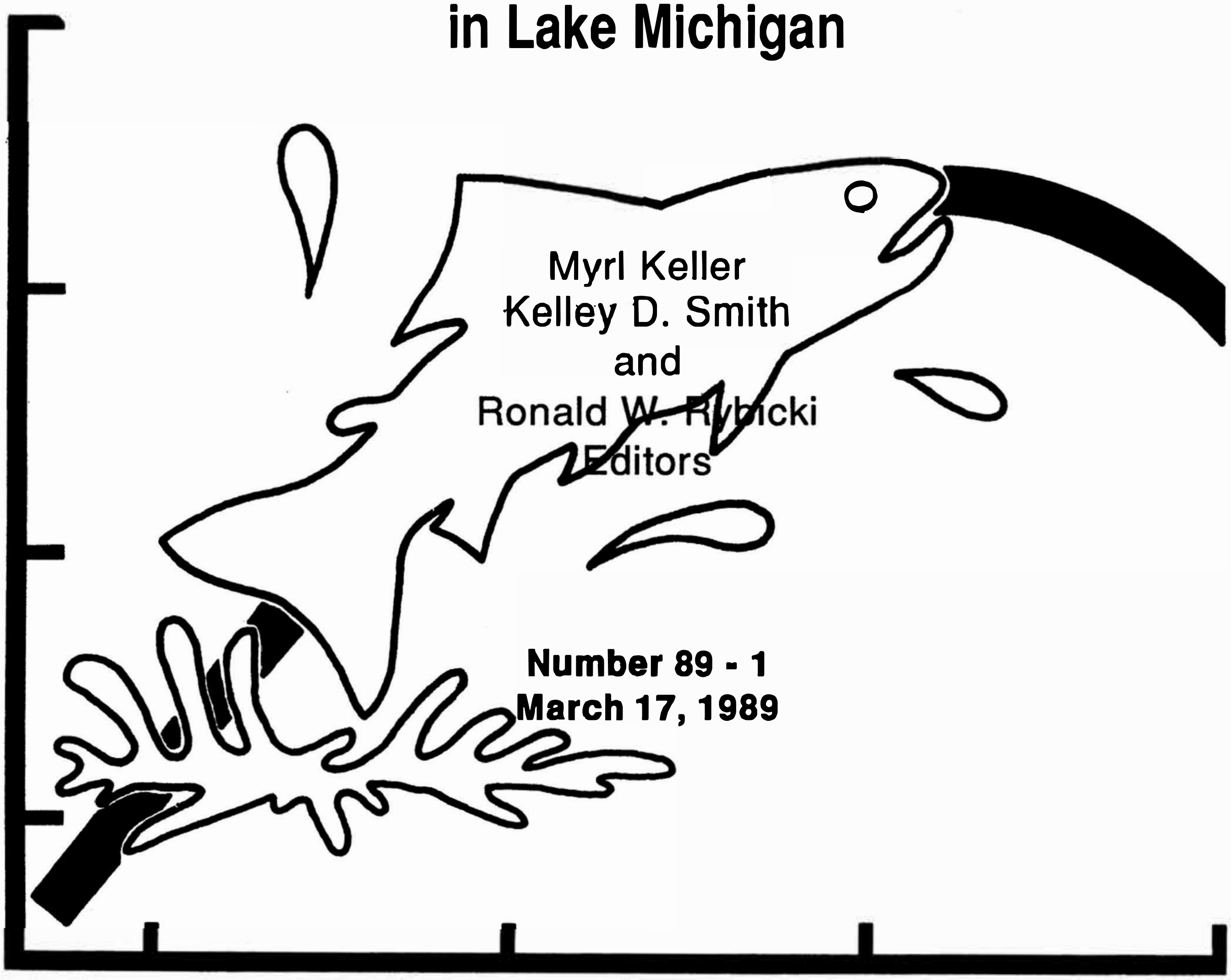
89-1

FISHERIES DIVISION

TECHNICAL REPORT

Summary of Salmon and Trout Management in Lake Michigan



Myrl Keller
Kelley D. Smith
and
Ronald W. Rybicki
Editors

Number 89 - 1
March 17, 1989

Michigan Department of Natural Resources

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FISHERIES DIVISION

Fisheries Technical Report 89–1

March 17, 1989

SUMMARY OF SALMON AND TROUT MANAGEMENT IN LAKE MICHIGAN[1]

Myrl Keller

Kelley D. Smith

and

Ronald W. Rybicki[2]

Editors

---

[1]Contribution from Dingell-Johnson Project F-53-R, Michigan.

[2]Prepared by Lake Michigan Salmonid Task Force. Presented at Natural Resources Commission Meeting March 9–10, 1989, Lansing, Michigan.

LAKE MICHIGAN TASK FORCE

<u>Cannon Downriggers</u>
Lou Pomaville

<u>Federation of Fly Fishers</u>
James Schramm

<u>Grand Traverse Bay Sportfishing Association</u>
William Hicks   James Mattis

<u>Great Lakes Fishery Advisory Committee</u>
Alberta Bradford

<u>Great Lakes Sportfishing Council</u>
Walter Olmstead

<u>Lake Michigan Sport Fishing Coalition</u>
John Keyser

<u>Michigan Boating Industries Association</u>
Ray Underwood

<u>Michigan Charterboat Association</u>
Dennis Grinold

<u>Michigan Department of Natural Resources</u>

Myrl Keller	Dell Siler
Jerry Manz (Retired)	Kelley Smith
Leo Mrozinski	Wayne Tody (Retired)
Donald Reynolds	John Trimberger
John Robertson	Bernhard Ylkanen

<u>Michigan Fisherman Magazine</u>
Kenneth Darwin

<u>Michigan Steelheaders Association</u>
Andrew Pelt   William Geisler
John Rutherford

<u>Michigan United Conservation Clubs</u>
Mark DuCharme

<u>Natural Resources Commission</u>
Gordon Guyer

<u>Trout Unlimited</u>
James Bedford

<u>U. S. Advisor to the Great Lakes Fish Commission</u>
Paul Wendler

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In 1964, the Michigan Department of Natural Resources made a major policy decision to launch a full-scale program to rehabilitate the fishery resource of its Great Lakes. Since then, ecological balances have been restored because of the successful introductions of Pacific salmon, increased plantings of steelhead and brown trout, controls placed on the commercial fisheries, the Great Lakes Fishery Commission's successful efforts to control the devastatingly predacious sea lamprey, and the stocking of lake trout by the U. S. Fish and Wildlife Service (USFWS). The combined effect of these monumental efforts, which have been heralded as one of North America's most outstanding achievements in fishery management, has been the creation of a multimillion dollar sport fishery on Lake Michigan.

However, the Lake Michigan sport fishery for chinook salmon in 1987 was atypically poor, a condition which prompted a review of current fishery programs on Lake Michigan. This charge was assigned to a task force consisting of Fisheries Division personnel and representatives from major user groups. The Indian tribes were also invited to participate in the task force.

The purposes of this report are 1) to consolidate the extensive information available on Lake Michigan's fisheries and fish stocks and 2) to present management and research recommendations designed to reestablish the quality of the fishery enjoyed in recent years. We make no attempt to explain factually why the 1987 salmon fishery failed to live up to expectations, however, several theories are advanced that could account for the problem.

