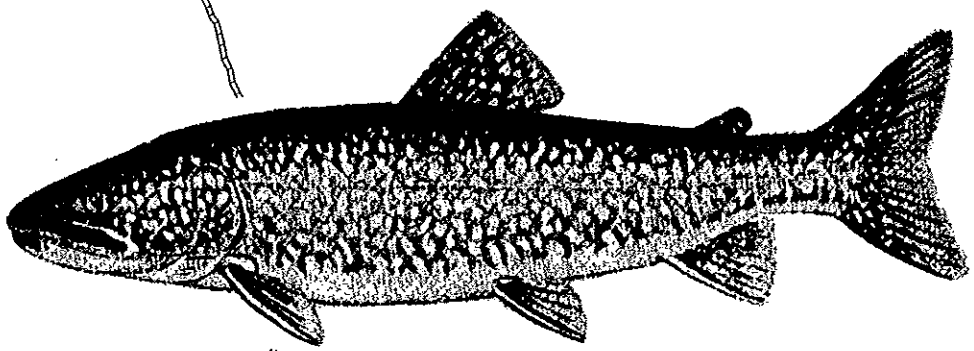
*Administrative Report No. 35*

# Progress Toward Lake Trout Rehabilitation in Wisconsin Waters of Lake Michigan from 1986-1992



**September 1993**

Wisconsin Department of Natural Resources
Bureau of Fisheries Management
Madison, Wisconsin

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**Abstract**

The Lake Michigan Fisheries Management Plan of 1986 addressed the objective of providing in Wisconsin waters of Lake Michigan a naturally reproduced year-class of lake trout that is detectable at the yearling life stage. In this report we review progress toward that objective in three areas defined by the Great Lakes Fishery Commission's lakewide rehabilitation plan: the Clay Banks Primary Zone, in the Midlake Refuge, and in the Secondary Zone.

Four measures of progress are examined: percentage of unclipped lake trout, total annual mortality rate, number of mature age classes, and catch rate of spawners. The percentage of unclipped lake trout remains insignificant, providing no evidence for natural reproduction. Total annual mortality rate has declined to the target of 40% in the vicinity of the Clay Banks Primary Zone, but not in the Secondary Zone. No mortality rate estimates are available for the Midlake Refuge. The number of mature age classes exceeded the goal of seven in the Clay Banks vicinity and near Milwaukee in the Secondary Zone, but not in the Midlake Refuge. The catch rate of spawners increased sharply in a refuge created in the Clay Banks Primary Zone but not in waters of the Primary Zone outside the refuge. The catch rate also increased in the Milwaukee vicinity. Spawning fish were not caught in the Midlake Refuge.

Taken together these data indicate that although no evidence exists for natural reproduction, large spawning populations of lake trout now exist in the Clay Banks Primary Zone and near Milwaukee.

One tactic, the reduction of lake trout harvest in the sport fishery, resulted in the imposition of three controversial sport fishing regulations in 1986; the Clay Banks Refuge was created near Sturgeon Bay, the open season was limited to May 1 through Labor Day, and the daily bag limit was lowered from five to two lake trout. Although the Clay Banks Refuge has not yet resulted in documented natural reproduction by lake trout, the fact that catch rates of spawning lake trout inside the refuge far exceed those in the same vicinity but outside the refuge suggest that the refuge is effective in protecting fish.

## Introduction

Since 1986, fisheries management decisions in Wisconsin waters of Lake Michigan have been guided by the Lake Michigan Fisheries Management Plan (Wisconsin Department of Natural Resources 1986). One of the three broad goals of that plan is the reestablishment of self-sustaining lake trout populations. Toward that long-term goal, the Lake Michigan Fisheries Management Plan of 1986 presented the following specific objective:

> **Provide a naturally reproduced year-class of lake trout that is detectable at the yearling life stage.**

The purpose of this report is to evaluate progress toward that objective through 1992. The term "naturally-reproduced", as used here, means resulting from spawning in Lake Michigan, with no human intervention.

Lake trout management in Wisconsin is part of a lakewide restoration program that involves all four bordering states, the U.S. Fish and Wildlife Service, and the Chippewa-Ottawa Treaty Fisheries Management Authority. That lakewide program was formalized in 1985 in the Lakewide Management Plan for Lake Trout Rehabilitation in Lake Michigan (Appendix B, Holey 1990). That cooperative plan guides efforts by the state of Wisconsin and other agencies to achieve lake trout rehabilitation.

To provide specific guidance to Wisconsin's fisheries managers, the Lake Michigan Fisheries Management Plan of 1986 (LMFMP) specifies a number of management tactics. In this report we review progress toward implementation of each of those tactics.

However, the primary purpose here is to evaluate progress toward the stated objective, that of providing a naturally reproduced year-class of lake trout in Lake Michigan.

### Background

Once the major predator in Lake Michigan, lake trout were driven to extinction by the mid 1950's. The cause of the decline of lake trout remains a matter of controversy, but commercial fishing, predation by sea lamprey, and habitat degradation have been implicated. By 1965 sea lamprey control measures were in place and large-scale stocking of lake trout was initiated in Lake Michigan. Lakewide, stocking increased to 2.5 million by 1972 and has been sustained at high levels.

Lake trout stocking in Wisconsin waters was initiated in 1965 when fish were released at Gills Rock and Kewaunee. The geographic distribution of stocking is best summarized in terms of the rehabilitation zones (Fig. 1) defined by the Great Lakes Fishery Commission (see following section). Since

the early 1980's, over half of all lake trout stocked in Wisconsin waters have been released over the Midlake Reef complex and most of the remainder have been released in waters adjacent to Door County (Fig. 2). Lake trout have been stocked as fingerlings (during the first summer after hatching) or yearlings (during the second summer after hatching). In this report annual stocking totals are expressed in yearling equivalents, the number of yearlings plus the number of fingerlings discounted for mortality between the first and second summers. Lake trout stocking in Wisconsin waters averaged around 900,000 yearling equivalents from 1966 through 1991, ranging from 600,000 in 1984 to 1,300,000 in 1985 (Fig. 2). Eight strains of lake trout have been stocked into Wisconsin waters (Fig. 3), but virtually all stocked fish represented a domestic strain of Lake Superior lake trout (the Marquette strain). Virtually all lake trout stocked in Wisconsin waters have been produced in Federal hatcheries, so the availability of particular genetic strains has at times been affected by epidemics of disease and resulting disinfection programs in those hatcheries.

## Lakewide Management Plan

The Great Lakes Fishery Commission serves as the forum and coordinating body for fisheries management issues that reach beyond the boundaries of individual states. In the early 1980's, the Commission, acting through the Lake Michigan Committee, directed the Lake Michigan Lake Trout Technical Committee to develop a lakewide rehabilitation plan for lake trout in Lake Michigan. The resulting Lakewide Management Plan for Lake Trout Rehabilitation in Lake Michigan (referred to here as the Plan) was completed in 1985. That document is the primary guide for lake trout restoration efforts lakewide. Each management agency is responsible for implementing the provisions that pertain to its jurisdiction. The Plan has been published as an appendix to the "Lake Michigan Lakewide Assessment Plan" (Holey 1990).

The basic objective of the Plan is to put sufficient numbers of the best available strains of lake trout into the best lake trout habitat in Lake Michigan and to protect them from commercial and sport fishing mortality so that they can grow, mature, and spawn. The Plan established four types of management areas: refuges, primary zones, secondary zones, and deferred zones (Fig. 1). Two refuges were created, one around the shallow water reefs near Beaver Island, Michigan, and the other, the Midlake Reef Zone, around the deep water reefs in the middle of the lake, off Port Washington and Milwaukee. In the refuges "fishing for lake trout by all means and by all user groups is strictly prohibited, and no lake trout can be held in possession -- except that assessment sampling by resource agencies is exempted". Primary zones, like refuges, encompass prime lake trout spawning habitat, but fishing can be allowed there (as in secondary zones) under rules established by the individual states. The only primary zone in Wisconsin extends from Baileys Harbor south to Kewaunee (Fig. 1). Secondary zones are areas where spawning habitat is probably not as good as that in primary zones and refuges. Wisconsin's secondary zone begins at Kewaunee and goes south to the Illinois state line, excluding the Midlake Refuge. The Plan calls upon the individual state agencies to provide sufficient protection to lake trout in the primary and secondary zones to limit total annual mortality in those areas to 40%. The Plan proposes no mortality goals for the deferred-rehabilitation zone and calls for the postponement of rehabilitation efforts there.

