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Chapter 7

History of the Great Lakes Salmon Fishery: A Michigan Perspective

Howard A. Tanner and Wayne H. Tody

Introduction

The greatly expanded Great Lakes sport fishery of today began in Michigan with the introduction of coho salmon *Oncorhynchus kisutch* and chinook salmon *Oncorhynchus tschawytscha* in the mid-1960s. Dr. Howard A. Tanner (who acquired the name of "father of the Michigan coho") served as chief of the Michigan Department of Natural Resources (MDNR) Fisheries Division (1964–1966) when the Great Lakes salmon fisheries began, resigning to accept a position as Director of Natural Resources at Michigan State University. Dr. Wayne Tody, Tanner's assistant chief in the fisheries division during 1964–1966, served as division chief from 1966 to 1976. Together, they oversaw the early years of the salmon-stocking program that sustains today's recreational salmon fishery in Lake Michigan. The following account provides their personal insights and perspectives into the background, rationale, expectations, and outcomes of establishing this significant fishery.

Background and Early History

The surface area of the Great Lakes covers about 95,000 square miles; the Great Lakes basin spans approximately 291,000 square miles (Figure 1). With the exception of the relatively shallow, more productive Lake Erie, the lakes are deep, cold, and well oxygenated, with low to medium productivity (see Beeton et al. 1999). The Great Lakes border two nations, with

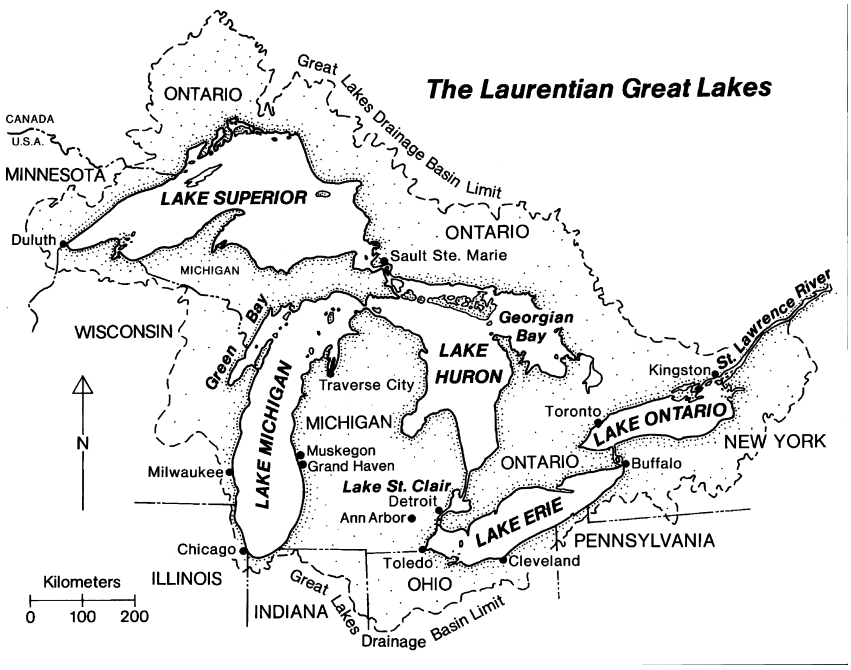

Figure 1. The Laurentian Great Lakes (from Beeton et al. 1999).

31% of their area located in Canada and 69% in the United States. In addition to the national jurisdictions, the Great Lakes are subject to the mandates of eight states, one Canadian province, and several Native American tribes (Dochoda and Jones, Chapter 11). Economic opportunity based on the vast natural resources within the Great Lakes basin fueled development, and by the end of the 20th century, more than 36 million people lived in the basin (30 million in the United States).

The Great Lakes have experienced a growing number of ecological disturbances over the centuries related to the expansion of human activities, which accelerated following the American Revolution and the War of 1812 (see Taylor and Ferreri 1999). Activities such as forest harvest, agriculture, mining, industrialization, and the resulting urbanization exposed soils to erosion, and sediments and pollutants moved easily throughout the basin's river systems, altering those arteries so vital to the Great Lakes' ecological health. The transportation networks needed for shipping, railroads, and highways further altered aquatic habitats through the construction of dams, canals, and bridges. Dams were also needed for logging, agriculture, flood control, and industrialization. By 1940, there were 110 hydropower facilities in Michigan, impounding 90% of Michigan rivers. These dams warmed

waters, obliterated critical fish habitats, and restricted the access of aquatic species to remaining habitat.