Management Recommendations

It has become evident that changes in our management plans, including some reductions in catch limits, are necessary to achieve equitable allocation of the Lake Michigan fishery resource, thus maintaining the quality fishery to which we have become accustomed. The following recommendations for future management of the Lake Michigan fishery resources are based on the idea that stocks are interjurisdictional and, therefore, should be managed within the context of the entire ecosystem to maximize public benefit.

1. *Establish uniform management goals for salmonid stocks between the states.*
2. *Establish uniform sport and commercial fishery regulations between the states.*
3. *Implement a "Joint Strategic Plan" between the states for the management of salmonid stocks which includes the following criteria.*

a) Consensus decisions.
b) Accountability performance.
c) Environmental management.
d) Information exchange.

4. *Manage alewife, bloater chub, smelt, and sculpin populations as the principle food source of salmonid stocks.*

5. *Seek opportunities to expand annual lake-wide salmonid stocking.*

   a) Adjust stocking levels to maximize predator usage of available forage species based on the biological and ecological constraints of the predator-prey interactions within the lake.
   b) Establish rigorous hatchery practices and procedures to guarantee future product quality.
   c) Seek cooperative long-term goals for planting salmonids in Lake Michigan with the other state agencies.
   d) Maintain close scrutiny on the predator-prey dynamics within the lake and commit to improved evaluation methods lake wide in conjunction with the other state agencies.

6. *Develop a new cooperative lake trout policy.*

   Short range goals:

   a) Extend the lake trout season to Labor Day (May 1 to Labor Day; 2 fish limit) to be compatible with Wisconsin.
   b) Continue the experiment of self-sustainability on a reduced scale.
   c) Include lake trout in the total salmonid sport fishery plan.

   Long range goals:

   a) Pursue and achieve the goal of self-sustainable lake trout stocks throughout Lake Michigan.
   b) If necessary, implement stocking of state-raised lake trout to maintain the salmonid species mix in the sport fishery.
   c) Reduce the demands on hatchery facilities in rearing and maintaining broodstocks by obtaining eggs from fish that have demonstrated their capability to survive the rigors of lake life. The broodstock program for lake trout should be de-emphasized and replaced by collecting eggs directly from spawning stocks in the lake.
   d) If and when state fish are raised and planted for a sport fishery, increase the daily catch or possession limit from 2 to 3 fish (lake or stream), with a year-round open season.

7. *Reduce indiscriminate losses of salmonid stocks to enhance sportfishing opportunities.*

   a) Increase enforcement of regulations.
   b) Remove damaging commercial gears under state jurisdiction from salmonid waters.
   c) Pursue recovery of all losses incurred from industrial or other activities which are detrimental to salmonid stock health.

8. *Sea lamprey control.*

   a) *The current level of funding for sea lamprey control on Lake Michigan should be expanded to ensure continued low levels of lamprey populations in the lake.*
   b) *New technology for controlling lamprey should be a top priority in sea lamprey research. Major emphasis should be centered on obtaining natural or biological controls rather than chemical. Research funding and capabilities should be increased and improved to implement the required studies.*

9. *Cooperative action and ecosystem management are vital to protecting Lake Michigan's natural resources, improving water quality, and ensuring adequate water supplies into the future.*

10. *If the continuation of state-licensed commercial fisheries on species other than valuable sport or designated forage fishes is desirable, it is mandatory to employ gear which minimizes losses of non-target stocks. The industry must apply new technology and ingenuity in developing this gear.*

11. *Charter industry.*

    a) *The need for discontinuing the open-access policy on licensing charter-fishing operations and creating a limited entry policy will be determined through future studies of the industry and its impact on salmonid withdrawals. A ceiling on the number of charter licenses will be established based on the findings of this research.*
    b) *The charter catch limit on any trip should be restricted to only that of customers. Captain and mate rods may be used to achieve this limit.*
    c) *Mandatory reporting of catch-by-species and effort data should be instituted as soon as possible.*

12. *Tournament angling events should encourage conservation ethics by establishing rules that minimize killing of salmonids.*

13. *Implement aquatic resource education programs and promote conservation ethics.*

14. *Implement the proposed Salmonid Research Plan cooperatively between bordering management agencies, universities, federal agencies, and the private sector.*

15. *Salmonid sportfishing regulations on Lake Michigan and tributary streams should comply with the 1988 Michigan Fishing Guide restrictions on hook-and-line angling with the following changes.*

    Short range goals (1989):

    a) *On Lake Michigan and its connecting waters, the size limit for trout and salmon shall be 10 inches and the possession limit shall be 5 fish singly or in combination but no more than 3 of any one species except pink salmon, nor more than 2 lake trout or splake.*
    b) *On Lake Michigan streams from the last Saturday in April to September 30, the size limit on trout and salmon shall be 7 inches in the Upper Peninsula and 8 inches in the Lower Peninsula and the possession limit shall be 10 in any combination but no more than 3 over 16 inches unless they are pink salmon. At all other times of the year on streams open to extended trout and salmon fishing, the size limit shall be 16 inches and the possession limit shall be 3 trout or salmon in any combination.*

c) The seasonal restriction on harvest of lake trout and splake shall be May 1 through Labor Day.

Short range goals (1990):

a) On Lake Michigan and its connecting waters, the size limit for trout and salmon should be 10 inches and the possession limit should be 3 fish singly or in combination for any species except pink salmon, nor more than 2 lake trout or splake.
b) On Lake Michigan streams from the last Saturday in April to September 30, the size limit on trout and salmon should be 7 inches in the Upper Peninsula and 8 inches in the Lower Peninsula and the possession limit should be 10 in any combination but no more than 3 over 16 inches unless they are pink salmon. At all other times of the year on streams open to extended trout and salmon fishing, the size limit should be 16 inches and the possession limit should be 3 trout or salmon in any combination.
c) The seasonal restriction on harvest of lake trout and splake should be May 1 through Labor Day.

Long range goals:

a) The 1988 sportfishing regulations on daily catch or possession limit for salmonids on Lake Michigan and its tributaries with extended trout and salmon seasons should be re-instituted for any species when catch rates and abundance levels warrant such action.
b) The seasonal restriction on harvest of lake trout and splake should be discontinued with the daily catch and possession limit raised to 3 fish (lake or stream).
c) Endorse and commit to the termination of legalized snagging in all waters of the State of Michigan.

Salmonid Research

Fishery biologists have been and always will be dependent on the results of research studies to provide methodology for the successful management of fishery resources. During the current review of the fishery program in Lake Michigan, it has become obvious that there are critical gaps in our knowledge of the salmonid resources and community interactions in Lake Michigan which preclude certainty in our management decisions. A major portion of the Great Lakes research program in Michigan has been devoted to monitoring commercial operations targeting on bloater chubs and whitefish, and monitoring and evaluating the efforts to rehabilitate lake trout stocks. It is now time to set a new direction for research that focuses on the valuable salmonid stocks prized by anglers who are paying for the management of our fishery resources.

Biology

With the exception of lake trout, very little is known about the biology of salmonids inhabiting Lake Michigan. Future research should be aimed at the following categories.

