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1980-1990
MICHIGAN FISHERIES
A FOUNDATION FOR THE FUTURE

W. C. Latta, Editor

Michigan Department of Natural Resources
Fisheries Division
Stevens T. Mason Building
Lansing, Michigan 48909

PREFACE

The Fisheries Division, Michigan Department of Natural Resources, is pleased to report to you on Michigan Fisheries in the 1980's. The importance of Michigan's fisheries warrants a periodic accounting of our stewardship of these resources. Review of our programs is essential if we are to serve the people of Michigan with the excellence they expect.

The State of Michigan contains 11,000 lakes, 36,000 miles of rivers and streams, and 43% of the Laurentian Great Lakes which contain more than 20% of the world's fresh water. These waters contain a variety of fish communities representing most of the types found in North America. These extensive resources in proximity to the large human population of Michigan and nearby states provide unmatched fishing opportunities.

Recreational fishing is the largest and highest-valued use of the State's fishery resources. Approximately two million Michigan residents and 334,000 non-resident tourists fish in Michigan each year. These anglers fish over 35 million angler days per year. Net value of fishing to these fishermen has been estimated at $950 million. In fishing, anglers spend $850 million per year with a resulting impact on tourism and fishing equipment sectors of Michigan's economy of $1.4 billion per year.

Commercial fishing in Michigan waters of the Great Lakes produces approximately 16 million pounds of whitefish, chubs, perch, lake trout, catfish, and other species with a dockside value of approximately $10 million each year. Wholesaling, processing, and retail sales after landing produce another $9 million in economic activity annually. These activities provide employment for about 1,000 Michigan residents. Approximately, two-thirds of the landed value is taken by treaty fishermen; the remainder is landed by state-licensed fishermen.

However, Michigan's fisheries resources are also fragile in many respects and are subject to heavy fishing and many other human impacts; thus they require fairly intensive protection and management. In the absence of management beyond statutory fishing regulations and habitat protection, the State's fisheries would quickly degenerate and would support no more than 40% of present fishing. Management of Michigan's fisheries began with establishment of the Michigan Fish Commission in 1873. The Fisheries Division of the Department of Natural Resources which evolved from that commission is now the second oldest administrative agency in the State's government.

Michigan's fishery managers try to apply the best available fishery science to meet the needs and interests of Michigan's citizens. Scientific progress and changing circumstances require periodic changes in fishery management programs. The pace of change has accelerated and we must constantly examine what we have accomplished, what we need to accomplish, and how we should proceed. This report is an important part of our continuing effort in strategic planning.

Through the late 1960's and the 1970's, Michigan pursued a fishery management strategy formulated in 1964-66 during a comprehensive review of the programs and organization of the Department of Conservation (now the Department of Natural Resources). By 1980, the need for a new strategy was apparent.

In the early 1980's, the Division examined its programs in great detail, consulted with its constituents, and formulated a new direction. We began pursuing this new strategy in 1983, with substantial changes in our programs and organization. Our direction was sharpened and reinforced by Governor Blanchard in his 1985 State-of-the-State message. We made further strides with new funding which became available in 1986. This report describes our progress on this new strategy.

New funds became available with expansion in 1985 of the Dingell-Johnson program of federal aid for sport fish restoration. These funds are derived from excise taxes and import duties on fishing and boating equipment and from taxes on fuel used in motorboats. Expansion of the Dingell-Johnson program increased our potential funding for fishery management programs by almost $5.2 million per year. However, to meet Federal requirements for State funding, the State had to increase license fees in 1986 to keep up with inflation. The largest share of this new funding has gone to habitat improvement projects and new facilities, and the rest has allowed us to increase the staff devoted to professional fishery management services. Even with this increased staff, Michigan ranks in the top five states in water population, anglers, and angling activity supported per fishery management employee. This report shows you the work we have been able to do with this increased budget.

Our strategy for managing Michigan's fisheries in the 1980's addressed many themes and issues. A few of these have been especially important:

> We accommodated Indian rights to participate in the commercial fisheries by increasing the production of commercial fish stocks and partitioning the fishery between tribal and state-licensed fishermen.
>
> We became more responsive to the public interest by increasing public involvement in our decisions, using market analysis to examine angler

preferences, and increasing our participation in cooperative fishery management projects.

We increased our efforts to provide direct services to anglers by providing fishing information and developing more small boat and shore access to the State's waters.

We improved the factual basis for managing Michigan's fisheries by surveying licensed anglers, sampling Great Lakes angler catches, developing standards for sampling fish populations in inland waters, and better integrating our research and fishery management activities.

We increased our management and research work on inland waters, especially in the warmwater lakes and streams of southern Michigan. This effort became possible with the improvements in water quality and habitat protection Michigan achieved in the 1960's and 1970's.

We found many ways to improve our internal management of fishery programs. We do a better job of planning our work and tracking our accomplishments. We have a better trained, more diverse work force. We are better equipped and do a better job of maintaining our lands and facilities. We progressed toward automating our information management.

Despite this progress, we still have a long agenda of potential fishery improvements. During 1990 and beyond, we will be using this report and your reactions to it as we continue to reexamine our strategy and improve your fisheries. We will continue to report back to you each year as we progress on our strategy, identify your changing needs, and set new directions.

John M. Robertson
Chief, Fisheries Division
February, 1990

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1980-1990
Michigan Fisheries
A Foundation for the Future

INTRODUCTION AND OVERVIEW

The purpose of this report is to document the performance of Michigan's fishery resources and the Fisheries Division during the 1980's. It provides a measure of the impacts of changes in the Division's structure and direction that have occurred during the decade. It ties deeds to dollars. One frame work for measuring that performance is compliance with the Division's goals which are to:

**Protect and maintain healthy aquatic environments and fish communities and rehabilitate those now degraded;*

**secure assured public access and appropriate facilities on all waters which support or have the potential to support significant public fisheries;*

**provide diverse fishing opportunities within geographic areas and maximize the value to fishermen of recreational fishing;*

**permit and encourage economically efficient and stable commercial fisheries which do not conflict with recreational fisheries;*

**insure a significant role in our commercial fisheries for those Indian tribes with recognized fishing rights;*

**recover the cost of management from resource beneficiaries; and*

**foster and contribute to public and scientific understanding of fish, fishing, and fishery management.*

The Fisheries Division pursues these goals through five programs -- recreational fisheries, commercial and Indian treaty fisheries, Great Lakes fishery resources, inland fishery resources, and fish production -- guided by Division management.

Programs and activities are examined and the Division's performance evaluated by examining the Division's response to our public's interests, our operational efficiency, the quality and growth of our fisheries and our progress in habitat protection and restoration.

We think the accomplishments documented in this report reveal the kind of resource stewardship and the "*quality fishing*" initiatives that our public and our leadership expect.

Even more significant than this assessment of our past performance is the potential value this document has to guide us through the meaningful changes which will be so necessary in the 1990's.

During the 1980's the Division was strengthened by several initiatives involving goal-oriented management, one being a major internal effort. The changes in the Division perspective and that of its people were not abrupt, but in retrospect these changes in perspective may be the most important thing to happen to us since salmon were introduced. The Division now routinely speaks of its vision and expectations for a lake, river, or for the Great Lakes. We prepare status reports following all survey work that compare waters' status to not only the past but to our long range expectations for the future. Management prescriptions are prepared to address problems that block the way to better fishing and periodic evaluation measures our progress toward our expectations.

The Division has played a strong role in Great Lakes fisheries matters during the '80s, much of it in the forum provided by meetings and coordination of the Great Lakes Fishery Commission.

During the 1980's, we have seen a recovery of lake trout in most of our waters of Lake Superior where lake trout stocks are now over 90-95% wild, naturally produced fish and are at strong levels of abundance. During the 1980's, all of our waters enjoyed record levels of whitefish harvest, a decade of whitefish production unmatched in this century.

Perch reached record abundance and perch fishing flourished in Lake Michigan and strengthened in Lake Huron's Saginaw Bay late in the decade.

The abundance of bloater chubs reached record highs in Lake Michigan in the 1980's, retreating from the brink of extinction they faced in the mid-1970's.

In March of 1985, an Indian Fishing Agreement was reached that did much to diffuse an explosive fishing conflict in waters governed by the treaty of 1836. The tribes agreed to concentrate their commercial fishing in the extreme northern parts of lakes Michigan and Huron and in eastern Lake Superior in exchange for exclusive commercial rights there, which left the rest of the lakes available to the important sport fishery and state-licensed commercial fishermen.

Walleye populations and walleye fishing increased dramatically in Lake Erie, southern Lake Huron, Saginaw Bay, and the Muskegon River, along with numerous inland situations.

The Division strengthened its resolve to provide good fishing opportunities to southern Michigan through intensified management and research efforts on warmwater lakes and rivers, and increased public access. More shore fishing and handicapped access was provided.

After 20 years of growth, the Lake Michigan salmon fishery peaked and declined in the mid-1980's, but growth of salmon fishing continued on Lake Huron.

Fish contaminants continued to cast a negative tone in the 1980's even though levels of most contaminants in fish fell substantially. Fish eating advisories (warnings) were expanded as result of better data and analysis.

A considerable shift in philosophy embracing catch-and-release fishing regulations aimed at elevating the quality of angling occurred in the 1980's. Catch-and-release fishing gained strong support, especially among trout, bass, and muskellunge fishermen and regulations were adopted in support of this ethic. A system of Blue Ribbon Trout Streams was designated in 1987 with accompanying management direction and policies.

Another shift came in the area of habitat protection with emphasis changing from instream or in-lake improvement structures toward broader and more important concerns at the watershed level. Some additional responsibilities were given to Division, most notable of which was the Federal Energy Regulation Commission's relicensing effort involving operation of dams at 50 power generating facilities in Michigan.

A broadening of perspective and the force of necessity caused interagency cooperation to increase toward the close of the decade. Especially noteworthy is the strengthening of the Division's working relationship with Land and Water Management and Surface Water Quality divisions and in the establishment of new partnerships with community and clientele leadership statewide.

Cooperative ventures with communities and support groups aided resource husbandry in the latter half of the decade and with it has come better understanding and increased goodwill.

RECREATIONAL FISHERIES

Sportfishing in Michigan has grown slowly and steadily during the 1980's. Fishing license sales increased 12% during the decade, but increased 50% from 1968 when the Great Lakes fishery for salmon and trout was just beginning. Also, two increases on the license fee this decade has not diminished the public interest in Michigan angling. For the past 4 years license sales have remained steady; 1.2 million residents and nearly 400,000 nonresidents have purchased licenses (Figure 1). An additional half-million people not requiring a license fished in the state. This group consists of young people under the age of 17 and spouses of senior fishing license holders.

Nonresidents have expressed a strong interest in Michigan sportfishing. Their numbers have more than doubled to about 400,000 since the late 1960's and have increased by 23% in the past 10 years. The average nonresident fishes 6.7 days so these anglers enjoy about 2.5 million days of angling recreation in Michigan each year.

States bordering Michigan contribute the most nonresidents. Ohio and Indiana account for 55% of these anglers and contribute 64% of the nonresident angling effort (Table 1). Other than the border states and Illinois; Minnesota, and the Province of Ontario lead the remaining states, provinces, and countries in supplying anglers. However, anglers from nearly all of the remaining states and nearly all the developed countries are represented in license sale files. Two out of three resident anglers are male. High participation in fishing is affected by geography. Residents residing in the northern two-thirds of the state fish much more frequently than those in the south. In the north over 20% of the population past the age of 16 participates in the sport (Figure 2). A variety of good fishing opportunities are available to this group a very short distance from their homes and the cost to participate is low. In contrast, people living in the south and primarily in the urbanized southeast (Detroit metro area) do not have a tradition of angling and have to travel some distance to fish because access is more difficult and cost is relatively high for the Great Lakes and inland lake fishery available nearby.

About 55% of all licensed anglers seek Great Lakes fish and 70% fish for species on inland waters. Inland fishing on lakes accounts for 73% of the total inland fishing effort while stream or river fishing claims the remaining 27%. Great Lakes fishing effort was split nearly evenly between salmon and trout versus other Great Lakes fish, primarily perch and walleye.

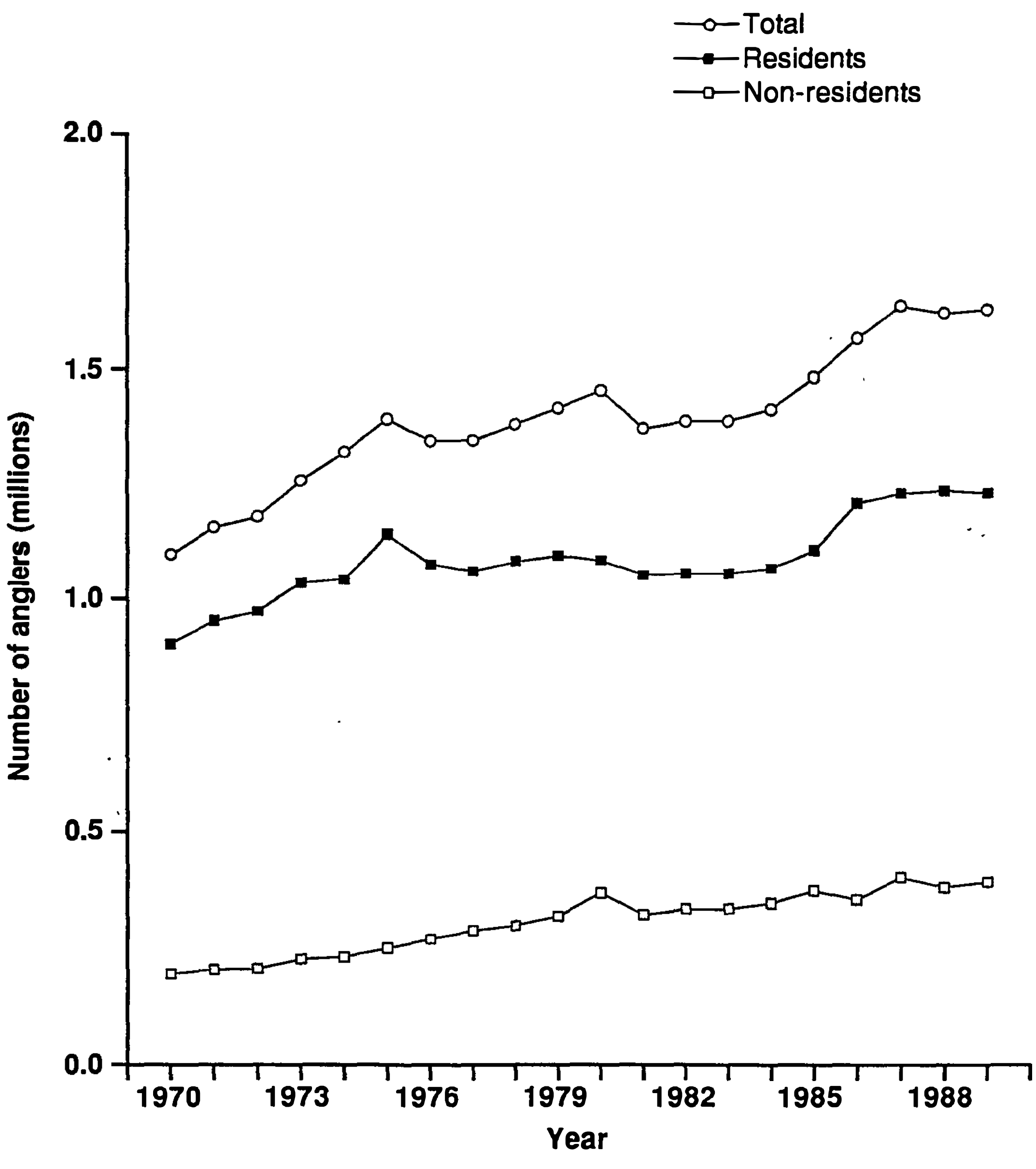

Figure 1. Number of anglers purchasing Michigan fishing license, 1970-89 (1989 projected).

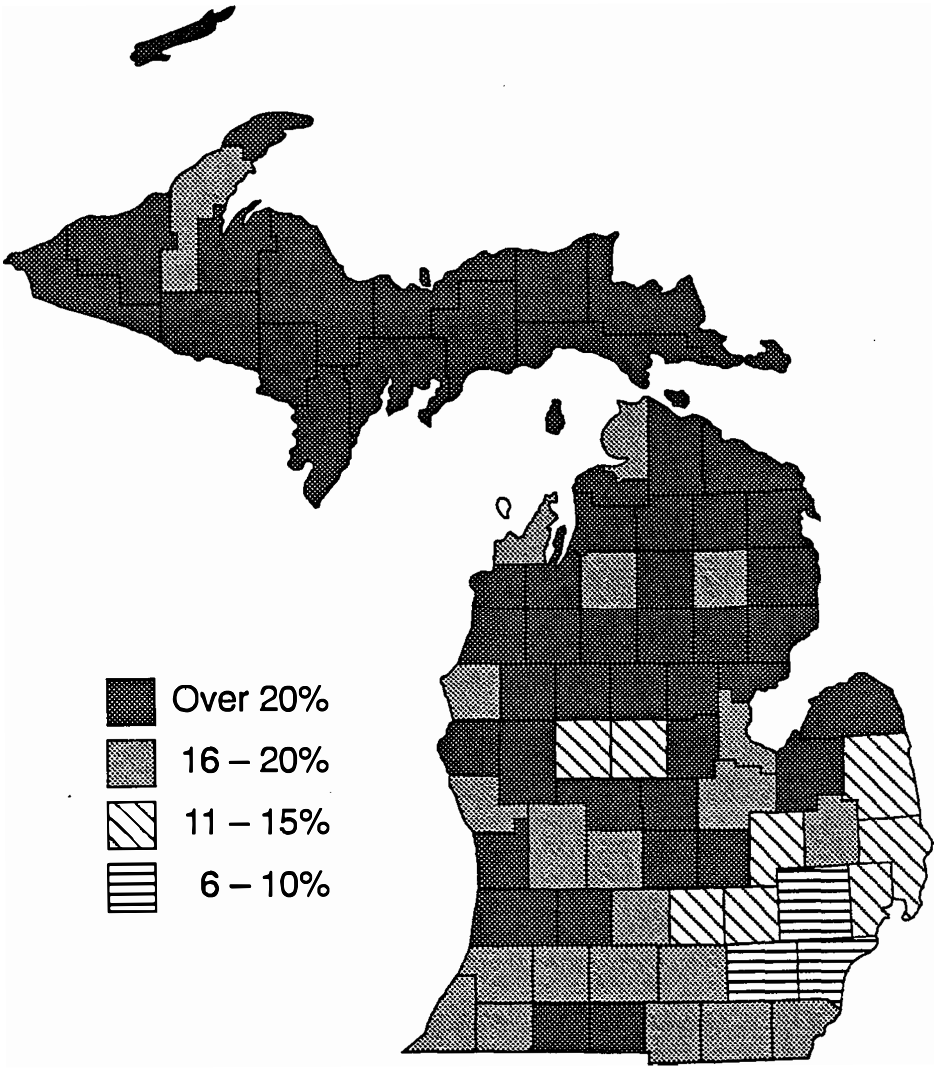

Figure 2. Percent of Michigan residents (by county), 17 years and older, participating in angling.

Table 1. Distribution of nonresident anglers and their fishing effort in Michigan.

State of residence	Percent of anglers	Percent of angler days
Ohio	31	33
Indiana	24	33
Illinois	15	16
Wisconsin	10	9
Other	20	11
Total	100	100

Stream fishing in contrast to Great lakes open-water fishing accounted for 20% of the total angling effort for Great Lakes fish.

Angling Information

Information on anglers and angling in Michigan has been collected by a variety of methods. The primary collection methods of the Michigan Department of Natural Resources (MDNR) have been the creel survey and the angler mail survey. The creel survey, often called the creel census in Michigan, is a means of measuring angler activity by interviewing a sample of anglers on or near their fishing site. The mail survey was introduced for the first time on a large scale in 1968 to begin measuring angling for Great Lakes salmon and trout. This involved sending a questionnaire to a representative group of licensed anglers.

From the 1920's into the 1960's the creel survey served to measure angling success in the state. Statewide a creel survey was conducted by conservation officers incidental to enforcing fishing laws. Since these interviews were not conducted with a statistical sampling design, the information gathered could not be extrapolated to represent all sportfishing in the state. It served as a qualitative index of angler success until the early 1960's when it was discontinued. In addition, however, creel surveys were used up to the present as an evaluation tool on many lakes and streams subject to research, stocking, or intensive management. In these surveys biological data on fish taken plus effort (days or hours of angling) has been the information most frequently collected. In 1983 a statewide creel survey was initiated to assess Great Lakes sportfishing. Its use has been necessary to assess the status of Great Lakes fish stocks.

Mail Survey History

The mail survey was first used on a broad scale in 1967 to assess the catch the first season adult Pacific salmon were available to anglers on the Great Lakes. That survey used a multi-page form to obtain angler activity and descriptive information about the fishery. Further experimentation continued in 1969 when postcard questionnaires were sent to samples of salmon and trout stamp purchasers. The card requested information about Great Lakes salmon and trout angling. In 1970, survey data for the first time were obtained on all types of sportfishing. From then through 1982, all sportfishing was covered in an annual survey used for year-to-year comparisons. In 1983 and 1984 seasonal surveys were conducted to test questionnaire formats, investigate bias effects, and study angler behavior using market research techniques. Mail surveys were discontinued in 1984. Since then the question of bias in catch and effort estimates has been investigated and procedures developed to automate survey sample selection, mailing procedures, and data collection and analysis processes. Mail surveys of anglers will be considered once an automated point-of-sale fishing and hunting license system is developed and operational.

Mail Survey Methods

The standard means of interviewing anglers by mail has been to send a four page form asking for a report on each location fished. The typical survey sample was approximately 1% of approximately 1.4 million anglers licensed annually. The mail survey used licensed anglers as the universe of all anglers. In the early years a representative sample was selected systematically with a random start from carbon copies of fishing licenses. In the 1980's when angler names and addresses were stored on computer files, random samples were selected for strata determined by zip code.

Up to three reminders were sent to individuals who received a survey form and did not respond. Non-response has averaged around 30% of the questionnaires delivered. Nondelivery has averaged about 5% due mostly to incomplete or incorrect addresses.

In the early years a two page form was used, followed by a four page form, and in the later years a six page form became the standard. This resulted from a need to obtain information for determining market segments and economic impacts. During the same period, a number of single species and seasonal surveys were conducted to better define angler activity over time and area. Also, starting in 1980, anglers have been tested on their ability to report their fishing on a daily basis for periods from 2 to 4 months.

Angler Effort and Catch Estimates

Today the best source of statewide estimates for fishing effort are from annual mail surveys of anglers (Table 2). These surveys were terminated after 1982 due to concern about upward bias in the catch estimates. The distribution of effort does not change much from year-to-year

Table 2. Michigan sportfishing estimates of effort in angler days (millions) from mail surveys of licensed anglers.

Type of fishing	Year 1980	1981	1982
Great Lakes salmonid (open water)	2.2	2.6	2.2
Great Lakes salmonid (rivers)	1.4	1.7	1.3
Great Lakes nonsalmonid	4.6	4.7	4.7
Inland trout	2.0	2.3	1.6
Inland nontrout	11.2	12.1	11.0
Total	21.4	23.4	20.8

so these figures from the early 1980's probably describe the distribution of effort today even though total effort is believed to be 10 to 20% higher than it was then.

In 1982 seasonal surveys were conducted in parallel with the annual survey. This permitted us to trace fishing activity month-by-month for the entire year and points out the seasonal nature of sportfishing in Michigan (Figure 3).

Angling effort by anglers seeking Great Lakes fish on the open waters and tributaries of each Great Lake were estimated from mail survey data in the early 1980's (Table 3). The present distribution would be somewhat different, but the general pattern should be very similar. Starting in 1983, thousands of anglers have been interviewed after returning from their fishing trips on the Great Lakes. These on-site interviews serve today as a basis for estimating angling catch and effort for Great Lakes fish.

The 1983 creel survey, initiated to measure Great Lakes fishing activity, was not intended to estimate the total annual harvest, but to test the concept of a lakewide survey over the primary fishing season (From April through mid-November) on Lake Michigan. The objective of the survey was to plan for a continuous record of sport catch, catch rates, and catch composition in the Great Lakes and important stream fisheries for anadromous Great Lakes salmon and trout. In 1983 and 1984 the survey was limited to Lake Michigan so appropriate interview sites could be selected and the distribution of fishing effort and catch determined.

Lake Michigan creel survey results, 1985-89.-In 1985 an intensive creel survey was conducted on Lake Michigan. All the major ports and sportfishing areas were surveyed. In addition, the 1985-86 winter ice fishery was assessed on Little Bay de Noc and Grand Traverse Bay. Since this survey was based on a stratified design using simple random sampling within strata, lakewide catch and effort estimates were generated. Approximately 45,000 anglers were interviewed during 1985 and the winter months of early 1986. In summary, angler hours declined from 6.9 million in 1985 to 5.7 million in 1987, while angler trips declined from 1.6 million to 1.3 million in the same period. The yellow perch was the most numerous species in the catch and in the 1985-87 period it ranged from 2.3-2.5 million during the April 1 through November 15 open-water season. The salmon (chinook and coho) sport harvest ranged from 504,000 to 648,000 and the trout (lake trout, rainbow, and brown trout) catch ranged from 209,000 to 249,000.

In 1988 total angler effort on Lake Michigan declined 14% to 4.9 million hours and 1.1 million trips when compared to 1987. Yellow perch accounted for 84% of the fish harvested

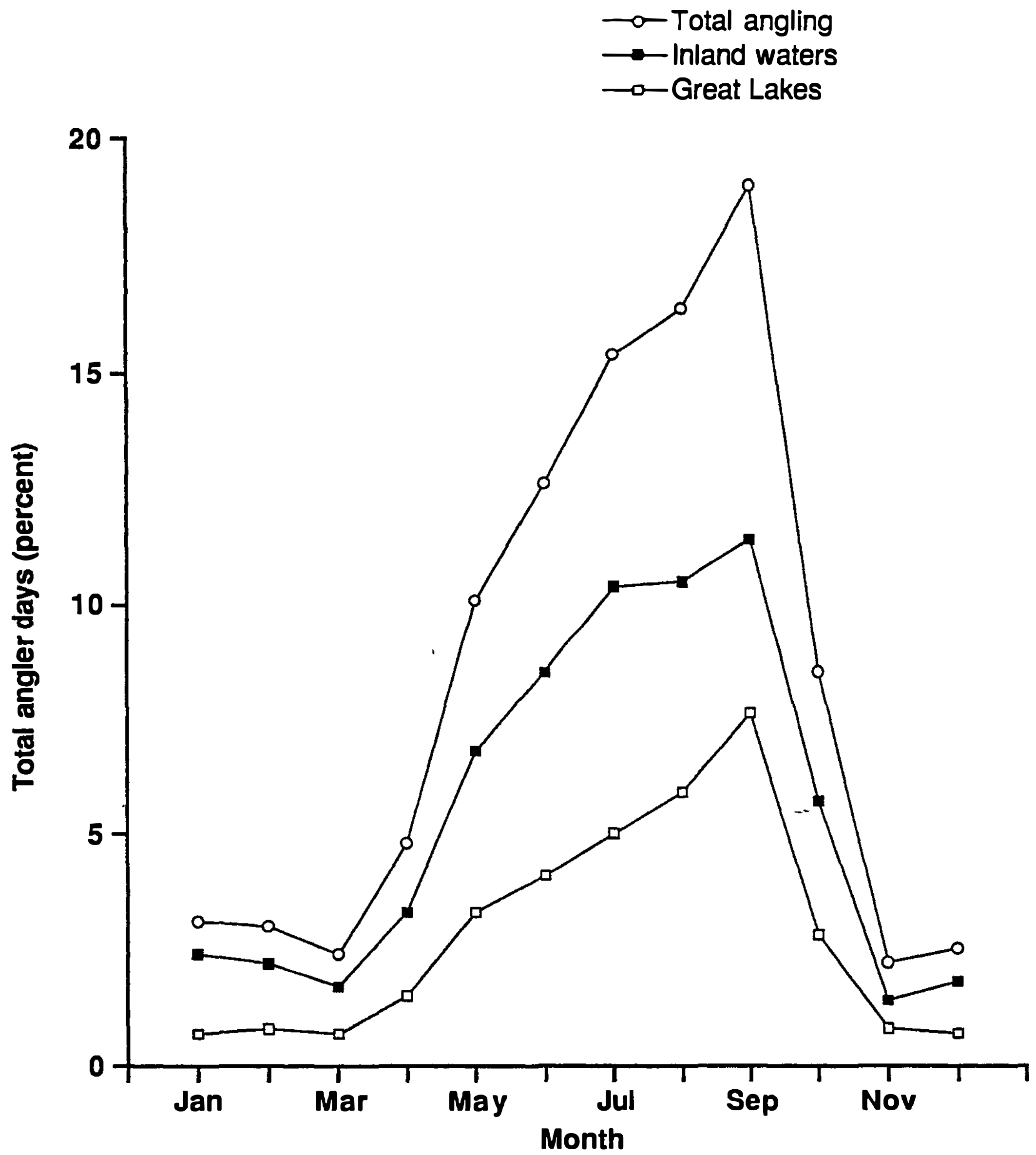

Figure 3. Distribution of angling effort in Michigan by month and location.

Table 3. Angler days (thousands) of fishing effort for Great Lakes fish by lake and watershed, 1981.

Location	Salmonid	Nonsalmonid	Stream salmonid	Total
Lake Michigan	1,730	906	1,328	3,964
Lake Huron	554	1,305	275	2,134
Lake St. Clair	59	1,892	1	1,952
Lake Erie	9	513	12	534
Lake Superior	220	74	117	411
Total	2,572	4,690	1,733	8,995

on Lake Michigan and the catch increased substantially to an estimated 3.2 million. The salmon harvest was estimated to be 265,000 and the trout catch at 207,000. This was a substantial decline from 1987 due to a 41% drop in the chinook salmon catch. Preliminary results for 1989 indicate the total salmon and trout catch on Lake Michigan increased slightly over 1988. However, fishing effort has continued to decline for a number of reasons. A bright spot was the 20% increase in the catch rate for all salmon and trout in 1989.

Great Lakes creel survey results, 1986-89.-In 1986 the creel survey was expanded to Lake Huron and Lake Erie. Over 70,000 anglers were interviewed. It was estimated that anglers spent 14.1 million hours fishing on the Great Lakes waters surveyed. Fishing effort was distributed as follows: Lake Michigan--48%, Lake Huron--33%, and Lake Erie--19%. Total catch was: yellow perch--9.6 million, salmon--774,000, and trout--343,000. In 1987 over 88,000 anglers were interviewed and Lake Superior was added to the survey. Great Lakes angling in 1987 in Michigan waters was estimated to be nearly 15 million hours or slightly more than 3 million angler days. The total catch was similar to 1986. Yellow perch catch declined about 20% and both salmon and trout declined approximately 10%. Boat fishing accounted for 84% of the angling effort on the Great Lakes and their connecting waters. These anglers targeted mostly on salmon or trout. In 1987, 72% of Lake Michigan anglers targeted for salmon or trout and 19% sought perch or walleye. Only 43% of Lake Huron anglers targeted salmon or trout and nearly 43% were after perch or walleye. The remainder for both lakes were after other species or did not express a choice. Of the total angler hours during the open-water season, 45% were spent on Lake Michigan to harvest 70% of the Great Lakes salmonids taken in the state. Seventy-one percent of these fish from Lake Michigan were chinook salmon or coho salmon.