Additionally, water quality throughout the basin was affected substantially by agriculture and industrial and urban development. It is estimated that almost 60%, or nearly 35 million acres of the Great Lakes coastal wetlands, have been lost since settlement (Office of the Great Lakes 2000). Nutrient levels in the Great Lakes increased, along with the concentrations of metals such as mercury and lead. Highly toxic persistent bioaccumulative organochlorines such as polychlorinated biphenyls (PCB), chlordane, and dioxins were released into the lakes. The pesticide DDT, used extensively beginning in the mid-1940s, spread throughout the Great Lakes basin, devastating bird populations and raising concerns for human health (Dempsey 2001). Pollution of the Great Lakes and the region's wildlife resources had a profound effect on the basin's residents in the 1960s and 1970s, as they became aware of the impacts of their activities and of their own vulnerability as a result.

Fisheries

Prior to the 1960s, most areas of the Great Lakes were considered the domain of commercial fishing, which was viewed as being valuable to the state of Michigan because it provided employment and economic returns. Although the Michigan Fish Commission was established in 1873 as a result of concern that the commercial fishery had overharvested Michigan's Great Lakes fisheries, the commercial fishery continued to dominate. State fisheries employees made every effort to regulate the fishery to stop overharvesting and waste, but commercial fishers guarded their interests by organizing an effective lobby to politically thwart Michigan's fishery officials. It was successful. Around 1900, the Michigan Legislature reduced the state fish management budget severely and stipulated that not "one red cent more" would be spent on the Great Lakes fishery. The legislature gradually relented and restored the budget, but the commercial fishery continued without effective regulation of gear, catch, or effort. Commercial fishermen supplied reports of catch and gear, and anyone could buy a commercial fishing license. By 1926, the approximate peak of the Great Lakes commercial fishing industry, more than 12,000 people were employed in fishing, fish processing, and fish marketing. The total Great Lakes-wide dockside value of commercial fish remained stable through the 1960s, at approximately US$12 million, although the abundance and species composition changed markedly over this time period (Brown et al. 1999).

Though Michigan had considerable management authority over the fisheries, little was exercised because of the lack of public support for managing Great Lakes waters. Importantly, in the absence of state management

of the Great Lakes, the U.S. Bureau of Commercial Fisheries exercised de facto management over the U.S. portion of the Great Lakes fishery. The mission of this bureau was to assist the commercial fishing industry, and it did. It produced data on the status of Great Lakes fisheries, conducted research, and provided marketing technology to commercial fishers. This reinforced the long-standing concept that commercial fishing should be the key value for the Great Lakes fishery.

As if the Great Lakes' instability were not already adequately challenged by alterations to habitat and an extensive commercial fishery, the introduction of exotic species precipitated additional impacts. The unintended introduction of exotic species, most notably the sea lamprey *Petromyzon marinus* and the alewife *Alosa pseudoharengus*, played a major role in modifying the Great Lakes ecosystem upon which fisheries depend (Goddard, Chapter 12).

Michigan Introduces Coho and Chinook Salmon

The stage was set for the introduction of coho salmon *Oncorhynchus kisutch* by a very unusual set of circumstances—some biological, some social, and some political—that came together in Michigan in 1962–1964. In the following paragraphs, we will briefly describe the circumstances as they existed and how they contributed to the decisions to manage the Great Lakes for sport fishing and to introduce Pacific salmon.

Ecologically speaking, the time was ripe for a successful introduction of salmon. By 1960, because of a combination of overfishing, sea lamprey predation, and possibly predation by smelt on the juveniles, the native lake trout *Salvelinus namaycush*, the most important predator in the indigenous food web, was extinct in Lakes Michigan, Ontario, and Erie, nearly so in Lake Huron, and seriously depleted in Lake Superior.