1. *Wild recruitment.—If stocking levels are to be adjusted such that predator-prey interactions are balanced, then the contribution of natural reproduction by each salmonid species must be determined.*

2. *Forage biomass.—Annual estimates of the available forage biomass and its productivity are desperately needed to establish and maintain the predator-prey balance.*

3. *Early life history.—Factors affecting the survival and growth of smolts must be analyzed to predict and improve the surplus of fish available to anglers.*

4. *Food habits.—If predator levels are to be linked to forage base, then food habits of all species during the various life stages and seasons throughout the Lake Michigan basin must be understood.*

5. *Hatchery practices.—Hatchery practices, from egg-take to the planting of smolts, should be evaluated to ensure the availability of the highest quality product.*

6. *Mortality.—Mortality due to natural causes and fishing must be determined and used in developing population dynamics models.*

7. *Age determination.—More precise methods of determining the age of fish are necessary to assess long-term trends in growth rates, which are important components of population dynamics models.*

8. *Distribution.—The spatial and temporal distribution of salmonid stocks are required to fine-tune stocking locations, classify individual stocks, and determine the number of fish harvested in and originating from the waters of other states.*

9. *Exotic species.—Newly introduced exotic species of aquatic organisms must be closely monitored to determine whether or not there are adverse effects upon the existing fauna.*

Ecology

If the future viability of the Lake Michigan ecosystem is to be maintained, then habitat quality and preference, predator-prey interactions, inter- and intra-specific competition, and stock identification are all necessary. The following studies need to be implemented on Lake Michigan.

1. *Predator-prey interactions.—This will allow continued assessment of the impact of predators on specific forage species.*

2. *Inter- and intra-specific competition.—The effects of inter- and intra-competition on both salmonid and forage species during critical life stages should be studied. Habitat preferences by these species need to be clearly defined in conjunction with the predatory and competitive interactions observed within the system.*

3. *Environmental quality.—Environmental quality should be monitored and improved whenevěr possible.*

4. *Stock identification.—Individual stocks should be identified for those species demonstrating significant levels of natural recruitment. This would allow more clearly defined management decisions to be made based on the dynamics of the individual stocks and their relationships with other stocks. Both marking and electrophoretic studies should be implemented to obtain this information.*

Economics

In addition to the foregoing biological research needs, it is important that managers know and understand the social and economic aspects of the people they serve. Management proposals often can have economic impacts on individuals or communities, and these impacts must be taken into account at some time during the decision making process. Although major efforts have been implemented to determine the economic impact of the Lake Michigan fisheries, more research is required to complete the picture.

Implementation

It is clear that a large amount of research is required before answers can be given to so many of the questions posed by both managers and user groups. Priorities need to be restructured such that research emphasis focuses upon salmonid stocks important to the sport fishery. The common stock concept and the complex interactions among fish species require that research studies be designed to treat Lake Michigan as a single community. This, in turn, necessitates full cooperation and coordination of research and management efforts among the four states bordering the lake. The cost of such research effort will be high. However, the rewards will be equally great, and following generations will be able to enjoy the quality fishing that has been ours for the past 20 years.

Management of Salmonid Fisheries

Hatchery practices and product quality

In the rearing of Pacific salmon, hatchery production has become predictable and quality smolts have been produced year after year. Estimated survival of smolts remains high, high by ocean standards, with values ranging from 15–30% based on returns to the sport fishery and harvest weirs. Current hatchery product appears satisfactory and fairly consistent from year to year. Variation in survival after stocking is likely due to environmental factors influencing fish health.

Management of the forage base

Although the future success of the salmon and trout sport fisheries depends on the proper management of a diverse forage base, management agencies have not allocated these forage species as the principal food source of the salmonid populations. Some states allow alewives, bloater chubs, and smelt to be harvested commercially for a low price per pound and used as pet food.

Since diet studies indicate that the 311 million pound biomass of adult chubs (over 150 mm in total length) is essentially unavailable as forage, the consumption rate of available forage is approximately 28% (146 million pounds eaten out of 500 million pounds available).

Although the most recent diet studies indicate a continued reliance by the major salmonine predators on alewives, salmonids will prey, to some degree, on the available stocks of bloaters and other forage species besides alewife. There are concerns about the instability of the alewife stocks and whether the predators will survive and grow as well if dependent on the other prey species (principally chubs).

It would be prudent to manage for a well-balanced forage base to ensure a stable, high-density salmonid population. Alewives, bloater chubs, smelt, and sculpins should be managed for the purpose of securing an essential, diverse mix of forage. Therefore, a reduction or, more likely, termination of commercial operations competing for these species is inherent to the success of this management proposal.

Salmonid stocking levels

Given the present composition and estimated abundance of forage in Lake Michigan and the current demand by predators, it is possible that a larger salmonid population could be supported than presently inhabits the lake. Therefore, it is recommended that the lake-wide stocking level (13.4 million fish in 1987) be adjusted to maximize predator usage of available forage species based on the biological and ecological constraints of the predator-prey interactions within the lake.

Indiscriminate losses

The commercial fishing industry and other water uses (e.g., the Pump Storage Plant at Ludington), have resulted in substantial indiscriminate losses of the fishery resource. Certain types of highly efficient commercial fishing gear, and more specifically the manner in which they are commonly employed, can be lethal to salmonids. In 1985, Indiana reported that their 20 commercial gill-net operations killed an estimated 76,000 young chinook salmon. In 1986, Illinois reported that 44,700 salmon and trout were killed by their 5 commercial gill-net operations, and in 1987 it was estimated that at least 110,000 salmonids were killed in commercial gear fished in Wisconsin's waters of Lake Michigan. Losses of salmon and trout to the Ludington Pump Storage Plant have been estimated to be about 5% of the population. Some states have taken, or expect to take, action to curb indiscriminate losses.

Lake trout management

Even though there have been 53 million lake trout stocked in Lake Michigan over the past 2 decades, natural reproduction by the species has been virtually nonexistent in the lake. The last 20 year's experience in Lake Michigan lake trout management has demonstrated that achieving the goal of full, lake-wide sustainability is open to question. It will remain so until tough regulations are imposed to decrease fishing mortality.

Stability of the high-quality sport fishery can only be sustained through a multispecies mix of trout and salmon, most of which are hatchery supported. However, the existing federal lake trout stocking policy is not totally compatible with this maxim. The USFWS policy on lake trout stocking clearly states that lake trout produced in national hatcheries for the Great Lakes are to be used to restore depleted stocks in accordance with the goal of self-sustainability. Under this policy many of the lake trout furnished by that agency will be placed in refuges where fishing for trout is prohibited. State agencies on the upper Great Lakes, through their own lake trout policies, can support the rehabilitation experiment by including lake trout in the total salmonid management plan, developing the hatchery capability to plant large numbers of lake trout for the sport fishery, and by establishing uniform, lake-wide regulations on sport and commercial fisheries for the purpose of improving the fishery resource.

Charter fishery

Lake Michigan sportfishing has become a major industry in most Michigan ports, and the growth of the charter-fishing industry has been dramatic. The number of Michigan licensed charter-fishing operations working Lake Michigan has increased from 177 boats in 1976 to 639 boats in 1986. Michigan's Lake Michigan charter industry has created customer expenditures estimated at 26.2 million dollars. Charter fishing is an important element of Michigan's tourism industry.

However, there is concern that continued growth of the charter industry could ultimately place such a demand on the fishery resource base that there would be no surplus available to other anglers. In that event, an expanded charter fleet would preempt the Michigan Department of Natural Resources (MDNR) policy of equitable allocation of the fishery resource, and likely would put an unobtainable demand on the fish stocks which, in turn, would greatly reduce the economic viability of the charter industry. Thus, the open-access policy for new charter operations should be reviewed for Michigan's waters of Lake Michigan. The need for changing the open-access policy to one of limited entry with a maximum number of licenses should be determined through further study of the industry and its impact on salmonid withdrawals. Any ceiling on the number of licenses issued should be established based on the findings of this research.