All the major Great Lakes ports were surveyed in 1988. A total of 65,056 anglers were interviewed. The interviews produced an estimate of 12.7 million angler hours of effort for Great Lakes fish. This amounted to 2.7 million trips with 42% on Lake Michigan, 28% on Lake Huron, 29% on Lake Erie, and 2% on Lake Superior. A total of 8.8 million fish were caught and 5.0 million of them were yellow perch. Over 690,000 salmon and trout were harvested from the areas sampled. Lake Michigan (68%) and Lake Huron (26%) had the greatest share of the salmon and trout catch. Catch estimates in 1988 for the major species follow:

Species	Number caught
Chinook salmon	319,000
Lake trout	210,000
Coho salmon	70,000
Rainbow trout	64,000
Brown trout	27,000

Preliminary estimates for Great Lakes angling in 1989 are only available for Lake Michigan and were reported in the previous section.

Catch characteristics.-The salmonid catch on Lake Michigan for the 1985-87 period was dominated by chinook salmon. Chinook salmon comprised 50-58% of all the salmonids harvested. About half of these salmon were taken from Pentwater to Platte Bay. Coho salmon made up 13-20% of the lakewide salmonid harvest. Between 50 to 58% were taken in the southern one-third of the lake from New Buffalo to Muskegon. Mean total length of coho jacks ranged from 15.3 to 17.0 inches and adults a year older ranged from 22.4 to 23.9 inches. Rainbow trout (steelhead) made up 4-8% of the catch. The mean total length of steelhead caught in 1987 was about 25 inches. Brown trout also made up 4-8% of the catch with up to 74% coming from the central one-third of the lake. Lake trout comprised 16-19% of the Lake Michigan harvest during 1985-87. Mean total length and weight ranged from 24.5-25.8 inches and 5.5-6.3 pounds. The modal length was about 24 inches. Small numbers of pink salmon, Atlantic salmon, brook trout, and splake were also taken. These species combined made up less than 1% of the total salmonid catch in Lake Michigan.

Fish Species Sought and Preferred

The Fisheries Division has long felt the need to understand the clientele they serve so as to design management strategies that improve services to users of the fisheries resource. An in-depth market analysis study was designed jointly by Fisheries Division staff and recreation research staff from Michigan State University (MSU). Information was obtained from nearly 11,000 licensed anglers returning survey questionnaires in 1983 and 1984. The survey data were collected and analyzed in a cooperative project between the MDNR Fisheries Division and the University (MSU). The study had multiple objectives, including assessing angler expenditures, characteristics, preferences, and behavior. Another objective was the development of criteria for market segmentation of Michigan's anglers to better serve the angling public. Angler behavior in terms of species sought (Table 4) and species preferred to catch and eat (Table 5) provide us with a much better understanding of how anglers value their recreational experience.

Great Lakes Economic Valuations and Impacts

The success of the Great Lakes fishery has resulted in substantial related public and private investments. Public investments include the development of boating facilities needed by Great Lakes anglers. An example is the string of 69 protective harbors and public marinas on the Great Lakes developed by the Michigan Waterways Commission to achieve their goal that no boater will be more than 15 miles from safety on the Great Lakes. Also, prior to 1967 very few launching ramps existed on the Great Lakes. With the impetus of the Great Lakes salmon and trout program, 158 launching facilities have been developed through construction grants to communities in Michigan.

Private investment is reflected in the sales of boats and boating accessories. Michigan ranked fourth among the states in sales of boats and accessories ($192 million) in 1983 and fourth in total sales ($286 million) which includes boats, outboard motors, trailers, and accessories. Other private investments have been in the Great Lakes charter boat industry and the support facilities necessary to satisfy angler demands. By 1988, charter boats in Michigan numbered approximately one thousand. The industry barely existed 20 years ago. Also, substantial investment in motels and other tourism facilities occurred in many Great Lakes port communities along with the growth in the fishery.

The following summarizes the economic value and impact of the Great Lakes sport fishery. Economic value measures the benefits anglers derive from fishing the Great Lakes. Economic impact describes the effects of angling activity on local economies.

Economic valuation.-- In 1987, R. J. Glass and R. M. Muth in the Transactions of the American Fisheries Society described economic valuation techniques currently being utilized in the field of fisheries noting that many past efforts have not carefully followed economic theory, and thus have not been suitable to management situations. Many of the methods they

Table 4. Species of fish sought by in 1983 by licensed anglers in Michigan.

Species	Percent of residents	Percent of nonresidents
Yellow perch	65	41
Bass	64	60
Panfish	64	50
Walleye	47	44
Pike	46	37
Chinook salmon	30	48
Coho salmon	30	47
Lake trout	26	29
Steelhead	25	27
Smelt	24	8
Brown trout	24	20
Catfish	23	25
Rainbow trout	21	22
Brook trout	20	13
Carp	18	8

Table 5. Species of fish preferred to catch and eat in 1983 by licensed anglers in Michigan.

	Percent of residents		Percent of nonresident	
Species	Catch	Eat	Catch	Eat
Bass	23	8	24	9
Walleye	18	26	18	29
Trout	17	15	13	15
Yellow perch	12	26	3	13
Salmon	11	5	30	18
Panfish	10	15	7	14
Pike/musky	7	3	3	1
Other	2	2	2	1
Total	100	100	100	100

described have been applied to the Great Lakes fishery resource. Most of the economic analysis of Great Lakes angling has been done for Michigan but estimates of sport fishery values for other states bordering the Great Lakes have also been attempted.

A Great Lakes Fishery Commission supported study in 1979 reviewed all economic values and economic impacts of sport and food fishing on the Great Lakes in the United States and Canada. In 1987 the review was updated as of 1985. Economic impacts in 1985 were substantial. Anglers in the United States and Canada spent between $1 and $2 billion dollars, with a best estimate of $2 billion, to catch Great Lakes fish. About half of this was spent for long-term outlays for boats, vehicles, and other angling-related equipment. The other half was for trip-related outlays for food, lodging, transportation, angling supplies, and other trip expenses. Total spending averaged about $36.50 per angler day; about $17.50 for trip expenses and about $19.00 for long-term outlays. The total economic impact of this spending on the regional economy is $2-$4 billion dollars. About $1.4 ($0.7-$1.4) billion of this $2-4 billion (about 35%) is personal income. About 75,000 worker-years were attributable to the sport fishery in 1985; 64,000 in the USA and 11,000 in Canada. Since the last assessment of Great Lakes angling values in 1979, the economic value to anglers using the entire Great Lakes more than doubled.

Economic impacts.--Economic impacts result from the effect of angler expenditures. The 1985 National Hunting and Fishing Survey (Table 6) is a primary source for expenditure by anglers in Michigan. Another source is the MSU market analysis study mentioned earlier. The results from this study (Table 7) are based on the last trip by anglers interviewed and point out the impacts that can be expected for angling on a species by species basis.

Additional studies from MSU focused on the economic impacts of angling for Great Lakes fish. They dealt with the Great Lakes charter-boat industry in Michigan and legal salmon snagging at five designated sites.

Key findings from the 1985 MSU charter-boat study are as follows:

1) Number of anglers hiring charters were estimated to be 239,000 for the nearly 1,000 charter boats licensed in Michigan.

2) Number of out-of-state charter anglers was 67,000, which comprised 28% of the total.

3) Total spending excluding charter fees was $21 million including $7 million by visitors from out-of-state whose primary reason for visiting was charter fishing.

4) Total statewide investment by charter-boat firms was estimated at $31.2 million.

Table 6. Average dollars spent per angler for fishing trip related expenditures in Michigan, 1985.[1]

Item	Residents	Nonresidents	Total
Food and lodging	140	102	133
Transportation	85	79	84
Fees	43	50	44
Boat fuel	65	30	59
Other boat expense	267	92	252
Bait	25	10	23
Ice	12	5	11
Total	273	176	253

[1]From 1985 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

Table 7. Estimated per-day angler expenditures and dollars by species on last fishing trip, 1983.

	Day trip expenditures		Overnight trip expenditures		Average overnight trip length
Species	Total	Local	Total	Local	(Days)
Yellow perch	36.00	7.00	219.00	97.00	7
Bass	35.00	6.50	206.00	84.00	6
Panfish	25.50	4.00	198.00	93.00	6
Walleye	45.36	7.50	259.00	115.00	7
Chinook salmon	50.50	12.00	258.00	130.00	5
Lake trout	56.00	11.00	279.00	120.50	5
Steelhead	68.00	7.00	227.00	110.00	4
Brown trout	50.00	5.50	195.00	98.00	4
Brook trout	58.50	2.50	184.00	58.00	5
Rainbow trout	45.00	3.20	220.50	92.00	5
Smelt	9.00	3.50	81.50	23.50	3

Findings from the MSU study on salmon snagging were as follows:

1) Salmon snagging effort totaling 74,321 days at five sites was estimated for 23.5 thousand licensed salmon snaggers.

2) Total snagging expenditures were estimated at $3.5 million with out-of-state anglers accounting for $1.2 million.

3) Average trip expenditures were $127 ($46 per day) for trips lasting an average of 2.8 days.

4) Fifty-six percent of the average trip expense of $71 was spent near the fishing site.

Boating is another important recreational activity on the Great Lakes that frequently is associated with angling. It has shown explosive growth on the Great Lakes since the early 1970's (Table 8). The resurgence of fishing on the Great Lakes has been a significant factor in the increase. D. J. Stynes and coauthors in a 1983 Michigan Sea Grant report and D. R. Talhelm and coauthors in a 1987 report from Michigan State University documented the economic impacts of boating in Michigan. Their conclusions were:

1) Michigan registered boat owners spent over $1 billion on boating in 1981 and $1.83 billion in 1986.

2) Average expenditures in 1981 were $1,787 per boat per year.

3) Out-of-state boat owners spent $41.5 million in Michigan in 1981.

Since 1980, boating growth has continued at a rapid pace. Great Lakes boating increased 63% from 1974 to 1980 and another 41% from 1980 to 1986. All boating increased by 48% from 1980 to 1986 and fishing accounted for 13.9 million of the 30.3 million total boat days estimated for 1986. Approximately 600,000 boats were active in Michigan in 1986 and five million visits were estimated for public launch sites and nearly one million at private launch sites. Marina development has continued at a rapid pace over the past few years (Table 9). Demand for marina space has continued to be strong.

Table 8. Great Lakes boating activity in Michigan, 1974-86.

Year	Boat days (millions)
1974	3.3
1977	4.4
1980	5.4
1986	7.5

Table 9. Applications for new marinas in Michigan requiring approval under the Inland Lakes and Streams Act.

Year	Number of marinas	Number of slips
1985	42	1,600
1986	47	3,600
1987	71	5,200
1988	76	6,000

Fishing Access Sites

The state legislature first earmarked funds for public water access in 1939. In 1968, the public access site program became the responsibility of the MDNR Waterways Division (now the Recreation Division). Since then, primary funding has been a small portion of motor fuel taxes. State and other government revenues have been responsible for developing nearly 1,100 public launching sites for boaters. Michigan Department of Natural Resources has also assisted in the development of 69 public marinas along the Great Lakes shoreline. Twenty-five of these serve as harbors-of-refuge for craft plying the Great Lakes.

In 1983, Michigan had 746 marinas with 36,651 slips that served the Great Lakes. This represented a 20% increase over 1978. Utilizing the latest inventory of marinas updated through mid-1989, there are presently about 1,200 marinas with approximately 60,000 slips serving the Great Lakes and inland waters of Michigan. Most of these marinas are privately held and are profitable enterprises.

Miscellaneous Information

Michigan Fisheries Interpretive Center.--The Michigan Fisheries Interpretive Center located at the Wolf Lake State Fish Hatchery in Mattawan, Michigan has been a very popular attraction to the public. The building contains many displays and artifacts showing the importance of fishes and aquatic resources plus the history of fisheries management in Michigan. Following is a summary of attendance at this facility since its opening in 1983:

Year	Walk-ins	Tours	Total
1983	2,316	1,177	3,493
1984	8,885	3,317	12,202
1985	9,983	3,134	13,177
1986	11,688	3,292	14,980
1987	11,921	5,143	17,064
1988	11,433	5,377	16,810
Total	56,226	21,440	77,666

Fishing information requests.--For the past few years, logs have been kept on fishing information requests. Written and telephone requests to the Lansing Office of the Fisheries Division amounted to 753 from April 10 to October 6, 1989. Fishing information has also been disseminated via recorded messages at the Fisheries Division Office in Lansing and from the State of Michigan Travel Bureau. Available records of the number of calls received annually are summarized below.

Number of telephone calls received by agency follows:

Year	MDNR Fisheries	Travel Bureau
1985	23,187	116,357
1986	30,658	107,235
1987	40,010	71,000
1988	41,525	Discontinued

COMMERCIAL AND INDIAN FISHERIES

Prior to the United States securing control of the Great Lakes after the War of 1814, the Great Lakes fish populations received only light exploitation. Only after 1817, when the United States was finally able to exert its control over its portion of the lakes and provide protection to its citizens, did limited commercial fishing operations begin to develop. It was, however, not until after 1825 when the Welland Canal opened a water route for the movement of New York salt (used in the preservation of fish) into the area that the fisheries had much capability for expansion. The American Fur Company, in 1834, seized on the idea of developing a fish business. They established operations throughout the Great Lakes with major fishing stations and warehouses at Sault Ste. Marie and Mackinaw Island. They were one of the first vertically integrated companies in the United States. They contracted for the fish to be caught; they bought twine and manufactured the nets, built the boats, imported the salt, made their own barrels, shipped the fish on their own vessels, and sold them in their stores in such metropolitan areas as Detroit, Cleveland, and Buffalo. By 1836 they were harvesting over 1 million pounds of fish (whitefish, walleye, herring, and lake trout) for commercial sale. However, the recession of the 1840's put them out of business. By then many small fisheries were springing up and marketing their own fish wherever possible. Fish were cheap, competition fierce, and production was expanding.

Commercial fish production reached its peak in Michigan waters between 1890 and 1900. However, starting about 1865, there were cries from fishermen in some areas that the stocks were declining. As a response to this feeling, the Michigan Legislature created the Michigan Fish Commission in 1873. Their responsibility was to assist the U. S. Fish Commission in rebuilding declining populations through stocking efforts. The Commissions were reportedly very successful in raising many eyed eggs and fry for stocking. However, their efforts were unsuccessful in rebuilding populations. Consequently, their rearing and stocking of commercial species was phased out by the 1920's. In the 1920's, Michigan developed an extensive set of commercial fishing regulations intended to assist in conserving the populations. However, continued extensive commercial pressure, combined with the introduced predator, the sea lamprey, continued to reduce the size of the populations of the more valuable lake trout and whitefish. With the depletion of the more valuable species, the alewife, bloater chubs, and smelt expanded during the 1950's and early 1960's to fill the voids left. With the more valuable larger chubs and herring gone, the bloater chub developed significant value in the marketplace. Heavy exploitation on the chubs reduced their numbers to where they could not compete favorably with the alewife. By the mid-1960's, the alewife and smelt populations, non-native species, made up the major portion of the fish biomass in much of the Great Lakes. The value of the fisheries in lakes Michigan, Huron, and Superior had reached a low ebb at this time and many of the fisheries went out of business. In Lake Michigan, by the 1960's, alewife populations were showing signs of stress and large die-offs were occurring annually.

In response to the alewife die-offs, which peaked in 1967 reducing the Lake Michigan summer recreational economy by an estimated $100 million, the U. S. Bureau of Commercial Fisheries developed a skimmer net. The net was to be used for skimming the dying alewife off the surface of the lake before they reached the beach. The net never received other than trial use as the die-off of 1967 was so extensive that it did not reoccur in 1968.

The State of Michigan, at the same time, was developing a different approach. This program proposed to turn the alewife into a positive economic opportunity by developing a recreational fishery for Pacific salmonids which, when stocked, would feed and grow rapidly on the alewife. The fishery was designed to create a new, attractive fishing opportunity while at the same time keeping the alewife populations in balance and preventing the extensive overwinter mortalities.

The program was a success beyond that of any other fishing opportunity created to that time. However, as the salmonid populations began to expand, so did the recreational fishery and so did the incidental take in the commercial gill nets. This incidental take was deemed a potential threat to both the redevelopment of self-sustaining lake trout stocks as well as the well being of the developing recreational salmonid fisheries. Consequently, the Michigan Department of Natural Resources developed a policy to give priority to recreational fishing where conflict arose with commercial harvest.

To reduce the conflict between the commercial and developing recreational fisheries, the Department initiated limited entry programs and quota systems in the commercial fishery, and phased out that portion of the gill-net fishery which threatened the continuing expansion of recreational fishing opportunities. The plan, in its early years, was very successful. Populations of stocked lake trout began to expand. Where there was not continued intensive harvesting pressure these populations have matured to the point where they are again partially self-supporting.

Limiting entry reduced the number of operations in the commercial fishing from roughly 450 full- and part-time operations in the mid-1960's to 200 full time operations by 1970. It also started bringing profit to operations that previously had been only marginal and it markedly reduced the economic failure rate in the fishery. Along with this improvement in the economic position of the commercial fishery, there was a dramatic expansion of the recreational fishery and the facilities to support it. However, there was controversy. One of the older established Indian communities became upset as they felt their members no longer had unlimited access to the fishery even though the state had offered them a hardship exemption from the licensing criteria so their members could remain in the fishery.

With the banning of the indiscriminate use of gill nets throughout the Great Lakes, the Ottawa and Chippewa Indian tribes of the 1836 treaty cession sued the State of Michigan in the early 1970's claiming that the State of Michigan could not govern fishing by tribal members, as they had a treaty right to fish unrestricted by state law. The federal government, after some time, supported the tribes position. The litigation continued throughout the 1970's in the State and Federal courts until a decision was reached in 1980. A similar case was brought by the Chippewa tribes of western Lake Superior descendants of the 1842 treaty cession tribes. This case was brought in a Wisconsin U. S. District Court. All decisions have now been through the appeals process with the U. S. Supreme Court refusing to review the Circuit County of Appeals' decisions. The decision in the 1836 treaty area says that it was the intent of the federal government to leave with these tribes a right to continue to fish at least Great Lakes waters of the cession. In the 1842 treaty, the decision infers a right to harvest resources within the total cession.

While the cases moved through the courts in the 1970's, the tribal fishers fished the Great Lakes waters with little regulation and their catch had an impact on that of the other users. Once appeals were out of the way, the Chippewa and Ottawas of the 1936 treaty area and the State of Michigan reviewed each other's fishing practices at the urging of the Federal Court judge through an approved master. He indicated either the parties develop an acceptable plan for harvesting the fisheries resources and enhancing the stocks or risk having to live with a court ordered plan which neither party might like.

In 1985, representatives of the state, the United States of America and the federally recognized tribes of the 1836 cession developed a 15-year plan for managing the fisheries resources within the Great Lakes portion of this cession. The plan essentially delineated how the parties would divide the fishing effort and how rule making and regulation would be carried out. At the present, both the State and the tribes openly admit some disagreement with the plan. However, the agreement seems to be working reasonably well and appears appreciably better than most federally mandated plans for the use of shared resources. The plan has been very successful in getting the principles together and has reduced strong tensions that were building before the agreement. If a disagreement occurs now that can not be resolved through a dispute resolution process, the parties can go back to the judge for clarification and decision making.

Due to recent decisions in the Wisconsin Federal Court system, the Indian tribes of Michigan and Wisconsin, who are descendants of the 1842 cession have expanded their fishing effort in the Michigan waters. This expansion has caused serious concern over a perceived set back in the Lake Superior lake trout rehabilitation program. Because of this concern, the State of Michigan petitioned the Secretary of Interior to adopt a set of rules for regulating this fishing effort. The rules were designed to provide adequate protection for fish stocks while not infringing on the harvest rights of the tribes.

Commercial Harvest

The commercial catch from 1980-88 for the Michigan waters of each lake averaged roughly 15 million pounds (Figure 4) with an average on-dock value of $7.5 million dollars (Figure 5). Tables 10 through 13 provide a breakdown of the catch by species. Table 14 delineates the catch in pounds by harvester (state licensee, 1836 tribal licensee and 1842 tribal licensee). Table 15 is a resume of the licensing pattern by all the parties. During the 1980's the state has been relinquishing commercial fishing opportunities to the tribes as per the 1985 agreement. Those state licensees forced to retire from fishing, as licensing opportunities are transferred to the tribes, are being compensated. Although great change has occurred during the 1980's in the manner by which Michigan's commercial fisheries are regulated, the State and tribes have been able to maintain a high level of production from self-sustaining populations.

Status of Commercial Fish Stocks

The lean lake trout population in Lake Superior has reverted from being sustained by stocking to where today the population is composed primarily of natively reproduced fish. While it is the goal of this program to develop self-sustaining stocks, the drop in survival of both the native and stocked fish is distressing. The adult fish in the population have declined to the point where natural reproduction may be threatened. The decline in survival of both the native and stocked fish appears to be mainly in response to increased harvesting pressure.

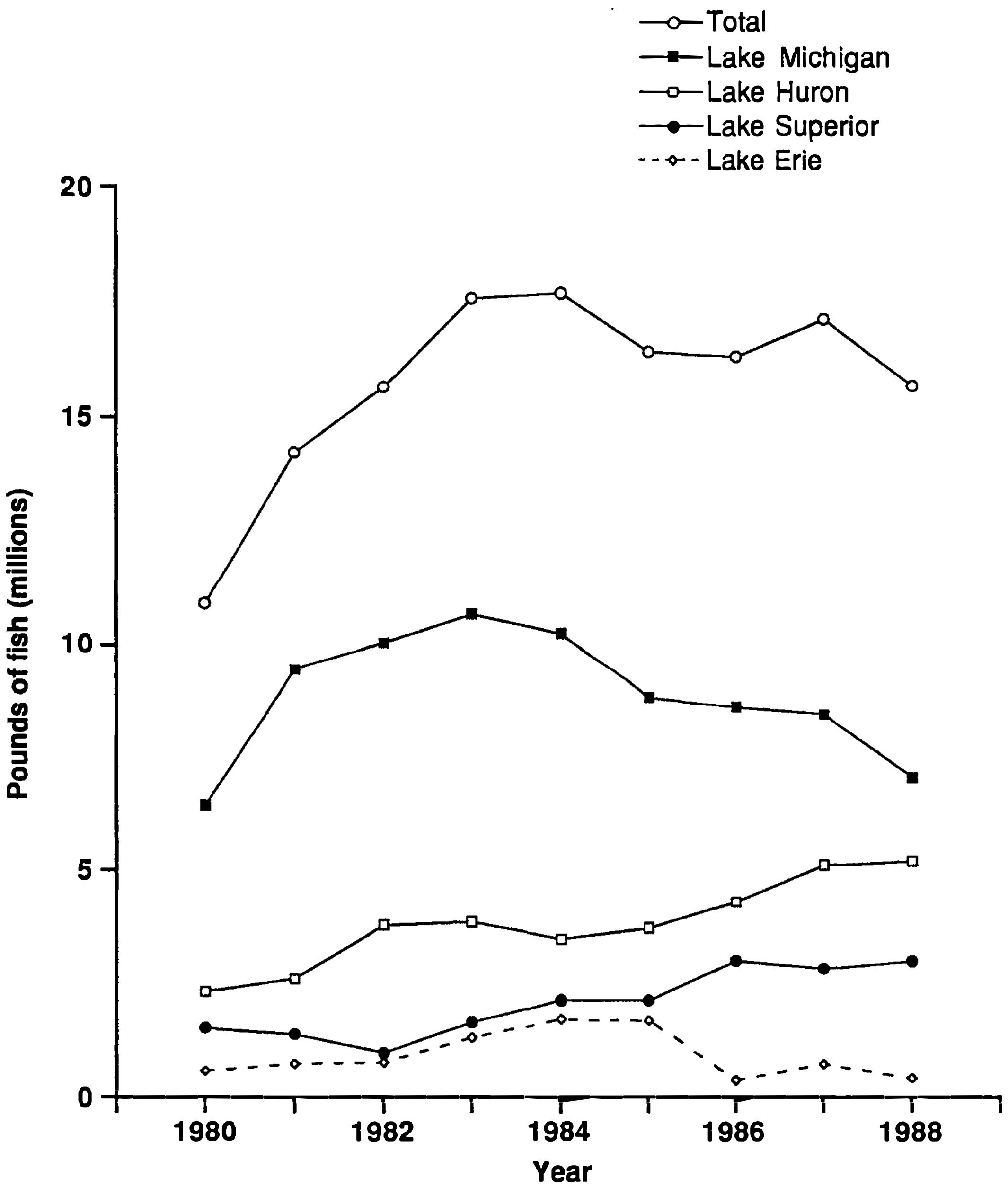

Figure 4. Dockside commercial fish production in Michigan, by weight, 1980-88.

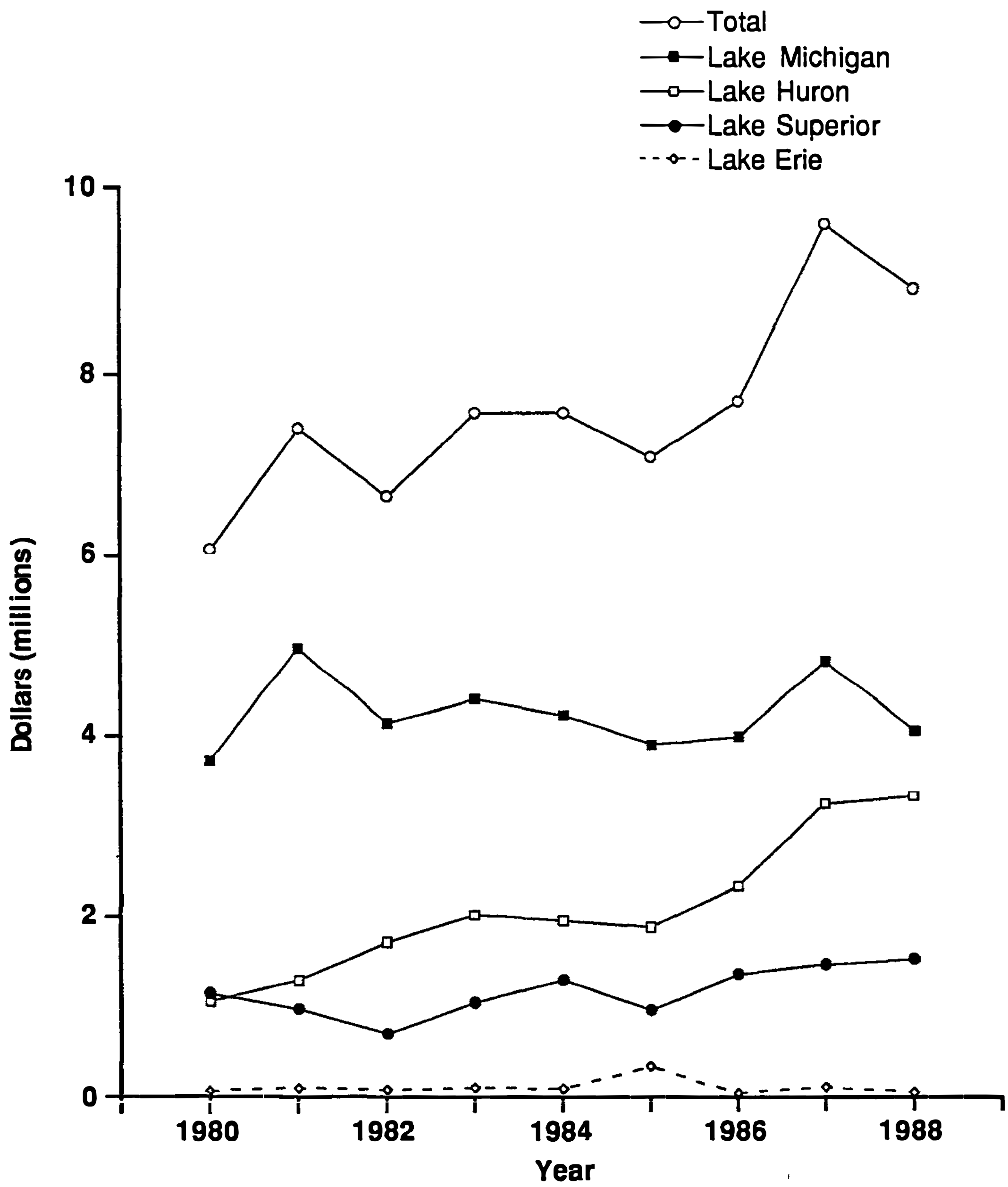

Figure 5. Dockside value of Michigan commercial fish production, 1980-88.

Table 10. Commercial fish harvest in pounds (x1,000) by state and tribal fisheries from the Michigan waters of Lake Superior, 1980-88.

Species	Year								
	1980	1981	1982	1983	1984	1985	1986	1987	1988
Alewife	T[1]	T[1]	0	0	0	0	T[1]	0	T[1]
Burbot	38	29	9	5	7	5	T[1]	T[1]	T[1]
Catfish	0	0	0	0	T[1]	0	0	0	0
Carp	T[1]	T[1]	T[1]	T[1]	T[1]	0	T[1]	0	0
Chinook	0	1	0	0	0	T[1]	0	T[1]	T[1]
Chubs	534	270	77	60	124	50	6	6	408
Coho	0	0	0	0	3	T[1]	7	5	1
Siscowet	72	36	23	12	96	53	366	618	468
Herring	78	43	20	31	37	35	29	44	35
Lake trout	93	122	100	122	226	257	425	325	230
Menominee	T[1]	3	1	1	2	T[1]	1	2	2
Northern pike	0	T[1]	0	0	0	0	0	0	0
Smelt	2	T[1]	T[1]	T[1]	T[1]	T[1]	T[1]	0	T[1]
Suckers	9	56	28	1	5	20	10	23	3
Walleye	0	0	0	0	T[1]	T[1]	3	4	2
Whitefish	724	850	747	1,442	1,667	1,737	2,180	1,820	1,808
Yellow perch	2	3	T[1]	3	1	T[1]	T[1]	T[1]	60

[1]T = Less than 1,000 pounds.

Table 11. Commercial fish harvest in pounds (x1,000) by state and tribal fisheries from the Michigan waters of Lake Huron, 1980-88.

