Status and Potential of Michigan Natural Resources: Fisheries
Michigan State University Agricultural Experiment Station and Cooperative Extension Service
Special Report

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Status and Potential of Michigan Natural Resources

Fisheries

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Reports on the Status and Potential of Michigan Natural Resources

This special report is one of a series (listed below) prepared for a project of the Michigan Agricultural Experiment Station (MAES) called the "Status and Potential of Michigan Natural Resources" (SAPMINR).

The project was designed to take an inventory of the current status of Michigan natural resources, identify emerging trends, and appraise future opportunities. The purpose was to assist MAES in establishing priorities and planning programs.

Both overview and focused topic assessments have been made. The overview reports provide background information on the political, economic, and social environments influencing Michigan natural resources. The focus reports examine specific resources, including timberland resources, fisheries and wildlife resources, parks and recreational resources, and land and water resources.

The SAPMINR project began in early 1993. At that time, interdisciplinary teams of MSU faculty members, graduate students, federal and state government officials, and others collaborated to develop preliminary reports. In March 1994, a SAPMINR conference took place during MSU's Agriculture and Natural Resources Week. The objective of the conference was to provide a public forum for discussion of the preliminary reports. Based on interaction with conference participants, the authors prepared the final drafts of the special reports (SR).

This report should not be considered final. Efforts to analyze the past and forecast the future are ongoing. Even so, this report is a base for dialogue on both the status and potential of Michigan natural resources.

To receive any of the reports listed below, contact: MSU Bulletin Office, Room 10B Agriculture Hall, Michigan State University, East Lansing, MI 48824-1039.

Status and Potential of Michigan Natural Resources List of Reports

Overview Reports

SR 67 --SAPMINR Highlights

SR 68 --Michigan Natural Resources Policy

SR 69 --Demographic, Social and Economic Trends

SR 70 --Integrated Natural Resource Systems

Focus Reports

SR 71 --Timber and Timberland Resources

SR 72 --Lumber, Furniture, Composition Panels and Other Solidwood Products

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SR 78 --Camping, Trails and Dispersed Recreation

SR 79 --Water Resources

SR 80 --Land Resources

SR 81 --Nonrenewable Resources

SR 82 --Natural Resources and Communities

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Fisheries

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Introduction

Michigan has extensive, high quality aquatic resources close to human population centers that provide excellent sport fishing opportunities and support commercial fisheries (Figure 1). These aquatic resources include:

- More than 3,000 miles of Great Lakes shoreline and 38,075 square miles of Great Lakes waters (43 percent of the total area).
- 11,037 inland lakes, which cover more than 1,194 square miles.
- More than 35,000 ponds.
- 36,350 miles of rivers and streams.
- 12,600 miles of trout streams, of which approximately 4,000 miles are classified as top quality trout waters that contain self-sustaining trout or salmon populations.

(Additional information on Michigan's water resources is summarized in SAPMINR Special Report 79.)

More than 50 kinds of native game fish—including brook trout, lake trout, sunfish, bass, northern pike, muskie, walleye, yellow perch, lake sturgeon and lake whitefish—inhabit Michigan waters. The state has introduced exotic fishes such as the rainbow and brown trout and chinook and coho salmon to complement our native fishes. The diversity of sport fishes is demonstrated in the Master Angler Awards presented by the Michigan Department of Natural Resources (MDNR) to recognize trophy fishes captured (Table 1).

Michigan anglers have fishing access opportunities that include:

- 1,094 public access boat launching sites.
- 12 state-operated harbors and 58 municipal harbors along Michigan's Great Lakes coastline.
- More than 600 fishing and sailing charters operating on the Great Lakes.
- 1,021 marinas with more than 52,000 moorings for boats statewide.

Michigan anglers are never more than a 30-minute drive from good fishing waters, and Great Lakes boat anglers are never farther than 15 shoreline miles from a harbor in Michigan waters.

Michigan has more registered boats than any other state. One out of 12 residents owned a boat in 1990. Fifty-two percent of recreational boaters use their boats for fishing. Over half of the licensed anglers in Michigan own boats used for fishing. Additional information on boating is summarized in SAPMINR Special Report 77.

Informative guides to Michigan's fishing opportunities are available from the Travel Bureau, Michigan Department of Commerce.

Importance to the Economy

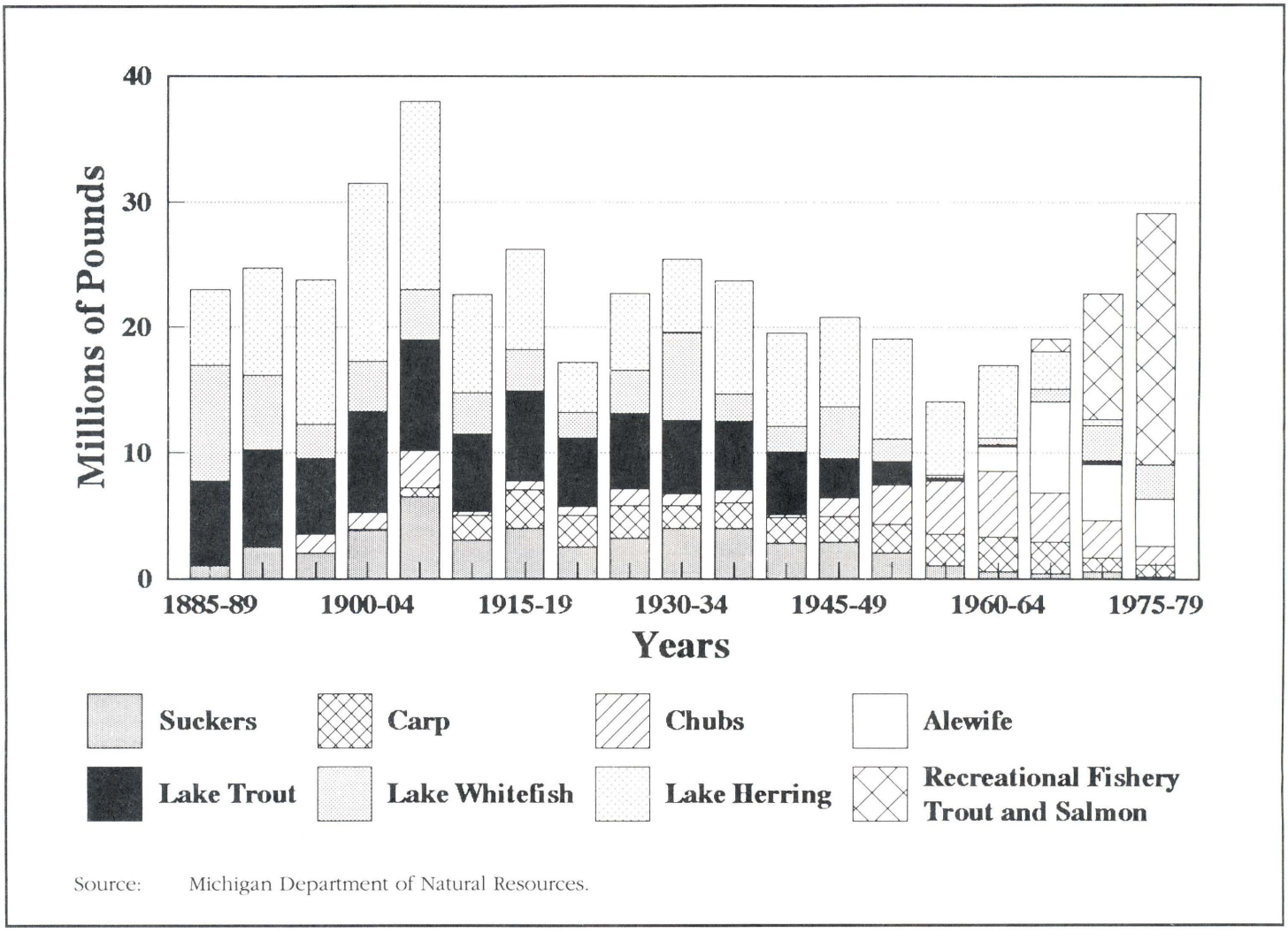
Recreational angling and commercial fishing significantly contribute to the Michigan economy. Recreational fishing is the highest valued use of the state's fishery resources. Michigan ranks first in the Great Lakes region and third and fourth in the nation in number of angler days and expenditures for recreational fishing, respectively (Table 2).

More than 1.4 million Michigan residents and 334,000 visitors 16 years of age or older fished for more than 24.5 million days in Michigan in 1991 (Table 3). It is estimated that 886,000 anglers spent 11 million days fishing Great Lakes waters. Additionally, about 500,000 anglers under the age of 17, who are not required to purchase a fishing license, fish in Michigan each year.

Michigan fishing license sales reached $20 million in 1989 (Table 4). Revenues from fishing licenses are placed in the Michigan Game and Fish Fund to pay for fisheries management programs.

Total recreational fishing expenditures in Michigan were estimated to have been nearly $1.3 billion in 1991 (Table 5). Anglers spent $500 million in trip-related expenditures ($200 million for food and lodging, $118 million for transportation and $182 million for other trip costs), $495 million in equipment-related expenditures, and $290 million for other items such as membership in organizations and magazine subscriptions. Boaters spent approximately $1.83 billion in Michigan in 1986 on boating-related goods and services. Federal excise taxes on fishing and boating equipment and motorboat fuel provide considerable funding, and are placed in the Sport Fish Restoration Fund, for management of Michigan's fisheries.

Commercial fishing in Michigan waters of the Great Lakes produced about 15.5 million pounds of lake whitefish, chubs, yellow perch, lake trout, catfish and other species with a dockside value of approximately $8.8 million in 1993. Wholesaling, processing and retail sales generate about $9 million in additional economic activity each year. Nearly two-thirds of the landed value is taken by Native Americans fishing in treaty waters; the remainder is landed by state-licensed commercial anglers.



Source: Michigan Department of Natural Resources.

Figure 1. Reported commercial and recreational catches of Michigan Great Lakes fishes, 1885-1979.

Historical Perspective

The early fisheries of the Great Lakes occurred in shallow inshore areas, in bays and tributaries and along the shoreline. Lake whitefish were the primary fish harvested because of their excellent flavor when salted, the common preservation method at that time. Lake trout, walleye and lake herring were also abundant in the catch. The gear commonly used included hook-and-line, seines, dip nets and spears, which were well suited to the relatively shallow waters.

Several bands of Chippewa and Ottawa Indians in the upper Great Lakes region retained the right to fish on lands they ceded to the U.S. government in the mid-1800s through treaties. Treaties are legally binding agreements made between two nations, in this case the United States and the Chippewa and Ottawa tribes. Today, the rights reserved by the tribes are referred to as treaty rights. In Michigan, the treaty-ceded areas that exist today were established by the treaties of 1836 and 1842.

The boundaries of the treaty-ceded areas and more detailed information on the specific treaties are contained in *A Guide to Understanding Chippewa Treaty Rights*, published by the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) in 1991.

Intensive commercial fisheries development in the Great Lakes began on Lake Erie about 1820 and spread to Huron, Michigan and Superior over the next 20 years. By the mid-1800s, inshore fisheries had declined and deeper waters were being fished. Sailing vessels were replaced by steam-powered vessels. Gill nets became the gear of choice because they could be easily fished in the deeper waters. Gill nets entangle fish, usually by the gills, as they swim into the thin-threaded nets. Factory-made gill nets and steam-powered gill net lifters appeared around 1850, increasing fishing time by decreasing the amount of time commercial fishermen had to spend mending and lifting fishing nets. By 1862, general declines in the Great Lakes fish harvest were noticed.

Table 1. Minimum entry lengths (inches) and weights (pounds - ounces) for Michigan Master Angler Awards and current state record fishes (pounds - ounces) caught on hook-and-line.

Species	Min. entry length	Min. entry weight	Current state record	Species	Min. entry length	Min. entry weight	Current state record
Lake Sturgeon	67	70-0	193-0	Green Sunfish	10	0-12	1-8
Atlantic Salmon	35	12-0	32-10	Bluegill	11	1-0	2-12
Chinook Salmon	41	27-0	46-1	Pumpkinseed	10	0-12	1-5
Coho Salmon	32	12-0	30-9	Redear Sunfish	11	1-0	1-13
Pink Salmon	22	3-0	8-9	White Crappie	15	1-12	2-10
Pinook (Pink/King)	25	9-0	14-0	Black Crappie	15	1-12	4-2
Rainbow Trout	37	17-0	26-8	Gar	37	5-0	15-0
Brown Trout	33	16-0	34-6	American Eel	32	3-0	7-7
Brook Trout	18	2-0	6-12	Channel Catfish	27	8-0	40-0
Tiger Trout	18	2-0	9-4	White Perch	10	0-8	1-2
Lake Trout	37	18-0	53-0	Flathead Catfish	29	10-0	47-8
Splake	32	14-0	16-4	Brown Bullhead	15	1-8	3-10
Great Lakes Musky	45	20-0	62-8	Black Bullhead	14	1-4	2-5
Northern Musky	42	20-0	45-0	Yellow Bullhead	14	1-8	3-7.25
Tiger Musky	47	20-0	51-3	Bowfin	27	7-0	14-0
Northern Pike	42	18-0	39-0	Redhorse Sucker	22	4-0	12-14
Hybrid Sunfish	10	0-12	1-7	White Sucker	20	3-0	7-3
Burbot	26	5-0	18-4	Longnose Sucker	17	2-0	6-14
Walleye	32	11-0	17-3	Hog Sucker	16	1-8	2-1
Black Buffalo	26	10-0	16-12	Carpsucker	19	3-0	7-8
Sauger	21	5-0	6-9	Carp	30	20-0	61-8
Yellow Perch	15	1-13	3-12	Freshwater Drum	24	7-0	26-0
Largemouth Bass	22	6-0	11-15	Lake Whitefish	25	6-0	14-4.5
Smallmouth Bass	21	5-0	9-4	Round Whitefish	16	1-0	4-0
White Bass	16	2-0	6-7	Lake Herring	18	2-8	5-6
White Bass Hybrid	24	7-0	7-15	Mooneye	13	0-12	1-7
Big Mouth Buffalo	32	20-0	—	Rainbow Smelt	10	—	11.8
Rock Bass	11	1-0	3-10	Gizzard Shad	16	1-8	3-8
Warmouth Bass	10	1-0	—				

Source: Michigan Department of Natural Resources, Fisheries Division, 1994.

Table 2. Number of angler days and expenditures for recreational fishing in the top five states in the United States and the states in the Great Lakes Region, 1991.

(Anglers 16 years of age and older; numbers in thousands)

State	Angler days	Expenditures
California	23,936	1,795,949
Florida	36,538	1,654,594
Texas	34,868	1,475,470
Michigan	24,517	$1,286,368
Illinois	16,465	1,111,262
New York	22,546	867,242
Ohio	18,430	861,554
Minnesota	17,710	846,246
Wisconsin	20,299	782,388
Pennsylvania	23,849	677,512
Indiana	12,138	404,367

Source: USDI, Fish and Wildlife Service, and USDC, Bureau of the Census, 1993.

The Great Lakes commercial food fish catch was dominated by lake whitefish until about 1890, when it was exceeded by the lake herring catch (Figure 1). Michigan food fish landings peaked during the period 1905-1909, when 47.5 million pounds of fish were caught each year. The commercial catch declined in the early 1920s; the average annual harvest for 1920-1924 was less than half the peak catch. During the 1930s, the commercial catch rebounded to an average of 29 million pounds annually. The invasion of the sea lamprey during the 1940s caused another significant decline in the commercial catch and a significant reduction in the number of commercial fishermen.

By the late 1960s, most important commercial fish stocks were depleted. As the resources declined, the state began limiting and reducing the number of commercial fishing vessels. By 1970, small and part-time commercial fishing operations were no longer licensed. Because many of these smaller operations were run by Native Americans, problems arose over their fishing rights. Legal actions taken in the 1970s and early 1980s served to further define the rights of Native Americans.

Recreational fishing has also had a rich history in Michigan. In the mid-1880s, Michigan was widely known for its excellent trout fishing streams. Many of the streams had been stocked with brook, brown or rainbow trout to establish trout populations. By 1896, the Au Sable and Pere Marquette rivers were rated the two best trout streams in the United States.

Table 3. Recreational angler participation in Michigan waters for 1980, 1985 and 1991.

(Anglers 16 years of age and older; numbers in thousands)

Category	1980	1985	1991
Michigan resident anglers	1,738	1,853	1,419
Michigan visitor anglers	549	590	334
Total days fishing	44,481	44,171	24,517
Resident	39,697	40,200	22,171
Non-resident	4,783	3,971	2,346
Michigan Great Lakes anglers		1,300	886
Resident		970	687
Non-resident		330	199
Total days fishing Michigan's Great Lakes		15,430	11,060
Resident		13,768	9,907
Non-resident		1,662	1,154

Source: USDI, Fish and Wildlife Service, and USDC, Bureau of the Census, 1982, 1988, 1993.

Table 4. Michigan fishing license sales for the 1989 fishing season.

License type (cost)	Numbers	Revenues[1]
Annual resident ($9.85)	967,877	$9,533,588.45
Annual non-resident ($20.35)	137,614	$2,800,444.90
Sportsperson ($45.35)	66,440	$3,013,054.00
Daily ($5.35)	271,678	$1,453,477.30
Senior ($1)	134,266	$134,266
Trout and salmon stamp[2] ($9.85)	327,683	$3,227,677.55
Salmon snagging stamp[2] ($7.35)	12,862	$94,535.70
TOTALS	1,918,420	$20,257,043.90

[1]Revenues from fishing licenses are placed in the Michigan Fish and Game Fund to pay for fisheries management programs.

[2]A daily, annual, sportsperson or senior fishing license was also required.

Source: Mahoney et al., 1991.

Table 5. Expenditures by resident and non-resident anglers in Michigan for 1980, 1985 and 1991.

(Anglers ≥ 16 years old; numbers in thousands)

Category	1980	1985	1991
Total trip-related angler expenditures in Michigan	$324,439	$551,276	$535,735
Resident	$260,968	$471,398	$440,991
Non-resident	$63,471	$79,878	$94,744
Total expenditures by Michigan anglers		$1,403,429	$1,286,368
Total trip-related expenditures		$502,397	$500,836
Food and lodging		$220,907	$200,530
Transportation		$135,721	$118,245
Other trip costs		$145,769	$182,060
Equipment-related expenditures		$764,031	$495,402
Miscellaneous expenditures		$137,002	$290,130

Source: USDI, Fish and Wildlife Service, and USDC, Bureau of the Census, 1982, 1988, 1993.