The U.S. Bureau of Commercial Fisheries, under the leadership of Dr. Vernon Applegate, was producing a workable sea lamprey control program. By the early 1960s, it was reasonable to expect that a significant degree of control over the sea lamprey could be achieved.

Meanwhile, without an effective predator and with no viable commercial market, the alewife population had erupted to extraordinary abundance levels in Lakes Michigan, Huron, and Ontario. All other fish populations were at low levels. Every summer, dead alewives piled up on the beaches and frequently plugged the water intakes of Chicago. The peak of these die-offs in Lake Michigan produced what has been described as "a pile of stinking alewives one foot high and 300 mi long." Beach-oriented tourism came to a halt, resulting in serious economic impacts on lakeside communities. From another perspective, however, this glut of alewives was clearly a very large food supply upon which to build a sport fishery for salmon and trout.

Simply stated, we could try to convert a nuisance into a resource—a very large resource!

More than 60 million people live within one day's drive of the Great Lakes. By the early 1960s, with substantial leisure time, expendable incomes, and good mobility, there was clearly a large demand for fishing opportunities. The paradox was that this large sport angling population lived on the shores of the world's largest freshwater system, but this array of lakes and connecting waters offered very little fishing opportunity. With the near extinction of the lake trout and very low levels of other native species, most commercial fishers were no longer fishing. Equally important, they were nearly politically bankrupt. The need to reallocate from commercial to sport fishing was becoming abundantly clear and possible.

In 1963, Michigan adopted a new constitution that included a proviso that "natural resources shall be preeminent." For the first time, the Department of Conservation (soon to become the Department of Natural Resources) was headed by a professionally trained biologist, Dr. Ralph MacMullan. He hired Dr. Tanner in September of 1964 as chief of fisheries. At the time, Dr. Tanner was working for the Colorado Department of Fish and Game as chief of fisheries research. During his 12 years in Colorado, he had gained some experience with both kokanee *O. nerka* and coho salmon in freshwater environments. As a member of an organization then known as the Pacific Coast Fishery Biologists, he had existing contacts with salmon biologists from the Pacific Coast states. These contacts were to become extremely important.

Although prior to 1964 little attempt had been made to manage the fisheries of Michigan's Great Lakes waters, there was a major fisheries division hatchery program to raise catchable size brook trout *Salvelinus fontinalis*, brown trout *Salmo trutta*, and rainbow trout *O. mykiss*. Usually, these were released in streams "at the rod" to be caught in periods of peak fishing activity. Therefore, Michigan hatcheries had the capability to rear potential predator species for release in the Great Lakes, although capacity was limited.

During this time period in the states of Oregon and Washington, there was for the first time in many years a surplus of coho salmon and chinook salmon *O. tshawytscha* returning to the hatcheries. This surplus may well have been produced by the creation of the Oregon moist pellet. This feed came into general hatchery use in the late 1950s and is credited with producing a more vigorous smolt having better rates of survival. Until these surpluses, neither Washington nor Oregon had been willing to fill requests for salmon eggs from outside the Columbia River watershed.

These are some of the more important elements that made up the situation that existed immediately prior to policy decisions made in the fall of 1964. We in the Michigan Fisheries Division proposed that, for the first

time, Michigan would manage those portions of the Great Lakes that lie within its boundaries. Further, and equally important, we proposed to manage the resource by replacing commercial fishing with sport fishing as the key value. Our director, Dr. MacMullan, and his administrative staff supported our proposal, and the Conservation Commission, the department's policy-making board, approved.

These changes in policy and management goals were very large indeed. Previously, our fisheries activities (i.e., management, hatchery production, lake and stream improvement, and research) had targeted only inland lakes and streams. Though these waters are extensive and important, they make up only about 3% of the water area of Michigan.