Species	1980	1981	1982	1983	1984	1985	1986	1987	1988
					Year				
Commercial harvest									
Alewife	0	T[1]	1	3	2	3	3	1	1
Bowfin	1	T[1]	T[1]	T[1]	T[1]	T[1]	T[1]	T[1]	1
Burbot	T[1]	1	1	2	1	2	T[1]	T[1]	1
Buffalo	5	T[1]	1	3	5	1	T[1]	1	1
Bullhead	2	3	8	7	3	5	4	1	2
Carp	563	693	726	511	552	509	851	953	667
Catfish	494	506	676	671	533	577	591	544	511
Chinook	0	0	0	0	4	6	12	128	420
Chubs	0	0	0	46	46	81	72	45	70
Coho	0	0	0	0	0	0	0	0	28
Crappie	7	20	11	9	5	7	11	14	11
Gar	T[1]	T[1]	T[1]	T[1]	T[1]	T[1]	0	0	T[1]
Gizzard shad	0	0	0	T[1]	T[1]	0	0	0	T[1]
Herring	0	0	3	2	0	1	8	10	5
Lake trout	2	4	240	260	197	226	232	173	167
Menominee	50	43	39	39	51	44	39	35	48
Mooneye	0	0	T[1]	0	0	0	0	0	0
Quillback	59	49	80	54	74	70	56	32	30
Rock bass	T[1]	0	1	T[1]	1	2	T[1]	T[1]	1
Sheepshead	14	15	35	21	30	44	38	39	24
Smelt	22	0	27	0	14	0	20	33	23
Suckers	134	181	151	152	172	109	129	83	131
Walleye	1	T[1]	14	9	7	4	7	3	7
White bass	T[1]	T[1]	2	12	17	20	15	7	---
Whitefish	802	936	1,632	1,940	1,680	1,955	2,139	2,860	2,935
White perch	0	0	0	T[1]	T[1]	T[1]	T[1]	1	3
Yellow perch	195	179	158	140	120	80	71	128	98
Weir harvest[2]									
Chinook	0	0	0	207	444	277	723	833	529
Coho	0	0	0	0	71	6	7	T[1]	0

[1]T = less than 1,000 pounds.

[2]Harvest at the state weirs during the taking of eggs for fish culture.

Table 12. Commercial fish harvest in pounds (x1,000) by state and tribal fisheries from the Michigan waters of Lake Michigan, 1980-88.

Species	Year								
	1980	1981	1982	1983	1984	1985	1986	1987	1988
Commercial harvest									
Alewife	605	1,082	1,693	927	0	0	0	T[1]	0
Burbot	28	19	32	9	7	10	16	19	20
Catfish	T[1]	T[1]	3	3	6	5	4	5	6
Carp	0	T[1]	2	2	T[1]	T[1]	T[1]	T[1]	T[1]
Chinook	0	0	0	4	5	6	7	14	92
Chubs	217	527	732	484	411	349	658	840	652
Coho	0	0	0	0	T[1]	T[1]	T[1]	T[1]	0
Herring	T[1]	T[1]	T[1]	0	0	T[1]	T[1]	T[1]	T[1]
Lake trout	245	484	284	336	365	542	249	248	289
Menominee	127	185	164	156	242	172	218	187	169
Northern pike	T[1]	0	0	0	0	0	0	0	0
Sheepshead	0	0	0	T[1]	T[1]	0	T[1]	T[1]	T[1]
Smelt	525	1,193	1,530	3,293	1,827	2,038	2,585	1,306	1,140
Suckers	1,177	840	809	1,094	1,722	687	783	1,218	601
Walleye	2	5	2	2	26	7	2	T[1]	T[1]
Whitefish	3,429	5,011	4,769	4,306	4,568	4,921	3,854	4,435	4,017
Yellow perch	56	56	38	66	99	53	216	154	50
Weir harvest[2]									
Chinook	259	223	188	580	49	509	353	625	282
Coho	707	975	671	1,190	891	526	304	392	179

[1]T = less than 1,000 pounds.

[2]Harvest at the state weirs during the taking of eggs for fish culture.

Table 13. Commercial fish harvest in pounds (x1,000) by state and tribal fisheries from the Michigan waters of Lake Erie, 1980-88.

Species	Year								
	1980	1981	1982	1983	1984	1985	1986	1987	1988
Buffalo	36	30	22	8	1	T[1]	15	18	9
Bullhead	0	10	T[1]	1	T[1]	7	8	4	5
Carp	545	665	678	623	423	740	367	685	417
Catfish	21	49	20	29	9	9	11	40	15
Gizzard shad	0	0	76	665	1,265	878	0	0	0
Goldfish	0	0	0	0	0	0	0	1	T[1]
Quillback	0	0	1	2	56	87	2	1	1
Sheepshead	0	0	1	4	T[1]	1	2	2	1
Suckers	0	0	T[1]	T[1]	T[1]	1	T[1]	T[1]	0
White bass	3	14	2	12	2	5	1	4	1

[1]T = less than 1,000 pounds.

Table 14. Total landed catch in pounds (x1,000) of the state and tribal fisheries 1980-88.

Species	1980	1981	1982	1983	1984	1985	1986	1987	1988
State	9,161	10,764	11,719	13,429	13,403	11,266	10,176	9,606	7,383
Tribal	1,760	3,451	3,954	4,149	4,298	5,149	6,157	7,527	8,316
Total	10,921	14,215	15,673	17,578	17,701	16,415	16,333	17,133	15,699

Table 15. Number of state and tribal commercial fishing licensees, 1980-89.

	Tribal licensees		State licensees			
Year	1842 cession	1836 cession	Lake Michigan	Lake Huron	Lake Superior	Lake Erie
1980	10	170	53	32	28	5
1988	30	174	47	31	16	5
1989	30	202	39	28	11	5

The populations of lean lake trout in lakes Huron and Michigan remain composed primarily of stocked fish. However, there are increasing numbers of native produced lean trout showing up annually in Lake Huron south of Rogers City and a few each year in Lake Michigan. Harvest in Lake Michigan appears to be a major factor delaying the development of large enough populations of adult fish to ensure reproduction. Although the rehabilitation of self-sustaining stocks south of Rogers City in Lake Huron has been encouraging, the fish in recent years show signs of increasing predation from lamprey. It is questionable as to how long the native production will continue, or increase, if more effective lamprey control is not achieved soon in Lake Huron. Also appearance of increased lamprey activity seems to be spilling over into Lake Michigan and maybe Lake Superior.

Self-reproducing populations of siscowet lake trout (fat trout), found only in Lake Superior, have continued to expand while sustaining a considerable harvest.

The whitefish populations throughout the Michigan waters of the Great Lakes have remained healthy throughout the 1980's and supported an annual fishery of roughly 7.6 million pounds production. They remain the major product of the State's commercial fishery.

The populations of yellow perch being commercially harvested have remained depressed. Effort is underway to attempt improvement of the stocks in both Saginaw Bay and on the north shore of Lake Huron.

The harvest of catfish and carp in Saginaw Bay, Lake Huron and Lake Erie remains heavily influenced by market conditions. These populations remain in excellent shape.

Production of smelt in Green Bay, Lake Michigan, has been high due to good market conditions and a healthy population of fish. Smelt populations have oscillated quite dramatically since their introduction in 1909, for reasons unknown. These oscillations are likely to continue in the future. Smelt populations have remained depressed in lakes Huron and Superior during the 1980's but appear to be holding at present levels.

Sucker populations remain healthy around the lakes but prices remain depressed. Alewife populations remain depressed.

Populations of menominee remain healthy and appear to be expanding.

The chub populations in Lake Superior appear to have declined during the 1980's under relatively light pressure. This decline may be in response to increasing predation from burbot and siscowet lake trout. The chub populations in Lake Huron have been slow to expand even though harvesting pressure was removed in the mid-1970's. Recovery appears to be proceeding fastest in the north end of the lake. In Lake Michigan, the bloater chub populations exhibited dramatic expansion in the 1980's and may now be at an all time high. The lake herring populations have continued to remain depressed in all lakes but there are encouraging signs of recovery starting to show in Lake Superior. Burbot, sheepshead, suckers, gizzard shad, bullheads, crappie, white perch, white bass, gar pike, quillback, buffalo, rock bass, and goldfish make up a small portion of the State's commercial harvest. The harvest comes usually from small isolated populations of which there is little information available on their status. As the cost of assessing these stocks would, in most cases, exceed the value of the catch, they are managed by providing only for a conservative harvest.

GREAT LAKES FISHERY RESOURCES

Natural Reproduction in Great Lakes Stocks

All species presently maintaining populations in the Great Lakes are self-sustaining except for brook trout, splake, chinook salmon, walleye, steelhead/rainbow, brown trout, lean lake trout, coho salmon, and Atlantic salmon. Populations of the named species are being augmented through stocking programs. The extent to which they are being supplemented by stocking varies from lake to lake. Natural reproduction is increasing among some walleye and lake trout populations in the Great Lakes. It is not, however, possible to predict with any degree of accuracy how long, if ever, it will take before these populations will become entirely self-sustaining.

Great Lakes Commercial Fisheries Monitoring

Throughout the 1980's, the Fisheries Division has conducted very limited monitoring of the State's commercial fisheries. The program has been designed to provide information for assessing the condition of the siscowet (fat trout), lean lake trout, and whitefish stocks in Lake Superior, the whitefish and chubs in Lake Michigan, and the whitefish and perch populations in Lake Huron.

In Lake Superior the program has consisted of onboard monitoring of all the netting efforts to assess the lean lake trout populations (between 20 and 30 trips annually); monitoring the whitefish trap net fishery by accompanying each operation in the spring, summer, and fall on a lifting day (roughly 12 trips annually); and accompanying each siscowet research contractor on the lake twice annually (total of 6 to 10 trips). During the assessments, lengths, weights, and representative scale samples are taken from the fish for determining age, growth, and condition of the population. The assessment monitoring is conducted in the waters west of the Keweenaw Peninsula, Keweenaw Bay, and the Marquette and Munising area.

In Lake Huron the monitoring program has consisted of sampling at dockside or onboard the whitefish research permit fisheries at Rogers City, Alpena, and Bay Port and two Saginaw Bay perch fisheries once each in the spring and the fall. The monitoring effort entails measuring, weighing, taking scales from a representative portion of the catch. The data generated are used to follow the age and growth trends of these populations.

In Lake Michigan the monitoring program has consisted of onboard monitoring of the State's one experimental whitefish trawl fishery in Green Bay (roughly 12 times per year); dockside monitoring of a trap-net operation in each Upper Green Bay, Lower Green Bay, Leland, and Muskegon during each spring, summer, and fall, and an on-dock monitoring of the chub research fisheries roughly twice a year at Leland, Muskegon, and Ludington.

As Michigan's licensed commercial fishery has declined in size with the transition to the effort the tribal fisheries throughout the 1980's, license revenues and effort have declined to the point where it is difficult to justify continuing the past level of monitoring of this fishery. As the tribal fisheries expand, there is an expectation that the cost and effort for monitoring the stocks they fish should be borne by the tribes and the Federal Government. At the present time, Fisheries Division does no monitoring to test the general efficiency or effectiveness of regulations.

Great Lakes Species Management

Abundance of chinook salmon in Lake Michigan has declined since 1987, a fact which has been reflected in the significantly lower harvest of chinook from Lake Michigan by sport anglers. This prompted the Fisheries Division to review its management policies for Lake Michigan. A task force, comprised of Division personnel and representatives from major user groups, was established to accomplish this review and make recommendations for future programs. The process made it obvious that there are critical gaps in our knowledge of the salmonid resources and community interactions in Lake Michigan. The task force made 15 recommendations for future management of the Lake Michigan fishery resource, based on the idea that stocks are inter-jurisdictional and should be managed within the context of the lake's entire ecosystem. New research programs were proposed to improve knowledge in areas of biology, ecology, and economics.

To respond to the continuing threat of lamprey predation on the Great Lakes fish stocks, the Fisheries Division has been working on developing instream electrical weir systems and low-head barriers for improving lamprey control. Presently experimental electrical barriers are under evaluation in four streams (Pere Marquette, Ocqueoc, Jordan rivers and Haymeadow Creek) and low-head barriers have been installed on four streams (Misery, Au Gres, Day rivers and Albany Creek). These barriers are expected to reduce the dependency on chemical control in these streams and improve the degree of control.

Fish ladders have been installed in the Boardman River, the Grand River, and are in the process of being installed in the St. Joseph River. These ladders will expand the distance anadromous fishes can move up these streams to provide new fishing opportunities.

Creel limits were reduced on yellow perch as well as those on lake trout, salmon, and other trout in an effort to redistribute the catch among more anglers and to protect populations from overharvest.

Numerous cooperative walleye rearing projects have been developed in an effort to expand the Great Lakes and tributary stream walleye rehabilitation and enhancement programs.

Two experimental reefs (Muskegon, Lake Michigan and Tawas, Lake Huron) have been built to test the merit of their use to expand fishing opportunities and spawning habitat in the Great Lakes. However, as the Great Lakes has numerous natural reefs, the value of experimental reefs will be assessed before planning for or constructing more such structures in the Great Lakes.

The Fisheries Division in this decade has taken an increasingly aggressive position toward protecting the Great Lakes fisheries habitats from sustaining further degradation from poorly designed dredging and construction programs. Also, during the 1980's, work with the Land Resource Trust Board, the Department of Natural Resources Recreation Division, the U. S. Corps of Engineers, and local units of government has continued in order to secure and develop safe access to the Great Lakes.

During this period, salmon weirs were installed on the Boardman River, Medusa Creek, the Jordan River, Swan Creek, and the Au Sable River. These weirs facilitate the harvest of surplus spawning salmon and the taking of salmon eggs while assisting in providing for orderly development of the Great Lakes salmon program.

Fish Contaminant Monitoring

Throughout the 1980's the levels of contaminants in fish continued to decline, but they continued to be of great concern. In this regard, the Great Lakes' states expanded their fish monitoring programs. With the expansion of programs, existing problems were further defined and fish advisories on restricting consumption were expanded to reflect the new data. Early on, expansion of the advisories often lead to dissemination of information confusing to the public, particularly on the Great Lakes' water bodies where several differing advisories might have been available. In an attempt to resolve this issue, the Governors of the Great Lakes' states have asked their agencies to work together to develop meaningful joint advisories for the Great Lakes.

The State of Michigan, in the late 1970's, in an effort to deal with the issue of contaminants in fish and wildlife, developed an interagency committee to share information between State agencies and work towards meaningful information for advising the public on the risks and attributes of eating fish and game. The committee, known as the Fish and Wildlife Contamination Assessment Committee (FWCAC), is made up of representatives of the Department of Natural Resources which does most of the contaminant assessment work, the Department of Agriculture which is responsible for assessing and regulating contaminants in fish in the marketplace, and the Department of Public Health, which is responsible for issuing consumption advice on fish caught for recreation.

Each year the MDNR takes and analyzes upwards of 1,000 fish samples in an effort to define any probable fish contaminant problems within State waters and to follow cleanup of past problem areas. The fish are sampled by size, species, and water body and then analyzed for a variety of contaminants which might likely be found in them.

Once a fish has been collected, the edible portion is removed from one side. This portion is analyzed for a variety of organic and heavy metal contaminants. Standard procedures are used for analysis. Quality control and assurance of work is conducted to maintain the integrity of the analytical program. Once the analysis is complete, the data are reviewed by the FWCAC committee and then the Department of Public Health decides what should go into the advisory for release to the fish eating public. Michigan has one of the most aggressive fish monitoring programs in the United States.

In 1985, the Governors of the Great Lakes' states told their agencies to develop generic fish consumption advisories for the Great Lakes' waters which would reflect conditions in the fish throughout each lake. As there is no monitoring program for whole lakes and not all agencies sample their waters with the same intensity, those sampling with the greatest intensity highly influence what is advised on edibility. As a result of this procedure, there have been times when restrictive edibility advice has been given for a particular species on which the data were generated in a small area of the lake which was not characteristic of the rest of the lake. Under this procedure the data on contaminants from this small area would determine the advice given for the rest of the lake until more sampling could be done.

The development of fish consumption advisories based on sample data and the extrapolation of the effects of contaminants on test animals to humans is controversial and was the subject of much discussion during the 1980's. The procedure of modeling the actual human health risks from ingestion of contaminants in fish cannot be done from human health studies as the data for the basis of such work does not exist. Rather, the modeling is done by extrapolating the effects of contaminants on lower animals studied and then assuming a similar response from humans. Because of the great potential for biases, it remains to be seen whether or not Michigan will adopt a pure risk assessment procedure for making its judgments on fish eating advisories. This issue is one which will come before the Governor's newly created Council for Environmental Quality within the Department of Public Health.

In general, there were rapid declines in chemical contaminants in fish in the 1970's, when their use was being banned or highly restricted. However, as the point source inputs have been reduced the declines appear to now more closely follow the pattern one might expect as the materials degrade at their anticipated rate.

Great Lakes Research and Assessment

Fishery research and assessment studies on lakes Superior, Michigan, Huron, and St. Clair-Lake Erie were conducted by personnel from the Great Lakes Fisheries stations at Marquette, Charlevoix, Alpena, and Mt. Clemens. These programs include monitoring commercial and sport harvests and studying fish community interactions. The research is aimed at understanding fish population dynamics, thus allowing better management of the fish communities. Much of the work is coordinated through the Great Lakes Fishery Commission in cooperation with state, province, federal, and tribal agencies bordering the lakes. The Fisheries Division also supports short-term university research on various phases of the life history of fishes. Results of this research are contained in the Fisheries Division research, technical, and other reports (Appendix 1).

Lake Superior

Research.--At the Marquette Fishery Station a 14-year study of rainbow trout-coho salmon population dynamics in Lake Superior tributaries was concluded in 1982. The study provided baseline data on juvenile salmonid abundance in streams and explored the interspecific relationships between salmonids. No competition between rainbow and coho juveniles was found. It also documented the establishment of naturally reproducing coho populations, and determined that scale characteristics could be used to distinguish hatchery from wild coho. The rainbow trout biology from the study contributed to an international assessment of rainbow trout stocks in the Great Lakes. Juvenile salmonid population data continue to be collected under two ongoing studies to compare current populations to those of the late 1960's and early 1970's. Current estimates of juvenile rainbow trout populations are generally lower than those during the earlier years and juvenile coho populations are generally higher.

A 9-year study of juvenile lake trout morphological characteristics was concluded in 1981. The objective of the study was to identify characteristics which would assist in differentiating between juveniles of lean, humper, and siscowet races of lake trout which are found in Lake Superior. Siblings of the three races were reared at Marquette and Thompson hatcheries and sampled at intervals as they grew. They were examined for differences in growth, coefficient of condition, specific gravity, dry weight, and numerous morphological and meristic characteristics. Differences were found in most parameters but none were definitive. Those that may be useful to distinguish among races included measurements of head features, girth, furcation, anal fin size, and dorsal and anal ray counts. Assistance is provided the U. S. Fish and Wildlife Service, Biological Station, Ashland, Wisconsin, for further work in this area by providing samples of the three races.

A study which assessed early survival of young lake trout was concluded in 1982. The objectives were: (1) to develop methods of sampling lake trout eggs and fry and then (2) to assess early survival of young lake trout in Lake Superior and Lake Michigan. The U. S. Fish and Wildlife Service, Biological Station, Ashland, Wisconsin, assisted with portions of this study. Various designed suction pumps, trawls, and traps were found to be effective gear for capturing lake trout eggs and young-of-the-year. Lake trout eggs and fry were found in Grand Traverse Bay, Lake Michigan. Lake trout young studied in Presque Isle Harbor, Lake Superior were found to reside in the harbor for up to 3 months after hatching where they fed mainly on insect pupa and larvae and grew to over 50 mm in total length. Suitable lake trout spawning substrate was determined to be rounded or angular rock 2-20 inches in diameter with crevices 12 inches or deeper.

A study to document distribution, abundance, size, age, and fecundity of pink salmon in the Great Lakes has been ongoing since 1973. The dominant odd-year runs appear to have reached their peak in all of the lakes and are now at somewhat lower if not stable levels. The

St. Marys River continues to receive a large spawning run, however, the 1989 run was smaller than in 1987.

A study of the dynamics of lake trout reproduction on two man-made spawning reefs was completed during 1977-80. Lake trout reproduction on the reefs in Presque Isle Harbor, Lake Superior was qualitatively and quantitatively described. Lake trout spawned during a 15- to 26-day period between October 12-November 14 from sundown to at least midnight. Most of the spawners were of hatchery origin but wild trout increased from 4% to 25% during the period. Lake trout rarely visited the reefs more than once and may have deposited sex products on more than one reef. Number of spawners in 1979 was estimated to be 1,600 males and 600 females on the intake reef and 2,100 males and 1,100 females on the discharge reef. Egg deposition and swim-up fry production on the intake reef during 1977-80 ranged 122-518/m^2 and 20-46/m^2, respectively. Physical characteristics, water chemistry, and biota indicated that these man-made reefs were favorable habitat for lake trout reproduction. Fecundity (egg number) of contemporary hatchery and wild lake trout collected in inshore waters of Lake Superior during 1977-82 was not significantly different. Fecundity was greater than for former native stocks and increased with increasing fish body weight. Hatchery influence through selection and culture of broodstock appeared to be most responsible for greater fecundity of contemporary lake trout in Lake Superior.

A study started in 1979 of planting eyed eggs as a means of restoring lake trout stocks in the Great Lakes achieved some success on small reefs on the south shore of Drummond Island, Lake Huron. Fry were captured on these reefs in emergent fry traps. Previous plants of eyed eggs, mostly on offshore reefs, produced no results probably due to no survival or the inability to adequately sample reefs in the open lake. At Drummond Island, eggs were planted at a density of slightly more than 200/m^2. Although fry production on the planted reefs was not quantified some emergent fry were captured and survival of eggs to fry in incubation cages on these reefs was in excess of 90%. All reefs planted were checked for adult lake trout during the spawning season 6-8 years from year of planting. No unclipped lake trout were captured, however, this area of Lake Huron has high populations of feeding-phase sea lamprey and a large gill-net fishery that may have reduced the chances of survival of these lake trout.

A cooperative study with U. S. Fish and Wildlife Service, National Fishery Center-Great Lakes (NFC-GL), Ann Arbor, Michigan; Great Lake Fishery Commission, Ann Arbor, Michigan; Ontario Ministry of Natural Resources, Picton, Ontario; Department of Fisheries and Oceans Canada, Burlington, Ontario; and Wisconsin Department of Natural Resources, Sturgeon Bay, Wisconsin to evaluate lake trout spawning habitat in the Great Lakes using an *in situ* bioassay procedure is being done. Objectives of the study are to determine if lake trout spawning areas in lakes Huron, Michigan, Erie, and Ontario, are suitable for incubation of lake trout gametes. To determine whether gametes produced in these lakes will incubate successfully under *in situ* conditions by determining the percentage survival to hatch and beyond of lake trout gametes incubated on treatment reefs in southern Lake Huron, Lake Michigan, Lake Erie, and Lake Ontario; on a control reef in Lake Superior; and in the NFC-GL laboratory at Ann Arbor, Michigan.

Field work was completed on a study to evaluate juvenile salmonid plants in Michigan waters of Lake Superior. Rates of return to the angler of hatchery-reared and wild trout and salmon at a major sportfishing area in Michigan waters of Lake Superior (Marquette, Michigan) were determined via creel census. These data will be compared with planting time, fish size, and number to determine the best rate of return relative to cost of production. Juvenile population estimates and observations of adult runs were done to determine if planted rainbow trout contribute to spawning runs on planted streams.

A lakewide study to determine origin and population dynamics of chinook salmon by the states and province surrounding Lake Superior was begun in 1988. Three successive year classes (1988, 1989, and 1990) will be marked, and contribution to the creel and spawning populations will be assessed during 1989-95. Two year classes have been marked by each of the management agencies to date. The only data collected as yet has been on micro-wire tag retention and fin-clip quality.

A study of the population dynamics of contemporary yellow perch and walleye stocks in Michigan waters of Green Bay, Lake Michigan was begun in 1988. Catch and effort data from the sport fisheries census are assembled annually. Indices of abundance for pre-recruit perch, pre-recruit walleye, and populations of other prominent species are being established using trawls, seines, electrofishing, and graded-mesh gill nets. Age and size composition, growth, and mortality are determined for fish from Big Bay de Noc and Little Bay de Noc. Mean size-at-age for yellow perch was not significantly different either between sexes or between bays. In Little Bay de Noc, male walleye between the ages of 6 and 8 exhibited slower growth than females; mean age of walleyes in the spawning run was 4.6 for males and 9.8 for females. Discreteness, movement, and range of perch and walleye populations, as well as the effects of tagging and handling on incidence of walleye lymphocystis are being determined by tagging studies. Since 1988, jaw tags have been attached to approximately 5,000 walleye and 2,500 yellow perch. As of March, 1989, 170 walleye tag returns documented that most (66%) fish were recaptured within 5 miles of the tagging site and the fish retrieved from the furthest distance was 12 miles away. Data on interspecific relationships (food habits, predation, and competition for food and space) are being collected. Data from 1989 samples have yet to be analyzed but stomach contents from 1,164 yellow perch were examined from fish collected June through October 1988. Diet consisted of taxa considered typical for perch until September and October when the exotic cladoceran *Bythotrephes cederstroemi* was found in 31% of the yellow perch collected from Little Bay de Noc and 4% of the perch from Big Bay de Noc.

Stock assessment.--Assessment of age, growth, and mortality of chub stocks on fishing grounds in Lake Superior north, east, and west of the Keweenaw Peninsula was completed in 1981. Catches were mainly of bloaters with kiyi common on most grounds. Shortjaw chubs were present but too sparse on any ground to provide sufficient data for analysis as was kiyi abundance east of the Keweenaw Peninsula. Length-frequency and length-weight of bloater and kiyi were not different between species, fishing grounds, seasons, or years. Ages of bloater and kiyi in commercial nets ranged 3-14 years with 6-9 the range of modal age groups in all but one sample. There were no consistent differences between age composition and calculated length for bloaters and kiyi. Bloater and kiyi instantaneous growth (G) and mortality (Z) were not different. Differences in mortality rates between grounds for certain year classes indicated that the fishing grounds may contain different stocks.

Remnant stocks of wild lake trout were responsible for rehabilitation of lake trout at Isle Royale, Lake Superior. Comparison of population dynamics of Isle Royale and inshore stocks may be helpful in understanding rehabilitation processes. Data collected since 1963 have been analyzed and a report is being written.

Assessment of inshore lake trout stocks in Lake Superior has been done since the late 1950's. Results are being written up in two reports, one as a Fisheries Research Report and another as part of a report covering all United States waters of Lake Superior by Michigan, Wisconsin, Minnesota, and U. S. Fish and Wildlife Service biologists. Data from this assessment have also been used in four Great Lakes Fishery Commission sponsored symposia, tribal negotiations, and to produce annual total allowable catch recommendations for tribal and state fisheries. The lake trout population in the 1980's has changed from one dominated by hatchery fish during the early part of the decade to one dominated by wild fish during the latter portion of the decade, however total abundance has declined due to high exploitation and reduced growth rates. Abundance of spawning-sized fish has also declined and recruitment of young fish may be affected.

A study was begun to determine the number of non-target anadromous salmonids and lean lake trout captured and killed in an exploratory commercial gill-net fishery for siscowet lake trout, to determine if siscowets are preying on salmon and other trout, and to determine relative abundance and harvestable surplus of siscowet lake trout. Stomach contents from 200 each of lean lake trout and siscowet lake trout have been examined from sampling of trout from similar depths. Some overlap in utilization of food items was noted and will be quantified. Additional samples have been obtained from siscowet occupying depths greater than 360 feet. Catch per unit of effort (CPE) of siscowets has been comparable to those of inshore lean lake trout (75-148 pounds per 1,000 feet). At the same time lean lake trout CPE has been only 0.7-7.6 pounds, and no anadromous salmonids have been observed during monitoring or reported by the fishers.

Two studies to assess lake whitefish stocks in Lake Superior were started during the early 1980's. The studies shared objectives to determine harvestable surplus of whitefish and to specify the rates of non-target fish catch and mortality. One study was also designed to document exploitation of previously unexploited whitefish stocks west of Keweenaw Peninsula. Non-target mortality has been low in all areas. Whitefish mortality has increased at West Entry, Keweenaw Point, and Big Bay, due to increased fishing by tribal fishers and has remained low at Marquette and Munising where harvest has been stable. Total allowable catches are calculated annually based on biological and catch data.

Lake Michigan

Research.--At the Charlevoix Fishery Station a major portion of the research program in the 1980's has been devoted to monitoring commercial whitefish and chub fisheries, and evaluating the efforts to rehabilitate lake trout stocks. The lake trout in Lake Michigan have failed to reproduce themselves, since their collapse in the 1950's. Possible reasons include overfishing, contaminants, strain of trout planted, improper stocking sites, or some combination of these factors. The northern refuge, which is located in the Beaver Island area of Lake Michigan, is approximately 900 square miles in surface area. The refuge contains reefs known to have been used by spawning lake trout in the pre-lamprey era. Three strains of lake trout were stocked on these reefs within the refuge in 1986. Each strain and planting location was identified with a uniquely coded-wire tag. Since most lake trout do not mature until 6 years old, no offspring will be found in the refuge before 1992 at the earliest. To date, there appears to be no difference in survival rate among the three strains, and all have been found at considerable distances outside of the refuge.

Selectivity of various combinations of mesh sizes in experimental gill-net gangs, which could be used to index the bloater chub population in Lake Michigan, was evaluated in 1984-85. No one combination of mesh sizes performed consistently well over all variables tested. A combination of varying mesh sizes produced the best overall result when fished in April, while a mesh interval of 3.2 mm provided superior results when fished in August. It was recommended that an experimental gill-net gang to index the exploitable segment of the bloater chub population consist of mesh sizes 50.9 mm to 73.0 mm, with an interval of 3.2 mm. Mesh intervals of 6.4 mm or larger for indexing chubs should not be used.

Large-mesh trap nets for harvesting whitefish were modified to determine if the number of non-target fish dying because of gilling could be significantly decreased. Modifications were made to the net by reducing the mesh size in the rear corners of the pot and over the tunnel using shoaling twine panels. Results indicated that changes made to the nets were effective in reducing incidental gilling mortality of non-target species in the modified sections of the nets. However, mortalities were not significantly different for any of the non-target species when comparing total performance of control and modified nets. Modification had no detrimental effect on whitefish harvest and, in fact, modified nets harvested significantly higher numbers of whitefish than did control nets in many of the months sampled. Lake trout was the most abundant non-target species in the nets with 72 caught per lift in 1985 and 88 per lift in 1986. Approximately 1,500 of the lake trout caught each year died as a result of gilling. The remaining non-target species occurred in relatively small numbers when compared to lake trout. Yellow perch had the highest abundance, followed by salmon, walleye, brown trout, and steelhead. On the average, 60-80% of all yellow perch, salmon, and steelhead caught died from gilling, compared to only 20% for brown trout and 13% for walleye.

Since 1983, the Fisheries Division has conducted a stratified random creel survey of the anglers fishing the state's Great Lakes waters and major connecting rivers. In the early years, because of the large geographical area covered and vast amounts of data collected, the analysis system employed was often inadequate to allow for timely report generation. This led to a reevaluation of the design and modeling capabilities. Currently, software for the IBM-PC micro-computer is being developed to alleviate the problem. This creel survey software (CREELAN), nearly complete, is capable of handling any size census regardless of the amount of data generated or the geographical area covered. Turn-around-time (from data collection to summarization) has been decreased from almost 6 months to about 3 weeks in Michigan.

