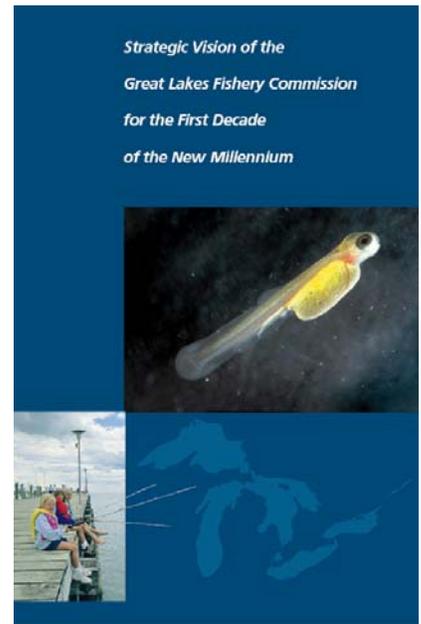


**A MID-DECADE REVIEW OF PROGRESS
UNDER A “*STRATEGIC VISION OF THE
GREAT LAKES FISHERY COMMISSION
FOR THE FIRST DECADE OF THE
NEW MILLENNIUM*”**



Great Lakes Fishery Commission

Miscellaneous Publication 2006-01

The Great Lakes Fishery Commission was established by the Convention on Great Lakes Fisheries between Canada and the United States, which was ratified on October 11, 1955. It was organized in April 1956 and assumed its duties as set forth in the Convention on July 1, 1956. The Commission has two major responsibilities: first, develop coordinated programs of research in the Great Lakes, and, on the basis of the findings, recommend measures which will permit the maximum sustained productivity of stocks of fish of common concern; second, formulate and implement a program to eradicate or minimize sea lamprey populations in the Great Lakes.

The Commission is also required to publish or authorize the publication of scientific or other information obtained in the performance of its duties. In fulfillment of this requirement the Commission publishes the Technical Report Series, intended for peer-reviewed scientific literature; Special Publications, designed primarily for dissemination of reports produced by working committees of the Commission; and other (non-serial) publications. Technical Reports are most suitable for either interdisciplinary review and synthesis papers of general interest to Great Lakes fisheries researchers, managers, and administrators, or more narrowly focused material with special relevance to a single but important aspect of the Commission's program. Special Publications, being working documents, may evolve with the findings of and charges to a particular committee. Both publications follow the style of the *Canadian Journal of Fisheries and Aquatic Sciences*. Sponsorship of Technical Reports or Special Publications does not necessarily imply that the findings or conclusions contained therein are endorsed by the Commission.

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March 2006

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TABLE OF CONTENTS

Introduction	1
Vision Statement on Healthy Ecosystems.....	3
Milestone 1. Conserve native biodiversity.....	3
Milestone 2. Prevent invasion of non-native fishes	7
Milestone 3. Increase natural recruitment.....	9
Milestone 4. Improve habitat	13
Milestone 5. Gain new information	17
Vision Statement on Integrated Management of Sea Lamprey.....	21
Milestone 1. Achieve economic injury levels.....	21
Milestone 2. Control the St. Marys River.....	27
Milestone 3. Use alternative control technologies	29
Milestone 4. Estimate recruitment	33
Vision Statement on Institutional/Stakeholder Partnerships	35
Milestone 1. Encourage coordinated fish-management programs.....	35
Milestone 2. Establish and promote research priorities	37
Milestone 3. Communicate with environmental management agencies.....	39
Milestone 4. Strengthen stakeholder and Advisor relationships.....	41
Milestone 5. Increase partnership funding.....	43
Appendix.....	45

INTRODUCTION

This report assesses the progress made by the Commission in achieving its current Strategic Vision [<http://www.glf.org/pubs/SpecialPubs/StrategicVision2001.pdf>]. Like its predecessor for the decade of the 1990s, the current Strategic Vision calls for a mid-decade review, in this case by June 15, 2005. In compliance with this stricture, commissioners and staff held workshops in June and September 2005. This workshop resulted also in modifications to Milestones 4 and 5 of the Vision Statement on Healthy Ecosystems. These revisions, documented in the Appendix, reflect the nature of milestones, intended at the time of their conception to be ambitious and challenging, i.e., visionary. A need for revision is consistent with an operating concept of aiming high as opposed to setting decadal objectives that, at the time of adoption, are palpably doable. A milestone may also be modified at such time that it becomes clear that it is no longer relevant and an alternative approach is needed. In keeping with this idea, Milestone 5 within the Vision Statement on Healthy Ecosystems was deleted in 2003, before this five-year assessment was made (see Appendix).

This report follows the order of vision statements and milestones in the Strategic Vision. The exposition for each milestone comprises sections on performance, status, progress, and discussion. The status section provides an appraisal, by commissioners, indicating how much has been accomplished in relation to expectations at the time a milestone was adopted. A three-tier rating system was employed: above expectations, meets expectations, below expectations. Expectations now may differ from those at the time a milestone was adopted, especially for those milestones known to be particularly challenging at the time of adoption. The reasons perceptions were altered after five years are addressed in ensuing discussion sections. Much of the material supporting individual accomplishments is available online under Reports and Publications [http://www.glf.org/pubs_out/communi.php]. A final assessment of progress can be expected in 2011. The Commission encourages its partners to examine closely what has been accomplished and what remains yet to be done within the second half of this decade.

Vision Statement on Healthy Ecosystems

The Commission shall encourage the rehabilitation and conservation of healthy aquatic ecosystems in the Great Lakes that provide sustainable benefits to society, contain predominately self-regulating fish communities, and support fisheries with increasing contributions of naturally reproducing fish. Conserving biological diversity through rehabilitation of native fish populations, species, communities, and their habitats has a high priority.

Milestone: 1. Conserve native biodiversity

- *Native fish species will not be lost from any Great Lake.*

Status: No fish species has disappeared, but the American eel is imperiled.

Performance: Above expectations. The Commission is likely over extended on this demanding issue, but the need is so great that the commitment is continuing.

Progress: Since 2000, no species of native fish has been reported as lost from any Great Lake. Of extant native species, the American eel is most threatened with being lost from the Great Lakes.

To prevent the loss of American eel in the Great Lakes, the following actions have been taken:

- White paper, “The Decline of American eel (*Anguilla rostrata*) in the Lake Ontario/St. Lawrence River Ecosystem: A Modeling Approach to Identification of Data Gaps and Research Priorities,” funded (June 2000).
- Co-sponsored (through participation and financing) International American Eel Symposium held at the American Fisheries Society annual meeting in Quebec City (August 2003).
- Provided \$23,300 to publish proceedings of the International American Eel Symposium, scheduled for release in 2007.
- Provided \$2,500 for and staff participated in “Technical Workshop Aimed at Investigating Methods for Providing Safe Downstream Passage for the American eel (*Anguilla rostrata*) past Hydroelectric Facilities on the St. Lawrence River” (February 2005).
- Update on the status of American eel provided to the Law Enforcement Committee in September 2004.
- Chair and staff attended the Atlantic States Marine Fisheries Commission meeting (2004).
- Contributed to the publication in *Fisheries* of “The Quebec Declaration of Concern,” a letter on the worldwide decline of anguillid eels (December 2003).
- Staff participated on the Plan Development Team that drafted a public information document through the Atlantic States Marine Fisheries Commission.
- Staff aided Tom Clarke in his Science Update to Nature: World’s Eels on a Slippery Slope (September 2003), www.nature.com.
- Provided administrative assistance to the Ontario Ministry of Natural Resources to facilitate buy-out payments for the American eel commercial fishery.
- Contributed to profiling concerns in an ICES Newsletter, Science magazine, and National Geographic, December 2003.
- “Emergency Declaration on American Eels,” released in December 2003, committed the Commission to a facilitator role among jurisdictions involved in restoration of the eel population.

Discussion: Preventing the loss of American eel from the Great Lakes is complicated by the lack of consensus about what needs to be done and who is primarily responsible. The vast majority of the species’ range is not within the Convention Area. The Commission’s role has been to maintain visibility, provide focus, and achieve international traction.

- ***Rehabilitation plans will be formulated for extirpated deepwater fishes by 2004.***

Status: Two plans, one for deepwater lake trout and the other for deepwater ciscoes, have been formulated.

Performance: Meets expectations. Considerable staff time has been allocated to the revision of the rehabilitation plan for lake trout in Lake Michigan, which calls for reintroduction of deepwater lake trout. Several research projects relevant to bloater and deepwater sculpin reintroductions have been initiated.

Progress: Within the Fishery Research Program's "Reintroduction of Native Great Lakes Fishes to the Great Lakes Proper" theme area, the following actions were taken:

- A white paper that described the rationale for the theme, reviewed the relevant literature, and listed pertinent research questions and hypotheses was developed by staff and is available online (April 2003).
- Five research projects have been funded as follows:
 - Status and Assessment, Research, and Restoration Needs for Lake Herring in the Great Lakes.
 - Morphological Diversity of Lake Trout: Differentiation between Deep and Shallow Forms.
 - Identification of a Genetically Diverse and Compatible Source of Bloater (*Coregonus hoyi*) for Reintroduction in Lake Ontario.
 - Comparative Genetic and Phenotypic Analysis of Lake Trout Morphotypes in Representative North American Lakes: Great Bear Lake, Great Slave Lake, Lake Nipigon, and Lake Superior
 - Conservation Genetics of Deepwater Sculpin in the Great Lakes.
- Two research coordination workshops were held (June 2002 and June 2004).

Because each lake already had a plan for rehabilitating the lean form of lake trout before the Strategic Vision was revised, efforts since then have gone into updating plans and expanding them to include deep-water forms of lake trout as follows:

Lake Michigan:

- An analysis of impediments to lake trout rehabilitation was completed and is available online (September 2003).
- Reintroduction of deep-water morphotypes is included in a new draft plan, which is being considered for adoption by the lake committee (May 2005).

Lake Erie:

- The plan was revised on an ad hoc basis to include reintroduction of deepwater lake trout. The goal is to stock 80,000 Klondike-strain lake trout each year beginning in 2006.
- The stocking of Klondikes was advanced to 2004 and amounted to 31,600 fish. Another 62,000 are scheduled for release in 2005.
- The Council of Lake Committees and the USFWS continue to work towards achievement of Allegheny National Fish Hatchery's production goals for lake trout, including deep-water lake trout, designated for Lake Erie.

The following actions have been taken to develop rehabilitation plans for ciscoes:

- A strategy for reintroducing the bloater into Lake Ontario, titled "Discussion Paper – Native Prey Fish Re-Introduction into Lake Ontario – Bloater (*Coregonus hoyi*)," was accepted in March 1999 by the Lake Ontario Technical Committee, which subsequently (in March 2001) charged a subcommittee to produce the requisite plan.

- A working plan for reintroduction of the bloater into Lake Ontario was partially implemented in 2002; the Commission funded also a search for a proper donor population and worked on resolving disease issues.
- Research to identify the best donor population(s) for reintroducing bloater into Lake Ontario was funded (December 2003).

The following actions have been taken to develop rehabilitation plans for deepwater sculpin:

- Funded research project on the conservation genetics of deepwater sculpin, aimed at identifying a suitable donor population for its reintroduction into Lake Ontario (December 2004).

Discussion: The milestone on reintroduction has had its desired effect. The spate of activities listed above represents a marked increase in activity, as compared to before 2000. Getting these efforts underway is painstaking, but progress should accelerate across lakes once these first efforts bear fruit.

The milestone is somewhat ambiguous as to whether the intent was to have plans for all possible reintroductions of extirpated deepwater fishes or plans for some. The former interpretation, all possibilities, is too ambitious considering that twelve opportunities exist for reintroduction of extant deepwater fishes. Insomuch as refocusing management planning among fishery management agencies is laborious, progress towards achievement should be considered good.

- ***Rehabilitation of lake trout will be achieved throughout Lake Superior and in Lake Huron's Georgian Bay, and naturally reproduced juvenile lake trout will increase in abundance elsewhere in the Great Lakes.***

Status: Not achieved but progress is being made. Approximately 90% of Lake Superior is considered restored. Achievement varies elsewhere from no wild juveniles (Erie and Michigan) to a consistent appearance of juveniles (lakes Ontario and Huron).

