3587
Fax: (541) 737-3489
E-mail: stevens@science.oregonstate.edu
E-mail: stevedon@onid.orst.edu

Kent Thornton (Workshop Chair)
Systems Ecologist
FTN Associates, Ltd
3 Innwood Circle, Suite 220
Little Rock, AR 72211
Ph: 501.225.7779
Fax: 501.225.6738
E-mail: kwt@ftn-assoc.com

Mike Whittle (Emeritus)
Dept of Fisheries & Oceans
Great Lakes Laboratory for Fisheries
and Aquatic Sciences
867 Lakeshore Road
Burlington, ON
L7R 4A6 Canada
Ph: 905-336-4565
Fax: 905-336-6437
E-mail: Mike.Whittle@dfo-mpo.gc.ca

Appendix B

Technical Charge to Reviewers

This page intentionally left blank.

Peer Review Workshop for Great Lakes Fish Monitoring Program – Quality Management Plan and Historical Database

U.S. Environmental Protection Agency – Great Lakes National Program Office
December 11-12, 2007

TECHNICAL CHARGE TO PEER REVIEW PANEL

Program Review Mission

Eastern Research Group, Inc., (ERG) is conducting the peer review of the Great Lakes Fish Monitoring Program (GLFMP) under contract to the U.S. EPA. The Great Lakes National Program Office (GLNPO) has developed this charge to provide background information and specific instructions for the peer reviewers. The peer reviewers are being asked to review and evaluate the GLFMP's Quality Management Plan (QMP) and historical database to assist in identifying present day Data Quality Objectives (DQO) and recommend future changes to both Elements 1 (Open Lake Trend Monitoring Program) and 2 (Sport Fish Fillet Monitoring Program) of the GLFMP. The GLFMP is revising it DQOs to be more representative of present day contaminant concentrations in Element 1 and to create a DQO for Element 2 using all available data. The revision and creation of DQOs will lead to changes in both elements of the GLFMP for the future.

The overall goals of the peer review are to enhance the quality and validity of the program, ensure the data generated under the program are statistically sound and representative of today's environment, and ensure any future decisions based on this program have a sound, credible basis.

Background

In 1977, GLNPO began collaborating with the US Geological Survey Biological Research Division (USGS-BRD) on a fish monitoring effort to measure the contaminant levels of various organic substances in lake trout in the Great Lakes ecosystem. This effort was previously managed by USGS since the mid-1960s. The study was further modified in 1980, when the US EPA, US Food and Drug Administration (FDA), USGS-BRD, and the eight Great Lakes States began a cooperative effort to monitor and better define the fish contaminant problem in the Great Lakes. The project is currently implemented by GLNPO with cooperation from the Great Lakes States, selected State agencies, and Native American Tribes.

Sport fish and predatory fish are collected from the five Great Lakes. Sport fish are collected by the eight states surrounding the Great Lakes (Ohio, Illinois, Michigan, New York, Pennsylvania, Wisconsin, Minnesota, and Indiana). Sport fish include Coho and Chinook salmon in Lakes Michigan, Superior, Ontario, and Huron and rainbow trout in Lake Erie. Predatory fish are collected from all five Great Lakes on an annual basis. Predatory fish include lake trout in Lakes Michigan, Superior, Ontario, and Huron, and walleye in Lake Erie. The Great Lakes Fish Monitoring Program (GLFMP) organizes collections through cooperative agreements with other state and federal agencies.

Over the life of the GLFMP, a wide variety of metals and organic chemicals have been analyzed in fish samples collected in the Great Lakes Basin. The list of analytes has changed in response to both budgetary constraints and information about new and emerging contaminants. The current list of analytes of interest consists of a wide variety of organic contaminants and mercury, a metal contaminant of specific concern in the Great Lakes.

The overall goals of the GLFMP include:

- monitoring temporal trends in bioaccumulative organic chemicals in the Great Lakes using top predator fish as biomonitors;
- assessing potential human exposure to organic contaminants found in these fish; and
- providing information on new compounds of concern entering the lakes ecosystem.

The GLFMP goals are broken down further into two elements:

- Element 1: Open Lake Trend Monitoring
- Element 2: Sport Fish Fillet Monitoring

Element 1 (Open Lake Trend Monitoring) is directed at monitoring contaminant trends in the open water of the Great Lakes and assisting in evaluating the impacts of contaminants on the fishery. Element 2 (Sport Fish Fillet Monitoring) is directed at monitoring potential human exposure to contaminants through consumption of popular sport species, as well as providing temporal trend data for top predator species, which have shorter exposures than the lake trout collected in Element 1. Data generated by the program are also used by States for their own programs including developing fish advisories.

Peer Reviewer Instructions

The peer reviewers are charged to objectively review the design, implementation, and scientific rigor of the GLFMP. Each reviewer is asked to comment on the program's sampling and analytical procedures and the uses of the data generated in the program. Your written comments should include general comments that address the questions raised in this charge in addition to any specific comments on the program. Following the peer review, GLNPO plans to review the design and implementation of the program in the context of the peer reviewers' comments and revise the design as appropriate.

Charge Questions

Please cut and paste the charge questions into a Word document, followed by your comments. Please specifically consider and address the questions/issues regarding the program listed below.

1. How can GLNPO optimize the existing top predator **open lakes trend monitoring** program to look at contaminants in Great Lakes fish on a lake by lake basis for an assessment of ecological health?

2. How can GLNPO optimize the existing **sport fish fillet monitoring** program to look at contaminants in Great Lakes fish on a lake by lake basis for an assessment of human health?

3. In conjunction with the current monitoring program for fillets and whole fish, how can GLNPO use this program to look at emerging bioaccumulative toxic contaminants?

Specific questions:

a. Regarding the three questions/objectives listed above, are the current designs feasible? These designs include sampling fish at two different locations on each lake over a two-year period for the open lakes trend monitoring program and/or the number of sites collected for the sport fish fillet monitoring program.

b. In order to provide policy-makers an indication of whether conditions of the Great Lakes are improving over the long term, GLNPO reports annually the average long term percentage concentration change of total PCB's in whole top predator fish for the whole Great Lake's Basin. Is this approach scientifically sound and feasible? If not please suggest a scientifically sound and feasible alternative.

In the event that changes to the program - Element 1 (whole fish), Element 2 (sport fish fillet), or both are suggested, please indicate the recommended path for change. Please also address any steps that should be taken to ensure data comparability between old and new data sets.

OVERVIEW OF REVIEW DOCUMENTS

The documents contained on the enclosed CDs encompass the Great Lakes Fish Monitoring Program *as a whole*. While they are all important and relevant to the Program, it is not reasonable to ask Peer Reviewers to read all the documents.

Therefore, we are providing hard copies of what EPA considers "priority" documents and articles for the reviewers to read and consider prior to the completion of your written premeeting comments, as listed below. All of these are also available on the CDs.

Depending upon your area of expertise, you may also want to read or refer to the other documents and spreadsheets on the CDs, as needed.

- **Great Lakes Fish Monitoring Program – Quality Management Plan** (on QMP CD)

- **Additional Documents and Articles to Read to Inform Your Review**

  From Appendix 2 (also on QMP CD)
  - Great Lakes Fish Monitoring Program Data Quality Objective Revision report – 2005

  From Appendix 6 (also on QMP CD)
  - GLFMP Reporting Examples (How the data is currently used and published, outside of scientific journal articles to provide reviewers the context in which GLFMP is routinely requested to be used.)
  - DeVault, D.S., Clark, J.M., Lahvis, G., Weishaar, J. 1988. Contaminants and Trends in Fall Run Coho Salmon. *Journal of Great Lakes Research.* 14(1): 23-33.
  - De Vault, D. S., Hesselberg, R., Rodgers, P.W., Feist, T.J. 1996. Contaminant Trends in Lake Trout and Walleye From the Laurentian Great Lakes. *Journal of Great Lakes Research.* 22(4):884-895.
  - Carlson, D.L., and Swackhamer D.L. 2006. Results from the U.S. Great Lakes Fish Monitoring Program and Effects of Lake Processes on Contaminant Concentrations. *Journal of Great Lakes Research.* 32 (2): 370 – 385.
  - Hickey, J. P., S. A. Batterman, S. M. Chernyak. 2006. Trends of Chlorinated Organic Contaminants in Great Lakes Trout and Walleye from 1970 to 1998. *Arch. Environ. Contam. Toxicology*. 50: 97 - 110.

- **The Excel databases for the Great Lakes Fish Monitoring Program** (on Peer Review Data CD)
  - Both whole fish and sport fish, have been provided for your information. They are very comprehensive and encompass all field and analytical data collected for the program over its existence. These databases have been provided in order to assist in answering some of the specific questions A and B in the charge.

- **Element 1 – Open Lake Trend Monitoring** (on Peer Review Data CD)
  - 1991-1998 description of data collected

- **Element 2 – Sport Fish Fillet Monitoring Program** (on Peer Review Data CD)
  - Statistical Comments on the Sport Fish Fillet Monitoring Program: A GLNPO intern (with a strong statistical and mathematical background) conducted a statistical review of the Sport Fish Fillet Monitoring Program in the summer of 2007. Her comments have been provided to help guide reviewer's interpretation of the data for Element 2.

FORMAT GUIDELINES FOR WRITING YOUR COMMENTS

Your comments will be submitted to EPA as received. Please prepare your comments addressing the issues and questions as stated above, and include any other comments at the end of your submission. To assist you in preparing your comments, ERG is sending you an electronic version of the charge so you may cut and paste each question into your text to be followed by your comments. Additional format recommendations are as follows:

TYPE SIZE: 11 point
PAPER SIZE: 8 2" x 11"
SPACING: 1.5 line spacing
MARGINS: 1" top and bottom margins, 1" left-hand and right-hand margins

- Please use a header with your name in the upper right-hand corner of each page of your comments.
- Please refer to the PAGE(S) and LINE NUMBER(S) for all specific comments.
- Remember to spell out acronyms when first used.
- Avoid incomplete sentences, abbreviations, and terms that might confuse the reader.
- If illustrations or tables are included, be sure that they are suitable for reproduction.

COMMENTS DUE DATE: *No Later Than* FRIDAY, NOVEMBER 30, 2007

When sending your comments via e-mail to ERG, please attach them as Word 2000 or later; save with the appropriate file name extension (.doc for Word documents). Send them to Kate Schalk at kate.schalk@erg.com. If sending via mail or courier, please address as follows:

Eastern Research Group, Inc. (ERG)
110 Hartwell Avenue
Lexington, MA 02421-3136
Attn: Kate Schalk

Your comments will be compiled with those of the other reviewers and **distributed to you to read prior to the workshop in preparation for the workshop discussions.** After the workshop, ERG will prepare a peer review summary report, which will cover the workshop discussions and recommendations, as well as the pre-meeting comments.

Thank you for your efforts. Feel free to contact me at 781-674-7324 (or the department line at 781-674-7272) with any questions or concerns.

Appendix C

Reviewers' Pre-Meeting Comments

This page intentionally left blank.

Ellen Bentzen

Great Lakes Fish Monitoring Program -

Quality Management Plan and Historical Database

Reviewer: Ellen Bentzen
November 30, 2007

Specific charge questions: (written in italics)

1. *How can GLNPO optimize the existing top predator* ***open lakes trend monitoring*** *programme to look at contaminants in Great Lakes fish on a lake by lake basis for an assessment of ecological health?*

Overall, the importance of the long term open lakes monitoring program (element 1) cannot be overemphasized. Historically it was vital for demonstrating the successful early and substantial reductions in contaminant burdens of top predatory fish in the Great Lakes following regulatory action on contaminants' use. A point not often acknowledged in reports is that establishment of these high profile monitoring programs on either side of the Great Lakes has helped advance environmental science. It has fostered research initiatives, both Government and University based, that has lead to substantial changes in both analytical abilities in terms of chemical resolution and in our understanding of physical-chemical properties of substances in aquatic environments. Concurrently, we learned that anthropogenic activities had deleterious impacts on the environment, between deformities and population losses of fish eating birds and fish to anoxic conditions and undesirable water quality in Lake Erie due to nutrient loading. The long term monitoring data have shown the partially successful reduction in contaminant burdens in top predatory fish of the Great Lakes but have recently driven home that more complex factors in the environment are moderating the declines. The long term monitoring program must be maintained, at least until acceptable levels for the protection of wildlife and human health are obtained. But, it also must be supported by process oriented studies of factors that influence contaminant concentrations in biota. This is discussed in detail below.

Specific objectives of the contaminants surveillance program: (from Section 2.2.1 Quality System Components) (summarized with respect to fish programs)

1. *Provide baseline information on contaminant residue levels in Great Lakes fish & other biota.*

2. *To provide information regarding trends of contaminant levels in Great Lakes Fish and other biota.*

3. *To determine from trend analysis when to re-open fisheries that were closed because of excessive residues in fish and to warn of the possible occurrence of intolerable residues in fish stocks.*

The original goal of the Element 1 program was designed to compare contaminant levels in fish on both temporal and spatial scales and aimed at detecting a 20% change in contaminant concentration between consecutive samplings (two years apart, with two sites each sampled alternatively over the 2 year cycle) with a 95% confidence interval. The Element 1 open lakes trend monitoring has provided ongoing information about both baseline information on contaminant residues in lake trout, and has allowed investigation into estimating rates of decline of contaminants over time following remedial action (specifically banning on production and use of identified persistent organic pollutants, POPs). These lead directly into determining the status of fisheries by comparing observed levels to desired end point concentrations. Intolerable residues in fish stocks in terms of human health pertains more to Element 2, discussed later.

The goal based upon detecting certain rates of change (ie 20% over a 2 year interval) are presumably aimed at achieving the safe target levels for wildlife (eg 100 ng/g ww for PCBs), our definition here of ecological health. The current goal for detecting change is set at 25% between 2000 to 2005, or 5% per year. It was not clear where these particular values were derived from nor do they seem realistic. It is the endpoint which counts and is determined by analysis of the trends data. The goal of detecting such a rate with a 95% confidence level has to do with statistical variability. There are two critical overall sources of variability: one due to the sampling design and analytical resolution, the other due to extrinsic factors in the environment (discussed below). Element 1 is based upon a design of sampling initially 60 lake trout in 3 size categories (or walleye in Erie) and later 50 lake trout between 600 to 700 mm in length. Samples are composites of 5 fish to make 10 replicates per site per lake. Extensive effort seems to be directed at controlling analytical variability with "checks" and other assessments of QA/QC (i.e. changes among the analysts). One potential criticism flagged by some previous reviewers (2005 review) may be changes in moisture content with stored samples, and if this has not been addressed, this is potentially a source of variability in the data which can be monitored. However, it seems that analytical variability is monitored rigorously.

There are some issues with establishing a rate of change per year as a data quality objective (DQO). Choosing a particular % change per year assumes understanding the mechanism behind the reductions in contaminant residues in top predatory fish. Is this based upon declines following the "tap being turned off"? This does not allow for the extrinsic sources of variability, such as climate changes, which may or may not modify a decline in contaminant burdens over time in a complex ecosystem, discussed further below. However, a percent change is also statistically problematic because the rate of change also is a function of absolute concentration, as pointed out by several reviewers in the February 2005 review session. Alternatively, basing the change on a set unit value, such as 0.1 mg/kg/yr also is problematic dependent upon starting concentrations, such that Lake Superior fish with lower contaminants for PCBs, for example, at all times, versus the more highly contaminated fish from the lower Great Lakes. This relates to the very important differences in loading sources of contaminants, which for Superior has been the atmosphere (with exception of toxaphene) whereas Michigan, Erie and Ontario have had significant point source loading of many POPs. This issue will be examined in context of the observed data as reported and current trends. Targeting the end result of acceptable levels and using the long term trends analyses on a rolling basis allows the ongoing estimates of how many years it will take to reach the targeted level. Admittedly, this results in making "best available" projections which may be less palatable for some stakeholders, but is more realistic.

It is clearly an important goal of the GLNPO to report on the observations of the Element 1 program. This is done by peer reviewed publications including analysis of the data and identification of the trends, as well by reporting overall results in a simpler format to the public (stakeholders, etc), i.e. are toxic fish residues declining to safe levels or not. The EPA website at http://www.epa.gov/glnpo/glindicators/fish.html seems very well laid out and accessible and clearly identifies that overall the goals of obtaining "ecological health" for the Great Lakes has not been achieved despite ongoing reductions in contaminant residues in fish. There are also a number of peer reviewed publications by several different parties that have analysed the trends data up to 1998. Key papers are by DeVault et al. (1988), DeVault et al. (1996), Carlson and Swackhamer (2006), and Hickey et al. (2006). Notable aspects of these papers are summarized in the table following these comments. Points to note are that there were clearly substantial reductions in POPs during the 1970's and early 80s. Both whole fish data from Element 1 and also fillets from Element 2 were used in various studies. There are a few more years of data, albeit incomplete (ie not all lakes for all years up to 2002) listed in the database. Note that lipid data for the more recent years are not included. (It is noted that several of the 2005 reviewers commented that the production of peer reviewed publications has lagged behind the collection of the data and this does seem to be a concern which should be improved upon.) I also noted that there were a few discrepancies between some of the values, at least for PCBs, published by Swackhamer and Hickey relative to the excel database.

Reductions in contaminant residues followed first order loss kinetics, with reasonably good fits as based upon the explained variance (r^2). However, by some point during the 1980's, residue concentrations appeared to be either unchanging, changing at a slower rate than anticipated from the simple 1^{st} order kinetic models, or were occasionally increasing relative to previous years. In other words, the data became more variable between years relative to any clear trend. In their 1996 paper, DeVault et al. used the more complete time series data from Lake Michigan to search for a change point between the earlier data and later years but was unable to pinpoint this. Hickey et al. (2006) modified the 1^{st} order kinetic models to allow for two first order processes and also built in an asymptotic value referred to as the "irreducible or baseline" concentration. This value is one they hypothesized represents a third, stable contaminant source as a possible mechanism behind unchanging or relatively slowly changing concentrations.

<u>What this indicates towards optimizing the existing programs?</u>

It is my belief that the DQO should be focused upon understanding the variability observed in contaminant burdens in recent years. The open water long term monitoring program is vital to help address this issue of variability. It is appropriate to use top predators as ecosystem indicators, as originally designed. The questions should be directed towards whether inter-annual fluctuations are due to

i. Actual declines in inputs

ii. Function of variability in extrinsic factors, notably issues relating to dietary shifts, food web dynamics, climatic variability, other physical and chemical changes

A recent publication examined the second issue in Lake Ontario: French et al. (2006) used fillets from coho and chinook collected by the Ontario Government (MNR, OMOE) from 1982 to

2004. They examined the hypothesis that variation in POP burdens in the salmonids could be related to fluctuations in alewife population dynamics. In addition to considering population abundance (by catch per unit effort), they also examined factors which could influence the food web, including nutrient loading changes, changes in algal and zooplankton abundances, and also temperature variations due to El Nino and El nina events in the 1990s. Their results suggest that variation in salmonid contaminant burdens indeed could be attributed to fluctuations in alewife abundance. Likewise, Carlson and Swackhamer (2006) suggested a role of lake temperature as a factor behind some of the dynamics in Lake Superior fish contaminants, and Hickey et al. (2006) noted a dietary shift in forage fish used by lake trout in Lake Superior. Food webs have changed substantially in all the Great Lakes due to concurrent changes in nutrients due to phosphorus abatement (although more recently Lake Erie appears to be increasing again with associated problems of anoxic hypolimnia), species invasions such as zebra mussels and round goby resulting in changes of native species such as *Diporeia* . Likewise, Hebert and Weseloh (2006) noted the impact of dietary shifts in another top indicator species, the herring gull, and that this shift has slowed rates of contaminant decline and accounts for interannual variability in their burdens. The comparison of the Great Lakes with variable point source loadings for contaminants relative to inland lakes of Ontario with atmospheric loading demonstrated variable concentrations of PCBs and DDTs in lake trout that could also be attributed to what they ate and the length of the food chain below them (Bentzen et al. 1996). One commentator at the 2005 review, Pete Redmon, noted that in studying Lake Michigan for 30 year, he has observed “4 or 5 ecosystems” due to changes in alewife abundance, chinook stocking & harvesting, zebra mussels, nutrients, etc. Several studies have also demonstrated the role of diet on Hg contamination of lake trout.

Therefore, what is needed is **to support the long term monitoring program with process oriented studies** directed towards examining the impact of trophodynamics, diets, and climatic variables on contaminant burdens. Part of this could be achieved with use of the available data combined with data from other parties monitoring the Great Lakes (ie as by French et al. 2006), but also by specifically designed studies. There were three independent studies on distribution of contaminants in the Lake Ontario food web, all within the same year (1992) (summarized in Bentzen et al. 1999). These allow estimation of biomagnification of POPs through the food web-variation in concentrations at the lower end of the food web would be indicative of changes in loading vs variation further up in the food web may be attributable to food web dynamics, for example. This type of study does not need to be frequent, ie may be considered in an intensive year of sampling with 3 or 5 year intervals. The actual interval and design should be determined, potentially at a workshop with review of any available data.

In addition to the role of changes in food web structures on biomagnification, POP variability may be due to changes in loading to the system. Hickey et al. (2006) proposed the possibility of the “irreducible base concentrations” due to some internal pool. This was statistically derived and has not been validated. However, it should show up as variation in the concentration of POPs at the base of the food web. What is thus needed is to include the previously considered but then abandoned sampling of smaller indicator fish, such as young-of-year fish, or zooplankton (easier to measure than water), to help track if there are changes in loading occurring over time. The problem now with the top predators is that loading changes cannot easily be distinguished from these other factors as discussed above. One possible way to do this cost effectively would be to annually collect samples of either zooplankton and/or young of year forage fish for archiving. They could be analysed as needed, ie to correlate with a fluctuation in salmonid POP burden. Zooplankton are useful because they reflect water concentrations and are easy (and inexpensive) to harvest.