Stock assessment.--A dispute about fishing rights between the State of Michigan and local Indian tribes was settled in 1985. The agreement includes an annual assessment of lake trout, whitefish, and bloater chub populations in treaty-ceded waters of Lake Michigan. This analysis is used to determine harvest quotas on these species for state sport, state commercial, and tribal commercial fisheries. An annual report is produced through the combined efforts of the Fisheries Division, tribal, and Fish and Wildlife Services personnel. Specifically, we provide growth and mortality rate estimates for lake trout and whitefish. These data are obtained through our annual surveys of Lake Michigan fish stocks. Rehabilitation of lake trout stocks in Lake Michigan began in 1965. Despite large plantings of this species, evaluations have shown that significant successful reproduction by lake trout has yet to occur anywhere in the lake. An important factor contributing to this reproductive failure is the high total mortality experienced by these populations, a significant portion of which is attributed to excessive harvest by sport and commercial fisheries. Consequently, lake trout still depend on the annual influx of hatchery fish to sustain their abundance.

Whitefish are the backbone of Michigan's commercial fishery in Lake Michigan. The condition of whitefish stocks under state jurisdiction is monitored by sampling commercial harvests throughout the fishing season. Typically, 80-90% of this commercial harvest comes from Green Bay. Total mortality rates of whitefish in the bay have continually exceeded the recommended level of 65%, ranging from 71-88% during 1983-88. Again, as for lake trout, a major part of this mortality was caused by exploitation of these stocks. Although stocks have not collapsed, a reduction in fishing-induced mortality would significantly decease the risk of a population crash and might increase yield.

The bloater chub progressively declined in abundance from the mid-1960's through the mid-1970's in Lake Michigan. However, closure of the commercial chub fishery and a decrease in the number of alewife have both aided in the recent recovery of this species. This recovery has led to the reopening of commercial fishing for chubs in Lake Michigan. The harvest of chubs is now regulated by quotas which have been established for each states waters. However, Fisheries Division is considering a change in its chub management policy, proposing that bloaters be managed as a forage species to feed the salmonine predators of Lake Michigan as opposed to being harvested by commercial operations.

In 1987, a multi-agency effort was initiated to assess forage fish abundance in the entire main basin of Lake Michigan using trawls and hydroacoustic equipment. Results from this survey show that the forage biomass included 114 million pounds of alewife, 611 million pounds of bloater chub, and 86 million pounds of smelt. Alewife and smelt abundance in Green Bay has been estimated at 46 million pounds.

Sport fisheries on Lake Michigan have been monitored since 1983. Creel surveys are being conducted on lakes Superior, Huron, Michigan, and Erie, and on the St. Marys River system. In addition, important river fisheries have been sampled on the Manistee, Grand, Muskegon, St. Joseph, Betsie, Au Sable, and Tittabawassee. Over 300,000 anglers have been interviewed since the inception of the program. The information obtained from these surveys helps managers keep abreast of changes in angler use of the fish resources and harvest levels for specific species. For example, the sport harvest of walleye in Lake Erie peaked in 1988 at 1.9 million fish. However, the Lake Michigan chinook harvest has been declining since 1987. The sport harvest of walleye in Saginaw Bay has expanded from almost nothing in 1983 to an estimate of over 100,000 fish in 1988.

Lake Huron

Research.--At the Alpena Fishery Station, biological and catch statistics gathered from the sport and commercial perch fisheries on Saginaw Bay were used to determine the present commercial restriction (8.5 inch minimum size limit) and management plan. The management plan prescribes promoting the recovery of an abundant predator population and reducing commercial effort which conflicts with an expanding sport fishery. The evidence suggests that the Saginaw Bay yellow perch population has recently become very similar in growth rate, abundance, and age composition to the population which was present during the 1950's, that is, an abundant population with a relatively slow growth rate. Due to the present growth characteristics and size structure of the population, the relatively small commercial harvest is not having an adverse impact on recruitment or survival. A comparison of the recent sport and commercial catch by size indicated that the sport catch exceeded the commercial catch by a factor of 11 by number and 5 by weight. Historically, the Bay probably never yielded more than a million pounds per year on a sustained basis, and commercial yields of over 1 million pounds in the mid-1960's led to a population collapse. In recent years, the combined annual harvest approached 1 million pounds. The April-September sport fishery catch of yellow perch in Saginaw Bay was 1,604,000 fish in 1986, 2,329,000 in 1987, and 1,183,000 in 1988. Concerns about slow growth rate and apparent low survival are being addressed by current research which is monitoring food habits, abundance, and growth rate. Also under investigation are the interactions of yellow perch with the rest of the Saginaw Bay fish community. Close attention is being given to the effects upon the Saginaw Bay fishery of white perch, a recent invader of the Great Lakes, which gained entry via the St. Lawrence Seaway.

The management goal for the Saginaw Bay fishery is to restore the balance between predators and prey, such that the fisheries for walleye, perch, and other species are benefited. To this end, a total of 5,534,000 walleye fingerlings were stocked in Saginaw Bay and its tributaries between 1978 and 1988. The buildup of the walleye population was documented by a sudden increase in commercial trap netters' incidental catch of small walleyes, beginning in 1979, and by a dramatic increase in the Tittabawassee River spawning run, beginning in 1981. A large sport fishery for spawning migrants developed in the Tittabawassee River during winter and spring. Summer fishing for walleye in Saginaw Bay suddenly increased during the mid-1980's. The catch was estimated by creel census to be 59,000 in 1986; 63,500 in 1987; and 100,000 in 1988. It is estimated that the Bay is capable of eventually yielding approximately 600,000 walleye to the sport fishery per year.

Since 1981, a total of 29,268 walleyes have been tagged during the spawning run in the Saginaw Bay tributary system. The objective of tagging is to estimate annual mortality, harvest rates, and walleye movement. Returns are being obtained from sport and commercial fishermen and from biological sampling. Harvest has been light, about 3% per year, for the sport fishery, suggesting that the fishery is capable of sustaining considerably more use than present. Annual survival is estimated to be 62%. Growth of walleye in Saginaw Bay is as fast as any walleye population in Michigan. Studies are currently being implemented that will assess spawning success (and the need for further stocking), identify spawning sites in the tributaries and at reef areas in the Bay, and index the status of populations of walleye and other species.

Recently, fall fingerling and yearling brown trout were fin clipped and stocked in Thunder Bay, Lake Huron, an area with an established brown trout sport fishery. The objective of this research was to improve cost effectiveness of stocking. A creel census was conducted from 1985-87 to document the characteristics of the fishery and to determine the relative survival of the two life stages, fingerlings and yearlings. Fish stocked as yearlings made up 96% of the return of marked fish. Unmarked fish of unknown origin were also present in the catch, but not in numbers great enough to have a significant impact on the results of the study. A 9-day festival in July accounted for an average of 30% of the annual fishing effort and 35% of the salmonid catch. July was the most productive month for brown trout fishing. Over 90% of the annual catch consisted of age-2 and age-3 fish. Survival beyond age 3 was found to be very low due to near 90% mortality apparently associated with the onset of maturity and spawning. The 1984 year class exhibited relatively high survival. This may have been related to its larger size at stocking or genetic strain. Continuous monitoring of the fishery from its inception has indicated that recent returns were lower than for early years, probably related to an increase in predators. The variable return of recent plants suggests that additional strategies, such as changing stocking practices, increasing size at stocking, and experimenting with different genetic strains may significantly improve returns to the fishery. The fishery collapsed in 1988, and further study along these lines is planned.

Stock assessment.--The Alpena Fishery Station survey netted U. S. waters of Lake Huron in 1978-89 to determine the status of the once native lake trout stocks. Stocking was initiated in 1973. Lamprey and fishery controls were put into effect in the late 1960's and early 1970's, prior to which native trout were virtually extinct. Stocking rate and distribution have varied, due to availability of hatchery fish and poor survival in some areas. The goal of the interagency rehabilitation program is to produce a self-sustaining lake trout population in Lake Huron.

The annual survey documented a rapid recovery of stocks in northern Lake Huron. This stock was subsequently lost after Michigan lost jurisdiction over the fishery. Northern Lake Huron has subsequently been designated as a deferred lake trout recovery area due to the existence of a tribal commercial fishery development zone there. A sustained recovery has occurred south of this zone. Lake trout survival has remained excellent in the rest of the lake. Annual survival estimates in the remainder has exceeded 55%. Adult fish have remained extremely rare in the north. Growth rate is most rapid in the south, and current growth is considerably faster than historical growth. Spawner abundance in the Rockport-Alpena area has increased, and now compares favorably to Lake Superior populations. Recently, the average age of female spawners was 7.2 years. Lamprey wounding in the south, where sample sizes of lake trout are largest, was lower in 1988 than the recent peak seen in 1985. Through 1985, smelt was the dominant food item in stomachs of trout sampled in the spring, but decreased in importance relative to alewife from north to south. Alewife was a common item in all areas, and made up over 40% of the items in the south from 1983-85, and outnumbered smelt 11 to 1 at the south district in 1988. Returns of coded-wire tagged fish stocked on a mid-lake reef were taken in substantial numbers along both east and west shorelines of the main basin.

A trawl catch of 37 young-of-the-year fingerlings in 1988 indicated that lake trout continued to spawn successfully in north-central Lake Huron. The majority (16 of 17) of the unclipped trout taken in the small-mesh gill net sample in 1988 also were taken from this site.

The catch per effort at this site increased from 0.50 unclipped fish per 1,000 feet in 1986 to 0.67 fish in 1988.

The catch of unclipped lake trout has consistently been highest in the north-central district over the 1986-88 period. Part of the disparity in catch among the districts, however, is undoubtedly due to the fact that the amount of effort and productivity of fishing grounds for stocked lake trout have also been highest in the north-central district. Sampling with small-mesh gill net during late summer, specifically directed at small lake trout, have taken a total of 53 unclipped trout in this area. Three each have been taken in two districts further south over the 1986-88 year period. The numbers at the southern two districts are too small to indicate a trend in, or even verify the existence of, reproductive success, but do suggest, along with additional samples in other surveys, that some limited reproduction is occurring. During the 1988 spring assessment with gill nets, four additional unclipped fish were taken. The incidence of unclipped juveniles during the early years of lake trout stocking was extremely rare. The gradual increase in the unmarked (predominantly wild) composition of the assessment catch provides encouraging evidence that recovery of a self-sustaining lake trout fishery is possible in Lake Huron. An attempt will be made to increase effort and search for more productive grounds for monitoring unmarked lake trout in the future.

A high incidence of unclipped lake trout in the creel catch at Alpena also indicates that substantial reproduction is occurring specifically in the north-central area. The 1988 creel census sampled 30 unclipped fish, which represented 28% of the observed lake trout catch. The higher percentage of apparently wild lake trout in the creel than in the gill net samples is probably related to the differences in ages between the two samples. The gill net samples were made up of juvenile lake trout which corresponded to year classes with relatively high stocking rates, whereas the creel census samples ranged in age from 3-8, which corresponded to some year classes stocked at lower rates.

The Alpena Station provided monitoring information on and biological analysis of northern Lake Huron whitefish stocks, as well as survey information on the performance of lake trout plants in the north, for use in the negotiations dealing with the 1985 treaty agreement. On a related subject, monitoring information from the non-treaty commercial whitefish fishery was used to develop permit regulations for the fishery. Commercial whitefish production is presently at record historical levels.

Lake St. Clair-Lake Erie

Research.--At the Mt. Clemens Fisheries Station results of a 1980-81 on-site creel census of the Detroit River and Michigan waters of Lake Erie and the tagging of walleye caught in trap nets in Lake Erie, southern Lake Huron, and Lake St. Clair were analyzed. Tag returns in the period, 1974-82, showed substantial numbers of walleyes move north out of Lake Erie into the Detroit River and from Lake St. Clair into the St. Clair River. Over 1 million fish were caught by anglers in the surveyed waters in both 1980 and 1981. White bass, followed by yellow perch, freshwater drum, and walleye, were the most numerous fish harvested by Detroit River boat anglers. The 1981 ice fishery in Lake Erie harvested more yellow perch than the combined catch of all other species for the entire year.

Smallmouth bass inhabiting Anchor Bay of Lake St. Clair were netted and tagged from 1971 through 1985. Analysis of data from this long-term study and from an intense on-site creel census in 1983-85 produced a report on the distribution and population dynamics of Anchor Bay bass. Tag returns established that the majority of the bass remain within Anchor Bay but significant numbers migrated into the St. Clair River. Tag returns also were used to estimate total, natural, and fishing mortality which were intermediate, highest and lowest, respectively, compared to eight other smallmouth bass populations in North America. Net catches revealed an increase in bass abundance in the years after the minimum size limit was increased in 1976. However, although this increase was correlated with the year of extended protection from exploitation afforded by the regulation change it was correlated as well to a trend to warmer June water temperatures which benefited hatching and survival of young bass in the latter period.

The sport and commercial harvest of walleye in lakes St. Clair and Erie are cooperatively managed by several states and two countries. A substantial Michigan contribution to the information base for these shared stocks was presented in an extensive report on the identification, movement, growth, mortality, and exploitation of walleye stocks in Lake St. Clair and western Lake Erie. Evidence of stock discreteness was derived from long-term (1975-87) tag and recapture studies in both lakes as well as from studies of growth and of allelic frequencies of representative walleye samples. A western basin of Lake Erie and a Lake St. Clair walleye stock were clearly delineated by these analyses. These stocks mix in the northern waters of the system. It was concluded, from the results of the analyses, that these walleye populations should be independently managed but with interagency coordination.

A study of the Great Lakes muskellunge in Lake St. Clair was conducted. Two groups of muskellunge in Lake St. Clair were delineated from analyses of tag returns. One group spawns in the north (Anchor Bay) and spreads southward to occupy the entire west side of the lake. Another group resides and probably spawns in the southeastern part of the lake. Analyses of length-at-age data showed there was no change in muskellunge growth rate since 1969. The Lake St. Clair muskellunge continues to be self-sustaining and the growth rate is excellent. The current restrictive lakewide regulations help assure a continuing world famous fishery for Lake St. Clair muskellunge.

An intense study of forage, focusing on the feeding response of walleye to seasonal and annual variations in prey availability, was conducted in Michigan's waters of Lake Erie. Gill nets and trawls were used to collect walleye and their prey from April through October of 1981 and 1982. Prey availability was low in the spring followed by increased abundance that peaked in early fall and then declined. Analyses of stomach contents showed that walleye feeding rate increased as prey availability increased. Walleye showed preference for gizzard shad, alewife, and emerald shiners; other species were utilized as the preferred forage declined in abundance.

An intensive 2-year study was undertaken throughout Michigan's waters of the St. Clair-Detroit River System (SCDRS). The ultimate purpose of this study, contracted with the U. S. Army Corps of Engineers, was to address the potential impact to the SCDRS from extending the winter navigation season about 2 weeks to January 31. The project, comprised of three major segments, included a creel survey of the angler fishery, a trap-net survey and a tagging study. Data from a Lake Erie netting study were also incorporated because of the significant interchange of fish between these adjacent waters. A main study objective was to describe the relative abundance and movement patterns of the fish populations and then relate these findings to the pattern of angling effort. Several major findings were derived from analyses of data from all segments of the study. It was shown that the sport fishery of the SCDRS is much more intense and productive per unit area than on any other of Michigan's Great Lakes waters. Fish movement was much reduced in the winter and it was evident that they did not concentrate in the vicinity of the shipping channel. It was apparent that fish in the fall sought out overwintering areas in the lake or adjacent marshes or streams. Movement rates accelerated again in the spring as fish moved to and from spawning grounds and to summer feeding grounds. Angling harvest was lower in the St. Clair River than in the remainder of the SCDRS. However, tag data showed that fish were more vulnerable to capture by nets and anglers in the St. Clair River, probably due to concentration resulting from shortages of habitat.

The St. Clair River would be the most vulnerable point in the system for impact from winter vessel passage. However, the data collected in this study did not show that an extension of winter navigation would effect the adult fish community enough to be detected by any conventional fishery sampling technique.

Netting and creel survey data from Lake St. Clair and the connecting channels were utilized to estimate fish harvest and productivity and presented in a report to the International Large River Symposium.

A study was initiated in 1988 for the purpose of reestablishing burrowing mayflies in Saginaw Bay. Restoration of mayflies to their abundance in the Bay prior to the 1950's would be very desirable. They are a preferred food item of yellow perch. Mayfly abundance has been positively correlated with excellent perch growth rate. The current growth rate of Saginaw Bay yellow perch is slow and has generated much concern among anglers. Limited *in situ* testing in 1988 showed nymph survival in various Bay areas. Further testing in 1989 was inconclusive due to vandalism of test cages and other problems. In July 1988, an estimated 7.5 million mayfly eggs were collected along the north shore of Lake St. Clair and subsequently released in Saginaw Bay. In 1989, an estimated 300 million eggs were collected and released in Saginaw Bay. Viability of the eggs was confirmed to be high based on frequent hatching assays. An attempt will be made in 1990 to collect a much larger quantity of mayfly eggs for release.

The yellow perch population of Saginaw Bay has become a serious management concern due to their high densities and resultant poor growth. A very intense 3-year field study (1986-88) was undertaken to address this problem. The primary objectives were to: (1) measure the abundance of walleye, yellow perch, and their forage species in Saginaw Bay; (2) measure the rate of forage consumption by walleye and yellow perch as a function of forage and predator abundance from spring through fall and; (3) measure the level of competition between walleye and perch at all life stages. Sampling gear consisted of bottom trawls and gill nets. Laboratory processing of samples continues as well as analyses of data from all sources. Sufficient information has been gained to permit some general conclusions. Prey and secondary predator fish species dominate the Saginaw Bay community which probably causes extreme predation on the zooplankton and benthos forage resources. Walleye growth rate is very good which is probably attributable to the high density of forage fishes. Walleye appear to primarily consume mid-depth or surface-oriented gizzard shad, alewife, and smelt while abundant forage species frequenting the bottom, including spottail shiners, troutperch, and yellow perch, are not often consumed by walleye. It is quite evident under the present set of conditions that walleye are not an effective management tool in the attempt to control the density of Saginaw Bay yellow perch. Zooplankton was the most abundant item in perch stomachs from May through July; thereafter, they declined in numbers. Benthos contributed about 12 items per stomach throughout the 6-month period of sampling. Forage fish, despite their abundance, were not a common item in adult perch stomachs.

Fish population abundance and biomass estimates are important objectives of the Saginaw Bay forage study. Knowledge of the catch efficiency of the gear is essential to obtaining this goal. A study, supplemental to the Saginaw Bay forage study, was designed and initiated in the spring of 1989 to address this need. A barrier net 1,000 feet in length by 100 feet in width was built and deployed in Anchor Bay of Lake St. Clair to enclose fish. Different species of fish of various sizes were marked and released within the net enclosure. Subsequently a trawl was dragged through the enclosure and captured marked or unmarked fish and were recorded. This sequence of activities was repeated for several days. The area swept by the trawl and the ratio of marked fish captured to total number marked was to be the basis for estimating catch efficiency, but the enclosure net did not effectively block the egress or ingress of fish because lake currents proved too strong for holding all sections of the net in vertical position. However, useful data were obtained since the catchability of yellow perch on 2 days was reasonably close suggesting that trawl efficiency, on these occasions, was being measured. The 1989 experience will be used to refine experimental design and correct the problems with the enclosure net before further testing in 1990.

Stock assessment.--Bottom trawl surveys were conducted each fall, 1970 through 1989, to assess the fish stocks of inner Saginaw Bay. Trawl catch per effort data are used to monitor abundance and recruitment of all fish species vulnerable to the gear. In addition, trawl catches of yellow perch are used to monitor growth and mortality of specific age and sex groups. Information from these surveys and also from the 1986-88 Saginaw Bay forage study contributed to the preparation of the 1987 report by Keller and others entitled *History, Status, and Management of Fishes in Saginaw Bay, 1891-1986*. This overview of Saginaw Bay fish stocks chiefly relates man-caused changes of the ecosystem to alterations in the fish community.

Trap-net surveys have been conducted in western Lake Erie near Monroe each spring since 1978. Major survey objectives have been to maintain current assessments of the major fish stocks as well as to continue a tagging study of walleye. The tag data have provided independent estimates of walleye survival and exploitation each year since 1978 as a check on other interagency research efforts. Stock assessment reports were prepared annually and presented at the Great Lakes Fishery Commission (GLFC)-sponsored Lake Erie Committee meetings of pertinent management agencies from Michigan, Ontario, Ohio, Pennsylvania, and New York. These surveys revealed the dramatic increases in western Erie of walleye. The net catches also documented the arrival and subsequent rapid expansion of white perch in the western basin. Results of the ongoing walleye tag study are analyzed and annually reported to the GLFC.

A supplementary study of the angler harvest of walleye was initiated in 1988 in addition to the regular Michigan Department of Natural Resources on-site creel census. Observers were stationed at the two launch sites most heavily used to inspect the walleye caught by boat anglers. A total of 29,713 walleye, only 8 of which were tagged,. were inspected between June 12 and August 19. Comparison of the average number of walleye caught per angler by the walleye tag observer versus the on-site creel clerk for the same period showed quite similar results (4.00 compared to 4.67). This helped confirm that the on-site creel is operating satisfactorily. The walleye tag census was repeated for a longer period in 1989; analyses of these data are incomplete.

An interagency index survey each fall, employing gill nets, has been ongoing in the western basin of Lake Erie since 1978. The purpose, in cooperation with Ontario and Ohio, is to provide estimates of the size of the western basin walleye stocks. The combined catch of walleye, particularly of yearlings, from nets set by all the agencies, is used in sequential projection methods to arrive at a population estimate. These estimates are made by the Walleye Task Group of the Lake Erie Committee. Walleye harvest quotas for Michigan, Ohio, and Ontario are then derived, based on the estimate of the stock size and apportioned according to relative area of the western basin owned by each of the jurisdictions.

The Michigan angler harvest, until 1987, was less than the allotted quota. Since then, the reported Michigan catch has increased several fold and has greatly exceeded the quota. In 1987 the population in the western basin was estimated from the ongoing walleye tag and recapture data collected near Monroe, Lake Erie. The estimate far exceeded the Walleye Task Groups estimate and suggested that the sequential projection method had substantially underestimated the western basin walleye stocks for a number of years. New methods of estimating the stock size are being implemented, in part, because of these disparities in estimates.

An index trap netting and tagging study has been conducted each spring in Anchor Bay of Lake St. Clair from 1970 through 1985. This provided an opportunity to annually assess the status of the major fish stocks of Lake St. Clair. This long-term study documented the trend toward increased abundance of Anchor Bay smallmouth bass and Lake St. Clair walleye.

The long-term tagging and netting catch statistics of smallmouth bass provided much of the data base for the report describing and assessing management of the Anchor Bay population. Similar types of data collected from trap-netted walleye were used in the extensive 1988 walleye stock report. Status of the major Lake St. Clair fish stocks has also been reported annually at the GLFC meetings.

INLAND FISHERY RESOURCES

Inland fisheries resources, administration, management, and investigation has, in the short span of 10 years, undergone substantial scrutiny and revision. The following review highlights the emphasis and changes that have occurred. This review specifically covers waters managed, waters surveyed, facilities developed and operated, habitat projects, prescriptions and plans, permits reviewed, inland fisheries grants, joint research-management projects, and outdoor recreation shows. The number of these activities in each category is given in Table 16.

Waters Managed

The expected result of inland fisheries management is more and better fishing and the lakes and streams are managed with this as a goal. Through the 1980's the number of waters managed has varied from a low of 571 to a high of 727. The manager has four basic management tools: (1) regulation, (2) stocking, (3) population manipulation, and (4) habitat enhancement. Any of these tools can be used singly or in combination with any other.

Regulations, which are the laws, that have two objectives: one is protection and the second is harvest distribution among individuals or user groups. Stocking is the use of fish culture to rear large numbers of various fish species to augment existing populations or make introductions into new environments. Manipulation is the use of toxicants or mechanical means (nets, electrofishing) to alter fish populations to provide increased angling opportunity. Habitat enhancement ranges from protection to restoration and has the greatest importance in maintaining healthy fish communities.

Included in managed waters are both lakes and streams. In each body of water one or more types of fisheries management may be taking place, i.e., total treatment and restocking or stocking and habitat rehabilitation, and so forth. For simplistic purposes no matter how many management options are exercised per water body in this compilation it is counted as one. A noticeable management effort increased after 1984 as several factors occurred simultaneously. Additional funds became available for management work as did increased numbers of fish for stocking. The slight decline of the past 3 years is attributable to increased demands for activities other than management.

Table 16. Number of inland fisheries management activities completed in various categories, 1980-89.

Category	Year 1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Waters managed	593	571	607	645	641	721	727	709	698	613
Waters surveyed	172	175	231	241	238	238	251	296	299	270
Facilities developed and operated	59	62	72	82	94	87	93	104	101	110
Habitat projects	18	17	14	23	22	32	18	54	27	47
Prescriptions and plans	---	---	---	---	99	187	318	471	278	NA[1]
Habitat protection permits reviewed	868	851	883	1,080	1,268	1,721	2,186	2,043	2,165	1,954
Inland fisheries grants	---	---	---	---	---	---	---	14	23	5
Research-management projects	2	2	2	2	2	14	14	9	12	19
Outdoor recreation shows	8	9	14	24	27	31	36	44	45	37

[1]NA indicates not available.

Waters Surveyed

Surveys determine the status of the fisheries and form the very foundation of fisheries management. They may be comprehensive or species specific. Survey tools include various types of nets, electrofishing devices, chemicals, thermometers, and personal observation. Any tool may be used in combination with another in some quantity for an unspecified amount of time, depending on the size, morphometry, and complexity of the lake or stream. The objective of surveys is to capture fish to obtain life history data and measure various environmental parameters. The analysis of the data provides the manager with the knowledge to formulate decisions affecting the fisheries. The need is to balance the best interest of the ecosystem with the interests of the angler.

The number of waters surveyed ranged from a low of 172 to 299 and increased steadily over the decade. There is no differentiation in the type of survey gear used or the length of survey as each situation is counted as one for both lakes and streams. Both instances where noticeable increases in surveys occurred can be attributed to increased funding which was reflected in additional personnel to do surveys.

Prescription and Plans

Analysis of survey information leads to the development of management recommendations in the form of prescriptions and plans. Prescriptions and plans as a concept and method of organizing fisheries management activities was initiated in 1984. Prescriptions that involve fish stocking activities are approved on a 6-year basis. The implementation of this administrative process peaked in 1987, with a maximum of 471, and has since decreased as management programs were absorbed into the system.

Facilities Developed and Operated

For anglers other than riparians, access to the State's lakes and streams is the critical link between the angler and quarry. Additional facilities include development of ponds and marshes for fish culture, habitat enhancement in lakes and streams, and ancillary appurtenances to facilitate working conditions. The number of facilities developed was 59 at the beginning of the decade and 100 at the end. The steady upward trend of facility development and operations is the sum of two separate and distinct forms of facilities. There is recognition that anglers need water access. Access includes land purchase, site development, and facilities, i.e., walkways, piers, and so forth. To meet the opportunities for additional walleye management, rearing facilities have been developed and operated statewide. The combined increase of facility development and operation has been made possible by additional project funding and increased personnel.

Habitat Projects

Through the development of riparian lands, much fisheries habitat has been altered or destroyed. Habitat restoration includes replacing destroyed habitat, eliminating point source degradation, and the enhancement of features which provide fish cover and production. Streambank stabilization, fish shelters, spawning reefs, etc., are some examples of habitat projects. The irregular pattern of projects over the past decade, a low of 14 and a high of 54, has been affected by two factors--funding and time. In 1982 and 1986, years of fiscal difficulty, a lesser priority was placed on habitat projects. As the number of dollars, personnel, and cooperative agreements increased, so has the decade's upward trend in numbers of habitat projects done.

Habitat Protection Permits Reviewed

Habitat protection is an invaluable component of aquatic ecosystem management. Protection efforts find their basis in the various environmental laws. Environmental awareness has resulted in a profusion of legislative acts that require a permitting process. A majority of permit applications are concerned with the alternation of the environment that affects or has the potential to affect fisheries habitat. Even with the establishment of environmental units that administer and investigate applications, fisheries expertise and opinion is solicited in a majority of the applications. The number of applications over the past decade has ranged from slightly under 900 to over 2,100 and this number has a direct relationship with the economic climate. As the economy waxes and wanes, so do the number of proposed waterfront developments that require entry permits.

Inland Fisheries Grants

The past decade has seen an increase and involvement of the public in fisheries improvement activities. As an expression of interest, individuals and organizations have volunteered to contribute time and money to work on fisheries problems. As a means of incorporating these interests into productive fisheries projects, the grant concept was developed. The year 1987 saw the implementation of the Inland Fishery Cooperative Grants Program. The program is one of cooperation with an entity willing to incumber project costs on an equal share basis for habitat restoration and angling opportunity enhancement. The total amount appropriated annually by the legislature is $200,000. In the start up year, 14 grants worth $175,464 were approved. The second year 42 grant requests received consideration and 23 were funded for a total of $199,875. In 1989, 41 grant requests were received and 23 were approved, however, because of budgetary constraints, only five grants were funded in 1989 with the balance of approved grants to be funded in 1990.

Outdoor Recreation Shows

To keep pace with the public's interest and desire for information, Fisheries Division's personnel commenced attending functions where large numbers of constituents assembled during the 1980's. At the beginning of the decade, outdoor recreational shows were few in number. In an effort to have direct contact with the outdoor enthusiasts, a concerted effort was made to have a manned display at the existing shows. As the decade progressed, so did the number of shows increased from 8 in 1980 to 45 in 1988, and subsequently the Division's participation. The number of shows for 1987, 1988, and 1989 remained relatively constant, but the Division's participation declined in 1989. It is anticipated participation in 1990 will be even less. This is a result of our analyses of public contacts made at various shows. Because of repeat visits by the public, 90% exposure can be reached in four or five major shows.

Federal Energy Regulatory Commission Licenses

The Federal Energy Regulatory Commission (FERC) has regulatory control over all hydroelectric facilities and their operation that impact interstate trade, contain reservoirs in excess of 2,000 acres, use surplus water or waterpower from a federal dam, occupy federal lands, or are located on navigable rivers. The Department of Natural Resources has some jurisdiction over and considerable management responsibility on rivers that have hydroelectric facilities located on them. Hydroelectric facilities alter both the riverine environment and the aquatic ecosystem which in turn limits the Department's management options on these watersheds. The Department's role, as a state resource agency, is to: (1) recommend data needed to evaluate these facilities, (2) recommend the needed mitigation for impacts, and (3) recommend license conditions for each project. FERC is the ultimate decision-maker in this process.

There are 113 hydroelectric facilities operating in the State of Michigan. They impact 49 river systems, including almost every major river system in Michigan. These facilities prevent, at minimum, anadromous fish movement into 2,063 mainstem river miles, directly impound 467 river miles and impact through their operation 733 river miles. The total reservoir area contained by these facilities is approximately 123,000 acres. These facilities produce, in net, 1.5% of the electricity in the State of Michigan.