Performance: Meets expectations. The Commission has promoted the mass marking of lake trout to better assess progress toward rehabilitation. However, increases in sea lamprey predation on lake trout in Lake Michigan could slow progress toward restoration.

Progress: Rehabilitation of lake trout populations in Lake Superior has been largely accomplished. In Georgian Bay, rehabilitation is off to a good start, but management (harvest) conflicts between the Ontario Ministry of Natural Resources and First Nations could lead to a setback. Elsewhere in the Great Lakes, the abundance of naturally reproduced lake trout varies from nil (lakes Michigan and Erie) to low (Lake Ontario) to sharply up (Lake Huron's Main Basin). Lake-by-lake progress is as follows:

Lake Superior:

- All four rehabilitation criteria have been met over approximately 90% of the lake, which has led to a cessation of stocking in these waters.
- Since 2000, the percentage of unclipped (wild) lake trout in Minnesota waters, where progress had been slow, increased from 30-40% to 65-75%.

Lake Huron:

Main Basin-

- The capture of young-of-year trout in assessment trawls jumped from a total of only two in the preceding 10 years to 20 in 2004.

Georgian Bay-

- Owen Sound has become a center for recruitment of wild fish, which comprise 50% or more of the assessment catch of adults. Parry Sound, rehabilitated earlier (before 2000), continues to support a self-sustaining population.

Lake Michigan:

- Spawning aggregations were detected acoustically over the mid-lake (southern) reef complex. Fry were recovered in the same areas over two consecutive years. Yearling and older wild fish were virtually absent in assessment nets.

Lake Erie:

- Putative wild trout recovered occasionally, but the population is essentially of hatchery origin.

Lake Ontario:

- For the twelfth consecutive year, wild yearling lake trout were taken in trawls, but their numbers remain low and no increase is apparent.

Discussion: Lake Huron, especially its Main Basin, is the center of attention now with respect to the prospects for rehabilitation there, and elsewhere. If young wild trout continue to appear in annual assessments, as they did in 2004, and the apparent collapse of the alewife population continues, the lesson learned will be that alewives, even at low levels of abundance, were the key impediment, all along, to rehabilitation in Lake Huron and, by extension, in lakes Michigan and Ontario. Assessment of natural reproduction depends primarily on trawling for age-1 and older lake trout that are not marked as having originated in hatcheries. Assessment will improve if all lake trout stocked in the Great Lakes receive a coded-wire tag and a fin clip. The mass marking program proposed by the Council of Lake Committees, and promoted by staff, would accomplish this approach.

Milestone 2. Prevent invasion of non-native fishes

- *No new non-native fishes will be unintentionally introduced in the Great Lakes.*

Status: No non-native fishes have become established in the Great Lakes since 2001. Threats continue, notably from Asian carp and snakeheads. Few laws have been enacted to slow the flow of new species.

Performance: Above expectations. Nevertheless, much remains to be done to “shut the door” on invasive species. New laws need to be enacted in both countries. The problem is enormous, but ratcheting the effort up even more is beyond existing staff capabilities, without new staff or reordering commitments.

Progress: No introductions of fish have been reported since 2000. Immediate threats, however, are Asian carp and snakehead. As long as ocean-going ships enter the lakes and until the Chicago-area connection with the Mississippi drainage is securely blocked, the Great Lakes have the vulnerabilities associated with an open system. Moreover, the live-market and aquarium trade continue to be big, uncontrolled potential vectors for introductions of fish and other organisms. Case-by-case responses to some invasive species (e.g., Asian carp, snakehead) have been made, but comprehensive legislation in Canada and the U. S. has not been enacted.

The following actions were taken since 2000 to prevent unintentional introductions of fishes:

- Secured \$150,000 from the Department of State to increase effectiveness of the first Asian carp barrier in the Chicago Sanitary and Ship Canal.
- Funded and participated in the development of a monitoring and rapid-response plan, should any Asian carp approach the first barrier.
- Facilitated the acquisition of federal funds for and worked with the state of Illinois on the construction of the second Asian carp barrier.
- Cosponsored the feasibility study “Long Term Solutions for Preventing the Transfer of Aquatic Species between the Great Lakes and Mississippi River Basins.”
- Worked with the Great Lakes Law Enforcement Committee and the Council of Lake Committees to develop and promulgate regulations to prohibit the possession, sale, and transport of live Asian carp and snakeheads in the basin.
- Funded the Environmental Law and Policy Institute to identify gaps in federal and state regulations regarding inhibiting potential invasions and to propose a framework for future regulations.
- Co-chaired the Aquatic Invasive Species Strategy Team for the Great Lakes Regional Collaboration, established by Executive Order 13340.
- Funded research to predict the identity, spread, and impact of future nonindigenous species (June 2000).
- Worked with Congress and non-government organizations to support the passage of the National Aquatic Invasive Species Act.
- Published a brochure and timeline with the International Joint Commission entitled *Then and Now: Aquatic Alien Invasive Species and the Great Lakes-St. Lawrence Ecosystem*. This document reviewed the progress of governments since the joint publication of 1990 by the two organizations.

Discussion: Considerable effort has been allocated to achieving this milestone and some progress has been made. Federal laws in the U. S. and Canada have not changed substantially since 2000. Therefore, the goal of not having a new introduction of a fish remains elusive because the system remains vulnerable because of its connections to the Atlantic Ocean and Mississippi River watershed and because of transportation of fish and other organisms in the hobby and live fish trades.

Milestone 3. Increase natural recruitment

- ***Natural reproduction will contribute a minimum of 50% of adult trout and salmon available for harvest from each lake.***

Status: Achieved for all salmonid species in Lake Superior except brook trout, and achieved for Chinook salmon in lakes Michigan and Huron. Natural reproduction of steelhead ranges from 0-90% in the other four lakes. The status of achievement is unknown for other species of salmon and trout elsewhere in the Great Lakes. The lack of inexpensive ways to determine whether a fish is of wild or hatchery origin prevents further assessment of progress on this milestone.

Performance: Meets expectations. The Commission's sea lamprey control program has been effective in allowing survival of adult trout and salmon to reproductive age. A major staff effort is focused on improving assessment via mass marking.

Progress: The percentage of naturally reproduced adult trout and salmon available for harvest has increased since 2000. Lake trout will not be reported here because its status is reported above under Milestone 1. Progress for the other species is as follows:

Lake Superior:

- Chinook salmon:
 - The proportion of wild fish in the population exceeded 75% in 1999.
 - Because most populations are largely self-sustaining, agencies are reevaluating their stocking programs.
- Coho salmon:
 - The final stocking occurred in 1996, and the population is now all of wild origin.
- Brown trout:
 - The proportion of wild fish in the population varied from 50-60% in 1994.
- Steelhead:
 - Naturally reproduced fish constitute the vast majority (more than 98%) of steelhead in the creel.
- Brook trout:
 - As many as six river populations and one lake-spawning population are sustained by natural reproduction.
 - Stocking is occurring in a number of streams to boost resident populations.
 - A rehabilitation plan was published by the Commission (May 2003).
 - Symposia were sponsored at the 2003 and 2004 annual meetings of the American Fisheries Society.

Lake Huron:

- Chinook salmon:
 - A six-year study of natural reproduction began in 2000.
 - The proportion of wild fish in the lake-wide population exceeded 80% in 2004.
 - Development of a management plan has been recommended by the Lake Huron Technical Committee (March 2005).
 - The Lake Huron Technical Committee identified the need for a less-costly method for marking stocked Chinook salmon.
- Coho salmon:
 - A small population is maintained almost exclusively by stocking.
- Brown trout:
 - The population is maintained largely by stocking.
- Steelhead:
 - The proportion of wild fish in the population in U.S. waters is approximately 40%.

- In Canadian waters over the past ten years, the proportion of naturally reproduced fish in the population averaged 73%. A recent survey of six rivers suggests that from 65 to 100 % of returning fish were of wild origin.

Lake Michigan:

- Chinook salmon:
 - Naturally reproduced fish comprised approximately 50% of the lake-wide population in 2005.
 - Development of a management plan was recommended by the Lake Michigan Technical Committee (March 2005).
- Coho salmon:
 - The most recent assessment of natural reproduction occurred in 1979, when wild fish comprised 9% of the population.
- Brown trout:
 - The contribution of wild fish to the lake-wide population has not been estimated.
- Steelhead:
 - Currently, wild fish comprise 10-35% of the lake-wide population in a given year.

Lake Erie:

- Chinook salmon:
 - The last stocking occurred in 1997, and now the population is all wild but small.
- Coho salmon:
 - The last stocking occurred in 2003 and natural reproduction is insignificant.
- Brown trout:
 - No natural reproduction is known to occur.
- Steelhead:
 - Naturally reproduced fish comprise up to 25% of returning adults in New York's tributaries and are abundant in high-quality streams on both sides of the lake.
 - Lake-wide estimates of natural reproduction are not available.

Lake Ontario:

- Chinook salmon:
 - The proportion of naturally reproduced fish in recent years varies from 25 to 52% in Ontario's waters, but whether this number is trending upwards is unknown.
 - A dramatic increase in production of wild smolts has occurred recently in New York's Salmon River, but the percentage of wild fish in their open-water fishery is not known.
- Coho salmon:
 - Natural reproduction is insignificant.
- Brown trout:
 - All of the catch is thought to have been stocked.
- Steelhead:
 - Natural reproduction in tributaries in Ontario's waters of Lake Ontario ranged from 25-33% during 1985-1995. More recent estimates of the level of natural reproduction are not available.
 - No estimates of the amount of natural reproduction in New York's tributaries have been made nor are lake-wide estimates available.

The following research projects/events that increase capabilities to assess the proportion of wild trout and salmon in the catch have been supported:

- Research project—Natural lake trout strain identification in Lake Huron (June 2002).
- Research project—Exploration of the existence of natural reproduction in Lake Erie lake trout, using otolith microchemistry (December 2002).

- A basin-wide demonstration of an automated mass-marking technology to assess natural reproduction of salmon and lake trout, requested by the Council of Lake Committees (CLC), was coordinated and funded (July 2004).
- A white paper titled, “Recommendations for mass marking hatchery-reared trout and salmon stocked into the Great Lakes Basin” was presented to the CLC by the Mass Marking Task Group. The use of the automated mass-marking technology for assessing natural reproduction of salmon and trout was endorsed by the CLC. A task group to secure funding for and implementation of the automated technology was formed by the CLC (March 2005).

Discussion: The status of achievement of this milestone is summarized in the following table.

Summary of progress towards meeting Milestone 3					
	Chinook salmon	Coho salmon	Brown trout	Steelhead	Brook trout
Superior	+	+	+	+	-
Huron	+	-	-	+/-	
Michigan	+	?	?	-	
Erie			-	-	
Ontario	?	?	?	?	
+ Objective achieved: population more than 50% wild. - Objective not achieved: population less than 50% wild (lakewide assessments may not exist). ? Assessment information not available. +/- Natural reproduction highly variable by location: unclear whether or not objective has been achieved lakewide. Species does not constitute a significant portion of the fishery.					

The largest barrier to evaluating progress on this milestone is the lack on information about the abundance of naturally reproduced fish in the Great Lakes. The need for a coordinated approach to ensure continued tracking of changes in the level of natural reproduction was identified by the Lake Huron and Lake Michigan Committees. To assess progress toward achieving this milestone, coordinated lake-wide marking assessments must be conducted. Without lake-wide assessments, changes in the amount of natural reproduction over the next five years will not be detected, and it will be impossible to determine whether the milestone has been achieved or whether stocking programs are beneficial.

Actions that either the Commission or natural resources agencies may take to achieve this milestone are limited ultimately by the amount of suitable stream habitats for salmonids in the basin. All of the species listed above are non-native species (except brook trout) and require high-quality tributary streams for spawning and rearing. Suitable streams in southern regions of lakes Michigan and Huron, much of Lake Erie, and most of the south shore of Lake Ontario are lacking, because of natural and human-induced causes. Some high-quality habitats are located upstream of dams and, without passage, are unavailable to salmonids. These same dams block sea lamprey spawning runs, and their removal would expand the range of the sea lamprey and the costs of control. Also, these upstream areas provide unique fisheries for resident salmonids that are highly valued by some anglers, and if dams were removed, these fisheries would be disrupted by migrations of large fish from the Great Lakes (e.g., Pine River and upper Manistee River, Michigan). Originally, lake-spawning lake trout were the dominant native salmonid in the Great Lakes. Hence, rehabilitation of lake trout populations could ultimately contribute to achievement of this milestone.