Management of Michigan's fisheries resource began in 1873 with the establishment of the Michigan Fish Commission. The Fisheries Division of the Michigan Department of Natural Resources (MDNR) evolved from that commission and is the second oldest administrative agency in the state's government.

Important events in the history of Michigan's fisheries management were summarized in 1974, when the Michigan Fisheries Division released a report highlighting its centennial, *Michigan Fisheries Centennial Report, 1873-1973*.

Michigan was an early leader in the development of fish hatchery techniques to produce fish for commercial and recreational fish stocking programs. Hatchery construction, fish husbandry development and fish stocking were the primary management techniques used to enhance Michigan's angling opportunities from 1873 through the mid-1900s. Hatcheries were built or acquired to produce salmonids, black bass and other game fishes. Over time, Michigan's fish production and stocking policies have changed significantly. In 1921, the policy on the introduction of exotic fish was changed so that approval required more than a request by an individual or group. The policy changed again in 1942, to stocking fewer but larger fish. In 1964, the policy was changed again to a "put-grow-take" strategy, which has subsequently been modified to take into consideration the concept of the carrying capacity of the environment to support fish stocks, and to focus on enhancing natural reproduction rather than stocking more fish.

Michigan established its first non-resident fishing license in 1914, which cost $3 or $1 (excluded trout). The first resident fishing license was established in 1933 and cost 50 cents. Six years later, the cost of a resident fishing license was raised to $1; however, 40 cents from the sale of each license was earmarked for acquisition of public access sites, habitat improvement and research. Twenty-eight public fishing sites were acquired the next year with fishing license funds.

Michigan has a distinguished history of habitat improvement of streams and lakes. In 1927, the first trout stream improvement project was done in Michigan. In 1930, experimental stream improvement work was begun on smallmouth bass streams in southern Michigan. The Rifle River in Ogemaw County was selected for one of the first watershed management projects in the United States in 1950.

Experimental lake improvement programs were started in the 1930s. Early lake improvement work was directed at increasing production and survival of young fish. Work included placing brush shelters to protect young fish, building gravel spawning beds, planting aquatic vegetation on barren lake shoals and placing wood slabs as spawning structures for certain minnows. Later work focused on improving harvest by concentrating adult fishes through the use of fish shelters.

A creel census program was started by the Fisheries Division in 1927. When results of the creel census for 1927-1932 were reported (1933), it was the first game fish inventory conducted by any state.

In the 1880s, Michigan's Fish Commission began working with state universities on technical problems. Later these interactions were formalized by establishing the Institute for Fisheries Research, an applied fisheries research unit, at the University of Michigan in 1929. This institutional arrangement helped make the Michigan Fisheries Division a leader in fisheries research. The first two publications of the Institute for Fisheries Research were *Methods for the Improvement of Michigan Trout Streams* and *The Improvement of Lakes for Fishing*. These publications are believed to be the first technical publications on habitat improvement for fishing waters published in the United States In 1993, research collaboration between Michigan State University and the Fisheries and Wildlife Divisions of the MDNR was formalized by the creation of the Partnership for Ecosystem Research and Management, a quantitative research unit focusing on ecosystem-level problems.

Over the past 175 years, significant changes have occurred in many of Michigan's recreationally and commercially important fish populations. These changes have been largely due to the activities of humans. Four main categories of human disruption have occurred within the Great Lakes basin that have affected Michigan's fisheries:

1. Increased fishing pressure, both commercial and recreational.
2. Intentional and accidental introductions of exotic species.
3. Changes in the land use patterns around the tributaries of the Great Lakes.
4. Physical and chemical changes in the environment caused by changing land use patterns, dams, effluents and atmospheric deposition of contaminants resulting from urban, agricultural and industrial development.

The Michigan grayling, a fish native to north central Michigan, is believed to be a casualty of logging, competition with introduced trout species and overexploitation. Logging increased siltation in Michigan streams, which may have reduced the grayling's spawning habitat. Floating logs down streams to sawmills further damaged stream banks and scoured stream bottoms. Brook, brown and rainbow trout introduced into grayling streams probably caused increased competition and predation. Grayling were also very vulnerable to fishing, and as the railways were expanded northward, grayling streams became more accessible to anglers, who harvested them in large numbers. Attempts to reestablish grayling to supplement dwindling natural stocks were unsuccessful. Grayling disappeared from the Lower Peninsula by about 1906. The last record of a grayling taken by a fisherman was in 1935, in the Otter River of the Upper Peninsula.

Since the 1800s, 139 exotic aquatic organisms have become established in the Great Lakes. Most of the introduced organisms have been plants (59), fishes (25), algae (24) or mollusks (14). Arrival of exotics in the Great Lakes basin has occurred by unintentional or deliberate releases, via introductions in ships' ballast water, by entry through or along canals, and by land transport. Exotic fishes from both intentional and unintentional introductions have affected Michigan's fisheries both positively and negatively.

Exotics purposefully introduced to enhance sport fishing include the chinook salmon (1873 and 1967), rainbow trout (1876), common carp (1879), brown trout (1883), rainbow smelt (1906 to about 1920) and coho salmon (1924 and 1966). Attitudes about intentionally introduced fishes have changed over time. For example, carp were extremely popular as sport fish from the 1880s through the early 1900s. Though some anglers continue to target carp, its popularity as a game fish declined long ago. Carp are, however, still an important fish in the Great Lakes commercial catch. The popularity of the brown trout has also fluctuated among sport anglers since its introduction from Germany. Adverse public opinion temporarily halted brown trout stocking in 1897. The program was resumed in 1909 to offset the depletion of brook trout. By 1920, sport anglers again opposed brown trout stocking and the program was stopped. Today, brown trout are stocked in marginal trout streams and two-story lakes and are self-sustaining in suitable habitats.

Completion of the Welland Canal and the St. Mary's Locks provided entry to our first unintentionally introduced species. The primary early invaders were the sea lamprey (1929) and the alewife (1931). The gravel streams and cold waters of the three upper Great Lakes provided excellent spawning habitats for the sea lamprey and populations thrived. Lamprey preyed on large fish, primarily the lake trout. By the 1950s, lake trout populations had collapsed by as much as 95 percent in lakes Michigan and Huron.

The Great Lakes Fishery Commission (GLFC) was formed in 1955 primarily to reduce sea lamprey populations. Mechanical and electrical barriers were built across spawning streams to prevent access to adult lamprey. The barriers were later replaced with the selective lampricide "TFM." Control methods and the reduction in large fishes led to a significant reduction in lamprey in some areas by the early 1960s. Today, the GLFC works with the governments of the United States and Canada, the eight Great Lakes states, the province of Ontario, and two tribal management authorities to administer the sea lamprey control program and to coordinate restoration and maintenance of important commercial and recreational fish stocks.

Alewife populations expanded in lakes Huron and Michigan because the sea lamprey had reduced the number of predators and ecological conditions favored expansion. The alewives competed with small native fishes for zooplankton—microscopic animal food items of many small fishes. Populations of emerald shiners, lake herring, chubs, perch, walleye and smallmouth bass may have declined because of competition from the alewife and other factors. Large die-offs of alewife in the early 1960s littered the beaches along the Lake Michigan shoreline.

The introduction of Pacific salmon into the Great Lakes in the late 1960s was, in part, a response to the problems created by the introduction of sea lamprey and alewives. With sea lamprey populations significantly reduced and large populations of alewife to serve as forage, fisheries managers in Michigan began stocking the Pacific salmon as large, open water predators. A world-renowned sport fishery was developed and persisted for nearly 25 years.

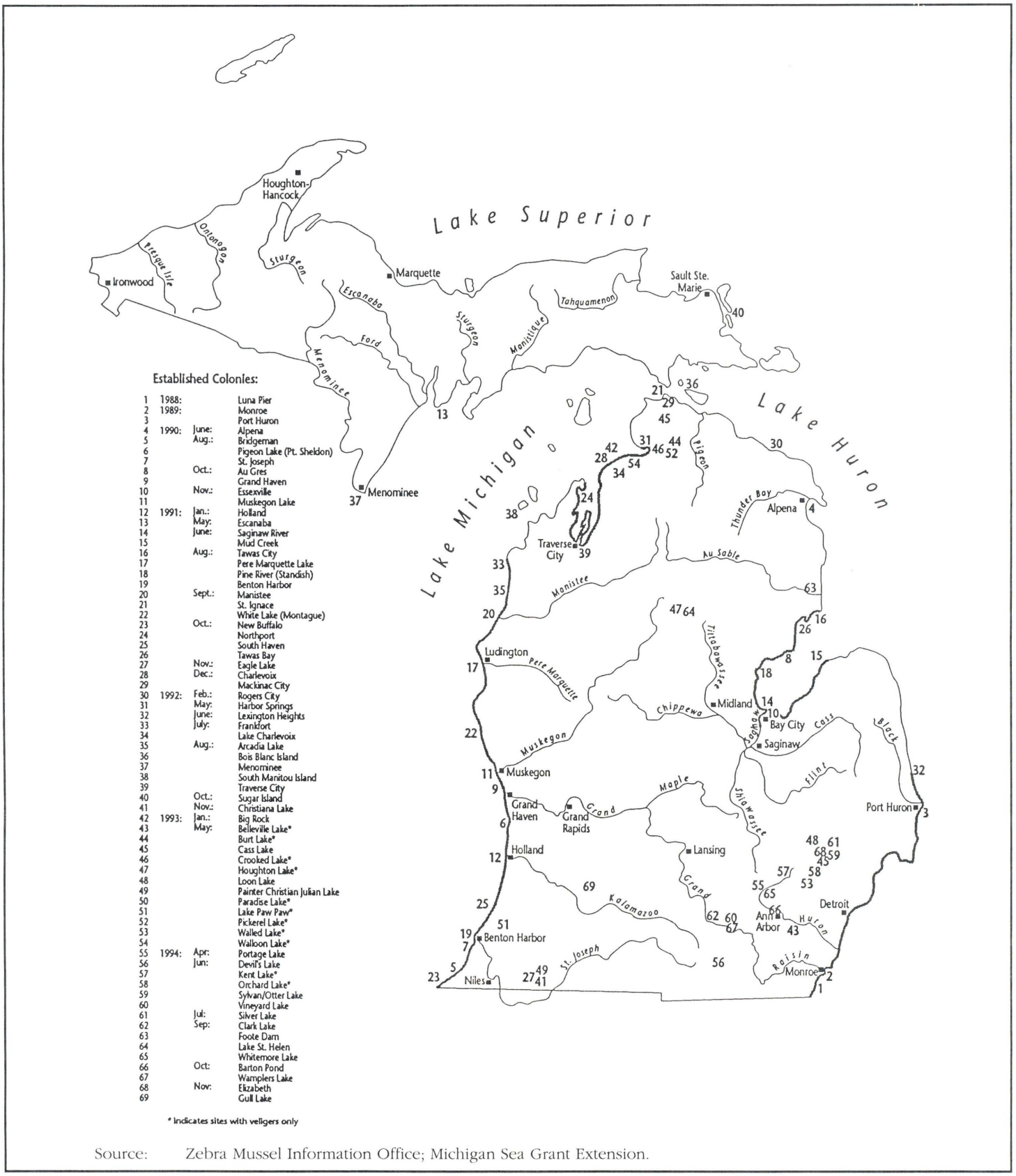
Of the early fish introductions into the state, four are generally considered to be detrimental to the fishery: alewife, goldfish, carp and sea lamprey. Alewife, however, have provided a forage base for salmon. Conversely, the rainbow, brook and brown trout; the coho, pink and chinook salmon; and the rainbow smelt have contributed to the sport fishery. Because of the potential for harm to the state's fishery, any new introductions should be carefully evaluated.

More recently, ballast water released from ocean vessels has been responsible for the unintentional introduction of the zebra mussel, the quagga mussel, the spiny water flea, the ruffe, the white perch and two gobies. Zebra mussels, which attach to hard structures in moderate water depths, have clogged water intakes for power plants and municipal water treatment plants. They reduce pumping efficiency and cause plant shutdowns for cleaning. Zebra mussels have spread throughout the Great Lakes since they were first observed in Lake St. Clair in 1988 and are now found in inland waters and the Mississippi drainage (Figure 2). The full ecological impact of these newly introduced exotics will not be known for many years.

Levels of toxic chemicals and phosphorous in the Great Lakes became a major national concern in the 1960s and 1970s. Contamination levels of toxic chemicals were progressively higher in fish farther up the food chain because of a process known as biomagnification. Levels of contaminants such as PCB and DDT increased to unacceptable levels in the largest predatory fish. These toxic chemicals and other contaminants may have been partially responsible for the failure of early attempts to rehabilitate lake trout stocks. Fish consumption advisories were issued to protect human health.

Phosphorous contamination increased the rate of eutrophication (nutrient over-enrichment) of the Great Lakes and inland waters. The increased level of phosphorous caused a shift in aquatic plant and animal communities, reduced oxygen levels, increased sedimentation, and caused other undesirable ecological impacts.

Federal and state legislation mandating controls on toxic substance and phosphorous discharge, water and air quality, and land development have significantly improved the environment. Contaminant levels in many Great Lakes fish have declined by more than 90 percent over the past 20 years. As a result, Michigan is considering removing coho and smaller chinook and lake trout from the fish health advisories. Many people, however, still express concern over contaminants in Great Lakes fish, and this has had an impact on the number of sport anglers.



Source: Zebra Mussel Information Office; Michigan Sea Grant Extension.

Figure 2. Zebra mussel distribution in Michigan, December 1994.

Management of Michigan's Fisheries

The MDNR Fisheries Division management authority was established and revised by the following Michigan laws:

Public Act 17, 1921. MCL (Michigan Compiled Laws) 299.1—Creation of the MDNR.

Public Act 165, 1929. MCL 301.1—Michigan Sports Fishing Law.

Public Act 84, 1929. MCL 308.1—The Commercial Fishing Law of 1929.

Public Act 28, 1955. MCL 3.652—Great Lakes Basin Compact.

Public Act 285, 1986. MCL 299.151—Non-game Fish & Wildlife Trust Fund Act.

Public Act 93, 1992. MCL 299.231—Biological Diversity Conservation Act.

The Environmental Code Commission appointed by Gov. Engler is currently attempting to rework the state's environmental laws. The goal of the commission is to streamline the patchwork of environmental laws developed over decades. Fisheries laws have been drafted under the title "Aquatic Species Conservation Act."

Michigan's fishery resources are held in public trust by the state for the benefit of its citizens in perpetuity. The state's responsibilities as trustee of the citizens' fishery resources are largely discharged through the MDNR Fisheries Division. Statutory and judicial application of the public trust doctrine have established five principles that guide the Fisheries Division's mission and goals:

1. Public trust resources are a special form of public property that may not be transferred to private ownership unless the transfer will serve a significant public purpose.
2. The interests of future citizens of the state are as important in resource management as those of the present citizens.
3. The state has an obligation to provide for the broadest possible benefits from use of public trust resources.
4. Government must act to develop natural resources and promote their use in the interest of the general welfare.
5. Resource managers must seek to define and serve the broad public interest as opposed to narrower, more focused interests.

The MDNR adopted the following mission and goals for the Fisheries Division in light of the public trust doctrine and the interests of the major stakeholders in Michigan's fishery resources. The division's mission is: To protect and enhance the public trust in populations and habitat of fishes and other forms of aquatic life, and promote optimum use of these resources for the benefit of the people of Michigan. In particular, the Fisheries Division seeks to:

- Protect and maintain healthy aquatic environments and fish communities and rehabilitate those now degraded.
- Provide diverse public fishing opportunities to maximize the value to anglers of recreational fishing.
- Permit and encourage efficient and stable commercial fisheries that accommodate Native American fishing rights and do not conflict with recreational fisheries.
- Foster and contribute to public stewardship of natural resources through a scientific understanding of fish, fishing and fishery management.

The Fisheries Division has established five programs to accomplish its mission and goals:

1. Recreational fisheries—To provide diverse public fishing opportunities to maximize the value of recreational fishing.
2. Commercial and Native American fisheries—To permit and encourage efficient and stable commercial fisheries that accommodate treaty fishing rights and do not conflict with recreational fisheries.
3. Great Lakes fishery resources—To protect and maintain healthy Great Lakes environments and fish communities and to rehabilitate those now degraded.
4. Inland fishery resources—To protect and maintain healthy inland waters and fish communities and rehabilitate those now degraded.
5. Fish production—To hatch, rear and transport fish required for management of the Great Lakes and inland fisheries.

The Fisheries Division works cooperatively with agencies of Canada and the United States to manage our shared Great Lakes fishery resources. The Great Lakes Fishery Commission provides the principal forum for cooperation among the agencies responsible for fishery resource management from the province of Ontario, the eight states surrounding the Great Lakes and tribal management authorities. The Fisheries Division also works with the International Joint Commission, established by treaty between the United States and Canada to manage water level, use and quality of the Great Lakes.

The Fisheries Division works with major research laboratories such as the U.S. Department of Interior National Biological Survey, National Fisheries Research Center – Great Lakes. The center's major research initiatives include:

- Lake trout rehabilitation—Develop self-sustaining lake trout populations by studying predator-prey interactions, the biology of larval and juvenile stages of lake trout, the effectiveness of sea lamprey control, genetic and reproductive differences between lake trout strains, and the geology and biology of the lake floor to identify suitable spawning sites.

- Fish population dynamics—Evaluate the well-being of fish populations by studying population dynamics of food and forage fish and the accumulation of toxic chemicals in fish tissues.
- Habitat studies—Understand habitat requirements of fish by studying the environmental requirements of organisms eaten by fish, spawning sites, and the effects of shoreline development and other habitat alterations on aquatic organisms.
- Chemical contaminants—Conduct experiments to determine how organisms respond to contaminants, develop models to predict which chemicals may be toxic to aquatic life and identify toxic chemicals that move through the food chain.
- Exotics—Determine the impact of non-native species on the Great Lakes system by studying the impact of Pacific salmon predation on alewife and rainbow smelt, fish adaptation to a new zooplankton food source, ecological and economic effects of rampant zebra mussel growth and plant community disruptions in adjacent marshes caused by invading purple loosestrife.