FERC has issued 61 licenses for projects in Michigan covering 71 power reservoirs and 7 storage reservoirs. There are 47 fully licensed projects and 14 exempted projects. Over the next 5 years, 30 hydroelectric facilities and 7 storage reservoirs will be relicensed on 26 licenses (55% of the total number of complete licenses), and 26 hydroelectric facilities and one storage reservoir will be licensed for the first time. In total, this relicensing and licensing process will affect 24 river systems representing almost all of our major river systems and approximately 89,000 reservoir acres (72% of all hydroelectric reservoir acres). These facilities, at minimum, block 1,593 mainstem river miles of anadromous fish habitat (77% of the total attributable to hydros), and impact, via operation, 462 river miles (64% of the total attributable to hydros).

The Fisheries Division's goals in the FERC licensing or relicensing process are to: (1) prevent significant deterioration of the natural resources, in particular aquatic resources, resulting from hydropower operations; (2) identify and abate or minimize or seek mitigation for adverse impacts of hydropower operations; (3) identify the responsibilities of the licensee for the long-term maintenance and/or removal of the structure when the licensee determines it is no longer cost effective to continue; and (4) obtain guarantees for the safe operation and maintenance of the structure for the life of the project.

Research-Management Projects

For the first half of the decade, cooperative research-management projects in the Fisheries Division were few in number, two each year for the first 5 years, as each section relied upon their individual resources for the accomplishment of their respective responsibilities. However, midway through the decade major shifts of dollars and personnel were made to combine the efforts of both research and management, so that in 1989 there were 19 combined projects. At the same time it was recognized that existing knowledge and remedies to effectively manage inland waters were lacking. In the last half of the decade, research emphasized the investigation of these shortcomings. It is hopeful these investigations will result in new knowledge and techniques the manager can use to improve inland fisheries.

Inland Research

Research and evaluation studies of inland fisheries were conducted at lakes, ponds, streams, and rivers out of research stations at Hunt Creek, Marquette, and Ann Arbor-Saline. Extensive work, on a variety of species, was finished or initiated during the 1980's. Results of this research are contained in the Division research, technical, and other reports (Appendix 1). Cooperative studies with The University of Michigan and Michigan State University increased during the decade with graduate students being supported in research for a master of science or doctoral degree. The research reported includes the work of the graduate students.

Warmwater lakes.--Research on walleye has been directed at optimizing stocking success, assessing artificial spawning reefs, and determining the potential for walleye predation to improve panfish populations. A number of experiments have dealt with stocking success in relation to habitat type, walleye size, and abundance of food and predators. Results demonstrated walleyes can survive and grow in a surprising variety of situations. The most important recommendation was that large fingerling walleye be used to stock lakes which already contain a full complement of native fish. However, even under relatively good conditions, walleye stocking in inland lakes is not likely to create more than modest adult populations, or fisheries over the long run, unless natural reproduction occurs. In Manistee Lake, a typical candidate for walleye stocking, a walleye population of 1.5 to 7.2 pounds per acre developed from stocking, and it was calculated that 3.3% of the large fingerlings stocked and 1.9% of the small fingerlings would eventually be harvested by anglers. For other types of lakes, returns can be expected to vary between 0 and 8%.

As an alternative to annual stocking of fingerling walleyes, rock reefs were installed in Six Mile Lake and Brevort Lake (in cooperation with the U. S. Forest Service) to improve walleye spawning success. On-going evaluations at both lakes indicate some improvement in walleye reproduction but at a relatively high construction cost. At Six Mile Lake, a substantial amount of spawning success is also occurring on supposedly poor-quality, sandy substrates. The Six Mile Lake reef, now 8 years old, has remained in good physical condition and will have many years of usefulness.

Slow-growing, small, overabundant, or "stunted" sunfish and perch are a major problem in inland lake management and the target of much completed and on-going research. This work has been intensified under the Inland Enhancement Program. The solution to this problem requires a much better understanding of the ecology of bluegills and yellow perch and of the factors controlling their numbers, growth, and reproduction. Many approaches are being used.

Walleye have clearly demonstrated they can control yellow perch reproduction and create a balanced fish community with an attractive fishery in an experimental lake, and it is recommended that walleye stocking be used as a practical tool for many lakes overrun with stunted yellow perch. Walleyes also show promise for improving stunted bluegill populations in two northern lakes, Jewett, and Six Mile, and a study involving stocking walleye in 16 typical stunted bluegill lakes in southern Michigan is underway. Also being evaluated in the 16-lake study are two other management tools used in combination with walleye: antimycin, a fish toxicant, and catch-and-release fishing regulations.

The importance of angler exploitation to the stunted bluegill problem was brought out in studies of three shallow, weedy lakes. Unexpectedly, these lakes contained exceptionally high numbers of large, old bluegills and well-balanced fish communities--apparently because they were lightly fished. Catch-and-release regulations were imposed at one of these lakes, Wakeley, to find out if good fishing and good populations of bluegill, largemouth bass, and northern pike can be maintained after the lake was opened to the public.

The importance of competition from suckers to yellow perch stunting was addressed in two studies in which suckers were greatly reduced by netting. In one study, a major improvement in yellow perch fishing clearly resulted. In the second study, there was little improvement in yellow perch and only a slight improvement in the availability of foods preferred by perch after 2 years of observation. Sucker removal is recommended as a management technique in situations where suckers make up most of the total fish weight and it is possible to easily remove by nets 80% or more of them.

Basic studies on bluegill biology are on-going in lakes and in controlled environments such as ponds. Bluegills often over-reproduce, leading to a shortage of food and stunting, and then fail to reproduce for several years. Controlling mechanisms which are being measured are number of eggs produced and losses of fry to predation or starvation. Eventually, all data will be used to refine mathematical models (descriptions) of bluegill populations and bluegill communities. The models will enable us to predict which management techniques are likely to be effective. Another basic study is considering the effect of habitat characteristics on bluegill growth and size by comparing the food supply (zooplankton and benthos) of 15 good bluegill lakes to 15 stunted bluegill lakes. Initial results indicate good lakes have zooplankton of larger size.

The structure of typical fish communities, and the factors which influence the quality of angling were described in an analysis of data from 229 lower Michigan lakes. Warmwater fishes predominated in 90% of these lakes and coolwater species in 10%. Bluegills alone made up more than half of the fish biomass in 41% of these lakes. In general, better angling was experienced in deeper, clearer, moderately vegetated lakes which had a layer of cool and oxygenated water in summer. Factors favorable to good fishing were relatively high proportions by weight of largemouth bass and other piscivors (greater than 20%); relatively low proportions of bluegill (less than 78%); relatively few carp or white sucker (less than 50%); good growth of bluegills (state average or better); and the presence of large bluegills (larger than 8 inches). In subsequent work, specific criteria and standards were developed for evaluating data collected in routine fish surveys. These enable managers to objectively interpret the quality of bluegill populations and evaluate the need for corrective management.

The growing popularity of bass angling prompted studies to assess the risk of over-exploitation and test methods of improving fishing quality. A simple pond study demonstrated all largemouth bass reach sexual maturity by a length of 9 inches and produce so many eggs that the 12-inch minimum size limit should assure good protection for all wild brood stocks. Bass exploitation rates were high but not excessive in three southern and six northern lakes, thanks, in part, to the voluntary release of many legal-sized bass by anglers. However, compulsory catch-and-release regulations have helped to maintain exceptional fishing quality for bass (and other species) in the unproductive Sylvania Tract for 20 years. These regulations are now being tested at Wakeley Lake, as mentioned above. Also underway at six lakes, and showing promise, is an experiment which will allow anglers to catch and release bass prior to the normal opening of the bass fishing season. This has high potential to produce many additional hours of bass fishing recreation without harming the bass resource.

Extensive evaluation of the success of tiger musky stocking program identified four factors important to tiger musky survival. These were time of stocking, size at stocking, predator density, and density of small soft-rayed forage fishes. Recommendations emphasized the advantage of rearing large fish, even at the expense of total numbers of fish. Subsequently, the hatchery rearing system was modified to produce large 12-inch tiger muskies.

Significant populations of this lake sturgeon, a threatened species, now occur in only 10 locations. For the Black Lake population, total mortality is about 10% per year, of which about 2.5% is due to spearing and angling. It was recommended that exploitation be kept below 4.8% per year and that the high, 50-inch minimum size limit be retained to assure that late-maturing sturgeon have a chance to spawn. The procedures for raising sturgeon eggs to stocking size obtained from wild fish were devised. Transmitters attached to sturgeon in Black Lake showed they preferred a depth of 33 feet, did not aggregate, did not have a defined home range, and with other ecological measurement helped define their niche.

Warmwater rivers.--For many years warmwater rivers in Michigan (in particular southern rivers) were largely neglected in both fisheries management and research programs. In the early 1980's, recognition of vastly improved water quality and the need to bring outdoor recreation closer to metropolitan areas, brought new attention to warmwater rivers. The initiation of the Inland Enhancement Program allowed for the development of a comprehensive research program on warmwater river fisheries, which is now underway. This comprehensive program includes an inventory and classification of river fish communities in the Lower Peninsula, and a variety of studies dealing with the biology and management of principal game fish species with emphasis on the smallmouth bass. The project to inventory the fish communities of the warmwater rivers of the Lower Peninsula was begun in 1986; watershed and local habitat characteristics are being inventoried as well. The collection of fish community data is built around the biological surveys which began in the late 1970's and are ongoing. These surveys are done on short stretches of river (700 feet) using rotenone, a fish toxicant. This has proven to be an excellent technique. Habitat data--such as watershed geology and land use, and local gradient and substrate--are being accumulated through the use of maps, existing data tables, a computerized Geographic Information System, and on-site surveys. By 1992, data on approximately 250 sites on 15 major river systems will have been collected. The coincident habitat data set will provide additional basic understanding of these rivers and will allow examination of the important physical characteristics which shape fish communities.

These results will be critical in the development of subsequent management and research programs. Several generalities concerning warmwater river fish communities are evident from a preliminary review of the data. These rivers contain a great many fish species. Most systems contain 60-70 species and a given sampling site will contain about 30 species. Communities vary from site to site. Biomass is typically dominated (70-90%) by several of eight fairly common sucker species. Smallmouth bass are abundant at most sites and are the primary game fish. However, significant populations of rock bass, northern pike, walleye, channel catfish, and flathead catfish also exist. In addition, this data base will provide a basis for developing sound arguments for the protection of river environments. For example, it is currently being used to estimate the losses of high-gradient stream miles, and subsequent losses of high-quality fishery and recreational resources, which may occur, due to the construction of dams.

The smallmouth bass is undoubtably the primary game fish in Michigan warmwater rivers and a number of studies focus on the biology and management of this species. An intensive study of the recruitment (reproduction), total mortality, growth, and harvest of the smallmouth bass population of the Huron River near Ann Arbor has been going on for 6 years. Both this study and the inventory described above show recruitment of smallmouth bass is excellent throughout the state, however, legal-sized (12 inches) fish are scarce in most areas. Creel census from the Huron River indicate that fishing pressure and catch are high. Nearly 100% of the legal-sized bass are caught each summer. Only the voluntary release of bass by the majority of fishermen prevents complete overharvest. For the next 5 years a catch-and-release regulation for all bass will be tested on one-half (5 miles) of the experimental stretch of the Huron River. The objective is to see whether this protective regulation will significantly increase the numbers of larger bass available to anglers. Anglers are enthusiastic about the program.

Of note, the long-term data set developed on the Huron River has attracted the attention of the U. S. Fish and Wildlife Service. Research biologists from Colorado, cooperating with the Division's research section and Michigan State University, have developed a concurrent long-term study of the effects of flow reduction and habitat on smallmouth bass populations.

As a logical extension of the Huron River study, smallmouth bass population and catch figures are being gathered on the Thornapple, Shiawassee, and Clinton (North Branch) rivers. This is a cooperative study between research and management biologists. After 4-5 years of baseline data are collected, the effects of either restricted regulations or habitat improvement on these populations will be imposed and tested.

Intensified smallmouth bass management will involve the management (regulations or habitat improvement) of small sections of large river systems. This requires some knowledge of the movement patterns and habitat needs of bass. The movements and habitat preferences of bass in the Huron River are being monitored. Small radio transmitters are surgically implanted in the abdomen of the fish. These bass can then be located and monitored with a portable receiver. Bass have been found to have a home range of one-half mile or less. They are almost always associated with cover such as logs or boulders which reduce current velocity and furnish protection.

As suckers comprise a large proportion of the fish biomass in Michigan rivers, it is essential to understand the ecological relationships between these and smallmouth bass. The diet and habitat preference of suckers and bass in two rivers are being examined. This will provide baseline data on the ecology of these fishes which is not presently available.

Fisheries Division has considered the introduction of the muskellunge--a large, highly-regarded, game fish--into warmwater rivers to spark fishing interest and to possibly fill an empty niche as a predator on the abundant, largely underutilized suckers. Such an introduction would involve both potential benefits and risks. A study was completed which reviews the biology of riverine muskellunge, outlines the rationale for introduction, provides a preliminary impact assessment based on the available literature, and assesses the potential for success. Overall, the potential negative impacts appear minimal. The potential for successful introduction appears quite good, in that muskellunge were native to some southern Michigan rivers, the available habitat seems ideal, and the appropriate food is extremely abundant. Research is needed on the interactions between muskellunge and northern pike (which are fairly abundant) in rivers.

Research has examined the biology of both wild and hatchery steelhead in the Lake Michigan, Superior, and Erie basins. Intensive studies were done of the smolting and returns of hatchery fish, and of the smolt production and population dynamics of wild fish in the Little Manistee River, home to one of Michigan's largest steelhead runs. It was found that the smaller hatchery fish (or parr) which were stocked prior to 1983 had almost no survival to either smolting or adult return, but that if larger "smolts" were stocked, survival to smolting and return was excellent. Wild smolt production was very high, (among the highest anywhere) with roughly 80,000 being produced in a good year. Survival in Lake Michigan was also quite high, resulting in an abundant adult population. Smolt and adult numbers were found to fluctuate in accordance with the severity of cold temperatures during the presmolt winter. Studies of the relative contributions of wild and hatchery fish showed that the historically large steelhead runs in central Lake Michigan tributaries have been almost entirely supported by wild fish.

Returns of small hatchery fish were monitored in the early 1980's in the St. Joseph and Grand rivers, and found to contribute only minimally to adult populations; most adults were either of wild or stray origins. Larger "smolts" have been stocked since 1983, and their returns and contribution relative to wild fish are currently being evaluated in several tributaries to lakes Michigan, Superior, and Erie. Wild juvenile and smolt production, and lake survival are being examined for Lake Superior populations also.

The use and efficiencies of six fish ladders on the Grand River were examined during 1982-85. These ladders were built to allow the migration of anadromous salmon and steelhead upriver past several dams to the Lansing area. The ladders were heavily used by a variety of anadromous and resident species. The upstream five ladders were found to be essentially 100% efficient. Spring floods aided steelhead migrations but hindered fishing. Annual salmonid catches were large, ranging from 16,100 to 39,000 for salmon, and from 4,600 to 12,300 for steelhead, however, relatively few fish were caught as far upstream as Lansing.

During the early 1980's the Skamania strain of summer-run steelhead became popular in the Indiana waters of Lake Michigan. Summer steelhead provided fishing during additional months (traditional steelhead provided fall, winter, and spring fishing), and they were exceptionally large and (reportedly) hard fighters. In Michigan, returns of four strains of hatchery-raised summer steelhead, including the Skamania strain were monitored. Summer steelhead returns peaked in August, effectively expanding river steelhead fishing into the late summer months. However, the numbers of summer steelhead caught and the catch-per-hour were extremely low. Extensive monitoring of returns to the Manistee River showed that, though fair numbers of fish were stocked (36,000), catch-per-hour of summer steelhead was 14 times lower than for the largely wild fall-winter-spring steelhead.

In response to concern about possible competition for stream resources between young steelhead and resident brown trout, their dietary and habitat preferences were examined. Both species were found to use similar resources, both when living separate from one another or together. This study indicated that competition may indeed be occurring and has led to a current, in-depth study of the effects of introduced young steelhead on a brown trout population.

Coldwater rivers.--During the last decade the trout biology (coldwater) research group has evaluated the effects of sand sediment on trout in streams and devised management techniques for preventing and removing sand bedload from streams. These techniques can more than double the number of the larger trout in streams.

A mathematical model has been developed which can accurately predict the effects of various combinations of size limits, creel limits, lure restrictions, rates of angler exploitation, and other factors on trout stock levels and size structures. This model provides a means for setting regulations which are biologically sound and which result in quality angling.

A test of the effect of differential cropping of the faster growing members of a trout population by anglers which may reduce the genetic growth potential of stocks has been completed for brown trout. The results suggested that this phenomenon may be occurring. A similar test on brook trout is in progress.

Two strains of longer-lived, faster-growing brook trout strains from Quebec, Canada, called Assinica and Temiscamie have been tested to determine their growth and survival potential in Michigan waters. Both strains proved superior to the domesticated strains of trout normally used by Michigan fish culturists. After further testing showed that hybrids of the Michigan and Quebec strains also had superior growth and survival, most of the brook trout reared for stocking in Michigan lakes have been hybrids. The positive results of this change are reflected by the Division's Master Angler program which has recognized a growing number of trophy-sized brook trout the last few years.

A report has been written which summarizes information on trout stock densities, size structures, age compositions, growth rates, and species complexes found in an array of good Michigan trout streams. The information is very useful to managers as a standard reference for comparing characteristics of other trout stocks. Further, these data can be used to judge change in trout populations over time.

An array of trout streams in the state were studied to determine if acid precipitation and deposition was impacting trout populations. A few streams in the Upper Peninsula of Michigan were found to have chemical characteristics approaching levels that are detrimental to trout production.

Biologists throughout the western United States and Canada were contacted and the literature was searched in an attempt to identify brown trout stocks with high growth potential. The stocks identified may be tested in Michigan waters as a means to improve brown trout angling.

The Divisions reintroduction of the Arctic grayling has been evaluated in a diverse group of Michigan's lakes and streams. To date survival in streams has been very low but substantial in many lakes. A number of factors contributing to the success or failure of various plants have been determined. The evaluation effort continues.

An important study is now underway to test the adverse impacts of water withdrawals from trout streams. The effects on trout, their food supply, and general habitat quality will be determined. Competition for water is increasing rapidly in Michigan and elsewhere. The results of this research will allow quantitative estimates and predictions of the effects of water withdrawal on stream trout populations.

FISH PRODUCTION

Michigan's fish hatcheries have undergone major changes during the last decade. Three hatcheries, Thompson, Harrietta, and Wolf Lake, were completely redesigned and rebuilt. These use only springs and wells as their water source now, except for Thompson, where 600 gallon per minute ultraviolet-radiated creek water can be used also. Fisheries Division opted to rely on these types of water sources since they provide stable flow, constant water temperature, excellent water quality and purity, and such sources are free of fish populations. These characteristics allow for a high production of fish per unit of water flow through serial reuse and reaeration. This reuse offsets the rather limited flows available. Furthermore, because such sources are free of natural fish populations, facilities built on this type of water can be maintained free of certain specific fish diseases. Thompson Hatchery was completed in 1978, followed by Harrietta in 1979, and Wolf Lake in 1982.

Soon it became apparent that the jet aeration system which allowed for three uses of the water aggravated rather than ameliorated a condition known as nitrogen gas supersaturation. Although this condition can cause acute mortalities, more often it functions as a stress on the fish which, over time, can result in high losses through disease. Experiments conducted with pure oxygen at the Marquette Hatchery demonstrated that introducing oxygen effectively controlled nitrogen gas supersaturation while simultaneously aerating the water. Thus, Michigan became a leader in developing this highly successful technology. Five hatcheries are now equipped with oxygen generators and closed aeration-degassing columns which significantly enhance the water quality, and consequently, the fish health and quality.

In the early 1980's, the circulating Burrows raceways at the Platte River Hatchery were modified to flow-through ponds. This resulted in significantly improved fish rearing conditions. During this same period, the Marquette Hatchery underwent some major remodeling. All outdoor production raceways were removed and replaced with new concrete ponds arranged in a two-pass serial reuse fashion. This greatly increased the production capacity. A new hatchery building will be constructed in the early 1990's to bring the indoor rearing capability in balance with the raceway capacities.

The rainbow and brown trout broodstock program at the Oden Hatchery was gradually phased out beginning in 1983. This increased the production capability for yearling trout. Inspected disease-free rainbow and brown trout eggs are provided through the U. S. Fish and Wildlife Service and cooperating states (Wisconsin and Wyoming). After the Oden Hatchery is renovated (part of a 5-year capital outlay plan for Michigan's hatcheries) it will again function as a combination broodstock-production facility, capable of maintaining a class A-1 disease-free status.

Any new hatchery will, initially, experience its share of problems for a variety of reasons, be it water quality (gas supersaturation for instance), mechanical system failures or design flaws (Burrows ponds, for instance). Michigan's new facilities were no exception. However, most, if not all, problems have been identified and corrected and Michigan's fish production system has since, consistently, produced a high quality product in adequate quantity for the state's fish management program (Figure 6). Table 17 compares production targets with actual production for the period 1985 through 1989 for coolwater and coldwater species. Tables 18, 19, and 20 show the number of fish stocked during the period 1980 through 1988.

Michigan's technically advanced hatcheries have drawn the attention of many out-state public agencies, especially with respect to the aeration-degassing designs, the high-density rearing approach, and the solids management through the use of baffles in the fish rearing units.

A more detailed account will be presented for each hatchery and the support units as well as fish transportation and fish health.

Marquette Hatchery

The Marquette Hatchery has, for many years, been the state's lake trout broodstock and production facility. In 1983, major mortalities occurred in the young lake trout while still in the hatchery building. Similar losses occurred again in the 1984 cycle. The hatchery building had been placed on well water and low level nitrogen gas supersaturation was identified. As a result personnel at this hatchery developed the concept of using pure oxygen to control this condition and they deserve full credit for this most successful technique. Despite this, major losses in young lake trout continued to plague the hatchery and after considerable research into this and similar problems at the Iron River National Fish Hatchery in Wisconsin, it was concluded that a virus was involved. This newly discovered virus disease was named epizootic epitheliotropic disease (EED) and it is still under investigation.

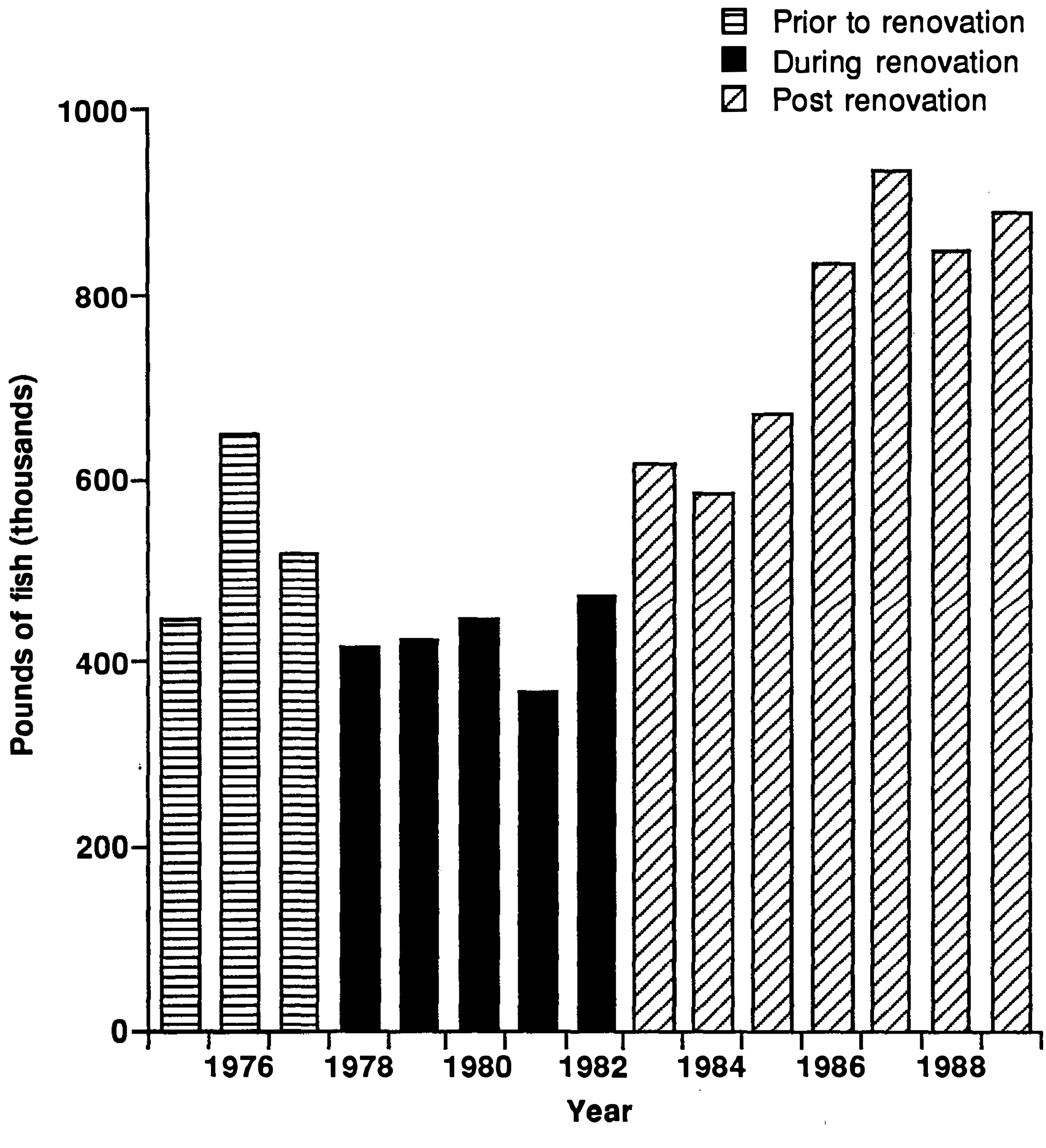

Figure 6. Production of salmonids in Michigan hatcheries prior to renovation (1975-77), during renovation (1978-82), and post renovation (1983-89).

Table 17. Numbers of coolwater and coldwater fish produced in Michigan hatcheries 1985-89 with a comparison of production with target numbers.

Species	Year 1985	1986	1987	1988	1989	Average	Target
Coolwater							
Tiger muskellunge	112,000	106,000	153,000	82,000	---	113,250	150,000
Northern muskellunge	9,600	7,200	26,000	1,500	---	10,950	41,000
Northern pike	472,000	434,000	145,000	362,000	---	346,750	350,000
Sturgeon	---	---	---	7,300	---	1,825	70,000
Coldwater							
Atlantic salmon	---	23,000	43,000	12,000	24,000	20,400	120,000
Brook trout	223,000	220,000	380,000	320,000	140,000	256,000	300,000
Lake trout	258,000	440,000	295,000	130,000	2,000[1]	225,000	4,170,000[2]
Splake	230,000	240,000	515,000	430,000	---[1]	283,000	500,000
Coho salmon	2,980,000	2,675,000	2,220,000	2,920,000	2,860,000	2,731,000	2,800,000
Chinook salmon	5,550,000	6,040,000	6,195,000	6,550,000	8,335,000	6,535,000	7,050,000
Steelhead	824,000	1,405,000	1,025,000	859,000	776,000	977,800	770,000
Rainbow trout	1,175,000	1,180,000	1,377,000	1,266,000	1,304,000	1,260,400	1,370,000
Brown trout	1,350,000	1,625,000	1,745,000	2,190,000	2,195,000	1,821,000	2,000,000
Grayling	---	---	103,000	37,000	---	28,000	?

[1]Disinfection of Marquette Hatchery for EED.
[2]This total includes lake trout from national fish hatcheries.

Table 18. Number of yearling fish stocked in Michigan waters, 1980-88.

Species	Year 1980	1981	1982	1983	1984	1985	1986	1987	1988
Grayling	—	—	—	—	—	—	—	103,160	38,862
Atlantic salmon	—	19,529	46,659	—	—	—	23,356	42,632	24,707
Brown trout	552,123	677,064	584,247	1,408,163	1,553,606	1,349,365	1,623,036	1,747,944	2,201,790
Brook trout	9,833	16,204	3,850	—	125,125	225,084	226,165	384,243	319,508
Coho salmon	3,466,411	2,339,818	2,362,909	2,919,147	2,739,374	2,981,789	2,675,804	2,222,500	2,918,636
Rainbow trout	656,433	457,246	553,824	1,028,035	685,545	1,181,559	1,194,080	1,380,456	1,279,050
Steelhead	756,729	925,900	655,300	985,804	761,794	824,215	1,409,122	1,033,741	871,507
Lake trout	906,800	2,970,610	3,187,104	3,341,760	1,439,200	3,524,059	3,857,874	2,482,910	2,866,171
Splake	—	188,165	247,504	125,246	170,290	227,585	241,544	514,973	427,951
Muskellunge	—	—	—	—	—	—	—	—	145
Northern pike	274	—	—	—	—	650	126	—	2,000
Walleye	200	2,930	2,514	—	497	9,798	6,498	1,000	—
Yellow perch	—	—	—	80,337	—	—	—	—	1,000
Largemouth bass	—	59	4,753	661	1,040	—	144	—	407
Sunfish	1,000	—	3,500	10,000	2,500	8,745	54,900	—	86,672
Crappie/rock bass	—	104	—	—	—	—	—	—	
Catfish	—	30,222	—	—	—	—	121,868	100,156	4,310
Forage fish	—	—	—	—	7,128	33,400	—	—	195,516
Total	6,349,803	7,627,851	7,652,164	9,899,153	7,486,099	10,366,249	11,434,517	10,013,715	11,238,232

Table 19. Number of fingerling fish stocked in Michigan waters, 1980-88.

Species	Year								
	1980	1981	1982	1983	1984	1985	1986	1987	1988
Atlantic salmon	---	---	29,694	---	---	---	84,961	---	300
Brown trout	316,339	4,000	622,552	1,260,570	853,034	789,062	1,005,795	532,383	514,794
Brook trout	201,331	203,176	181,909	193,426	174,674	129,027	146,825	454,488	202,700
Coho salmon	5,000	5,040	275,769	---	---	10,260	5,073	11,070	10,000
Chinook salmon	5,030,545	4,102,398	5,018,873	6,043,880	6,873,254	5,556,386	6,038,265	6,195,091	6,547,640
Rainbow trout	90,250	117,309	51,830	84,102	143,042	443,150	863,296	650,353	489,368
Steelhead	1,012,000	102,236	896,013	358,618	945,000	435,520	300,000	411,113	472,691
Lake trout	---	622,300	814,142	81,400	1,412,016	1,526,117	828,760	1,180,083	1,641,600
Splake	---	19,800	8,500	3,600	54,700	297,200	47,241	217,549	75,000
Muskellunge	13,540	15,977	5,237	12,631	4,228	9,106	7,611	26,327	1,502
Tiger musky	251,607	104,947	263,126	90,210	131,708	112,077	106,179	154,316	81,886
Northern pike	382,745	133,327	105,898	422,104	289,646	421,896	434,454	105,622	361,629
Walleye	1,199,869	1,354,473	1,022,181	2,635,724	2,847,142	4,136,704	5,226,831	2,912,422	3,258,941
Yellow perch	---	---	---	500	---	---	1,500	---	15,550
Largemouth bass	22,058	63,487	10,903	37,829	42,133	50,637	17,615	38,389	31,478
Smallmouth bass	21,475	13,720	21,800	9,207	13,368	10,466	16,935	2,300	29,440
Sunfish	53,100	8,250	6,600	24,700	331,974	209.300	155,800	156,950	102,661
Catfish	---	32,809	---	640	---	950	30	38	336,467
Forage fish	---	---	---	---	131,700	---	---	---	---
Sturgeon	---	---	275	8,591	30,094	---	---	---	7,329
Total	8,599,859	6,903,249	9,335,302	11,267,732	14,277,713	14,137,858	15,287,171	13,048,494	14,180,976

Table 20. Number of fry-sized fish stocked in Michigan waters, 1980-88.