Milestone 4. Improve habitat

- *Gains and losses of aquatic habitats will be classified and inventoried in a comprehensive manner for each Great Lake.*¹

Status: Gains and losses of habitats have neither been classified nor inventoried for any of the Great Lakes.

Performance: Below expectations. This milestone was no longer tractable with the deletion in 2003 of the second bullet under Milestone 5 (see Appendix).

Progress: Several important steps have been taken to classify and inventory existing aquatic habitat for each Great Lake. Assessing gains and losses of aquatic habitats as envisioned, however, has proven to be an overly ambitious undertaking.

The following actions have been taken to classify and inventory aquatic habitat for each Great Lake:

- Habitat theme initiated under the Fishery Research Program (1999).
- Research project, “Network to coordinate research on fish habitat in the near-shore and tributary environments of the Great Lakes,” funded (June 2000).
- Research project, “Ecosystem-based assessment of fish habitat in coastal wetlands of the Great Lakes,” funded (June 2000).
- Research project, “Binational GIS Database of Coastal Wetlands for Lake Ontario and the St. Lawrence: A Demonstration Project,” was funded (November 2001).
- Thesis research on the development and use of a wetland fish index to assess the quality of fish habitat in coastal wetlands of the lower Great Lakes sponsored through the Baldwin Scholarship (2003).
- White paper, “Assessing Gains and Losses of Riverine Habitat in the Great Lakes,” drafted by Board of Technical Experts (October 2003).
- White paper, “An approach to classify and inventory aquatic habitats in the Laurentian Great Lakes basin, with an emphasis on coastal wetlands,” drafted by Board of Technical Experts (December 2003).
- Lake Huron aquatic habitat GIS completed and made available on GLFC web site (2003).
- Lake Michigan aquatic habitat GIS under development.
- Lake Erie aquatic habitat GIS under development.
- Lake Ontario aquatic habitat GIS funded and will be initiated in September 2005.
- Lake Superior aquatic habitat GIS funded and will be initiated in September 2005.
- A research partnership between the Environmental Protection Agency (EPA), the Great Lakes Fisheries Trust (GLFT), and the Commission will fund research that enhances inventory, classification, and rehabilitation of Great Lakes lower riverine and near-shore habitats. Request for proposals issued in January 2005 and full proposals requested in March 2005.

Discussion: Several actions have been taken to address this milestone including development of aquatic-habitat GIS databases for each of the five Great Lakes—a substantial undertaking conducted cooperatively with support from the Restoration Act, which is administered by the U.S. Fish and Wildlife Service. At the beginning of the decade, the Commission funded several research projects through the Fishery Research Program that were directly related to assessing gains and losses of habitat. Researchers with expertise in habitat inventory and classification were recruited to the Board of Technical Experts. Board members hosted workshops designed to provide a method for assessing gains and losses of habitat (as required in Milestone 5) and drafted several white papers in an effort to identify or develop a method for assessing gains and losses of habitat in each Great Lake. These workshops revealed the absence of a well-accepted conceptual basis for organizing research to assess gains and losses.

¹ Milestone deleted in September 2005. See Appendix for current milestones.

The workshops resulted in a recommendation that the Commission clarify its role in habitat research. Assessing gains and losses of aquatic habitat for each Great Lake requires a scientifically accepted method for classifying and inventorying habitat, establishing the newly developed method as the habitat mapping method of choice for each agency involved in habitat assessment in the basin, coordinating a basin-wide habitat mapping and assessment effort, determining the baselines to be used for assessing gains and losses of habitat, and updating the habitat inventories under changing conditions. The enormity of this task is recognized in the Strategic Vision, but the increase in the number of habitat classification and inventory methods available, and the lack of agreement among scientists and managers about which methods are best, has made this task even more difficult than envisioned originally. The Commission does not currently have the resources necessary to accomplish this objective as written because of the huge undertaking that would be required. The Commission is better suited for a coordination role in a partnership framework where Commission funds can be leveraged. Hence, the research partnership with EPA and the GLFT (see above) represents the best approach for achieving this milestone.

Although some progress relevant to this milestone had been made, a revision in 2003 to a related milestone made this, the gains-and-losses, milestone unachievable. The revision deleted the second bullet under Milestone 5, which had charged the Board to “*provide a workable method for detecting gains and losses of critical Great Lakes habitats by 2005,*” and replaced it with “*promote the development and use of complementary approaches for assessing gains and losses of Great Lakes habitat.*” (see Appendix). Inasmuch as the deleted milestone was a necessary precursor to the milestone presently under discussion, the original concept of enumerating gains and losses was no longer operational, and in 2005 the milestone discussed in this section was deleted (see Appendix). In summary, the need to account for gains and losses of Great Lakes habitats is still recognized as important, but the role of the Commission is now seen as facilitating the effort in contrast to leading it.

- ***An interagency effort to protect critical habitats and restore other habitats will be organized and begun.***²

Status: An inter-agency effort to protect habitat has not been organized.

Performance: Below expectations. Achievement of this milestone depended on identifying a workable method for inventorying and classifying aquatic habitats, but as discussed above the associated milestone was deleted in 2003.

Progress: Notwithstanding the difficulties discussed above, some progress related to the intent of the milestone has been made by working with other agencies to protect and restore aquatic habitat.

The following actions have been taken to protect and restore habitats:

- Established CLC Project Review Committee to recommend restoration projects to the USFWS (January 2000). Commission staff has administered portions of the Restoration Act program for the USFWS since 2000.
- Project titled, “Managing proposals for physically altering lakebed habitat” was funded (December 2004).
- Drafting of Environmental Objectives for Lake Huron was funded and the report was completed (March 2004).
- Drafting of Environmental Objectives for Lake Michigan was funded and a final report was submitted (December 2004).
- Environmental Objectives for Lake Erie were drafted and are expected to be submitted to the Commission by June 2005 for publication.
- Contributed to formation of the CLC’s Great Lakes Fishery and Ecosystem Restoration Program Review Committee, which allows member agencies to review and recommend habitat and ecosystem restoration projects to the U.S. Army Corps of Engineers (March 2005).

² Milestone deleted in September 2005. See Appendix for current milestones.

Discussion: Achievement of this milestone to organize an interagency effort depended on accomplishing the preceding milestone on enumerating gains and losses (see Improve Habitat). Both the milestone under discussion and the preceding milestone on inventorying gains and losses depended on achievement of the now-deleted milestone aimed at finding a workable method for detecting gains and losses (see above and Appendix). Therefore, the revisions made to the workable-method milestone in 2003 made this milestone intractable, and it was deleted in 2005. Achieving this milestone was made all-the-more difficult because the Commission is not viewed as a primary player in this area.

- ***An action plan that reviews past roles and policies regarding toxic substances and that identifies new ways for the Commission to interact with other agencies to achieve reductions will be developed by 2003.***³

Status: No action plan has been developed.

Performance: Below expectations. The Commission has a very limited role in affecting the levels of toxic substances in the basin.

Progress: To date, no action has been taken to review past roles and policies regarding toxic substance or to identify new ways for the Commission to interact with other agencies to achieve reductions.

Discussion: The primary difficulty in identifying new ways for the Commission to interact with other agencies to achieve reductions in toxic substances is that the Commission has no regulatory authority or explicit role defined within the Convention as regards toxic substances. Many other agencies, including the states, U.S. Environmental Protection Agency, Environment Canada, and the International Joint Commission have authority to develop toxic substance guidelines, regulations, and enforcement. Additionally, these agencies have already formed the institutional partnerships necessary to work collaboratively with other agencies and stakeholders to address these concerns.

³ Milestone deleted in September 2005. See Appendix for replacement.

Milestone 5. Gain new information

The Board of Technical Experts by 2002 will initiate research that:

- *assesses causes of change in Great Lakes fish communities*

Status: Several research projects have been completed or are underway to assess fish community changes.

Performance: Meets expectations. Staff have been involved in the development of a research theme, a partnership, and a symposium (SCOL II) to achieve this milestone.

Progress: Two large initiatives within the Fishery Research Program have been undertaken to assess causes of change in Great Lakes fish communities: the Salmonid Communities in Oligotrophic Lakes (SCOL II) theme and the Food-web Disruption theme. These initiatives have assessed causes of change, produced published research, and forged new partnerships. Other progress towards meeting this objective include sponsorship of a workshop to assess the causes of declines in abundance and growth of lake whitefish and declines in abundance of the benthic amphipod *Diporeia* spp. The results were published in the Technical Report Series.

The following actions have been taken to assess causes of change in Great Lakes fish communities:

- SCOL II theme was completed under the Fishery Research Program in February 2004.
 - Research project titled “Fish communities of the Laurentian Great Lakes: the SCOL tradition revisited for the 21st century” funded (June 1998).
 - Research project titled “The Lake Huron Case Study and Cross Lake Comparisons of Top Predators,” undertaken as part of SCOL II.
 - Research project titled “Analysis of potential effects of global climate change on Great Lakes fishes” undertaken as part of SCOL II.
 - Research project titled “Pivotal Social, Political, and Ecological Events in Great Lakes History” undertaken as part of SCOL II.
 - Workshop on lake case histories held (May 2000).
 - Workshop on cross-lake comparisons held (August 2001).
 - Workshop on synthesis of case histories and cross-lake comparisons held (August 2003).
 - Three manuscripts have been published in CJFAS.
 - Two case studies have been submitted to the Commission for publication as Technical Reports.
 - Nine additional publications are expected in CJFAS.
 - Three additional manuscripts are expected to be submitted to the Commission for publication.
- Food-web Disruption theme initiated under the Fishery Research Program (December 1999).
 - Research project titled “Exotic invertebrates, food-web disruption, and lost fish production” funded (December 1999).
 - Partnership formalized among the Commission, the Great Lakes Fishery Trust, Illinois-Indiana Sea Grant, Michigan Sea Grant, Minnesota Sea Grant, New York Sea Grant, Ohio Sea Grant, Pennsylvania Sea Grant, and Wisconsin Sea Grant (May 2001).
 - Web site describing theme activities and publications initiated (2001).
 - Research project titled “Quantifying the impact of exotic invertebrate invaders on food web structure and function in the Great Lakes: a network analysis approach” funded (June 2002).
 - Research project titled “Comparative modeling of the ecosystem impacts of exotic invertebrates and productivity changes on fisheries in the Bay of Quinte and Oneida Lake” funded (June 2002).

- Research project titled “The effects of food quantity/quality on growth rates and nutritive condition of the opossum shrimp *Mysis relicta* and the amphipod *Diporeia*” funded (December 2002).
- Research project titled “Disruption of fish recruitment in Lake Michigan by *Cercopagis pengoi* and *Bythotrephes longimanus*” funded (December 2002).
- Research project titled “Effect of Exotic Cercopagids on Fish: Food Web Disruption Through Density- and Trait-Mediated Effects” funded (December 2003).
- Research project titled “Research Co-ordination for the Theme of ‘Exotic Invertebrates and Food Web Disruption in the Great Lakes’” funded (December 2003).
- Research project titled “Preserved Fish as a Restoration Tool: Use of Stable Isotopes to Reconstruct Historical Great Lakes Food Webs” funded (December 2003).
- Research project titled “Effects of Exotic Species on the Potential for Lake Ontario to Support a Re-introduced Bloater Population” funded (December 2004).
- Theme symposium titled “Symposium on Invasive Invertebrates: A Global Threat to Large Lakes” held at IALGR annual meeting (June 2003).
- Theme workshop titled “Workshop on Invertebrate Invaders in the Great Lakes” held following IAGLR annual meeting (June 2003).
- A Great Lakes Whitefish-Diporeia Workshop was funded and held in 2002.
 - Proceedings of a workshop on the dynamics of lake whitefish (*Coregonus clupeaformis*) and the amphipod *Diporeia* spp. in the Great Lakes, comprising 14 papers, published by the Commission (March 2005).