Other variables:

It was appropriately noted in the 2005 review that better estimates of fish age should be obtained since fish of similar size between lakes or even between years may not be of similar age. It was also noted by some of the 2005 reviewers that analytical detection of residues would be improved by harvesting a larger sample size of tissue (eg 5 g instead of 2 or 3). This is important to review as contaminants decline. There also is concern about the Lake Superior Lake trout since no distinction has been made between the siscowets and the lean trout, with highly variable lipid content between them.

Lipid content:

The role of variable lipid seemed to be largely ignored in the publications and analyses since "no apparent trends" were noted. However, lipid is an important variable as it relates to organic contaminants, as shown in the food web studies by Bentzen et al. (1999). I did some quick calculations with PCBs and lipid from the more recent years (1990s) data and in fact observed some modest relationships between PCB concentrations and lipid content in some of the lakes. Variation in lipid content also is a function of both fish size (only important when a large range of sizes is used) and fish diet, which relates to the discussion above of further examining for changes in other variables in these lakes.

Statistical analyses:

Each publication employed different approaches or models for statistical analyses. Goodness of fit to kinetic models was assessed by the explained variance, r^2. Note, however, that these are likely enhanced by the early years rapid decline in POPs. It is no longer necessary to include the early data in statistical models- we have clearly established those early reductions and the explained variance of those data may unduly influence the later data. Addressing the temporal variability of current years is critical. The hypothesis of an irreducible baseline concentration as indicated by Hickey's analyses in some of the Great Lakes must be rigorously examined. This worked statistically but in the real system, it probably reflects a large pool of contaminant recycling, declining at a very slow rate that cannot be accurately measured over the short term. Examining this would be possible in the process based studies as discussed above, as well as continuing the long term monitoring.

Overall: what DQO?

-Aim for a target reduction of levels determined safe for wildlife (eg 100 ng/g ww PCBs). Long-term monitoring studies aid in determining how long that will take.

-include process oriented studies

-include sampling for biota low down in the food web to more closely track concentrations in water, which should reflect any changes in loading. This will help address whether there is an irreducible baseline amount in perpetuity?

2. *How can GLNPO optimize the existing* ***sports fish monitoring*** *program to look at contaminants in the Great Lakes fish on a lake by lake basis for an assessment of human health?*

This pertains to the sampling done in Element 2. It is not as easy to assess the results of Element 2 as for Element 1. There is some debate about the use of these data for monitoring trends. Results from Element 2 sampling were used in several publications for examination of long term trends, and a number of other publications have been published using fillet contaminant data from the Ontario sampling program demonstrating that a properly designed program can yield information both for consumption guidelines and for tracking within lake variability, among species variations, and temporal trends. Bentzen et al. (1999) reported on correlations allowing comparison of the whole fish burdens (which are greater) to the fillet concentrations. Note that this can also be readily done using lipid normalized data.

However, the short report at the end of the review package is poorly presented and makes it difficult to assess adequately. It does indicate potential problems with assessing “size” that may not be consistent, and if correct, would be a serious problem. The discussion of “selection of DQOs” discusses significance levels and statistical power, but it would help to know what statistical analyses were done, and how. I do not know what the unknown author is doing with their “baseline” year- seems to be a subjective analysis (see section 4.3). They seem to want to remove annual variation as a source of loss in power and note that “calculations are screwy”. Frankly, if a student handed in a report like this, they would get a failing grade. The raw data file given on my disk was corrupted, although the means data file was accessible. However, time precluded a thorough re-examination of these data.

In terms of using sports fish monitoring to be used as an assessment of human health, I recommend looking at the Ontario Sports Fish Monitoring Program. Individual fish, sized, then grouped into clear guidelines.

3. *In conjunction with the current monitoring program for fillets and whole fish, how can GLNPO use this program to look at emerging bioaccumulative toxic contaminants?*

As noted by others in the 2005 review, this is achieved by keeping the archived samples such that when new contaminants are identified, it is possible to go back and track them. However, caution must be taken to avoid possible artifacts, eg moisture loss.

Specific questions:

4. *Regarding the three questions/objectives listed above, are the current designs feasible? These designs include sampling fish at two different locations on each lake over a two year period for the open lakes trend monitoring program and/or the number of sites collected for the sports fish fillet monitoring program.*

Most of this question has been addressed in longer format above. The bottom line is that for Element 1, the current designs are feasible such that for the sake of consistency, the two locations should still be sampled in each lake. Studies have suggested that while there is some variability among sites, largely the sites can be used as replicates, and therefore biannual sampling also seems to be reasonable and cost effective. There was discussion but I did not see if this has ever been done, about more intensive sampling on a 5 year interval. This is useful to do at least once, but if the Element 2 program were potentially improved to include assessment of within lake variability, then it would not need to be duplicated for Element 1. See comments above relative to Element 2 sampling.

5. *In order to provide policy-makes an indication of whether conditions in the Great Lakes are improving over the long term, GLNPO reports annually the average long term percentage concentration change of total PCBs in whole top predator fish for the whole Great Lake's Basin. Is this approach scientifically sound and feasible? If not, please suggest a scientifically sound and feasible alternative.*

I believe I have answered this question above, with my opinion that percent change is less meaningful than estimating time to reach target levels, as determined on a rolling basis as data is collected.

Review summary chart of pertinent publications:

Source data, range, details	**Handling**	**Comments**
DeVault et al 1988 fall run coho 1980-1984 **FILLETS** POPs	estimated 1st order loss kinetics	-flagged potential ecosystem impact in Erie due to anoxia impacting DDT metabolism: higher DDD in Erie -variable lipid noted in 83, 84: account for variability in OCs?

Source data, range, details	Handling	Comments
DeVault et al 96 lake trout & walleye 1972 - 92 **whole fish composites** POPs	initial 1st order loss kinetics, then looked for change point in Michigan data when conc's more stable over time -data not lipid normalized ever	-decreases apparent in all lakes -note changes in lipid content , esp. in Superior: mixed between siscowets & lean? -also variable fat in Ontario: dietary shifts -hypothesized role of food webs on POP burdens -data suggest minimal changes in burdens from mid 80's to 1992 -no single year found for change point analysis
Carlson & Swackhamer both **FILLETS & WHOLE FISH** included 1999 & 2000	-considered congener profiles for PCBs	-suggested role of lake temperature as potentially influential, ie re planktonic growth, role of food web metabolism -slower growth & physico-chemical impacts in Superior
Hickey et al 2006 1970 to 1998 data from 1990's in table **WHOLE FISH**	1st order kinetics model modified with aysmptote C_0 called the irreducible or baseline concentration -follow by allowing two 1st order processes allowing for both fast (early years) and slow (later) rates plus the irreducible -argue irreducible is due to third, stable contaminant source (proof?)	-shows reasonable fits as based upon the r^2 : however note that may be driven by initial 1st order losses which are substantial from early years -no lipid data considered -also discusses possible role of dietary shifts, ie known in Superior that lake trout have shifted their forage base
excel data sheets	sporadic data available until 2002, no lipid data repored	-note also a few discrepencies between values published in Swackhamer, Hickey, vs what is given in the excel data- mostly trivial but one point was significantly different
other studies:		

Source data, range, details	Handling	Comments
French et al. 2006 in Limnology & Oceanography temporal trend data on **FILLETS of coho, chinook** 1982-2004 PCBs, DDT, Hg, mirex Lake Ontario	-checked for age & gender and found not to be a variable with these data -hypothesized that temporal variations in POP burdens a function of alewife population dynamics -also considered climate: temperate due to variations in El nino and El nina years -inlcuded data to examine trophodynamics of Lake Ontario	-noted trends in variation in alewife abundance & contaminant levels in salmon -also noted trends between alwife & zooplankton, zooplankton & algae, algae & phosphorus -discussed changes in food webs, alewifes, temperatures, -noted two phases in contaminant data: 1976-1980 where alewife variations had no impact on contaminants (consider loading source decline phase: my comment) -post 1980: alewife likely influenced variations in POPs but also noted impact of temperature fluctuations

Additional references cited:

Bentzen, E., D. Mackay, B.E. Hickie, D.R.S. Lean. 1999. Temporal trends of polychlorinated biphenyls (PCBs) in Lake Ontario fish and invertebrates. Environ. Rev. 7: 203-223

Bentzen, E., D.R.S. Lean, W.D. Taylor, D. Mackay. 1996. Role of food web structure on lipid and bioaccumulation of organic contaminants by lake trout (*Salvelinus namaycush*). Can. J. Fish. Aquat. Sci. 53: 2397-2407.

French, T.D., L.M. Campbell, D.A. Jackson, J.M. Casselman, W.A. Scheider, A. Hayton. 2006. Long-term changes in legacy trace organic contaminants and mercury in Lake Ontario salmon in relation to source controls, trophodynamics, and climatic variability. Limnol. Oceanogr. 51: 2794-2807.

Hebert, C.E. and D.V. Weseloh. Adjusting for temporal change in trophic position results in reduced rates of contaminant decline. Environ. Sci. Technol. 2006: 5624-5628.

Ross J. Norstrom

Peer Review Workshop for Great Lakes Fish Monitoring Program – Quality Management Plan and Historical Database

U.S. Environmental Protection Agency - Region 5

December 11-12, 2007

REVIEW COMMENTS

Ross J. Norstrom
RJN Environmental
Ottawa, Canada

1. **How can GLNPO optimize the existing top predator open lakes trend monitoring program to look at contaminants in Great Lakes fish on a lake by lake basis for an assessment of ecological health?**

I would like to congratulate GLFMP for the excellent data set on organochlorine contaminant trends in lake trout (walleye) that it has provided over the years. Without this information stretching back to the late 1970s it would have been very difficult to understand the processes governing the decreases in contaminant loading to the Great Lakes ecosystem following various measures to eliminate sources. Continuity of a monitoring program over such a long period of time requires a lot of foresight, ability to pass the enthusiasm from one generation to another, and political savvy not to be sacrificed to some other priority of the moment.

Goals in contaminant trend monitoring programs frequently skirt the issue of how the data are to be used in the broader sense. Providing data as an indicator of trends in ecosystem health and in human and wildlife risk assessment is the primary objective of GLFMP. Ecosystem health is a very vague concept which likely means many different things to stakeholders in the Great Lakes. Is a high quality data set on trends of a few chemicals of concern a measure of ecosystem health in itself? Is precise measurement of incremental temporal changes the most important information needed to meet these objectives? It is common in most long-term monitoring programs that the question of how the data are to be interpreted and used only becomes clear after considerable data have been gathered and analyzed. By then the monitoring programs have taken on a life of their own and tend to lose the big picture. GLFMP needs to keep in mind that numerical objectives like DQOs are not the primary objective, they only facilitate it. The challenge is not only to provide quality data, but to encourage in-depth interpretation and maximize linkages to other monitoring programs and other components of the ecosystem.

In response to a query from one of the reviewers to clarify the charge questions, EPA stated, "The GLFMP cannot be all things to all people, but a concrete review of the program that outlines the pluses and minuses of the program will allow us to justify our reporting and how we are able to participate or not participate in any given program or report depending on the circumstance." The focus of this statement is on reporting mechanisms and vehicles. But the issue is not just whether the data have the appropriate statistical imprimatur to be put into reports of other government agencies or other exercises in the Great Lake basin such as SOLEC, websites, BTS, LaMP, Great Lakes Index. The issue should also be whether the data are collected and reported in way that facilitates use by scientists who are interested in effects on wildlife, comparing trends in other components of the ecosystem, etc. It seems to me that data from all the various monitoring programs in the Great Lakes, including GLFMP, could be better linked and synthesized than they are. An excellent example of monitoring program linkage was use of herring gull egg 2378-TeCDD concentrations in the analysis of lake trout reproductive impairment in Lake Ontario[4].

In Element 2 of this program the objective is clearly related to the species being analyzed – can they be safely eaten. In Element 1 the connection between the objective and the data is somewhat more amorphous. There is no reason *a priori* that determining trends in a predator fish is more useful than monitoring further down the food web in terms of the usefulness of the data in predicting trends in other compartments of the lake or as a surrogate for ecological health in a more general sense. In the 2005 review it was stated, "In evaluating trends for Element 1 of the program, the levels of interest should be tied directly to…risk-based concentrations for humans and wildlife." Lake trout, walleye and salmon may be important food for some wildlife in the Great Lakes basin, e.g., for bald eagles during salmon spawning runs. However, the major fish biomass in the Great Lakes consists of primarily of prey fish, typically alewife (*Alosa pseudoharengus*) and rainbow smelt (*Osmerus mordax*), and it is these species which are the major component of the diet of fish-eating birds. From the standpoint of assessing risk to fish-eating wildlife from predator fish data, it is necessary that the monitoring data be predictive of levels and trends in these prey fish. I note in the historical program description on page 10 that smelt were included as part of GLFMP from 1989, but dropped because of lack of funding. While prey fish analysis may not be needed on an annual basis, I would very much like to see more effort lower down the food web. Quantitative assessment of ecosystem health requires this connection.

As a wildlife monitoring specialist it has always been a concern to me that fish monitoring programs in the Great Lakes basin were designed primarily with human consumption in mind, paying rather little attention to understanding food web dynamics of contaminants and risk to wildlife. Thus, smelt were chosen as the lake-wide monitoring species in the Canadian program, and briefly in GLFMP. From an ecosystem trend and fish-eating wildlife perspective, it would have been far better to have chosen alewife, which dominate the biomass of fish in many of the lakes. When attempting to validate a model for bioaccumulation of POPs in Lake Ontario herring gulls, it was amazing how few data were available for alewife, the primary diet of the gull in this lake. Despite decades of monitoring POPs in fish in Lake Ontario, the data base was almost entirely for smelt (largely unusable because detection limits for some chemicals of interest were too high) and lake trout. We were obliged to obtain alewife and smelt to do our own analysis to provide a database for model validation. It was demonstrated that contaminant concentrations in alewife were a much better representation than smelt of the herring gull diet. Is this likely to be true also for lake trout and salmon?

---

[4] P. M. Cook, J. A. Robbins, D. D. Endicott, K. B. Lodge, P. D. Guiney, M. K. Walker, E. W. Zabel, and R. R. Peterson, 2003, *Environ. Sci. Technol.* **37**, 3864.

As an example of a higher level ecosystem interpretation of lake trout data, consider the ratio of PCDD (polychlorinated dibenzo-*p*-dioxin) and PCDF (polychlorinated dibenzofuran) concentrations in herring gull eggs and lake trout muscle in Lake Ontario in the table below [5]. The maximum ratio, for 2378-TeCDD, 123678-HxCDD, and 1234678-HpCDD, was in the range 3.0–4.8. After correction for the

Table 5 Mean concentrations (ng kg^{-1} fresh weight) of PCDD/Fs in lake trout muscle from the Great Lakes; ratio of herring gull egg/lake trout concentrations in Lake Ontario

	Lake trout			Walleye		Lake trout	Lake trout Lake Ontario, 1977–1993[b]				Gull egg/trout[c]	
	Superior[a]	Michigan[a]	Huron[a]	St. Clair[a]	Erie[a]	Ontario[a]	Mean	SE	Min	Max	Mean	SD
2378-TeCDD	1.0	3.5	8.6	6.6	1.8	49	37	3.9	20	79	3.0	1.2
12378-PnCDD	2.3	8.4	11.2	5.9	2.9	8.4	6.7	0.4	4.4	11.2	1.6	0.6
123478-HxCDD	0.3	0.8	0.6	0.3	0.2	0.4	0.5	0.1	0.2	1.3		
123678-HxCDD	1.3	6.1	3.9	2.3	1.9	4.0	3.8	0.3	2.2	6.5	3.8	1.6
123789-HxCDD	0.3	0.8	0.6	0.3	0.3	0.4	0.57	0.0	0.34	1.08		
1234678-HpCDD	0.7	1.1	1.0	0.8	1.1	0.9	1.2	0.1	0.8	2.4	4.4	2.1
OCDD	1.0	1.1	0.7	1.8	2.8	1.2	9	1.5	1	26	1.8	1.7
Σ-PCDD	7.2	22	27	18	11	65	60	5.4	36	113		
2378-TeCDF	15	35	23	25	11	19	32	1.8	21	45	0.03	0.02
12378-PnCDF	1.7	4.9	6.3	3.6	1.4	4.1	7.3	0.5	4.3	10.5		
23478-PnCDF	2.5	10.2	12.8	5.4	2.7	20	28	2.3	16	50	0.31	0.13
123478-HxCDF	0.5	1.4	1.6	0.5	0.2	9.7	11	1.4	5	24	0.64	0.44
123678-HxCDF	0.3	1.1	1.2	0.5	0.3	1.6	2.8	0.2	1.3	4.1	2.1	2.0
234678-HxCDF	0.3	1.3	1.4	0.9	0.5	1.1	1.5	0.1	1.0	2.3		
1234678-HpCDF	0.3	0.9	0.5	0.5	0.6	0.8	1.0	0.1	0.5	1.9		
OCDF	0.4	1.0	0.1	0.2	0.9	0.4	1.7	0.4	0.4	6.1		
Σ-PCDF	21	56	47	37	18	56	84	5.4	55	130		

[a] From De Vault et al. [64]. Fish were sampled in 1984
[b] Adapted from Huestis et al. [65]. Mean ($N = 15$) of mean ($N = 6$–12) concentrations of PCDD4/Fs, 1977–1993
[c] Mean ratio of pooled herring gull egg to mean lake trout concentrations, 1981–1993 ($N = 7$–12). Calculated from herring gull data in Hebert et al. [71], and lake trout data for the same year [65]

R.J. Norstrom

herring gull whole body/egg ratio of 1.2–1.4, this is roughly the ratio of annual food consumption, and therefore intake rate of contaminant, by a herring gull and lake trout of similar size. This comparison shows that the dynamics of slowly-depurated PCDD/Fs (most likely PCBs too) in lake trout and herring gulls are similar, and that these species are integrating trends of contaminant burdens in a similar array of prey fish in Lake Ontario, quite probably in the other lakes as well. This knowledge is helpful in linking the two longest biomonitoring programs in the Great Lakes.

Analysis of long-term trends in predator fish data with respect to whole lake trends requires knowledge of food web stability. If there are significant changes to the trophic structure, contaminant trends at high trophic levels may be more related to this than to real changes in loading to the lake. Shortening or lengthening of the food chain, change from pelagic to benthic-basis, introduction of species which alter contaminant dynamics (e.g., zebra mussels in Lake Erie), and so on all affect the interpretation of trends. An objective based on the statistics of detecting a certain percentage change in contaminant concentrations in predator fish over a certain period only makes sense scientifically if it can be reasonably assumed that it is the only

[5] Norstrom R.J. 2006. Polychlorinated dibenzo-p-dioxins and dibenzofurans in the Great Lakes. *In*: The Great Lakes, The Handbook of Environmental Chemistry, Vol. 5 Water Pollution, Part N, R.A. Hites, Ed., Springer Verlag, Heidelberg, pp 71-150.

variable changing, and that change is systematic. Over periods of time longer than a decade, declines of most organochlorine compounds have been exponential. Increases in PBDEs (polybrominated diphenyl ethers) in Great Lakes biota in the 1980s and early 1990s were also clearly exponential. However there are many examples in the Great Lakes where contaminant trends were quite irregular. For example, Borgman and Whittle (1991) noted an increase in Lake Ontario lake trout PCB concentrations a year or two after massive alewife winter dieoff in 1976-77[6]. Madenjian et al. (1995)[7] found they could only explain PCB trends, 1979-1985, in lake trout in Lake Ontario if concentrations in alewife were constant followed by a nearly 3-fold decrease in 1986. The PCB concentrations in 1979-1985 were attributed to the high abundance of alewife in the early 1980s, which created competition for food resources, prevented growth, and affected the age structure of the population. These findings illustrate the futility of attempting trend analysis outside of an ecological context.

It is entirely possible to meet the DQO of detecting a 0.1 mg/kg/y change, $p<0.05$, over a 6 year period but to have no idea why the change occurred, whether it will continue or reverse direction even, or whether it is reflected in other species and the physical environment. How valuable is such a trend analysis in isolation? Is it an index of ecosystem health? I submit that single species contaminant trends cannot be interpreted without knowledge of ecosystem stability. Such interpretation is likely viewed as a higher order use of the GLFMP monitoring data. However, perhaps GLFMP itself could do more to incorporate relevant ecological data in its communications its to ensure better ecosystem-wide interpretation. From a trophic transfer standpoint, including modeling and integration of data sets, it is important to know whole body burdens. I suggest less emphasis on fine-honing the DQO, more emphasis on broadening the scope of data interpretation. One way of doing this would be to routinely incorporate nitrogen stable isotope analysis into the analytical protocol and carry out a limited retrospective analysis of archived samples. Incremental cost to the program would be low. Nitrogen stable isotope analysis is a valuable tool in determining trophic level. Nitrogen stable isotopes and fatty acid profiles have both proven valuable in helping to interpret long-term trends of organochlorine contaminants in Great Lakes herring gull eggs[8]. Decreasing trends in herring gull egg PCB concentrations were significantly slower (and noisier) after correction for trophic level than the raw data indicated[9], suggesting that trends based on the raw data would have overestimated decreases in the ecosystem, but perhaps not in lake trout if they experienced the same changes in diet as the gull.

There probably needs to be some toxicological criteria built into the DQO. I presume that PCB concentrations in lake trout are still in the sub-lethal effect range in Lake Ontario due to their contribution to total dioxin-like equivalents and the relatively high concentration of 2378-

---

[6] U. Borgmann and D. M. Whittle, *Journal of Great Lakes Research*, 1991, **17**, 368-381

[7] C. P. Madenjian, D. M. Whittle, J. H. Elrod, R. O'Gorman, and R. W. Owens, 1995, *Environmental Science & Technology*, **29**, 2610-2615.

[8] C. E. Hebert, M. A. Arts and D. V. Weseloh, 2006, *Environ. Sci. Technol.* **40**, 5618-5623.

[9] C. E . Hebert and D. V. Weseloh. *Environ. Sci. Technol.* 2006, **40**, 5624-5628.