Direction of Future Management

Concept of common stocks

The Lake Michigan fish community is inextricably linked to man's activities. Thus, humankind is obligated to exercise careful stewardship over this sensitive, bountiful natural resource. In a sense, the evolution of the Lake Michigan fish community is analogous to that of a shepherd and his sheep seeking new pasture lands for grazing. The lake is comparable to a pasture with an abundance of green grass (the untapped forage base), the introduced salmonids are the sheep, and the various management agencies act in the role of shepherds. If sound management practices are applied and stability is attained, then the flock should do well far into the future. Even with just casual tending, the Lake Michigan pasture land has provided one of the most productive recreational fisheries on the North American continent. Since the flock is free to move throughout an ever changing pasture, it is clear that they, the grazing rights, and therefore the pasture are not under the control of a single shepherd, but must be shared with others. This leads one to the conclusion that the common stock concept compels all agencies to cooperate in developing lake-wide research and uniform management plans, if the future success of the salmonid sport fishery is to be assured.

Joint strategic plan

Although fishery agencies of states bordering Lake Michigan have been partially successful in solving management problems, many issues remain unresolved because of differing philosophies among state management groups.

The necessity of uniform regulations was underscored when native stocks were being depleted from Lake Michigan. Recent rapid changes in the fish community have tested the ability of agencies to respond, in a coordinated and timely manner, with appropriate management practices and goals.

In 1980, a joint strategic plan for the management of Great Lakes fisheries was prepared and endorsed by all agencies bordering the lakes. The plan identified underlying obstacles which have thwarted past management efforts, suggested broad strategies to resolve them, and proposed a coherent set of procedures to initiate implementation. The plan has not yet been fully implemented but progress is being made. It is important that this process continue.

<u>Sea lamprey</u>

The predatory sea lamprey, a native of the Atlantic Ocean, was first recorded in Lake Ontario in 1835. Completion of the Welland Canal in 1825, which connects the Hudson River to Lake Ontario, allowed this species to invade the Great Lakes system. By 1921, lamprey were found in Lake Erie and have since spread throughout the remaining three Great Lakes. Lamprey, along with overexploitation, were responsible for the collapse of native fish stocks in the upper lakes during the 1950s.

In 1955, the United States and Canada ratified the "Convention on Great Lakes Fisheries" and the Great Lakes Fishery Commission (GLFC) was established. One of the major tasks of the GLFC is to formulate and implement programs for eradicating sea lamprey populations from the Great Lakes. The sea lamprey management plans provided by the GLFC to date have been successful in reducing the impact of this species on Great Lakes fish stocks.

Sea lamprey control was, and will continue to be, basic to any fishery management plans aimed at restoring, maintaining, and enhancing Great Lakes fish stocks. To date, the Great Lakes fishery restoration program has created annual economic activity estimated in the billions of dollars, with the Lake Michigan salmonid sport fishery and related businesses benefitting most from these programs. Without sea lamprey control, the fishery restoration program would never have succeeded.

The GLFC's funding for sea lamprey control is shared by the United States (69%) and Canada (31%), with each jurisdiction sharing half of the costs for other operations and administration. The GLFC has recently announced that, because of funding short falls, it will cutback the sea lamprey control program starting in 1990. It has been estimated that this reduction will allow sea lamprey numbers to double in the lower four Great Lakes with a corresponding decrease (upwards of 50%) in trout and salmon populations by the year 2000. This poses a serious threat not only to the fishery resources of the Great Lakes, but also to the quality of life in the Great Lakes region. A complex variety of businesses, which constitute the sport and commercial fishing enterprises and tourism infrastructure in the Great Lakes area, will be in serious jeopardy.

The beneficiaries of the sea lamprey control program are not only the fishery resources themselves, but also the user groups and economies of the jurisdictions bordering the Great Lakes. The cooperating agencies, local governments, and private enterprises continue to increase their investments in the fishery resources. The two federal governments must fully fund lamprey control and research in order to ensure the continued quality and enhancement of our fishery resources and to guarantee that the benefits of past and future investments will not be lost.

Water quality

Lake Michigan is a unique and valuable resource shared by four states. Public interest in protecting this fragile ecosystem has expanded to cover all facets from invertebrate to vertebrate species, habitat degradation, water loss or diversion, and all forms of pollutants which invariably end up in the water and sediments of the lake. These concerns affect people in all bordering jurisdictions implying that Lake Michigan is truly a regional resource and should be managed in a context which crosses political boundaries.

As a major shareholder in Lake Michigan, the State of Michigan will be the keystone in any regional water management initiative. The state has played a leadership role in the protection and development of Lake Michigan, supporting regional actions including the adoption of a Great Lakes Charter in 1985 and the Great Lakes Toxic Substances Control Agreement signed in 1986. The four bordering states and the U. S. Environmental Protection Agency worked together to develop a Lake Michigan Toxic Pollutant Control/Reduction Strategy. Many of these actions are currently being implemented.

However, there is much to be accomplished to fully protect the Lake Michigan ecosystem from all sources of degradation. Controlling municipal pollution sources, phosphorous, and non-point source pollution are major challenges facing Great Lakes decision makers. Recognition of what is potentially the greatest problem, toxic pollution, is relatively new. As a result, appropriate control technologies have yet to be identified. The sheer volume of toxic compounds and the variety of pathways of contamination frustrate many attempts to develop solutions.

Indirect sources of pollution also pose a threat to the quality of Lake Michigan water. For example, wastes often enters the lake system through uncontrolled disposal. Contaminated sediments pose several problems due to the re-suspension of toxic substances which results from dredging and continual natural recycling of the water column. In addition, all of the Great Lakes are particularly susceptible to airborne pollutants due to their large surface area and proximity to major industrial centers.

Ecological factors, such as the natural or man-induced invasion by non-native species, habitat changes, and random variations in organism populations must also be recognized for their particular impact on the quality of Lake Michigan. Cost-effective and realistic management can only come through interagency cooperation in utilizing an ecosystem approach to address these concerns on Lake Michigan.

Cooperative action and ecosystem management is vital to protect Lake Michigan and ensure adequate water supplies into the future. However, the challenge of managing Lake

Michigan cannot be met solely by government, industry, the scientific community, or the public, but requires cooperation of all four. This group needs to commit itself to addressing critical problems and identifying development opportunities. Michigan will need to continue its leadership role in supporting policies and laws that strengthen regional stewardship. By acting in concert with all concerned groups, Michigan can help to establish a comprehensive water management process that will protect the Great Lakes for present and future generations.

REPORT SUMMARY

Description of Lake Michigan

Lake Michigan ranks sixth in size among the world's freshwater lakes, and is the only Great Lake entirely within the United States. Lake Michigan has a surface area of 22,400 square miles, a length of 307 miles, and a maximum width of 118 miles. Its maximum depth is about 923 feet and averages 276 feet. Its shoreline length is 1,661 miles and the drainage basin covers 67,860 square miles (including the lake).

The historical fish fauna of Lake Michigan was comprised of a wide array of species. Directly or indirectly, man's activities have resulted in great change in the past 130 years. All but one of seven cisco species, sturgeon, lake herring, lake trout, and the emerald shiner had declined in abundance or disappeared entirely by the 1960s. Commercial exploitation, invasion by marine species, accelerated eutrophication in localized areas, and inadequate management of the resource were contributing factors. In the 1960s, however, lamprey control was well underway, the alewife population burst into pestilential proportion, Pacific salmon were introduced to redress the ecological imbalance, and lake trout restoration was begun.