Discussion: SCOL II and the Food-web Disruption themes, using different approaches, were targeted at assessing the causes of change in Great Lakes fish communities. The SCOL II employed a retrospective approach to evaluate the changes in fish communities over the last 30 years for each Great Lake. The Food-web Disruption theme resulted in increased funding for research directed at investigating the impacts of invertebrate invaders. Most of the research, funded by the Commission and its eight collaborators under this partnership, is currently in progress and publications should be forthcoming. The Whitefish-Diporeia workshop was held because of growing concern in the Great Lakes about changes resulting from declines in abundance and growth of lake whitefish and declines in abundance of their prey, the benthic amphipod *Diporeia* spp. The workshop proceedings, comprising 14 papers, have been published in the Commission’s Technical Report Series.

- *promote the development and use of complementary approaches for assessing gains and losses of Great Lakes habitat*⁴

Status: This milestone was adopted only in December 2003, and since then a research-funding partnership with the Great Lakes Fishery Trust and U.S. EPA, aimed at identifying approaches for assessing gains and losses of habitat, has been launched.

Performance: Below expectations. Achievement of this milestone will depend on the success of the new partnership discussed above.

Progress: See discussion under Milestone 4.

Discussion: See discussion under Milestone 4.

- *identifies the degree to which toxic substances and diseases together have influenced fish populations*⁵

⁴ New milestone adopted in December 2003. See Appendix for current Gain New Information milestones.

⁵ Milestone modified in September 2005 (see Appendix).

Status: The degree to which toxic substances and disease have synergistically affected fish populations has not become a major focus within the Commission's research program.

Performance: Below expectations. Approaches toward achieving this milestone have evolved with the results of workshops and white papers generated through the Fishery Research Program. More recently, the role of contaminants, in affecting fish populations at more than a local level in the Great Lakes, has been downgraded while at the same time the profile of diseases like early mortality syndrome has increased.

Progress: The following actions were taken:

- Supported six-year research-coordination project titled "Investigations into the Causes of Thiamine Deficiency in Great Lakes Salmonids and the Effects of Low Thiamine on Swim-up Fry Behavior" that included a study on the toxic effects of planar halogenated hydrocarbons (PHHs) and low thiamin (vitamin B1) in developing lake trout and a study of the effects of maternally-transferred organochlorine contaminants and thiamine on reproductive success of walleye.
- Discussion paper titled "Toxic Substances" drafted for the Board of Technical Experts (October 2000).
- Research project titled "Ecology of infectious diseases in Great Lakes fishes: Effects of lake management strategies" funded (November 2001).
- Proposal for theme area titled "Role of Nutrition, Contaminants, and Disease on Great Lakes Fishes" drafted for the Board of Technical Experts (March 2002) but never adopted.

Discussion: Several proposals were drafted to initiate a Fishery Research Program theme that addresses this milestone. None of these proposed themes, however, developed into a full research theme for several reasons. As stated in the review under Milestone 4, many other agencies, including the U.S. EPA, Environment Canada, and the IJC have authority to develop toxic substance regulations and are required to address toxic substance concerns. As a result, initial discussion papers noted that a major difficulty was identifying a research focus on contaminants towards which the Commission could contribute. Additionally, toxic contaminants are now highly regulated and contaminant levels are low compared with the past. Research suggests that, although there are some synergistic effects between toxic substances and diseases, such effects are weak and the interplay between toxic substances and disease is likely not a major driving factor in fish population dynamics.

- ***establishes a forum for intercontinental exchange of information on issues affecting large lakes:***

Status: Several forums for intercontinental exchanges of information have been implemented.

Performance: Meets expectations. Asian, European, and African ecologists and managers have been engaged in discussions through workshops and symposia. These interactions will continue under the new Intercontinental theme formulated by the Board of Technical Experts.

Progress: The centerpiece of progress on this milestone is the Intercontinental theme.

The following actions have been taken to establish a forum for intercontinental information exchange:

- The Intercontinental theme under the Fishery Research Program was completed (July 2003).
 - Symposium titled "Fitness of fish communities in large lakes of the world" held at IAGLR annual meeting (May 2001).
 - Symposium titled "Vision, Visibility and Viability in Fish Populations" held at IAGLR annual meeting (May 2002).
 - Workshop titled "Viability of Exploited Fish Populations in Great Lakes of the World" held at IAGLR annual meeting (May 2003).
 - Total (15) or partial support (8) for attendance by African researchers and managers provided.

- GLOW-GLFC symposium on Great Lakes Canaries sponsored by the Commission with the goal of bringing together experts on lakes Victoria, Winnipeg, and Erie to review and compare historical changes, current trends, and possible futures for these highly responsive and heavily impacted lakes (May 2004).
- A new Intercontinental theme paper was drafted (2005). The new theme will focus on cross-system comparisons of ecosystem health through a series of intensive, selective workshops.
- Staff support provided to the International Conference on Lake Victoria held in Jinja, Uganda (2000).
- Staff support provided to the U.S.-Russia workshop on invasive species held in Borok Russia (2001).
- Staff support provided for the conference titled “Ecologically Equivalent and Exotic Species of Hydrobionths in the Great and Larger Lakes of the World” held in Ulan Ude, Russia (2002).
- Staff support provided to the “International Symposium on Comparing Great Lakes of the world (GLOW III): Climate, Food-webs, Biodiversity and Integrated Management” held in Arusha, Tanzania (February 2002).
- Staff support provided to the session “Reconciling Harvest with Conservation in Reservoirs and Lakes” held at the Fourth World Fisheries Congress in Vancouver, Canada (2004).
- Staff support provided to the USGS for “Watershed Conservation: Multidisciplinary Approaches for Natural Resource Management Conference” held at Lake Biakal, Russia, and Lake Hövsgöl, Mongolia (September 2004).
- Assisted with the organization of and participated in tours of the Great Lakes region by a delegation of Lake Victoria scientists and managers. These tours included attendance at GLFC annual meetings (June 2004 and June 2005).
- Partially sponsored a six-week visit by a scientist from the Institute of Geo-Ecology Mongolian Academy of Sciences, who works on the Hövsgöl Project funded by the GEF/World Bank (April 2005).

Discussion: The now-completed Intercontinental theme was the single largest initiative aimed at achieving this milestone. The completed series of workshops successfully brought together scientists working on the large lakes of the world. Nevertheless, no publications have resulted. A replacement theme was produced in 2005 and will focus more on publication. The new theme will feature four annual workshops focused on defining measures of ecosystem health for the large lakes of the world and a multi-authored review of each workshop will be published. This approach retains the function of information-exchange objective of the original theme while requiring publication.

Vision Statement on Integrated Management of Sea Lamprey

The Commission will provide an integrated sea lamprey management program that supports the Fish Community Objectives for each of the Great Lakes and that is ecologically and economically sound and socially acceptable.

Milestone: 1. Achieve economic injury levels

- *Suppress sea lamprey populations to economic-injury levels (maximize net benefits of sea lamprey and fishery management) by the year 2005.*

Status: Sea lamprey abundances are above targets on the three upper lakes and abundances are declining in lakes Michigan and Huron. Average abundances are near target ranges on lakes Erie and Ontario, but populations have increased on both lakes during the past two years.

Performance: Below expectations. Quantitative targets for sea lamprey abundances and wounding rates that support each lake's fish community objectives were developed and accepted by the lake committees. Corresponding economic-injury levels have been calculated for only Lake Ontario. The Commission has increased control to improve suppression where sea lamprey abundances are above targets.

Progress: Suppressing sea lampreys to target levels that support fish community objectives in each of the lakes is central to the Strategic Vision. Efforts to attain this milestone include: establishing targets; measuring status relative to these targets; and responding to abundances that are above targets with increased suppression.

The Commission's main action for reaching targets is lampricide applications that kill larvae before they metamorphose and feed on fish in the lakes. Along with lampricide applications, achieving and maintaining targets requires controlling populations in the connecting channels, developing new and using existing alternative control methods, and finding all sources of sea lampreys. These additional actions are discussed in subsequent milestones.

Establishing Fish Community Objective Targets

In 1982, the Commission adopted an integrated-pest-management approach to sea lamprey control. Under this concept, pest populations should be reduced to targets beyond which further reductions do not yield benefits commensurate with the costs of additional control. These targets are called economic-injury-levels (EILs), and their estimation requires knowing the sources of the adult (parasitic) population, the effectiveness of control actions and their costs, the effects of attacks by sea lampreys on their prey, estimates of the value of lake trout and other prey fishes, and the process error in these parameters. Recognizing the complexity of these calculations, empirically based interim targets were developed to guide the control program.

These interim targets, expressed as numbers of adult sea lampreys per lake, have been calculated in a comparable manner for all five lakes. They were adopted by the lake committees and the Commission and represent sea lamprey abundances that must be achieved to meet the fish community objectives for each lake. The following actions were taken to establish these targets:

- Carried out training workshops on identification of sea lamprey marks on fish to insure comparable data collection among agencies (Ebener et al. 2003).
- Assembled marking-rate data from all lakes in comparable units and developed new methods for estimating these values and their variance (Rutter et al. 2003).
- Estimated historical abundances of spawning-phase sea lamprey and their variances for all five lakes using trap-catch data and a common estimation procedure (Mullett et al. 2003).

- Established tolerable mortality rates using Lake Superior's Fish Community Objectives as a model (<5% annual rate).
- Established tolerable marking-rate targets by developing a relationship between marking and mortality rates (Bence et al. 2003).
- Calculated targets for sea lamprey abundance from periods when marking rates were tolerable. Estimated target ranges that reflect the variation in observations.
- Worked with technical committees during spring 2004 to achieve acceptance of these (empirical) targets by lake committees.

Estimation of comparable economic-injury levels for all lakes is continuing. Once established and adopted by the lake committees and the Commission, these injury levels will represent optimal targets based on ecology and economics. The following actions have been taken to calculate EILs:

- Economic-injury-level targets for Lake Ontario have been recalculated and published in SLIS II. This re-estimation used updated information from quantitative sea lamprey assessments and an updated version of the original Integrated Management of Sea Lamprey (IMSL) model.
- Economic-injury-level targets for Lake Erie were estimated and published using the same IMSL model as applied to Lake Ontario.
- Preliminary economic-injury-level values have been calculated for lakes Michigan and Huron using a simulation model being developed at Michigan State University.
- Analysis is underway to extend the new simulation model and EIL calculations to all lakes.
- The Sea Lamprey Integration Committee plans to work with the Committee of Lake Technical Committee Chairs to complete the analysis and policy workshops necessary to establish consensus-based economic-injury levels for consideration by the Commission.

Status of sea lampreys relative to Fish Community Objective targets

All four of the preliminary economic-injury-levels are lower than the current empirical fish-community-objective targets, which indicated that additional suppression is justified. The status of suppression relative to fish-community-objective targets follows:

Lake Superior:

- Sea lamprey abundance is above the target and increased significantly from 2004 to 2005.
- Marking rates were also above target, especially in northwestern waters, during the last three years.
- Sea lamprey abundance and marking rates were at target levels during the mid 1990s but thereafter exceeded targets.
- Untreated lentic areas and production from the Nipigon River system are thought to have contributed to the increases.
- Estimates of lamprey-induced mortality in Michigan's waters exceeded mortality caused by the fishery and are a concern to fishery managers.

Lake Michigan:

- Not on-target, but the sea lamprey abundance estimate for 2005 was significantly lower than in 2004, ending an upward trend during the past five years
- Marking rates on lake trout did not decline in parallel with the decline in numbers of adult sea lampreys.
- Increased mortality on lake trout in northern waters (combined with inadequate stocking) is thought to have set restoration efforts back by a decade. Sea lamprey induced mortality is high enough in northern waters to severely limit catch quotas for the commercial fishery and threaten the underpinnings of the Consent Decree between the tribes and the state.
- Increases in the adult population of sea lampreys during the early 1990s were thought to reflect emigration from Lake Huron's St. Marys River.
- The more-recent increases have been attributed to a large, untreated population above the dam on the Manistique River.