TeCDD[1]. The requirement for detecting a change becomes much more critical near thresholds for effects than if the primary objective is to quantitatively track long-term trends which are well below any thresholds. These thresholds may apply to the predator species themselves, consumers of predator fish (humans and wildlife), or use of predator fish species as surrogates for exposure (e.g., estimating prey fish concentrations to assess risk to wildlife). I am no statistician, but in general terms what I propose would be that if the upper 95% confidence limit concentration exceeds some fraction of a NOAEL, resources be redirected to increase sample numbers and frequency of sampling for that site (lake?) in the subsequent year(s) to improve the precision of trend determination. The reason for changing the DQO after the 2005 review to an incremental concentration change from a percentage change was the difficulty of achieving the required sensitivity of measurement. This seems like a very sensible modification. However, the general applicability of the 0.1 mg/kg/y over 6 years should be validated against thresholds of concern to see if adjustment for some lakes is required.

I understand that PCBs are the class of compounds of most concern in the Great Lakes, but I did not read any justification why there is a DQO for PCBs only. The recent experience of exponential increases (doubling times as low as 3 years) in PBDE concentrations in Great Lakes biota, if it had continued, is a wake up call that not all contaminant loads should be assumed to monotonically decrease. It could be argued that DDE concentrations are still of concern to bald eagles, especially if they are consuming gulls instead of fish. Another concern to fish, wildlife and humans (certainly historically) is 2378-TeCDD in Lake Ontario. It has been estimated that there are in the order of 1000 kg of 2378-TeCDD sitting in fractured bedrock in the Hyde Park, Niagara Falls, NY landfill site only 0.6 km from the Niagara River gorge. This is a great deal more than has already been flushed into Lake Ontario, considering that 2378-TeCDD is a small percentage of the inventory of 5800 kg total PCDD/Fs in Lake Ontario sediments. I am not aware of trend studies on perfluorinated alkane contaminants in the Great Lakes, although such might exist. but I assume the trend for these contaminants was also up or relatively flat. Have DQOs for some of the other compounds been considered?

Hebert and Weseloh (2003)[10] took annual herring gull egg monitoring data (total PCBs, DDE, HCB, dieldrin, heptachlor epoxide, mirex and oxychlordane) from one colony in each of the Great Lakes, 1980-2001 and censored it to mimic sampling schemes every 2, 3, 4 and 5 years. Some of the later data were based on analysis of pools of 10 eggs. Earlier data were arithmetic means of 10 analysis of individual eggs. During this 21 year period, concentrations of most organochlorines decreased at what visually seemed to be a relatively steady rate, although there was a lot of year to year variation. Regression analysis revealed that 94% of 35 colony-compound decreases were statistically significant using annual data. The percentage of significant decreases for the other scenarios were: 80% (2y), 100% (3y), 54% (4y) and 63% (5y). The actual rates of decrease were not compared but half-times are typically in the order of 5-10 years, similar to those in lake trout. The lack of a consistent loss in significance with increasing sampling interval was due to chance landing on peaks or valleys in the ‘noise’. If the data set had been offset one year either side, the results for each scenario would undoubtedly have been different. What this illustrates is there is a real chance that highly significant decreases may be

---

[10] C. E. Hebert and D. V. Weseloh, 2003, *Ecotoxicol.* **12**, 141-151.

found, but be figments of the background noise. However there is generally a loss of statistical power with decreasing frequency of sampling as expected.

The data were also analysed to find out the duration of program needed to obtain a significant trend, p = 0.05 for annual, 2 year and 4 year sampling periods. The results are given in the table below as the extra time it took to detect a significant trend when one was found by annual monitoring. The order of lakes from left to right (SMDAG) is Ontario, Erie, Huron, Superior and Michigan (north). It can be seen that many trends over the 20 years would have been insignificant with biannual monitoring. Trends in Lake Erie and Lake Ontario tended to be less sensitive to biannual monitoring than in Lake Huron and Lake Michigan because the declines were more regular. Hebert and Weseloh (2003) concluded that annual monitoring was definitely superior, but acknowledged that there was a balance between keeping costs under control and delaying the ability to detect significant trends.

Table 2. The lag time (years) between when a consistent significant temporal decline was first detected in Scenario 1 versus Scenarios 2 and 4. NT indicates that for either Scenario 2 or 4 there was no significant trend detected for that contaminant at that colony. Results are shown for each Great Lakes colony (S—Snake Island, M—Middle Island, D—Double Island, A—Agawa Rocks, G—Gull Island)

	Every 2nd year					Every 4th year				
	Colony					Colony				
POP	S	M	D	A	G	S	M	D	A	G
DDE	3	0	NT	11	NT	9	0	NT	NT	NT
PCB	2	0	11	3	NT	10	4	13	NT	NT
HCB	4	1	10	4	4	6	7	NT	6	8
Dieldrin	3	4	2	3	3	11	10	6	7	5
Median			3.5					9.5		

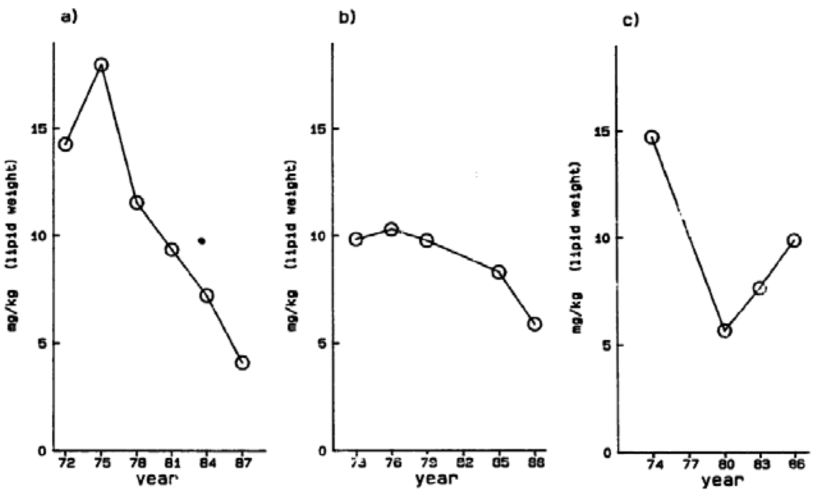


Fig. 6. Annual mean concentration of total PCB (mg/kg lipid weight) in young herrings collected during the breeding season in the archipelago of Karlskrona. The three examples demonstrate the time-series that would be obtained if sampling were performed every 3 years starting in 1972, 1973 and 1974, respectively.

The effect of sampling frequency on detecting PCB trends in Baltic Sea herring was studied earlier by Bignert et al. (1993)[11]. The effect of sampling every three years, beginning in three consecutive years is illustrated in the figure at left. Although this is an extreme example, it illustrates the kind of difficulties that may arise if cost-cutting takes precedence over annual monitoring.

Contaminant trends in lake trout and walleye are not generally as noisy as in the Baltic Sea herring example above or in Great Lakes herring gull eggs. Nevertheless, the general conclusions apply to GLFMP. Analysis of trends may be compromised by not monitoring annually. Without actually *doing* annual monitoring over long period of time, it is not really possible to assess whether there is a significant effect of every other year monitoring or not. I did not delve into the details of the transition to biannual monitoring. Was a thorough analysis of type given in the examples above done on the annual monitoring data prior to 1982 to predict what effect this change in frequency would have on detecting trends?

Hebert and Weseloh (2003) pointed out that "…it is critical to be able to assess temporal changes in the bioavailability of environmental contaminants in a timely manner." This segues directly to my most serious criticism of this program, the timeliness of generation of analytical data. It appears that analytical delays are a more serious hindrance to meeting the DQO than analysis frequency. In response to my query why the latest data we received were from 2003, it was explained that there were problems with the previous contract laboratories. As I recollect, there was some mention of difficulty of splitting samples among laboratories for the various types of analysis, and so on. Frankly, I find it surprising that there is nothing in the primary review material that addresses this issue head on, although there may be some mention in material on the CDs that I have not read. It is a serious deficiency that out-of-date data is being reported in peer-reviewed journals. A 2006 publication (Carlson and Swackhammer) reports 1999 and 2000 data. Another 2006 publication (Hickey et al.) discusses trends from 1970 to 1998. The only reasonably up to date trend reporting is for PBDEs, 1979-2005 (Batterman et al. 2007), based largely on analysis of archived samples, and not part of the routine program.

---

[11] A. Bignert, A. Gothberg, S. Jensen, L. Litzen, T. Odsjö, M. Olsson and L. Reutergårdh, 1993, *Sci. Total Environ.* **128,** 121-139.

The QMP has certainly been very thoroughly thought out and documented. If it was functioning as it should, surely it would not have taken three to four years to put the work flow back on track. What time line is envisioned to catch up on the backlog? I note with interest that in Section 1.2, Quality Management, Policy, Goals and Objectives that flexibility is one of the operating principles. It is stated that, "..all QA policies and requirements should provide added value to the GLFMP, rather than inhibit the program through unnecessary restraint." I wonder how well this principle works in reality and whether contracting practices have gotten in some sort of bureaucratic tangle and become part of the problem of timely data generation. Every time I review a US monitoring program I am surprised at the complexity and high proportion of resources devoted to quality management. Data quality is certainly important, and must be addressed, but I am often left with a vague feeling that it is overkill relative to the resources devoted to data generation and interpretation. Perhaps I am spoiled. I come from a background of low budget, necessarily very pragmatic biomonitoring programs with very low bureaucratic overhead. Delays of more than a year in obtaining data were infrequent and considered deplorable. Due to fragmentation of my and other scientists' responsibilities among various programs, delays in publishing the data were quite another matter, however. So I confess to being the pot calling the kettle black. When it comes to timeliness of publication I cannot lecture by example.

2. How can GLNPO optimize the existing sport fish fillet monitoring program to look at contaminants in Great Lakes fish on a lake by lake basis for an assessment of human health?

The draft procedure in the QAPP for fish egg collection as an alternative to analysis of whole fish is interesting and worth pursuing. There is sufficient evidence to show that concentrations on a lipid basis are the same in female and her eggs. Would this reduce costs enough to allow analysis of a site in each lake annually?

3. In conjunction with the current monitoring program for fillets and whole fish, how can GLNPO use this program to look at emerging bioaccumulative toxic contaminants?

I assume this charge question is aimed at incorporating analysis of PBDEs, PFAs, pharmaceuticals, musks, etc. into GLFMP. PBDE determination is approaching routine, but most other emerging contaminants will not be picked up by simply adding an analyte to an existing analytical protocol. As such, the only feasible approach is to analyze a limited number of pooled samples. Assuming that 5 pools per site could not be accommodated, I would prefer that a pool made by compositing an equal weight sample of the 5 primary pools and analyzed for emerging chemicals, rather than simply analyzing one of the pools of 10.

I would further suggest that GC-MS and LC-MS screens for previously undiscovered compounds in various compounds classes be made using one of the pooled samples from each lake each year. Apparently something of this nature has already been done (pg. 14)? If this approach was too costly or difficult, perhaps screening one lake each year and rotating through them could be done. I strongly believe in early warning analysis of this type. My laboratory has discovered a number of totally unsuspected chemicals using an environmental forensics screening approach, including a class of naturally-occurring compounds previously unidentified.

Specific questions:

a. **Regarding the three questions/objectives listed above, are the current designs feasible? These designs include sampling fish at two different locations on each lake over a two-year period for the open lakes trend monitoring program and/or the number of sites collected for the sport fish fillet monitoring program.**

The issue of pooling vs. individual sample analysis is always a question of whether paying for the statistics is worth it or not. Most environmental scientists are very aware of the importance of considering statistical power in experimental design. Some take a very conservative approach and claim that data interpretation is so hampered by anything other than individual analysis that it is unconscionable to do anything else. Unless there are a lot funds available, it is likely taking this statistically conservative approach will attenuate the number sites or/and the frequency of sampling.

The most recent approach taken in GLFMP to analyze 5 pools of 10 fish from each site is a compromise which will undoubtedly gives good average values and allows some measure of variance. If all the fish in each pool are close to the same weight, concentrations in each pool will be approximately equivalent to arithmetic means in the 10 fish making up the pool. It seems much more the rule than the exception that residue data are log-normally distributed. Pooling eliminates any chance of treating the data this way, so the statistical treatment waters are already muddied in the present protocol. What would be lost if only one pooled sample was analyzed each year? A 5-fold reduction in numbers of samples per year would allow annual sampling which would enhance the chance of defining long-term trends. Of course, the statistical significance of incremental changes as defined by the DQO would not be possible. But do we need such a measure? Let me give you an example I have been involved with since its inception, the herring gull monitoring program.

There were severe cutbacks, in fact temporary loss of the herring gull egg monitoring program, after a government change in 1984. When the program was reinstituted in 1985, we were faced with significantly reduced resources and needed to significantly curtail the number of analyses. Prior to this, the protocol had been analysis of 10 individual eggs from ca. 12 colonies throughout the lakes and connecting channels. After some opposition from horrified biologists, it was finally agreed that one composite sample of 10-13 eggs from each site would be analyzed annually, and individual analyses would be done on the two main sites in one Great Lake each year, to give a measure of variance on a 5 year rotation. We had been analyzing individual samples for 8 or more years prior to 1985, so we already knew that coefficients of variance were relatively constant among chemicals, sites, lakes and over time. It simply did not seem necessary to devote scarce resources to continue measuring a statistic which we already had a good historical handle on. Confirmation of the sample distribution statistics every 5 years seemed like a reasonable compromise. With this protocol, numbers of routine analyses dropped from ca. 120 to 30 per year. It even allowed us to add a few more colonies to the program. Another factor in changing to primarily pooled sample analysis in the herring gull egg program was the realization in the 1981 that we needed to add PCDDs and PCDFs to the list of analytes. In the mid 1980s non-ortho (TCDD-like, coplanar) PCBs were added. There was no way that individual analyses could be performed for these chemicals, even in rotation years, with the analytical capacity we had. From the very beginning, these 'special' chemicals were analyzed only in a single pooled sample per colony. In more recent times, the same approach has been taken for analysis of brominated flame retardants. Over 20 years since instituting pooled sample/rotating individual sample analysis protocol, there have been no serious program implications.

There may be many valid reasons (including political and bureaucratic) raised why an approach similar to that taken for the herring gull egg program would not work for GLFMP. However, if resources are constant, and numbers of analyses are an issue, it is certainly worth debating whether a trade off in statistical power by more aggressive pooling and analyzing samples every year is matched by a trade-off in loss of statistical power by biannual analysis.

It is excellent that fish are collected every year whether they are analyzed or not. However, I think it would be a good idea to homogenize some individual fish from each site, store an aliquot of each, and make pools of the rest for routine analysis. This way, if any serious issues arise about statistical significance arise, it is possible to analyze individual samples. Perhaps this could be done on one of the 5 pools, for 10 individuals per site. I understand that this suggestion has significant bearing on field sample protocols and significantly increases the cost of sample preparation. It may be that my statistical naïveté is showing here. Perhaps the 5 pools approach already covers this contingency.

As discussed in my comments under Charge Question 1, I highly recommend that nitrogen stable isotope analysis be incorporated into the analytical protocol and that a limited retrospective analysis of archived samples also be done to assist in interpretation of trends.

The idea of developing a DQO which increases in precision as toxicity thresholds are approached is also discussed under Charge Question 1.

I recommend that comprehensive analysis of prey (what the predator fish eat, not just smelt) and predator fish in each lake at some point in time, perhaps on a lake by lake rotation basis, to better 'connect' the predator fish data to lower trophic levels, e.g., through biomagnification factors.

b. In order to provide policy-makers an indication of whether conditions of the Great Lakes are improving over the long term, GLNPO reports annually the average long term percentage concentration change of total PCB's in whole top predator fish for the whole Great Lake's Basin. Is this approach scientifically sound and feasible? If not please suggest a scientifically sound and feasible alternative.

I am not sure I understand what is being reported and I ran out of time to ask, so I will have to comment on this at the meeting when it is clarified for me.

Alan Stern

Peer Review of Great Lakes Fish Monitoring Program

Alan H. Stern, Dr.P.H., D.A.B.T.

General Comments

The Great Lakes Fish Monitoring Program and its historic database present a unique record of ongoing high quality data that can serve multiple purposes. Overall, these data are reflective of trends in the Great Lakes (GL) environment in general as well as trends in the impact of the some GL fish on ecological and human consumers. My specific concerns with the data and their ability to serve their intended purposes are detailed below. However, with respect to the task of this review itself, my experience with this review has been that the program has been presented less as an organic whole, than as the sum of multiple fragmentary parts contained in multiple documents. To some extent, one of my tasks as a reviewer has been to attempt to construct a somewhat complete mosaic from these parts in order to view the program in its entirety. This has not been a straightforward task. It appears that, to some extent, the mosaic structure of the information presented for review reflects the mosaic nature of the program, itself. Nonetheless, the reviewer's job would be not only easier, but more productive if, in the future, the program was able to present a single comprehensive document that synthesized the big picture of the GLFMP. Such a document could include all of the elements gathered together in the present package: discussion of the goals of the program, and its methods as well as the peer-reviewed papers and comprehensive summaries of the data, but in a more organized and connected structure.

Response to Charge Questions

1. *How can GLNPO optimize the existing top predator open lakes trend monitoring program to look at contaminants in Great Lakes fish on a lake by lake basis for an assessment of ecological health?*

My reading of the materials provided raises some fundamental questions about the nature and intent of the open lakes monitoring program (Element 1). The stated purpose of this part of the program is that "The data are used to assess time trends in organic contaminants in the waters of the GLs using fish as biomonitors" (Appendix 3)). This statement points out what is to me a lack of clarity in the intent and design of this program. For what outcome or environmental endpoints are these fish taken as biomonitors? What is the purpose of analyzing these contaminants in the open waters of the GLs *per se*? Are the fish themselves, and their ecological health the endpoints as well as the biomonitors of those endpoints? If so, the health of the fish is not examined. Is the ecological health of or contaminant levels in the species consuming these fish the endpoints? No such data are presented, nor is there a discussion of how the fish that serve as biomonitors fit into the food chain such that their contaminant levels can be considered in the appropriate context. If they are intended to reflect changes in the chemical environment, with respect to deposition and mobilization of the specific targeted contaminants, such changes do not appear to be linked in any obvious way to biological outcomes. It is clearly stated that the open lakes (whole fish) data are not intended to support fish consumption advisories. They are potentially very useful to those with an interest in investigating such biological outcomes and endpoints, but if the intent of biomonitor data is to facilitate such investigations, then such an intent should be addressed in the design of the element. There is no indication that this is the case, nor is there an indication of who are the intended users of these data. Furthermore, even from the standpoint of reflecting trends in the chemical, the data do not appear to reflect regional environmental trends in a clear manner since they are, to some extent, confounded by changes in the biological environment that are presumably independent of these chemical changes (e.g., dietary changes in L. Superior). This raises questions about the extent to which these data can be used to drive decision-making about source control. Rather, these data appear to be self-contained, and perhaps merely observational without being clearly linked to a specific intended application with respect to ecological health. Without sufficient clarity on the intended use of these data, it is difficult to assess how the program can be optimized.

A separate, but somewhat related concern with the use of these data is the fact that, as discussed in section 2.2.1.1 of the GLFMP Quality Assurance Management Plan, many of the fish sampled occupy specific regions of each lake. The essentially local nature of the lake trout sampled in the Open Lake Trends Monitoring Program raises questions about the ability of these data to reflect large scale lake or region-wide trends. The term “open lake,” suggests that the original intent was to determine lake-wide trends. However, the data cited here indicate that these are not “open lake” fish in the sense of “sampling” contaminant levels throughout a given lake. Furthermore, while there is a region-wide background of PCBs resulting from atmospheric deposition, elevated concentrations of PCBs above this background tend to reflect specific sources of discharge or atmospheric deposition. Such local sources can confound analyses of lake-wide trends such as those presented in (e.g.) Hickey et al. (2006).

In this context, there is no mention in any of the review material about investigating links trends in fish contaminant concentrations to air deposition data. The difficulty in doing this that is posed by the abovementioned changes over time in the biological environment notwithstanding, If fish tissue concentrations are linked to regional atmospheric sources (as many models predict), one would expect to see a correlation (perhaps with a lag) between air deposition trends and fish contaminant concentration trends. On the other hand, an inability to see such a correlation should raise suspicions about possible local source of input to the Lakes that obscure regional deposition trends. Thus, use of the data in this manner would not only be useful in the larger environmental context, but could also be very useful in assessing the utility of the Element 1 data for making judgments about lakewide trends.

Another issue in terms of maximizing the usefulness of the Element 1 data is the relative paucity of mercury (Hg) data. Not only is collection of Hg data not systematic and not comparable in amount or scope to the PCB data, but there is also little discussion of the Hg data, its significance, or trends. .While the GLFMP specifically states that the goal of Element 1 is to provide data on the trends in *organic* contaminants, this seems like an arbitrary decision given that mercury is not only a major contaminant in fish with significant ecological consequences, but also, the Great Lakes region is one of the nation’s hot spot areas for mercury deposition much of which is attributable to regional (i.e., Midwest) sources, especially coal-fired power plants. It is important to monitor the impact of changes in the emissions from these sources on GL fish and their ecological (as well as human) consumers.

2. *How can GLNPO optimize the existing sport fish fillet monitoring program to look at contaminants in Great Lakes fish on a lake by lake basis for an assessment of human health?*

It appears that the collection of data in Element 2 occurs largely, or entirely for the purpose of aiding states' efforts in issuing their own fish consumption advisories. Thus, without knowing how the states use these data, it is difficult to know the program can be optimized. What fraction of the data necessary to support the states' advisory needs is provided by the Element 2 data? To what extent are these data secondary and supplementary and to what extent are they primary and critical?

The Element 2 database (with the exception of the 2003 data for Hg) ends with 2002. Given that this review is occurring in late 2007, it is difficult to understand why there is such an offset in data availability. If the Element 2 data are intended to support fish consumption advisories, this delay in data availability would seem to render the data largely useless for this purpose.