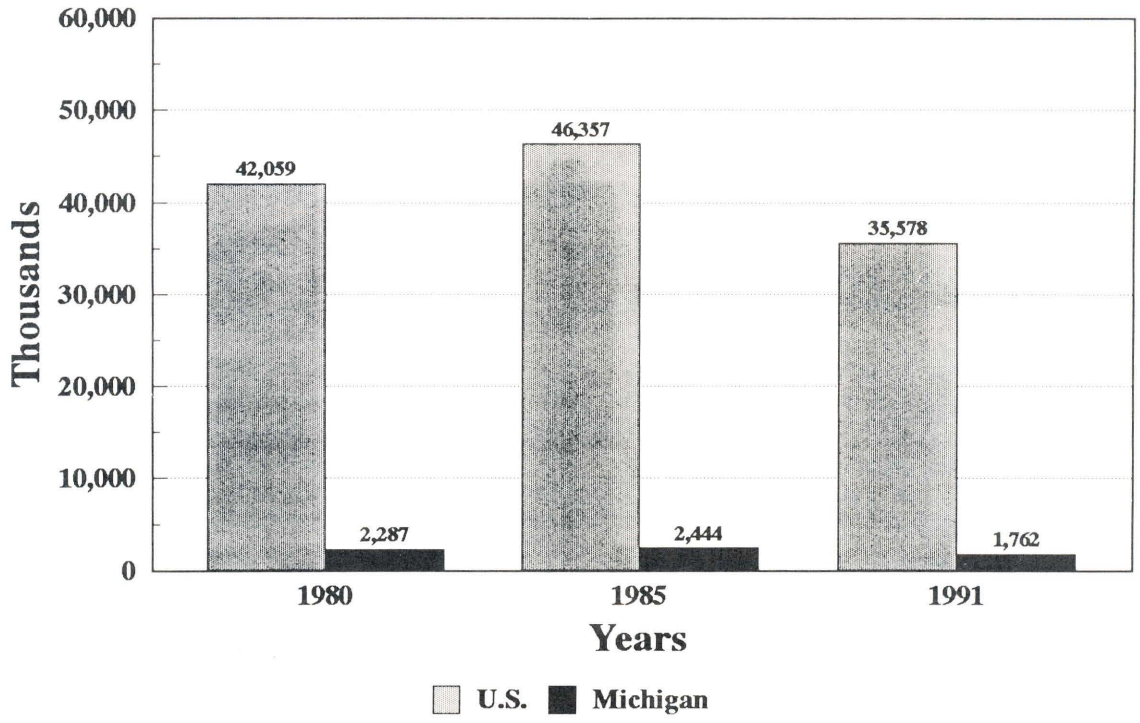
Research results generated by the center help fisheries managers maintain and restore desirable fish communities for sport and commercial fishing.

Recent Trends

Trends in Recreational Fisheries

Recreational fishing in Michigan has continued to be a popular pastime for both resident and non-resident anglers. Nationally, angler numbers and participation grew significantly between 1980 and 1985. By 1991, however, numbers of anglers had decreased nationally to below 1980 levels (Figure 3). Though the decade of the 1980s saw little change in the number of Michigan fishing licenses sold (Figure 4), angler numbers and participation measured as angler days (Figure 5) followed national trends. The percentage of non-resident to resident participants also dropped from about 24 percent in 1980 and 1985 to 19 percent in 1991.

The number of resident fishing licenses sold between 1985 and 1992 has remained relatively constant. Maximum sales over that period occurred in 1987. Peak sales during 1987 are attributed to new regulations that required spouses of licensed anglers to purchase individual licenses if they wished to fish. The sale of trout and salmon stamps between 1985 and 1992 decreased noticeably. Modest declines in license sales do not fairly reflect trends in trout and salmon fishing participation—since 1984, anglers who purchased sportsman's licenses were not required to purchase separate stamps to fish for trout or salmon.



Source: USDI, Fish and Wildlife Service, and USDC, Bureau of the Census, 1982, 1988, 1993.

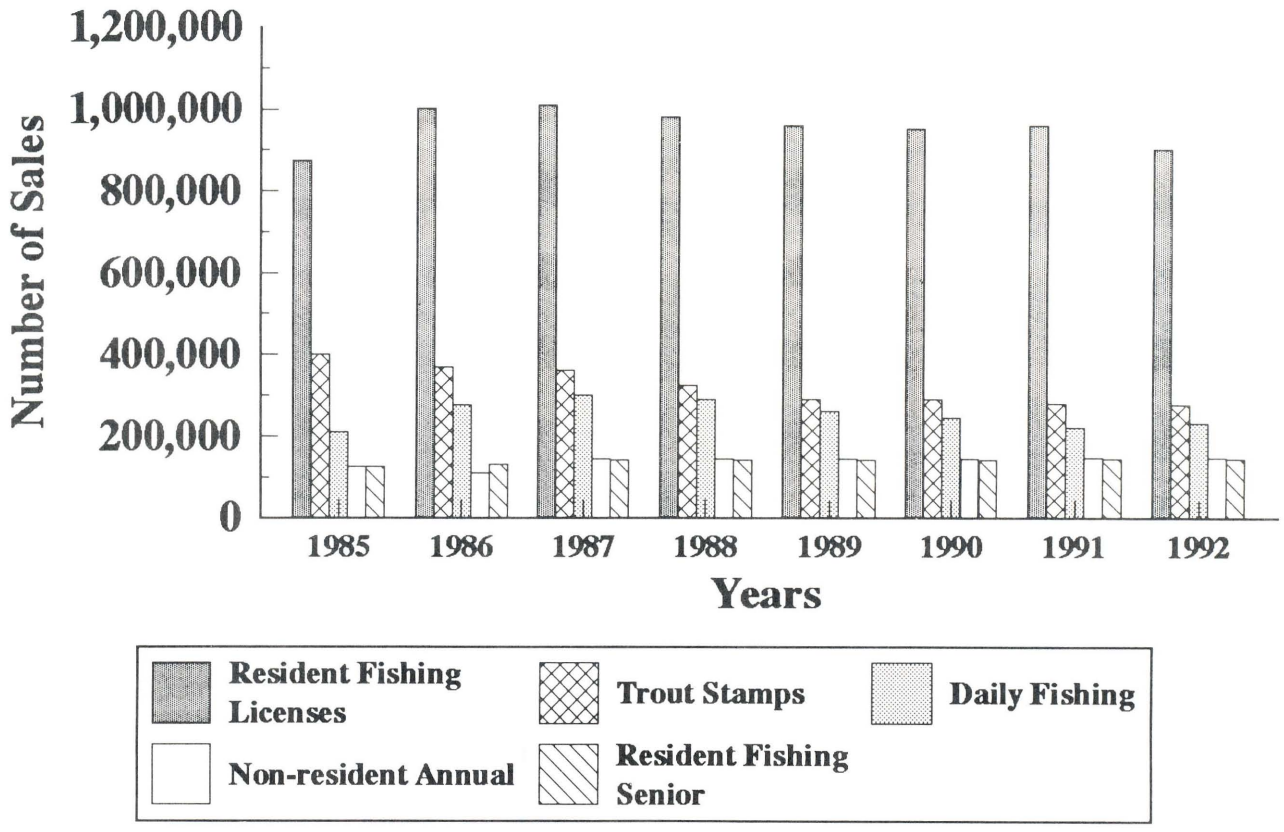
Figure 3. Anglers by location where fishing took place.

Economic concerns may have been a major factor contributing to declines in both state and national angler participation. Decreases in popular sport fish populations, lower catch rates of desired species and concern over contaminated fish may have also affected angler participation in Michigan. For example, in 1992, the estimated sport fishing harvest of chinook salmon at seven popular sport fishing ports was less than 20 percent of the size of the total catch in 1986 (Figure 6). Catch rates and sportfishing effort also declined drastically during this period (Figures 7 and 8).

Geography may also be an important factor affecting resident angling participation in Michigan (Figure 9). In all but two counties in the northern two-thirds of the state, at least 16 percent of the population age 17 or older participated in angling. In southeastern Michigan, less than 15 percent of the population participates. Angling in the Detroit metropolitan area is lowest, with 6 to 11 percent participation. Limited physical access to quality inland fisheries, limited economic access to Great Lakes fisheries and lack of a cultural tradition of fishing are the primary reasons speculated for the lower participation rate in the Detroit area.

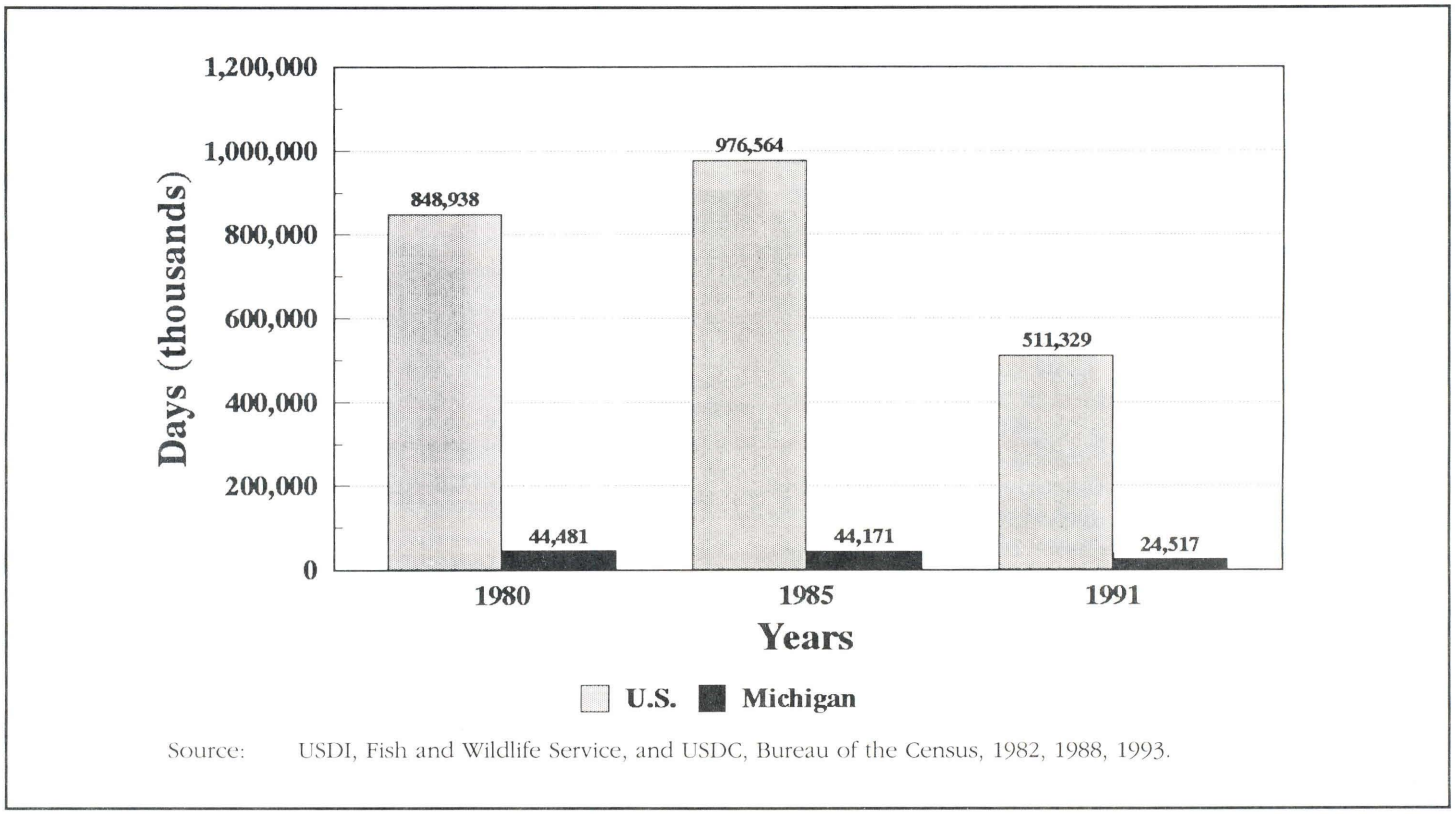
The distribution of angling effort is seasonal in Michigan. The majority of angling effort occurs between May and September (Figure 10) and supports seasonal sport fishing-related businesses. Sport fishing in Michigan is supported by nearly 1,100 boat launch sites, 69 protected harbors and more than 1,000 marinas containing approximately 600,000 slips. Fifty-two percent of licensed Michigan resident anglers own boats or canoes for fishing. (More information on boating recreation in Michigan can be found in SAPMINR Special Report 77.)

A 1983-84 survey of sport anglers conducted cooperatively by the MDNR Fisheries Division and MSU indicated that the species of fish anglers preferred to catch and to eat varied between residents and non-residents. Residents preferred to catch bass (23 percent), walleye (18 percent) and trout (17 percent), but preferred to eat walleye (26 percent), yellow perch (26 percent), panfish (15 percent) and trout (15 percent). Non-residents preferred to catch salmon (30 percent), bass (24 percent) and walleye (18 percent), but preferred to eat walleye (29 percent), salmon (18 percent) and trout (15 percent).



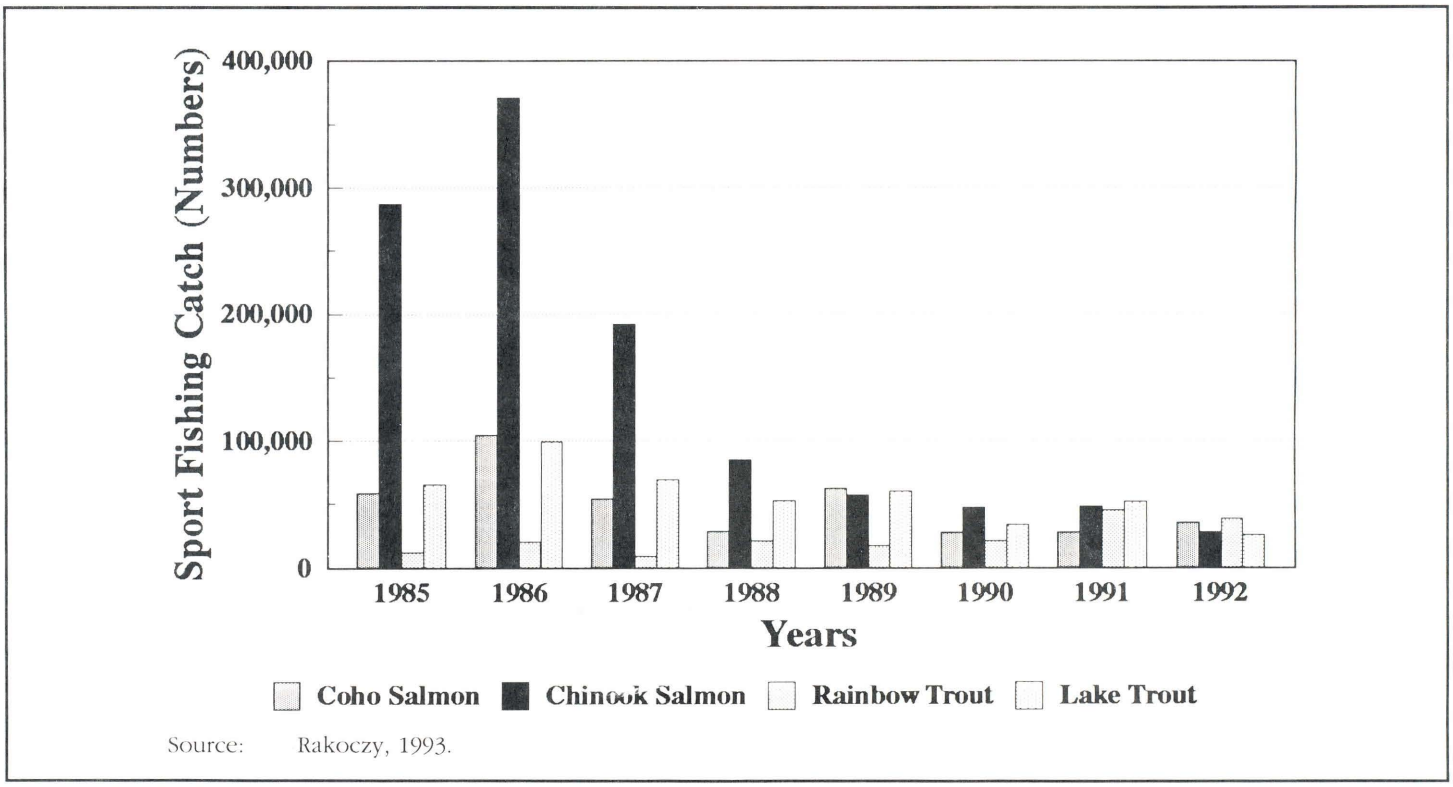
Source: Michigan Department of Natural Resources.

Figure 4. Michigan fishing license and trout stamp sales, 1985-1992.



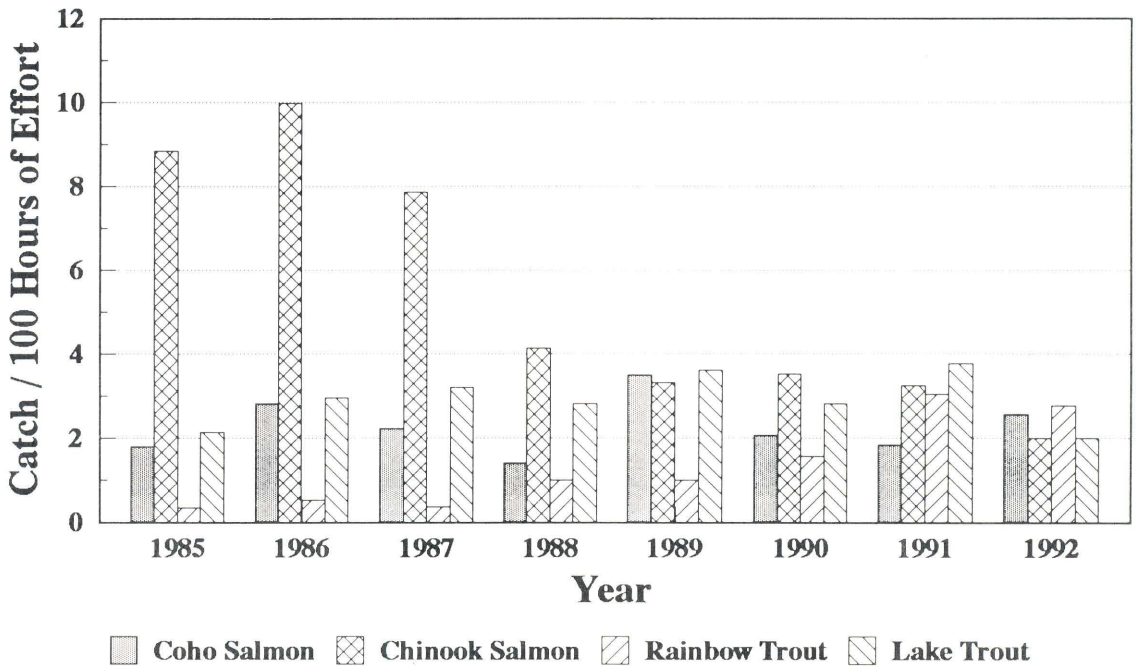
Source: USDI, Fish and Wildlife Service, and USDC, Bureau of the Census, 1982, 1988, 1993.