History of the Lake Michigan Fishery

The early commercial fishery developed with settlement along the shoreline and grew rapidly. The lake whitefish was the backbone of the early fishery, as it is today. Lake-wide catches of the species peaked at 12 million pounds before 1900 and have since fluctuated greatly. A near collapse of the whitefish population occurred in the mid-1950s, but it has increased in abundance since the 1960s because of lamprey control and restructuring of the commercial fishery by the MDNR. As a result of the restructuring process, the number of state-licensed participants in Michigan's over-capitalized commercial fishery was gradually reduced from 405 licenses in 1967 to 30 in 1987.

Lake Michigan's historical recreational fishery is much more difficult to quantify than its commercial fishery. The earliest reference to fishing for sport came in 1895 when mention was made of pleasure fishing by a great many people in the Chicago area. For many years the Michigan Department of Conservation operated under the de facto policy that the commercial fishery should have the highest priority for utilization of valuable fish populations. In 1966, the MDNR broke from tradition and established a Great Lakes fishery policy which made recreational fishery management its primary goal and relegated commercial fishing to a secondary role. Henceforth, the commercial harvest of major sport species, such as walleye, lake trout, and yellow perch was prohibited. As a direct result of that policy and other management initiatives, the Lake Michigan sport fishery blossomed in 1968 and has since grown to maturity.

History of the Broodstock

Lake trout

Most of the lake trout planted in Lake Michigan today come from the Marquette Hatchery's domesticated broodstock, which has a predominantly Lake Superior gene pool. These brood fish originated from eggs produced by a strain of inshore lean trout taken from Marquette Harbor, Lake Superior in 1948.

Rainbow trout (steelhead)

Great Lakes rainbow trout (popularly called steelhead) usually result from eggs obtained from spawning, wild fish that resemble the ocean variety in appearance. Steelhead officially were introduced by the Michigan Fish Commission in 1880 and were from eggs imported from California's McLoud River.

Chinook salmon

Two strains of chinook salmon eggs for Michigan's 1967 plants came from Oregon and Washington. The first was the Tule strain which came from Columbia River migrants and the second was the Puget Sound strain from Washington's Green River Hatchery. The state now obtains all of its chinook salmon eggs from fall spawning runs trapped at the Little Manistee River weir.

Coho salmon

Coho salmon were first planted in Lake Michigan in the spring of 1966. These smolts were produced from eyed-eggs obtained from the Columbia River at the Bonneville Dam, Oregon. Subsequently, coho salmon eggs have been obtained from the Cascade River (Oregon), the Toutle River (Washington), and Alaska. Michigan became self-sufficient in the production of coho eggs in 1967. The Platte River serves as the source of broodstock for the Washington and Oregon strains. The Alaskan strain, which was perpetuated from spawning runs in Thompson Creek, has since been lost.

Atlantic salmon

As early as 1875, Atlantic salmon were stocked in numerous waters, including Lake Michigan tributaries. However, none of the early plants became an established population. In 1972, Michigan obtained and stocked 20,000 Atlantic salmon smolts of the Cascapedia River strain from Quebec, which has since been lost. The planting of Gullspang Atlantic salmon imported from Sweden in 1973 also failed. Presently, Michigan is embarking on an Atlantic salmon program involving the landlocked Sebago strain obtained from Maine. It is expected that there will be an egg-take in the fall of 1988 and hopes are eventually to produce 250,000 smolts annually.

Brown trout

Brown trout were released into the Pere Marquette River, a Lake Michigan tributary, by the Michigan Fish Commission in 1884. These original brown trout were imported from Germany. Michigan ultimately developed its own variety of brown trout, known as the Harrietta strain, after many years of broodstock selection. However, the brown trout broodstock program was discontinued in 1983. Since that time, the USFWS has provided the state with eggs from its Plymouth Rock and White Sulphur Springs strains.

Characteristics of the Hatchery Product

Lake trout

Lake trout are planted as yearlings often having spent about 18 months in the hatchery. Beginning in 1983, epizootic epitheliotropic disease (EED) virus in the Marquette and Iron River (Wisconsin) hatcheries has threatened the lake trout stocking program. These hatcheries went through a complete disinfection in the spring of 1988 in hopes of ridding the facilities of this virus.

Rainbow trout (steelhead)

Steelhead smolts show the best survival when released at 7 to 8 inches in size. To reach this length in 1 year, the fish must be reared in relatively warmwater (50 °F or more), which makes the Wolf Lake Hatchery the only suitable facility. Although the Wolf Lake Hatchery has been quite successful in producing a quality smolt, the main disease problem of steelhead has been recurring bouts with furunculosis. This hatchery was also disinfected in 1988.

Chinook salmon

For the most part, chinook salmon have been plagued by disease only sporadically, perhaps because they spend a relatively short time in the hatchery environment.

Coho salmon

Diseases which have been or are still a problem in coho include furunculosis, bacterial kidney disease, columnaris, infectious hematopoietic necrosis (IPN), coldwater disease, and viral erythrocytic necrosis (VEN). In addition to these diseases, coho salmon also show a high incidence of corneal and lens cataracts, which can effect up to 50% of the hatchery population.

Brown trout

Brown trout have encountered no persistent problem, although the species is susceptible to furunculosis.

Stocking History

From 1966 to 1982, all Lake Michigan jurisdictions stocked 79 million fingerling and 103 million yearling salmonids. Michigan waters of Lake Michigan received the most at 41 million fingerlings (52%) and 63 million yearlings (61%). During this period, Michigan waters received 36.2 million coho salmon yearlings, 18.7 million lake trout yearlings, 6.5 million rainbow trout yearlings, 2.2 million brown trout fingerlings, and 30.2 million chinook salmon fingerlings.

During the period 1983–87, 46 million fingerlings and 32 million yearling salmonids were stocked in all of Lake Michigan. Michigan stocked 8.6 million coho yearlings, 4.9 million lake trout yearlings, 2.7 million rainbow trout yearlings, 1.7 million brown trout fingerlings, and 13.4 million chinook fingerlings.

Stocking Plans

In the early 1980s, the MDNR became concerned about perceived changes in the average size of sport caught salmonids and changes in the forage base. As a result of these concerns, Michigan conducted a review of its pre-1985 salmonid stocking program and determined that it should reduce its overall stocking effort in Lake Michigan by 8.5% (as compared to 1980–84 average), beginning in 1985 and extending through 1990. The plan was implemented in the 1985 stocking year and has been adhered to each year since. An analysis of the Wisconsin stocking data revealed that the target stocking levels for 1987 and beyond were to be reduced by 8.5% as well.

Stream Management

The successful introduction of Pacific salmon into the Great Lakes began a new era in stream fishery management. Problems accompanied benefits. Fishermen, who found the dense schools of salmon irresistible, caused trespass problems on private land, littered fishing sites, caused physical damage to the stream by trampling banks and removing cover to take the fish, and illegally sold spawn. Large numbers of salmon in a stream made unintentional foul-hooking inevitable and illegal snagging easy. The ever-present snagging issue has progressed through a number of regulatory stages, beginning with seasonal snagging permitted on all rivers in 1969 to legislation in 1984 that authorized snagging at just four locations. The adverse impacts to salmon streams have been greatly reduced over the years because of fewer snagging sites, controls on salmon egg sales, installation of weirs that restricted upstream abundance of fish, and increased open-water catches.