The considerations for the design and structure of the sport fish monitoring program appear to arise from a fisheries perspective rather than from a human health perspective.(e.g., Who consumes what fish, how often?). This focus is particularly clear in sec. 2.2.1.1 (pg. 22-23) of the GLNFO-QMP). It is stated that Chinook and Coho salmon were chosen as the primary fish for monitoring for the sport fish monitoring program on account of their "popularity as a sport fish." While these fish may, indeed, be popular sport fish, this observation (at least in the relatively impressionistic way that it is stated in the QMP document) is not sufficient by itself, to justify this choice as the primary focus of monitoring for assessing the human health impact of sport fish consumption. Rather, from the standpoint of human health risk assessment and the related construction of fish consumption advisories, Element 2 should be based on data on the rate and frequency of fish consumption by-species among anglers and their families and friends. Such data are not equivalent to creel surveys or surveys of anglers' fishing preferences (although such data also do not appear to have been considered) since anglers may practice catch-and-release for some species while keeping other species for consumption. A related concern is how were the sampling locations for this program determined? From a human exposure and health risk assessment standpoint, the sampling locations should be chosen as a function of where fishing occurs. These should include, where feasible, urban areas on or close to the lake. I can find no information on the choice of the sampling locations with respect to fishing activity. In the broader context of linking Element 2 data collection to human health, the only link I can find between these data and fish consumption advisories *per se* appears to be a 1992 EPA memo and associated papers in the supporting documents. In contrast, it would seem that the Element 2 sampling design should be guided by fish advisory needs, but this is not in evidence.

At the very end of section 2.2.1.1 (pg. 23) of the QMP, it is stated that, "*Another issue with the sport fish fillet monitoring Element is the small number of sites per Lake…it would be impossible to say with certainty that those few sites are representative of the entire Lake…This limitation of sampling sites in the remaining Lakes [i.e., excluding Michigan] also prohibits the use of GLFMP sport fish data from trend analysis*."

Additionally, in section 2.4 (pg. 29), it is stated that, "*Because of the voluntary nature of the program and the limited number of collection sites in some lakes, portion of the GLFMP is not able to identify trends in sport fish contamination.*" This seems to reflect a logical disconnect.

If sport fish data do not support trends analysis, how can they reflect human exposure since one would expect trends to be a critical aspect of exposure analysis. That is, if the data are not sufficient to determine whether contaminant levels have changed over time, this would imply that the data also cannot support a change in fish consumption advisories. And, following this to its logical conclusion, this also, therefore, means that the data cannot reliably support any fish consumption advisory. Perhaps this conclusion undervalues the true utility of these data, but, in that case, However, if that is the case, the QMP should make clear what the true utility of these data are. That would mean, in part (and as above), showing how these data are linked to the setting of fish consumption advisories. Given that fish consumption advisories are ultimately set by the various states and not by the GLNPO, the linkage may not be entirely clear. However, if that is, in fact, the case, it raises the fundamental question of exactly how and for what purposes these data are collected.

Ideally, the sport fish monitoring program should also address those fish that are caught both individually for recreational and subsistence purposes (Given the subsistence/dietary nature of consumption by some consumers, "sport fish" does not seem to be the best overall term for such activity.) as well as those fish that are caught commercially. I am aware that, in general, commercial fish fall under the purview of the FDA rather than the EPA. In part, however, this distinction appears to have arisen because, with the notable exception of the Great Lakes, almost all commercial fish consumption comes from marine fish. Much of marine fish is caught in open oceans and is not necessarily caught by U.S. fishermen or in waters under U.S. jurisdiction. This has resulted in a logical separation of responsibilities between the two agencies with EPA providing support and guidance for freshwater (and possibly estuarine) fish consumption, and FDA providing guidance and, (at least in theory) regulatory control for commercial (i.e., marine) fish. The GLs, however, do not easily fit this pattern because many of the fish that are harvested commercially are also "sport fish." Potentially, this means that there could be one advisory for a given type of fish that would apply if the fish were caught as a sport fish, and a different advisory that would apply if the fish were caught commercially even though there would be no actual difference in the consumption. This argues for linking the Element 2 data collection and interpretation to FDA commercial fish advisory needs as well as to the states' sport fish advisory needs.

There appears to be an overwhelming emphasis on PCB and DDT in Element 2 (as well as in Element 1). Given the nature of the fish and the contamination in the GLs, this may be appropriate and justifiable. However, little support for this emphasis is provided in the review documents. The choice of contaminants should be driven by one of two factors. Either, that the contaminant is one that, under the conditions of consumption, poses a significant health risk, and/or the contaminant is an emerging contaminant whose levels in the environment are changing and/or it is suspected of posing a significant risk under the conditions of consumption, but the risk is unclear. Justification of the choice of PCBs and DDT would appear to require the first criterion. However, what is missing from the review materials in this regard, is an analysis of the PCB and DDT concentration is various fish relative to their known or likely consumption and the resulting risk. This also applies to other contaminants potentially addressable through Element 2.

Appendix 3 indicates that PBDEs were added to the list of analytes, but I did not find any results reported for PBDEs. In addition, Hg is given short-shrift relative to PCBs. Although sorting the

Element 2 database by year reveals a somewhat greater focus on Hg in 2003, this represents a small fraction of the overall database, and program review materials, however, almost completely ignore Hg. The reason for this is not clear. Hg is, by no means, an obscure contaminant and, in fact, accounts for the majority of fish consumption advisories nationwide. Furthermore, the levels that are reported, while not alarmingly high, are often in a range (0.15-0.25 ppm) that under most states' advisories places them under a restrictive consumption advisory category. Considerably higher concentrations are likely to be found in GL's walleye which, to my knowledge, is a commonly fished and consumed GL fish. It is, therefore, significant and surprising that this is not one of the major target fish for Element 2. Hg is also a significant pollutant for the GLs in terms of sources and deposition. For all of these reasons, it is not at all clear to me why comparatively little effort has been devoted to the collection of Hg data in favor of PCB and DDT data. Perhaps this stems from an *a priori* decision to focus on Coho and Chinook salmon, but such an explanation begs the question of why these fish in particular were chosen and/or why they continue to be the main focus of sampling. This point relates to my earlier observation about the need to link the generation of fish sampling to data on consumption and ultimately to risk.

3. ***In conjunction with the current monitoring program for fillets and whole fish, how can GLNPO use this program to look at emerging bioaccumulative toxic contaminants?***

The same concerns about the intended uses of the data, and the impact of local versus regional sources of contaminants and their impact on the ability to determine lakewide trends apply here, too. However, with respect to the contaminants themselves, among the chemicals on EPA's priority persistent and bioaccumulative toxics (PBTs), the only one that is not currently included in the GLFMP that is likely to be both elevated and pose a significantly elevated health risk at realistic levels of exposure are the PCDDs and related compounds (PCDFS, dioxin-like PCBs). While these chemicals can no longer be considered emerging contaminants, their absence from among the routine analytes in the program is surprising, particularly in light of the fact that the EPA's Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-***p***-Dioxin (TCDD) and Related Compounds (The Dioxin Reassessment) identifies freshwater fish as the largest individual source of 2,3,7,8-TCDD TEQs in the U.S. diet. With respect to bioaccumulative contaminants that are more legitimately emerging, perfluorooctanoic acid (PFOA), and perfluoroctanesulfonic acid (PFOS) are obvious candidates – not only because they bioaccumulate in fish, but also because fish eating predators appear to accumulate high levels of these compounds as a function of their fish consumption and because humans these compounds have long half lives in humans. Furthermore, PFOA contamination (albeit at low levels) has been found in 78% of drinking water systems in NJ selected without reference to known or suspected sources of contamination. This suggests that PFOA is ubiquitous in the environment and therefore, has the potential to bioaccumulate in GL fish. Finally, PFOA has adverse health effects in animal models that suggest the potential for both wildlife and human health risks. PCDDs and PFOA-PFOS contamination in the environment is not, in general, linked to specific point sources of contamination. This does not mean that there are no such point sources in or in contact with the GLs (as there may well be point sources of PCB contamination in the GLs that (as discussed previously) may confound lakewide trends analysis), but it does suggest the feasibility of using the current sampling structure (or an improved version of that structure) to also monitor for these contaminants.

a. ***Regarding the three questions/objectives listed above, are the current designs feasible? These designs include sampling fish at two different locations on each lake over a two-year period for the open lakes trend monitoring program and/or the number of sites collected for the sport fish fillet monitoring program.***

With regard to the Element 1 data, the lack of a clear context for these data and the lack of linkage of the data to specific intended applications make it difficult to judge whether current designs are feasible. Also, as mentioned previously, the apparent lack of a clear demonstration that the sampling sites reflect lakewide trends both with respect to the mobility of the sampled fish and with respect to the absence of local sources of contamination make it difficult to judge the ability of the current design to unambiguously reflect large scale trends in each lake. With only two sites in each lake for this purpose, there is, obviously, only a limited basis for assessing whether one of the sites in a given lake is anomalous. As discussed for the Element 2 data, the database (with the exception of the 2003 data for Hg) essentially ends at 2002. While the offset in data availability is less an issue for environmental trends data than it is for human health-based fish consumption advisories, it still makes the data less useable for its intended purpose in the near-term.

With regard to the Element 2 data, the ability of the data to reflect lakewide trends is less of an issue because such trends are not necessarily relevant when providing consumption advice to consumers who catch and consume fish from specific locations. However, as discussed above, the feasibility of the current design to address this purpose depends on linking the samples to data on fishing and consumption with respect both to location and to the type of fish consumed. The apparent absence of such linkage makes it unclear as to whether the current sampling design is feasible. Furthermore, (as discussed above) the explicitly stated inability of the Element 2 data to reflect temporal trends raises doubts as to the ability of these data, in general, to meaningfully support health-based consumption advisories. In addition, a key issue in assessing the feasibility of the current design to meet the intended purposes of the data is, obviously, a clear statement of the intended purposes of the data. While the Element 2 data are intended to support human health-based fish consumption advisories these data are intended to be used by the states in the construction of their own advisories. In order to judge the adequacy of the current design, it is necessary to have a clearer picture of how these data are ultimately used by the states in the construction of those advisories. Are these data supplemented by other, state-generated data? Do they form the entire basis for consumption advisories for some or all of the states?

b. ***In order to provide policy-makers an indication of whether conditions of the Great Lakes are improving over the long term, GLNPO reports annually the average long term percentage concentration change of total PCB's in whole top predator fish for the whole Great Lake's Basin. Is this approach scientifically sound and feasible? If not please suggest a scientifically sound and feasible alternative***.

This question actually has (at least) two separate questions embedded in it. The first question deals with whether PCB concentration in whole fish is the appropriate metric for assessing the overall status of the Great Lakes, or at least of the monitored fish. The second question deals with whether the structure of the current sampling plan is adequate discerning trends over the time frame of one to several years. With respect to the first question, it is not clear to me that PCBs are clearly the unique indicator of the "condition" of the GLs or, for that matter, that there is a single best indicator of these conditions. Part of the problem in evaluating this question is the lack of clarity in the question, itself. Clearly, there are many "conditions" in the GLs. Although, the measurement of PCB concentration in fish reflects at least that particular condition with its attendant environmental effects, it is not clear what else this condition is linked to either causally or mechanistically. That is to say, that PCB in GL fish can arise from air deposition, from cycling of PCBs within the lakes, themselves, from source waters, and from point sources. Other contaminants, such as DDT, while following similar patterns of bioaccumulation, can have very different etiologies. Hg, is also a significant ecological stressor, but has different sources, and different bioaccumulative mechanisms as well as different ecological effects. "Conditions" in the GLs in the larger sense also include eutrophication and invasive species. Thus, there does not appear to be a unique measure of GLs conditions or to perhaps suggest a more useful term, environmental quality. Given the multi-faceted nature of environmental quality in general and of the GLs in particular, it is more reasonable to utilize multiple measures of environmental quality each of which is designed to be responsive to changes in the relatively short-term. To the extent that PCBs continue to be used as a measure of environmental quality, the GLNPO should specify, the rationale for that choice, and what aspects of GL's environmental quality (other than simply the concentration of PCBs in fish *per se)* are reflected in this measure.

With respect to the second question, it is, of course, difficult to know what information is not being captured by the data. However, the data for PCBs do show a reasonable trend over time that is consistent with what is known about PCB air deposition and PCB cycling in the aquatic environment. However, it seems odd that the data (at least those data presented in the review materials do not extend beyond 1992 or 1998 depending on the particular data set. Clearly, the ability of the PCB data to reflect at least an aspect of GL environmental quality depends in large part in being able to evaluate that metric in more or less real-time.

Text-specific comments

<u>GLNPO QMP</u>

Pg. 10, par. 3 - *"Because this part of the program was designed to assess the overall <u>effects</u> of toxic chemical son fish…"*

Sampling for chemicals in fish (whole or otherwise) provides data on biomarkers of exposures, but not on the effect of these chemicals.

Pg. 12, par. 4 - *"The usefulness of direct water quality measurements were limited by both spatial and temporal restraints."*

What does this mean?

Pg. 17, par. 5 - *"The value of whole fish was recommended as a way to decrease both biological and analytical variance. Biological variance was less for whole fish, because while there were seasonal differences in contaminants concentrations in various fish body tissues total body burden varied little on a seasonal basis."*

Are thee data to substantiate this? How much of a difference was there between whole body and fillet concentrations across seasons? If both Elements 1 and 2 could use the same fish sample metric, the utility of each could be improved. Also, the rationale given elsewhere in the QMP is that whole fish are a better reflection of ecological exposure since various fish predators eat the entire animal. This is a different rational than the one presented here.

Pg. 23, par. 1 - *"It is because of this demonstrated migratory behavior that salmon were thought to be excellent choices for contaminant monitoring* [in the Sport Fillet Monitoring Program]."

Although this is not explained in sufficient detail, it appears that the rationale here is that because salmon are migratory, they may be consumed throughout the GLs rather than in specific locations. However, this observation does not address fishing and consumption patterns. That is, to what extent are salmon caught? By who? How often? How often are they consumed? By who?

Par. 3 - *"Generally, data quality objectives (DQOs) are statements of the overall maximum uncertainty associated with the measurement system and the population that the data users are willing to accept in the results derived from data collection activities."*

This sentence does not scan.

"Essentially, the DQO design is intended to answer the primary question of the program."

This "primary question" is never stated.

Pg. 24, par. 2 - The statistical description here does not make sense to me. What does a 20% change within the 95% CI mean? Does this mean an α of 0.05? And what does it mean that this was changed to use mean statistics? Doesn't this still require an α or a corresponding CI?

Par. 3 - *"Rather it was designed to take advantage of existing Sate run fish consumption advice monitoring programs."*

In what way? To what end? The overall program purpose here is not clear. Was the intent that the data from each state would complement and/or inform each other? If so, were there data to indicate overlap or continuity of the data across states?

Pg. 25, par. 4 - As per my previous comment, what exactly is meant by this statistical description – particularly with respect to "*within the 95% confidence interval*?"

Pg. 28, par. 2 - What is meant by, "*Lake trout data collected between 1977 and 1979 were adjusted to be compatible with other time periods.*?"

I don't understand adjustment procedure described here for the compositing.

Pg 29, par. 1 - The nature of these check samples is not clear. Are these just a sort of reference sample? If so, why is it necessary to use a grand composite?

Data Quality Objectives Revision Report 2005

Pg. 3, par. 3 - The notion of detecting a proportional change in PCB concentration across geographically unrelated sites implies a common source reduction and/or a common reduction mechanism. The underlying assumptions should be clearly spelled out.

Pg. 4, par. 2 - *Representativeness*

This is a very valid comment and goes to the potential differences in contaminant source and processing across sites as well as biological differences in indicator fish as well as the food chin in general across sites.

Appendix 6 – Verification and Validation Statement for the Budget (GLFMP) Pg 162-164

Reporting Narrative – Description - "*…(PCBs) qre sued as the represnetatie PBT chemical since they are a common cause of fish consumption advisories."*

The fact that PCBs are a common source of fish consumption advisories does not, by itself, imply that they are a representative PBT. Other PBTs have other sources and/or other mechanisms of bioaccumulation and environmental reduction. Furthermore, Hg is a more common source of fish consumption advisories.

Rationale - *"Fish consumption is the primary route of exposure to humans for PBTs"*

This is not necessarily correct. With respect to PCBs for example, fish is a significant source of PCBs, but for the average diet, fish is not necessarily the major source of PCBs (meat and dairy products account for more exposure than fish). Even to the extent that fish consumption does account for significant PCB exposure, is consumption of *these* fish the primary route of exposure in the GLs?

Carlson and Swackhamer – "Results from the U.S. Great Lakes Fish Monitoring Program…"

Pg. 8, par. 2 – *"The GLFMP was not designed to compare concentrations of contamiannts across lakes as the fish of a constant length are not the same ages across the lakes."*

While this makes sense, it points out an inherent contradiction in the purpose of Element 1. if the purpose is to use the fish as some sort of generalized environmental biomarkers to detect trends in the physical environment, then the varying concentration with size and the lack of inter-lake correlation of size with age should be a concern. However, if the goal is to use the fish as biomarkers of ecological impact, then the fact that fish of different lengths are different in age across lakes is not necessarily a problem.

Statistical Comments on Element 2 – 2. Methods: Composting sport fish 1980-2001

"Usually, the fish from each station are divided into groups for compositing according to length."

If the purpose of this sampling is to provide consumption guidance, then it is not appropriate to composite by size class unless consumption varies by size class within the size range collected, or unless consumption advisories are issued by the states according to size class. Otherwise compositing should be done across the size classes consumed.

"Right now, we see high degrees of variability in PCB concentrations within groups of composites from the same satation in the same year…If we seek to detect trends of 0.1 ppm/year, within year fluctuations of twice that amount will obscure any trends…"

Earlier text in the review materials makes it clear that given the nature of the sampling design, trends could not be determined in the Element 2 data, and that this was not a goal.

4.3 Change relative to previous year or relative to a baseline sample?

The key question does not concern a year-to-year comparison, but the overall trend. Even if Element 2 is not designed to elucidate trends, you would still want to see a consistent decrease over 2-3 years before changing an advisory.

Quantifying Trends – text box

"It seems logical to regard the 1.58 ppm as an outlier..."

In using composites, it is hard to argue that an unusual sample result is an outlier in the sense of being artifactual or irrelevant unless there is reason to believe that the analytical result is questionable. If, instead, this is referring to an "outlier" in the statistical sense, there is no *a priori* reason to disregard it.

Don Stevens

Peer Review Comments
Great Lakes Fish Monitoring Program

Quality Management Plan and Historical Database

Element 1 – Open Lake Monitoring Program
Element 2 – Sport Fish Fillet Monitoring Program

Don L. Stevens, Jr.

General comments:

1. I found the QMP very difficult to read, particularly in trying to separate specifics of the current program from the historical precedents. (I'm still not sure what the sampling design for Element 2 is. The only reference I could find was "15 sport fish from a variety of sites on each lake", but I couldn't find any discussion of how the sites were selected.) It would be very helpful to have the current GLFMP design and DQO's summarized near the beginning of the document.

2. There seems to be some disjunction between the Program Review Mission Statement ("…review and evaluate the GLFMP's Quality Management Plan (QMP) and historical database to assist in identifying present day Data Quality Objectives (DQO) and recommend future changes to both Elements 1 (Open Lake Trend Monitoring Program) and 2 (Sport Fish Fillet Monitoring Program) of the GLFMP….") and the specific charge questions. It's not clear to me how answering the specific questions addresses the mission statement. In this written response, I'll respond to the specific questions.

3. There are multiple statements of objectives for the overall program and for the two Elements of the program. (pp. 5, 10, 11, 13, 17, 23, 25, Appendix 4). It is difficult to separate the historical versions of the objectives from the current ones and to determine what the goal of the GLFMP is. Generally, the objective statements seem to have an implicit scope of the entire Great Lakes, but the scope never is made explicit. Without more explicit scope and objective goals, developing a DQO is a daunting undertaking.

4. A sensible DQO cannot be determined without an explicit statement of spatial scope and resolution of the program. Also, there seems to be some ambivalence about whether "trend" or "status" is the objective. In either case, the spatial support needs to be explicitly stated: status of the Great Lakes Ecosystem is a much more complex goal than average tissue concentration of some contaminant at a particular location in one lake. Similarly, developing a DQO for "regional trend of a contaminant in fish tissue for the Great Lakes" is much more complex that developing one for a single site. The consideration of whether to use a relative or absolute change is irrelevant until the target trend is clearly identified. For example, the concept of regional trend (or "trend for the Great Lakes") needs to be carefully defined and distinguished from trend at a single location. The DQO (and the design of the program) will flow from that definition.

Responses to specific questions

1. How can GLNPO optimize the existing top predator open lakes trend monitoring program to look at contaminants in Great Lakes fish on a lake by lake basis for an assessment of ecological health?

The current program objectives are much too diffuse guide the design of an optimal program. An explicit and precise statement of the program objective should include identification of the spatial scope and scale of the program results. A goal of a "lake by lake assessment of ecological health" carries an implicit spatial scale that is not consistent with the current design of Element 1.

2. How can GLNPO optimize the existing sport fish fillet monitoring program to look at contaminants in Great Lakes fish on a lake by lake basis for an assessment of human health?

As for the parallel question for the top predator program, a discussion of optimizing is pre-mature. The goals of Element 2 need to be much more clearly articulated.

According to the "Statistical Comments", much of the data was unusable because of inconsistent sampling protocol: number of fish, species, and compositing rules varied substantially from site to site and year to year. Has that been changed? Have the SOP's in the current QAPP in Appendix 1 been implemented?

In conjunction with the current monitoring program for fillets and whole fish, how can GLNPO use this program to look at emerging bioaccumulative toxic contaminants?

From a design perspective, I don't see how a program can address "emerging bioaccumulative toxic contaminants" without a rigorous synoptic monitoring design or a design directed at known potential sources of emerging contaminants. I don't think the current monitoring program has either of these attributes.