Figure 5. Angler participation (days) by location where fishing took place.



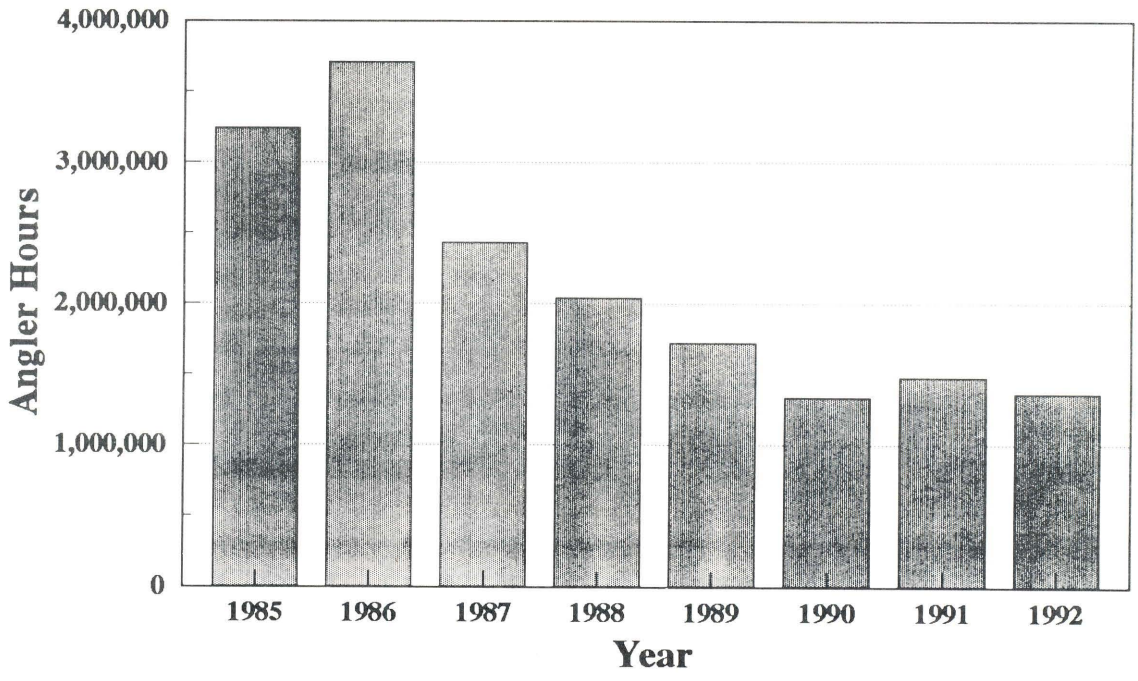
Source: Rakoczy, 1993.

Figure 6. Estimated sport fishing catch combined for seven Lake Michigan ports, April-August, 1985-1992.



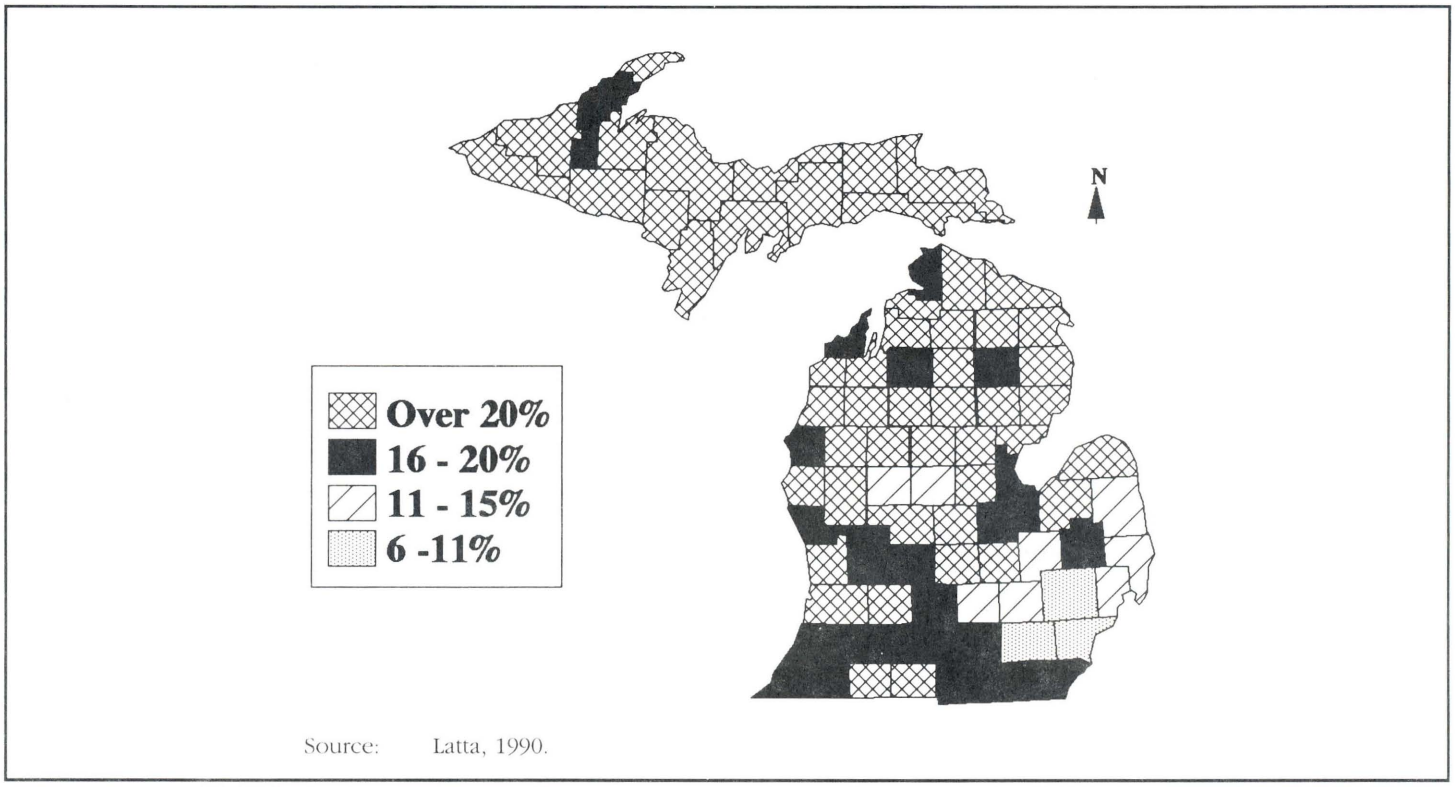
Source: Rakoczy, 1993.

Figure 7. Salmonid catch rates (fish/100 angler hours) for seven Lake Michigan ports, April-August, 1985-1992.



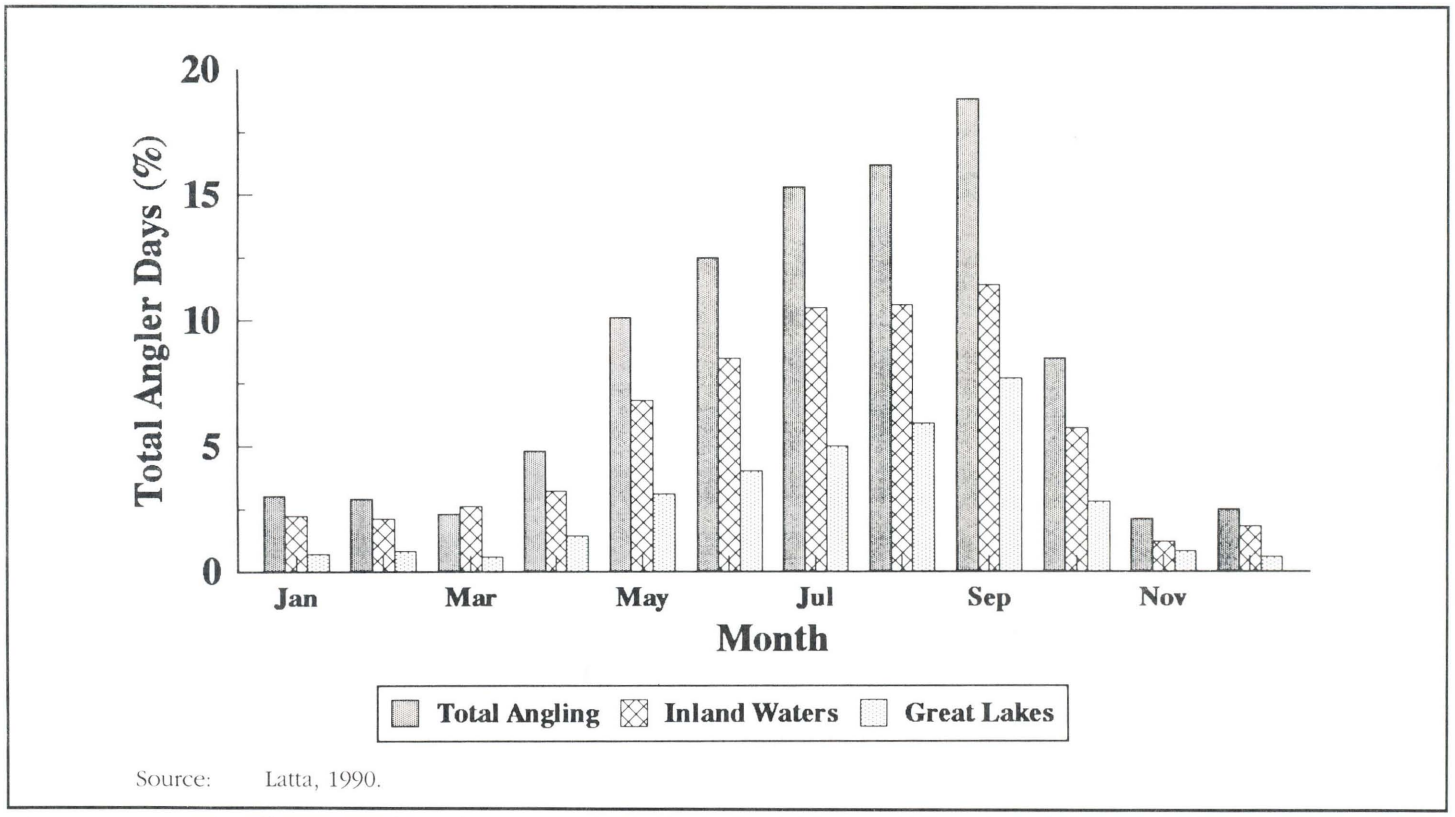
Source: Rakoczy, 1993.

Figure 8. Estimated sport fishing effort for seven Lake Michigan ports, April-August, 1985-1992.



Source: Latta, 1990.

Figure 9. Percent of Michigan residents (17 years or older) participating in angling.



Source: Latta, 1990.

Figure 10. Distribution of angling effort in Michigan by month and location.

Estimates of private investment in fishing trips range from $1 billion to $4 billion annually. This figure includes such expenditures as boats, vehicles, food, lodging, transport and angling supplies. Michigan ranks first in the region and fourth in the nation in expenditures for recreational fishing (Table 2).

In the early 1980s, about 55 percent of licensed Michigan anglers fished for Great Lakes fish. The Great Lakes fishing effort was almost equally divided between salmonids (trout and salmon) and percids (walleye and yellow perch). Lake Michigan received the most salmonid angler days and lakes St. Clair and Huron received the most non-salmonid angler days (Table 6).

As late as 1988, interest in Great Lakes fishing supported a fleet of approximately 1,000 charter boats in Michigan. In 1985, 30 percent of the 239,000 persons who charter fished were non-residents primarily from Ohio, Illinois and Indiana. Trip expenditures by charter fishing customers were estimated to be as high as $59.5 million in Michigan in 1988, with about 40 percent spent within 10 miles of the charter boat dock. Aggregate charter boat revenues were $13.8 million. The state of the economy, concerns over fish contaminants and the reduction in the Lake Michigan chinook fishery have significantly affected the charter boat industry and the economy of major port cities.

During 1992, the Fisheries Division conducted creel surveys by interviewing more than 22,700 anglers at the conclusion of their trips from 18 key fishing ports and fishing areas on Lake Michigan. (Similar creel censuses and charter boat reports have been conducted for Michigan waters of the other Great Lakes.) Results of the survey indicated that non-charter anglers fished an estimated 2.25 million hours. Charter captains reported making 10,714 trips that provided fishing experiences for 47,025 charter anglers. At nine Lake Michigan "index ports" that the MDNR has surveyed since 1985, the estimated number of coho salmon, rainbow trout and yellow perch caught did not change significantly from 1991 to 1992. However, significant declines were observed in the sport catches of chinook salmon (decreased 39 percent), brown trout (45 percent) and lake trout (55 percent). Based on the 1992 harvest and angler participation, anglers experienced about average success for coho salmon, rainbow trout and yellow perch, but catches of chinook salmon, lake trout and brown trout were below average compared with the previous seven years (1985-1991).

Bacterial kidney disease (BKD) has been implicated in mortalities leading, in part, to the decline of the chinook salmon fishery. BKD has also been found in feral coho, steelhead, and brown trout from Lake Michigan. Control measures and strategies are being developed and implemented to try to bring this disease under control. Michigan has also cooperated with the Fish Disease Control Committee, established in 1973 by the Great Lakes Fishery Commission, to formulate fish disease control policy and recommend measures to reduce disease-induced mortalities of hatchery stocks and to prevent the introduction of exotic diseases into the Great Lakes basin.

Michigan's inland waters support about two-thirds of the state's recreational fishing. A variety of inland aquatic habitat types are actively managed: cold-water streams, cool/warm-water streams, and cold/warm/two-story inland lakes. The inland fisheries management techniques most commonly used in Michigan include: general harvest restrictions by size and species, fish stocking, special fishing regulations, facilities for managing fish migrations, habitat improvement (sediment traps, gravel spawning beds, spawning reefs, erosion control, etc.), and reduction of fish abundance through netting or use of piscicides.

Table 6. Angler days (thousands) of fishing effort for Great Lakes fishes by lake, 1981.

Lake	Salmonid	Stream salmonid	Non-salmonid
Michigan	1730	1,328	906
Huron	554	275	1305
St. Clair	59	1	1892
Erie	9	12	513
Superior	220	117	74

Source: Latta, 1990.

On the average, the Fisheries Division annually surveys 290 inland waters to determine the status of the fisheries and provide a basis for sound management planning. The analysis of survey information leads to management recommendations in the form of prescriptions and plans. Facilities have been developed to improve access to the state's lakes and streams, to provide ponds and marshes to enhance the production of fish for stocking programs, and to enhance habitat in lakes and streams.

In 1987, the Inland Fishery Cooperative Grants Program was implemented to enhance cooperation between the Fisheries Division and individuals, groups or communities that wish to contribute to management of specific fishery habitats consistent with the Fisheries Division's management plans. The program is based on matching funds for habitat restoration and angling opportunity enhancement. Inland fisheries research efforts have been summarized in *1980-1990 Michigan Fisheries: A Foundation for the Future,* MDNR Fisheries Special Report No. 13.

New attitudes being adopted by the public may influence the overall fisheries management program in Michigan. Catch-and-release fishing, reduced creel limits, larger minimum sizes and more restrictive gear limitations are growing in favor and public acceptance. The MDNR Fisheries Division has adopted formal policies on catch-and-release fishing and tournament fishing to reduce the harvest of game fishes.

An apparent trend with significant implications for resource management in Michigan is the declining opportunity for citizens to spend time pursuing various recreational choices such as hunting and fishing. An increasing demand for quality experiences may be one way of compensating for decreasing quantity of experience. One way of substituting quality for quantity may be to specialize in the methods used or species pursued in hunting and/or fishing. There are many such fishing specialists currently, and this tends to increase the demands on the resources and to increase competition for limited recreational opportunities. For example, trout anglers who use artificial flies and ascribe to catch-and-release practices as the most ethical approach to trout angling lobby for special regulations on highly valued trout fisheries, such as the Au Sable River. Allocating limited fisheries resources to various trout angler groups in the state thus becomes a complex social issue for fisheries managers.

Trends in Commercial Fisheries

The Great Lakes continue to support an economically important commercial fishery. In 1993, the total commercial fishing harvest, by state-licensed and tribal fishermen, was 15.5 million pounds (Table 7), worth about $8.8 million. Lake whitefish has been the dominant species harvested in recent years. In 1993, more than 10.3 million pounds of whitefish worth nearly $7 million were harvested.

Michigan began to limit the number of commercial fishing enterprises and commercial fishing effort in 1968 to reduce the conflict between the commercial industry and developing recreational fisheries. Also, commercial fishing regulations were changed to eliminate the use of large-mesh gill nets. These were replaced with trap nets to reduce incidental mortality of fishes preferred by recreational anglers. These actions significantly reduced the number of commercial fishermen in the fishery.

A number of Native American commercial fishermen were among those forced out of the fishery by limited entry or gear conversion. Adjudication established that their aboriginal fishing rights were not relinquished by treaties and must be accommodated. (Tribal commercial fisheries are discussed in a separate section.)

In 1992, the Fisheries Division issued 94 commercial fishing licenses. The licenses specify fishing areas, species that can be harvested, and the type and amount of gear that can be used. The majority of Michigan's state-licensed commercial fishermen harvest fish from either Saginaw Bay in Lake Huron or Green Bay (including Bay De Noc) in Lake Michigan, though commercial fishermen harvest fish from all four of Michigan's Great Lakes.

The reported commercial harvest of selected species by Michigan's state-licensed commercial fishermen for 1993 is summarized in Table 7. The total reported harvest increased steadily from 7.3 million pounds in 1988 to 9.9 million pounds in 1992. In 1993, the harvest decreased to 7.2 million pounds. The dock-side value of the state-licensed commercial fish harvest in 1993 was $4.4 million.