For purposes of allocating federally produced and stocked lake trout, the Plan prioritizes the management areas as follows: 1) refuges (Beaver Island and Midlake, not Clay Banks), 2) primary zones, and 3) secondary zones. No fish are to be stocked in the deferred zone.

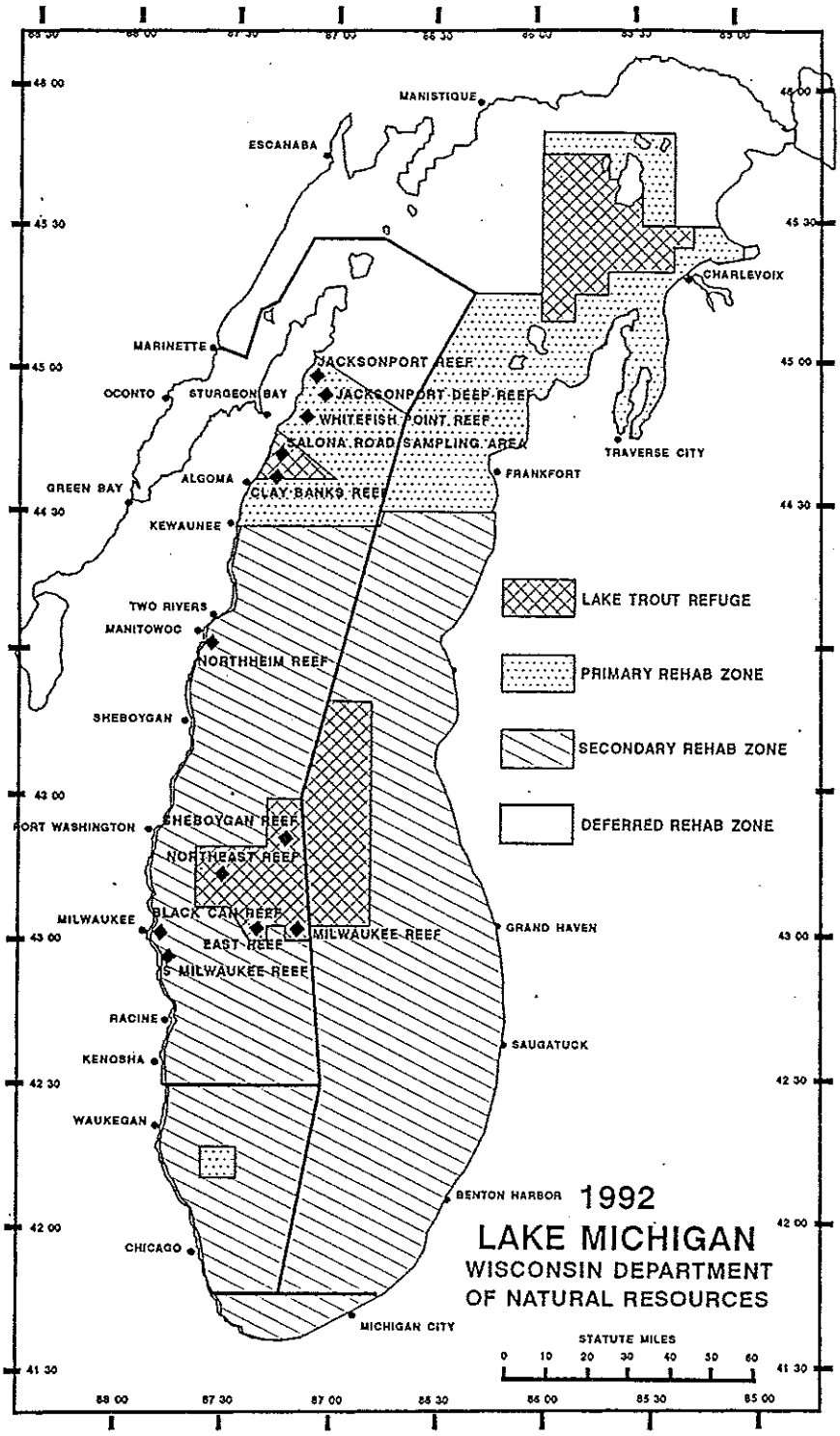


Figure 1. Lake trout management areas and assessment locations.

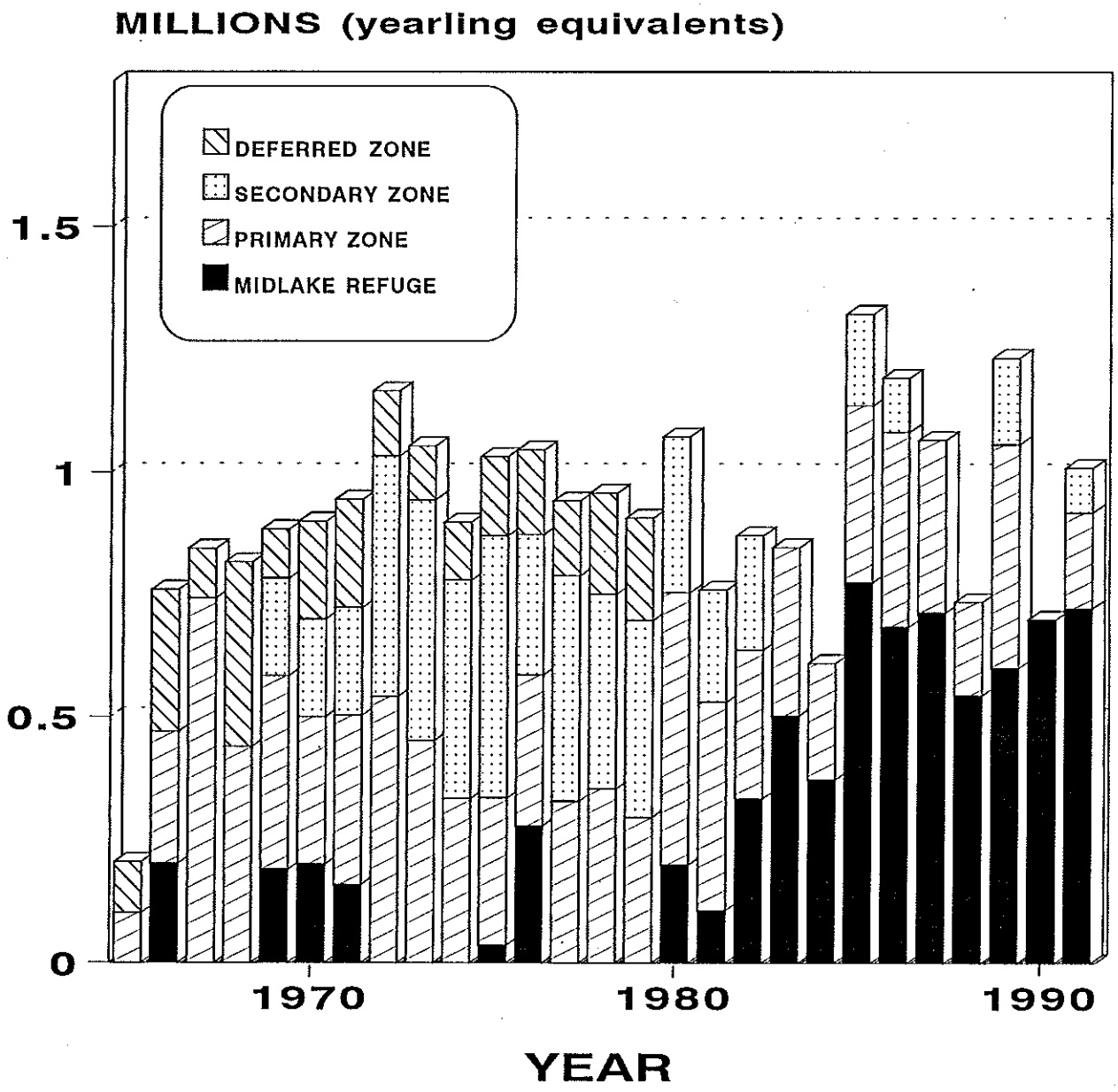


Figure 2. Numbers of lake trout stocked in four lake trout management areas Lake Michigan annually from 1966 through 1991.