Species	Year								
	1980	1981	1982	1983	1984	1985	1986	1987	1988
Steelhead	---	---	---	---	---	---	---	---	726,219
Muskellunge	133,553	12,750	251,710	---	---	---	---	---	151,500
Tiger musky	---	58,400	---	---	---	---	---	---	---
Northern pike	700,850	1,197,473	1,438,200	593,537	92,000	250,000	---	1,005,000	4,532,631
Walleye	10,577,469	27,503,970	42,624,300	21,226,420	20,686,650	37,171,300	16,752,000	17,930,638	24,814,000
Total	11,411,872	28,772,593	44,314,210	21,819,957	20,778,650	37,421,300	16,752,000	18,935,638	30,224,350

In the meantime, the hatchery building was disinfected after the 1985 cycle. The disease has not occurred in the building but, instead, it affected the fish after they were transferred to the outdoor raceways. In 1987, these production ponds were disinfected. Unfortunately, in the fall of 1988 the disease again manifested itself in the lake trout fingerlings.

In the spring of 1989, all fish, including the broodfish, were removed from the hatchery and this time all outdoor ponds and water delivery channels were disinfected, including Cherry Creek above the hatchery. Hopefully the virus has been permanently eliminated from the hatchery, but to prevent it from reinfecting via predators (especially birds) the outdoor raceways will be enclosed and Cherry Creek water will be treated with ozone or ultraviolet radiation under the current 5.8 million capital outlay program.

These measures will provide Marquette Hatchery with a pathogen-free water source and will permit this facility to fulfill its role even more successfully as the state's production unit for all species of char, lake trout, splake, and brook trout. Its capacity will be 2.0 million yearlings in any combination and will include the production of 6 to 8 million eggs.

Thompson Hatchery

The new Thompson Hatchery, located near Manistique, came on line in 1978. Low-level nitrogen gas supersaturation, along with inadequate oxygen, limited production capacity to 96,000 pounds for a design capacity of 140,000 pounds of salmonids annually. In 1983, the jet aeration was replaced with packed column aeration-degassing. This system was only partially effective at reducing nitrogen gas levels. In 1987 oxygen generators were installed and the packed columns were converted to sealed or closed columns. Dissolved oxygen levels have since been maintained at 100% saturation or more, while total gas pressure is kept at 100% or below, thus preventing gas bubble disease or trauma.

The benefit was immediate and the 1987-88 production cycle, for the first time, exceeded design capacity. Thompson has produced a great variety of salmon and trout; rainbow, brown and brook trout, splake and steelhead, and chinook salmon. In addition, this facility has produced three species of coolwater fishes; northern pike, tiger muskellunge, and walleye. Since 1984, up to 16 million walleye fry have been produced annually. This hatchery, too, has the potential to be disease-free. The goal is to accomplish that after the raceways have been enclosed to prevent bird predation.

Oden Hatchery

The Oden Hatchery, although not renovated as was Thompson, Harrietta, and Wolf Lake hatcheries, did undergo many changes during the 1980's. A large production well, exceeding 1,000 gallons per minute was constructed. This high quality water moderates the winter and summer temperature extremes of the spring water and allows for increased fish production under improved rearing conditions. Starting in 1983, the broodstock program was gradually phased out "temporarily" until this facility could be rebuilt and placed on a closed water source.

With the installation of an oxygen generating system in 1988, water quality conditions were further improved which has resulted in better growth and feed conversions. With these improvements in place, this hatchery is now capable of producing about 150,000 pounds of yearling trout annually. Oden Hatchery has extremely high quality groundwater and is capable of successfully rearing any species of salmon and trout. The plans for the 1990's are to modernize the hatchery and design it for both broodfish and yearling fish production on a specific pathogen free water source.

Harrietta Hatchery

The Harrietta Hatchery, with reconstruction completed in 1979, encountered immediate problems with low-level nitrogen gas supersaturation. Packed columns were installed but were only partially effective. Not until oxygen generators were installed in 1986 was nitrogen gas supersaturation brought fully under control and fish production has improved since. The hatchery has a design capacity for 200,000 pounds of yearling trout. Production will be at 165,000 pounds in 1989, twice that of the years before oxygen use.

Since 1985, the hatchery has been specific pathogen free. The facility operates strictly on groundwater, which is pumped from three or four wells at a rate of 4,000 gallons per minute. This water is of high quality and has a constant temperature of 48°F. Raceway rearing densities have been as high as 10 pounds per cubic foot of rearing space. This is equivalent to 100, 6-inch fish per cubic foot. Harrietta can successfully produce any species of salmonid, but its production program for the last 5 years has involved rainbow and brown trout. This facility will continue to play an important role in the production of high-quality, disease-free trout for Michigan's fish management program.

Platte River Hatchery

The Platte River Hatchery was constructed in the late 1960's to produce Michigan's anadromous fish species; the steelhead, coho, and chinook salmon. It was designed according to the, at that time, latest techniques for the rearing of Pacific salmon. This included the circulating Burrows raceways. Ultimately this raceway design proved undesirable and in the early 1980's half of these ponds were converted to straight flow-through raceways. The remaining ponds were left as unusable, due to the fact that flow through ponds operate on twice the water flow as do Burrows ponds, yet at the same time they carry twice or more the poundage of fish.

This hatchery was one of the first facilities nationwide to incorporate a large, 4-acre effluent treatment pond to trap or settle out the solids. During the operation of the circulating ponds, all solids (feces, wasted food, river debris, and sand) settled out in this pond. After changing to flow through ponds, most of these solids settle within the raceway and are collected behind the fish retaining screen. From there they are physically removed and spread on farmland.

Despite these effluent treatment techniques, the hatchery has been identified as the only point-source contributor of phosphorus and is perceived to be responsible for accelerated eutrophication of Big Platte Lake, downstream from the hatchery. Although the phosphorus is present in great dilution, the annual contribution has been around 1,000 pounds per year during the last 3 years. This is down considerably from the 3,000 pounds calculated in earlier years.

However, the Platte Lake Improvement Association (PLIA) desires to see it reduced to much lower levels. The hatchery is presently under a court order to be below 928 pounds which will be accomplished through feeding a low phosphorus fish food and reduced production. All the details of this conflict have not been resolved. There is no doubt that the hatchery will be involved in an increased phosphorus monitoring program, continuation of feeding low phosphorus feed, and investigating improved solids management in the form of better interception, removal, and disposal. The accumulated sludge and sand was removed from the effluent treatment pond in 1989. This pond will now receive minimal amounts of solids and should function well as a "polishing" lagoon.

Platte River Hatchery has consistently produced the major portion of coho and chinook salmon. Steelhead production was discontinued in 1983 when Wolf Lake Hatchery took over this program. The same is true for tiger muskies, which for a number of years, were reared in the relatively warmwater of the Platte River during the summer months.

Wolf Lake Hatchery

This hatchery, rebuilt in the early 1980's, started production of cool- and coldwater fish in 1982. It is supplied with 4,000 gallons per minute of spring and well water. Species that have been produced include coolwater fish such as muskellunge and its northern pike hybrid, the tiger musky, northern pike, walleye, and some lake sturgeon. Of the coldwater fish species, steelhead rank first, but Atlantic salmon, chinook salmon, and brown trout are also routinely reared. In 1987 and 1988, Wolf Lake produced some grayling as well.

The water for the coolwater species is heated by way of solar ponds and with natural gas. The natural groundwater temperature is 50° to 52°F, which is ideal for the production of steelhead, Atlantic salmon, and chinook salmon smolts.

In 1985, the hatchery installed oxygen generators to eliminate low-level nitrogen gas supersaturation. This has also increased its production potential through increased dissolved oxygen levels. Annual production has approached 200,000 pounds since then.

The Michigan Fisheries Interpretive Center is located on the hatchery grounds and draws nearly 20,000 visitors per year. This number is expected to increase significantly in the next decade.

Transportation

To transport and stock 800,000 pounds or more fish annually to hundreds of sites is a logistics challenge, to say the least. A fish planting coordinator has handled this program from a central location since the mid-1970's. A fleet of 15 fish transport trucks travel nearly 200,000 miles per planting season, making over 700 trips. This fleet has a total capacity of 19,000 gallons of water and can carry a maximum load of 27,300 pounds of fish per haul. Since 1980, the fleet of trucks has been modernized and expanded to include two large semi-trucks, with capacities of 3,500 and 4,000 gallons each. Because many sites are located in remote areas, some small, 600-gallon capacity trucks are also a very important segment of the fleet. A full-time auto mechanic and helper are responsible for fleet maintenance and repairs.

Table 21 provides some of the fish stocking statistics for the 1980-88 period.

Table 21. Transportation statistics for stocking fish in Michigan waters, 1980-88.

	Year								
	1980	1981	1982	1983	1984	1985	1986	1987	1988
Miles traveled	85,216	114,078	119,863	132,447	139,585	179,818	210,841	230,183	199,006
Number of trips	477	455	410	534	469	578	686	722	711
Man hours	2,527	1,940	2,111	2,339	3,605	2,862	3,160	3,403	5,143
Pounds stocked	456,207	377,553	470,400	611,514	598,103	688,932	864,547	938,751	830,938
Cost per pound	$0.415	$0.723	$0.612	$0.745	$0.735	$0.771	$0.726	$0.758	$0.982

Fish Health Laboratory

This support unit is staffed by a fish pathologist, a laboratory scientist and a half-time secretary. It is located on the grounds of the Wolf Lake Hatchery but serves all hatcheries. The goal of the fish production system is to produce healthy fish for stocking. The Fish Health Laboratory performs annual fish health inspections on all hatchery salmonid stocks and of adult fish during spawning, both of the captive brood fish and the "wild" stocks. The fish are checked for selected parasitic, bacterial, and viral pathogens. Hatcheries are classified according to the pathogens found in a sample of their fish stocks. Routine inspections were started in 1972. Table 22 shows the disease classification, by hatchery, from 1980 through 1989. Parenthetical designations indicate that a particular pathogen was not found during the inspection but was present the previous year or eggs and/or fish were moved into the hatchery from a facility that had that particular classification, including eggs from wild stocks.

The goal is to have all hatcheries specific pathogen-free (A-1 or A-2 classification). An A-1 classification can be assigned where the hatchery water source is free of fish; an A-2 classification indicates that the hatchery receives some, or all, of its water from an open source. Treating such water with ultraviolet radiation, ozone, or chlorine can destroy pathogens, thus preventing reinfection. At present there are only two major bacterial diseases that must be targeted, furunculosis and bacterial kidney disease. Hopefully, these can be eliminated during the next decade. The viral disease of lake trout (EED) must also be brought under control and, hopefully, this was accomplished with the disinfection of the Marquette Hatchery and Cherry Creek in 1989.

In addition to the routine health inspections, the Fish Health Laboratory performs diagnostic services for all the state hatcheries, and private hatcheries when time allows or where disease of concern are suspected. Natural mortalities are also investigated. In 1988 and 1989, laboratory personnel spent considerable effort investigating mortalities of chinook salmon in southern Lake Michigan. In 1985, a Fish Quality Control program (a monitoring of fish health in relation to survival in the wild) was initiated but due to budget constraints, this important program was reduced to a minimum effort. There are plans to return it to a full scale program in the near future.

At times, the laboratory conducts specific studies in the wet room or in conjunction with a hatchery to find answers to some of the more baffling conditions or pressing needs, such as, the eye cataract in coho salmon or excessive fin erosion or testing of low phosphorus feeds.

Table 22. Disease classification[1] for state fish hatcheries, Michigan, 1980-89.

Year	Hatchery					
	Marquette	Thompson	Oden	Harrietta	Platte River	Wolf Lake
1980	A-2	B-BK	B-BK,BF	C-BK,BF(VP)	B-BK(BF,VP)	Under const.
1981	A-2	B-BK	B-BK,BF	B-BK,BF(VP)	B-BK,BF,VP	Under const.
1982	A-2	B-BF(BK)	B-BK,BF	B-BK,BF(VP)	B-BK,BF(VP)	C-(VP,BF)
1983	C-(A-2)	B-BF	B-BK,BF	B-BK,BF(VP)	B-BK,BF	B-BF(VP,BK)
1984	C-(A-2)	B-BK(BF)	B-BK,BF	B-(BF,BK)	B-BK(BF)	B-BK,BF
1985	C-(A-2)	B-BK(BF)	B-BK,BF	B-(BF)	B-BK(VP)	B-BK(BF)
1986	C-(A-2)	B-BK	B-(BK,BF)	A-1	B-BK	B-BF(BK)
1987	B-BF	B-BK,BF	A-2	A-1	B-BK,BF	B-BK,BF
1988	B-BF	B-BK(BF)	A-2	A-1	B-BK,BF	B-BK,BF
1989	B-BF	B-BK	A-2	A-1	B-BK,BF	B-BK,BF

[1]C = Class C: hatcheries which have a free ranging spawning population with an unknown disease history or have undergone only one or two complete inspections.
BF = Furunculosis (*A. salmonicida*).
BK = Bacterial kidney disease (*R. salmoninariem*).
VP = Infectious pancreatic necrosis virus.

This laboratory also reviews new game fish breeders license applications and issues the same, as well as permits for the importation and transportation of salmonids.

Facility Maintenance and Protection

Michigan's modern hatcheries depend, to a large degree, on mechanical systems. Where this involves the life support system for the fish, such as pumping of water and/or generating oxygen, back-up power and redundancy are essential. Such systems have to be dependable at all times. This demands a tight and religiously executed preventative maintenance program. All hatcheries now use a computer program to carry out this vital function. Before well designed monitoring and alarm systems were in place, malfunctions resulted in major fish losses. Such accidents did identify weak links in the design, and after corrective action was taken, there has been no repeat of these types of incidents. Since 1984, hatcheries have been equipped with department radio page systems, allowing for greater mobility for those staff members having on-call duty. A 15-minute response time is required.

Broodstock and Egg Production

In 1983, the decision was made to phase Oden Hatchery out of the broodstock program (rainbow, brown, and brook trout). This decision was part of the goal toward specific pathogen-free rearing. The Thompson, Harrietta, and Wolf Lake hatcheries were, by then, all on closed-water sources. These facilities could, therefore, be specific pathogen-free provided only "clean" or "certified" eggs or fish entered these hatcheries. Since Oden operated, at least in part, on an open-water source, and the hatchery is very susceptible to predators, it was not able to produce certified eggs. Such eggs, however, were available from the federal hatchery system. The egg production from Oden since 1980 is shown in Table 23.

The Marquette Hatchery has "traditionally" been a lake trout broodstock and production facility and has been the mainstay for eggs during the early years of the Great Lakes lake trout rehabilitation efforts. Table 24 shows the number of lake trout, splake and brook trout eggs produced from 1980 through 1989.

Table 23. Number of eggs (x1,000) produced from the Oden Fish Hatchery, 1980-86.

	Species				
Year	Brook trout	Brown trout	Rainbow trout	Atlantic salmon	Splake
1980	1,500	2,538	3,079	42	866
1981	4,433	4,757	2,174	253	---
1982	1,398	6,317	2,254	---	929
1983	1,179	1,655	---	---	2,250
1984	1,500	---	---	---	1,925
1985	1,200	---	---	170	---
1986	1,100	---	---	126	---

Table 24. Number of eggs (x1,000) produced from the Marquette Fish Hatchery, 1980-89.

	Species		
Year	Lake trout	Splake	Brook trout
1980	14,777	868	---
1981	13,677	809	---
1982	13,738	929	---
1983	13,792	2,519	---
1984	15,835	1,925	---
1985	13,438	1,375	---
1986	14,144	?	---
1987	12,560	2,516	---
1988	8,613	2,628	---
1989[1]	---	---	1,897

[1]All broodfish were released in order to disinfect hatchery for EED.

Eggs from anadromous species (steelhead, coho, and chinook salmon) are collected from natural runs. The Platte River Hatchery collects the coho eggs, while the egg-take facility on the Little Manistee River collects the steelhead and chinook salmon eggs. Table 25 shows the number of eggs obtained from these anadromous species from 1980 through 1989. Each year a large percentage of these eggs were made available to other Great Lakes states, such as Minnesota, Wisconsin, Illinois, Indiana, Ohio, Pennsylvania, and New York. Some of these states are now self-sufficient.

In 1975 the State of Indiana introduced the Skamania or summer-run steelhead into Lake Michigan. In 1984, Michigan introduced this strain and since then eggs have been secured from adults collected at Trails Creek in Indiana and transported to Michigan. In 1989, however, adults were taken from the St. Joseph River in Michigan for the 1990 egg take. Coolwater fish eggs--northern pike, muskellunge, and walleye--are collected from natural populations also. Adults are trapped in nets and, usually, spawned on-site. Table 26 provides a record of eggs taken from these coolwater species, including lake sturgeon.

Production Costs

Public hatcheries which produce fish for stocking must meet very specific production goals, i.e., proper numbers of a large variety of species of the right size and at the right time of year. Almost all of the fish are released in the spring (March through May), although some fish, such as the hybrid and pure muskies, are stocked in the early or even late fall. A small number of trout are also released as fall fingerlings often into rotenone treated waters.

Because of the unique mission of public hatcheries, the production facilities are used very inefficiently when compared with commercial hatcheries. Public hatcheries have a single cycle production program. Eggs of each species enter but once a year and the resulting fish are reared until they have completed their hatchery life cycle. Life cycles vary from a few months for northern pike (a few days only for walleye), to 6 months for muskellunge and chinook salmon, 12 to 14 months for steelhead and, 18 months for all other trout and salmon.

With most of the stocking to occur in the spring time, public hatcheries are at maximum carrying capacity at that time of the year, and shortly thereafter, they are down to a very low poundage with the new crop still being quite small. Commercial hatcheries, on the other hand, maintain a near maximum biomass or poundage year-round, continually harvesting fish throughout the year. As a result, the annual production of a commercial operation is two and a half to three times that of a similar size public hatchery.

Table 25. Number of eggs (x million) taken from chinook salmon, coho salmon, and steelhead trout, 1980-89.

Year	Species		
	Coho salmon	Chinook salmon	Steelhead trout
1980	16.9	24.2	3.6
1981	14.4	22.1	5.3
1982	12.1	26.9	6.6
1983	16.1	28.0	6.1
1984	15.3	25.5	8.8
1985	14.1	21.5	6.5
1986	12.5	16.6	5.5
1987	14.5	19.5	5.0
1988	2.5	17.1	6.3
1989	11.3	18.7	4.6

Table 26. Number of eggs (x million) taken from coolwater fish species, 1980-89.

Year	Species				
	Northern pike	Tiger muskellunge	Pure muskellunge	Walleye	Sturgeon
1980	3.4	2.3	0.3	---	---
1981	4.3	1.6	0.3	4.4	---
1982	4.0	2.0	---	34.3	---
1983	3.1	1.6	0.2	46.5	0.2
1984	3.7	1.4	2.3	57.9	0.3
1985	3.5	1.7	7.9	82.7	---
1986	2.9	1.3	1.1	51.9	---
1987	8.1	1.2	0.9	57.2	---
1988	10.6	2.3	2.0	109.3	---
1989	4.5	1.0	1.0	131.4	---

Table 27 shows the basic cost breakdown of Michigan's six hatcheries for 1988. The average cost per pound of fish was $4.60. For the Wolf Lake Hatchery, this cost was $5.00 per pound but this included the production of over 23,000 pounds of coolwater fish, primarily northern pike and tiger muskies. These species are more expensive to produce per unit of weight than are salmon and trout. These types of production costs have only been collected since the 1984-85 production year. The per unit cost of production has remained quite constant between $4.00 and $5.00 per pound.

Of interest is the fact that the feed cost constitutes only about 10% of the total cost, this in contrast with commercial hatcheries where it varies from 40 to over 50%. The relative cost for surplus fish in public hatcheries is, therefore, quite low since it basically consists of feed cost only.

Table 27. Cost per pound in 1988 to raise fish in state fish hatcheries of Michigan with a breakdown by percent of cost components.

		Cost components in percent					
Hatchery	Cost per pound (dollars)	Feed	Personnel	Energy	Contractual services, supplies, and materials	Trans-portation	Admin-istration
Marquette	3.92	12.7	54.9	7.8	8.7	7.7	7.8
Thompson	4.22	7.5	60.4	8.3	6.5	8.9	8.0
Oden	4.69	10.2	57.5	7.8	5.6	9.4	8.3
Platte River	4.82	13.4	44.5	20.4	6.1	8.7	5.2
Harrietta	4.98	6.8	55.8	15.3	6.6	8.5	6.1
Wolf Lake	5.00	11.2	48.2	17.0	14.4	5.0	4.2
Total average	4.60	10.2	54.8	12.7	7.9	8.0	6.6

DIVISION MANAGEMENT

Strategy

In the early 1980's, Fisheries Division management decided the Division should pursue improvements of Division programs in part through better ongoing program management. In particular, the Division decided to pursue a strategic approach to management. Strategic management can be characterized as focusing an organization's attention and resources on a defined long-term course of action. The tools of strategic management usually include written mission and goals, planned development of organizational capability in identified key result areas, explicit management control of select organizational resources, and focusing of attention by periodic formulation and tracking of shorter-term objectives.

Mission, goals, and key results.--The Division's mission and goals were developed by the Division after consultation with stakeholders and adopted by the Natural Resources Commission in 1983. The Division identified a set of key result areas and set goals for the Division's capabilities in these key result areas by 1984. The Division now has considerable capability in most of these key result areas.

Organizational resources.--The Division identified four organizational resources which should be explicitly managed in support of the Division's strategy: informed public consent, personnel, information, and financial assets.

The Division currently has few explicit management systems to insure that the Division acts with informed public consent. The Division's communications skills have been enhanced through professional communications staff in the central office and use of communications and public involvement skills as hiring criteria for new personnel. Division management now gives greater emphasis to informed public consent than it did before the 1980's. The Division has imposed requirements for environmental assessment and modest public involvement in relation to fishery management prescriptions. Citizens advisory committees have been appointed for two of the Great Lakes and are planned for the other two in coming years. Nonetheless, there is considerable scope for improvement.

The Division's organization and staffing were substantially changed in 1983 and 1987 based on the Division's strategy. Most of the jobs in the Division were formulated based on explicit consideration of the tasks and level of effort required by the strategy. Most hiring in the 1980's was based on criteria shaped by the Division's strategy. Training has been directed toward some elements of the strategy but has fallen short of needs for other elements of the strategy.

Information management by the Division has been explicitly linked to the program strategy. The data which the Division collects or obtains from other sources is largely determined by the strategy. Database systems development has been guided by the strategy. However, the Division's data management systems still fall far short of needs and are progressing slowly.

The Division's key results were organized into budgetary programs and the Division's annual appropriations have used this structure since 1984-85. These appropriations are annually allotted to the Division's work units based on work plans which are organized by program and key result area. Activity records are kept in relation to key result areas but payroll costs are allocated only to the appropriate program. The Division's financial management systems are explicitly linked to strategy but do not yet support sufficient program analysis.

Objective management.--In 1985, the Division began to formulate objectives by evaluating the status of each key result area in the Division's strategy. In 1986, such objectives were formulated as guidance for development of the Division's annual work plan and were assigned as individual performance objectives to various Division managers. In 1987, individual performance objectives were assigned based on the Division's strategy but work plan guidance was not prepared. Since 1987, the Division has not formally evaluated progress on the objectives set in 1985-87 and has not developed new program objectives except in relation to a few specific activities.

Public Affairs of the Division

Free Fishing Weekend.--On April 24, 1986, Governor James J. Blanchard, signed into law Senate Bill 634, the Free Fishing Bill. Senate Bill 634, sponsored by Senator Connie Binsfeld, authorized the Natural Resources Commission to create "Free fishing" days in Michigan. Under the Bill's authorization the Natural Resources Commission established an annual "Free Fishing Weekend"; the weekend to coincide with National Fishing Week in June of each year.

The First Free Fishing weekend was held on June 7-8, 1986. A number of fishing clinics and derbies were held that weekend in conjunction with the free fishing. In 1987 the Free Fishing Weekend was on June 6-7. In addition to promoting fishing clinics and derbies the

Division, in cooperation with the Michigan United Conservation Clubs (MUCC), promoted free fishing with a colorful poster of a pumpkinseed sunfish.

The 1988 Free Fishing Weekend was June 11-12. Again, clinics, derbies and a poster were part of the promotion. In addition the Division, working with the Michigan Department of Transportation (MDOT) Welcome Centers at New Buffalo and Clare, provided fishing information at the Centers on Friday and Saturday of the Free Fishing Weekend.

In 1989, free fishing was permitted on June 10-11. Clinics, derbies, a poster and fishing information booths at MDOT Welcome Centers were continued by the Division as major promotional efforts. The promotional program was expanded with additional Welcome Center fishing informational booths at Dundee in southeast Michigan and at Menominee in the Upper Peninsula. A new promotional program provided charter fishing trips (donated by various charter boaters) to outstanding youth achievers in the State. The youth were selected through the State's 4H program.

Urban fishing and handicap program.--The urban fishing program, over the past decade, has continued to be a very important portion of the Division's overall mission. Since 1985 added emphasis has been placed on the need for barrier-free design so that physically impaired persons can fish.

All fishing structures built or sponsored in some manner by the Division during the 1980's have incorporated barrier-free design. Major projects include the following: Lake Delta fishing pier and parking lot, Eaton County; Gun Lake fishing pier, Barry County; Pontiac Lake, Heron, Alderman, Lower Pettibone, and Dickinson lakes fishing piers, Oakland County; Bill Bullen fishing pier, Delta County; and Mio Pond fishing pier, Oscoda County. In addition, Division representatives worked with or provided technical assistance to local governments or groups in several locations around the State to construct barrier-free fishing piers. Piers at Tawas and Bay City are examples of this participation. The Bay City pier is an outstanding example of intra-state cooperation, where the Division staunchly supported funding and provided technical assistance to a local community. The result is a spectacular fishing facility totally barrier-free.

Several fishing facility projects which have been funded and which are in the early stages of development include a large fishing pier and parking lot at Belleville Lake, Wayne County, a series of fishing ports (small improved fishing sites) along the Tittabawassee River at Midland, Midland County and a fishing pier.

Master Angler Awards program.-- The Master Angler Awards program awards a certificate to those anglers who catch a state-record size fish or one of the top five largest fish of their kind during the year. Also, arm patches are given to all entrants catching a fish larger than a minimum entry weight. The program, started as a fledgling program in 1973, has developed into an extremely successful and popular program through the 1980's. There has been a general increase in the number of applications received each year, peaking in 1987 and then tapering off over the last several years. The reduction in the number of anglers in 1988 and 1989 reflects the increase in the minimum size requirements for several species of fish. This has resulted in less fish from these several categories being entered. The number of Master Angler awards given each year 1980-89 is shown in Figure 7.

Trout/salmon stamp art contest.--The Fisheries Division in 1980 instigated an art contest to determine the design for the annual trout/salmon stamp. The contests, run each year in conjunction with Wildlife Division's waterfowl design contest, have produced excellent designs. The winning artists, from 1980 through 1989 are listed below:

Artist	Species	Stamp year
Lawrence Cory, Jr.	Brown trout	1980
Rod Lawrence	Brook trout	1981
James Hublick	Rainbow trout	1982
Lawrence Cory, Jr.	Chinook salmon	1983
Heiner Hertling	Brown trout	1984
Loren Fry	Brook trout	1985
William Langlois	Rainbow trout	1986
Rod Lawrence	Chinook salmon	1987
Russell Cobane	Atlantic salmon	1988
Elaine Swanton	Brook trout	1989

Fisheries access acquisition program.--The 1980's ushered in a new era of access acquisition by the Division. The Natural Resources Land Trust Program (formerly known as the Kammer Land Trust Program), starting in 1982, authorized Fisheries Division a lump sum grant of \$500,000 annually through 1988. The lump sum was provided primarily to purchase fishing access on streams in the southern third of the state, although eventually authorization was given to purchase access on streams in the upper part of the Lower Peninsula. In 1989 the

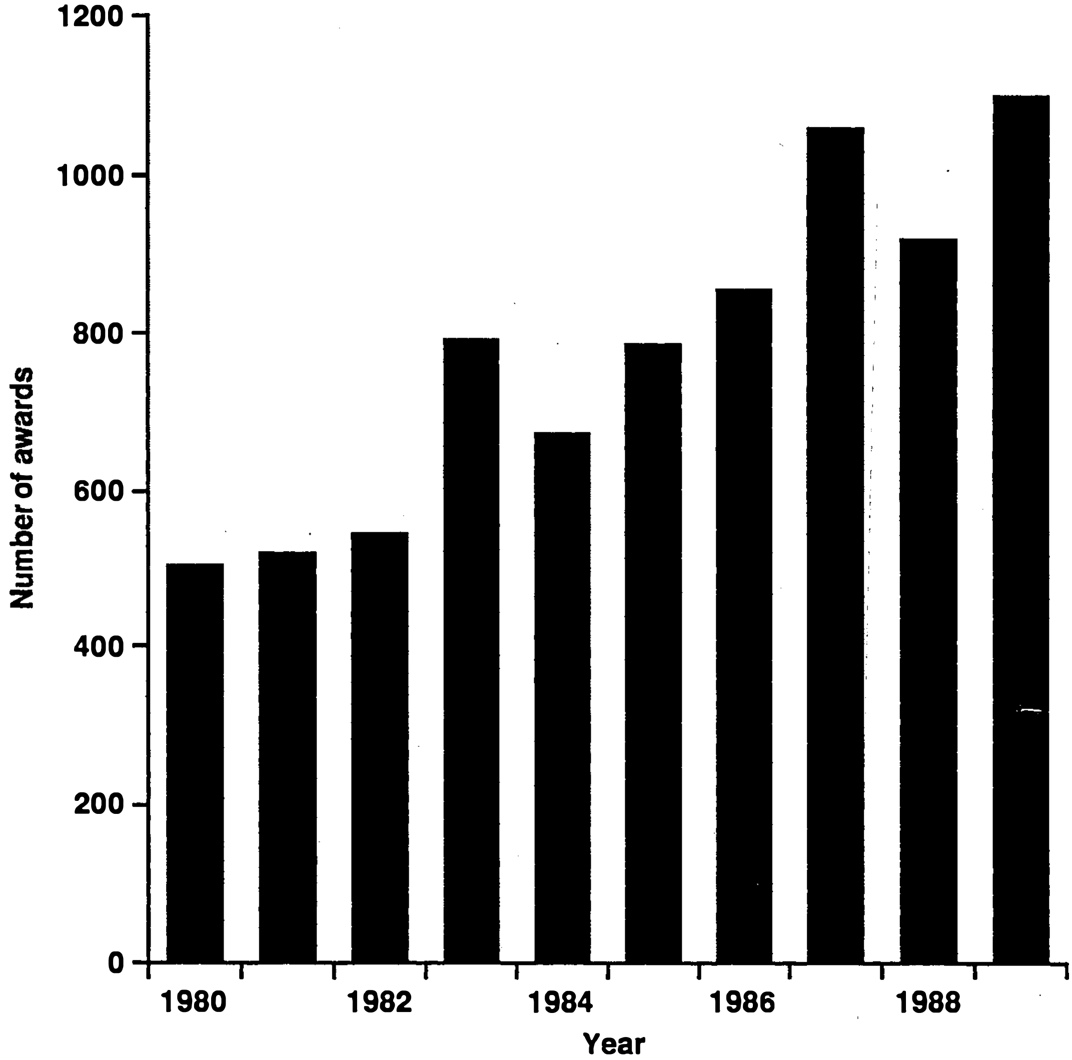

Figure 7. Number of Master Angler Awards granted 1980-89.

in the Lower Peninsula and on streams and small lakes in the Upper Peninsula. Since 1980 the Division has acquired a total of 2,779.03 acres of waterfront access, representing a total of 117,418 feet (22.23 miles) of shoreline at a total cost of $3.7 million.

lump sum was increased to $600,000 with authorization to also purchase access on small lakes

Fishing regulation changes.--The 1980's saw a number of changes in fishing regulations, including several pieces of legislation, which significantly reflects the mood of a changing department and public. As a result of these changes, which included a vastly expanded fish health advisory by the State Public Health Department, the Fishing Guide has expanded from a small pamphlet of 16 pages to a large complex publication of 24 pages. The following are the major regulation changes which occurred from 1980 through 1989:

1980.--Number of streams open to snagging reduced from 12 to 8. Streams remaining open to snagging: Au Sable, Big Manistee, Pere Marquette, Muskegon, Grand, Kalamazoo, and St. Joseph.