Harvest levels of lake whitefish have risen steadily for the past five years. The total reported whitefish catch by state-licensed commercial fishermen was 3 million pounds in 1988 and 4.7 million pounds in 1993. In 1993, the state-licensed commercial harvest of lake whitefish represented an approximate dock-side value of $3.6 million.

Trends in Tribal Fisheries

In 1985, the Chippewa and Ottawa tribes in Michigan entered into an agreement with the state of Michigan for joint management of the fisheries in the 1836 treaty-ceded waters of lakes Michigan, Superior and Huron. The tribes and the state agreed to allocate the fish stocks by a combination of exclusive zones, fishing methods and species restorations.

The treaty-ceded waters are now divided into tribal commercial fishery development zones, state-regulated zones, lake trout refuges and transition zones. Tribal commercial fishery development zones represent nearly half of all the treaty-ceded waters. In these zones, the tribes can fish with large- and small-mesh gill nets and impoundment gear. State-licensed commercial fishermen were excluded from these zones to accommodate the expansion of the tribal fishery. Three lake trout refuges

Table 7. Reported commercial harvest (pounds) of selected species by Michigan's state-licensed commercial fishermen (SL) and tribal fishermen (T) by lake, 1993.

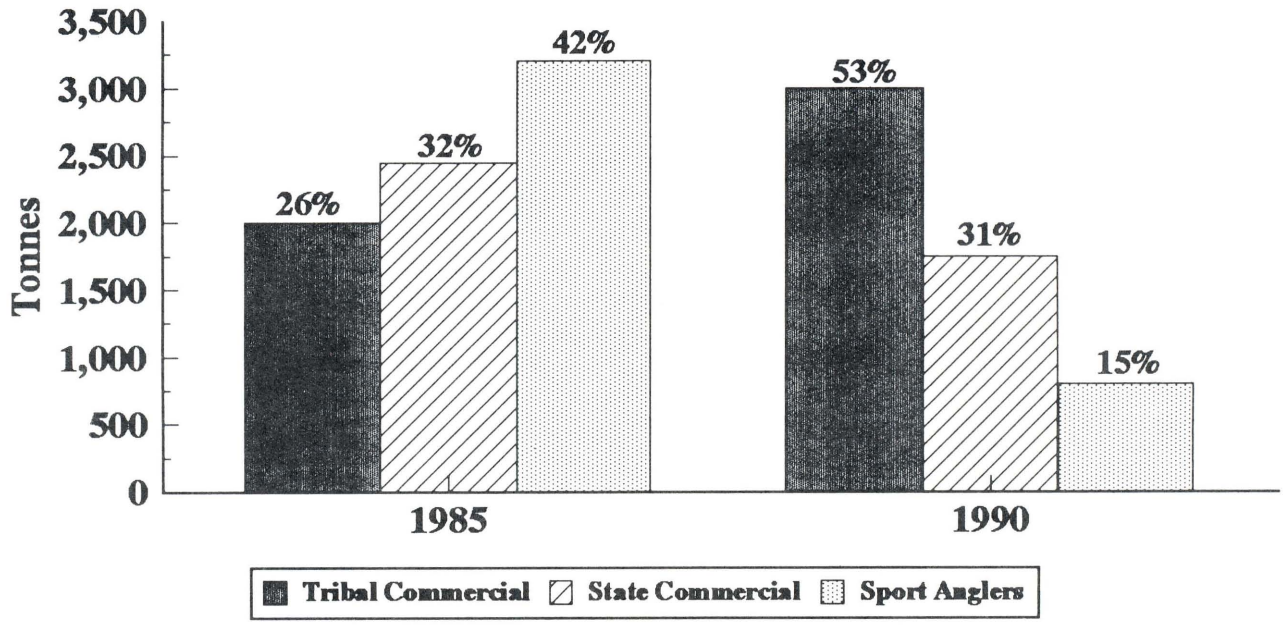
Species	Lake Superior		Lake Michigan		Lake Huron		Lake Erie
	SL	T	SL	T	SL	T	SL
Whitefish	284,764	1,089,171	2,874,428	3,166,371	1,579,603	1,338,672	
Burbot	29		605	23,501	3,209		
Chub	1,150	28,125	323,200	470,346		99,702	
Lake Herring	32,495	93,937		67		3,318	
Menominee	13	1,139		227,047	7,002	8,706	
Rainbow Smelt[a]		4,814[a]	716,926	4,189[a]	10,000	3,112[a]	
Suckers[a]	5,210	4,814[a]	249,078	4,189[a]	83,988	3,112[a]	
Yellow Perch		229		12,300	75,010	434	
Carp[a]	96	4,814[a]		4,189[a]	82,501	3,112[a]	238,805
Channel Catfish			39	2,772	394,114	5,301	9,152
Totals[b]	338,230	1,631,992	4,164,276	4,348,423	2,375,064	2,376,998	283,699

[a] Values for carp, smelt and suckers were combined in tribal report—numbers are approximate.
[b] Includes species reported that are not included in this summary.
Source: Kinnunen, 1994.

were established to support rehabilitation efforts in northern Lake Michigan, central Lake Michigan and northern Lake Huron. The use of gill nets and the taking of lake trout by any method are prohibited in these refuges. Transition zones are historically important recreational fishing areas. In these areas, tribal commercial fishing was accommodated, but the tribes were required to replace gill nets with impoundment nets over a period of years.

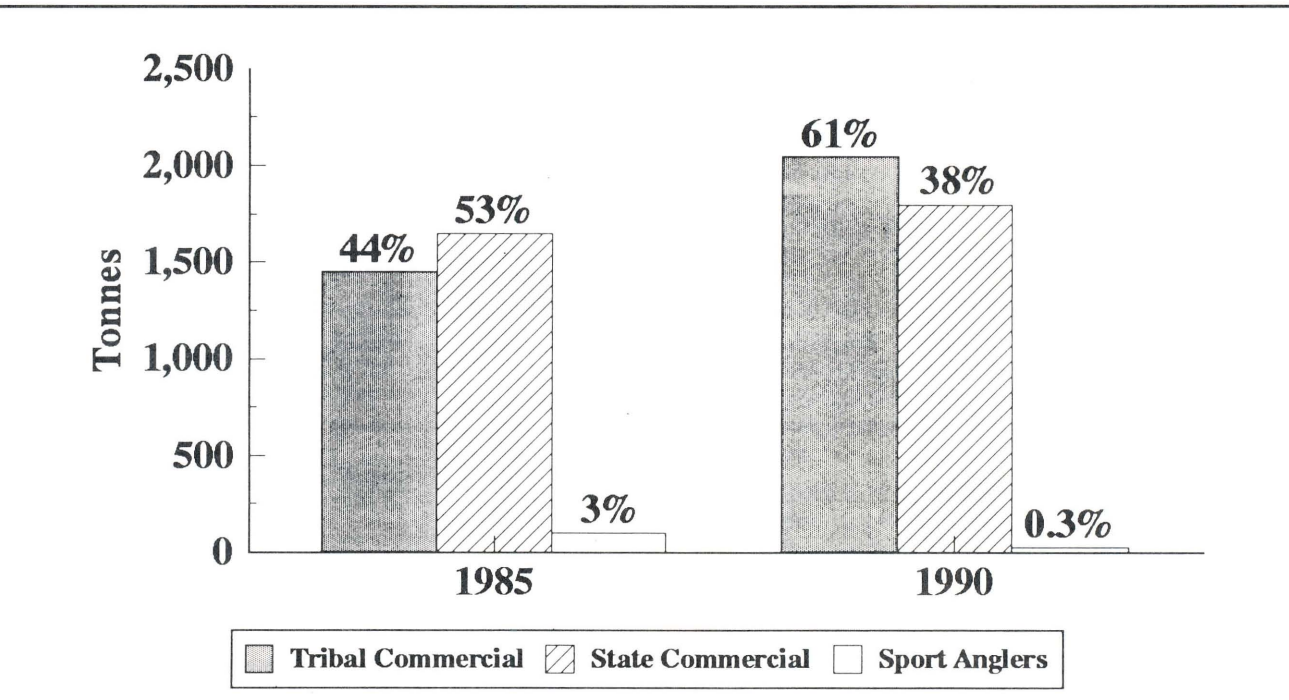
The 1985 consent order also established groups to help implement the joint management of the fisheries. The executive council—consisting of representatives from the tribes and the state and federal governments—meets at least annually to consider issues such as the status and management of the fisheries, the implementation of the agreement, the expenditure of funds and the resolution of disputes. Three standing committees were established to assist in this task: the Joint Enforcement Committee, the Technical Fisheries Review Committee, and the Information and Education Committee.

The consent order also required the parties to collect and exchange fisheries information to protect the fishery resources. Catch data are collected for treaty commercial fishermen by the Inter-Tribal Fisheries and Assessment Program regulated by the Chippewa/Ottawa Treaty Fishery Management Authority (Bay Mills, Soo Tribe and Grand Traverse) and the Great Lakes Indian Fish and Wildlife Commission (Bad River, Keweenaw Bay and Red Cliff bands of Lake Superior Chippewa Indians). Catch data for the treaty-ceded waters are summarized in Figures 11-15. The reduction in the sport fishery from 1985 to 1990 (Figure 15) was not a result of the consent order. The sport fishery decline reflected the reduction in the chinook salmon fishery caused by BKD. With the exception of lake trout, commercial fish stocks within the treaty-ceded waters appear stable. The value of the tribal commercial fishery approaches the value of the entire state-licensed commercial fishery.



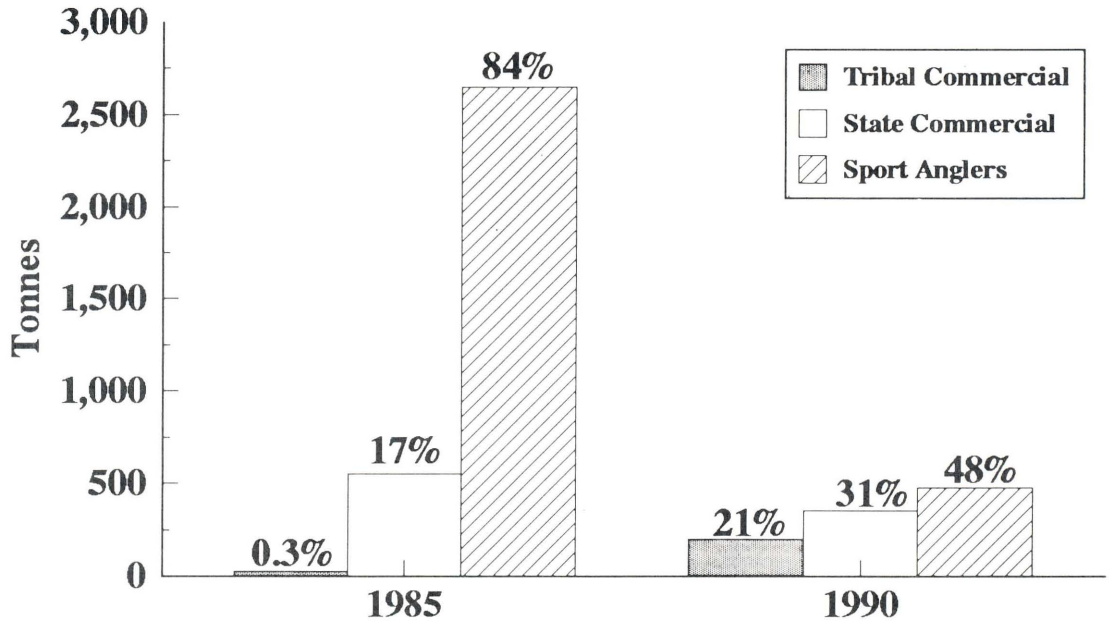
Source: J. Stanley, National Biological Survey (NBS), and T. Gorenflo, Chippewa/Ottawa Treaty Fishery Management Authority (COTFMA), (personal communication).

Figure 11. Total harvest from treaty-ceded waters of lakes Michigan, Huron and Superior, 1985 and 1990.



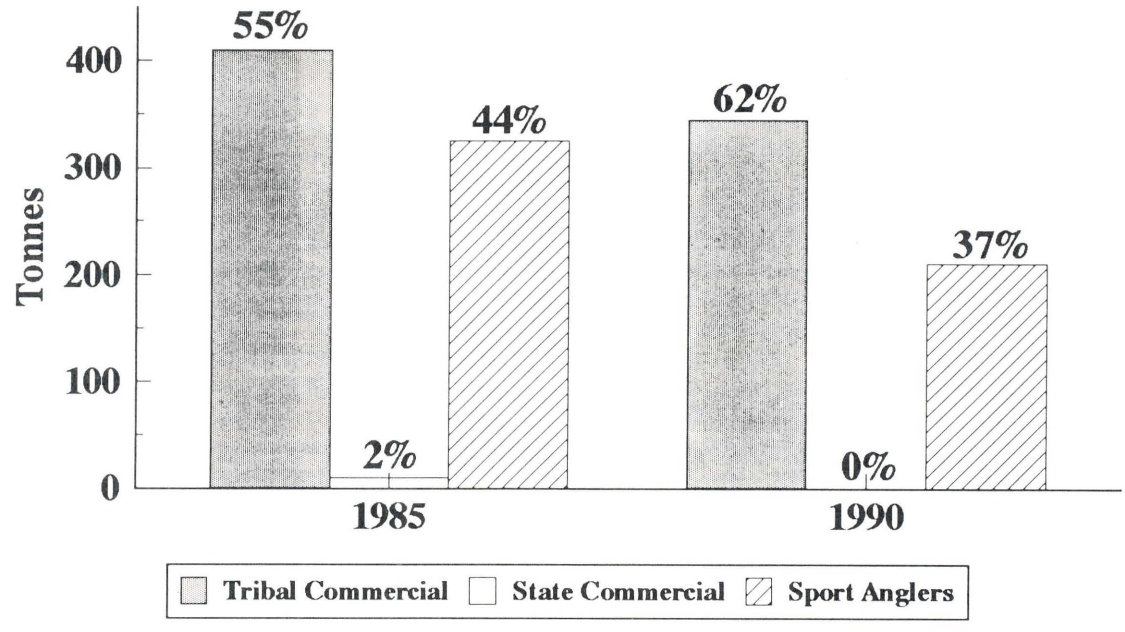
Source: J. Stanley (NBS) and T. Gorenflo (COTFMA), (personal communication).

Figure 12. Lake Whitefish harvest from treaty-ceded waters of lakes Michigan, Huron and Superior, 1985 and 1990.



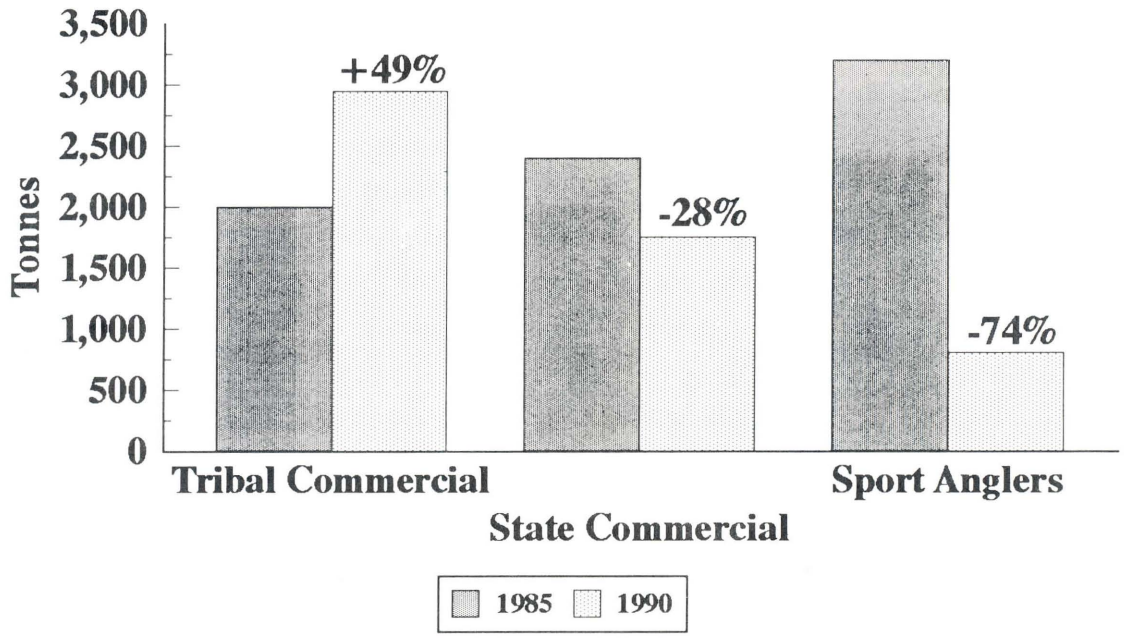
Source: J. Stanley (NBS) and T. Gorenflo (COTFMA), (personal communication).

Figure 13. Pacific Salmon harvest from treaty-ceded waters of lakes Michigan, Huron and Superior, 1985 and 1990.



Source: J. Stanley (NBS) and T. Gorenflo (COTFMA), (personal communication).

Figure 14. Lake Trout harvest from treaty-ceded waters of lakes Michigan, Huron and Superior, 1985 and 1990.



Source: J. Stanley (NBS) and T. Gorenflo (COTFMA), (personal communication).

Figure 15. Change in fish harvest from treaty-ceded waters of lakes Michigan, Huron and Superior from 1985 to 1990.

The reported commercial harvest of selected species by Michigan's tribal fishermen for 1993 is summarized in Table 7. The total reported harvest was 8.4 million pounds; the dock-side value of the fish harvest in 1993 was $4.3 million.

Lake whitefish is the dominant species taken each year by tribal fishermen. The total reported whitefish catch by tribal fishermen was 3 million pounds in 1988 and 5.6 million pounds in 1993. In 1993, the tribal commercial harvest of lake whitefish had an approximate dock value of $3.1 million.

Direct conflicts between the tribal commercial fishery and the state-licensed recreational fisheries have been greatly reduced. The conversion of the tribal gill net fishery to impoundment nets is continuing. The tribes have also developed tribal fish hatcheries. Currently 13 tribal fish hatcheries and/or rearing stations exist in the Great Lakes region. Within Michigan, hatcheries located at Keweenaw Bay, Lac Vieux Desert and Nunns Creek contribute lake trout, brook trout and walleye for joint stocking programs of treaty-ceded waters. Now that most of the conflicts have been addressed, the parties can concentrate on long-range management planning.