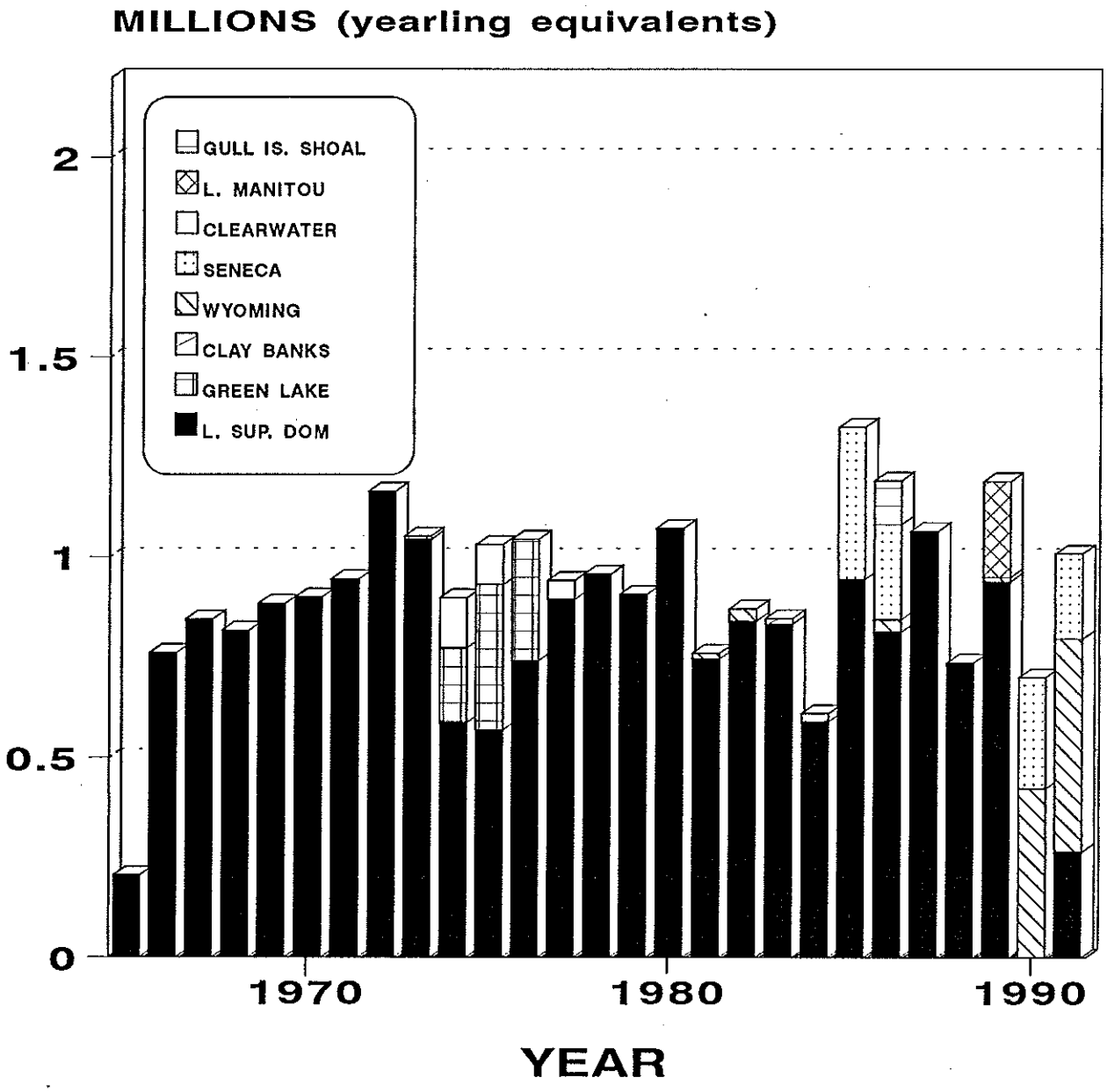


Figure 3. Numbers of lake trout of eight strains stocked in Lake Michigan annually from 1966 through 1991. The name "Clay Banks" refers to feral fish collected in the vicinity of the Clay Banks Primary Zone.

This has resulted in substantially higher levels of stocking in the refuges and primary zones than in the secondary zones. The Plan specifies, however, that if the individual state agencies cannot protect lake trout sufficiently to hold total annual mortality below 40% in any zone, the technical committee will recommend downgrading of the planting priority for that zone.

## Implementation of Tactics

The Lake Michigan Fisheries Management Plan of 1986 (LMFMP) expresses the goal of reestablishing self-sustaining lake trout populations. The LMFMP does not define what constitutes reestablishment of self-sustaining populations. We would consider the goal to have been attained when the offspring of stocked lake trout themselves reproduce in Lake Michigan, but not until then.

The LMFMP also presents the more limited objective of producing a naturally reproduced year-class of lake trout that is detectable at the yearling life stage. Within a framework of recognized problems and subobjectives, the LMFMP specifies a number of tactics designed to lead to attainment of the objective. In this section we review progress toward implementation of each of those tactics.

OBJECTIVE: Produce a naturally reproduced year-class of lake trout that is detectable at the yearling life stage.

Problem 1: An insufficient number of lake trout eggs are being deposited on ideal spawning substrate.

Tactic: Develop an egg-taking operation or a brood stock as naturally produced lake trout begin to mature to enhance egg deposition.

> Current Status: Because no naturally produced fish have been detected, no egg-taking operation has been developed.

Tactic: Map the spawning reefs designated for rehabilitation to identify ideal spawning substrate.

> Current Status: Bathymetric charts have been completed for Sheboygan Reef, Clay Banks Reef, and Whitefish Point Reef. The chart for Clay Banks (Edsall et al. 1992) also includes substrate composition that has been verified by underwater video and diving. Data for the Jacksonport Deep Reef has been collected but not summarized in chart form.

Problem 2: Knowledge of the relationship between levels of micro-contaminants and early-life mortality is insufficient.

Tactic: Monitor micro-contaminant levels in lake trout closely, and periodically describe the survivability of eggs taken from lake Michigan fish.

> Current Status: Contaminant levels in lake trout have been monitored and the survivability of lake trout eggs from Lake Michigan has been measured. Monitoring indicates that the concentration of some contaminants in lake trout from Lake Michigan have decreased over theyears. When eggs of lake trout from the Clay

Banks Primary Zone were incubated in Lake Michigan, nearly 50% survived to hatch (Edsall et al. 1992). Sub-lethal effects of contaminants have not been studied.

Problem 3: It is difficult to detect young naturally reproduced lake trout.

Tactic: Develop and utilize techniques for detecting naturally reproduced lake trout at an early life stage.

Current Status: A small mesh gill net survey has been established in the Clay Banks area to assess the relative abundance of two-year-old lake trout. To sample younger lake trout would require the use of trawls or smaller-mesh gill nets. Traps and nets have been developed elsewhere for collecting lake trout eggs (Marsden et al. 1991) as they are spawned. Attempts to use those devices in the Clay Banks primary zone yielded only two eggs (Edsall et al. 1992).