Weirs

Weirs have been, and continue to be, constructed for the purpose of intercepting salmon and anadromous trout during their upstream spawning migration. Weirs usually are classified either as a blocking device to prevent the passage of salmon in some streams where their presence is considered undesirable, or as a harvest structure when 1) spawn products are stripped, and the donor either is passed upstream or the carcass is disposed of, or 2) salmon are trapped exclusively for marketing.

Fish passage

The enhancement of fish passage involves one of three processes: dam removal, fish ladders, or trap and transfer. The expansion of anadromous fishing through dam removal has opened up 54 miles of stream. When dam removal is not possible or desirable, one alternative is to build fish ladders around dams. Six ladders have been constructed on the Grand River alone, which allows salmon and steelhead to migrate inland through 155 miles of mainstream and 270 miles of tributaries. Occasionally, adult salmonids are trapped and manually transferred to another stream system; for example, mature steelhead have been transferred to the Pine and Big Manistee rivers to establish naturally reproducing populations there.

Sea lamprey control

Finding a method to control the rapacious sea lamprey precluded restoration of Great Lakes' fish populations. But in 1957, after screening over 6,000 chemicals, a compound called 3-trifluoromethyl-4-nitrophenol (TFM) was found which efficiently killed larval lamprey while in the stream environment. Lamprey-producing streams have since been chemically treated on a rotational basis, and adult lamprey populations have been reduced to less than 10% of pretreatment levels. Despite a reduction in number, lamprey remain a constant threat. Any reduction in the level of control is almost certain to result in a larger lamprey population, which will cause a corresponding loss of salmonids.

Rainbow trout (steelhead) fishery

Steelhead trout are managed primarily for a stream fishery. Management procedures on Michigan's top quality wild steelhead rivers are aimed at maintaining moderate runs that normally can be sustained by natural reproduction through habitat protection and angling regulations. Within the last several years, steelhead have become increasingly popular with the open-water fishery.

Salmonid Sport Harvest

Angling effort

Over 90,000 Lake Michigan anglers were interviewed during 1985–87. Fishing effort on waters within Michigan's jurisdiction was 6.3 million hours in 1985, 6.6 million in 1986, and 5.5 million hours in 1987. As compared to 1985 and 1986, angling effort in 1987 had decreased by 13% and 16%, respectively. The greatest angling effort (47–53%) was expended on the southern one-third of the lake (New Buffalo-Muskegon). The least amount of angling effort (15–17%) was spent on the northern one-third of the lake (Leland and northward) in the same period.

Chinook salmon

Chinook salmon are the most important salmonid in the Lake Michigan sport fishery. Chinook salmon comprised 50–58% of all the salmonids harvested during 1985–87. The majority (47–55%) of chinook salmon are caught in the central one-third of the lake (Pentwater to Platte Bay).

The poor representation of the 1984 year class may have contributed to the decrease in the 1987 catch of chinook salmon. The return to the creel of the 1984 year class (3.8%) at age 0.3 was much lower than the returns of the 1982 (8.5%) and 1983 (10.6%) year classes at the same age. Catch rate of chinook salmon in 1987 (4.3 fish per 100 angler hours) dropped slightly from that in 1986 (6.0 fish per 100 angler hours) and 1985 (5.8 fish per 100 angler hours).

Mean total lengths-at-age of harvested chinook salmon have shown some year-to-year variations during 1983–87. These annual variations in mean length-at-age may be dependent in part upon seasonal weather patterns and forage composition.

Coho salmon

Coho salmon made up 13–20% of the lake-wide salmonid harvest in Michigan's waters during 1985–87. The lake-wide harvest ranged from 99,800 coho salmon in 1985 to 138,600 in 1987. The majority (50–58%) of coho salmon were harvested in the southern one-third (New Buffalo-Muskegon) of the lake in 1985–87. The poor chinook fishery in the southern zone during 1987 was partially offset by the better than average coho catch. The sport fishery in Michigan waters harvested 8.5% of the 1984 year class and 8.7% of the 1985 year class.

Michigan-reared coho salmon appear in the fishery of the other Lake Michigan states. Wisconsin and Illinois anglers harvested 315,000 coho in 1985, of which 300,000 conceivably could have originated from Michigan hatcheries.

Mean total length of coho salmon taken by the sport fishery has not changed significantly since 1983. Mean total length at age 1.0 ranged from 15.3 to 17.0 inches, and at age 1.1 ranged from 22.4 to 23.9 inches.

Rainbow trout (steelhead)

Rainbow trout (steelhead) have made up only a small proportion (4–8%) of the Lake Michigan salmonid harvest during 1985–87. The lake-wide harvest ranged from 35,000 in 1986 to 46,000 in 1987. The offshore (usually 4–25 miles) fishery for steelhead has been developing for several years, and occurs mostly during the months of June through August. Recently, concern has been expressed by some members of the angling fraternity that the escalating popularity of this fishery may cause overharvest of the species.

The mean total length of steelhead caught in 1987 was about 25 inches.

Lake trout

Lake trout have been called the bread-and-butter fish of the Lake Michigan sport fishery. The overall role of lake trout in the sport fishery has decreased over the last 10 years because of angler preference for chinook salmon. However, lake trout are a very important substitute when the seasonal availability of chinook salmon is low.

Lake trout comprised 16–19% of the salmonid harvest during 1985–87. The lake-wide harvest of lake trout in Michigan waters in 1985–87 was quite stable and ranged from 127,500 to 139,900 fish. Catch rate was slightly higher in 1987 (3.5 trout per 100 angling hours) than in

1985 (2.6) or 1986 (2.7), perhaps because more anglers were targeting lake trout in 1987 due to the relatively poor chinook fishery.

Average total length and weight of lake trout in the sport fishery during 1983–86 ranged from 24.5–25.8 inches and 5.5–6.3 pounds. The modal length of harvested lake trout was about 24 inches. Raising the size limit to 18–20 inches would have little impact on the number harvested because few lake trout less than 21 inches are kept.

Brown trout

Brown trout made up 4–8% of the Lake Michigan salmonid harvest during 1985–87. The total catch in Michigan waters of Lake Michigan was 73,800 in 1986 and 27,700 in 1987. The 62% decline in harvest from 1986 to 1987 may have been due in part to the mild winter and early spring, which caused the brown trout to migrate to inshore waters earlier than expected and thus be missed by anglers. Most (up to 74%) of the brown trout catch comes from the central one-third of the lake.

Other salmonids

Small numbers of pink salmon, Atlantic salmon, brook trout, and splake are harvested each year by Lake Michigan anglers. These species combined make up less than 1% of the total salmonid catch in Michigan waters. Some 3,300 pink salmon were harvested in 1987. Fewer than 1,000 each of Atlantic salmon and brook trout are taken annually from Lake Michigan.

Weir Harvest

The first harvest and egg-taking facilities were constructed on the Little Manistee River and at the Platte River Hatchery. Fish harvested at these weirs through the 1970s were disposed of in several ways. Originally, they were sold on an annual contract basis to the highest bidder. Later, contaminant problems made such sales impractical or illegal, which resulted in the salmon being buried. And finally, fish were given away in some years to persons possessing a valid fishing license; although this was a popular method of disposal, the practice was stopped because the fish were determined contaminated by chlorinated hydrocarbons. Presently, surplus salmon harvested at the weirs are sold on bid for marketing within the United States (including Michigan) and overseas. In recent years, permanent harvest weirs have been installed on the Boardman River and Medusa Creek. Temporary weirs also have been used on the White and Jordan rivers to block the upstream migration of salmon.