Aquaculture

The largest producer of fishes in Michigan is the MDNR Fisheries Division. The division operates six state-of-the-art fish hatcheries that produce more than 800,000 pounds of game fish annually to meet fisheries management needs. Species produced between 1985 and 1993 included 10 coldwater fishes and four cool water fishes. The division also operates the Fish Health Laboratory, which serves all of the state's hatcheries. The Fish Health Lab performs annual fish health inspections of all hatchery salmonid stocks and of adult spawning fish, both hatchery and wild fish. The fish are checked for selected parasitic, bacterial and viral pathogens with the goal of ensuring the production of healthy fish for stocking.

Three of Michigan's hatcheries—Thompson, Harrietta and Wolf Lake—were completely redesigned and rebuilt in the mid- to late 1970s. The newly installed aeration systems at these hatcheries exacerbated a condition known as gas bubble diseases (GBD) caused by nitrogen gas supersaturation. Michigan became a leader in research and development of techniques to eliminate GBD.

Today, Michigan hatcheries are faced with a new set of challenges, including:

- **Bacterial Kidney Disease (BKD):** BKD is a bacterial disease first observed in chinook salmon and implicated in their die-off. This disease has been observed to infect a small percentage of other salmonid species.
- **Phosphorus effluent discharges:** Phosphorus discharge can increase aquatic plant growth in receiving streams. The division has undertaken a major research effort to reduce hatchery effluents at the Platte River Hatchery, including modification of fish feeds to contain less phosphorus and mechanical removal of solid fish wastes.
- **Improvement of hatchery stocks to meet management needs.**

Private sector aquaculturists grow at least 17 fish species in Michigan. Fish are raised for food, fee-fishing, planting stock or bait. Additional characteristics of private sector aquaculture in Michigan are described in *Michigan Aquaculture,* MSU Extension bulletin E-2456 (1993).

Further development of commercial aquaculture in Michigan has the potential to positively affect the state's economy. For more information on the potential for development of the commercial fish culture industry in Michigan see *Status and Potential of Michigan Agriculture – Aquaculture,* Michigan State University Agricultural Experiment Station Special Report 50 (1992).

The Fisheries Division has drafted a position statement on development of the aquaculture industry in Michigan. The position statement addresses the division's concerns about water quality deterioration and the spread of fish, diseases and other organisms. Draft legislation under the Environmental Code Commission and the Draft Aquaculture Development Act for the Michigan Department of Agriculture (MDA) further clarify the roles of the MDNR and MDA in the development of environmentally sound commercial aquaculture in Michigan. The Michigan Legislature, by House Concurrent Resolution No. 234, has requested that the MDNR study the feasibility of implementing a private sector-based fish hatchery system.

The Michigan Fish Growers' Association has identified ten potential areas for privatization in fish production:

1. Production of adult trout for stocking in special regulation waters.
2. Micro-wire tagging and fish marking.
3. Production of special brood stock.
4. Isolation facilities for feral stock production.
5. Development of quarantine facilities.
6. Distribution of fish in unusual quantities.
7. Production of eyed eggs.
8. Waste management at fish production facilities.
9. Large-scale production of cool water species.
10. Fish production and stocking of large inland lakes

Trends in Water Quality and Fish Contaminants

Each year the Michigan United Conservation Clubs (MUCC) publishes its Environmental Quality (EQ) Index. The EQ is a non-scientific synthesis of environmental health assessments made by environmental and resource specialists. The EQ for Michigan's water and wetlands has remained at about 70 on a 100-point scale since the first EQ was published in 1980 (Figure 16). This "C" grade is primarily a response to wavering state and federal support for clean water and wetlands protection initiatives. However, substantial progress has been made in reducing levels of toxins in Michigan's fishes.

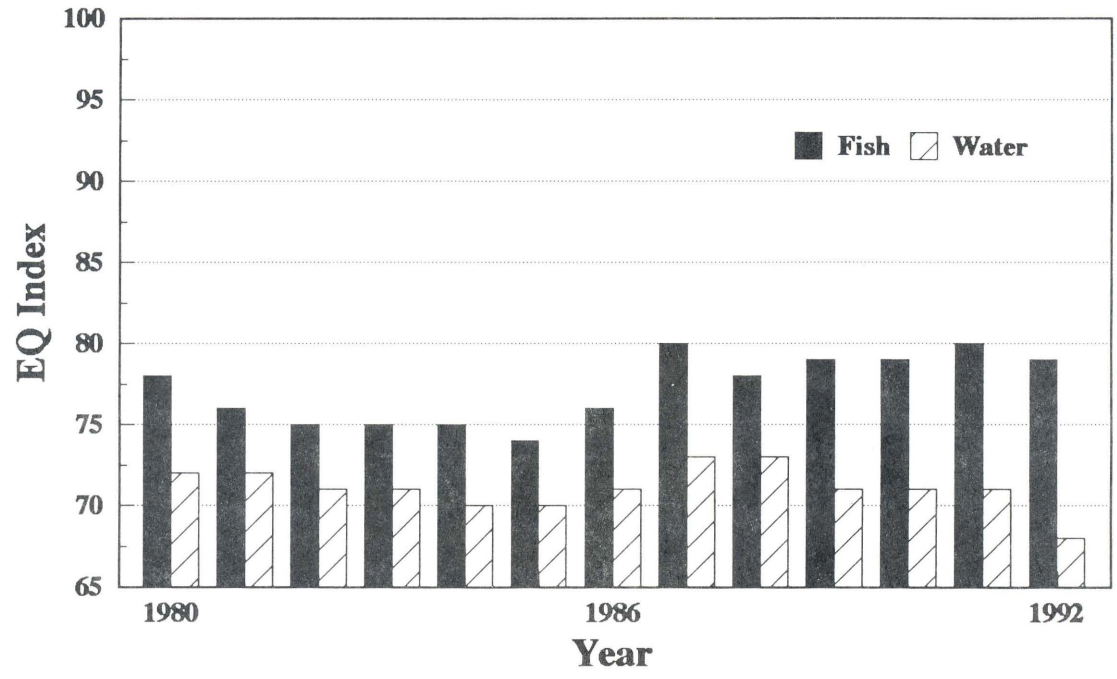
In the 1970s and 1980s, numerous fish consumption advisories were issued because of the bioaccumulation of mercury, chlorinated hydrocarbon pesticides such as DDT, and polychlorinated biphenyls (PCBs) in Great Lakes and inland fish. Government policymakers and agencies responded to this situation by forcing industry to reduce or eliminate the sources of these toxins.

In 1970, the level of mercury found in Lake St. Clair walleye was four times the background levels. Consequently, the discharge of mercury was curbed from industrial sites in Wyandotte, Michigan and Sarnia, Ontario. By 1991, mercury levels had returned to natural background levels (Figure 17).

The sale and use of DDT were banned in Michigan and Wisconsin in 1969. By 1972, a national ban was also in place. Existing stores of DDT were incinerated to ensure they would not be used. The ban resulted in a dramatic decrease in DDT concentrations in fish. DDT concentrations in whole lake trout fell from over 19 parts per million (ppm) in 1970 to less than 2 ppm in 1990 (Figure 18). Concentrations of DDT in fish fillets would be even lower because DDT accumulates in fatty tissues that are removed during filleting.

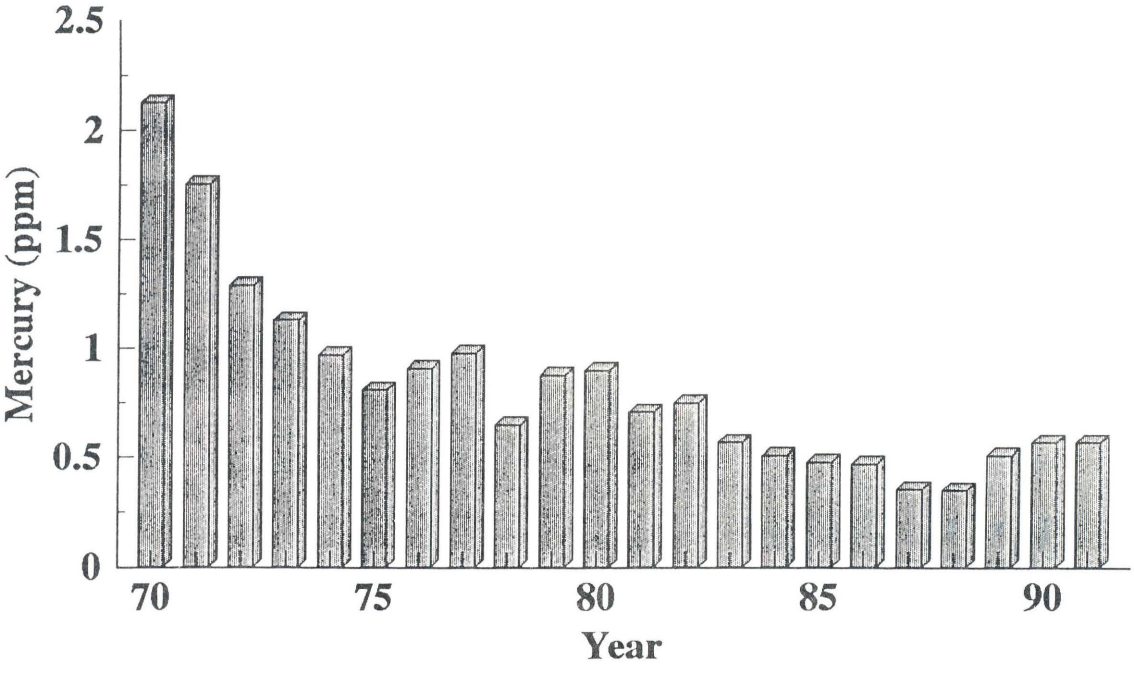
The use of two additional chlorinated hydrocarbons, chlordane and dieldrin, was questioned after unacceptable levels of these compounds were found in Great Lakes fish. Both chlordane and dieldrin were banned by 1988. By 1990, dieldrin levels had decreased to 60 percent of 1979 levels. The persistence of chlordane in the environment has yet to be determined.

The fate of PCBs in Michigan and the United States is similar to that of DDT. In 1976, Michigan began to phase out the use of PCBs. The federal government followed in 1978 with a national ban on PCBs. Though PCBs are still found in Great Lakes fish, levels have continued to decrease (Figure 19).



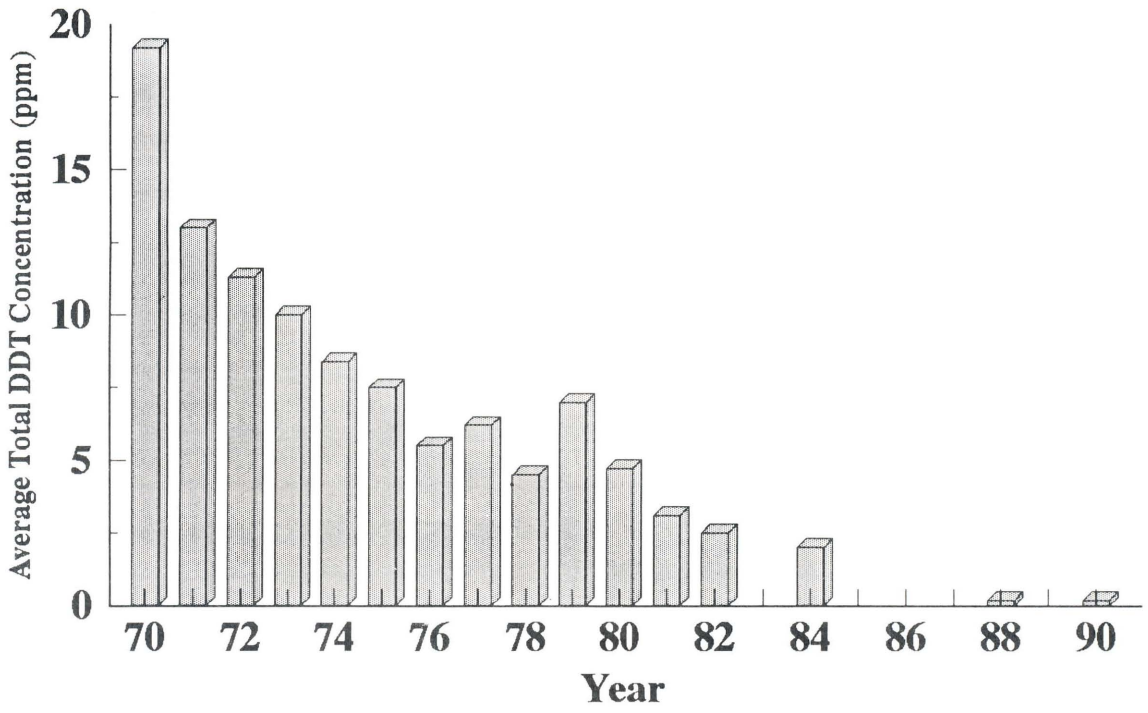
Source: Michigan United Conservation Clubs.

Figure 16. Michigan's Environmental Quality Index (EQ), 1980-1992.



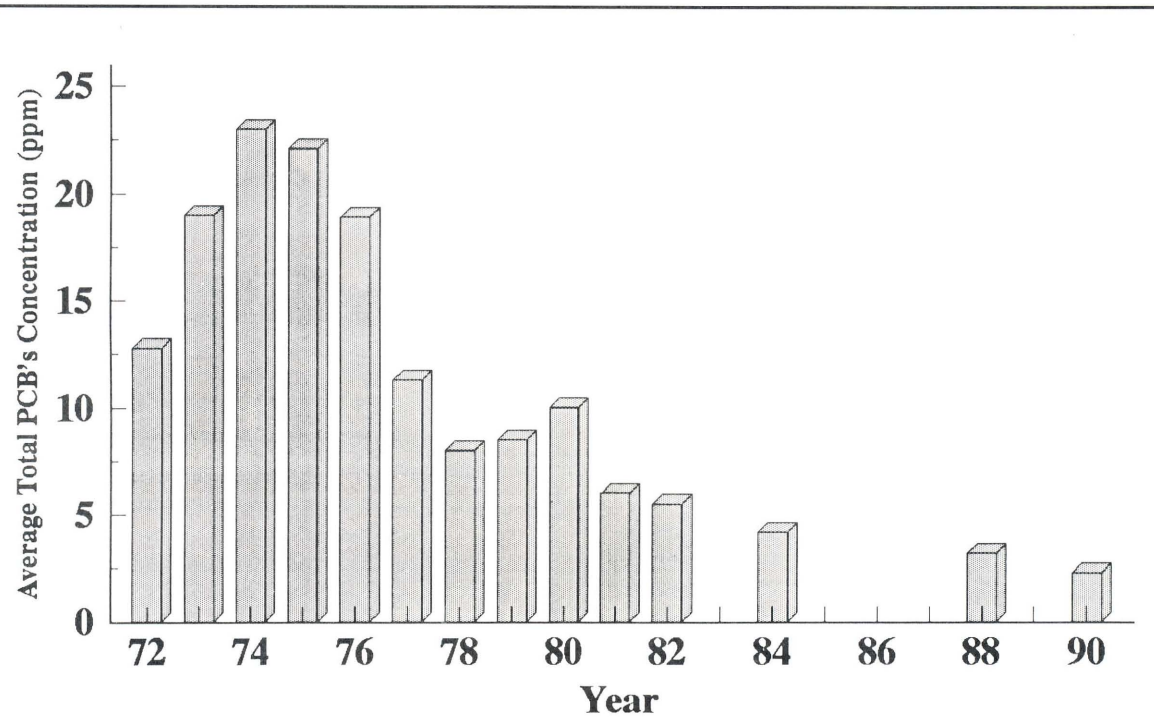
Source: Michigan Department of Public Health.

Figure 17. Lake St. Clair Walleye–mean annual mercury, 1970-1991.



Source: Michigan Department of Public Health.

Figure 18. DDT in Lake Michigan Lake Trout, EPA data, whole fish, averages, 1970-1990.



Source: Michigan Department of Public Health.

Figure 19. PCBs in Lake Michigan Lake Trout, EPA data, whole fish, averages, 1972-1990.

In 1978, the discovery of dioxin contamination in the Tittabawassee and Saginaw rivers led the Michigan Department of Public Health to issue a warning against consuming any species from those rivers. By 1987, the Dow Chemical Company, a major point source of dioxin, had implemented a decontamination program that reduced dioxin discharges by 93 percent. Dioxin levels in Tittabawassee River walleye decreased about 35 percent between 1984 and 1988. Reduced dioxin discharges from the Mead Corporation on the Escanaba River and the Champion Paper Company on the Menominee River have also resulted in greatly reduced concentrations of dioxin in fishes from those rivers.

Though levels of contaminants in Michigan fishes have in most cases decreased substantially, they will inevitably persist for many years. Questions have been raised about the safety of even trace amounts of contaminants in food fish. This concern was publicized by the National Wildlife Federation, which made consumption recommendations in 1989 that were significantly more restrictive than those issued by the U.S. Food and Drug Administration and the Michigan Department of Public Health (MDPH). In response, the Center for Environmental Toxicology at Michigan State University assembled a panel of toxicologists to review the scientific evidence on health hazards associated with eating Great Lakes fish. The panel found that the recommendations of the National Wildlife Federation could not be supported scientifically. They concluded that following the Michigan Department of Public Health's fish preparation and consumption guidelines would minimize exposure and provide an adequate margin of safety.

Concern over the safety of eating Michigan fish, together with national "bad press" about contaminated seafood, may partially explain the declining numbers of resident anglers in Michigan. If anglers' concerns are not addressed through educational programs, Michigan industries that depend on angling—charter boats, bait and tackle shops, restaurants and lodging—may decline proportionately. The MDNR and MDPH publications and Michigan State University Extension and Sea Grant bulletins (*Michigan Fishing Guide* and *Eating Great Lakes Fish*, respectively) provide anglers with fish consumption and preparation information. Such educational materials help anglers make informed decisions about where to fish, what to fish for and which fish to avoid eating. Theoretically, angler confidence should increase with the knowledge that all Michigan fish are not high-risk food items.

The MDNR cooperates with other Great Lakes states, tribal programs, provincial resources agencies and the U.S. Environmental Protection Agency (EPA) in a continuing effort to protect and restore the quality of Michigan waters and fishes. Currently, these agencies are studying ways to significantly reduce mercury and PCBs in the Great Lakes region. In November 1993, the MDNR approved funding for 11 grants under the Michigan Great Lakes Protection Fund. The grants, totalling more than $600,000, will fund research to reduce toxic contamination in the Great Lakes, to understand the effects of toxic substances on human health and the health of fish and wildlife, and to determine how toxic substances enter and move through the Great Lakes ecosystem.