Problem 4: Public support for the lake trout rehabilitation plan is weak.

Tactic: Provide regular reports to user groups to keep them informed.

Current Status: Annual reports have been prepared for the Great Lakes Fishery Commission. A number of oral presentations have been given. Regular written reports to the user groups have not been prepared.

SUBOBJECTIVE A: Manage fisheries mortality of lake trout to provide an average annual mortality of not more than 40%, lakewide.

Problem 1: Too many lake trout are being removed by commercial and sport fishers.

Tactic: Reduce lake trout removal by commercial and sport fisheries by the following means: <u>Commercial</u> 1) Don't stock near fishery. 2) Create restricted fishing areas by depth. 3) Require low-profile nets in shallow water. 4) Issue lake trout tags and close the season when lake trout are caught. 5) Develop gear that selects against lake trout. 6) Create refuge areas. 7) Close fisheries. <u>Sport</u> 1) Don't stock near fishery. 2) Reduce bag limit. 3) Shorten the season. 4) Issue lake trout tags. 5) Create no-possession areas. 6) Create refuge areas. 7) Close the season. 8) Set a size limit. 9) Limit use of lake trout gear (wire lines).

Current Status: A series of sport and commercial regulations have been implemented to limit the total kill of lake trout. A Midlake Refuge had already been created to protect lake trout on the

Sheboygan Reef. The boundaries have been enlarged several times since then, with the final enlargement of the Midlake Refuge in 1989. It now encompasses all four midlake reefs (Fig. 1).

The increasing sport harvest of lake trout from Lake Michigan in the early 1980's prompted the WDNR to implement new regulations on the sport fishery. In 1986 the open season was limited to May 1 through Labor Day, the daily bag limit was lowered from five to two, and a refuge between Sturgeon Bay and Algoma was created (Fig. 1). Fishing for lake trout is prohibited inside the refuge.

In 1986, to address the concern of incidental kill of lake trout and chinook salmon by gill nets set for bloater chubs and yellow perch, the WDNR restricted the height of gill nets used in water shallower than 150 feet. In 1989 the WDNR eliminated most commercial fishing from Baileys Harbor to Kewaunee (with limited exceptions for entrapment gear targeting lake whitefish and small-mesh gill nets targeting bloater chubs). In 1989 the WDNR opened a winter chub season, but limited fishing to waters deeper than 360 feet. 1989 was also the first year in which lake whitefish and yellow perch (outside southern Green Bay) were allocated through individually transferable quotas.

Problem 2: Lamprey continue to prey on lake trout and could become a major limiting factor.

Tactic: Continue support of the lamprey control program at the 1981-83 level or better.

Current Status: The State of Wisconsin has continually supported the sea lamprey control program of the Great Lakes Fishery Commission.

Problem 3: Present number of assessment surveys is inadequate to measure the mortality rate lakewide.

Tactic: Conduct lake trout assessment surveys in representative areas lakewide in a consistent format, to provide adequate population data for determination of mortality rates and spawning densities.

Current Status: The Lake Michigan Lake Trout Assessment Plan (Holey 1990) outlines lake trout assessment needs and procedures for Wisconsin. Surveys conducted in conformity with that assessment plan are outlined below under "Methods".

SUBOBJECTIVE B: Develop lake trout populations in two primary rehabilitation areas that exhibit seven mature age classes and either a) an October spawning density of four trout per acre of spawning reef or b) an annual egg deposition density of 3,000 fertilized eggs per acre of spawning reef.

Problem 1: The number of mature lake trout spawning on suitable reefs is inadequate.

Tactic: Stock lake trout with rehabilitation as the main objective and with harvest as a secondary objective.

Current Status: Stocking since 1985 has been directed to those areas that we think have the best chance to realize natural production, the Midlake Refuge and the Clay Banks Primary Zone (which includes a refuge).

Tactic: Stock lake trout over ideal spawning habitat instead of from shore.

Current Status: Since 1985 all lake trout have been stocked by boat over traditional spawning reefs identified by Coberly and Horrall (1980) by subsequent reef mapping studies (Edsall et al. 1992).

Tactic: Investigate whether stocking lake trout at earlier life stages than the yearling stage would result in better homing of those fish as adults.

Current Status: Wisconsin Department of Natural Resources (WDNR) biologists working in Lake Superior have developed a technique (known as astroturf incubators) for stocking lake trout eggs in such a way that they were sheltered from predation (Swanson 1982). In 1988 and 1989 that technique was used to stock a total of 2.6 million eggs on an offshore reef called the Jacksonport Deep Reef (Fig. 1). This was a cooperative project between WDNR and commercial fishers from Door County.

Tactic: Construct an artificial spawning reef.

Current Status: This has not been done, but it remains under consideration.

Tactic: Determine locations of all suitable spawning reefs.

Current Status: Extensive diving surveys have been conducted to locate suitable spawning habitat. The WDNR has worked cooperatively with the U.S. Fish and Wildlife Service to conduct sidescan sonar and underwater video surveys and to produce a contour and substrate map of Clay Banks Reef (Edsall et al. 1992).

The WDNR has also used sonar to produce contour maps of Sheboygan Reef, Clay Banks Reef, and Whitefish Point Reef.

Problem 2: The strain of lake trout stocked may be inappropriate for rehabilitation in Lake Michigan.

Tactic: Begin to stock and evaluate the performance of the following lake trout strains as recommended by the Lakewide Management Plan for Lake Trout Rehabilitation in Lake Michigan: Lake Superior domestic, Gull Island Shoal and domestic cross, Wyoming strain, Green Lake strain, and Seneca strain.

Current Status: Since 1985 the federal hatchery system has produced a number of lake trout strains that have been stocked in Lake Michigan. However, disease problems in federal hatcheries have limited production of the strains that were called for by the Plan, so roughly two-thirds of all lake trout stocked in Wisconsin waters since 1985 have been of the Marquette domestic strain. Most of the special strains have been stocked in the Beaver Island and Midlake Refuges.

## Evaluation Methods

The preceding section provides a review of the tactics employed to achieve the objective of providing a naturally reproduced year-class of lake trout. But the primary purpose of this report is to evaluate progress toward that objective. Because we are interested in three distinct rehabilitation areas (Midlake Refuge, Clay Banks Primary Zone, and Secondary Zone), a separate evaluation was made for each area. Only data collected from 1986 through 1991 are summarized here.

### Collection of adult lake trout

The primary assessment tool used to collect adult lake trout was the graded-mesh gill net. Collections were made during summer and fall using graded-mesh multifilament-nylon gill nets. Summer collections were directed at both immature and mature lake trout; fall collections were directed at only mature fish. During summer the standard net consisted of nine 100-foot sections, with mesh sizes (stretch measure) of 2", 2.5", 3", 3.5", 4", 4.5", 5", 5.5", and 6". During fall the standard net consisted of four 250-foot sections, with mesh sizes of 4.5", 5", 5.5", and 6". The dimensions and mesh sizes of gill nets used in the assessment work occasionally departed from these standards. Gill nets were, with few exceptions, set for one night.

Summer collections were made in each of the rehabilitation areas (Fig. 1). Each year from 1987 through 1991 they were made on all four reefs encompassed by the Midlake Refuge. In 1986 collections were made on three of four reefs, with only the Milwaukee Reef omitted. Summer collections in the Midlake Refuge were made at the shallowest depths on each reef. Within the Clay Banks Primary Zone, summer collections were made in the Clay Banks Refuge adjacent to the Clay Banks Reef annually from 1986 through 1991. In the Secondary Zone, summer collections were in the South Milwaukee Reef area and in the Northeim Reef area near Manitowoc.