Lake Huron:

- Not on-target, but improving.
- The 2005 estimate of spawning-phase sea lampreys is similar to that of the previous year, which was considered an improvement over 2003.
- During the early 1990s, the sea lamprey population in Lake Huron was so large that lake trout restoration efforts in northern waters were put on hold until mortality could be reduced.
- Spawning-phase abundance has been significantly lower since 2001 and is attributed to the completion, two years earlier, of treatments of larval hot-spots in the St. Marys River.
- Marking rates on lake trout have also declined significantly.
- With the inception of control on the St. Marys River, restoration of lake trout in northern waters has resumed, and survival of lake trout has improved from what it was when restoration was discontinued.

Lake Erie:

- Near target, but with some signs of population increase.
- The five-year average abundance of sea lampreys is not significantly different than the upper bound of the target range. The 2005 spawning-phase estimate is above target levels, but the estimate has low precision because of trapping failures.
- Sea lamprey control began with a complete round of treatments during 1986-1987, and resulted in reductions in sea lamprey abundances and marking rates consistent with target levels.
- Sea lamprey abundances and marking rates increased from target levels to near pre-control levels during the mid 1990s. These increases were associated with failure to treat important streams and with reduced effectiveness of scheduled treatments, which was attributed to weak assessment information and concerns about non-target effects.
- Increased treatment effort and improvements in lampricide applications after 2001 once again reduced the population to target levels.
- The abundance of mature lake trout has increased following the improvements in suppression.

Lake Ontario:

- Near target, but with some signs of population increase.
- The most-recent five-year average of sea lamprey abundance is not significantly different than the upper bound of the target range. The 2005 spawning-phase abundance estimate is above target but is significantly lower than in the previous year.
- Spawning-phase abundance was within the target range for the previous decade (1994-2003).
- The fall 2004 marking rates were above target levels, but changes in observation methods may have contributed to this increase. Marking rates were above target levels during the last decade, but they have since declined.
- Sea lamprey induced mortality on lake trout has been sufficiently low to maintain the abundance of mature lake trout.
- Recent increases in sea lampreys may have resulted from ineffective lampricide applications on important streams.

Suppressing sea lampreys to targets

The Commission has responded to increases in sea lamprey abundance with increased lampricide applications and assessments. Because performance measures lag treatments by at least two years, the effects of treatments during 2004 and 2005 are yet to be observed. The following actions have been taken to suppress sea lamprey populations to target levels:

- Since 2001, the Commission treated more streams and lentic areas. The increased investment in staff time and lampricides averaged about \$1 million per year.
- The total amount of TFM applied has been increased from an average of 73,000 lbs active ingredient during 1996-2000 to 91,000 lbs during 2001-2005 (see Milestone 3).
- The increased control during 2001-2005 was made possible in part by earlier efforts to reduce the price of lampricides, which is lower now than in the 1990s, increasing only modestly in the first half of this decade. This success resulted from the following actions:

- Competition between new manufacturers, brought on line during the 1990s, continued to pay dividends in 2001-2005.
- Long-term purchase and cost averaging allowed the Commission to further reduce costs.
- During 2003 and 2004, a large population of larvae, established above a deteriorating dam on the Manistique River (Lake Michigan), was treated.
- Expanded the assessment of untreated lentic areas in Lake Superior, which resulted in new treatments. A basin-wide “year of the lentic area” habitat inventory is underway during 2005.
- Expanded the assessment of untreated streams including surveys along the southwest coast of Lake Michigan and the northwest coast of Lake Superior.
- Improved assessment of larvae in deep-water habitats in rivers where sampling was previously limited. The failure to adequately assess these habitats contributed to underestimates of production from the Manistique and other large rivers.
- Completed treatments in 2005 of more larval hot-spots on the St. Marys River (see Milestone 2).
- Improved the stream-treatment and selection process by:
 - Including all streams and predictions of residual populations
 - Improving parameter estimates (e.g., rate of metamorphosis) for the selection model using statistical analyses
 - Incorporating lentic areas and St. Marys River-granular-Bayluscide treatments into the stream ranking to select treatments on a more-effective cost-per-kill basis
 - Expending additional effort on lakes with higher marking rates.
- Reduced larval-assessment costs and applied these savings to other programs including lampricide treatment. During the last two years, streams with a record of consistently large populations of larval sea lampreys were scheduled for treatment without a quantitative assessment.
- Either repaired or replaced deteriorating dams (e.g., Trout River, Lake Huron) to prevent passage of adult sea lampreys or worked with dam-removal and fish-passage proponents to maintain the integrity of existing structures (e.g., Rouge River, Lake Ontario; Iron River, Lake Superior; and Beaver River, Lake Huron).
- Improved the protocols for lampricide treatments, which previously called for reduced concentrations to protect lake sturgeon and other non-target species. The previous protocols may have reduced lampricide concentrations too much, allowing too many sea lampreys to survive treatment. The improved protocol for treating over sturgeon populations still represents an increased risk of leaving too many residual larvae.
- During 2005, deferred using the protocol for sturgeon (used the standard protocol) on Lake Michigan streams. This deferment was approved by fisheries agencies and pesticide regulators in Michigan and Wisconsin.

Discussion: Lake Committees have uniformly called for the Commission to expend every effort to suppress sea lampreys to targets. In Lake Michigan, especially, the increase in sea lamprey-induced mortality on lake trout threatens restoration efforts and undoing consensus management among the tribes, states, and the U.S. government. On Lake Superior, managers for northwestern waters remain concerned that rehabilitated lake trout populations are threatened. Around that lake, managers are concerned that fish lost to sea lampreys are limiting harvest of commercial fisheries. In Lake Huron, although the decline in sea lamprey damage and signs of recovery of lake trout are encouraging, areas exist where marking is still a concern. The Lake Huron Committee wants the Commission to use every reasonable measure to ensure adequate control on the St. Marys River. In Lake Erie, the increased survival of lake trout due to increased control has encouraged all jurisdictions to allow treating over populations of sensitive species. In Lake Ontario, managers are pleased with control and the protection it provides for lake trout populations. Recent observations of increases in marking rates have, however, are a concern.

The empirically based targets must be evaluated eventually against economic-injury levels so that the Vision Statement, calling for an ecologically and economically sound program of control, is achieved. Further progress on calculating injury levels for each lake requires a better understanding of the origin (sources) of adult lampreys and how well these sources can be controlled (see Milestone 4). Current calculations of economic-injury-levels include only lampricide control and need to be extended to alternative controls, which will affect the outcome (see Milestone 3). Previous economic-injury-level calculations have been deterministic and have not taken into account process or measurement uncertainty.

This uncertainty and the effects of variation on injury levels need to be explored. Injury levels also account for the value of fish saved, but reliable estimates of such values are not available. Moreover, the lethality of a sea lamprey attack on a given fish may vary among lakes and would affect the number of fish saved. An agreement between fishery management agencies and the Commission on these values will eventually be needed.

Adult sea lampreys in the lakes originate from three sources: unidentified, identified that are not selected for treatment or cannot be treated, and treated ineffectively leaving survivors. More effective control will require:

- *Unidentified sources:* Streams previously without sea lamprey larvae but that have the potential to produce them are surveyed about every 10 years. Such detection surveys have been reduced in number to lower costs. Detection surveys have now been increased and may be increased even more in the future. Populations above dams that no longer block sea lampreys are the greatest potential unidentified source of sea lampreys and will receive increased survey effort (see Manistique River example, Milestone 4).
- *Identified sources that are not selected for treatment:* Treating all the streams that produce sea lampreys in a given year would cost more than \$35 million as opposed to the \$6 million currently spent. The effectiveness of control depends on the accuracy and precision of the estimates of the number of larvae from each stream that will metamorphose into parasites; improving the precision and accuracy of these estimates is critical. As well, uncertainty must be incorporated into the stream-selection process. Decision analysis, which accounts for uncertainty, has been used on the St. Marys River and should be applied elsewhere.

Biological and physical impediments may affect the Commission's ability to apply lampricides to producing sources. The St. Marys River was not treated with conventional methods because of its size. Novel assessment techniques, aerial lampricide applications, and alternative methods resulted in a successful integrated control effort. Diffuse populations in lentic areas off stream mouths are being treated using novel techniques. For example, sonar technologies are being used to define the bounds of larval habitat in these areas.

Institutional impediments may impede delivery of control. During the 1990s, delays in treating streams in Ohio, because of opposition from the Ohio EPA, contributed to increases in the sea lamprey population in Lake Erie. Successful negotiations based on sound data now have allowed all needed treatments to take place. Concerns about threatened or endangered species may affect control in the future.

- *Sources that have been treated, but sea lampreys have survived.* To be successful, a lampricide treatment must kill nearly all of the exposed lampreys. Decreasing the concentration of lampricides or reducing the duration of the application too much results in increased survival of larval sea lampreys. Changes were made to improve the efficiency of treatment and to meet the Commission's milestone from the 1990s for reduced use of TFM. During the 1980s, the length of time that lampricides (the block) were applied in a given application was reduced from 12 to 9 hours. This change reduced staff costs. By 1992, new application protocols were implemented that accounted for pH as well as alkalinity in defining the minimum lethal concentration. This change contributed substantially to reducing the amount of lampricide used and to the achievement of the Commission's earlier milestone on reducing the use of lampricide and implementing alternative controls. These new treatment protocols were thought to have been successful because, since their inception, sea lampreys were suppressed to target levels, at least for a while, in all lakes except Lake Huron. But, these new protocols may have increased the potential for larvae to escape treatment so they should be reassessed.

The maximum application concentration has been reduced and the treatment season has been extended to increase protection of non-target species. A protocol to protect lake sturgeon was introduced during 1998, which reduced the maximal application concentrations from 1.5 to 1.2

times the minimum lethal concentration. These changed protocols may have increased the risk of sea lampreys surviving a treatment, and small differences in survival would be hard to detect with existing assessments. Evaluating the trade-offs between protecting non-target species and killing an adequate number of sea lampreys will require more research.

Milestone: 2. Control the St. Marys River

- *Suppress sea lamprey populations in the St. Marys River to a level that allows rehabilitation of lake trout in northern Lake Huron.*

Status: Control efforts have reduced sea lamprey populations in the river and lake. Lake trout survival has improved, increasing the population of mature adult fish and the amount of natural reproduction.

Performance: Above expectations. The Commission has maintained an integrated program consisting of alternative and lampricide control along with an assessment that evaluates success.

Progress: The St. Marys River is the premier example of an application of integrated pest management to sea lamprey control. New and innovative quantitative assessment, modeling, and decision analysis have been applied to identify the best strategy. Two alternative (to lampricides) methods—trapping and sterile-male release—are used only on the St. Marys River. During 2003, decision analysis suggested that continuing the combined strategy of maximizing trapping, full-scale sterile-male release, and lampricide treatment of top-ranked infested habitats provided the most cost-effective and least-risk approach for control on the St. Marys River.

Status of control on the St. Marys River and effects on Lake Huron lake trout

Key indicators suggest that the integrated control strategy has been successful:

- Larval sea lamprey populations in the river have been reduced by 50% from pre-control levels.
- Abundance of newly metamorphosed sea lampreys migrating out of the river, as measured by fyke netting, has declined by 72%.
- Spawning-phase sea lampreys have declined by 38% (see also Milestone 1).
- Lake trout wounding has declined by 61%.
- Lake trout mortality has declined 66% and is below target rates.

The abundance of large lake trout of reproductive age in Lake Huron has increased, and during 2004 the number of naturally reproduced lake trout taken in bottom trawls increased dramatically in the main basin. Earlier concerns about excessive sea lamprey damage to lake trout resulted in achievement of effective control becoming a precondition in an agreement on treaty-fishing rights between Native American tribes, the state of Michigan, and the U.S. The parties to this agreement now see that control in the St. Marys River is adequate to allow for rehabilitation of lake trout to be renewed. Sea lamprey induced mortality is estimated to be low enough in the affected waters of Lake Huron to allow increased commercial and recreational fishing. This situation is in striking contrast to Lake Michigan, where increased mortality caused by sea lampreys threatens to constrain harvest, causing the same parties to delay the implementation of an agreed-on quota-management strategy.