The successful programs for contaminant reduction in Great Lakes fishes can serve as a model of a toxic substances clean-up program. Agencies must be diligent, however, and continue to advocate strong regulations to limit or prevent future inputs from all sources. Because of the large watershed surrounding the Great Lakes, airborne pollution abatement programs must extend well beyond the borders of Michigan and the Great Lakes region.

Acid rain also poses a threat to lakes and streams in the Upper Peninsula. Upper Peninsula soils are not buffered adequately to neutralize rain or melting snow that has been acidified by atmospheric oxides of sulfur (SO_x) and nitrogen (NO_x).

Trends in Habitat Loss and Degradation

Most of Michigan's streams and their watersheds have been altered by human activity. These human perturbations have included dam construction, dredging and filling, road construction, forest management practices, and changing land use patterns. Such alterations usually have a negative impact on fish. The MDNR is attempting to restore the productivity and aesthetic quality of affected streams, using minimally disturbed streams as a frame of reference. Stream restoration must include both mitigation of past damage and prevention of future disturbances. Mitigation of past damage may include dam removal, provisions for fish passage at dams, replacement of removed cover material, modifications of stream flow, bank stabilization and erosion control. Total watershed management can help ensure against future stream degradation. Maximizing groundwater inputs greatly enhances streams by affecting stable stream flow and water temperature.

Watershed management plans generally contain both historical and current assessments of the watershed, including geology, hydrology, channel morphology, soil and land use, status of aquatic organisms, appraisal of streams' fishery potential, identification of potential management options, selection of management options, and description of actions required to implement the plan.

The MDNR uses the following principles when devising a stream or watershed management plan:

- Prioritize restoration of streams that are minimally disturbed.
- Recognize that the enjoyment of an environment is enhanced by its aesthetic qualities.
- Incorporate human use into the value of the resource and plan to minimize human impacts on the stream.
- Recognize and identify the limits of watershed and stream resiliency to human use.

- Increase the likelihood of successful restoration by including stream and watershed management plans into larger scale management plans.
- Endeavor to minimize conflicts between native species and exotic/naturalized species.

The watershed management approach for stream remediation and damage prevention is desirable in two ways. First, it can control for factors such as erosion that can affect streams from remote distances. Second, it may provide an opportunity for public involvement and increased environmental awareness.

A successful watershed management plan must consider several factors to be biologically sound and socially acceptable. These factors include species diversity and community structure, target species, presence of introduced species, major limiting factors to productivity, habitat fragmentation, basin hydrology and channel form, land use patterns (including forest management practices), zoning and jurisdictions, navigability, recreational use and potential, presence and situation of dams, barriers, bridges and culverts, water quality, present management practices and citizen involvement.

Hydroelectric dams are an important stream quality issue in Michigan. The 113 hydroelectric dams in Michigan affect 49 river systems and prevent the movement of fish into and throughout 2,063 mainstem river miles of water.

The daily operation of these dams is under the jurisdiction of the Federal Energy Regulatory Commission (FERC). A 1986 amendment to the Federal Power Act requires that FERC now give equal consideration to power generation and recreational/environmental concerns when relicensing hydroelectric dams. These facilities account for only 1.5 percent of the total electrical power used in Michigan. At the same time, they negatively affect the environment by altering flow regimes, restricting fish passage, reducing water quality, impairing recreational use and aesthetic quality of the river, exacerbating pressure on rare or endangered species, and posing maintenance and safety risks. On the other hand, impoundments formed by these dams do provide recreational opportunities for the surrounding communities and may limit sea lamprey access to suitable spawning waters.

The MDNR's goals in the FERC licensing and relicensing process are to include the following requirements for licensure: return river flows to natural levels, take measures to reduce or eliminate turbine-related fish mortality, provide fish passage around dams, improve recreational access, improve management of upland timbered areas controlled by FERC-related projects, improve dam safety, and identify parties responsible for maintenance and removal of structures.

Many of Michigan's inland lakes have also been altered by human activity in their watersheds. Increased sedimentation, nutrients from fertilizer and chemicals have entered the lakes through runoff. The result has often been an increase in the productivity of the lakes in the form of excessive aquatic plant growth. This process is called cultural eutrophication.

Eutrophication causes many changes in the lake system, including increased sedimentation, lower levels of dissolved oxygen, and changes in the plant and animal populations. Typically, coldwater and cool water fishes are replaced by warmwater fishes.

Excessive aquatic plant growth usually has a negative impact on fish populations. Excessive aquatic plants can provide refuge for small panfish such as bluegills. Most predators are not efficient in reducing panfish numbers and, consequently, stunting can occur. Exotic plants such as Eurasian milfoil and curly leaf pondweed have also invaded inland lakes. These plants can overtake a lake and reduce its recreational and aesthetic value. Nuisance aquatic plant control information is available from Michigan State University Extension and the Inland Lakes Management Unit of the MDNR.

Good fish communities exist in lakes with good native aquatic plant communities, so the Fisheries Division has developed a policy that recommends minimal manipulation of native plant species. In highly eutrophic lakes, an integrated aquatic plant management plan should be developed to reestablish healthy native aquatic plant populations and to minimize nutrient input from riparian development.

Trends in Exotic Species

The introduction of exotic species may sometimes be useful and beneficial—e.g., Pacific salmonids. This is often the exception, however. Freed from the predators, parasites, pathogens and competitors that kept their numbers in check in one environment, species introduced into a new environment will often compete with and negatively affect desirable native species. In the presence of enough food and a favorable environment, their numbers may explode (e.g., carp, alewives, sea lamprey). Under these conditions, an introduced species can be considered among the most severe agents of habitat alteration and degradation and a major cause of the continuing loss of biological diversity.

Once established, exotic species rarely can be eliminated. The most recent exotic species to be introduced to the Great Lakes include the zebra mussel, the quagga, the round goby, the tubenose goby and the ruffe. These intruders were introduced as a result of ballast water discharge from ocean-going transport vessels. Other potential vectors of accidental release of exotic species are aquaculture, bait, aquarium or other unintentional releases.

Zebra mussels are freshwater mollusks that were accidentally transported from Europe to North America in the mid-1980s. First discovered in Lake St. Clair in June 1988, the mussels quickly spread to lakes Erie and Ontario and the St. Lawrence River. Since then, they have spread to all of the Great Lakes and a growing

number of U.S. and Canadian inland waterways. They are expected to spread to the majority of the United States within a decade. Their distribution in Michigan is shown in Figure 2. Other inland sightings include the Chicago Canal, and Illinois, Ohio, Tennessee and Mississippi rivers. The mussel's ability to populate a body of water quickly is due to its high reproductive rate, planktonic dispersal of larvae and limited natural predators. Their long-term impact is presently unknown but could be detrimental.

The feeding method of zebra mussels points to one of the growing concerns about aquatic food chains. Each adult mussel is capable of filtering about one liter of water per day and removing nearly all particulate matter, including phytoplankton and some small forms of zooplankton from the water. Zebra mussels can remove significant amounts of phytoplankton from the water. Phytoplankton are the food source for microscopic zooplankton, which in turn are food for larval and juvenile fishes and other plankton-feeding fish that support sport and commercial fisheries. This competition for phytoplankton, the base of the food chain, could have a long-term negative impact on Great Lakes fisheries.

One significant impact of zebra mussels has been their negative effect on native Great Lakes mussels. Zebra mussels readily settle on live native mussels—sometimes several thousand zebra mussels are found on a single native mussel. In lakes St. Clair and Erie, heavy fouling by zebra mussels has virtually eliminated populations of native mussels. Some native mussel species are more tolerant to fouling than others, but even for these resistant species, zebra mussel encrustation leads to reduced energy reserves and leaves them vulnerable to other environmental stressors. In addition, a number of native mussel species are very rare and are officially listed as endangered species. Experiences in Europe suggest that, as zebra mussels spread, populations of native mussels may decline and some of the rarer species may be completely eliminated.

In 1990, two newly introduced fishes, the tubenose goby and the round goby, were discovered in the St. Clair River. These new species of fish come from the same area as the zebra mussel (around the Black and Caspian seas) and are thought to have arrived the same way: in the ballast water discharge of a transoceanic vessel. The tubenose goby is rare in the St. Clair River and has not proliferated. However, recent studies by the MDNR and the University of Michigan confirm a rapid dispersal and population increase of the round goby in the St. Clair River.

Many factors have allowed the round goby to expand and proliferate in its new riverine habitat. The round goby is an aggressive fish that may feed on young native sculpins, darters and logperch. Their aggressiveness may enable them to occupy optimal foraging sites among rocks and to defend spawning sites, thus preventing native species access to these areas. Round gobies also grow larger than our native benthic fish species, which may give the gobies a competitive advantage over native species. Round gobies spawn over a long period of time, so they can take advantage of optimal temperature and food conditions. They are repeat spawners, spawning every 20 days or so, and males of this species protect their nests vigorously.

The round goby can be expected to continue its expansion into the upper and lower Great Lakes. The round goby may adversely affect deep water sculpin, an abundant and important fish inhabiting the deep areas of the upper Great Lakes. Gobies are reported to overwinter in up to 150 feet of water, which is generally the shallowest depth occupied by deep water sculpin.

Ruffe were introduced to Lake Superior at Duluth Harbor and were first collected there in 1986. By 1991, ruffe were spreading and had become the most abundant fish in the harbor. Less than two years later, ruffe made up 95 percent of the total fish biomass in Duluth Harbor. The ruffe offers little value for commercial or recreational fisheries because of its small size.

The ruffe has temperature requirements similar to those of the yellow perch and has been observed feeding on the eggs of yellow perch and whitefishes. This and its potential for explosive population growth could make the ruffe a serious threat to yellow perch and other native Michigan fisheries. Among the introduced exotics discussed above, ruffe are the only subject of intensive control efforts.

Water quality improvements in the Great Lakes have increased available habitat for the sea lamprey, resulting in a resurgence in lamprey populations. Budgetary shortfalls for Great Lakes sea lamprey control have precluded the Great Lakes Fishery Commission from implementing the full sea lamprey management program (application of TFM and development of non-chemical control methods). The St. Marys River is a major spawning area for sea lamprey where current management techniques are impractical. Lamprey scars on lake trout and other large predator fishes in northern Lake Huron are increasing.

Other Stakeholders

Michigan's fisheries support a large array of constituencies and interests (Table 8). In addition to the primary stakeholders—such as sport anglers, state-licensed and tribal commercial fishermen—other constituencies include angling-related businesses, boating interests, riparians and near-shore residents, water users, tourists and tourist-related businesses, and resource managers.

Businesses that serve anglers usually have interests that closely relate to but may not be consistent with angler's interests. Tackle and bait retailers, fishing license agents, fishing equipment and tackle manufacturers, charter boat operators and fishing guides, and fish cleaning station operators all have a direct interest in angling activity. Many resorts, motels, campgrounds, marinas, boat rental services, restaurants, gas stations and other

travel-related businesses have great interest in the fisheries that attract tourists to their area.

Because much fishing is done from boats and much boating is done to engage in fishing, there is considerable correlation between the interests of anglers and boaters. Both anglers and boaters need access to the water and prefer clear, clean water and pleasant settings with quality fish populations.

Riparian landowners and managers, and near-shore residents often have a direct interest in fishing but also have many correlative interests. Many private riparians and near-shore residents live near water in part because of their interest in fishing. Public riparian agencies—including the U.S. Forest Service, various MDNR divisions and local governments—make specific efforts to accommodate fishing. Riparian activities such as weed control, water level management, beach maintenance, dredging, seawall construction and dockage can completely dominate the shoreline and eliminate critical fish habitat. Erosion, nutrient loading and water use by riparians can profoundly affect fish habitat in lakes and streams.

Industrial and agricultural users of surface and groundwater and agencies that manage water and its use have important effects on fisheries interests. Water users may be significantly constrained by water management efforts designed to protect fish and fishing. Water withdrawal, especially by steam electric and hydroelectric plants, often kills fish by impinging them on screens or

Table 8. Some fisheries stakeholder groups in Michigan.

Agency and institutional stakeholders

- MDNR - various divisions
- Soil Conservation Service
- Michigan Association of Conservation Districts
- American Fisheries Society, Michigan Chapter
- North American Lake Management Society, Michigan Chapter
- Michigan Sea Grant College Program
- Tribal organizations, including the Chippewa/Ottawa Treaty Fishery Management Authority and the Great Lakes Indian Fish and Wildlife Commission
- U.S. Fish and Wildlife Service
- National Biological Survey
- Great Lakes Fishery Commission
- U.S. Forest Service
- National Park Service
- Local governments
- Universities, including Michigan State University and University of Michigan
- MSU Extension

Citizen stakeholders

- Michigan United Conservation Clubs and local and state affiliate organizations
- Michigan Council of Trout Unlimited
- Michigan Lake and Stream Association (and local chapters of lake associations)
- Michigan Outdoor Writers' Association
- Michigan Salmon & Steelheaders
- Bass Anglers Sportsman's Society
- Watershed councils
- Education organizations:
  - Michigan Science Teachers Association, Michigan Alliance for Environmental and Outdoor Education, Project WILD-Aquatic, Project WET

Industry/private sector stakeholders

- Sportfishing industries and distributors
- Boating industries and distributors
- Consultants
- Commercial fishing organizations
- Michigan Fish Producers' Association
- Michigan Charter Boat Association

passing them through the facility. Water withdrawal from streams (e.g., for irrigation) also has a profound effect on their capacity to support fish. Drainage management can have similar effects. Dams affect water flow, temperatures and fish movement and, hence, fish populations. Discharge of wastewater from municipalities, industry and agriculture can also significantly affect water quality.

Emerging Issues

Research has been conducted by MAES researchers to identify issues in fisheries management (Peyton, 1987; Gigliotti and Peyton, 1993; Gigliotti, 1989). This research area within the human dimensions of fisheries management will continue to grow in the future as resource issues become more complex and as public acceptance of resource management policies and strategies becomes a greater part of decision-making processes.

A fisheries issue exists when conflicts arise among groups (stakeholders) with vested interests in the resource (Peyton, 1987). Several components of an issue may contribute to conflict: the status of science or technology pertaining to the issue (and public perceptions of this science), conflicts in public beliefs about the "facts," and conflicts in public values and priorities regarding the issue (Peyton, 1987).

To address current and emerging issues, several initiatives and programs are underway to positively affect fisheries management in Michigan. These include:

- MDNR Fisheries Division program reviews (a review of the fish production program has recently been completed).
- Comprehensive River Management Plans are being developed by the MDNR Fisheries Division.
- The MDNR/Multi-agency Fish Passage Work Group Initiative.
- Great Lakes Restoration Act initiatives (through the U.S. Fish and Wildlife Service's Great Lakes Coordination Office).
- The FERC/hydropower relicensing process.
- The Lake Sturgeon Restoration/Passage Initiative.
- The U.S. Fish and Wildlife Service Recovery Plan initiatives for Threatened and Endangered Species.

The following summary distills the emerging issues recognized by agencies with fisheries management responsibilities and major stakeholder groups. Summaries of emerging issues and research priorities prepared by the MDNR Fisheries Division and the Great Lakes Fishery Commission may be found in Appendices 1 and 2, respectively.

Issue Area: Fisheries management, planning and administration are changing in light of changing institutional constraints and changing constituency demands/contributions.

Status of Scientific Understanding of the Issue Area:

Over the most recent decades, Americans have become more knowledgeable about and active in government's role in resource management. Public interests have become more varied. Correspondingly, agencies have recognized the need to meet the demands and expectations of historically non-traditional clientele groups regarding fisheries resources. Traditional clients—sport anglers and commercial fishers—have remained static or declined in numbers, and as a result, their fiscal contributions (in the form of license revenues and excise taxes, Figure 20) have remained static or declined. This presents managers with dilemmas in fiscal planning and administration and in fisheries management planning. These dilemmas include:

- Devising strategies for financial management of agency functions and activities (including exploring the feasibility of privatization of some functions).
- Increasing government efficiency and accountability to these diverse clients.
- Meeting needs to inform a diverse public (including urban audiences) about fisheries resource management and responsible conservation, while maintaining services to and providing access for traditional clients, such as anglers.
- Incorporating innovative strategic planning and public involvement techniques into fisheries management planning.
- Addressing fishing recruitment issues to meet the agency's public trust mission of promoting use of the fisheries resource in the interest of general welfare.
- Diversifying human resources within the agency to better reflect the diversity of clients and management philosophies.

Some data exist to inform fisheries management in the face of the challenges listed above. Fiscal accounting data exist, as do some data on changing constituencies. The new, computerized, point-of-sale, licensing system in Michigan will allow better monitoring of angling participation and will allow easier sample selection for angler studies in the future. The sciences and the arts of public involvement and strategic planning in resource management are evolving and are being tested thoroughly throughout the United States.

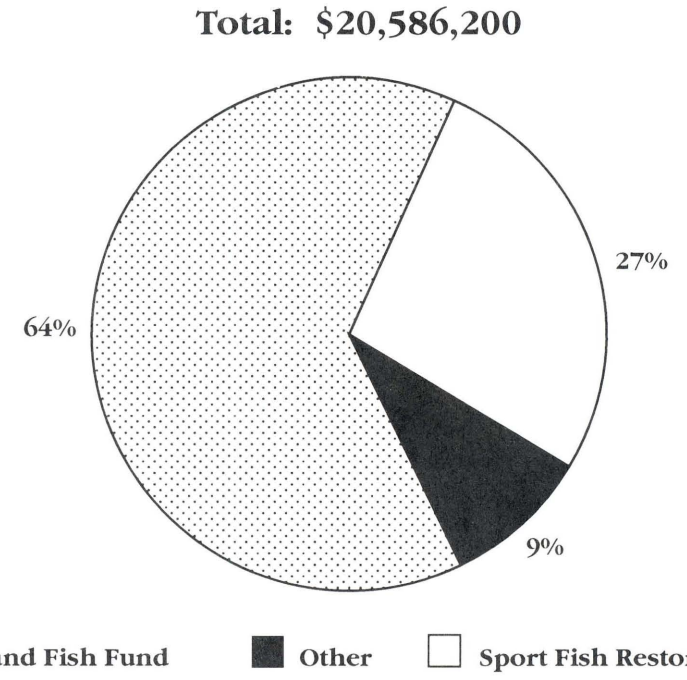
Stakeholders' Beliefs, Values, and Priorities:

Numerous studies outside this region have demonstrated that improved public involvement in management can increase public acceptance of management

strategies, improve management plans, represent broader ranges of public values and develop citizen responsibility for resource conservation (Peyton, 1987). Little is known about stakeholders' beliefs, attitudes and values toward fisheries management–to date, studies have been conducted on trout anglers on the Au Sable River (Gigliotti and Peyton, 1993), on Great Lakes salmonid anglers (Peyton et al.) and on Michigan anglers and Great Lakes charter boat customers (Mahoney et al., 1986; Kinnunen and Mahoney, 1989; Kikuchi 1986). More work remains to be done.