Fall collections in the Midlake Refuge were confined to the Sheboygan Reef. Five areas within the Clay Banks Primary Zone were visited for fall sampling. Within the Clay Banks Refuge fall collections were made in the Salona Road area and near the Clay Banks Reef annually from 1986 through 1991. Outside the Refuge collections were made at the nearshore Jacksonport Reef area in 1986 and 1987, at the Jacksonport Deep Reef in 1989, and at the Whitefish Point Reef in 1987, 1989, and 1991. Fall collections within the Secondary Zone were made annually during 1986 through 1991 in the South Milwaukee Reef area and near Black Can Reef.

From 1986 through 1990 spring (May and June) collections were made annually using a 30-foot-deep commercial whitefish pound

net in the Clay Banks Refuge near Sturgeon Bay..

Measures of progress

One direct measure of success is the **percentage of unclipped lake trout** found in assessment collections. Almost all stocked lake trout are clipped (i.e., one or more fins are clipped off), so this percentage approximates the percentage of naturally reproduced lake trout present. However, because some stocked fish escape the clipping process and because fins can be regenerated, some adult lake trout will appear unclipped even when no natural reproduction occurs. Other measures of success are indirect and are designed to detect conditions that are probably necessary for significant natural reproduction.

In order to provide a basis for evaluating progress toward the objective, the LMFMP provides the following criteria, which are considered necessary conditions for attainment of the objective:

1) A total annual mortality rate not exceeding 40%.

2) A minimum of seven mature age classes.

3) A spawning density of 4 mature lake trout per acre of spawning reef.

4) A minimum annual deposition of 3,000 fertilized eggs per acre of spawning reef.

We used **total annual mortality rate** and **number of mature age classes** to address the first two criteria. We did not address the third criteria with estimates of absolute spawning abundance. Instead we used **catch rate of spawning adults**, a measure of relative abundance. We attempted to assess egg deposition but did not estimate egg deposition rates (Edsall et al. 1992).

Ages of captured lake trout were determined from fin clips and scales. Only females collected during fall were used in determining the number of mature age classes. The number of mature age classes is the number of distinct ages (among females in the catch) equal to or older than the age of female maturity (six years for nearshore fish, eight years for lake trout in the Midlake Refuge). Catch rates, expressed in lake trout per 1000 feet of gill net (gill nets were almost always set for one night), were computed by age group for each assessment. Total annual mortality rates were computed, using standard methods (Ricker 1975), from age-specific catch rates of age classes fully vulnerable to assessment gear. Egg traps (Marsden et al. 1991) were used to assess egg deposition.

## Results

As described above, we used four measures of progress toward the lake trout objective. The percentage of unclipped lake trout was a direct measure of progress. Total annual mortality rate, number of mature age classes, and catch rate of spawners were indirect measures of progress. We attempted to assess egg deposition, but did not develop estimates of egg deposition rates.

### Unclipped lake trout

Midlake Refuge: Summer surveys in the Midlake Refuge showed increasing percentages of unclipped lake trout (Table 1), except on the Northeast Reef. In 1991 unclipped lake trout comprised 8.8% (based on a sample size of only 34 fish) of the catch on the Milwaukee Reef, 3.0% on the East Reef, 2.2% on the Sheboygan Reef, and 0.0% on the Northeast Reef. Fall collections in the Midlake Refuge were confined to the Sheboygan Reef where the percentage of unclipped lake trout never exceeded 1.9% and showed no increasing trend.

Clay Banks Primary Zone: The percentage of unclipped lake trout caught during summer surveys in the Clay Banks Primary Zone never exceeded 2.2% and fell to 0.0% in 1990 and 1991 (Table 1). Percentages among spawning males caught during fall in the Clay Banks Primary Zone never exceeded 3.4% and varied from year to year with no clear pattern.

Secondary Zone: Unclipped lake trout never made up over 2.0% of fish collected during summer and fall in the Manitowoc, South Milwaukee, and Black Can Reef areas (Table 1).

### Total annual mortality rate

Midlake Refuge: Slow growth and maturation of fish in the Midlake Reef and, possibly, migration of fish out of that area prevented the calculation of reliable mortality estimates.

Clay Banks Primary Zone: The only area in Wisconsin waters of Lake Michigan where adequate surveys were conducted and where the 40% total annual mortality goal was achieved is the Clay Banks Primary Zone. Estimates of mortality based on fish collected during summer and fall gill netting and during spring pound netting declined to levels near or below 40% (Fig. 4).

Secondary Zone: Mortality estimates in most years from both the Northeim Reef (near Manitowoc) and the South Milwaukee Reef usually exceeded 50% (Fig. 5).

### Number of mature age classes

Midlake Refuge: Lake trout in the Midlake Refuge grow slower and mature later than lake trout in near-shore areas. We were not able to capture significant numbers of spawning

Table 1. Percentages of unclipped lake trout in summer and fall collections in the Midlake Refuge, the Clay Banks Primary Zone, and the Secondary Zone.

| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|
| SUMMER | | | | | | |
| Midlake Refuge | | | | | | |
| Sheboygan Reef | 0.2 | 0.1 | 0.0 | 0.3 | 1.2 | 2.2 |
| Northeast Reef | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| East Reef | 1.0 | 0.0 | 0.4 | 0.0 | 3.8 | 3.0 |
| Milwaukee Reef | - | 0.0 | 0.0 | 4.7 | 5.0 | 8.8 |
| Clay Banks Primary Zone | | | | | | |
| Clay Banks Reef | 1.2 | 0.6 | 1.9 | 2.2 | 0.0 | 0.0 |
| Secondary Zone | | | | | | |
| Northeim Reef | 0.4 | 0.0 | 0.5 | 0.0 | 0.9 | - |
| S. Milwaukee Reef | 1.4 | 0.8 | 0.0 | 0.4 | 1.9 | - |
| FALL[1] | | | | | | |
| Midlake Refuge | | | | | | |
| Sheboygan Reef | 0.1 | 0.8 | 1.9 | 1.0 | 0.3 | 0.3 |
| Clay Banks Primary Zone | | | | | | |
| Clay Banks Reef | 2.0 | 2.0 | 1.8 | 2.4 | 2.7 | 1.3 |
| Salona Road area | 1.0 | 1.1 | 0.7 | 2.1 | 3.4 | 1.4 |
| Secondary Zone | | | | | | |
| S. Milwaukee Reef | 0.8 | 0.5 | 0.5 | 0.3 | 1.6 | 0.6 |
| Black Can Reef | 1.0 | - | 0.7 | - | 0.6 | 0.3 |

[1] Data from fall collections in the Primary and Secondary Zones include only male lake trout.

females in the vicinity of the Sheboygan Reef in the Midlake Refuge, but the limited catches indicate that female lake trout do not mature before the age of eight. The number of mature age classes collected on the Sheboygan Reef never exceeded two. The mean age of all lake trout (males and females) caught in fall never exceeded 6.1 years, well below the age of maturity.

Clay Banks Primary Zone: Most females mature at the age of six in near-shore areas. The number of mature age classes collected during fall in the Salona Road area and on the Clay Banks Reef ranged from six to ten during 1986 through 1991 (Table 2). The number increased in each area, from eight to ten on the Clay Banks Reef and from seven to nine in the Salona Road area. That pattern is reflected in mean ages of males collected from those areas. The mean age of males collected in the Salona Road area increased from 6.2 years in 1986 to 7.3 years in 1991. On the Clay Banks Reef, the mean age increased from 6.3 years in 1986 to 7.2 years in 1991. In areas outside the refuge but within the Primary Zone the number of mature age classes collected never exceeded five (Table 2).

Secondary Zone: The oldest male lake trout caught during our assessments were in the Secondary Zone. At Black Can Reef and South Milwaukee Reef the number of mature age classes never fell below seven (Table 2).