Continuing suppression

Continuing suppression of sea lampreys in the St. Marys River involves several issues. The population of larvae in the river is large (\cong 2 million) relative to other sources. Trap effectiveness has varied widely and has not reached the goal of capturing and removing 70% of the spawning run. Males for sterilization are limited. If sea lamprey suppression can be improved on Lake Michigan and elsewhere, the number of males available for sterilization may be reduced. The following actions have been taken to maintain and improve suppression on the St. Marys River:

- Plots that had an estimated production large enough to be included in the stream-treatment queue for Lake Huron were selected for treatment. Granular Bayluscide was applied to 200 acres in 2003 and 2004, and the area proposed for treatment in 2005 was increased to 350 acres.
- Granular Bayluscide applications were found to kill 75% of larvae in treated plots, confirming earlier studies.
- Changes were made to improve the effectiveness of existing traps, which captured a record 60% of the spawning run in 2002 and from 27% to 49% during 2003-2005.
- Carried out telemetry studies during 2001-2002 to define the best locations for new traps.
- Built in 2005, in partnership with the Corps of Engineers, a new trap at the Soo Edison Generating Station in Sault Ste. Marie, MI.
- Built, in partnership with the City, a new permanent trap at Great Lakes Power in Sault Ste. Marie, Ontario. This trap is designed for the eventual application of pheromones.
- Applied, beginning in 1997, all available sterile males to the river, resulting, in combination with trapping, in a reduction of 80-94% in the effective number of spawning females.
- Larval population abundance was more-precisely estimated using an adaptive stratified random design.
- The larval survey was modified to provide estimated abundances of larvae and potential transformers in individual plots for subsequent ranking for treatment.
- Estimated the number of yearling larvae remaining in the river. These estimates support the conclusion that trapping and sterile-male release have markedly suppressed larval populations in the river.

Discussion: By committing its entire supply of sterile males to the St. Marys River, the Commission was successful in improving overall control in the river, in demonstrating the utility of alternative controls, and in reducing lampricide use (see Milestone 3). Nevertheless, this integrated approach has not provided for experimental manipulation of the sterile-male release and trapping efforts, which would have better defined their individual contributions to suppression. Instead, inferences, derived from assessment results, and modeling analyses have been used to estimate the effectiveness of trapping and sterile-male release. Deciding among control options to maximize suppression on the river will remain a challenge. New modeling and assessment efforts will be necessary to move forward over the long-term.

Milestone: 3. Use alternative control technologies

- ***Accomplish at least 50% of sea lamprey suppression with alternative technologies while reducing TFM use by 20% through***
 - ***use of at least one new alternative-control method,***
 - ***increased use of current methods such as sterile-male-release, trapping, and barrier deployment.***

Status: Alternative controls accomplish an estimated 21% of sea lamprey suppression and, with construction of planned sea lamprey barriers, an additional 4% is anticipated by 2010. Since 2001, lampricide use increased in response to increasing sea lamprey populations. A new alternative control technique based on pheromones looks very promising, but will not be implemented until the next decade. The network of barriers is being increased, in part, through a partnership with the U.S. Army Corps of Engineers, but existing alternative controls, including sterile-male release cannot be increased enough in this decade to account for 50% of the over-all suppression.

Performance: Meets expectations. Reasonable progress has been made towards increasing suppression with alternative controls, but reduced use of TFM is not envisioned until pheromone-based technologies come online at the end of the decade.

Progress:

Achieving Fifty-Percent Control with Alternatives and Reducing TFM Use

The Commission made it a priority to reach Milestone 1 (suppress sea lampreys to target levels that support Fish Community Objectives) and in so doing increased the amount of TFM used in the basin. The following has been accomplished as regards working towards 50% of total suppression using alternative technologies in lieu of lampricides:

- A network of 69 barriers and modified dams, developed over 40 years, is estimated to have reduced the amount of stream habitat available for producing sea lampreys, and the corresponding need for suppression, by 14% across all five lakes.
- The application of sterile males and traps on the St. Marys River can be viewed as decreasing the area of the river now requiring treatment with lampricides (in this case granular Bayluscide) from that treated originally (in 1998-1999). This reduction in amount of habitat now requiring treatment amounts to 7% of the total for all five lakes (the St. Marys River itself amounts to 15%). This figure of 7% is preliminary and can not be confirmed until two full treatment cycles are completed over eight or more years.
- In combination, the suppression achieved by barriers throughout the basin (14%) and trapping and sterile-male release in the St. Marys River (7%) amounts at mid decade to 21%, whereas the target for the whole decade is 50%.
- A total of 16 new barriers are planned for construction before 2010. They should reduce the basin-wide production of sea lampreys and need for lampricide suppression by an additional 4% (see below).
- Development of new pheromone technologies is on track for a first full-scale application by 2010. These techniques have great potential to reduce suppression even further (see below).

The following progress has been made toward reducing TFM use by 20%:

- The average annual use of 91,000 lbs (active ingredient) of TFM during 2001-2005 represents a 25% reduction from the baseline usage during 1986-1990. However, only a small fraction of that reduction, 5%, was achieved during the last five years. The 20% goal, at the time it was written (in 2000), was viewed as the add-on needed to complete achievement of a milestone for the 1990s of a 50% reduction. However, TFM use had already declined by 40% by the very late 1990s, making further reductions in this decade all-the-more difficult. Therefore, although TFM use in the first

half of this decade is down 25% from the historical baseline, it is considerably higher than it was at the end of the 1990s. The reasons for low usage of TFM in the 1990s and the problems it caused are discussed in Milestone 1.

Discussion: Given a priority of suppressing sea lampreys to target levels, the control program, during the previous five years, has increased the overall amount of TFM used, rather than reduced it. The risks of decreased treatment effectiveness were too great to reduce TFM concentrations any further (see Milestone 1). Attaining 50% suppression with alternative controls is unlikely to come about by reduced applications of lampricides. Sea lamprey populations are at higher-than-acceptable levels in four out of five of the lakes, but especially so in lakes Superior and Michigan. The high populations have likely occurred for a number of reasons, including using reduced concentrations of lampricides in treatments. In the future, programmed reductions in application rates, including those intended to protect non-target species, need to be better researched before they are implemented.

Use One New Control Method

The use of sea lamprey pheromones is the primary new alternative-control method being pursued. Two sea lamprey pheromones, the migratory (released by ammocoetes) and mating (released by spawning males), have been identified. The structures of the mating pheromone and its components were determined and synthesized in 2002. Only one of two synthesized batches elicited a response in female lamprey, and the synthesis was expensive. Recently, a contract was let for a synthesis of large quantities (10 g) of the two primary components (3-ketopetromyzonol 24-sulfate and 3-ketoallocholic acid) of the mating pheromone, and delivery was taken in June 2005. The development of a synthetic mating pheromone was a critical step for an eventual operational program. Synthesis of the migratory pheromone has lagged behind the synthesis of the mating pheromone. The structures of the migratory pheromone and its components were determined during 2005.

The first field experiments examining sea lamprey behavioral responses to pheromones were begun in 2004. Mature female lampreys, in experiments conducted in June 2004, clearly detected the synthetic mating pheromone at 10^{-12} M concentrations and were readily guided into traps. Trials of the migratory pheromone, using extractions from larval washings, were also successful in guiding adult lampreys into traps. Both studies revealed unequivocal evidence for the important role pheromones play in the reproductive biology of sea lampreys. Additional field trials are scheduled for 2006.

The ability to detect small concentrations of the migratory pheromone may become important in assessing larval abundance in streams. Likewise, to enhance trapping, background concentrations of naturally released pheromones must be known to establish what concentrations of synthesized pheromones are necessary to override such natural signals.

Accomplishments in 2001-2005 were:

- Mating Pheromone Research Funded
 - Determination of structure (3 keto-petromyzonol sulfate) and female-sea lamprey attraction (January 2000).
 - Molecular cloning of petromyzonol sulfotransferase and enzymatic synthesis of petromyzonol sulfate (January 2000).
 - Experimental determination of function, production and release by male sea lamprey (January 2000).
 - Synthesis of the pheromone by Toronto Research Chemicals, Inc. (2002).
 - Contingent upon the successful synthesis of 1.0 g of each of the constituent bile acids, large-scale syntheses of bile acid derivatives were approved (2003).
- Migratory Pheromone Research Funded
 - Determining the sources and complete chemical composition of the lamprey larval pheromone, and assessing the merit of measuring one of its principal components in river waters – Phase II (April 2000).

- A first step toward developing a field test to determine whether a larval pheromone can be used in sea lamprey control: ascertaining its effects on adult behavior in a lake and characterizing the complete pheromone (February 2001).
- Identifying and producing the sea lamprey migratory pheromone (April 2003).
- Structure determination of the primary components of the sea lamprey migratory pheromone and elucidation of their biological importance (March 2004).
- Synthesis of the components of the sea lamprey migratory pheromone is currently advancing in the SLRP research cycle (2005).
- Other Pheromone Research Funded
 - The analysis of pheromone identification by sea lamprey through functional imaging of olfactory glomeruli (January 2003).
 - Field trials to evaluate the potential use of pheromones in sea lamprey control: A proof-of-concept study (January 2004).
 - A field test of the potential for sea lamprey pheromones to promote trapping success in natural streams (January 2005).
 - The neural mechanisms underlying pheromone activated movement in lampreys (January 2005).
- Other Activities
 - The Reducing Reproduction Task Force was formed (2003).
 - To coordinate and implement pheromone technology in the field, a Behavioral Ecologist was hired at Michigan State University (2004).

Discussion: Two sea lamprey pheromones, the migratory (released by ammocoetes) and mating (released by spawning males) are expected to be the basis for new alternative technologies and are on-track for implementation around 2010. Good progress has been made in understanding how these pheromones function and in how they could be used for control. The primary application of pheromones will be to increase the effectiveness of traps, thereby expanding their usage. Major accomplishments to date are identification of some of the pheromones' chemical structures, synthesis of large batches of components of the mating pheromone, and behavioral experimentation in the laboratory and field.

Increase Use of Current Alternative Methods

Sterile-male release and trapping together are one of two currently used methods of alternative control, and their deployment on the St. Marys River was discussed under Milestone 2. Barrier deployment is the second method, and this effort has been expanded, but the costs and complexity of building barriers has raised questions of program viability. Funding for alternative control has been increased to 30% of the sea lamprey management budget. The following progress was made toward increased use of sterile-male-release and trapping:

- The maximum available number of males were sterilized and released in the St. Marys River. All available sources of sea lamprey large enough to warrant collection, including those from Lake Ontario were used.
- The automatic injector for the sterilizer was completely refurbished. This unique machine, developed to inject males with Bisazir, was reconstructed with new modular components to ensure continued functionality and to reduce the risk of shut-downs.
- A strategic review of sterile-male-release found it to be cost-effective and contributing to control on the St. Marys River. The review also recommended:
 - Exploration of the potential for sterilized females to be used in control
 - Finding new sources of males for sterilization
- A model analysis demonstrating the feasibility of using sterile females was published and field trials are proposed for 2006.

The following progress was made toward increased use of barriers:

- An action plan was completed for the development and deployment of barriers, and as a result staffing was increased by new hires and reassignment.
- The partnership with the U.S. Army Corps of Engineers (COE) was advanced.
- Sea lamprey control projects were awarded funding under Section 1135 of the Water Resources Development Act (WRDA), despite constraints on these funds.
- A memorandum of understanding was established to allow barrier construction in the state of Michigan and agreements are in place with the Province of Ontario.
- A barrier siting policy, dealing with potential effects on stream fish, was adopted.
- A cost-effective protocol for fish assessment was adopted to support implementation of the siting policy.
- A Canadian Partnership for Ecosystem Research and Management (PERM) was established at the University of Guelph with two scientists, who will focus on barrier, fish-passage, and trapping research.
- The COE is constructing two new barriers on Lake Michigan (Carp Lake outlet and Galien River) with 75% funding under Section 1135 and completion is scheduled in 2005 and 2006.
- The FWS plans to construct on the Cedar River (Lake Michigan) in 2006 the first barrier that it has solely planned, designed, and contracted.
- DFO is planning to construct a major barrier on Bronte Creek, Lake Ontario.
- The fish assessment protocol is being field tested this year and a common protocol will be instituted during 2006.
- Behavioral and physical research on sea lamprey and fish responses to barriers and fishways is underway by the PERM team and DFO researchers.
- A research project applying decision analysis to barrier and fishway-design questions is being undertaken.
- Revisions of the barrier strategy and ranking of deployment sites are in process.