Number and percent return

The total pounds of chinook salmon harvested at weirs on Lake Michigan tributaries during 1983–87 fluctuated from a low of 353,000 pounds in 1986 to a high of 624,000 pounds in 1987.

In the 1983–87 period, coho salmon harvest varied from a high of 1,268,000 pounds in 1983 to a low of 374,000 pounds in 1986.

Returns of chinook salmon (complete cohorts) to the Little Manistee weir decreased slightly from 5.9% of the 1981 year class to 5.7% of the 1982 year class, and still further to 5.0% of the 1983 year class. The 1984 year class has produced a cumulative return through age 0.3 of 1.8%, which is substantially below the average return of 4.1% for the 1981–83 year classes through the same age.

Poor returns of coho salmon have been reported for the last several years. Return rates for age-1.1 coho salmon at the lower Platte River weir consistently dropped from 15.6% for the 1981 year class to 6.5% for the 1984 year class. However, it appears the return rate of coho salmon has stabilized near 8% and is close to the return rate of chinook salmon.

Steelhead, brown trout, and lake trout have all been intercepted at the lower Platte River weir. Estimated numbers of steelhead at this weir have never exceeded 3,000 fish in a season during 1980–87. Brown trout numbers were much lower and lake trout numbers were negligible.

Size-at-age of fish harvested

The average length and weight of chinook salmon taken at the Little Manistee River weir was highly variable among years. However, some general trends can be seen. With the exception of large age-0.5 fish, both the average weight and length dropped between 1985 and 1986. For age-0.1 and age-0.2 chinook salmon, length and weight recovered somewhat between 1986 and 1987. However, age-0.3 and age-0.4 fish continued their downward trend in 1987.

The growth of coho salmon has been quite variable over the years. However, the magnitude of change has been small. Coho salmon harvested in 1987 were only slightly smaller than those taken in 1983.

Tribal Harvest

Unlike the state-licensed commercial fishery, the Ottawa-Chippewa Indian tribes possess the treaty right to commercially harvest lake trout and salmon in Lake Michigan. Since the negotiated settlement between the state and the tribes in 1985, Indian commercial fishing activity has been restricted mostly north of Traverse City. In 1987, the Indian commercial fishery reported harvesting 43,300 (216,600 pounds) lake trout and 872 (9,800 pounds) chinook from the northern zone of Lake Michigan.

Commercial Fishing Impacts

Although state-licensed commercial fishermen may not harvest trout and salmon, these fishermen sometimes take trout and salmon incidental to authorized chub and whitefish fisheries. Research has indicated that, in trap nets, the number of lake trout killed was very low in comparison to the number caught in the nets. On the average, 3–6% of all lake trout caught died from gilling during the 2-year study period. Other protected species observed in trap nets included steelhead, brown trout, salmon, yellow perch, and walleye. Only about 10% of all brown trout and walleyes caught in the trap net died from gilling. Mortality of steelhead, coho salmon, and chinook salmon averaged about 60%, however, the actual number of these species caught was low in comparison to lake trout abundance in the trap nets.

Michigan also authorizes six chub operations, which use small-mesh gill nets. In order to reduce gilling of lake trout, chub nets must be set on the lake bottom in depths greater than 240 feet. Research has shown that incidental harvest of lake trout at these depths is less than one trout per 1,000 lineal feet of gill net lifted.

Salmon Egg Sale

Under Michigan law, fish or parts of fish taken under the authority of a sportfishing license may not be sold. With the exception of salmon eggs, the unlawful sale of sport fish has not been a problem. Salmon eggs are commercially important because salmon caviar is considered a delicacy in some overseas markets, and are in much demand for use as fish bait throughout the United States. To control the black marketing of salmon roe and to enumerate the volume of egg sales, the MDNR authorized the sale of salmon eggs through a system of egg buying stations, which was ruled illegal by the Attorney General in 1985. Subsequently, enabling legislation was passed that authorized anglers to exchange salmon eggs for fish cleaning services at designated fish cleaning stations.

Biology of Salmonids

Coho salmon

Coho salmon have a 3-year life cycle. They spawn in streams during the fall of the year, hatch the following spring, and live as juveniles in the stream for an additional year. They migrate to Lake Michigan in the spring of the second year of life when smolting occurs.

Hatchery-reared coho salmon are planted in streams at about 18 months of age just prior to smolting. After spending about 18 months in Lake Michigan, the adult coho salmon return to their natal streams where they spawn and die.

The food consumed by coho salmon while in Lake Michigan has changed with a shifting forage base. In recent years, alewives, smelt, and bloater chubs have comprised the major portion of the fish diet of coho salmon in Lake Michigan.

Coho salmon have reproduced successfully in a number of Michigan streams, although the present contribution of naturally produced coho to the sport fishery is sketchy. In a study conducted in 1978–79, the lake-wide sport catch of coho salmon from Lake Michigan consisted of about 9% naturally recruited fish.

The available evidence indicates that coho salmon have had little competitive effect on native trout species in streams. The absence of competition may in part be due to spatial segregation between the species.

Chinook salmon

Fall chinook salmon, the strain chosen for introduction in Michigan's Great Lakes, migrate to and spawn in streams in the autumn. They usually return as 3- and 4-year-old adults to the stream in which they were either stocked or spawned. The young chinook smolts leave the rivers the following spring as soon as flows increase and temperatures rise.

A changing species composition of the Lake Michigan forage base has been reflected to some degree in the diet of eastern Lake Michigan chinook salmon. During 1969–72, alewife, smelt and a few sculpins accounted for nearly 100% of the fish-food items consumed by chinook salmon. By 1983–84, the predominant prey species was still alewife, but significant numbers of smelt and young bloater chubs were also found in the chinook salmon diet.

Naturally recruited chinook salmon fingerlings have been observed in at least 14 Lake Michigan tributaries. It has been estimated that wild chinook smolts produced in Lake Michigan tributaries accounted for about 23% of total production (hatchery plus wild) in 1979.

Lake trout

Populations of lake trout were extinct in Lake Michigan by the mid-1950s because of decimation by the parasitic sea lamprey and overfishing. Despite massive plantings, which began in 1965, lake trout have failed to reproduce themselves in significant quantities anywhere in Lake Michigan. Nevertheless, hatchery-reared lake trout have thrived in Lake Michigan and have provided a highly successful sport fishery.

The growth of lake trout in the southern zone appears to have decreased over the years. Length-at-age data show that length was consistently smaller over all age groups in 1985–87 than in 1975. The cause of the apparent loss in growth by southern zone lake trout is unknown, but it may be related to interspecific competition and more recently to the shift in the species composition of the forage base. The mean length of 5-year-old lake trout varied without trend from 1975 to 1987 in the central and northern zones.

The diet of lake trout in Lake Michigan has changed dramatically over the decades in response to an equally dramatic change in the fish-forage base. During 1966–67, 43% of the lake trout examined contained alewives, 16% were feeding on smelt, and 25% had consumed sculpins; at this time, bloater chubs were rapidly declining in abundance and ciscoes were virtually extinct. By 1983–84, alewives were overwhelmingly the most important food item (65%) followed by smelt (17%) and recovering bloater chubs (10%).