Now came the serious and difficult questions of *how* to manage the Great Lakes as a sport fishery. The only feasible option was to insert one or more top predators into the food web. Clearly, the physical, chemical, and biological nature of the Great Lakes dictated the top choice of predators to be trout or salmon. We quickly concluded that the native lake trout could not be the principal species employed in a program designed to replace commercial fishing with sport fishing. In precedent and by law, the lake trout was clearly established as a commercial species. Though the commercial fishing interests had been unable to block our declared intent to manage for sport fishing, their opposition was not to be ignored.

Furthermore, the U.S. Bureau of Commercial Fisheries, with headquarters for the Great Lakes in Ann Arbor, Michigan, had been assigned the roles of controlling sea lamprey and reestablishing lake trout populations. This federal agency had built and would operate the Jordan River hatchery (in Michigan) to raise lake trout. It actively opposed our shift in allocation from commercial to sport fishing. These considerations combined to make clear that the lake trout was not the species for the Fisheries Division to promote as the foundation for a sport fishery. Additionally, we could reasonably expect that the lake trout would be stocked in substantial numbers from the federal hatchery on the Jordan River in an attempt to facilitate its rehabilitation, thereby providing redundancy in the predator complex of the Great Lakes.

Our rejection of the lake trout was based on other assumptions, as well. We concluded that the lake trout was not a very interesting fish to catch. Remember that this was at a time when there were no downriggers and no fish finders. Traditional lake trout fishing techniques were usually to troll with a long metal line and heavy weights. Under those circumstances, the lake trout was not an exciting fish to catch. (As an aside, even today, in the opinion of most sport anglers, the lake trout ranks below coho salmon, chinook salmon, and steelhead *O. mykiss* as a sport fish.) Because those who would fish the big open waters have to be willing to purchase bigger

and more expensive boats and gear and to invest a substantial share of their leisure time, it was our opinion that a truly exciting fishery was essential.

We started, in 1964, with a program to introduce kokanee salmon with eggs from Colorado, where Dr. Tanner had previously worked and where eggs were available. A program of stocking kokanee in a limited number of inland lakes was developed from eggs to be collected annually from Higgins Lake, a large inland lake in northern Michigan. However, the kokanee program was discontinued after a few years because of a lack of interest.

Then, in early October 1964, came the exciting and unexpected news that coho eggs might be available from Oregon and Washington. A quick review of the coho—its needs, attributes, and reputation as a sport fish—was enough to convince us that this was a species we wanted for a Great Lakes sport fishery. Most importantly, we knew that, on the west coast, it was a highly desirable sport fish and was well understood from a hatchery-rearing perspective. Additionally, in the Pacific Ocean, the coho feed on prey species not too different from alewife. Hence, we quickly decided to introduce coho salmon (Tody and Tanner 1966).

With the approval of our department's administration and commission, we requested a million coho eggs from Oregon and another million from Washington. Following an exchange of letters and phone calls, both states initially agreed to honor our request provided we follow their proven guidelines for best results. Some elements of their instructions were feed only Oregon moist pellets; rear the coho in a hatchery on a stream where we desired the fish to return for egg take and/or spawning; rear them to smolts (18 months old) before planting; and plant no fewer than 200,000 at any one location. We eagerly accepted their advice. Before the eggs could be sent, opposition developed in the state of Washington, and it was unable to deliver any coho eggs. Coho eggs were received from Washington and Alaska in subsequent years.

A total of 1 million eyed coho eggs were received from Oregon in late December 1964 and early January 1965. The eggs and subsequent fry were given the greatest attention in various Michigan hatcheries and later moved to the dirt-lined raceways of a rearing station located on the Platte River, a tributary of Lake Michigan, to be imprinted prior to release. The official release of the first coho smolts was on 2 April 1966 with a "golden bucket" ceremony near the site of our new fish hatchery on the Platte River (upstream about 10 mi from the town of Honor, Michigan). For the sake of historical completeness, we will mention that there were newspaper reports that some small number of coho smolts were released into Bear Creek, a tributary of the Big Manistee River, in late March, a few days prior to the official 2 April release. We have no personal recollection of this. Over the

next few days, about 264,000 coho smolts were released into the Platte River and 394,000 into Bear Creek. State Sen. Joe Mack from Michigan's Upper Peninsula (UP) was chairman of the State Senate Appropriations Committee. To receive approval of a US$500,000 budget increase to feed the young coho in our hatcheries, we had to agree that some coho would be released into a tributary of Lake Superior. In May 1966, 160,000 coho smolts were released into the Big Huron River, a few miles northeast of the UP town of L'Anse. The salmon fisheries that would develop throughout the Great Lakes had begun.