Discussion: Planning and coordination for barrier placement has advanced to the point that four new structures will be constructed in 2005-2006. The partnership with the COE is advancing, but challenges remain regarding funding commitments, costs, and rates of project completion. The funding under Section 1135 is limited by Congressional authorization and competition for funds is keen. The planning phase for the COE is protracted, the construction is very expensive, and moving to the construction phase is slow. Barriers are more expensive to build than previously estimated. Estimates suggest a 2.5-fold increase in costs from earlier (1999) estimates. This increase reflects, in part, better accounting for the real costs of planning and design and higher costs of easements. Barriers incorporating new technologies to minimize their impacts on stream fish and river flow did not function properly: two variable-crest barriers and two DC electrical barriers have failed to stop passage of sea lampreys. The evolution of barrier design toward “barrier-less” traps is a promising concept. This approach involves integration of barrier research and development with pheromone-based control.

Milestone 4. Estimate recruitment

- *Estimate recruitment of sea lampreys from all sources, including non-treated rivers, estuaries, and connecting channels, by 2005.*

Status: Sources have been inventoried, but recruitment from all sources has not been fully quantified.

Performance: Meets expectations. Investment in quantitative assessment data, modeling analyses, and use of new assessment technologies have all contributed systematically to identification of sources, but this milestone is challenging and uncertainty will always exist.

Progress: Knowing where adult sea lampreys spent their larval lives is the key input for making the most-effective allocation of treatment effort. Larval, parasitic, and adult assessments have focused on estimating sea lamprey abundances at all life-stages, but the results are inconsistent, suggesting that either the assessments are inaccurate or that unknown sources exist. The larval assessment program, in particular, has aggressively searched for unknown sources, but too few have been found to account for the numbers of adult sea lampreys seen, for instance, in Lake Superior.

The following actions were taken to achieve this milestone:

- Inventoried all areas that conceivably could provide nursery habitat for larval sea lampreys.
- Identified, enumerated, and treated populations in lentic areas in the Nipigon River (Lake Helen), and off the mouths of large rivers during 2003-2005.
- Estimated the amount of useable habitat and ammocete density in the Niagara River, which was estimated to contribute up to 20% of the adult sea lampreys found in Lake Ontario.
- Completed detection surveys in the St. Clair and Detroit rivers, which appear to be insignificant producers.
- Completed detection surveys in remote areas of Lake Superior, including the Pukasa and Isle Royale regions.
- Completed detection surveys along the western shore of Lake Michigan, including the urban watersheds in the Milwaukee area, during 2005.
- Estimated abundance of newly metamorphosed juvenile sea lampreys (transformers) in lakes Huron, and Superior, using coded-wire tags and mark-and-recapture methods, and extended mark-and-release efforts to Lake Michigan.
- Estimated adult abundances lake wide in all lakes annually, using trapping and mark-and-recapture or regression models in lieu of mark and recapture.
- Improved design for larval assessments, including better representation of deep-water riverine habitats and better allocation of sampling effort.
- Improved abundance estimates of larval populations using a statistical analysis of new quantitative assessment data, and improved model predictions of transformer production.
- Evaluated the accuracy and precision of larval assessments and predictions of transformer abundance using mark-and-recapture methods. Quantitative-assessment estimates of larval populations were consistently lower than mark-and-recapture estimates.
- Supported the publication of early findings on statolith micro-chemistry to assess stream of origin, which suggested modest discrimination among geographic regions, and supported new research on use of statolith micro-chemistry to identify sources..
- Improved whole-lake estimates by increasing trap assessments, especially in larger streams.
- Modeled the uncertainty in larval and transformer assessments and evaluated the impacts on stream selection. These studies predict how mistakes in stream selection could affect the numbers of sea lampreys out migrating to the lakes.
- Began a study during 2005 that uses the return rates of coded-wire-tagged larvae to estimate recruitment to the lakes from sea lampreys that survive treatment.
- Assembled lake trout marking data and developed new statistical methods for its interpretation. This information was used in quota estimation procedures for treaty-ceded waters of lakes Huron, Michigan, and Superior, and will soon be applied to lakes Erie and Ontario.

- Began development of a GIS inventory of dams that currently block sea lampreys. This inventory includes information on current structural status and identifies risks of sea lamprey passage via deterioration, removal, or installation of fishways.
- Funded modeling the productive capacity of river habitats above existing barriers to better predict the potential risks posed by loss of “de facto” barriers.

Discussion: Quantifying the sources of sea lamprey recruitment will require: 1) a complete inventory of possible sources; 2) estimates of the abundance of sea lampreys at each life stage; 3) information on survival, growth, and rate of metamorphosis among sources; and 4) analyses connecting 1, 2, and 3. Estimates of economic-injury levels (Milestone 1) depend on assumptions about sources of sea lampreys. Current economic-injury-level estimates assume that the vast majority of adult sea lampreys come from treatable streams and imply that lampreys can be suppressed to low levels economically. Findings to the contrary, that many adults originate from hard-to-treat or untreatable sources, will elevate injury levels, i.e., allow more parasitism. Alternative controls offer the promise of suppressing difficult-to-treat sources, but application of that technology is in the future. Therefore, quantification of sources has big implications for fishery management.

Uncertainty in larval-abundance estimates and model predictions of transformer production affect estimates of recruitment from streams and selection of streams to be treated. Validation studies suggest that larval populations have consistently been underestimated and that estimates of the number of transformers emerging in years after surveys were less precise but unbiased. Modeling is underway to interpret the effects of these uncertainties on stream selection and to estimate the numbers of sea lampreys recruiting from streams not selected for treatment. Large uncertainties also exist about the number of sea lampreys surviving treatment. Stream treatments with TFM reduce larval populations severely (mean kill of 95%), but variation in treatment effectiveness is large. Estimates of the effectiveness of granular Bayluscide treatments on the St. Marys River are less variable, but lower (75%). Further, whether the effectiveness of treatments have been affected by reductions in the dosage of TFM is not clear. The need for research on treatment effectiveness, identified in Milestone 1, is reiterated here.

Mark and recapture studies using coded-wire tags have yielded population estimates of transformers and juveniles that are inconsistent with estimates of larvae and adults. The recovery rates of marked lampreys have changed over time, suggesting that survival of the marked animals may be changing and affecting the resulting estimates. A recently concluded study suggests that mark and recapture estimates do not improve population estimates based on spawning-phase trap catches. Mark and recapture studies are expensive, and if found to have limited value, should be terminated. Likewise, studies are underway to determine the minimum amount of assessment necessary to effectively select streams for treatment.

Vision Statement on Institutional/Stakeholder Partnerships

The Commission will encourage the delivery of complementary programs focused on healthy Great Lakes ecosystems and integrated management of sea lampreys through:

- leadership from the Lake Committees in development and pursuit of Fish Community Objectives,
- coordination of fish management programs,
- development of coordinated research programs,
- recognition of Fish Community Objectives by environmental agencies as these agencies implement their programs, and
- strengthened and broadened partnerships among fish management agencies, environmental agencies, and non-agency stakeholders.

Milestone 1. Encourage coordinated fish-management programs

- *Fish Community Objectives will be reviewed after State of the Lake Conferences and revised as necessary.*

Status: Fish community objectives have been reviewed during every state-of-the-lake conference (SOLs).

Performance: Meets expectations. Staff has worked with the lake technical committees to encourage the review and revision of fish community objectives and a common format for SOLs has been developed.

Progress: Fish community objectives are now routinely reviewed during state of the lake conferences and this need is clearly identified in the February 2005 guidelines, approved by the Council of Lake Committees, for producing the required oral and written reports. All lakes (not connecting waters) now have fish community objectives, but only Lake Superior's, the first to be written, have been revised and republished.

Editing and publication/republishing activity since 2000 relating to fish community objectives follows:

- Authors of the St. Lawrence River Fish Community Objectives have decided to rewrite/update this document based on the secretariat's August 2004 edit.
- Lake Superior (revised), published March 2003.
- Lake Erie (original), published March 2003.
- Lake St. Clair (includes connecting rivers), edit completed in July 2004, but authors have not approved the revised manuscript for publication.

Discussion: The "fish community objective-state of lake" process is working amazingly well, considering the workload involved. These reports, made on a five-year cycle, are very professional—indeed, the technical committees deserve recognition for their efforts. The new guidelines for state-of-lake reports are expected to streamline the process; getting the first report out will take a major effort, but thereafter this report will likely become a template for those to follow. Completing Lake Erie's (first) written state of the lake report will likely require considerable input from secretariat staff and may require contracting out portions of the writing.

Milestone 2. Establish and promote research priorities

- ***The Commission will lead a review and revision of lake-specific research priorities in conjunction with State of Lake Conferences and communicate priorities to research funding agencies.***

Status: Lake-specific research priorities are now reviewed by lake technical committees on an annual basis and communicated via the Commission's website.

Performance: Meets expectations. Appropriate coordination efforts with partners have occurred to accomplish this milestone.

Progress: Beginning in 2002, the Commission initiated an annual review and revision of lake-specific research priorities, basin-wide research priorities, and fish-health research priorities in collaboration with lake technical committees, lake committees, the Council of Lake Committees, and the Great Lakes Fish Health Committee. Research priorities are communicated to other agencies by postings on the Commission's web site and by referencing the web address in the annual call for proposals.

The following actions have been taken to ensure review and revision of research priorities through the Council of Lake Committees and lake committees:

- Research priorities are reviewed and revised by each lake technical committee (annually in summer) and reviewed by each lake committee during its annual March meeting;
- Basin-wide research priorities, including those related to achievement of basin-wide environmental objectives were reviewed and revised by the Council of Lake Committees for the first time in April 2005. These research priorities will be reviewed annually during the Council's fall meeting in the future;
- Fish-health research priorities are reviewed and revised annually by the Great Lakes Fish Health Committee; and
- All revised research priorities are posted on the Commission's web site before the annual request for proposals is released (annually in late fall).

Discussion: The process described above allows for annual revision of research priorities by lake committees and the fish health committee. The research priorities are organized to reflect fish community objectives, and guide the Fishery Research Program and the Great Lakes Fish and Wildlife Restoration Act program, making them responsive to the rapidly changing ecology of the lakes and the needs of lake and fish-health committees. The annual review is timelier than a revision of the priorities once every five years, as required at each State of the Lake Conference.

- ***New research partnerships will be developed to address priority research.***

Status: New partnerships have been established with the University of Guelph, Great Lakes Fishery Trust, NOAA Sea Grant, Lotek Wireless, Inc., and U.S. Environmental Protection Agency.

Performance: Meets expectations. The Commission has aggressively sought to develop new partnerships.

Progress: Many new research partnerships have been developed to address priority research needs. These partnerships have allowed the Commission to leverage funds, resulting in more purchasing power for priority research.

The following actions have been taken.

- Canadian PERM program secured two tenure-track faculty members to investigate behavioral ecology and physiology of fish in relation to migration and passage around stream barriers (2001).

- Partnership established among the Commission, the Great Lakes Fishery Trust (GLFT), Illinois-Indiana Sea Grant, Michigan Sea Grant, Minnesota Sea Grant, New York Sea Grant, Ohio Sea Grant, Pennsylvania Sea Grant, and Wisconsin Sea Grant to solicit and fund research investigating the effects of invertebrate invaders on food-web disruption (May 2001).
- Partnership established with the Aquatic Ecosystem Health and Management Society (Great Lakes of the World) to sponsor an intercontinental workshop on shallow great lakes of the world (December 2003).
- Partnership with Lotek to develop a fresh-water pop-off tag that will contribute to the achievement of various research and assessment priorities (March 2004).
- Partnership with the GLFT to fund the Lake Michigan Federation to conduct a feasibility study titled, “Long Term Solutions for Preventing the Transfer of Aquatic Species Between the Great Lakes and Mississippi River Basins” (June 2004).
- Partnership with AquaNet established to conduct research related to thiaminase deficiency syndrome/early mortality syndrome (December 2004).
- Partnership established among the EPA, GLFT, and GLFC to fund research that will compile and synthesize research and management techniques that address inventory, classification, and rehabilitation of Great Lakes lower riverine and aquatic near-shore habitats. Request for pre-proposals was issued (January 2005) and full proposals have been requested (March 2005).
- Informal leveraging of funds also occurs when researchers use results from Commission-sponsored projects to gain funding from other funding agencies. For example, the Commission’s funding for lamprey-mating pheromone research in the Li laboratory (MSU) has generated approximately \$1,950,000 from other funding sources (National Institute of Health, National Science Foundation, and Great Lakes Protection Fund), which is more than three times the funds invested by the Commission to identify this pheromone.