Catch rates of spawners

Midlake Refuge: Large numbers of spawning lake trout have yet to be sampled on the Sheboygan Reef. Immature lake trout do not segregate during spawning on the midlake reefs like they do at near-shore sites, so the majority of lake trout caught during fall surveys in the Midlake Refuge were immature. The total catch rate of lake trout caught on the Sheboygan Reef during the fall declined from 71 per 1000 feet of net in 1986 to 18 in 1991.

Clay Banks Primary Zone: The catch rate of spawning lake trout increased substantially within the Clay Banks Refuge. The catch rate in the Salona Road area increased from 91 fish per 1000 feet in 1986 to 143 in 1991 (Table 3). At the Clay Banks Reef site the catch rate increased from 68 fish per 1000 feet in 1986 to 179 in 1989, declining to 153 in 1991. Outside the Refuge the catch rate peaked at 19 fish per 1000 feet at Jacksonport Reef in 1987.

Secondary Zone: The second highest catch rate of spawning lake trout occurred in the Secondary Zone near Milwaukee. At Black Can Reef near Milwaukee the catch rate of lake trout ranged from 94 to 143 fish per 1000 feet, with a peak in 1990 (Table 3). At the South Milwaukee Reef the catch rate increased from 91 fish per 1000 feet in 1986 to a peak of 128 in 1989, but dropped to 94 in 1991.

Table 2. Number of mature female age classes in fall collections in the Clay Banks Primary Zone and the Secondary Zone.

| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|
| Clay Banks Primary Zone | | | | | | |
| Within the Refuge | | | | | | |
| Clay Banks Reef | 8 | 7 | 7 | 6 | 8 | 10 |
| Salona Road area | 7 | 7 | 7 | 7 | 8 | 9 |
| Outside the Refuge | | | | | | |
| Jacksonport Reef | - | 5 | - | - | - | - |
| Jacksonport Deep Reef | - | - | - | 1 | - | - |
| Whitefish Point | 2 | 4 | - | 1 | - | 5 |
| Secondary Zone | | | | | | |
| S. Milwaukee Reef | 9 | 9 | 8 | 9 | 8 | 10 |
| Black Can Reef | 9 | - | 9 | - | 7 | 9 |

Table 3. Catch rates (fish caught per 1000 feet of gill net set one night) of spawning lake trout in fall collections in the Clay Banks Primary Zone and the Secondary Zone.

| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|
| Clay Banks Primary Zone | | | | | | |
| Within the Refuge | | | | | | |
| Clay Banks Reef | 68 | 106 | 131 | 179 | 157 | 153 |
| Salona Road | 91 | 84 | 199 | 141 | 136 | 143 |
| Outside the Refuge | | | | | | |
| Jacksonport Reef | - | 19 | - | - | - | - |
| Jacksonport Deep Reef | - | - | - | 4 | - | - |
| Whitefish Point | 7 | 8 | - | 7 | - | 8 |
| Secondary Zone | | | | | | |
| S. Milwaukee Reef | 91 | 92 | 100 | 128 | 80 | 94 |
| Black Can Reef | 109 | - | 94 | - | 143 | 137 |

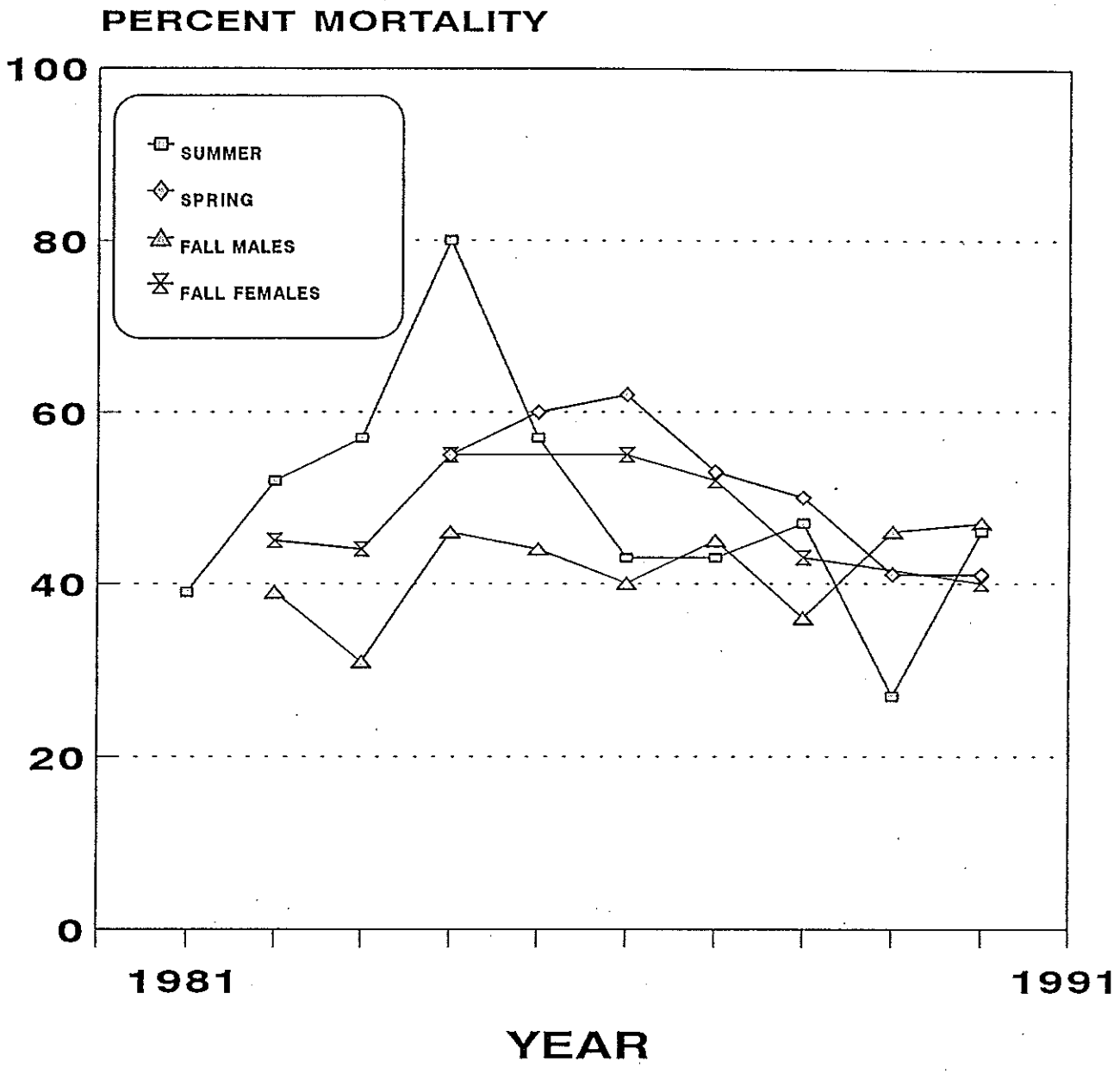


Figure 4. Total annual mortality rates estimated for the Clay Banks Primary Zone using summer collections (both sexes), spring collections (both sexes), and fall collections of males and females.