1981.--Fishing license fees raised: resident annual - $7.25; non-resident annual - $15.25; non-resident husband/wife - $20.25; daily - $3.75; and trout stamp - $7.25. Both resident and non-resident spouses must buy trout stamps for the first time.

Snagging stream numbers reduced from 8 to 5. Streams remaining open to snagging: Au Sable, Big Manistee, Pere Marquette, and Muskegon.

Lake trout and splake limit reduced to 2 fish in Lake Michigan south of the tip of the Leelanau Peninsula. North of the tip of the Leelanau Peninsula, east of Crisp Point in Lake Superior and north and west of a line from Forty Mile Point to the International boundary in Lake Huron the limit was reduced to 1 lake trout or splake.

Muskellunge size limit raised to 38 inches in Lake St. Clair and the St. Clair and Detroit rivers.

1982.--Public health fish consumption advisory expanded in response to new data.

Lake trout and splake limits raised to 3 except for Lake Michigan and tributary streams which were given a 2 fish limit.

Yellow perch limit restrictions lifted from all Lower Peninsula and Great Lakes waters (50 limit retained in Upper Peninsula waters).

1983.--Walleye and sauger limit in Lake Erie raised to 6 fish.

Sturgeon fishing closed in the Great Lakes and connecting waters during the months of May and June.

1984.--Muskellunge minimum size limit raised to 38 inches on Murphy, Gun, Hudson, Thornapple, Brevort, and Bankson lakes.

Lake trout open season of May 1 through August 15 established on lakes Michigan and Huron and their tributary streams.

1985.--Salmon snagging areas reduced from 5 to 4. Snagging areas remaining are on the Au Sable, Pere Marquette, Big Manistee, and Muskegon.

Salmon snagging stamp required of all anglers fishing in the snagging areas. Price - $7.25.

Walleye and sauger limit in Michigan waters of Lake Erie raised to 10.

1986.--Public health fish consumption advisory expanded and upgraded in response to new contaminant data.

Possession limit of salmon raised to allow an additional 2 daily limits.

Yellow perch minimum size limit for Lake Huron waters of Mackinaw County set at 7 inches starting October 1, 1986.

Spouses of resident anglers (no longer permitted to fish free) required to purchase a fishing license.

1987.--Yellow perch size limit for Lake Huron waters of Mackinaw County set at 8 inches starting October 1, 1987.

Possession limits of salmon and trout expanded to include pink salmon along with the additional brook and brown trout allowed from streams.

Minimum size limits set at 18 inches for Atlantic salmon in Gull Lake, Kalamazoo, and Barry counties with a 2 fish bag limit and a season of the last Saturday in April through September 30.

Minimum size limits set at 16 inches for all trout and salmon in Higgins Lake, Roscommon County.

Minimum size limit of 36 inches set on muskellunge, Chicagon Lake, Iron County.

Fishing license fees increase: resident annual--$9.85; non-resident--$20.35 (The husband/wife non-resident license was eliminated); daily--$5.35; trout/salmon stamp--$9.85.

The establishment of the concept and the development of a list of Blue Ribbon Trout Streams was approved by the Natural Resources Commission in August 1987.

1988.--Fish health consumption advisory expanded significantly to update advisory with new data.

Yellow perch minimum size limit for Lake Huron waters of Mackinac County reduced from 8 to 7 inches.

Walleye, northern pike and muskellunge seasons changed: Upper Peninsula inland and Great Lakes waters--May 15 through March 15; Lower Peninsula inland waters--last Saturday in April through March 31; Lower Peninsula Great Lakes and connecting waters open year-around.

Bass catch-and-release (no-kill) April 1 through Friday before Memorial Day on Muskegon Lake, Muskegon County, Hardy Pond, Newago County, Holloway Reservoir, Genesee County; and Cass, Pontiac, and Kent lakes, Oakland County.

Lake trout refuges established in Lake Michigan (two) and Lake Huron (one) for lake trout rehabilitation. Closed to all fishing.

Legislation enacted by the legislature and signed into law as Act 373, P. A. 1988 by the Governor gave the Department of Natural Resources Director authority to regulate the take and sale of reptiles, amphibians, crustaceans, and mollusks. The same legislation also established a $150 commercial reptile and amphibian license.

1989.--Lifetime licenses were offered: lifetime fishing--$200; lifetime fishing and trout/salmon stamp--$440; lifetime sports person--$1,000. Legislative amendment to the Sports Fishing Act gave Department of Natural Resources Director the authority to regulate the take of amphibians, reptiles, mollusks, and crustaceans.

Pink salmon - 5 extra may be taken in the St. Marys River.

Yellow perch limits reduced to 50 except for lakes Huron, St. Clair, and Erie, and the St. Clair and Detroit rivers which were given limits of 100. Legislative action in mid-year raised the Lake Michigan limit to 100.

The Department of Natural Resources Director approved an Order, DFI-166.89, regulating for the first time the take, possession, and sale of all native reptiles and amphibians in the State.

Personnel Management

The 80's decade for Fisheries Division represented a time of change and progress in organizational development and personnel management. It reflected major shifts in staffing as program emphasis changed and funding and positions were increased. It brought increased involvement with employee unions and awareness of a new type of work force and their needs for more personal attention. It represented a time of responding to stricter Federal and State safety standards to ensure protection of employees, and training programs reflecting the need to keep employees informed of technological advancements. The Division has consisted of up to 230 full-time employees, and throughout any given year, has hired between 100 to 250 temporary employees. The number of full-time people by type of position employed each year 1980-89 is shown in Figure 8. A roster of current fisheries employees is listed in Appendix 2.

Major program direction changes occurred in the early 80's and set the stage for staffing the Division in the mid and latter half of the decade. In early 1980-81 the Division recognized the need to expand beyond its current programs, necessitating a reorganization of the Division. One of the intents of this reorganization was to put more emphasis on fish monitoring, through analysis and assessment of the Great Lakes fish communities. This was accomplished by abolishing the Wolf Lake Research Unit and disbursing staff in order to meet critical needs elsewhere in the Division; by combining the Great lakes Fisheries Station and Fisheries Research Station at Marquette; by placing the Great Lakes stations at Marquette, Charlevoix, and Mt. Clemens under the supervision of a Fish Research and Evaluation Program Manager; and establishing the Charlevoix Fisheries Station as the statewide Center for analysis and assessment of Great Lakes and anadromous fisheries. This also involved adding Great Lakes responsibilities to district offices which bordered the Great Lakes through the addition of 13.5 positions to assist in the development of a creel census program.

Included in this reorganization was the development of an Inland Fisheries Enhancement program, which involved increasing staff and funds for intensive surveys, problem analysis and management of inland lakes and streams. This reorganization divided the Division into three basic organizational units which it operates under today: Regions and Districts, Research and Assessment, and State Hatcheries.

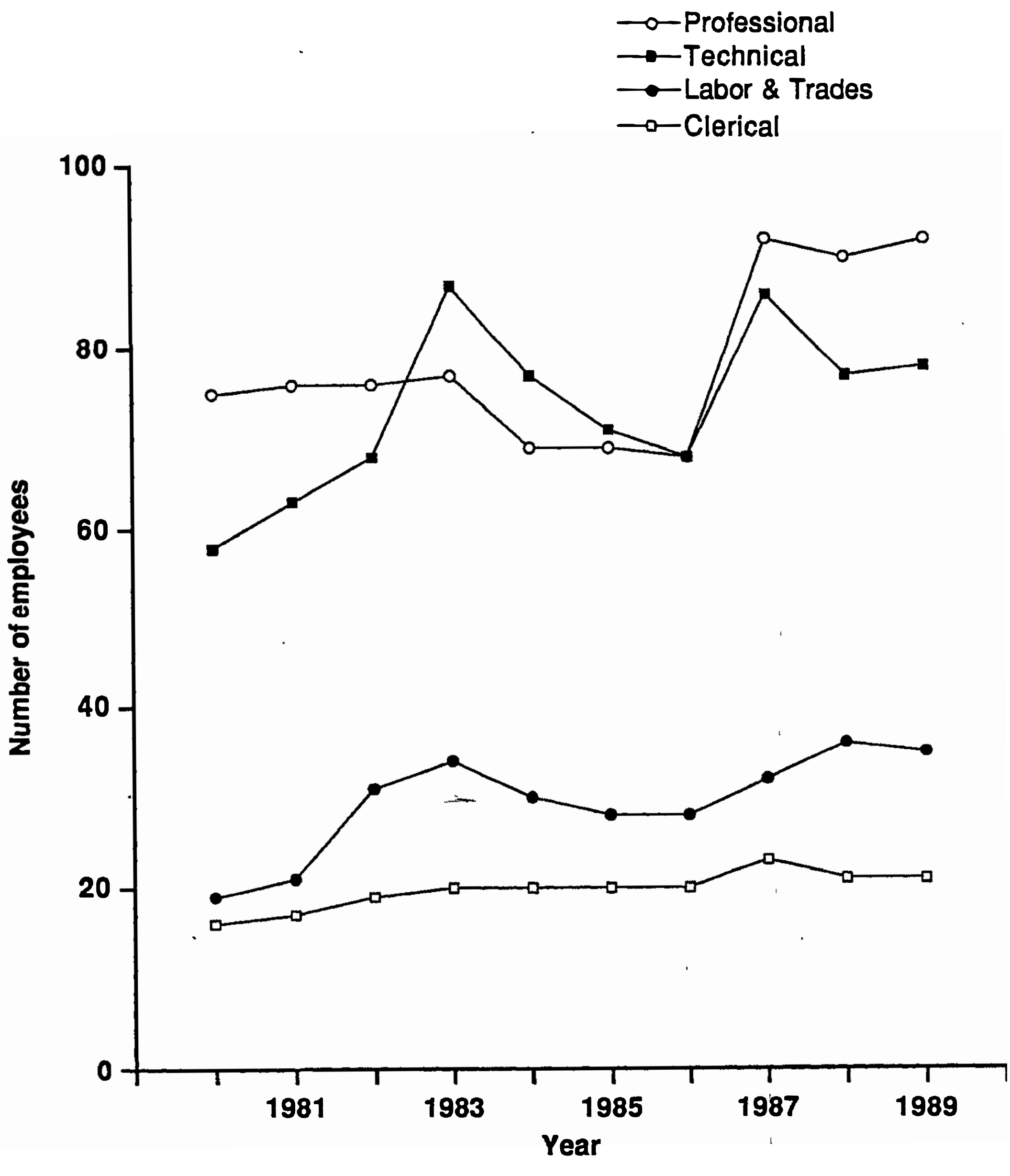

Figure 8. Number of employees by type of fisheries positions, 1980-89.

Portions of the implementation plan for the above noted program and staffing changes were difficult to achieve. The anticipated funding for the Inland Fisheries Enhancement program was based on passage at the federal level of the supplemental Dingell-Johnson Bill which was defeated. In addition, it was anticipated Michigan's Game and Fish Protection funds would decrease without a license increase, the Governor committed to reducing the state work force through ceilings on the number of employees hired, lay-off days were implemented statewide, and the first early retirement program, "80-and-Out" was introduced. This retirement program had a severe effect on Fisheries as 7.2% of Division employees retired versus the 2.7% statewide average.

Further reorganizational impact was felt by the Division through the Department reorganization during 1983-84, dividing the Department into three Bureaus with Fisheries Division placed in the Bureau of Resource Management.

Because of budgetary set-backs, plans for the inland enhancement program were delayed and implemented only after the Dingell-Johnson bill made funds available in 1985-86. In 1987, due to this increase in funding, plus increased revenue from the Game and Fish Protection Fund (and to alleviate the loss of staff which occurred during 1984 through the early retirement program) Fisheries Division implemented a massive hiring effort in which 49 positions were added. Twenty-five of these positions were assigned to the inland program.

Again, in 1988, an early retirement program was offered to state employees however, the impact was not as harsh as in 1984 as Fisheries Division lost only nine individuals to that program and the regular retirement program.

In 1987 a new Regional and District Boundary plan was proposed by the Department for Regions II and III, which was implemented on November 1, 1988. This plan established common district boundaries for all field divisions in the Department, utilized county lines for all boundaries and maximized division representation at the minimum number of district headquarters.

For Fisheries Division the impact is most directly felt in Districts 8, 7, 11, 12, and 14, due to the change in district headquarters to Bay City, West Branch, Rose Lake, Kalamazoo, and Northville, respectively, and by employees who are required to move their homes to accommodate these changes. At this time, only District 8 has moved its headquarters from Clare to Bay City.

Training.--In preparation for the reorganization of the early 1980's, it was recognized that a higher level of training was required for the technical positions in the Division. Consequently job requirements were changed for these classes from a high school education to a 2-year associates degree in fisheries biology, management, or a related field. To bring existing staff in line with this new requirement, an extensive internal training program was established culminating in a testing program to verify individuals had obtained the higher skills necessary. Research biologists were also the focus of higher education skills. In 1987 a new classification was established for Research Biologist requiring a master's degree in fisheries management or biology. Many of the Division's research biologists have Ph.D.'s and Michigan can proudly boast of having one of the finest research biologist staff's in the nation.

Other internal training programs through the decade have focused on in-service training sessions in which staff are brought together on an annual basis to hear presentations from other state fisheries organizations, and other department and division staff members. The latter half of the 80's has seen more extensive training in the area of safety, management, and computers. With the increasing usage of computer technology by the Division, training in this area has become vital. Fifty percent, or approximately $30,000 of the training budget for 1989-90 will be spent on computer training alone.

The Division is also in the process of developing management and career advancement training to keep staff knowledgeable about the latest management practices, to keep them better informed on the Division and Department's programs and to develop future leaders of Michigan's fisheries programs.

Safety.--Stricter Federal and State safety standards have been a strong focus in Fisheries Division's personnel management in the 1980's. The Federal Right-to-Know law has gone a long way to increase employee awareness of individual safety rights and the responsibility of management in assuring a safe working environment for everyone. Formalin, named in 1987 as a carcinogen, and widely used in our State hatcheries, has emphasized the importance of proper chemical safety. The last few years has seen an increase in the use of respirators, physical monitoring, and training in chemical usage. With the advent of the new Commercial Motor Vehicle Safety Act requiring physical examinations for employees driving trucks with a Gross Vehicle Weight Rating (GVWR) of 26,001 pounds or towing another vehicle with a GVWR of 10,000 pounds, which includes the Division's fish planting units, and stricter requirements in chemical and solvent usage, it is estimated that by the early 1990's at least 60% of our employees will be required to have annual medical monitoring.

Much of the Division's work is done outside, near, on, or in the water, sometimes under very harsh weather situations. The work can be physically strenuous and involves such functions as lifting and pulling of nets, carrying heavy equipment, and construction work. The chart below is a listing of total accidents experienced by full-time employees, which have numbered between 170 to 240, and part-time employees which have numbered from 70 to 250 for any given year. Hand and leg accidents have been the most prominent parts of the body injured by Fisheries Division personnel with back and head injuries a close second.

Year	Number of injuries	Lost work days
1980	19	313
1981	4	58
1982	9	14
1983	13	85
1984	12	48
1985	5	10
1986	7	63
1987	18	164
1988	7	34
1989	13	NA[1]

[1]NA indicates not available.

Information Management

In 1981, the Fisheries Division decided to pursue a management strategy in which administrative functions would direct key program resources in support of the Division's fishery management strategy. Four key program resources were identified: informed public consent, personnel, information, and financial assets.

The Division's information management strategy is profoundly influenced by modern information management technology. In the late 1970's, personal computers made it cost effective to automate many information management tasks. Computer-based communications technology made it possible to organize communications without the participants being attentive at the same time. Database management technology made ad hoc use of data possible. Emerging artificial intelligence technologies will permit text to be created automatically based on current data.

Thus by 1984, the Division adopted a four-part information management strategy:

1. Automate all information management activities which can be automated cost-effectively.

2. Manage the Division's communications to permit timely decisions and action based on thorough consultation within the Department.

3. Secure and maintain the Division's data so that it is readily usable by anyone in the Division or a cooperating agency from the time it is created until it is no longer useful.

4. Communicate information and decisions to the Division's publics through semi-custom documents which are both current and appropriately focused at the time of the communication.

Automated information.--In 1986, all Division employees were surveyed to determine their activity in categories relevant to automated information management. Activities of each employee which could be cost-effectively automated were identified after consideration of potential productivity gains, equipment costs, and training costs. By this analysis, approximately 35% of all work done in the Division should be supported by automated information management.

The investments required to achieve this level of automation were also estimated. The necessary equipment included at least 78 personal computers with software. Annual depreciation for this equipment was estimated at $150,000. Formal and on-the-job training required to achieve this level of automation was estimated to average 40 workdays per employee over a 5-year period. About half of this training was expected to occur in formal classes.

Equipment purchases and training were begun before 1986 but were increased in 1986 to approximately these target levels. At the end of 1989, the Division owned 81 personal computers, although all of these were not yet fully equipped. Most professional and secretarial staff had received approximately one-third of the necessary training. Few technicians have yet received formal training.

By the end of 1991, the Division should achieve the inventory of equipment and software planned for 1991 in the 1986 plan. However, a new analysis which may lead to revision of these targets is underway. Training, however, lags about 2 years behind the targeted level at present and either will require substantial time in 1990 and 1991 or will fall short of the 1991 target.

Communications.--Various management studies and employee surveys conducted by the Department of Natural Resources or the Fisheries Division have shown need for more effective internal communications. Chief among needed improvements has been greater participation in decisions both within and between Divisions. Other major needs have included more timely response to requests for information or action and more timely communication of news.

The costs and delay associated with communication have been the principal barrier to addressing these concerns. Computer-based communication allows messages to be stored and accessed at the convenience of the recipient. This permits communication to proceed when the communicants are participating at different times and in different places, without the attendant delay associated with mail. Thus each person in the organization can more freely organize time and attention and the organization can avoid much of the overhead costs of setting up meetings, traveling, calling when the other party is out, and so on. Hence, use of computer-assisted communications can make communication both more timely and more efficient.

The Division has sought for better communications with the rest of the Department as well as within the Division, and has pressed for departmental action on this goal. Although the Division has been prepared to participate in computer-assisted communications since 1985, the Department did not permit access by the Division until 1989. In 1989, the Division established at least one physical communication link to the Department's mainframe computer from each of the Division's office locations. All of the additional links required for the Division's strategy should be established by 1991.

In addition to physical links to the Department's mainframe, the communications strategy also requires software support. The Department has installed PROFS, an electronic mail and calendar system, but has not yet provided all of the necessary support. Electronic mail does not support group communication other than by all possible one-to-one communications, nor does it allow the participants to organize their communications into topics. Both of these features are needed if computer-assisted communications are to be used for increased consultation and involvement in decisions and activities. The Division has proposed additional software on the Department's mainframe to achieve these features, but the Department has not yet acted on this proposal.

Data management.--Traditional methods of managing data, either on paper or with computers organized the data when it was initially recorded for its main intended uses. Any new use might require enormous effort or be impossible because of the way the data was organized. Data was generally retained by the people who initially obtained it or by someone assigned to administer the data. Others who wanted to use the data had to obtain it from the administrator and often had to request the necessary analysis rather than gaining direct access to the data.

Modern database management technology makes it possible to manage data as a utility open to everyone in the organization. Data organization can be designed to support all logical uses of the data without specifying these uses ahead of time. Common access methods for all of the organization's data and use of a central data dictionary make ad hoc use of data possible for everyone who has computer communications capability and is authorized access.

Ad hoc access to data permits more pertinent decision analysis when a decision has been formulated. Open access permits greater participation in decisions. Timely access to data permits quicker consideration. Hence, modern data administration can greatly enhance management.

However, data administration using database management methods requires substantial investment in database design and programming. The Division budgeted professional data systems analysis beginning in 1982. Some immediate needs were met in 1982 and 1983, but it was also apparent that formal database planning was needed so that cumulative progress would occur. In 1984, Division staff developed a data management plan which has since guided data management activities.

The data management plan was developed by examining the data which was needed or created in each of the activities identified in the Division's program strategy, then determining the associations between these data categories and the priorities for management of these data. The effort required to create database applications to support the Division's needs was estimated at 45 worker years. Data management systems in current use address hatchery operations and fish inventory, angler creel surveys, commercial fish catch and wholesale records, and fish stocking records. Few of these systems yet satisfy the goal of immediate availability of data or of universal internal access. By the end of 1990, current efforts will create completely satisfactory data management systems for inventory of water bodies, access sites, fishery management prescriptions, and fish stocking.

Databases which are needed but for which development work is not yet planned include licensed anglers, angler surveys, angling market data, angling regulations, angling opportunities inventory, commercial fishing licenses, minnow harvest reports, charter fishing reports, inland limnological and habitat data, fish collections, fish stock analyses, fish marking data, fisheries facility inventory, fish health and quality control, facility maintenance and repair, equipment management, personnel and payroll data, activity reports, work plans and accomplishments, public communications tracking, public issue tracking, and objectives management.

Document management.--The Division's document management strategy depends on availability of databases containing the data and decisions which are to be communicated by way of the documents. Because few such databases are available, no effort has been made to create "living" documents which are automatically kept current and organized to provide exactly the information which needs to be communicated. The first such document definition will be done in 1990 based on fish stocking data. However, the Division's software selection has been made to support this strategy and a number of standard document outlines have been formulated in recent years which will aid future automation of document creation.

Division Budget

Fisheries operating revenues are composed of the Game and Fish Fund (sale of hunting and fishing licenses), Dingell-Johnson (federal excise tax on fishing tackle), General Fund (State of Michigan tax revenue), and other miscellaneous sources. The Game and Fish Fund represents 77% of the Division's funding and with inflation adjustments has stayed relatively constant for the last 8 years. The only change that has occurred in the Game and Fish Fund was in 1985 when a license increase was received. This restored inflationary losses and increased the operating budget by 6%. Fisheries' second largest funding source, Dingell-Johnson, was amended (Wallop-Breaux) in 1985-86 to include additional taxes on boats, fishing gear, and motor boat fuel. This additional revenue boosted Michigan's apportionment substantially. From 1984-85 to 1985-86 Dingell-Johnson revenues for operating increased 118%. The percent of total funding went from 12% to 23%. This with the changes that occurred with the Game and Fish Fund resulted in the biggest increase in the Division's budget. Fisheries Division receives the least revenue from the General Fund for operating. In 3 of the 10 years the Division received nothing, in 2 years they received just over $200,000, and for the last 4 years they received under $51,000. By 1989, the General Fund represented less than 1% of the total budget. Miscellaneous revenue comes from such sources as Soil Conservation Service, U. S. Army Corps of Engineers, National Oceanic and Atmospheric Administration, and private funds. In some years the Division has received over $400,000 in miscellaneous revenues but they are usually around $100,000. In 1988-89 they were only 1% of the budget. Division revenues for 1979-80 through 1988-89 are presented in Figure 9.

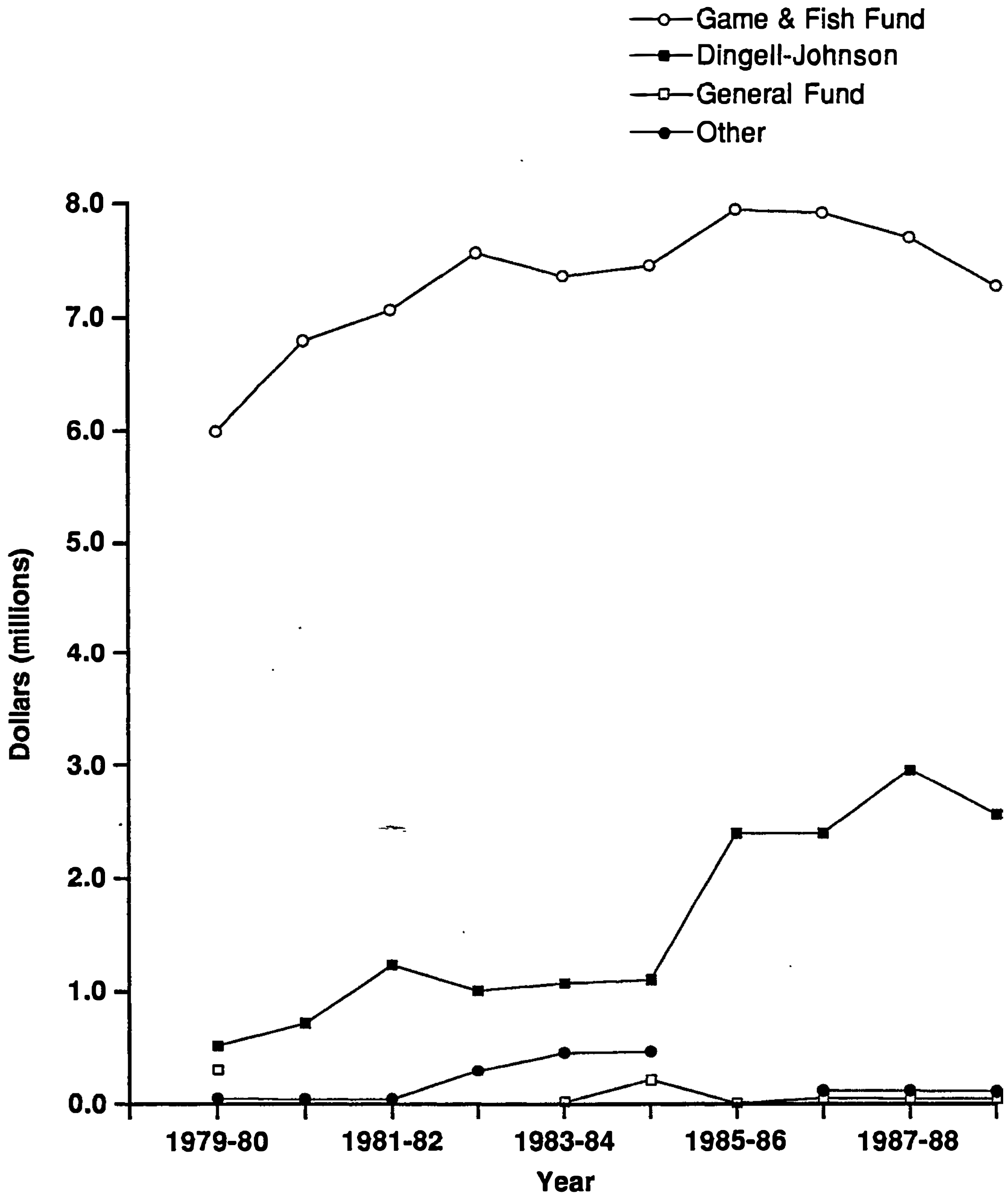

Figure 9. Fisheries Division revenues (in 1980 dollars) from various sources, 1979-80 through 1988-89.

The Division appropriations (total legislative authorization to spend) increased from $6.9 million in 1979-80 to $10 million in 1988-89 (figures adjusted to 1980 dollars) (Figure 10). The drop in 1989 represents inflationary losses. The $1.2 million increase in 1985-86 reflects 118% increase from Dingell-Johnson revenues, 6% from Game and Fish Fund, and a decrease in miscellaneous.

Divisions budget and staffing were appropriated and expended by line items prior to 1983-84. Since then the Division's funds have been allocated by program (Administration, Recreational, Great Lakes, Fish Production, Commercial, and Inland). All programs stayed relatively constant through 1984-85. However, the increase in Dingell-Johnson funds, with the stabilization of the Game and Fish Fund resulted in an increase in both the Inland and Fish Production programs in the following years (Figure 11). The table below shows Division's expenditures as percent of total appropriation by cost units.

Years	Salaries	Css&m[1] & travel	Utilities and fish food	Equipment
1979-80	70	19	9	2
1980-81	73	16	9	2
1981-82	73	15	10	2
1982-83	70	17	10	3
1983-84	79	11	9	1
1984-85	72	15	10	3
1985-86	71	16	11	2
1986-87	66	21	9	4
1987-88	66	23	8	3
1988-89	67	24	8	1

[1]Contractual services, supplies, and materials.