Discussion: Collaborative research partnerships enable the Commission to leverage funds, resulting in more purchasing power for priority research needs. Additionally, the growing need for interdisciplinary expertise and new technologies requires the formation of new partnerships to achieve Strategic Vision milestones. Partnerships are a widely recognized method for addressing large-scale research needs or research requiring diverse expertise. Developing and maintaining partnerships involves a major commitment of staff time.

Milestone 3. Communicate with environmental management agencies

- *Lake committees will communicate to environmental management agencies the biological, physical, and chemical requirements necessary to meet Fish Community Objectives and will seek to have these requirements incorporated into the plans of these agencies, e.g., into LaMPs and RAPs.*

Status: Development of environmental objectives is underway for each of the five Great Lakes. Once complete they will be ready for communication to the IJC as input to LaMPs and RAPs.

Performance: Meets expectations. The Commission has sponsored workshops and experts to assist with drafting environmental objectives. More attention to this milestone would undoubtedly speed its achievement. Funding to facilitate development and communication of environmental objectives could come through the Commission's Science Transfer Program

Progress: Environmental objectives (EO) are being developed for each lake.

- Lake Superior: the Lake Superior Committee approved a format for their environmental objectives in March 2005 and the Lake Superior Technical Committee will begin preparation of the first draft this summer.
- Lake Huron: the Commission provided U.S. \$50,000 to the Ontario Ministry of Natural Resources to secure a person to draft the environmental objectives. The draft environmental objectives were posted on the Environmental Bill of Rights Registry in Ontario for public comment and are also available on the Commission's web site. The public comment period concluded April 30, 2005, and the comments are currently being compiled. The Lake Huron Technical Committee will be addressing the comments this summer, and Lake Committee approval of the environmental objectives is expected during the fall of 2005.
- Lake Michigan: Funded (U.S. \$68,134) a professor to prepare the draft Environmental Objectives. The draft is being revised to address comments provided by the Lake Michigan Committee and is available on the Commission's web site. The Environmental Objectives will be discussed sometime during the fall of 2005 by the Lake Michigan Committee.
- Lake Erie: the Lake Erie Committee has provided comments on the final draft of the Lake Erie Environmental Objectives, which will be posted on the Commission's website.
- Lake Ontario: the Lake Ontario Committee is coordinating the production of its Environmental Objectives with the Lake Ontario LaMP Management Committee. The two committees are currently planning public meetings as a step in their development and will then contract out the writing.

The following actions were taken since 2000 to support environmental objectives:

- State-of-the-Lake meetings have been held for each of the five Great Lakes. These meetings have included explicit attention to environmental objectives.
- The Commission has sponsored workshops to coordinate and facilitate the development of Environmental Objectives and to identify the related research priorities. These workshops were held in conjunction with fall Council of Lake Committees meetings.
- Funded the production of environmental objectives for lakes Huron and Michigan.
- Developed a recommended format for the second round of State-of-the-Lake reports.

Discussion: During the 1997 review of the Joint Strategic Plan, signatory agencies agreed that environmental objectives should be developed for each of the Great Lakes and incorporated into fish community objectives. One way to make progress toward that goal, the signatories agreed, was to hold "State-of-the-Lake" meetings for one of the five Great Lakes each year. This process has occurred, State-of-the-Lake reports are being published, and the best format for them is emerging.

Milestone 4. Strengthen stakeholder and Advisor relationships

- ***Travel funds and a policy for their use by citizen Advisors will be established by 2002 to promote communications between Advisors and their constituents and between Advisors and Commissioners.***

Status: Travel funds are available and a policy for their use has been completed.

Performance: Above expectations.

Progress: The milestone has been achieved.

The following actions were taken since 2000 to support Advisor travel:

- Guidelines for Advisor travel were developed in consultation with the chairs of the Canadian and U.S. Committees of Advisors.
- Advisors were notified about the availability of funds and provided with the guidelines.

Discussion: Support for Advisor travel makes them more effective, as the funds encourage them to attend more meetings and events related to the Great Lakes fishery and the Commission. Advisors have used these travel funds to participate in many types of events including Lake Committee meetings and lake committee-related meetings, the Great Lakes Regional Collaboration, scientific conferences, and non-government-organization meetings. Attendance at these and other types of meetings has significantly improved the function of the Advisors while making them better informed. Advisors have also played a key role in staffing the Commission's educational displays.

- ***The Commission's communications program will be evaluated and updated by 2003 to strengthen relationships with stakeholders and Advisors.***

Status: The communications program has not been evaluated.

Performance: Below expectations. Overall, the communications program has been successful, notwithstanding the fact that it has not been evaluated. The program—started in 1995—has focused its efforts on communicating with new audiences, solidifying the Commission's relationship with long-standing partners, improving outreach with elected officials, and nurturing more media attention. Plans are underway to implement an internal evaluation and an external peer-review of the communications program.

Progress: The secretariat has yet to initiate an evaluation and update of the communications program.

The following actions were taken since 2000 to evaluate and update the communications program:

- The secretariat continues to monitor press reports to help evaluate whether messages are being reported.
- Feedback from user groups and other constituents is regularly received and acted on.

Discussion: Feedback and evaluation are critical elements of any communications program. Without feedback, communicators have little idea about whether messages were received and understood. Moreover, as communications go in both directions, it is important to understand the needs of those with whom the Commission communicates. An evaluation and update of the communications program would allow the Commission to know whether audiences, messages, and approaches are appropriate and effective.

- ***A communications framework for A Joint Strategic Plan for Management of Great Lakes Fisheries will be developed and implemented by 2003.***

Status: A communications framework has been developed and presented to lake committees, but not yet implemented.

Performance: Below expectations.

Progress: The following actions were taken since 2000 to implement the communications framework for the Joint Strategic Plan:

- The secretariat continues to remind signatory agencies that the communications framework exists and that its implementation would be desirable.
- The secretariat's communications officer and other Commission staff deliver "light" communications on behalf of the Joint Strategic Plan signatory agencies by issuing press releases as appropriate, coordinating letters to Congress and others, issuing meeting notices, and assisting Lake Committee members with presentations.

Discussion: Although a communications framework for the Joint Strategic Plan has been produced and approved by the signatory agencies, it has not been fully implemented, because the member agencies have not had the resources to implement it. The communications framework envisions communication professionals from the agencies attending the lake committee meetings, strategizing on the appropriate messages from the meetings, and carrying out appropriate communications. One reason for slow implementation is the fact that the agencies can barely muster travel for the lake committee and lake technical committee members themselves, let alone travel for communication staff. This is unfortunate, as communications are important. Success of this milestone will require a rekindled interest by Lake Committee members on the importance of communications and a willingness to make the related efforts happen.

Milestone 5. Increase partnership funding

- ***Partnership funding for enhanced delivery of Commission programs will increase and be reported annually.***

Status: Partnership funding has been secured to enhance delivery of the Commission's programs.

Performance: Meets expectations. New research and funding partnerships have been sought aggressively.

Progress: The Commission has developed and nurtured several new research and fisheries management partnerships to improve the management of the Great Lakes ecosystem (research partnerships are discussed in milestone 2 above). These partnerships have helped the Commission pool resources, leverage funds, and better coordinate activities with other groups.

The following actions were taken since 2000 to enhance delivery of partnership funding:

- Several new research partnerships have been initiated (see milestone 2).
- Partnered with the U.S. Army Corps of Engineers to implement the new Great Lakes Fishery and Ecosystem Restoration Program (GLFER). GLFER will leverage substantial funds to allow the Corps and management agencies to partner on projects to restore Great Lakes habitat.
- Established and implemented a program to partner with the Corps of Engineers (COE) on the construction of sea lamprey barriers.
- Received funds from the Department of State and leveraged funds from other agencies to prevent passage of Asian carp through the Chicago Sanitary and Ship Canal. Specifically, the Commission has partnered on research, helped develop a rapid response plan for the canal, purchased a backup generator, and helped facilitate multi-state contributions to the barrier project.
- Uses funds it receives under the *Fish and Wildlife Improvement Act* (these funds are part of the Dingell-Johnson/Wallop-Breaux funds, provided by anglers) to leverage research dollars.
- Worked with the U.S. Fish and Wildlife Service to eliminate its overhead charge for administering the sea lamprey program. With the elimination of overhead, the FWS has been able to improve its partnership with the Commission and to devote additional resources to sea lamprey control.
- Under President's Bush's Executive Order of May, 2004, the Commission has cooperated with many other agencies and non-government organizations to develop an aquatic-invasive-species action plan. The overall effort under the executive order may generate new funding and will most certainly lead to better coordination of activities by involving governments at all levels and NGO's in Great Lakes restoration.
- Trust fund accounts were established to accept donations from organizations and individuals.
- Subsequent to Canada's recent increase in funding, the secretariat has initiated discussions with the Ontario Ministry of Natural Resources and the Ontario Federation of Anglers and Hunters to identify opportunities for new partnership contributions to sea lamprey control.

Discussion: A scarcity of funds for resource management activities necessitates partnerships. Partners can often accomplish together what is beyond the scope of individual parties. The Commission has made substantial progress in seeking and implementing both research and fisheries management partnerships. These partnerships have improved delivery of the Commission's program and the management of the Great Lakes ecosystem.

APPENDIX

Revised Milestones for the Healthy Ecosystem Vision Statement

4. Improve habitat

- ~~Gains and losses of aquatic habitats will be classified and inventoried in a comprehensive manner for each Great Lake. [Deleted in September 2005]~~
- ~~An interagency effort to protect critical habitats and restore other habitats will be organized and begun. [Deleted in September 2005]~~
- Promote the development and use of complementary approaches for assessing gains and losses of Great Lakes habitat. [Adopted in December 2003 and relocated from Milestone 5 to Milestone 4 in September 2005]
- ~~An action plan that reviews past roles and policies regarding toxic substances and that identifies new ways for the Commission to interact with other agencies to achieve reductions will be developed by 2003. [Deleted in September 2005]~~
- Assess the potential for “aquatic protected areas” (APA’s) to contribute to rehabilitation of native deep-water species and identify potential information needs that must be met prior to their effective implementation. [Added in September 2005 to replace bullet two above]

5. Gain new information

The Board of Technical Experts by 2002 will initiate research that

- assesses causes of change in Great Lakes fish communities,
- ~~provides a workable method for detecting gains and losses of critical Great Lakes habitats by 2005, [Deleted in December 2003]~~
- identifies the degree to which ~~toxic substances and diseases together~~ have influenced fish populations, and [Modified by strikeouts in September 2005]
- establishes a forum for intercontinental exchange of information on issues affecting large lakes.

MISCELLANEOUS PUBLICATIONS

- February 1993 What's next? the prediction and management of exotic species in the Great Lakes (report of the 1991 workshop). E.L. Mills, J.H. Leach, C.L. Secor, and J.T. Carlton. 22 p.
- August 1993 A survey of fish-community and habitat goals/objectives/targets and status in Great Lakes areas of concern. J.H. Hartig. 95 p.
- August 1993 Toward integrating remedial-action and fishery-management planning in Great Lakes areas of concern. J.H. Hartig. 34 p.
- September 1994 Walleye-rehabilitation guidelines for the Great Lakes area. P.J. Colby, C.A. Lewis, R.L. Eshenroder, R.C. Haas, L.J. Hushak. 112 p.
- April 1996 A lake trout restoration plan for Lake Superior. M.J. Hansen [ED.]. 34 p.
- August 1998 A lake trout rehabilitation guide for Lake Huron. M.P. Ebener [ED.]. 48 p.
- May 2003-01 A rehabilitation plan for walleye populations and habitats in Lake Superior. M.H. Hoff [ED.]. 22 p.
- May 2003-02 A lake sturgeon rehabilitation plan for Lake Superior. N.A. Auer [ED.]. 28 p.
- May 2003-03 A Brook Trout Rehabilitation Plan for Lake Superior. L.E. Newman, R.B. DuBois, and T. N. Halpern [EDs]. 39 p.