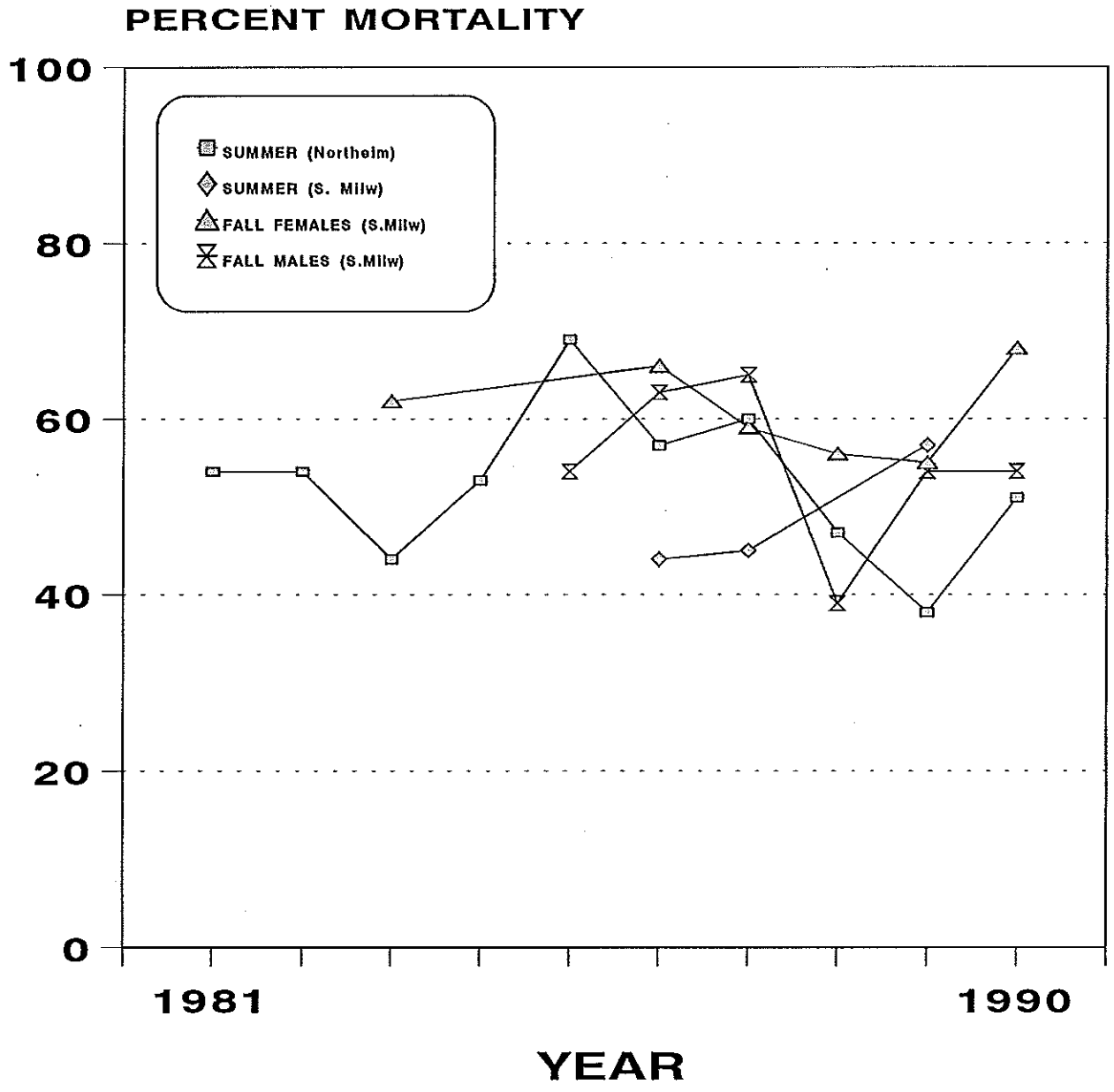


Figure 5. Total annual mortality rates estimated for the Secondary Zone using summer collections (both sexes) from Northeim Reef and South Milwaukee Reef and fall collections of males and females from South Milwaukee Reef.

## Discussion

Lake trout rehabilitation efforts in Wisconsin waters of Lake Michigan since 1965 have allowed the development of fishable stocks. The goal of restoring self-sustaining stocks, however, remains elusive.

The Lake Michigan Fisheries Management Plan of 1986 presented a specific objective, that of providing a naturally reproduced year-class of lake trout that is detectable at the yearling life stage. Attainment of that primary objective would represent the first step in re-establishing self-sustaining lake trout populations.

Has the primary objective been met?

There is no conclusive evidence that the primary objective has been met. The occurrence of increasing percentages of unclipped lake trout would be the best evidence of a naturally reproduced year-class. Unfortunately, we cannot conclude that any meaningful number of naturally reproduced lake trout have been detected by our surveys. It may seem encouraging that in the Midlake Refuge the percentages of unclipped lake trout seem to be increasing (Table 1). But those percentages are still low, are based on very small sample sizes, and could easily represent a few stocked fish that were missed in the clipping process or whose clipped fins have regenerated. It is discouraging that the percentages of unclipped lake trout within the Clay Banks Refuge fell to zero in 1990 and 1991 (Table 1).

Are sport fishing regulations imposed in 1986 working?

Regulation changes imposed since 1986 have affected both commercial and sport fishing in Wisconsin waters of Lake Michigan. Although those regulations probably played a role in allowing the development of large spawning populations, particularly in the Clay Banks Primary Zone, there is no direct evidence that they have resulted in attainment of the primary objective of the LMFMP, the production of a naturally-reproduced year-class of lake trout. However, it is too soon to expect that outcome from regulations enacted so recently. In nearshore waters (where lake trout reach sexual maturity at the age of 6) offspring of stocked lake trout would not be detectable as spawning adults until twelve years after stocking (Table 4).

Collectively the sport and commercial regulations seem to have worked to protect lake trout and enhance spawning stocks, although other factors, including stocking practices (Fig. 2), may have played important roles. Three indirect measures of progress are encouraging: (1) Total annual mortality rate has been reduced to approximately 40% inside the Clay Banks Primary Zone (Fig. 4). (2) The

spawning populations within the Clay Banks Refuge and in the Milwaukee area comprise nine or ten mature year classes (Table 2). (3) Catch rates of spawning lake trout are high inside the Clay Banks Refuge and in the Milwaukee vicinity (Table 3). Progress was greater in the Clay Banks Primary Zone, where total mortality rates declined (Fig. 4) and catch rates increased sharply (Table 3), than in the Secondary Zone, where total mortality rates did not decline (Fig. 5) and catch rates increased only moderately (Table 3).

The fact that catch rates of spawning adults was very high inside the Clay Banks Refuge but very low in areas inside the Clay Banks Primary Zone but outside the refuge (Table 3) indicates that the refuge is effective in protecting lake trout. Progress in enhancing spawning stocks in the Clay Banks Primary Zone can therefore be attributed to the existence of the refuge. We do not believe that present data allow a firm conclusion to be drawn regarding the effects of the other two sport fishing regulations imposed in 1986: limitation of the open season, and reduction of the daily bag limit. Assessment of the effects of those regulations is confounded by (among other things) changing stocking patterns (Fig. 2) and changes in incidental lake trout kills in commercial fisheries (Fig. 6).

One factor affecting lake trout survival within the Clay Banks Primary Zone but outside the refuge was the incidental kill of lake trout in the commercial fishery for lake whitefish. Regulation changes imposed since 1989 seem to have brought this problem under control. The number of lake trout killed in that fishery in the waters of Door county jumped from 4,000 in 1985 to 40,000 in 1988, before dropping sharply in 1989 and falling to 7,000 in 1991 (Fig. 7). Throughout those years the sport harvest of lake trout in Lake Michigan waters of Door and Kewaunee Counties remained fairly constant (Fig. 8).

Unanswered questions

Rehabilitation techniques employed since 1965 have focussed on two types of actions: 1) Large scale stocking of yearling or fall-fingerling lake trout. 2) Controlling mortality due to sport fishing, commercial fishing and lamprey predation. Those broad strategies might not adequately deal with the factors that limit successful rehabilitation. Among the factors that might be involved are stocking practices, habitat degradation, genetic adaptations, and toxic contaminants.