The first coho jack salmon run in Bear Creek and the Platte River began in September 1966. More than 3,700 were caught in weirs on these streams. Anglers took an estimated 1,500 in addition. The jacks were generally 2- to 4-pound fish, with the largest weighing more than 7 pounds. Of significant importance was that 32 females were stripped of 45,000 eggs, which produced 22,000 fry. Observations indicated that natural spawning probably occurred. During this period of time, we invited the fisheries chiefs of Oregon and Washington to view the run of jack coho. Given their experience on the west coast, where the jack run of any year-class will accurately reflect the strength of the subsequent year's mature run, they told us to get ready for a very large run of big mature coho in the following year.

A favorable sequence of events brought about great public acceptance and enthusiasm for our Great Lakes salmon fishery. As described earlier, the first coho smolts were planted in the spring of 1966. The alewife die-off in Lake Michigan, in June of that year, was extensive. There was a great public outcry to solve the alewife problem. In the fall of 1966, there was a run of large jack coho weighing 2 to 7 pounds. The few hundred caught by anglers that fall raised the level of excitement and expectation. In the early summer of 1967, an even worse alewife die-off occurred. Later that summer, the first year-class of adult coho created fishing excitement that was true pandemonium. The news media were full of positive news regarding the spectacular Great Lakes salmon fishery that had been created, often referring to this event as creating coho madness.

During the summer of 1968, there were no dead alewife problems on the Lake Michigan beaches, and the public immediately concluded that the coho had controlled the alewives. What had really happened was that, by 1967, the alewife population had grown to exceed its food supply and had collapsed following the stress of spawning. Since the public "knew" the salmon had eliminated the alewife problem, the only thing we could do was accept the credit that the public insisted was due us. From that point on, the public and the legislature were enthusiastically in support of the Michigan salmon program.

As an aside, we frequently hear the Michigan salmon program described

as designed to control alewives. Our intent was much more important than controlling alewives. To build the attractive sport fishery that we envisioned, we clearly needed to introduce attractive sport fish (i.e., one or more species of trout or salmon). We needed to choose species that could be expected to eat the most abundant forage species (i.e., the alewife). However, to describe our program as one designed to control alewife, which, in the process, happened to produce a great sport fishing opportunity, is demeaning. Again, and for emphasis, our goal was to turn the alewife nuisance into a very large, important, and valuable public resource.

With the success of the coho jack run, we recommended to the Natural Resources Commission (the renamed Conservation Commission) that we proceed immediately to introduce fall run chinook salmon to increase the diversity of the predator base and angling experience. By this time, the political winds had changed in the West, allowing for Michigan to receive eyed eggs of salmon populations more readily than before. The commission quickly approved our recommendation.

In this effort, Dr. Tody, who was now the chief of the MNDR Fisheries Division, developed a close working relationship with Dr. Loren Donaldson, professor at the University of Washington, who had developed a three-year strain of chinook salmon and, most importantly, endorsed our planned introductions. Cliff Millenbach, chief of the Sport Fish Division of the Washington Department of Fish and Game, volunteered as our western coordinator for planting stock, and Bud Ellis and Richard Noble, hatchery chiefs of Washington's Department of Fisheries, provided the necessary eggs—1 million eggs a year for three years. These were generously provided from stream runs most similar to Michigan's. The first plants of six-month-old chinook salmon smolts were made in the spring of 1967.