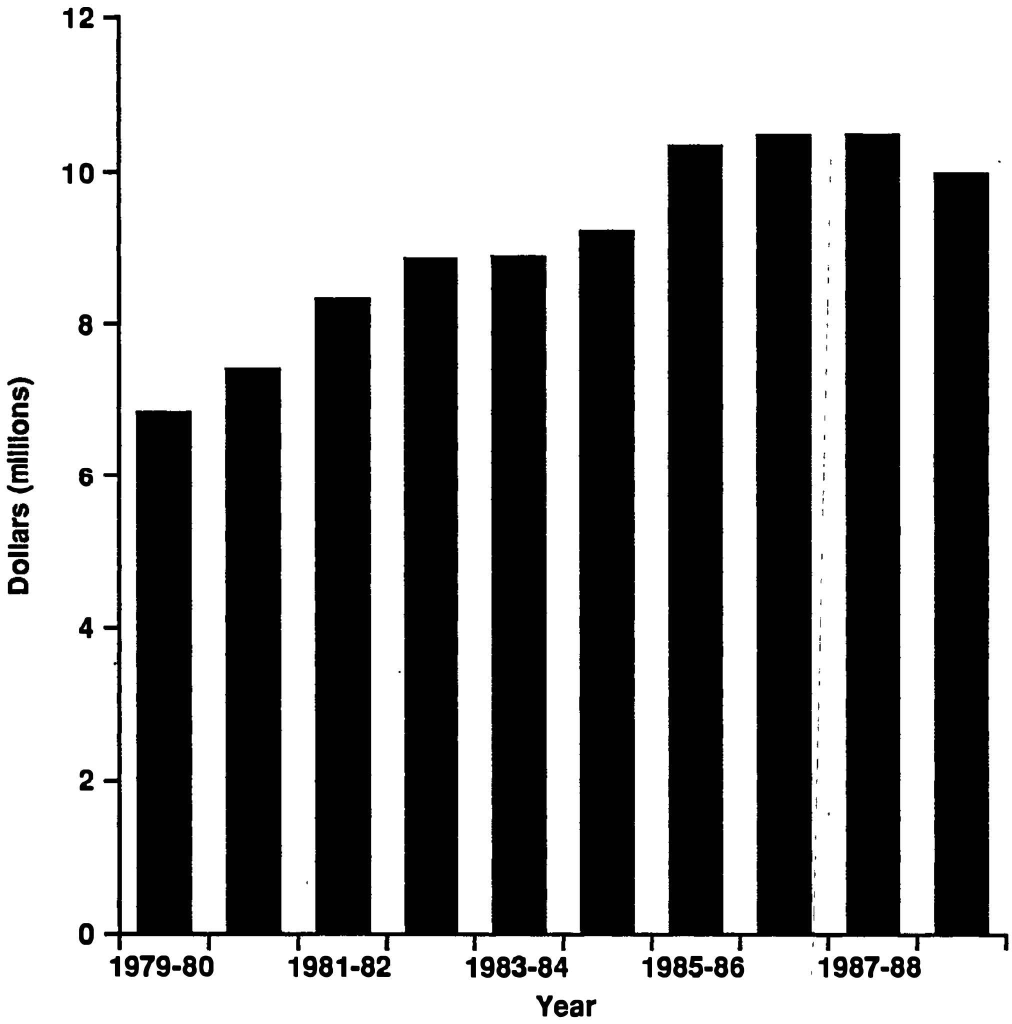

Figure 10. Total appropriations to the Fisheries Division (in 1980 dollars) 1979-80 through 1988-89.

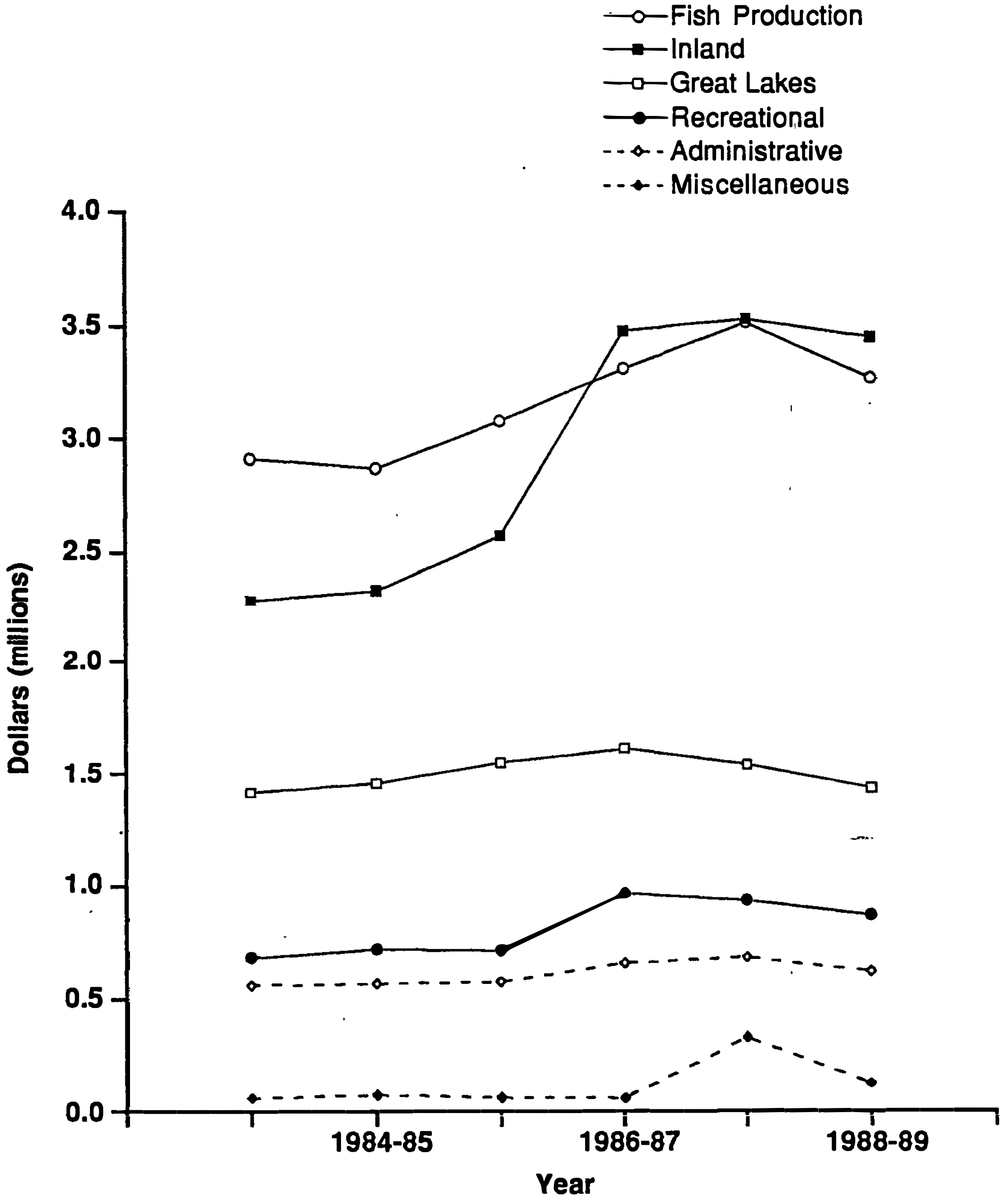

Figure 11. Fisheries Division's expenditures (in 1980 dollars) for individual programs 1983-84 through 1988-89.

When comparing expenditures in percent by cost units (salaries, Css&m and travel, utilities and fish food, and equipment) the following should be noted.

1. Except for 1983-84 salaries have remained constant through 1985-86. The last 3 years of the decade, salaries have decreased.

2. Utilities, fish food, and equipment expenditures have been relatively constant through the decade.

3. Css&m and travel experienced an increase in 1986-87. This reflected the increased Dingell-Johnson funds and the resulting increase in inland fisheries projects.

For the decade over $12.6 million was spent on non-operating expenditures. Funding has come from various sources which included: General Fund, Game and Fish Fund, Dingell-Johnson, private, Great Lakes Fishery Commission, and others. Over $8.6 million of the General Fund was appropriated for Indian treaty and commercial fishing settlements. The remaining dollars from the other sources were used for the following: planning the Marquette Hatchery renovation, access to the Grand River, Wolf Lake Hatchery renovation, Inland Grant Program, and other miscellaneous projects.

Appendix 1. List of Fisheries Division's research, technical, and other reports, 1980-89.

Research Reports

1876. Beyerle, G. B. 1980. Contribution to the anglers' creel of marsh-reared northern pike stocked as fingerlings in Long Lake, Barry County, Michigan.

1877. Gowing, H., and G. R. Alexander. 1980. Population dynamics of trout in some streams of the northern Lower Peninsula of Michigan.

1880. Laarman, P. W. 1980. Size selectivity of trap nets for eight species of fish.

1881. Laarman, P. W. 1980. Vital statistics of the fish population in Manistee Lake, Kalkaska County, with special emphasis on mortality and exploitation of stocked 15-cm walleye fingerlings.

1882. Latta, W. C. 1980. Institute for Fisheries Research 1930-1980. Fifty years of fisheries investigations.

1883. Baker, J. P. 1980. The distribution, ecology, and management of the lake sturgeon (*Acipenser fulvescens* Rafinesque) in Michigan. (M.S. thesis.)

1884. Stauffer, T. M. 1980. Collecting year for lake trout eggs and fry.

1885. Wagner, W. C. 1980. Reproduction of planted lake trout in Lake Michigan.

1886. Laarman, P. W., and J. W. Merna. 1980. Reproductive potential of largemouth bass in ponds and food habits of fingerlings.

1887. Schneider, J. C., and W. R. Crowe. 1980. Effect of sucker removal on fish and fishing at Big Bear Lake.

1888. Galbraith, M. G., Jr. 1980. Use of sucrose to stimulate the production of *Daphnia pulex* in aquaria.

1889. Patriarche, M. H. 1980. Movement and harvest of coho salmon in Lake Michigan, 1978-1979.

1890. Schneider, J. C. 1981. Fish communities in warmwater lakes.

1891. Galbraith, M. G., Jr. 1982. Population dynamics of *Chaoborus* and zooplankton in a small lake before and after the introduction of fish.

1892. Peck, J. W. 1981. Dispersal of lake trout fry from an artificial spawning reef in Lake Superior.

Appendix 1. Continued:

Research Reports

1893. Wagner, W. C., and T. M. Stauffer. 1981. Distribution and abundance of pink salmon in Michigan tributaries of the Great Lakes, 1967-1980.

1894. Beyerle, G. B. 1981. Comparative survival and growth of 8.9- and 17.8-cm (3.5- and 8.0-inch) tiger muskellunge planted in a small lake with forage fishes.

1895. Clark, R. D., Jr. 1981. Analysis of "quality fishing" regulations through mathematical simulation of a brown trout fishery.

1896. Goudy, G. W. 1981. The exploitation, harvest, and abundance of largemouth bass populations in three southeastern Michigan lakes. (M.S. thesis.)

1897. Smith, K. D. 1981. A general numerical model for evaluating size limit regulations with application to Michigan bluegill (*Lepomis macrochirus* Rafinesque). (M.S. thesis.)

1898. Anderson, E. R. 1984. Artificial propagation of lake sturgeon *Acipenser fulvescens* (Rafinesque), under hatchery conditions in Michigan. (M.S. thesis.)

1899. Alexander, G. R., and D. R. Peterson. 1981. Trout of Newton Creek, Clare County, Michigan: a transitional zone trout stream.

1900. Merron, G. S. 1982. Growth rate of brown trout (*Salmo trutta*) in areas of the Au Sable River, Michigan, before and after domestic sewage diversion. (M.S. thesis.)

1901. Hansen, E. A., G. R. Alexander, and W. H. Dunn. 1982. Sand sediments in a Michigan trout stream. Part I. In-stream sediment basins: a technique for removing sand bedload from streams.

1902. Alexander, G. R., and E. A. Hansen. 1982. Sand sediments in a Michigan trout stream. Part II. Effects of reducing sand bedload on a trout population.

1903. Clark, R. D., Jr. 1982. The impact of voluntary catch and release of legal-sized fish on recreational fisheries.

1904. Wagner, W. C. 1982. Lake trout spawning habitat in the Great Lakes.

1905. Schneider, J. C. 1983. Experimental walleye-perch management in a small lake.

1906. Alexander, G. R., and E. A. Hansen. 1983. Effects of sand bedload sediment on a brook trout population.

1907. Clapp, D. F. 1988. Movement, habitat use, and daily activity patterns of trophy brown trout in the South Branch of the Au Sable River, Michigan. (M.S. thesis.)

Appendix 1. Continued:

Research Reports

1908. Lorantas, R. M. 1983. Assessment of the channel catfish fishery in Saginaw Bay, Lake Huron. (M.S. thesis.)

1909. Clark, R. D., Jr., and B. Huang. 1983. The dynamics of competition between sport and commercial fishing: effects on rehabilitation of lake trout in Lake Michigan.

1910. Beyerle, G. B. 1983. Survival and growth of 5-, 10-, and 15-cm walleye fingerlings stocked in ponds with bluegills.

1911. Koziol, A. M. 1982. Dynamics of lightly exploited populations of the lake whitefish, Isle Royale vicinity, Lake Superior. (M.S. thesis.)

1912. Rakoczy, G. P. 1983. Harvest levels for commercially exploited stocks of lake whitefish in Michigan waters of Lake Superior.

1913. Cosentino, P. M. 1983. Fish community structure and the utilization of Harsens Island marsh-bay complex, Lake St. Clair. (M.S. thesis.)

1914. Rybicki, R. W. 1983. Lake trout populations in Michigan waters of Lake Michigan, 1976-1982.

1915. Schneider, J. C. 1984. Yellow perch maturity and fecundity as a function of age and growth.

1916. Fenske, J. L. 1983. Attitudes and attributes of anglers who fish for trout in Michigan. (M.S. thesis.)

1917. Clark, R. D., Jr. 1984. The effects of fishing regulations on annual fluctuations in abundance and harvest.

1918. Bryant, W. C. 1984. Status of the walleye in Michigan waters of Lake Erie and connecting waters, 1980-1983.

1919. Peck, J. W. 1984. Lake trout reproduction on a man-made spawning reef.

1920. Beyerle, G. B. 1984. Comparative survival of pellet-reared muskellunge stocked as fingerlings in bluegill ponds with and without largemouth bass.

1921. Gowing, H. 1984. Survival and growth of matched plantings of Assinica strain brook trout and hybrid trout (Assinica male *x* domestic female) in six Michigan lakes.

1922. Ryckman, J. R. 1985. Michigan on-site creel surveys, 1975-1982.

Appendix 1. Continued:

Research Reports

1923. Beyerle, G. B. 1984. Survival and growth of early- and normal-plant tiger muskellunge stocked in a small lake with forage fish and largemouth bass.

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Research Reports

1939. Clark, R. D., Jr. 1986. Minimizing cost of transporting fish from hatcheries to public fishing waters.

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1942. Peck, J. W. 1986. Fecundity of hatchery-origin and wild lake trout in Lake Superior.

1943. Alexander, G. R., and E. A. Hansen. 1988. Decline and recovery of a brook trout stream following an experimental addition of sand sediment.

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1945. Wagner, W. C. 1988. Largemouth bass in Michigan's Upper Peninsula lakes.

1946. Hayes, D. B. 1988. Potential for competition between yellow perch (*Perca flavescens*) and white sucker (*Catostomus commersoni*) in two northern lakes.

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1948. Fielder, D. G. 1987. An assessment of the introduction of summer steelhead into Michigan. (M.S. thesis.)

1949. Hay-Chmielewski, E. M. 1987. Habitat preferences and movement patterns of the lake sturgeon (*Acipenser fulvescens*) in Black Lake, Michigan. (M.S. thesis.)

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1953. Smith, K. D. 1988. Evaluation of modifications to trap nets for reducing gilling in a commercial whitefish fishery.

1954 Haas, R. C., M. C. Fabrizio, and T. N. Todd. 1988. Identification, movement, growth, mortality, and exploitation of walleye stocks in Lake St. Clair and the western basin of Lake Erie.

Appendix 1. Continued:

Research Reports

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1956. Peck, J. W., and R. G. Schorfhaar. 1988. Lake trout management and population dynamics in Michigan.

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1963. Nuhfer, A. J., and G. R. Alexander. 1989. Hooking mortality of trophy-sized wild brook trout caught on artificial lures. (In preparation.)

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Appendix 1. Continued:

	Technical Reports
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80-4	Jamsen, G. C. 1980. Michigan's 1979 sport fishery.
81-1	Miller, B. R. 1981. A 1979 fisheries survey of the St. Marys River system in Chippewa County, and comparisons with 1975 results.
81-2	McClay, Wm. 1981. Status of tiger muskellunge management in Michigan.
81-3	Nelson, D. D., and D. W. Smith. 1981. Rotenone fisheries survey of the Grand River.
81-4	Schrouder, J. D. 1981. The trout streams of Michigan. No. 34, Indian River.
81-5	Jamsen, G. C. 1981. Michigan's 1980 sport fishery.
82-1	Hnath, J. G. 1982. The history of infectious pancreatic necrosis (IPN) virus in Michigan.
83-1	Schneider, J. C. 1983. Significance of acid rain to Michigan lakes and their fisheries.
83-2	Merna, J. W., and G. R. Alexander. 1983. Effects of snowmelt runoff on pH and alkalinity of trout streams in northern Michigan.
84-1	Seelbach, P. W., G. R. Alexander, and R. N. Lockwood. 1984. An inclined-screen trap for salmonids in large rivers.
84-2	Lockwood, R. N. 1984. A statistical comparison of catch per hour rates between complete and incomplete fishing trips in Michigan.
84-3	Weber, J. R., and R. D. Clark, Jr. 1984. Mortality and growth of lake trout in western Lake Huron.
84-4	Clark, R. D., Jr. 1984. A tale of two whitefish fisheries: the Boom-and Buster and the Green-Branch.
84-5	Seelbach, P. W., and G. B. Beyerle. 1984. Interpretation of the age and growth of anadromous salmonids using scale analysis.

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	Technical Reports
84-6	Spitler, R. J. 1984. Drawndown related winterkill of Pontiac Lake, Oakland County, 1981-82.
84-7	Towns, G. L. 1984. A fisheries survey of the Kalamazoo River, July and August 1982.
84-8	Pecor, C. H., and G. B. Beyerle. 1984. Platte River harvest weir and coho salmon egg-take report, 1983.
84-9	Trimberger, E. J. 1984. White River harvest weir report, 1983.
84-10	Hay, R. L. 1984. Little Manistee River harvest weir and chinook salmon egg-take report, 1983.
84-11	Schnicke, G. T. 1984. Au Sable harvest weir report, 1983.
84-12	Siler, D. H., and G. B. Beyerle. 1984. Introduction and management of northern muskellunge in Iron Lake, Michigan.
85-1	Scott, J. A., D. P. Borgeson, W. C. Latta, and D. B. Jester, Jr. 1985. Proceedings of the workshop on future direction in coolwater-warmwater fisheries research and management in Michigan, May 20-22, 1985.
85-2	Pecor, C. H. 1985. Platte River harvest weir and coho salmon egg-take report, 1984.
85-3	Towns, G. L. 1985. A fisheries survey of the River Raisin, August 1984.
85-4	Jamsen, G. C. 1985. Michigan's 1981 sport fishery.
85-5	Jamsen, G. C. 1985. Michigan's 1982 sport fishery.
85-6	Baker, J. P. 1985. An examination of methods to eliminate adhesiveness and increase survival of walleye eggs for hatchery production.
86-1	Hay, R. L. 1986. Little Manistee River harvest weir and chinook salmon egg-take report, 1984.
86-2	Gigliotti, L. M. 1986. Illegal harvest: impact on recreational fisheries.
86-3	Pecor, C. H. 1986. Platte River harvest weir and coho salmon egg-take report, 1985.
86-4	Ryckman, J. R. 1986. A creel survey of sportfishing in Saginaw Bay, Lake Huron, 1983-84.

Appendix 1. Continued:

Technical Reports	
86-5	Spitler, R. J. 1986. Evaluation of ice-cold water rotenone treatment of Tipsico Lake.
86-6	Clapp, D. F., and R. D. Clark, Jr. 1986. Hooking mortality of smallmouth bass caught on live minnows and artificial spinners.
86-7	Bullen, Wm. H. 1986. Revised procedure for taking and handling walleye eggs in the field.
86-8	Alexander, G. R., and J. R. Ryckman. 1986. Effect of an abnormal discharge of sediment from the Lansing Club Impoundment on the trout population in the Pigeon River, Otsego and Cheboygan counties, Michigan.
86-9	Norcross, J. 1986. The walleye fishery of Michigan's Lake Gogebic.
86-10	Hay, R. L. 1986. Little Manistee River harvest weir and chinook salmon egg-take report, 1985.
87-1	Pecor, C. H. 1987. Platte River harvest weir and coho salmon egg-take report, 1986.
87-2	Keller, M., J. C. Schneider, L. E. Mrozinski, R. C. Haas, and J. R. Weber. 1987. History, status, and management of fishes in Saginaw Bay, Lake Huron, 1891-1986.
87-3	Towns, G. L. 1987. A fishery survey of the Battle Creek River, August 1986.
87-4	Schneider, J. C., and R. J. Spitler. 1987. A study of walleye in Belleville Lake, Wayne County, Michigan, 1976-80.
87-5	Merna, J. W., and R. J. Spitler. 1987. Circulation of a lake by operating outboard motors through the ice.
87-6a	Rakoczy, G. P., and R. D. Rogers. 1987. Sportfishing catch and effort from the Michigan waters of lakes Michigan, Huron, and Erie, and their important tributary streams, April 1, 1986-March 31, 1987.
87-6b	Rakoczy, G. P., and R. D. Rogers. 1987. Sportfishing catch and effort from the Michigan waters of lakes Michigan, Huron, and Erie, and their important tributary streams, April 1, 1986-March 31, 1987. (Appendices.)
88-1	Hnath, J. G., and C. H. Pecor. 1988. Viral erythrocytic inclusion body syndrome (VEN)-like disease in Michigan coho salmon.
88-2	Waybrant, J. R., and M. V. Thomas. 1988. Results of the 1986 creel census on Orchard, Cass, and Maceday-Lotus lakes.

Appendix 1. Continued:

Technical Reports	
88-3	Hay, R. L. 1988. Little Manistee River harvest weir and chinook salmon egg-take report, 1986.
88-4	Hnath, J. G., and J. Zischke, and M. DuCharme. 1988. Attempts to detect enteric redmouth (ERM) in chinook salmon fingerlings.
88-5	Seelbach, P. W. 1988. Considerations regarding the introduction of muskellunge into southern Michigan rivers.
88-6	Nuhfer, A. J. 1988. A comparison of growth of brown trout from selected western rivers with growth of brown trout from Michigan waters.
88-7	Bullen, W. H. 1988. Fisheries management plan for the Salmon Trout River, Marquette, Michigan.
88-8	Fenske, J. L. 1988. Medusa Creek harvest weir report, 1987.
88-9a	Rakoczy, G. P., and R. D. Rogers. 1988. Sportfishing catch and effort from the Michigan waters of lakes Michigan, Huron, Superior, and Erie, and their important tributary streams, April 1, 1987-March 31, 1988.
88-9b	Rakoczy, G. P., and R. D. Rogers. 1988. Sportfishing catch and effort from the Michigan waters of lakes Michigan, Huron, Superior, and Erie, and their important tributary streams, April 1, 1987-March 31, 1988. (Appendices.)
88-10	Pecor, C. H. 1988. Platte River harvest weir and coho salmon egg-take report, 1987.
88-11a	Rakoczy, G. P., and R. N. Lockwood. 1988. Sportfishing catch and effort from the Michigan waters of Lake Michigan and their important tributary streams, January 1, 1985-March 31, 1986.
88-11b	Rakoczy, G. P., and R. N. Lockwood. 1988. Sportfishing catch and effort from the Michigan waters of Lake Michigan and their important tributary streams, January 1, 1985-March 31, 1986. (Appendices.)
88-12	Towns, G. L. 1988. A fishery survey of the upper St. Joseph River, July and August 1987.
89-1	Keller, M., K. D. Smith, and R. W. Rybicki. 1989. Summary of salmon and trout management in Lake Michigan.
89-2	Schneider, J. C., J. R. Waybrant, R. P. O'Neal, and R. L. Tillitt. 1989. First-year results of early-season catch-and-release bass fishing.

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	Technical Reports
89-3	Seelbach, P. W. 1989. Characteristics of adult steelhead populations, including returns of hatchery yearlings, in the St. Joseph and Grand rivers, Michigan.
89-4	Pecor, C. H. 1989. Platte River harvest weir and coho salmon egg-take report, 1988.
89-5	Hay, R. L. 1989. Little Manistee River harvest weir and chinook salmon egg-take report, 1987.
89-6	Hay, R. L. 1989. Boardman River harvest weir report, 1987.
89-7	Grimm, K. S. 1989. A fisheries survey of the St. Marys system, Chippewa County, August-October, 1987.
89-8	Herman, M. P. 1989. Results of 1987 creel survey of Devils and Vineyard lakes, Lake Lansing and two sites on the Grand River.
89-9	Schneider, J. C., and R. P. Juetten. 1989. An evaluation of special fishing regulations on Sylvania lakes.
89-10	Waybrant, J. R. 1989. Responses of some Michigan anglers to a questionnaire on bass management.

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Miscellaneous Reports

Haas, R. C., M. G. Galbraith, and W. C. Bryant. 1983. Movement and harvest of fish in Lake St. Clair, St. Clair River, and Detroit River. 1983 Annual Report, Winter Navigation Study, U. S. Army Corp of Engineers.

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Diana, J. S., C. A. Jones, D. O. Lucchesi, and J. C. Schneider. 1987. Evaluation of the yellow perch fishery and its importance to the local economy of the Les Cheneaux Islands area. Final Report, Grant LRP-8C-7, Coastal Management Program.

Appendix 2. Names of Fisheries Division employees and their work location, 1989.

DIVISION OFFICE

Administration - Lansing

Acker, Steve
Barker, Carol
Borgeson, David, Assistant Chief
Cole, Donald
Cummings, Nancy
Feldpausch, Deborah
Fogle, Ned
Herek, Anthony
Houghton, Walter
Jamsen, Gale
Jester, Douglas
Jurney, Starre
McClay, William
McFadden, Kathryn
Robertson, John, Division Chief
Simon, Anita
Sylvester, Joseph
VanHouten, Terri
Walker, Barbara
Weaver, David
Westers, Harry
Whelan, Gary
Wood, Patricia
Wright, Asa

FISH HATCHERIES

Harrietta Hatchery - Harrietta

Bennett, Vernon
Casteel, Jeri
Chesney, Gerald
Eisch, Ed
Lake, Therowin
Mania, Louis
Murphy, Dave
Rise, Linda
Smith, Ronald

Marquette Hatchery - Marquette

Babbitt, Sharon
Dewitt, Steve
Driver, John
McConnell, Laurie
Morales, Helen
Smith, Robin
Timmons, James

Oden Hatchery - Oden

Bedrick, Donald
Corey, Dennis
Guzinski, Stephen
Mania, John
Poynter, Richard
Robbins, James
Snider, Jacob
Stine, David
Sullivan, Catherine

Platte River Hatchery - Honor

Bailey, George
Baker, James A.
Borrero, Angelo
Cooper, Randall
Eggleston, Robert
Fairchild, Joseph
Hubbell, Roger
Humphrey, Robert
Johnson, Richard
Martin, Roger
Matthews, Marcia
Pecor, Charles
Tolar, Terry

Appendix 2. Continued:

Thompson Hatchery - Manistique

Brinkman, Lon
Cogswell, Stewart
Demars, Patrick
Halvorsen, Thomas
Hoag, John
Maki, Kelly
McLeod, Daniel
Smith, Douglas
Yoder, Warren

Wolf Lake Hatchery - Mattawan

Blind, Alison
Chilcutt, Martha
Coles, Thomas
Copeland, James
Elliott, Alfred
Frontjes, Thomas
Gallery, David
Hall, Douglas
Jacobson, Martin
Klage, Christopher
Lincoln, Russell
McKenzie, Connie
Mulka, Dennis
Pamment, Melvin
Tisland, Conrad
Vanamberg, Jan

Wolf Lake Fish Health Lab - Mattawan

Hnath, John
Zischke, Julia

<u>FIELD OFFICES</u>

Region I - Marquette

Ylkanen, Bernard

District 1 - Baraga

Deephouse, William
Juetten, Raymond
Miller, Barry
Pearce, Joseph
Spaczynski, Valerie

District 2 - Crystal Falls

Abrahamson, Arnold
Larmour, Paul
Nurenberg, Vernon
Schnicke, Gary
Ziegler, William

District 3 - Escanaba

Harrison, Richard
Madison, George
Mulzer, Brian
Peterson, Jerome
Siler, Dell

District 4 - Newberry

Grimm, Kathrin
Payment, Fredrick
Scott, Steven

Region II - Roscommon

Berney, Reid
MacLean, David
Schrouder, John

District 5 - Gaylord

Fenske, Janice
Hollenbaugh, Lyle
Holser, James
Hoxie, Brian
Miller, Harold
Shouder, Mason
Swan, Stephen

Appendix 2. Continued:

District 6 - Cadillac

Allen, Alfred
Hay, Ralph
Lazar, Steve
Makoweski, Peter
Manz, Dann
Mrozinski, Leo
Rozich, Thomas
Sapak, Janice

District 7 - Mio

Casey, Gerald
Kruger, Kyle
Phillips, Michael
Sendek, Steven
Smiddy, Edward
Smith, David

District 8 - Bay City

Baker, James P.
Hamilton, Ralph
Jeffery, Charles
Kolson, Francis
Shepherd, Raymond

Region III - Lansing

Reynolds, Donald

Rose Lake Warehouse - Haslett

Debelak, Kenneth
Dedafoe, Ronald

District 9 - Grand Rapids

Borgeson, David J.
Gustafson, Cary
Hilt, Amy
Kort, Douglas
O'Neal, Richard
Trimberger, Eugene
Vanderlaan, Steve
Vogt, Jonathan

District 11 -Imlay City

Anderson, Torre'
Barnard, Donald
Drew, Joseph
Gerlach, Marvin
Gruhn, William
Hardigan, Carrie
Nelson, Don

District 12 - Plainwell

Anson, Dan
Clevenger, John A., Sr,
Dexter, James
Duffy, Joan
Gordon, Dennis
Johnson, David
Markham, Sally
Waite, Donald

District 13 - Jackson

Dodge, Kenneth
Herman, Michael
Rupright, William
Stark, James
Sweet, Robert
Towns, Gary

District 14 - Pontiac

Adams, Thomas
Hay-Chmielewski, Elizabeth
Leonardi, Joseph
Spitler, Ronald
Thomas, Michael
Torello, Gloria
Waybrant, James

Appendix 2. Continued:

RESEARCH AND ASSESSMENT

Alpena Fisheries Station - Alpena

Cross, Charles
Cross, Clarence
Johnson, James
Svoboda, Ronald
Weber, John

Institute for Fisheries Research - Ann Arbor

Bennett, Marlene
Breck, James
Clark, Richard
Fabrizio Wilde, Mary
Gapzcynski, James
Gould, Barbara
Latta, W. Carl
Lockwood, Roger
Merna, James
Ryckman, James
Schneider, James
Seelbach, Paul
Zorn, Troy
Zurek, Grace

Charlevoix Fisheries Station - Charlevoix

Bice, Susan
Cutler, Charles
Gelderblom, Paul
Keller, Myrl
Meggison, Jerry
Rakoczy, Gerald
Rogers, Richard
Russell, Robert
Rybicki, Ronald
Smith, Kelley
Stevens, Jeffery

Hunt Creek Fisheries Station - Lewiston

Alexander, Gaylord
Nuhfer, Andrew
Rodgers, Jack

Marquette Fisheries Station - Marquette

Duvall, Sandra
Hannuksela, Paul
Jamsen, Richard
Kleaver, Greg
Koval, Karen
Peck, James
Schneeberger, Philip
Schorfhaar, Richard
Wagner, Wilbert

Mt. Clemens Fisheries Station - Mt. Clemens

Bryant, William
Clevenger, John
Haas, Robert
Hodge, Jack
Koster, Kenneth
Menovske, Bonnie
Shubel, Lawrence

Saline Fisheries Station - Saline

Sutton, Alan