Specific questions:

Regarding the three questions/objectives listed above, are the current designs feasible? These designs include sampling fish at two different locations on each lake over a two-year period for the open lakes trend monitoring program and/or the number of sites collected for the sport fish fillet monitoring program.

No. The objectives certainly imply that there is a need to relate the results of the GLFMP to the entire extent of the Great Lakes. As it is, the sampling design limits application of the results to the two sites per lake that are actually sampled. Sampling design does not necessarily have to be a probability sample covering the entire extent of the Great Lakes. Nevertheless, given the charge of "describing both qualitatively and quantitatively the health of the Great Lakes Ecosystem.", a synoptic sample is essential. The QMP has a lake by lake justification of the representativeness (Section 2.2.1.1) of the chosen sites, but there is no insight as to how those particular sites were picked. I appreciate Mr. Blume's comment made during the conference call to the effect that there is a need to sample where the fish are, but, surely, the target species are known to occur at more than the two sites per lake that are sampled. Some effort should be made to give the sampled locations in the program greater spatial coverage. Is it possible to identify locations where the top predator species are likely to be found, and to spread the samples (either subjectively or probabilistically) over those locations? There are two ways in which more sites can be visited without substantial budget impact: collect (and analyze) fewer samples per site or spread the samples through time by increasing the interval between revisits. It appears that the latter approach is already being used, but perhaps the rotation could include additional sites.

I am aware of several studies that have examined the trade-off between sampling a few sites extensively versus more sites less extensively. Every one of the studies that I know of have concluded that a more precise estimate of population attributes is obtained by sampling more sites less extensively. Generally, this occurs because the between-location variation is much larger than the within-location variation. The QMP does not contain enough detail to compare the cost of collecting 50 fish at one site versus collecting 25 fish at two sites, but the latter will almost certainly provide more insight into population attributes.

In order to provide policy-makers an indication of whether conditions of the Great Lakes are improving over the long term, GLNPO reports annually the average long term percentage concentration change of total PCB's in whole top predator fish for the whole Great Lake's Basin. Is this approach scientifically sound and feasible? If not please suggest a scientifically sound and feasible alternative.

With the current design, no. There is no justification for aggregating the data from the individual sites and representing the aggregate as applying to the Great Lakes. This comment applies generally to both Elements 1 and 2, and not just to PCB concentrations.

Any assessment of condition that is used by policy-makers to manage must have a spatial scale that is coherent with the management scale. If policy is made at the scale of the Great Lakes

Basin, then the condition assessment should have a spatial support that synoptically represents the Great Lakes Basin. The current design is much too spatially limited to provide a reliable assessment of the Great Lakes Basin. See the response above for suggestions for scientifically sound & feasible alternatives.

Kent Thornton

Peer Review Comments
Great Lakes Fish Monitoring Program

Quality Management Plan and Historical Database

Element 1 – Open Lake Monitoring Program
Element 2 – Sport Fish Fillet Monitoring Program

General Comments:

1. The Program Review Mission of the Technical Charge to Peer Reviewers, page 1, states the peer-reviewers are being asked to…assist in identifying present day Data Quality Objectives and recommend future changes to both Elements 1 and 2. The Background Section of the Technical Charge to Peer Reviewers, page 2 states that the overall goals of the GLFMP include:

    a. Monitoring temporal trends in bioaccumulative organic chemicals in the Great Lakes using top predator fish as biomonitors;

    b. Assessing potential human exposure to organic contaminants found in these fish; and

    c. Providing information on new compounds of concern entering the lakes ecosystem.

    These goals reflect Element 1: Open Lake Trend Monitoring (Goal a above), and Element 2: Sport Fish Fillet Monitoring (Goal b above). I am reiterating the two issue statements highlighted in the Technical Charge because the Charge Questions didn't appear to me to directly follow from these issue statements. If I have misinterpreted the intent of the peer-review, I will modify my comments in the final workshop report.

2. I applaud you for emphasizing the DQOs for Elements 1 and 2 because monitoring designs flow from the DQOs. Without an understanding of what quantitative information is needed for decisions, it is difficult to select monitoring designs and sampling protocols that will adequately provide the desired information.

3. I recognize the Great Lakes Program has a long history, is a large program, and has multiple components, but the Quality Management Plan, for me, was difficult to read. I suspect a major part of the difficulty is a result of the specific format for Quality Management Reports required by EPA. The Plan would have been easier for me to understand if the DQOs had been explicitly stated early in the document, and a comprehensive discussion of the historical and current programs provided in one Section, with the historical and current differences summarized in a Table. Different facets of the sampling and monitoring program for each Element were described under Section 1.3 Program Description, Section 1.3.1 Mission, various subsections under Section 2.2.1 Systematic Planning, and Section 2.4 Standard Operating Procedures. It was difficult to

gain a comprehensive perspective on the overall Program with information on specific topics of interest scattered throughout the Plan.

4. The peer-review panel has members with excellent statistical, sampling, fisheries, ecological and human health expertise. These are not my specific areas of expertise, so my comments are confined primarily to programmatic and DQO issues.

Charge Questions:

1. How can GLNPO optimize the existing top predator open lakes trend monitoring program to look at contaminants in the Great Lakes fish on a lake by lake basis for an assessment of ecological health?

Response:

- I encourage you to eliminate discussions of optimizing the program and focus on implementing a monitoring design that is adequate to answer the questions. Optimize implies there is a single, "best" program for all the Great Lakes. There are likely several designs, including the current design, that will provide adequate information for addressing GLFMP objectives. Some designs will have advantages that warrant their selection, but it is unlikely there will be a single design that satisfies all desired attributes. If the current design is adequate, continue with it.

- Detecting change (pages 17, 18, 24, 25) versus trends (page 26) is discussed in several places in the Quality Management Plan. Based on the original GLFMP objectives, the 2005 review recommendations, and the DQO stated on page 26 (1st complete paragraph, lines 7-10), the intent is to measure trends, not change. However, Question 5 below again refers to presenting annual changes in total PCB concentration in whole top predator fish. Change estimates can be made from trend data, but, in my opinion, the DQO should be for trend detection, not change, because trend detection is a Program goal.

- I suggest you reframe the questions, which will still be consistent with the original GLFMP objectives: Identify contaminant levels in fish (Status) and their trends (page 10). The reframed questions might be:

    - Is there a problem with the current levels of PCBs (or any other organic contaminant) in fish?

    - Is it getting better or worse over time?

- I am not a toxicologist so I don't know if fish tissue total PCB concentrations of 800 to 1800 ng/g (current PCB levels in lake trout, Hickey et al., 2006) result in chronic toxicity to lake trout. However, if there is no baseline of chronic toxicity in lake trout, monitoring changes or trends provides limited information for management or policy decisions because there is no reference for determining if there is a problem. Once it is determined whether or not a problem exists, the next question becomes relevant, "Is it getting better or worse over time?" The current DQO of detecting trends in concentrations of 0.1

mg/kg/year at the 95% confidence level based on three consecutive sampling periods for a specific site with a power of 80% or greater should be adequate to answer that question. The trend is either increasing, decreasing, or not significantly different from zero. I did not understand the concern about concentrations asymptotically approaching some irreducible concentration. Unless this irreducible concentration is greater than the chronic toxicity concentration, why is it an issue to indicate there is no longer a decreasing trend in concentrations over time? In fact, given the PCB concentrations in regional rainfall patterns, it might be expected that fish tissue PCB concentrations would asymptotically approach this regional level.

- From my reading of the Quality Management Plan and the comments made on the conference call, it does not appear that the GLFMP is responsible for issuing regulatorily-driven ecological or human health advisories. These advisories are issued by the respective Great Lake States. If this assumption is correct, then perhaps the GLFMP could serve in the capacity of foretelling trends by relaxing the confidence level for significance. For example, if there were an increasing trend in a particular organic contaminant that was detected at the 80% confidence level, would it not be preferable to initiate more intensive sampling or specific investigations to confirm this trend, than wait until you are 95% confident there is an increasing risk to the ecological health of the Great Lakes? There are few problems that are easily and readily reversible once it is conclusively documented that a problem exists. The PCB, DDT and Toxaphene concentrations in the Great Lakes illustrate how long problems persist once they are conclusively documented and management actions (such as bans) are taken. The Monitoring DQO could remain the same (i.e., 95% CL), but the Assessment Reporting could be at the 80% CL. This would ensure that the monitoring would be adequate to scientifically document trends, but also provide earlier warnings of potential, emerging trends. In fact, it would be preferable to report the confidence level, the level of statistical significance (e.g., $\alpha = 0.23$ or 0.16), and the power so the decision makers can decide for themselves if that level of risk warrants additional action. There is nothing magic about $\alpha = 0.05$ and for many studies and monitoring efforts, particularly fisheries and wildlife studies, differences at the $\alpha = 0.20$ are considered ecologically significant.

- Question Number 1 specifically relates to ecological health. Lake trout represent the top aquatic predator in the Great Lakes (walleye as its equivalent in Lake Erie) and appear to be a logical target species for open water. If nearshore, piscivorous wildlife species (raccoons, eagles, osprey, grebes, terns, etc) are also to be protected, then an alternative fish species might be selected. I assume nearshore waters are primarily the jurisdiction of the respective States.

- The current DQO, as stated on page 26 of the WMP, provides a useful starting point for discussion at the meeting.

2. How can GLNPO optimize the existing sport fish fillet monitoring program to look at contaminants in the Great Lakes fish on a lake by lake basis for an assessment of human health?

Response:

- The same comments related to optimization discussed in the Response to the Question Number 1 are applicable to this question.

- For human health, there are FDA Action Levels for some contaminants that can be used to answer the question: "Is there a problem [i.e., Do fish tissue PCB (other organic contaminants) concentrations exceed the FDA Action Level?]. A generic DQO for all contaminants and lakes can be developed to answer this question or specific DQOs could be developed for each lake and each organic contaminant of concern. For example, does the 75th percentile total PCB concentration in Coho (Chinook) salmon or rainbow/steelhead trout exceed the FDA Action Level of 2000 ng/g concentration at the 80% confidence level with a power of 80% or greater?

- The trend detection DQO for Element 2, Sport Fish Fillet Monitoring Program is likely to be different than the DQO for Element 1, Open Lake Monitoring because of the differences in sample size (e.g., 60 fish/site for Element 1, 15 fish/site for Element 2). However the process of formulating the DQO and its parts (i.e., rate of change of overtime, specific time period for trends, α and β levels) should be similar.

- A suggestion was made at the 2005 review by Robert Day that GLNPO review the original questions to be answered by Elements 1 and 2, gather and evaluate the data collected to date, and review the underlying assumptions used to develop the current design of Elements 1 and 2. Based on these analyses, it would be useful if the EPA scientists could formulate a strawperson DQO for Element 2 to initiate discussion for the December meeting.

3. In conjunction with the current monitoring program for fillets and whole fish, how can GLNPO use this program to look at emerging bioaccumulative toxic contaminants?

Response:

- The current effort of:

    - Having the most contaminated composite of each species from the lower three Great Lakes examined for all halogenated compounds;
    - Conducting a workshop on emerging contaminants every 5 years;
    - Having the analysis contractor conduct a complete scan through an Extended Program year over the course of five years; and
    - Archiving samples

  is an excellent approach to look for emerging bioaccumulative toxic contaminants. With 10,000 new organic chemicals being produced each year, staying abreast of emerging contaminants is a daunting task, and one better left to academic and research institutions and periodic screenings at selected sites. In addition, some agencies, such as the USGS, have research projects specifically to identify emerging contaminants that elicit biological effects. The original wording of the Program objectives stated that bioaccumulative *organic* chemicals were to be monitored. This question is for bioaccumulative *toxic* contaminants. If this later statement is the programmatic focus, then the scans of fish tissue should also include metals in addition to organic chemicals. I noted that mercury has been added for long-term monitoring.

- I suggest that some fish also be included from sites that typically are not considered the most contaminated. For example, mercury contamination of fish tissue, in many instances, occurs not in the most organically contaminated sites, but in the least organically contaminated sites.

4. Regarding the three questions/objectives listed above, are the current designs feasible? These designs include sampling fish at two different locations on each lake over a two-year period for the open lakes trend monitoring program and/or the number of sites collected for the sport fish fillet monitoring program.

Response:

- This question can better be addressed following the formulation of the DQO. The current designs appear feasible based on results from several of the supporting studies accompanying the Quality Management Plan. However, the statistical comments on Element 2 (last section in the QMP) clearly indicate the adequacy of the current design depends on how the DQO is formulated (0.1 mg/kg/yr, 25% change/year, 20% change/year, etc.).

- The current sampling sites appear to provide an index of conditions in each of the Great Lakes and the data are reported as an indicator of condition at that site, not as representative of the entire lake. It may no longer be possible after 30+ years, but it would be useful to have a brief paragraph on why the location of each site was originally selected.

5. In order to provide policy-makers an indication of whether conditions of the Great Lakes are improving over the long-term, GLNPO reports annually the average long-term percentage concentration change of total PCBs in whole top predator fish for the whole Great Lakes Basin. Is this approach scientifically sound and feasible? If not, please suggest a scientifically sound and feasible alternative.

Response:

I have difficulty answering this question without knowing how the information is presented. I indicated in Question 4 above that the monitoring sites index conditions at each specific site, but are not representative of the entire lake. These are not probabilistic samples, but rather targeted sites at which the investigators were relatively confident they could catch fish. If the annual, average long-term percentage concentration change in PCBs in whole top predator fish is estimated by averaging the concentrations from two sites in each lake and extrapolating to the entire Great Lakes, I do not consider it scientifically sound or feasible. I'm also not sure why this information is desired. As indicated throughout the document, the land use patterns, agricultural, municipal and industrial activities, lake characteristics and other factors vary on a lake by lake basis as do some of the management and policy actions. People typically prefer place-based information over general information about the region. If estimates for the Great Lakes system are desired, the preferred approach is to implement a probability-based monitoring program. The second alternative is to develop model-based estimates for the Great Lakes system. Either approach will require more sites than are currently being monitored, and additional design and analysis.

D. Michael Whittle

A REVIEW OF THE EPA/GLNPO GREAT LAKES FISH MONITORING PROGRAM:

- **OPEN LAKES TREND MONITORING**
- **SPORT FISH FILLET MONITORING**
- **EMERGING BIOACCUMLATIVE TOXIC CONTAMINANTS**

D. Michael Whittle **November 30, 2007**

1. *How can GLNPO optimize the existing top predator **open lakes trend monitoring** program to look at contaminants in Great Lakes fish on a lake by lake basis for an assessment of ecological health?*

The open lakes fish contaminants program has historically monitored contaminant burdens in top predator (lake trout and walleye) fish species collected annually from each of the Great Lakes. Each year samples of fish are collected at one of two designated offshore sites on each of the Great Lakes. The collections are switched from site to site on each lake in alternate years. The target sample consists of 50 adult lake trout within a total length range of 600 -700 mm. Only walleye, total length 450-550 mm, are collected in Lake Erie. All fish are subsequently processed in composites of 5 fish each to produce an annual sample size of 10 composite fish samples per lake.

The simple analyses of contaminant burdens for whole fish will not provide an indicator of ecological health of the population of fish species (lake trout or walleye) monitored nor will it provide sufficient data to determine the ecological health of the whole lake system in which the fish are residing. The contaminant burden data may provide an indicator of populations under stress. These populations may warrant further examination utilizing specific tools and techniques to measure sublethal responses resulting from exposure to various levels of environmental contaminants. Therefore, a combined measurement of the contaminant burdens in the indicator species and a subsequent evaluation of the extent of sublethal responses attributable to these contaminant burdens could provide a lakewide assessment of ecological health. The original objectives of Element 1, Open Lakes Trend Monitoring, did include only the goal of identifying potential harm to fish stocks as a ecological health focus. Element #4, Fish Tumor and Ecosystem Health Monitoring, would have been a mechanism to track some changes in Great Lakes ecological health, but this element was never implemented due to funding limitations. Therefore, the measurement of contaminant burdens in top predator fish species in isolation will not provide ecological health information. Some consideration of implementing an associated Great Lakes contaminant effects survey might be undertaken as part of any discussion of the revision of the GLFMP activities.

The use of composite samples of fish compromises the ability to generate robust statistical data to describe temporal trends of contaminant burdens. The current selection protocol for generating composite samples further detracts from the ability to generate reliable data to generate statistically valid temporal trend determinations. The analysis of individual fish would significantly strengthen the statistical power of the resulting data set.

The selection of fish for inclusion in the annual composite samples using size (total length) as the sole criteria for the sample presents a number of issues. The specified size range for lake trout (600-700mm) and walleye (450-550mm) selected would represent some of the largest fish in the Great Lakes for these 2 species. The grouping of these fish by size is an attempt to generate composite samples consisting of similar aged fish. Age is the ultimate descriptor of the duration of exposure and hence the opportunity to bioaccumulate contaminants. Unfortunately fish size is not a consistent or accurate indicator of fish age and consequently the duration of exposure.

Fish size obviously increases with age but the rate of change (growth rate) is governed by several variables. The principle controlling factor is the overall productivity of the aquatic ecosystem. This productivity is influenced by the abundance and quality of food sources for the top predator species. Ambient water temperature and the composition of the forage base are factors contributing to the degree of productivity exhibited by an aquatic ecosystem. Many of the Great Lakes lake trout populations are supported and maintained to varying degrees by the annual introduction of hatchery reared species. There is often a significant difference in the growth rate of hatchery reared species vs. native or non-stocked species. There may even be differences in the growth rate among the various stocked species depending on the genetic background of the hatchery stocks contributing to the population of lake trout in an individual lake.

Change in fish size with increasing age is not a constant relationship. Changes in diet with the stage of development (maturation), the composition and energy quality of the forage base and other related environmental variables all contribute to changes in growth rate with increasing age. Individual fish are influenced by these variables differently. This is evidenced by an increasing variability in individual fish size within a population as the ages of the members of this community increase. Therefore, a sample of several fish representing the upper range of sizes expected for that species could incorporate a significant range of ages. This biological variability of size at age is very predominant in the top predator fish communities across the Great Lakes. In the most productive lake systems with elevated growth rates, the range of ages represented in a size class at the upper range for a species may incorporate > 5 separate age classes. In less productive systems such as Lake Superior, where the growth rate is slower, the same size class may contain significantly older fish in comparison to fish in the comparable size class sampled from a more productive system (i.e. Lake Ontario).

The Great Lakes have been subjected to a variety of stressors over the past 30 years which have resulted in differing changes to the overall productivity of each of the lakes. These changes have subsequently altered the composition of the food web which is often expressed as changes in the growth rates of top predator fish species within the various lake ecosystems. This results in changes of size at age for fish over time and therefore, the mean age of fish and hence exposure period of those fish in a composite sample selected solely by size will vary over time.

In summary the variability in size at age presents a variety of problems relating to the contents of a composite sample of fish selected on the basis of size alone such as 600-700mm total length for lake trout and 450-550 mm for walleye. For Lake Ontario lake trout this composite sample of 5 fish may often represent 5 different ages and hence 5 different exposure periods. For Lake

Superior lake trout, a 600-700mm total length composite sample may consist of fish that are, on average, older than Lake Ontario fish and thus have a longer exposure period. A 5 fish composite sample of walleye from Lake Erie, a very productive system, may also contain fish of several different ages.

Therefore, the attempt to calculate long term temporal trends of contaminant burdens based on data resulting from the analyses of somewhat dissimilar annual samples is more than challenging. Similarly a comparison of lake to lake differences in contaminant spatial trends is presented with the same difficulties.

The overall recommendation for a modification to the sample collection and processing protocol would be to incorporate the analyses of aged individual fish into the program. If it were necessary to maintain the composite sample protocol, the suggestion would be to age individual fish prior to generating composite samples. Each of the 10 composite samples should include 5 fish of the same or very similar ages. Ideally the range of the mean ages of all 10 composite samples should be as narrow as possible. It still may not be possible to generate composite samples that have lake to lake similar mean ages using the current size range field collection and sample processing protocol.

Some instruction to the field collection staff could include the recommendation to modify their collection gear to focus on the collection of a narrower range of fish sizes within the prescribed fish length window (600 -700 mm or 450-550 mm). For example, a narrower range of gill net mesh sizes could be selected to assist in reducing the variability of size of fish captured. If a sample containing a narrower age range of fish results perhaps less fish could be collected (25 vs. 50) and the fewer fish could be analyzed as individuals.

For fall spawning fish such as lake trout, all collections should be completed prior to the commencement of any spawning activities for that particular lake. The incorporation of post spawning female fish in the collection will influence the mean contaminant burden for the composite sample. The deposition of the lipid rich egg mass by spawning female fish prior to collection will significantly reduce the lipophillic contaminant concentrations in the whole fish homogenates. A composite sample consisting of 2 or 3 post spawn female lake trout would potentially have a much lower than average lipopillic contaminant concentration. Walleye are spring spawning fish so the timing of the fall collection activities is not as critical.

The frequency of some collection activities may be altered after a review of the historical data for each individual lake. The recent reduction in the rate of decline of contaminant levels in fish monitored may permit a future reduction in the frequency of measurements for some lakes. In addition most organic contaminant burdens in fish from the upper Great Lakes are significantly lower than those measured in lower lakes fish. This fact combined with a slowing of the rate of contaminant burden decline creates a situation where it is often statistically difficult to define a year to year reduction in mean contaminant levels in some fish communities. A review of the historical temporal trend data may result in the recommendation to reduce the monitoring frequency within some lakes. A reduction in the current annual sampling frequency may permit a more intensive sampling effort to be undertaken in the years when this activity is planned for any individual lake system. The resulting sampling changes may include sampling at both of the designated sites on a lake in selected years to produce a more comprehensive assessment of the contaminant profile for fish in that lake. This reduction in the frequency of monitoring activities may also partially offset the cost of analyzing individual fish if that protocol is adopted.