The 1967 run of coho salmon electrified not only sport fishermen, but also the general population of Michigan, and it was hailed as top news from coast to coast of the United States. Anglers took about 40,000 adult salmon averaging 12.1 lb. Our best estimate of survival to harvest was an astounding 35%. In addition, more than 1,500,000 lb was taken at Michigan Department of Natural Resource (MDNR) weirs, of which 785,000 lb were sold for human consumption before sale was halted because of contamination by DDT. This created for us a new management problem: how to dispose of millions of pounds of pesticide-contaminated salmon. At one time during this period, Michigan Gov. William Milliken asked us to consider stopping all planting of trout and salmon to avoid problems of contamination leading to human health problems. Our review quickly showed that the constituencies of those enjoying the new fishery supported environmental cleanup, and their advocacy was too valuable to lose. Therefore, we looked for other ways to protect human health while maintaining and

enhancing our salmon and trout fisheries. The main thrust here was to reduce or eliminate the contaminants that bioaccumulated in the flesh of Great Lakes fish. Director MacMullan played a major role nationally in achieving the ban on DDT.

In addition to the spectacular returns of coho salmon in 1967, we were able to take 8 million eggs to continue the hatchery program. Of these, 1,100,000 were divided between Wisconsin (300,000), Ohio (200,000), Pennsylvania (300,000), New York (100,000), and the province of Ontario (200,000) to initiate the program throughout the Great Lakes. Thereafter, we continued to share eggs and worked closely with the other Great Lakes states and the province of Ontario to further the salmon program.

Establishing a population of large, highly sought after sport fishes created additional management needs as the public rushed in to utilize this new resource. Maintenance of and improvement to the fishery demanded a vast array of new facilities, both private and public. Special credit is due to Keith Wilson, chief of MDNR's Waterways Division and the Michigan Waterways Commission, for rapid development of access sites, marinas, and harbors of refuge for small craft on all of Michigan's Great Lakes. Today, even though Michigan now has more registered boats than any other state, the long lines waiting to launch at the limited facilities are gone. Boating access and boat service of all kinds are excellent. Weather warnings are more accurate and timely. Anglers are more skilled and experienced in dealing with the large, sometimes dangerous waters of the Great Lakes. The fishery has become much more sophisticated and anglers more knowledgeable. A charter boat fleet is present and busy. Boats are larger and more seaworthy, and many have been designed specifically to accommodate sport fishing. Gear has really become high-tech. Electric downriggers, radar, global positioning systems (GPS), navigational aids, fish finders, temperature probes, dipsy divers, and endless numbers of lure types are commonly present on the boats of serious Great Lakes anglers. Trolling with artificial lures is the primary technique employed when fishing from boats in the open lakes. Live, frozen, or preserved bait is rarely used. There is also a large fishing effort from piers, in the surf, and in the tributary rivers. In these modes, fresh spawn is commonly used, as well as artificial lures.

As the Great Lakes sport fisheries developed, we recognized that existing commercial fisheries posed a severe threat to the program. Wisconsin trawlers were taking millions of pounds of alewife for industrial fish meal processing plants at a price of only one to two cents a pound. The U.S. Bureau of Commercial Fisheries regional fish chief, Dr. Fent Carbine, promoted federal assistance for building additional meal plants in Michigan and aggressively renounced our predator approach to utilize the alewife as "forage." In the end, this controversy became political, and under pressure from Michigan elected officials, the administrative regional office of the

bureau was removed from Michigan, as was its fishery technology branch. All other functions remained, including research and the bureau's Ann Arbor facilities that today are the Great Lakes Science Center for the Biological Resources Division of the U.S. Geological Service.

Michigan's Fisheries Division field personnel found, in an intensive 1968 survey, that commercial gill nets were killing large numbers of juvenile lake trout in northern Lake Michigan waters incidental to fishing for lake whitefish *Coregonus clupeaformis*. It became apparent that these nets posed a major threat to salmon and trout stocks as the salmonid propagation program expanded; thus, they had to be addressed. As a result, a restructuring of Michigan's commercial fishery, which had a 150-year history of aggressive fishing, was mandated. A primary premise for this restructuring was that sport and commercial fishing had to be made complementary if we were going to be successful in the rehabilitation of Great Lakes fish populations. With a policy of sport fishing being dominant over commercial fishing (which we then believed and still believe represents the best allocation of the fishery resources), a political battle was unavoidable. Sport fishermen and Great Lakes port cities organized powerful political lobbies to promote their interests. Admittedly, their interests influenced our biases. In the end, the state's fisheries regulations were rewritten, setting species, seasons, size, and catch limits for sport fishing. Large-mesh gill nets for commercial fishing were essentially banned.