Research, Education or Action Needed:

- Continued monitoring of administrative functions, revenues and expenditures, conducted by the MDNR Fisheries Division and other fisheries agencies and institutions.
- Exploration of future funding strategies for fisheries management.
- Utilization of a new angler data base for monitoring angling participation and for designing clientele surveys.
- Development of surveys that assess stakeholders' (including agencies') beliefs, values, reactions to alternative management strategies and thoroughness of respondents' evaluation of issues (Peyton, 1987).
- Development and evaluation of strategies that increase the public's informed participation, taking into consideration diverse values and priorities among fisheries stakeholders.



Game and Fish Fund monies are derived from license sales.
Other funds are derived from litigation, settlements, and state General Fund (less than 1% of Fisheries Division funding).
Sport Fish Restoration funds are derived from federal excise taxes on sporting equipment.

Figure 20. MDNR Fisheries Division funding sources, fiscal year 1993-94.

Issue Area: Ecosystem management and fisheries rehabilitation are evolving management approaches with varying degrees of acceptance among fisheries stakeholders.

Status of Scientific Understanding of the Issue Area:

Managers and researchers in agencies, universities and other institutions have embraced ecosystem management as the strategy for fisheries management. This evolving management approach encompasses the following issues:

- Land uses within watersheds, including hydropower facilities, fish passage, fish habitat quality and fish production. As increasing human pressures are placed on ecosystems, the need increases to address the results of these pressures in comprehensive fisheries management planning, which now is broadened to include wetlands, groundwater and watershed protection measures.
- Biodiversity issues are gaining increased attention. Biodiversity—within systems, among species and within the genetic pool of given species—as a focal goal of resource management is gaining increased support.
- An issue related to biodiversity is control of non-indigenous aquatic species, such as the sea lamprey. Scientific understanding of means of control is always improving—for example, a tentative plan for feasible control of sea lamprey in the St. Marys River system now exists, and research continues on control alternatives to TFM, such as sterile male release. Paying for these control strategies is another issue involving international, federal and state levels of government. The willingness of publics to absorb these management costs and the long-term economic benefits of control are largely unknown.
- Another issue related to biodiversity is the roles of fish stocking and hatcheries in maintaining sport fish populations and in enhancing or delaying the recovery of native species, such as lake trout. Also, what has been the contribution or roles of naturalized fish species in Great Lakes ecosystems? More research is needed in this area.
- Many resource management and research institutions within Michigan gather data on the status of fish populations; for example, the collapse of Pacific salmon in Lake Michigan has been well documented. Data on the population status of predator and forage fishes will continually be needed to identify possible mechanisms of fish response to fishing pressure, habitat changes and abiotic factors, such as climate. These data will also be needed to plan for protection of threatened and endangered species, and to describe species interactions and dynamics. When data do exist, institutions may not interpret them in similar ways and may not have well-established mechanisms for sharing and managing the data in information systems.
- Fishery management goals and visions differ among agencies—some agencies are striving for restoration of ecosystems to previous states, while others advocate rehabilitation of ecosystem functions. Fisheries resources are multijurisdictional in nature—many parties influence fisheries at various geographic levels, from local government (i.e., drains, county planning bodies), to watersheds (e.g., the Saginaw Bay National Watershed Initiative), to state, federal, and international levels (e.g., the Great Lakes Fishery Commission).

Stakeholders' Beliefs, Values, and Priorities:

The extent of public acceptance and willingness to become involved in fisheries management from an ecosystem framework or to support Great Lakes fisheries rehabilitation is unknown (Peyton, 1987). Traditional clients (e.g., sport anglers) may be reluctant to support ecosystem management with dollars that have been aimed at game fish or single species management efforts. On the other hand, if stakeholders are given the opportunity to participate actively in management decision making and if they develop an understanding of ecosystem management principles, they may become avid supporters of this approach. Management agencies, however, will first have to agree on ecosystem management definitions and approaches.

Research, Education or Action Needed:

- Continued cooperation and collaboration among institutions with fisheries research data and fisheries management responsibilities.
- Continued monitoring and research on fish population status, habitat quality, non-indigenous species, nuisance species control measures, land use pressures on ecosystems supporting fisheries resources, the role of stocked fish in abundance and recovery of fishes, and fisheries genetics.
- Research into stakeholders' beliefs, values and attitudes about ecosystem management frameworks and principles, catch-and-release and fisheries regulations.
- Outreach programs that involve stakeholders in decision making and contribute to development of understanding of ecosystem management.

Issue Area: Conflicts stemming from the beliefs, attitudes, values and behaviors of fisheries user groups, stakeholders and even agencies continue.

Status of Scientific Understanding of the Issue Area:

Fisheries management in Michigan has a long history of addressing the differing beliefs, attitudes and values of various stakeholders, particularly the stakeholder groups of sport, commercial and tribal fisheries. Some research has been conducted on the economic impacts of these fisheries (Talhelm, 1988; Mahoney et al., 1991), but work will need to continue into the future. Another area of research that is just beginning is the investigation of impacts of fisheries regulations on resources and on stakeholders. Recent focus group research has examined the reactions of sport anglers to various regulations and related communications strategies (Grise et al., 1993). More work is needed to improve the nature of commercial fishing regulatory processes (MDNR Fisheries Division, 1994). A limited amount of work has been conducted to examine angling vs. non-angling recreationist conflicts (e.g., Gigliotti, 1989).

Stakeholders' Beliefs, Values, and Priorities:

Conflicts among fisheries stakeholder groups will continue as long as the resource is limited, habitats are affected by land use and other pressures, and multiple user groups have varying beliefs, values and behaviors related to the resource.

Research, Education or Action Needed:

- Continued research on direct and indirect economic impacts of sport, commercial and tribal fisheries.
- Examination of the effects of harvest rates on population status of stocks/populations of interest or concern, to better inform fisheries allocation decision making.
- Research on stakeholders' beliefs, attitudes, values and involvement in decision making.

Issue Area: Issues surrounding the contamination of fishes and bioaccumulation of toxins in aquatic food chains, public perceptions of risks associated with fish consumption and ecological remediation measures will continue.

Status of Scientific Understanding of the Issue Area:

Recent research has focused on means of minimizing fish contaminants when preparing fish for consumption (Zabik et al., 1993), on bioaccumulation processes in aquatic ecosystems and possible reproductive effects of contaminants on consumers in food chains (Giesy et al., in progress), and on teachers' perceptions of risk (Zint and Peyton, in progress). A growing area of research is ecological risk assessment (Kamrin, 1994).

Stakeholders' Beliefs, Values, and Priorities:

Since the publication of *Silent Spring* in the 1960s, public concern about chemicals in the environment has been an important force shaping research and policy making. Complexities in institutional responsibilities for environmental quality and human health issues have also been persistent. Recently, agencies in the Great Lakes basin have been designing the means to issue uniform fish consumption advisories. This area of research and policy making will grow in the near future.

Research, Education or Action Needed:

- Continued monitoring of contaminants in all components of ecosystems, including human populations.
- Research in human exposure, toxicity and risk assessments, and in ecological risk assessments.
- Investigation of means of minimizing human exposure to contaminants in fish consumed.
- Better understanding of human perceptions of risk and development of research-based risk education programs.
- Better understanding of the role of contaminants in fish population dynamics in the wild.

Issue Area: Discussion will continue on the role of fish culture and stocking in fisheries resource management.

Status of Scientific Understanding of the Issue Area:

The role of fish culture and stocking in fisheries resource management has recently been a controversial topic. Though significant sport fishery resources have been developed and maintained through stocking programs, opponents list a number of potential and perceived negative impacts of hatchery programs. These include:

- Sport anglers may perceive that hatchery fish are not as desirable as "wild" fish.
- Loss of genetic diversity and genetic changes in stocks resulting from large numbers of hatchery fish overwhelming native stocks, and from hatchery stock selection that may reduce genetic variability of hatchery and wild stocks.
- Loss or reduction of native species (or delay in recovery) due to interspecific competition with introduced species for limited forage resources.
- Introduction of hatchery diseases into wild stocks (e.g., bacterial kidney disease).
- Negative effects of hatchery wastes on receiving waters.
- Use of limited financial resources for hatchery production instead of habitat restoration and improvement.
- Public assumption that future stocks can rely on artificial propagation rather than mitigation of negative impacts on fish habitats and populations.

Similar concerns exist within the MDNR Fisheries Division over the accidental release of species by commercial aquaculture operations.

Research on the role and impacts of hatchery stocks and on production of quality fishes to meet management needs will grow in importance.

Stakeholders' Beliefs, Values, and Priorities:

The MDNR fish hatcheries are responsible for hatching, rearing and transporting the majority of the fish required for management of Michigan's Great Lakes and inland waters. After recent hatchery fish losses, an interest group member requested a comprehensive review of the MDNR Fisheries Division fish production program to develop recommendations to improve the hatchery system. Additionally, interest groups were invited to identify issues and concerns for the review team to consider during the program review process. A comprehensive fish production program review document was developed by the MDNR Fisheries Division for the review process.

The review process was recently completed and the review team has issued its Hatcheries Review Report. The review committee believes that real and perceived problems in the Michigan hatchery system can be minimized by filling key vacancies in the hatchery system, implementing facility improvements detailed in the strategic hatchery plan, enhancing hatchery employee involvement and morale, and committing to stable levels of funding and staffing. They urge the stakeholders in Michigan's fishery resources to help the MDNR to gain the political support needed to implement its strategic plan.

Research, Education or Action Needed:

- Research on the roles of natural and artificial reproduction in maintaining sport and commercial fisheries.
- Investigations of means to maintain genetic diversity of hatchery stocks and to evaluate genetic impacts of hatchery progeny through field tests based on predetermined criteria.
- Investigations to develop methods to produce quality hatchery products and enhance fish health so that fish meet management needs and angler expectations.
- Aquaculture regulations that permit ecologically sound development of commercial aquaculture.
- Research in fish hatchery waste management.
- Educational programs to improve stakeholders' understanding of stocking programs and aquaculture.

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Appendix 1: Emerging Issues Identified by the MDNR Fisheries Division

The following emerging fisheries issues are summarized from the *Fisheries Division Strategic Plan*, MDNR Fisheries Division (1994).

- **Need for an informed public**
  In the past 20 years, Americans have become more knowledgeable about and active in government, expecting agencies to perform efficiently and effectively for both individual and community interests. As interests become more varied and divided, agencies must seek the informed consent of their publics. The technical and complex nature of fisheries management means it is not easy to obtain the informed consent of the public. Considerable effort is needed to educate interested publics about the choices that can be made.

- **Direct services to anglers**
  Increasing interest by anglers for direct information services has reduced staff time available for fishery management. Strategies need to be developed to manage services to provide fishing information, management plans and public communications about management programs.

- **Economic impacts of recreational fisheries**
  Businesses and local governments are demanding information on recreational fisheries markets and expenditures that they can use in business planning and investment development. These interests provide the opportunity for fishery development partnerships between the Fisheries Division and local constituencies. Those who invest in fisheries-related businesses, however, need information on the dynamic and widely fluctuating nature of fisheries resources The MDNR could provide market data and technical assistance to local interests, and local interests could contribute to fishery management efforts through cost-sharing grants.

- **Small boat and shore access**
  Efforts by the MDNR Parks and Recreation Division to provide public access sites have traditionally emphasized developing harbors and docks. However, many anglers fish from shore or use small boats and would like to fish in small waters or in places without conflicting boat uses. Many of Michigan's anglers would be better served if the state also provided small boat and shore access.

- **Fish contamination**
  Many waters are contaminated with toxic chemicals. Several issues regarding fish contamination need to be addressed, including possible impacts on organisms or ecosystems, tribal and state commercial fishery regulations, human health risks associated with consumption, public perception of risks, reduction of environmental contamination, and implications for stocking and other fisheries management programs.

- **Native American fishing**
  Native American fishing rights are legally established and must be accommodated. Conversion of the tribal fishery from gill nets to entrapment nets should continue.

- **Conflicts between recreational fisheries and commercial fisheries**
  Michigan has resolved most conflicts for stock allocation and space between commercial and recreational fisheries in the Great Lakes. Remaining conflicts need to be resolved.

- **Problems in state-licensed commercial fishery regulation**
  Rules and regulations governing state-licensed commercial fishing rely on administrative decisions about individual fishing licenses. Problems associated with commercial fishery regulation should be resolved by seeking legislation to create a marketable, quantitative usufruct (right to use) in state-licensed commercial fishing.

- **Aquaculture regulation**
  Concerns regarding aquaculture are associated with water quality deterioration and the spread of fish, diseases and other organisms. Draft legislation under the Environmental Code Commission and the Draft Aquaculture Development Act for the Michigan Department of Agriculture address these issues.

- **Fishery management planning**
  Fishery management plans need to be prepared for the state's major fisheries. These plans will help provide an important vehicle for public involvement in the fishery management process and help the divisions work with other agencies more effectively.

- **Ecosystem management**
  Complex interactions between components of the Great Lakes and inland water ecosystems and their impact on fisheries require that fishery management plans be based on an ecosystem perspective. A set of principles has been developed and is being implemented to rehabilitate and maintain fish communities and ecosystems.

- **Urban initiatives**
  The proportion of Michigan citizens living in metropolitan areas has increased to 78%. This part of the state is also the most difficult and expensive area in which to develop and provide access to fisheries resources. Development of additional urban fisheries opportunities and information services is needed.

- **Resource protection and mitigation**
  Hydropower, steam-electric plants, other industries, land-use patterns, and shoreline development affect streams and fisheries. Reducing loss of habitat and fishes and mitigating the remaining losses on fisheries values will benefit Michigan citizens.

- **Promoting responsible conservation**
  As land use and human behavior patterns change, it is important to defend the traditional values of resource management and the sustainable productivity of water resources. Preserving the range of resource uses and opportunities traditionally available in Michigan will require an informed and supportive public.

- **Limits on fish stocking**
  The value of stocking as a fisheries management tool is limited and needs to be defined, and this information needs to be conveyed to the public. Stocking is not a panacea. The division's future attention will be on measuring fishery contributions of stocked fish and on management planning for Great Lakes stocking.

- **Financial management**
  The Fisheries Division is funded primarily through license fees and excise taxes paid by anglers. These funds have remained relatively stable because license fees do not increase with inflation. Stable funding, adjusted for inflation, is needed to maintain the current quality of fisheries management programs. Automation, research, asset management and human resource management are also needed to achieve productivity increases.

- **Other issues**
  Other fisheries management issues (some of which are discussed in the text of this SAPMINR Report) include: nonindigenous species, angler recruitment, intensive fish culture, disease control, managing fish losses, and privatization.

Appendix 2: Emerging Fisheries Issues Identified by the Great Lakes Fishery Commission

The following emerging fisheries issues were compiled from *Research Priorities for the 1990s,* GLFC Board of Technical Experts Report (1993).

Research in Support of Healthy Great Lakes Ecosystems

- **Biodiversity**
  Identify and characterize anthropogenic causes of loss of species, strains or stocks. Identify stocks and their level of differentiation. Determine stock status and biological characteristics. Determine the consequences of fish stocking on genetic diversity and fitness of wild fish.

- **Exotics**
  Develop prevention and control strategies for invasions of exotics and evaluate their social, economic and biological consequences. Develop an understanding of established exotics with a view to their management.

- **Sustainable production**
  Develop innovative methods of determining the range of allowable harvest consistent with sustainable production. Determine the relationship between harvest and rehabilitation success. Determine the effects of exotics on sustainable production. Assess food web effects on sustainable production. Evaluate social, economic and biological trade-offs between stocked and natural fish production. Develop techniques for identification and control of fish diseases and evaluate their social, economic and biological consequences for sustainable production.

- **Habitat**
  Develop a system of habitat classification appropriate for determining Great Lakes ecosystem health. Identify species that indicate habitat and ecosystem health. Inventory habitats deemed important to ecosystem health. Improve understanding of the relationship between specific habitat characteristics and the success of dependent species.

- **Contaminants**
  Determine fate and transport of contaminants in the Great Lakes. Improve understanding of the ecological consequences of contaminant levels in Great Lakes fishes. Improve understanding of social and economic consequences of contaminants.

Research in Support of the Integrated Management of Sea Lamprey

- **Develop a valuation scheme to quantify the benefits of sea lamprey control.**
  Develop an optimization framework for allocating resources among elements of the control program. Improve cost effectiveness of existing control practices. Conduct basic research on sea lamprey biology as a foundation for development and application of new control technologies. Conduct research on aspects of sea lamprey biology to identify specific opportunities for new control strategies. Develop and assess new control technologies.

Research in Support of the Institutional/Stakeholder Partnerships

- **Develop means to identify and characterize the interests of stakeholders affected by the quality and productivity of the Great Lakes ecosystem.**
  Develop means of determining the size and distribution of stakeholder groups. Develop means to measure and compare the interests, needs and expectations of various stakeholder groups.

- **Develop means to identify economic consequences of alternative allocation decisions.**
  Develop economic criteria for the allocation of aquatic resources. Identify and examine means whereby stakeholders pay for benefits generated from their allocation of aquatic resources. Develop the means to identify and evaluate a multi-account framework so that values are comparable across stakeholder groups.

- **Develop means to identify the social consequences of alternative allocation decisions; identify and evaluate strategies for conflict resolution related to allocation decisions.**
  Identify and evaluate mechanisms by which stakeholders receiving an allocation of aquatic resources return benefits to the ecosystem.

- **Foster communication among stakeholders to achieve effective stakeholder partnerships.**
  Develop means to assess information needs among stakeholders. Develop means to identify communication networks within stakeholder groups and potential networks among stakeholder groups. Develop and/or evaluate education and communication strategies.

- **Integrate the institutional/partnership vision statement with the other vision statements during the implementation of the strategic vision.**

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