Finally, Lake Erie is the only lake in which walleye are collected for contaminant trend analyses. Walleye represent conditions in the western and central basin of Lake Erie. There is virtually no migration of this species into the colder eastern basin of the lake. Since the early 1980's there has been a lake trout stocking program implemented in the eastern basin of the lake with the goal of developing a self sustaining lake trout population. The lake trout population has remained steady over the years and the stocking programs are ongoing. In order to provide data comparable to the other Great Lakes, the inclusion of a lake trout monitoring program for the eastern basin of Lake Erie should be considered.

Summary:

- Consider using individual fish versus creating composite samples.
- Age individual fish.
- If composite samples are used, age individual fish prior to creating composites of similarly aged fish.
- Instruct field staff to modify collection gear to capture a smaller size range (age range) of fish.
- Complete lake trout sampling prior to the commencement of any spawning activity in a particular lake.
- Consider reducing frequency of monitoring activities at sites where the rate contaminant decline in fish has decreased significantly.
- Consider the addition of a lake trout sampling program in the eastern basin of Lake Erie.
- Consider the development of a contaminants effects program in association with the GLFMP activities.

Changes to the analytical protocols for determining PCB concentrations over the duration of the program confound the calculation of temporal trends of contaminant burdens in fish. Changes in analytical techniques (packed column chromatography vs. capillary column chromatography), the incorporation of various analytical instrument systems (MSD – mass selective detector) and the calculation of concentrations via the sum of arochlors 1242, 1248, 1254 and 1260 vs. the summation of selected PCB congeners may result in changes to the levels of PCBs reported in the samples over time. A verification of the relationship of historical analytical protocols to current methods with respect to data comparability/compatibility should be undertaken. A previous study by Huestis et al., 1996 (J Great Lakes Res. 22(2): 310-330), discussed the relationship between historical data (pre 1980) for PCBs and PCB data derived via the summation of selected PCB congeners. Their observation indicated comparability between data sets but the number of PCB congeners summed in this study was greater than reported by the GLFMP during portions of the program. An evaluation of relationship of the historical vs. the current total PCB data needs to be undertaken in order to assess the validity of calculation of long term temporal trend data. The Huestis paper also reported on the relationship of historical column chromatography DDT data Vs. ECD (electron capture detection) derived data and found them to be similar.

The decision to eliminate the analysis of o-p' DDT and mirex from the suite of compounds routinely analysed may need some revaluation. Often the presence of the o-p' DDT metabolite in a sample from the Great Lakes indicates a "new" source of the parent compound DDT. The o-p'-DDT metabolite is the initial breakdown product of DDT. These "new" sources of DDT are often from sites remote from the Great Lakes basin. The presence of the o-p' DDT metabolite in a Great Lakes sample therefore, would indicate a contribution from a source outside the Great Lakes basin (i.e. Central America) and this offers some insights into the degree of impact that long range atmospherically transported compounds are having on Great Lakes contaminant profiles. The incorporation of the o-p' DDT metabolite into the analytical protocol is not a significant workload addition.

Mirex is a compound whose primary source has been identified to be Lake Ontario basin sites within the Great Lakes basin it but has been detected in other Great Lakes. Sergeant et al.,1993 (J. Great Lakes Res. **1**: 145–157) reported this compound in fish from several of the other Great Lakes. Although this study is dated, is does point the fact that mirex is an atmospheric contaminant and may be an indicator that sources outside the basin are contributing to the overall contaminant profile in Great Lakes biota. Therefore, retaining this compound in the analytical protocols for all the Great Lakes fish samples may provide useful insights into the extent to which remote contaminant sources are impacting biota within the basin. Again the inclusion of this parameter is a minor addition to the total analytical effort.

Summary:

- Review the relationship of historical total PCB data to current congener specific data to determine the validity of long term temporal trend assessments for PCBs.
- Maintain o-p' DDT and mirex determinations for samples from all lakes in the routine analytes list.

2. *How can GLNPO optimize the existing* ***sport fish fillet monitoring*** *program to look at contaminants in Great Lakes fish on a lake by lake basis for an assessment of human health*?

The current sport fish monitoring program utilizes samples of coho and Chinook salmon and rainbow trout to provide data for Great Lakes state agencies to generate sport fish consumption advisories. Since 1998 EPA, GLNPO has assumed the analytical costs for these samples in addition to providing a contribution to each of the states for collection and sample shipping costs. The program provides contaminant data on 3 composite salmon samples (small, medium and large size fish) for each lake each year. Each composite consists of skin on fillet of 5 fish. Collections of coho salmon vs. Chinook salmon are made in alternate years for all lakes with the exception of Lake Erie. Rainbow trout are collected each year in Lake Erie. The size range for rainbow trout is defined as fish in the range 600 – 700 mm total length.

The table of significant events for the GLFMP indicates that several states have discontinued stocking of Chinook and coho salmon in Lake Erie which supports the need to find an alternate top predator species, rainbow trout, for that lake. Instead of using the small, medium and large fish categories for defining the makeup of the 3 composite samples, the designated rainbow trout size range of 600 – 700 mm total length represents very large (& old) fish from that population.

If these fish are to provide data related to the potential for safe human consumption, these data will represent the highest level of contaminant accumulation based on the elevated mean age of the fish analysed. Adopting the small, medium and large size categories for the 3 composite samples of rainbow trout would result in data being produced for a range of fish sizes that the average fisher and consumer is more likely to encounter. This change would reduce the production of data which only describe the maximum levels of contaminant accumulation detected in these species.

Chinook and coho salmon plus rainbow trout represent a small portion of the variety of sport fish species routinely harvested by Great Lakes fishers. Therefore, the overall contribution to the various states sport fish advisory programs is minimal. Secondly the data contribution for 3 samples per lake per year is an extremely small addition to the overall database on sport fish contaminant levels maintained by each of the state advisory groups.

The use of skin-on fillet samples for contaminants analyses can produce data different from the traditional data used by some agencies. For example, the State of Michigan uses skin-off fillet samples in their sport fish advisory program. The higher lipid level (> 50%) in a skin-on fillet would result in higher values for many lipophillic organic contaminants than obtained through the analyses of leaner skin-off tissue sample. Therefore, the GLFMP derived data for fish fillets would not be compatible to the contaminant data routinely collected by the State of Michigan. There may be other States where this difference in sample types analysed also occurs.

The collections of coho and Chinook salmon occur in the fall during the spawning cycle of these fish. Fish approaching a spawning event, particularly these two species, cease feeding for some time before they commence their spawning run up rivers and streams. They utilize lipid reserves for energy requirements. The utilization of these contaminant rich lipid reserves would influence the lipophillic contaminant distribution patterns within their bodies. Thus the fish captured during the spawning season may not have contaminant profiles similar to those exhibited by open lake fish. It is the open lake fish that most anglers are catching and consuming. Since data derived from the analyses of spawning fish do not reflect the contaminant conditions most anglers encounter on the Great Lakes for these 2 fish species and they are not directly comparable to some of the State fish consumption advisory databases

Summary:

- Consider using size ranges (small, medium, large) of rainbow trout to generate the annual 3 composite samples.
- Avoid the extremely large rainbow trout (> 650mm) as data for these fish may represent extreme conditions not experienced by most great Lakes anglers/consumers.
- Determine the fillet sample types used by agencies to create their consumption advisories and provide compatible data. Ensure that state agencies do not use the data from the GLNPO sport fish program to generate temporal trend contaminant level assessments for these fish.
- Avoid the use of spawning cycle salmon and focus on fish collected at a period and location when a majority of anglers are harvesting these species.

In the light of the fact that this activity is no longer funded by FDA and that EPA does not have a direct mandate to provide human health oriented data, there should be a consideration to withdraw from the program entirely. The amount of data provided per species is minimal. The range of sport fish species surveyed is very limited. Overall the contribution to the various state fish consumption advisory programs is probably insignificant and in some cases the data may not be appropriate to be incorporated into some or all of the advisory databases. Resources from this program could be redirected at the Open Lake Fish Monitoring Program. This would allow GLNPO to implement some of the modifications and additions to the program previously discussed in the previous section on the Open Lake Fish Monitoring Program. This activity would seem to be a primary responsibility for EPA/GLNPO and fit closely with other Great Lakes activities under the Surveillance umbrella.

3. *In conjunction with the current monitoring program for fillets and whole fish, how can GLNPO use this program to look at **emerging bioaccumulative toxic contaminants**?*

The current analytical service agreement calls for the contract laboratory to conduct an expanded set of analyses once during the 5 year cycle of the agreement. The list of additional analytes includes PCNs, PBB-153, PFOS and dacthal. A previous workshop conducted to identify emerging contaminants produced a list of future candidate compounds which included TBBPA, SCCPs, APEs and chlorothalonil. This list of compounds represents a wide variety of chemical classes.

There are notes throughout the description of the program that indicate archive samples (~ 80g) were set aside from each composite sample processed. If these samples represent a tissue archive and appropriate storage conditions can be documented, the collection would provide material for some retrospective analyses.

Depending on the definition of "emerging" contaminants this archive collection can be utilized in two ways. If emerging means recently detected compounds, then retrospective analyses can be conducted on the archived homogenates to provide a perspective on the trends of these newly detected compounds over a 30+ year period of the monitoring program. A process for conducting this retrospective analysis would be to analyse samples of a similar type (species, size range, lake collection site). Samples could be selected encompassing 5 year intervals to minimize the analytical workload. The range of candidate emerging chemicals is large so selecting 1 or 2 at a time would seem to be prudent. Additionally only 1 or 2 lakes might be chosen for this type of analyses. The choice of lakes could include those with traditionally elevated contaminant levels (Michigan & Ontario), lakes vulnerable to atmospheric inputs (Superior), lakes with significantly different profiles of routinely measured contaminants (Superior Vs Ontario) or lakes where the historical collection represents 2 different species (Erie walleye Vs Lake Ontario lake trout).

The resulting data from this type of retrospective analyses would provide an indication of whether this newly identified contaminant was increasing or decreasing in Great Lakes ecosystem.

Secondly, if the emerging contaminant is thought to be recently introduced into the Great Lakes system, an across the basin analytical design could be implemented. Select the largest size current fish sample from each of the lakes and compare these data with a similar group of samples from the archived material collected 5 years previously. Again these data would identify the current significance of this newly identified chemical across the Great Lakes basin. It would give a short term perspective on how quickly the contaminant is being incorporated into the top of the Great Lakes aquatic food chain and implications for potential human exposure. Using the largest fish, representing the longest period of exposure may maximize the chances for detection if the compound has been in the system for > 5 years or so.

The data from the analyses of whole fish composites could be provided to those agencies responsible for determining human health risks from the Great Lakes basin community. The data might be used by state agencies to focus their sport fish monitoring programs to assess the potential for human exposure to the compounds detected for a range of species commonly consumed by Great Lakes anglers and subsistence fishers.

The range of potential compounds is so large that the analyses could not be completed by a single lab within a reasonable period of time. Either the analytes selected would have to analysed by several labs contracted to serve EPA/GLNPO or cooperative analytical support arrangements could be made with other agency labs at the state and federal level.

The critical issue in being able to identify the significance of recently detected or introduced toxic chemicals is the availability of a reliable archive collection. Knowledge of the history of the archived samples is important as some temperatures, storage containers or sample processing methods may invalid some subsequent chemical analyses.

NOTE: If a sample archive program was going to be continued or a new version initiated, some discussion with other archive holders would be warranted. Simple steps like producing multiple smaller aliquots (~ 20g ea) for each sample processed would permit multiple retrospective analyses to be completed on the same sample plus allow for future analyses for new emerging compounds. In addition, future archive material should be stored at -80C Vs -20C to ensure the chemical integrity of the samples. Many of these details are documented in the SOPs of existing biological tissue archives.

Summary:

- Conduct retrospective analyses for candidate emerging bioaccumulative toxic contaminants utilizing archived samples from the GLFMP activities.
- Select the samples to be analysed to represent 5 year intervals.
- Select the lakes to be evaluated based on the properties and suspected usage of the target chemical.
- Focus on the largest size fish to maximize the ability to detect contaminants which may be present at ultra low concentrations.
- Understand the history of the archived samples in order to assure that they will provide valid analytical data.
- Revise the future archive sample holding conditions incorporating a storage temperature of -80C and the storage of multiple small volume (20g) aliquots per processed sample.

Appendix D

Chair's Summary of the Pre-Meeting Comments

This page intentionally left blank.

Great Lakes Fish Monitoring Program

Quality Management Plan and Historical Database

Summary Comments

We want to commend the Great Lakes Fish Monitoring Program for its long history of monitoring organic bioaccumulative toxic contaminants in fish. Long-term trend monitoring information is critical not only for better scientific understanding of Great Lakes ecosystems, but also in the formulation of informed policies and management actions. The Great Lakes Program is also to be complimented for emphasizing data quality, and an interest in developing data quality objectives that will ensure monitoring information can address regional, national, and programmatic questions about the Great Lakes.

These summary comments are organized around the two Program Elements - Element 1 - Open Lake Monitoring Program, and Element 2 - Sport Fish Monitoring Program, and the Charge Question related to emerging bioaccumulative toxic contaminants. We will address the other Charge Questions in comments on these three topical areas.

Programmatic Questions/Objectives

First, we would like additional information on the primary questions or objectives of the Great Lakes Fish Monitoring Program. The Quality Management Plan, in general, was difficult to read and did not adequately describe the overall program. This contributed to some of the discussion comments, and, perhaps, some of the misunderstanding of the program in reviewers' comments. All of us were, and are, interested in providing comments that can be used to improve the Great Lakes Fish Monitoring Program. Additional clarification of Programmatic questions and objectives, therefore, is critically important.

Without additional insight into Program questions and objectives, including spatial and temporal considerations of the Program, it was difficult for us to address the specific Charge Questions. For example, is a long-term monitoring objective to provide annual estimates of temporal trends in bioacummulative organic chemicals in top predator fish or to determine trends in ecosystem health? Are these trends to be reported for selected sites in each lake, for each of the lakes, or for all the Great Lakes combined? Is a Program objective to provide status estimates of the ecological and human health risk for selected sites in each lake, for each of the lakes, or for the Great Lakes? Is the Program interested in estimates of change or trends? If the interest is to provide lake-wide estimates or estimates for the entire Great Lakes system, neither Element 1 nor Element 2 designs are adequate. To be able to provide useful suggestions for the Program, we need to better understand the Programmatic questions and objectives.

Element 1 - Open Lake Monitoring Program

Second, without this understanding, it is difficult to provide recommendations for optimizing the monitoring program design for Element 1 - the Open Lake Monitoring Program. For example, if the objective is to address trends in bioaccumulative organic chemicals in top predator fish, then the current selection of fish species might be adequate. However, if the emphasis is on addressing the ecological health of each Great Lake, then alternative approaches, as discussed in the peer-review comments, might be more appropriate. These alternative approaches could include different target species, such as smelt or alewife. If prey species were selected instead of top predator species, then synoptic probability sampling designs can be adopted. The use of prey species instead of top predator species might also obviate some of the issues associated with composites of similar length, but different aged fish having different periods of exposure to organic chemicals. It might be that intensive, process-oriented studies nested within annual or biannual monitoring would be a more efficacious approach to answering Programmatic questions or addressing Programmatic objectives.

Incorporating toxicological fish and wildlife criteria into the monitoring effort can also assist in the development of DQOs. For example, management actions would be significantly different if an exponentially decreasing trend in tissue concentrations approached a plateau above chronic toxicity criteria or threshold versus below this threshold. The Quality Management Plan emphasized estimating trends in PCB concentrations in top predator fish. However, without more information, we can’t determine if the DQO for Element 1 (to detect trends in PCB concentrations in lake trout (walleye) of 0.1 mg/kg/yr at the 95% confidence level based on three consecutive sampling periods for a specific site with a power of 80% or greater) is relevant.

Element 2 - Sport Fish Fillet Monitoring Program

Insight into Program questions and objectives is even more important in addressing Element 2 - Sport Fish Fillet Monitoring, because there currently is no DQO for this element. It also appears that the Great Lakes Fish Monitoring Program does not use this information either for issuing fish consumption advisories or for monitoring trends in sport fish tissue contamination by bioaccumulative organic chemicals. One option might be to eliminate this Program Element and use the available funding to augment and supplement Element 1.

Several other design alternatives are available if Element 2 is retained, such as using rainbow trout as the only target species for monitoring, conducting studies to determine which fish species are consumed both by recreational and subsistence consumers, and redeploying monitoring stations to better conform to where these fish for consumption are caught. Greater emphasis also needs to be given to mercury contamination of fish tissue in both Element 1 and 2.

Emerging Trends in Bioaccumulative Toxic Contaminants

There was general agreement among reviewers that the current effort of:

- Archiving samples
- Conducting a workshop on emerging contaminants every 5 years
- Having the analysis contractor conduct a complete scan through an extended program year over the course of the 5 year contract, and
- Having the most contaminated composite of each species from the lower three Great Lakes examined for halogenated compounds

were useful approaches for staying abreast of emerging trends in bioaccumulative toxic compounds. It might also be useful to consider extended scans on composites from all five lakes, even those not considered the most contaminated. The issue with emerging trends is that we don't know what we don't know.

Quality Management Plan

Additional comments on the Quality Management Plan are included in the individual reviewers' comments.

Appendix E

Meeting Agenda

This page intentionally left blank.

Review Workshop for Great Lakes Fish Monitoring Program—Quality Management Plan and Historical Database

U.S. Environmental Protection Agency
Region 5
December 11-12, 2007

Agenda

TUESDAY, DECEMBER 11, 2007

Meeting Location: EPA, 3rd Floor, Room 330

8:30AM **Welcome, Introductions, Workshop Ground Rules** .... *Kate Schalk, ERG*

8:50AM **EPA Overview of Workshop Purpose and Goals**

- Peer Review Objectives and Technical Charge Presentation .... *Paul Horvatin, GLNPO Monitoring, Indicators, and Reporting Branch Chief, EPA*
- GLFMP Quality - Successes and Outstanding Issues .... *Louis Blume GLNPO Quality Manager, EPA*

9:05AM **Peer Review Comment Summary** .... *Kent Thornton, Workshop Chair FTN Associates, Ltd.*

9:25AM **Proposed Format for Discussion to Achieve Workshop Goals** .... *Kent Thornton*

9:30AM **Elaboration of Element 1** .... *Beth Murphy, EPA*

- Specific Objectives
  — Index of Lake
  — Lake Estimates

9:45AM **Discussion on Element 1 - DQO** .... *Reviewers*
- Target Population
- Indicator(s)
- Sampling Issues

10:30AM BREAK

10:50AM **Continued Discussion – Element 1** .... *Reviewers*

12:15PM LUNCH

1:30PM **Summary of Morning Discussion** .... *Kent Thornton*

1:35PM **Continued Discussion Element 1** .... *Reviewers*

Tuesday, December 11, 2007 (Continued)

3:00PM	**Elaboration of Element 2**	*Beth Murphy*
	▪ Specific Objectives — Index of Lake — Lake Estimates — Trends or Change	
3:15PM	BREAK	
3:30PM	**Discussion on Element 2** ▪ Target Population ▪ Indicator(s) ▪ Sampling Issues	*Reviewers*
4:45PM	**Wrap-Up of Day's Discussion, Action Items, Wednesday's Agenda**	*Kent Thornton*
5:00PM	ADJOURN	

WEDNESDAY, DECEMBER 12, 2007

Meeting Location: EPA, 12thFloor, Lake Erie Room

8:30AM	**Announcements**	*Kate Schalk*
8:45AM	**Observer Comments**	
9:00AM	**Additional Discussion Elements 1 and 2**	*Reviewers*
10:15AM	BREAK	
10:30AM	**Emerging Contaminants Discussion**	*Reviewers*
12:00PM	LUNCH	
1:15PM	**Additional Issues and Discussion**	*Reviewers*
3:00PM	BREAK	
3:15PM	**Summary of Workshop Discussion** Wrap-Up and Key Highlights	*Kent Thornton*
3:45PM	**Next Steps**	*Kate Schalk*
4:00PM	ADJOURN	

Appendix F

Presentation by Paul Horvatin, EPA

This page intentionally left blank.

Great Lakes Fish Monitoring Program Peer Review – *Objectives and Technical Charge*

Paul Horvatin – Great Lakes National Program Office

December 11, 2007

Goals of GLFMP

- Monitor temporal trends in bioaccumulative organic chemicals in the Great Lakes using top predator fish as biomonitors.
- Assess potential human exposure to organic contaminants found in sport fish.
- Provide information on new compounds of concern entering the lakes ecosystem.

Objectives of Peer Review

- Enhance the quality and validity of the GLFMP.
- Ensure the data generated under the program meet the needs of the stakeholders.
- Ensure any future decisions based on the program have a solid and credible scientific basis.

Peer Review Technical Charge

- How can GLNPO optimize the existing top predator **open lakes trend monitoring** program to look at contaminants in Great Lakes fish on a lake by lake basis for an assessment of ecological health?
- How can GLNPO optimize the existing **sport fish fillet monitoring** program to look at contaminants in Great Lakes fish on a lake by lake basis for an assessment of human health?
- In conjunction with the current monitoring program for fillets and whole fish, how can GLNPO use this program to look at emerging bioaccumulative toxic contaminants?

Technical Charge - *specifically consider and address*

- Are current sampling designs scientifically defensable?
  - Alternating sampling by lake
  - 2 sites per lake for whole fish
  - Varying sites per lake for sport fish
  - Are individual sites representative of a whole lake?
- Are current reporting standards scientifically feasible and sound, if not please help us determine appropriate reporting statements?
  - Element 1 - Detect a 5% decline in average PCB concentrations in whole fish from 1990 to the present for all 5 lakes.

Next Steps

- The final report and recommendations from the Peer Review will be reviewed and considered by GLNPO management.
- Based upon budgets, recommendations will be incorporated into the Great Lakes Fish Monitoring Program or recommended changes will be made.

Appendix G

Presentation by Louis Blume, EPA

This page intentionally left blank.