Displaced commercial fishermen were reimbursed by the state's general fund for their boats and gear and were encouraged to convert to selective gear (see Lupi and Jester, Chapter 10). Michigan Fisheries Division expert Walter Crowe developed plans for limiting entry to the commercial fishery. These were adopted. Next, we recommended a plan of zone management for the combined fishery. This included sport, commercial, and restricted fishing rehabilitation zones. Plans were to gradually develop a franchise type of commercial license, wherein specific gear, catch, and seasons would be negotiated with individual fishermen. This very desirable end product was never brought to fruition because it lacked commercial fishermen support and became stalled because of new legal battles over federally-sponsored Native American treaty fishing rights.

Progress from 1968 to the Present

In the 37 years since Michigan declared its intent to shift allocation from commercial to sport fishing and to introduce salmon, many changes have occurred. Across the basin, the dockside value of commercial landings has risen sharply since the 1970s—from an estimated US$12 million to $52 million in 1990. The number of licensed commercial fishers in the Great Lakes has decreased from approximately 10,000 in 1920 to 2,200 in 1990

(Brown et al. 1999). It is not possible to compare precisely commercial and recreational fisheries values with the data available, but an indication of relative values may be made. In 1990, the basin-wide dockside value of commercial fish was US$52 million and was estimated to have a regional impact of $200 million. In 1991, U.S. recreational fisheries in the Great Lakes alone accounted for US$1.3 billion in direct angler expenditures, with an estimated total economic impact of $2 billion to $4 billion (Bence and Smith 1999). Many factors have contributed, but there is little question that there has been a basin-wide shift in values favoring sport fishing.

One result of the shift of the Great Lakes to sport fishing has been a growing advocacy group for the integrity and well-being of the Great Lakes. The popular Great Lakes sport fisheries (2 million anglers in 1996) have produced many hundreds of thousands of people who now know and appreciate the importance of the Great Lakes. These individuals represent a demonstrable voting constituency that supports stringent environmental regulations and sound scientific management of the Great Lakes. Additionally, the public's environmental awareness has increased significantly since the 1960s, resulting in the adoption of legislation at the state/province and federal levels to curb the loss of valuable habitats and bring pollution under control. As a result, many critical habitats are now protected, and efforts are underway to restore habitats that have been impaired. Much has been accomplished, but much remains to be done—particularly related to how our land use decisions affect the quality of the Great Lakes ecosystem.

Natural reproduction of fish is one indicator of improved habitat. Michigan now estimates that nearly 40% of the chinook salmon entering the fishery are from natural reproduction. Significant reproduction of coho salmon, steelhead, and brown trout is occurring in all accessible sections of rivers with good water quality. A dramatic improvement in natural reproduction was achieved when hydroelectric facilities were required to operate on a "flow of the river" regimen, rather than fluctuating the rivers by operating only at times of peak power demand. Many millions of lake trout have been stocked during the past 40 years in an effort to establish self-sustaining populations. This goal has been achieved or is clearly possible in Lake Superior and northern Lake Huron. However, it is our opinion that basic changes have occured in Lake Michigan and southern Lake Huron that may permanently preclude significant lake trout reproduction. We believe competition and predation on newly hatched lake trout by alewife and smelt are probable causes. It is our opinion that lake trout should continue to be included in the array of salmon and trout being stocked, but that we should recognize that, in Lake Michigan, southern Lake Huron, and probably Lakes Erie and Ontario, little natural reproduction can be expected.

Overall, nutrient levels have decreased in the Great Lakes, principally

as a product of better sewage treatment and a ban on phosphates in detergents. Michigan was the first state to ban phosphates in detergents. Dissolved oxygen levels have increased as well. During the past 20 years, there has been a general decrease in concentrations of many toxics in the Great Lakes as a result of regulation of direct water discharges. Perhaps few remember the days when concentrations of DDT in lake trout frequently exceeded 20 ppm. There are still some warnings about the human consumption of larger trout and salmon, but concentrations of toxics found in those fish are much lower, and more fish of larger size are rated as safe for consumption.