The lack of meaningful natural reproduction by lake trout continues to thwart the rehabilitation of the species in Lake Michigan. The cause of reproductive failure has not been conclusively demonstrated, but often is attributed to inadequate numbers of spawners and/or contaminant-laden eggs and fry.

The annual total mortality rates of Lake Michigan lake trout were very large during 1975–86, when the estimates ranged from a barely acceptable 45% to an unacceptable 76%. Annual exploitation rates during this period ranged from a low of 25% in 1976 to 53% in 1984. Hooking mortality of released lake trout averaged about 15%.

Rainbow trout (steelhead)

Present Lake Michigan populations of steelhead, the anadromous form of the rainbow trout, are maintained by a combination of natural reproduction and supplemental plantings of hatchery-raised fish. After 1–5 years in the lake, adult steelhead return to spawn in tributary streams in the spring. Juveniles spend from 1 to 3 years in the stream before migrating to the lake. Unlike Pacific salmon, steelhead do not invariably die after spawning.

Juvenile steelhead in Great Lakes tributaries feed primarily on drifting aquatic insects and, to a lesser extent, on terrestrial invertebrates. Older steelhead in the lake feed during the spring and summer predominantly on terrestrial insects in the surface film and on alewives. Steelhead in southern Lake Michigan also incorporate yellow perch and bloater chubs into their diets. In the fall, steelhead feed primarily on young-of-the-year smelt, bloater chubs, and alewives. Steelhead have also been found to eat the European waterflea which was accidentally introduced into Lake Michigan only a few years ago. While in the rivers, adult steelhead feed on aquatic invertebrates and, when available, on salmon eggs.

Naturally reproducing, or wild, steelhead populations exist in many tributary streams, in particular those in both northern lower and upper Michigan. Although Michigan has long had a substantial rainbow trout stocking program, it has been largely ineffective because of inappropriate hatchery practices, which are being corrected. Analysis of scale growth patterns has shown that steelhead populations in northern lower Michigan consist of more than 90% wild fish. Thus, the good-to-excellent steelhead fisheries of northern Lower and Upper Peninsula Michigan have been supported by natural reproduction.

Little is known about the movements or distribution of steelhead during their life in Lake Michigan. Anglers find adult steelhead near the shore during the spring and fall and far-off shore during the summer, generally inhabiting the near-surface waters.

Brown trout are the most abundant potential competitor of steelhead. Preliminary studies of the stream habitat preference of juvenile steelhead and brown trout indicated a great deal of overlap suggesting that competition for this resource may occur. The lake distributions and food habits of salmonids suggest that steelhead have a relatively unique niche throughout much of the year, which implies a minimum of interspecific competition.

Mortality during early stream life is generally believed to be variable and quite high. Egg-to-emergence mortality rate has been estimated to be as large as 95% on steelhead in a Lake Ontario tributary. Overwinter survival of age-1.0 parr to age-2.0 smolts was found to range from 13–90% and was negatively related to the severity of winter temperatures. Mortality rates for steelhead cohorts while in Lake Michigan are not known.

Brown trout

Brown trout populations presently in Lake Michigan and its tributaries can be classified into 1) wild stream-resident fish, 2) wild anadromous fish, and 3) hatchery fish that are stocked directly into the lake. Brown trout spawn in October and November in tributary streams and do not necessarily die after spawning. Young fish go through parr and smolt life stages that are similar to those described for steelhead. The fishery for brown trout is almost exclusively in the near-shore waters of Lake Michigan and in connected drowned river mouths.

Minor species

For the purposes of this report, pink salmon, brook trout, splake, and Atlantic salmon are treated as minor species. They are low in abundance and, for the most part, contribute little to the Lake Michigan fishery.

Pink salmon were unintentionally introduced into the Great Lakes in 1956 when 20,000 fingerlings were released into a north-shore tributary of Lake Superior. They have since successfully reproduced themselves, extended their range into lakes Huron and Michigan, and have been observed in 32 Lake Michigan tributaries. Pink salmon are potential competitors with other salmonines. The diet (by volume) of pink salmon in Lake Huron was found to be 45% smelt, 39% alewives, and 7% unidentified fish remains. Pink salmon normally have a 2-

year life cycle and spawn in streams in odd-numbered years but have developed in the Great Lakes a run in even-years, also.

Although highly prized by anglers, the native coaster brook trout population in Lake Michigan is very small and largely has been ignored by fishery managers. Most hatchery-reared brook trout planted in the Great Lakes have been stocked in Grand Traverse Bay of Lake Michigan and at a few locations in Lake Superior. These plants provided a good, albeit brief, fishery. Hatchery-raised brook trout typically inhabited shallow water and often disappeared about 18 months after planting.

Before the advent of lamprey control, the splake, a cross between male brook trout (or speckle trout) and female lake trout, was considered as having potential for filling the ecological niche vacated by the then extinct lake trout in lakes Michigan and Huron. However, a splake program was never developed for Lake Michigan, although a few token plants were made in Grand Traverse Bay in 1985–86.

Sporadic attempts the past 100 years have failed to establish Atlantic salmon in Lake Michigan. Nevertheless, some observations have been made on the species in Michigan. The Atlantic salmon usually begins its spawning run in streams in late May and early June, but does not spawn until early in the fall. The young salmon parr generally remain in the stream about 2 years before smolting and migrating to the Great Lakes. Some adult Atlantic salmon may survive to spawn two or more times. Of all of the Atlantic salmon releases made in and near the Manistee River system, only the 1982 plant was considered to have been minimally successful, perhaps because of the singularly large number planted.

Economics

The success of the Great Lakes salmon fishery resulted in substantial public and private investments. An example of public investment is the string of 68 protective harbors and public marinas developed by the Michigan Waterways Commission and 158 launching facilities developed through grants to communities in the state. Private investment is reflected in the sales of boats and boating accessories. In 1983, Michigan ranked fourth among the states in total sales (286 million dollars) of boats and accessories. Other private investments have been in the Great Lakes charter-boat industry (31.2 million dollars in 1985) and the support facilities necessary to satisfy angler demands. By 1986, charter boats in all waters of the State of Michigan numbered approximately 1,000; the industry barely existed 20 years ago. It is believed that the number of charter-boat operations on Lake Michigan has temporarily peaked and leveled off after 20 years of growth.

Economic impacts in 1985 were substantial, when Great Lakes anglers in United States and Canada spent between 1 and 2 billion dollars in pursuit of Great Lakes fish. About 75,000 worker years were attributed to the sport fishery in 1985. Comparing the assessment of Great

Lakes angling values in 1979 with 1985, the economic value of anglers using the entire Great Lakes more than doubled.

A conservative estimate of the impact of the Lake Michigan sport fishery in 1986 and 1987 would be approximately 51 and 40 million dollars, respectively. Anglers fishing Lake Michigan spent an overall average of $44.67 per day, those years, indicating a day of fishing on Lake Michigan may be somewhat more valuable than an average day ($36.50) on the Great Lakes in general.

Lake Michigan anglers, who number 449,000 and fish an average of 1.5 million days per year, have had a substantial impact on the major ports that support the fishery. To assess the economic impact of angling on communities located on the Lake Michigan shore, six coastal counties were surveyed. Total angler spending ranged from a high of $4.6 million in Ottawa County to a low of $181,000 in Grand Traverse County.

Report approved by W. C. Latta