Great Lakes Fish Monitoring Program Quality Management System: Successes and Challenges

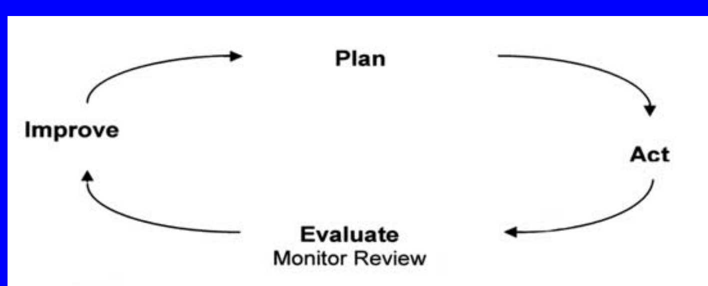
Louis Blume

GLNPO QA Manager

December 11, 2007

The Importance of Quality

- It is the policy of the Great Lakes National Program Office to ensure that collected information is of adequate quality for the intended use.



GLNPO's Quality Philosophy

"A true functional value-added quality system is not driven by approved documentation, but more so, by the activities implemented on a daily basis that enhance the quality of the environmental decision."

Great Lakes National Program Office's QMP: http://www.epa.gov/glnpo/qmp/index.html

GLFMP Quality Successes

- Approved SOPs for sample collection, shipping, homogenization, and analysis
- Program Review in 2005
- Draft QMP delivered to GLNPO Quality Manager in June of 2007 to document GLFMP history – *under review*
- New PI awarded in 2006 which has helped timeliness, reporting and sensitivity issues.

GLFMP Quality Successes (cont.)

- Audits of both homogenization and analytical labs
- Documentation of history of the program
- Performance evaluation study of current grantees analytical and reporting capability
- Round Robin Study with other GL Fish Laboratories

GLFMP Quality Issues

- Element 1 continues to operate on the historical design of the program and Element 2 was adopted from a voluntary program started by USFDA.
  - Can data from these programs be extrapolated to represent a whole lake or the basin?
- Do age versus length assumptions hold true in the present environmental condition and should new assumptions be made and incorporated into the GLFMP?

The Bottom Line

What is the primary use for GLFMP data and how can we implement a sampling design that achieves these goals?

- Element 1 - Monitor changes in contaminant trends in whole fish over time for ecological health
- Element 2 - Identify general statements or trends in contaminants in sport fish fillets for human health and help augment State and Tribal consumption advisories

Appendix H

Presentation on Element 1 by Elizabeth Murphy, EPA

This page intentionally left blank.

Great Lakes
Fish Monitoring Program
Element 1 Clarifying Statements

Great Lakes Fish Monitoring Program

The GLFMP consists of 2 parts:

Open Lake Trends Monitoring

- Monitor contaminant trends in the open waters of the Great Lakes (using fish as indicators)
- Top predator fish are great surrogates for ecosystem health by assessing wild life risk.
- Whole lake trout and walleye

Sport Fish Fillet Program

- Monitor potential human exposure to contaminants through consumption of popular sport species
- Salmon and rainbow trout skin on fillets

Open Water Trend Monitoring

- Predator fish are collected in the fall from alternating sites (one urban & one rural per lake).
- Lake Trout in Lake Superior, Michigan, Huron, and Ontario. Walleye in Lake Erie.
- Fish of similar size collected to reduce impact of size variation on data (Lake Trout 600-700 mm) or (Walleye 450-550 mm).
- Whole fish are analyzed, including parts not usually eaten by humans, such as liver and bones.
- 10 composite samples of five fish (50 fish).
- Detect 20% change in conc. within the 95% confidence interval between any 2 samplings.

Data

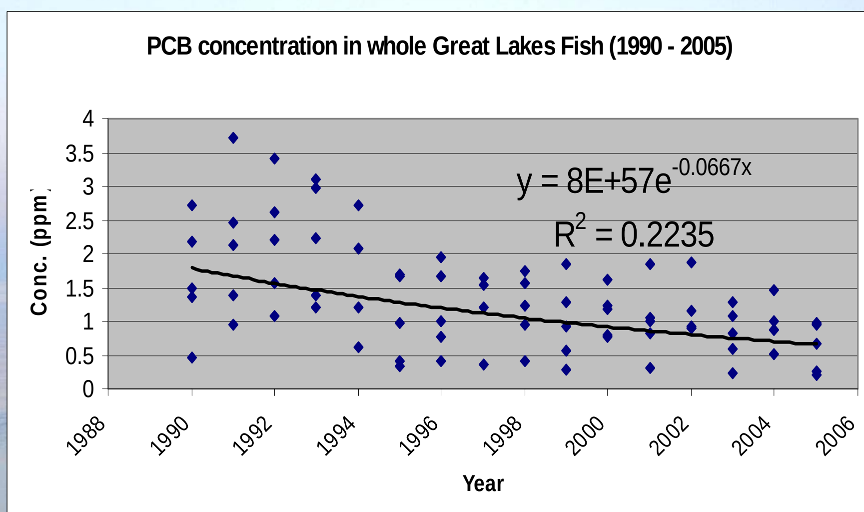
- GLFMP competitively competed in 2006
  - New grantee (Clarkson U)
  - PCDD/Fs added to routine analyte list
- Equipment problems continue to plague University of Minnesota.
  - Expect full 2001 – 2003 datasets in early 2008
  - Hg added to routine list in 1999
- New data expected in Jan. 2008

Great Lakes Fish Monitoring Program (GLFMP) Contaminant List

- PCB congeners
- PCB co-planers
- Hexachlorobenzene
- Octachlorostyrene
- Lindane
- Alpha BHC
- Dieldrin
- Heptachlor epoxide-b
- Cis-chlordane
- Trans- chlordane
- Oxychlordane
- Cis- nonachlor
- Trans- nonachlor
- pp, -DDT
- pp, -DDE
- pp, -DDD
- Endrin
- Mirex (Lake Ontario Only)
- Toxaphene& homologs
- PBDEs
- Hg
- Fraction Lipid
- PCDD/Fs
- ***PCNs***
- *APEs*
- *PPCPs*
- *BFRs*

Reporting

- Report annually on all 5 Great Lakes
  - Contaminant concentrations of routine analytes (SOLEC, LaMPs, BTS, etc.)
- GPRA (Government Performance & Results Act)
  - Budget is reporting dependant
  - 5% decline of Total PCB in whole fish from 1990 to most recent data point



PCB concentrations in Great Lakes whole fish have decreased 6.4% since 1990.

At the current rate of decline, the EPA's wildlife protection value goal of .16ppm will not be reached for X years.

GLFMP Future Goals

- Continue analyses/modeling time trends of organic contaminants in the GL
- Identify emerging contaminants of concern
  - Extended year of analysis in GLFMP in 2008
  - Historical screening of emerging contaminants in archived fish tissue and gull eggs using DSL and TSCA screening
- Use data in wildlife health risk assessments
- Routine GLNPO summary report on program, changes, data, and general trends

Closing Thoughts

- The GLFMP is a "Big Picture" program
- Recommendations for the future from Peer Reviews need to consider the 30 years of data collected to date
- We live in a budget and resource limited world
- Reporting is currently linked to DQO
  - Changes to both may be warrented

Thank you

&

Questions

Appendix I

Presentation on Element 2 by Elizabeth Murphy, EPA

This page intentionally left blank.

Great Lakes
Fish Monitoring Program
Element 2 Clarifying Statements

Game Fish Fillet Monitoring

- Coho salmon and chinook salmon are collected in the fall when they return to spawn (Small, Medium, and Large)
- Skin-on fillets
- Three composite samples of five fish (15 fish) per site
  - Sites per lake range from approx. 2 - 8
- Program originally created by FDA and taken on by GLNPO in 1980’s as Volunteer program. Permanent in 2003.

Reporting

- Report annually on all 5 Great Lakes
  - Contaminant concentrations of routine analytes (SOLEC, LaMPs, BTS, etc.)
- Great Lakes Index Reporting Narrative
  - Rating 1 – 5 based on Uniform Protocol for Consumption Advice for PCBs
  - Each Lake is assigned a score based on the rating guidelines. The average for all five Great Lakes will serve as the fish contamination score.
  - 5: Unlimited consumption (.05 ppm or less)
  - 4: One meal per week (Between .05 and .2 ppm)
  - 3: One meal per month (Between .2 and 1 ppm)
  - 2: One meal every two months (Between 1 ppm and 1.9 ppm)
  - 1: No consumption (greater than 1.9 ppm)

Future Goals

- Identify emerging contaminants of concern
  - Extended year of analysis in GLFMP in 2008
  - Historical screening of emerging contaminants in archived fish tissue and gull eggs using DSL and TSCA screening
- Routine GLNPO summary report on program, changes, data, and general trends

Closing Thoughts

- Program adopted from expiring FDA program
  - EPA QA requirements never imposed on E2
- States and Tribes identified E2 as a potential source for emerging contaminant information to augment their existing advisories at Program Review in 2005
- A "Big Picture" Program
- We live in a budget and resource limited world
- No existing DQO, but program is routinely asked to make general trend statements.

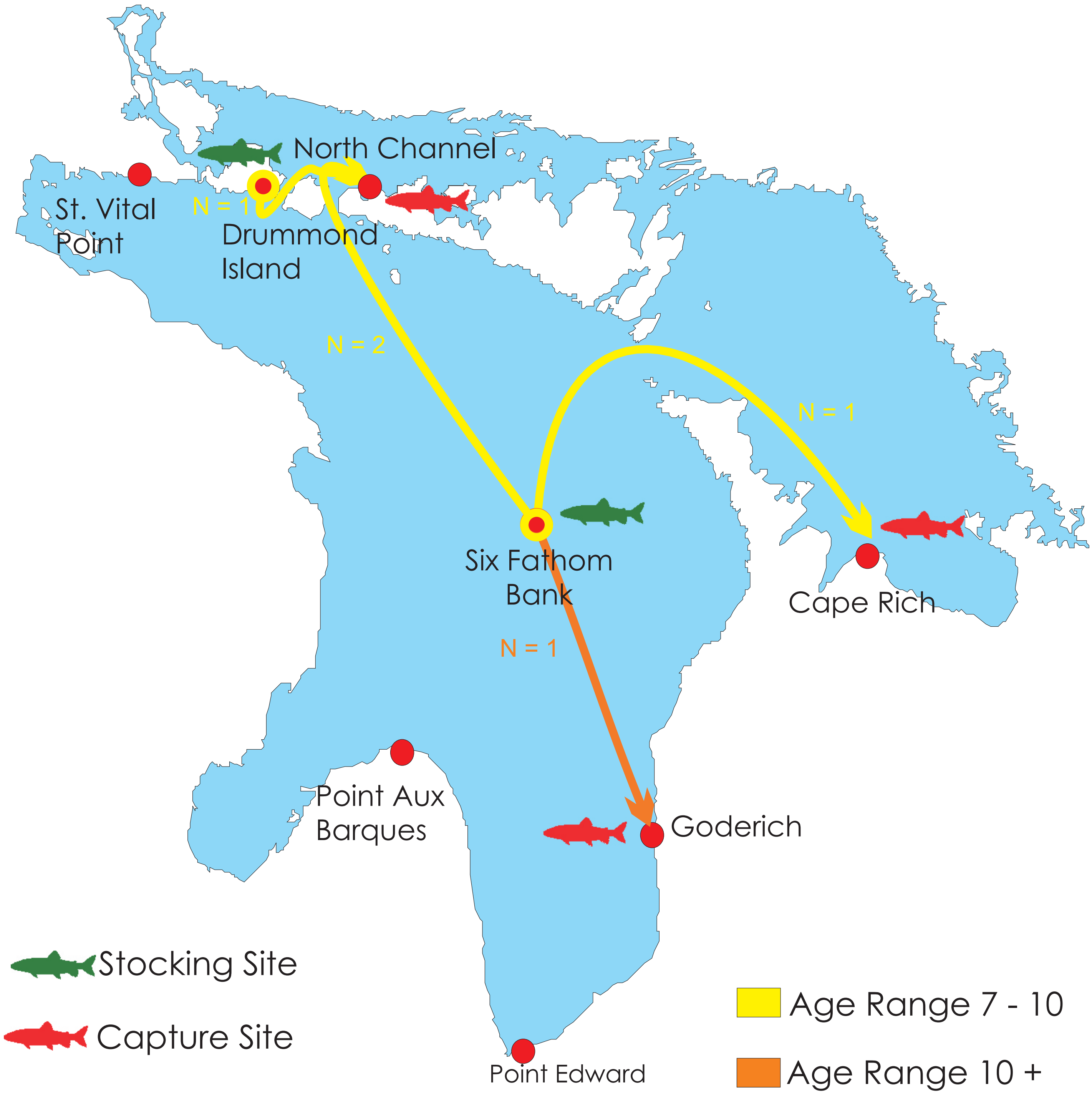
Thank you
&
Questions

Appendix J

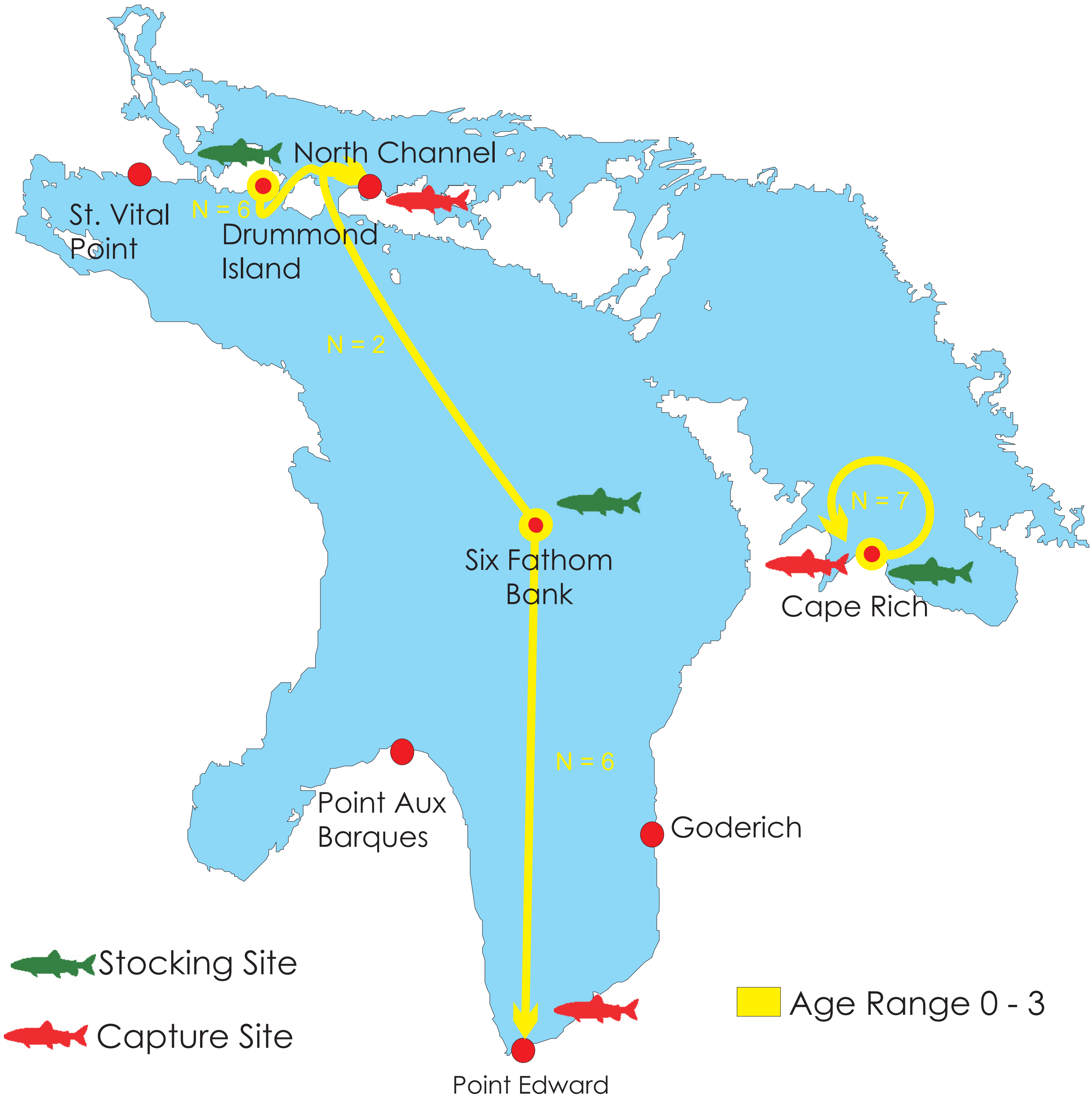
Lake Trout Migration Patterns

This page intentionally left blank.

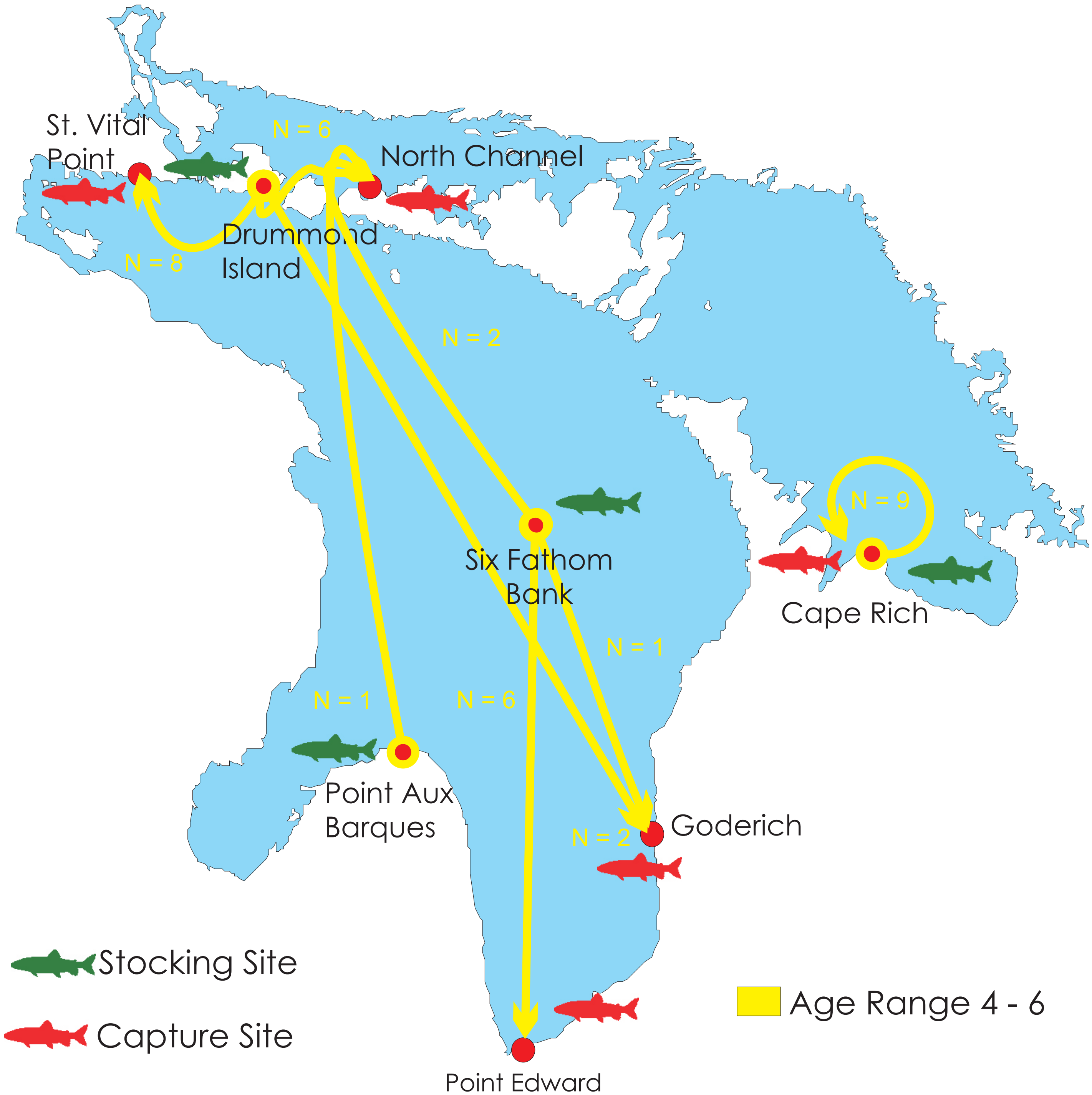
Extremes of Lake Huron Lake Trout Migration Patterns By Age