Exotics are considered second only to loss of physical habitat in terms of severe impacts on native species, and they are a major cause of the continuing loss of biodiversity in the Great Lakes (see Mills et al. 1993). More than 144 new species have been intentionally or accidentally introduced into the Great Lakes basin since the 1800s. The greatest number of exotic species introduced coincided with the 1959 expansion of the St. Lawrence Seaway, which allowed the passage of more and larger ships into the Great Lakes. Exotic species have also found their way into the system through commercial aquaculture, the aquaria trade, and the bait industry. Many more exotics will be introduced if we do not provide an adequate protection program for the Great Lakes.

Fisheries management decision making has become much more integrative and multidisciplinary across the Great Lakes. In part, this has been a result of the efforts of the Great Lakes Fishery Commission, which has provided a forum for a more integrative and collaborative approach to fisheries management in the Great Lakes basin (see Dochoda and Jones, Chapter 11). There exists today a clear recognition among management agencies that the pursuit of individual interests is best achieved by collaborating with those other agencies with a shared interest in determining the future of a resource held in common. The focus today also moves toward management of the Great Lakes basin as an ecosystem—an approach that has become much more holistic in recognition of the fact that the Great Lakes basin habitat—physical, chemical, and biological—defines the boundaries of potential fisheries opportunities. Awareness is growing that an adaptive management approach to the future must be taken because the Great Lakes basin has changed and will continue to change into the foreseeable future.

Today's Fishery

The sport fishery in U.S. waters of the Great Lakes basin, considered insignificant in 1960, was replaced by a sport fishery that—conservatively estimated for 1996—involved 2 million anglers and 20 million days of recreation. These anglers took 17 million trips and spent US$1.4 billion on

trips and equipment (U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, Bureau of the Census 1997). In addition to the catch by sport anglers, there is a notable commercial harvest of salmon and trout by fishermen with treaty rights.

We would be remiss if we did not recognize the web of professional and public support that has developed in support of the Great Lakes fishery programs. We realize that to name some is to risk the unintentional overlooking of others. So be it. As mentioned earlier, the Great Lakes Fishery Commission has been there since the 1950s, but its more recent success in serving as a forum for functional cooperation between all aspects of interstate and international research and management programs is an essential element for the future well-being of the resource. The Sea Grant College Program provides another set of essential services. Its service as a conveyor of useful information to all user groups of the Great Lakes fisheries is a very durable function that has been greatly appreciated by the public and the agencies. Additionally, colleges and universities are now more effectively linked to management agencies, providing much needed research and education regarding our Great Lakes and its fisheries. One such example is the Partnership in Ecosystem Research and Management unit at Michigan State University, which was organized through the leadership of the MDNR and the MSU Department of Fisheries and Wildlife. Finally, numerous public interest groups of anglers and boaters, citizen advisory panels, and elements of the boating and tackle industry all add support and strength to those responsible for policy and action programs.

Summary and Conclusions

The Great Lakes of the early 1960s were a dismal sight. Habitat—ravaged physically, chemically, and biologically—reflected the historically passive efforts of natural resource managers to maintain and nurture fishery and wildlife values.

The introduction of salmon into the Great Lakes has been a remarkable undertaking that has yielded immense benefits. It created a new, valuable, and high-profile recreational fishery. The success of the early salmon fishery served as a catalyst to encourage resource managers throughout the basin to accept the challenge of proactively managing the Great Lakes to restore and develop fishery and wildlife values.

An international array of professional fishery biologists working together during the past four decades can take pride in today's Great Lakes salmon and trout fisheries. State, tribal, federal, and international programs have, with reasonably good cooperation, produced an array of salmon and trout species that are the best means available to stabilize the inherently

unstable biology of the Great Lakes. While doing so, they created an enormously valuable sport fishing industry. An international constituency of concerned and better informed citizens supports sound professional management, and existing and new problems will continue to require the best efforts of our profession. We are confident that this fishery can be sustained and improved.

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