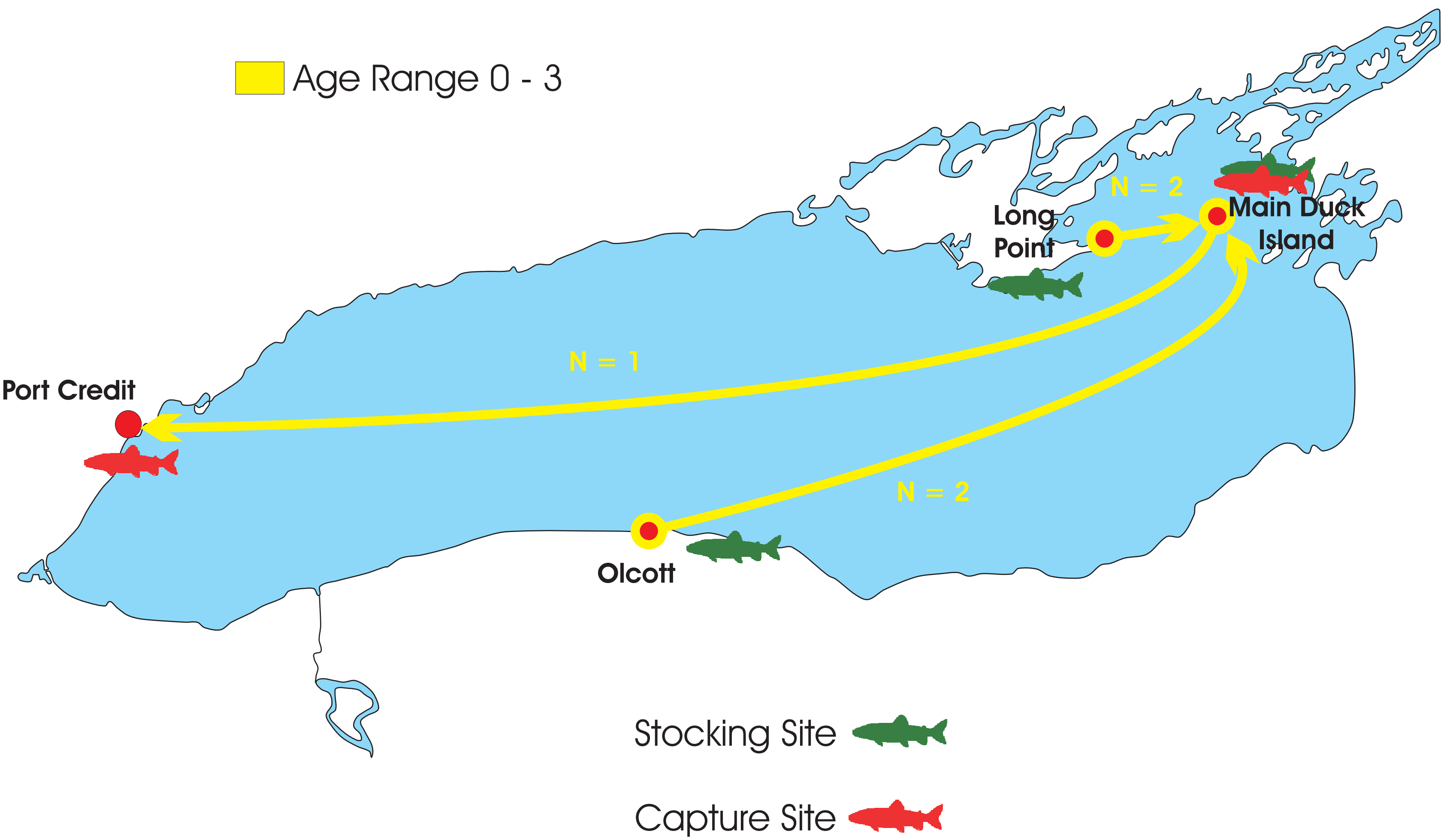
Extremes of Lake Huron Lake Trout Migration Patterns By Age



Extremes of Lake Huron Lake Trout Migration Patterns By Age

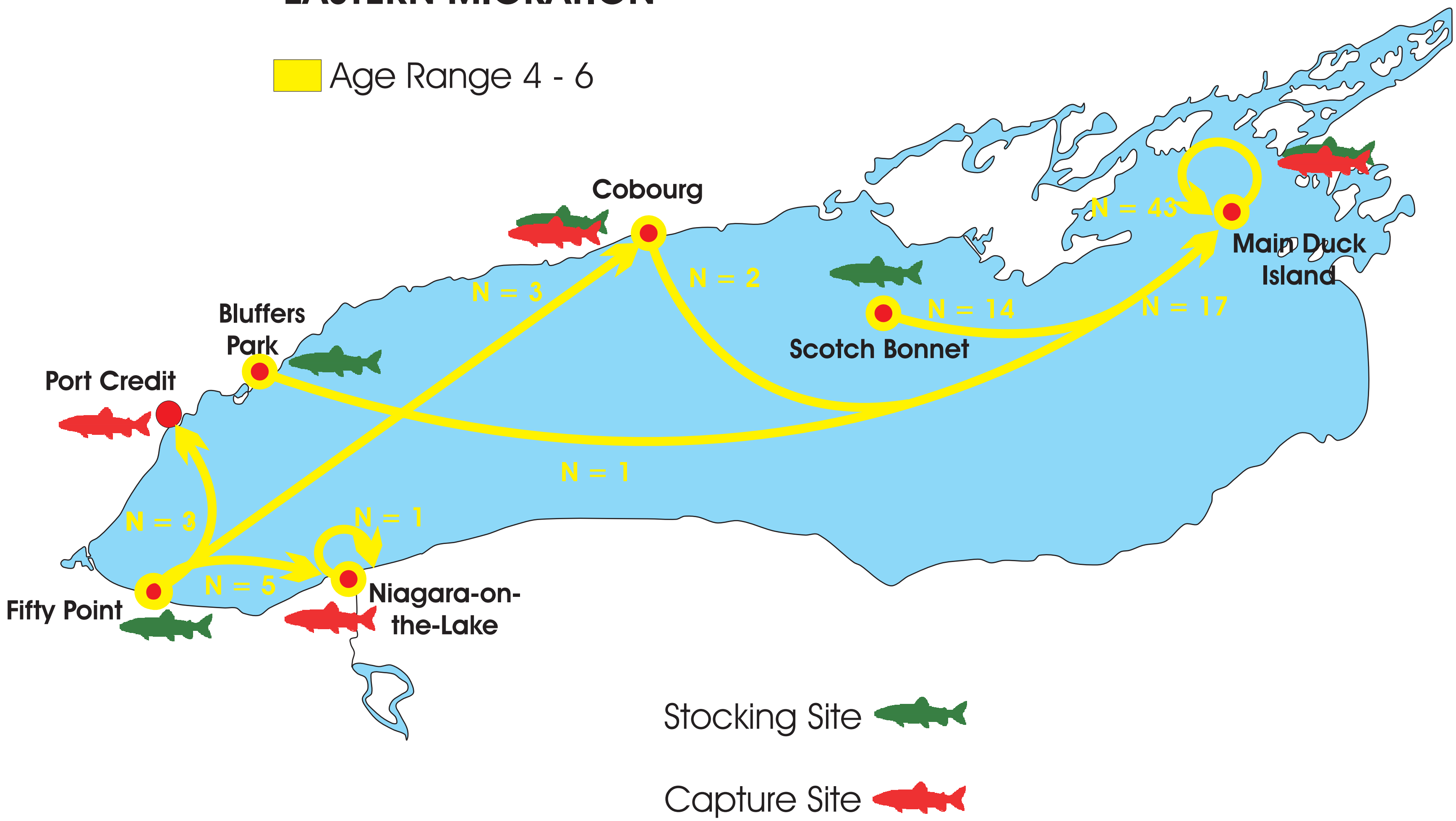


Extremes of Lake Ontario Lake Trout Migration Patterns By Age

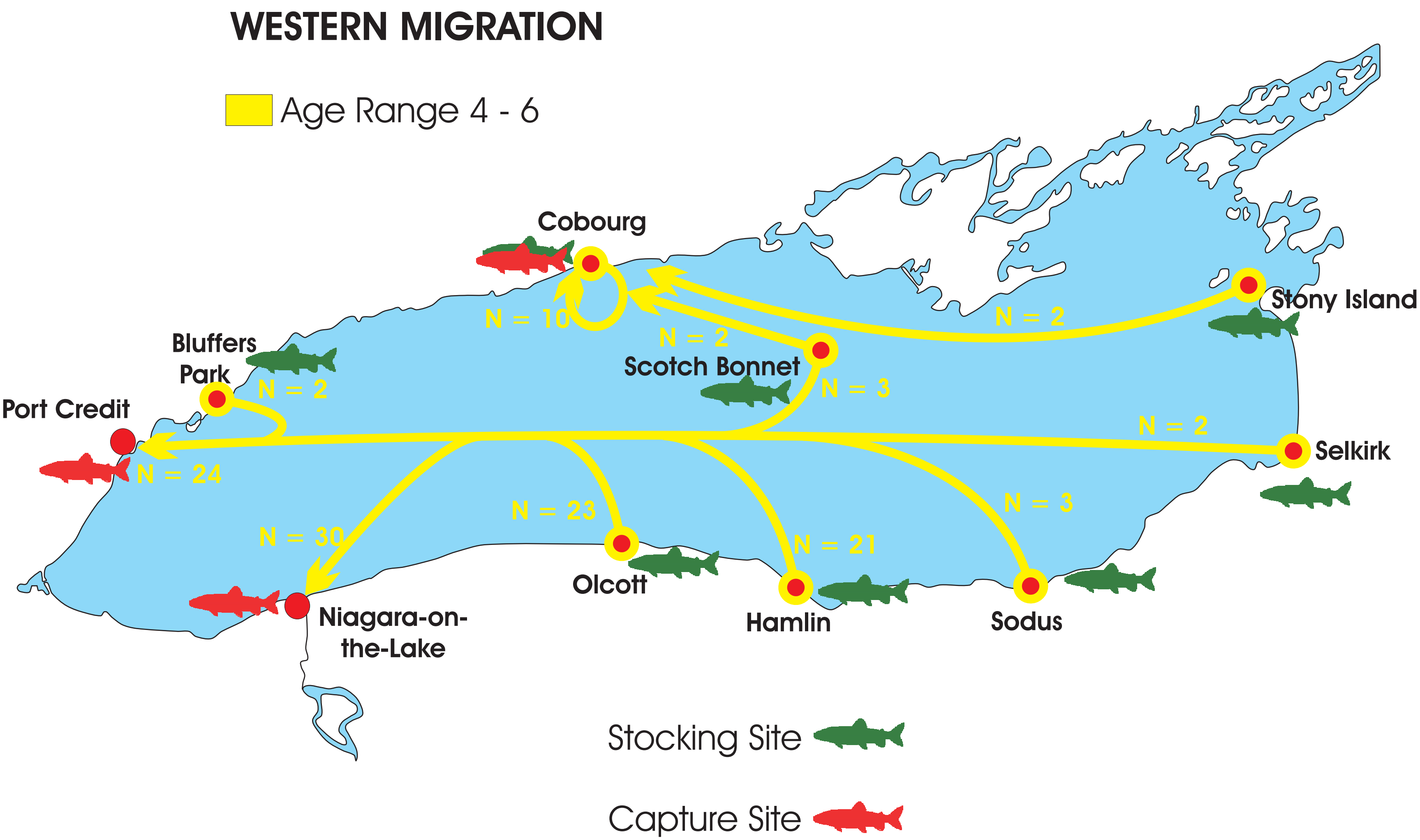


Extremes of Lake Ontario Lake Trout Migration Patterns By Age

EASTERN MIGRATION

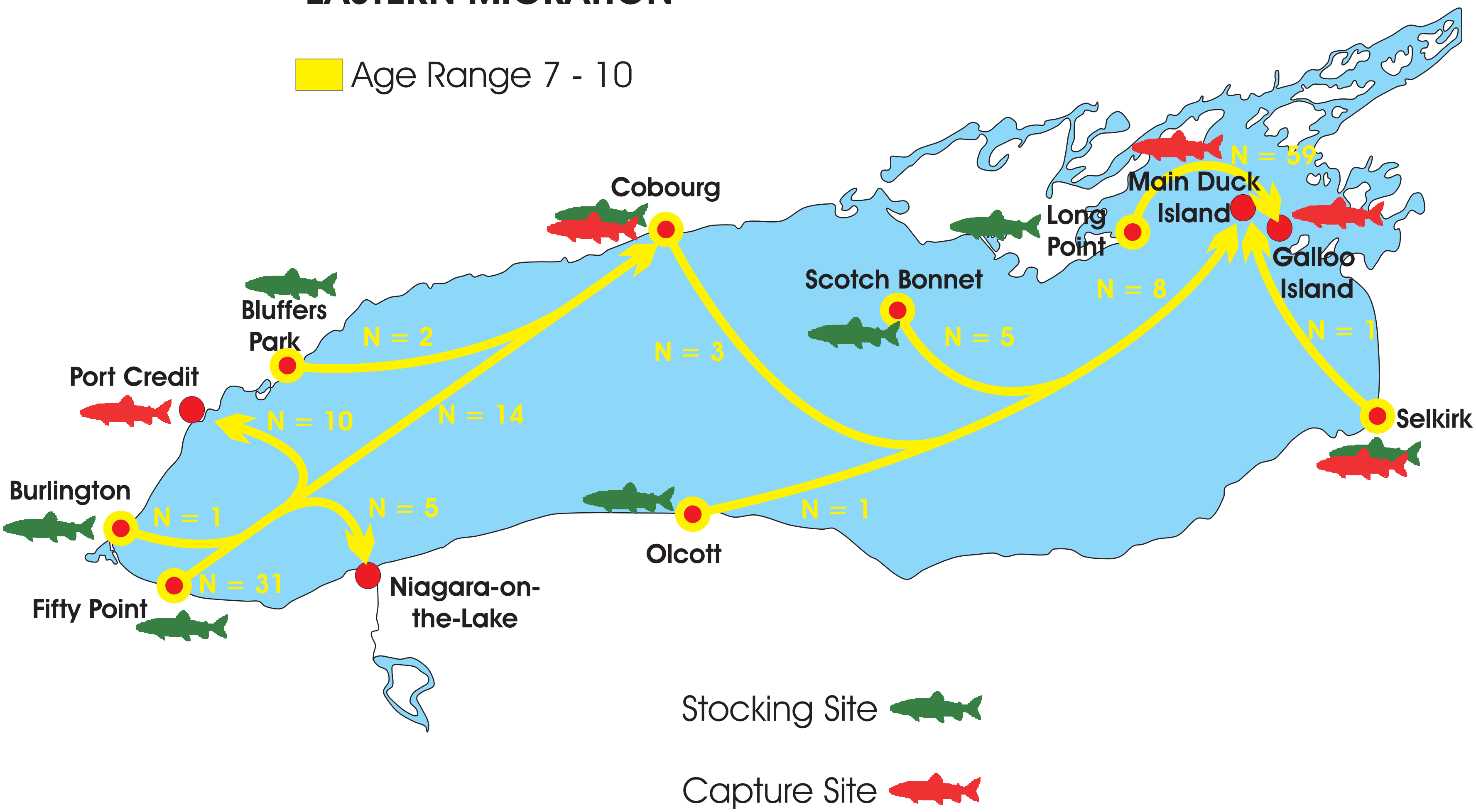


Extremes of Lake Ontario Lake Trout Migration Patterns By Age



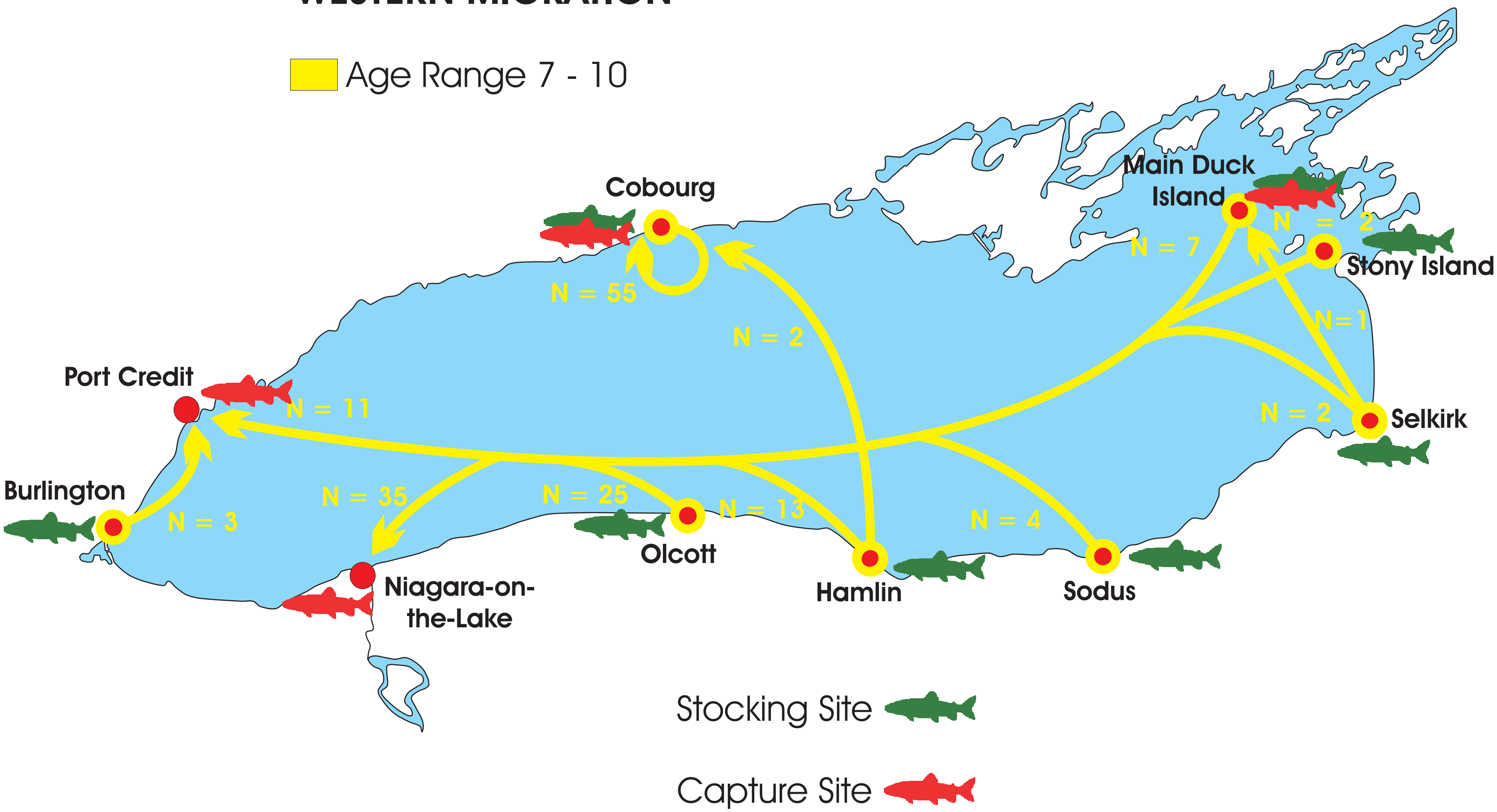
Extremes of Lake Ontario Lake Trout Migration Patterns By Age

EASTERN MIGRATION



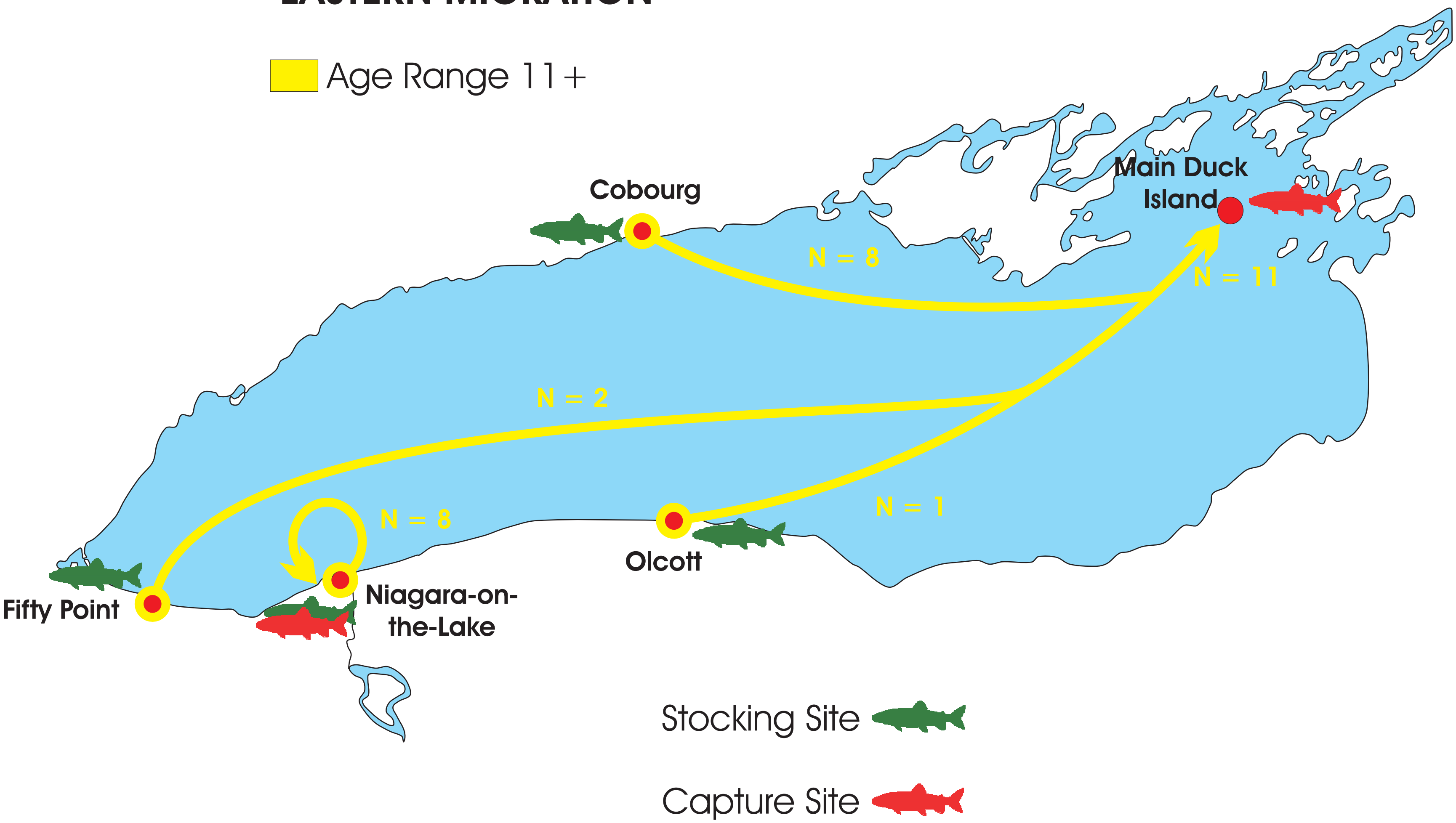
Extremes of Lake Ontario Lake Trout Migration Patterns By Age

WESTERN MIGRATION



Extremes of Lake Ontario Lake Trout Migration Patterns By Age

EASTERN MIGRATION



Extremes of Lake Ontario Lake Trout Migration Patterns By Age

WESTERN MIGRATION