**Stocking practices.** The technique of stocking yearling and fingerling lake trout has been adequately tested, but other potentially useful techniques have not been given an adequate test. Although

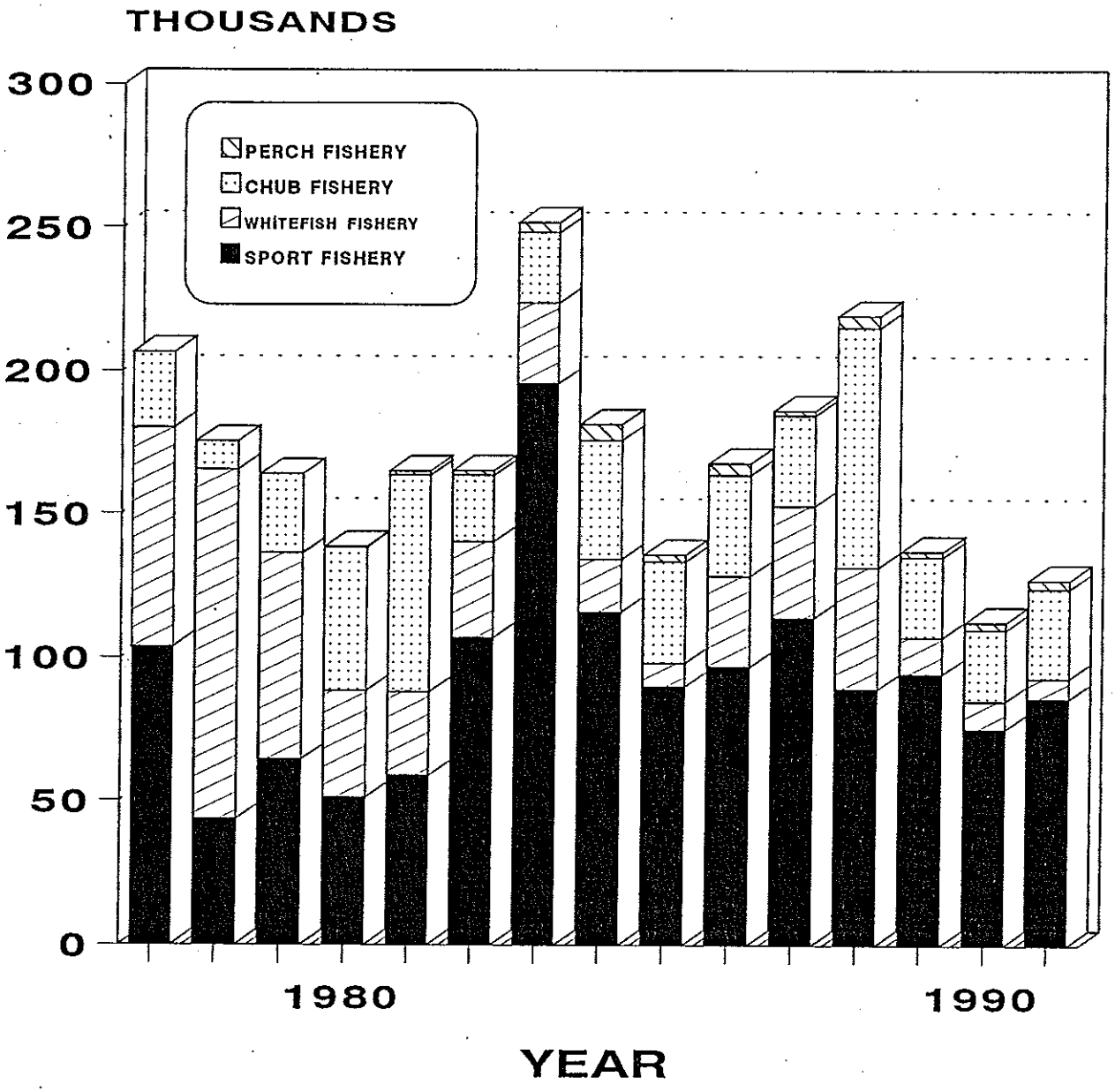


Figure 6. Estimated numbers of lake trout killed annually from 1977 through 1991 by the sport fishery and by commercial fisheries for lake whitefish, bloater chubs, and yellow perch.

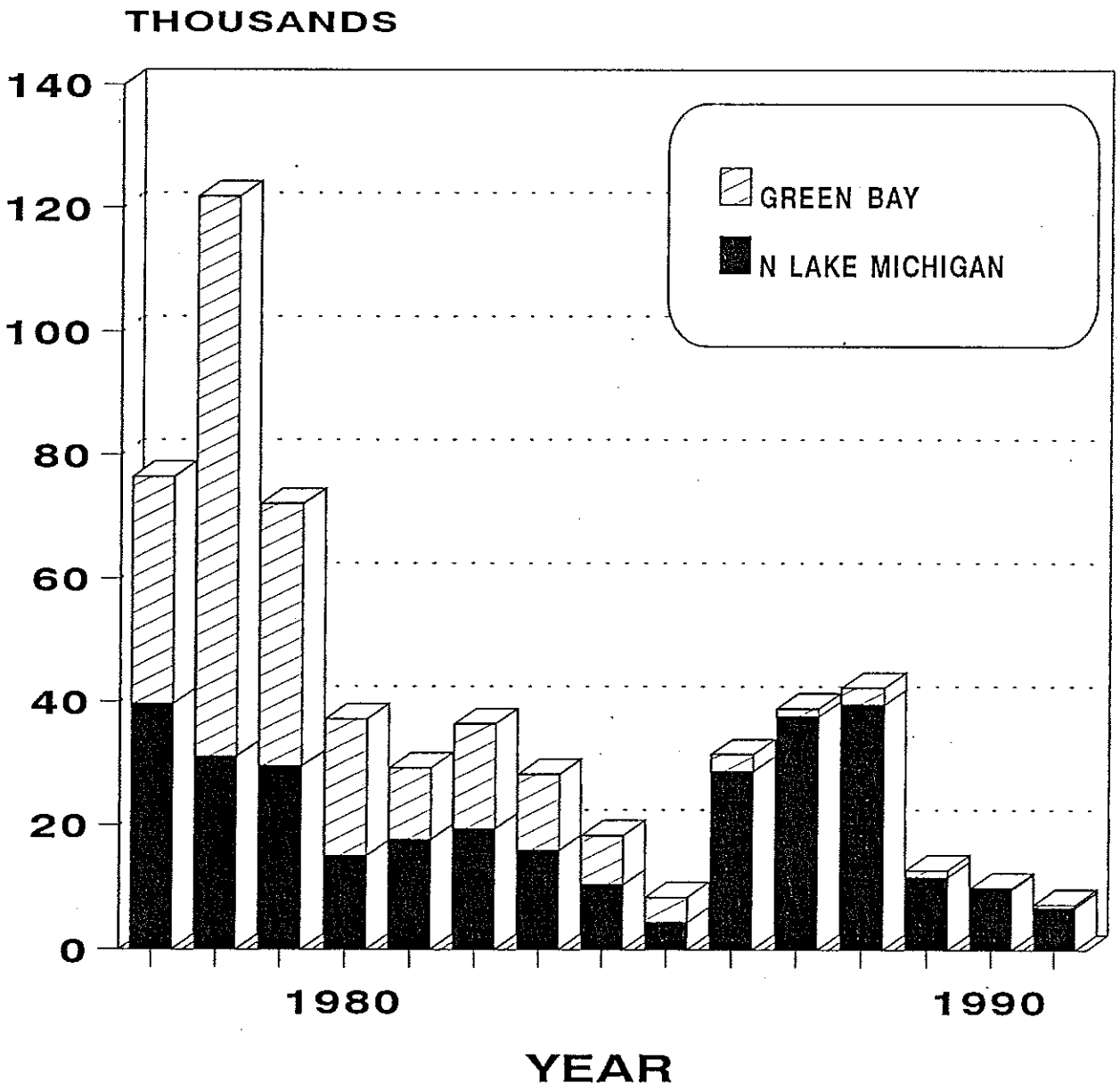


Figure 7. Estimated numbers of lake trout killed annually in the commercial fishery for lake whitefish from 1977 through 1991 in Lake Michigan and Green Bay waters of Door County.

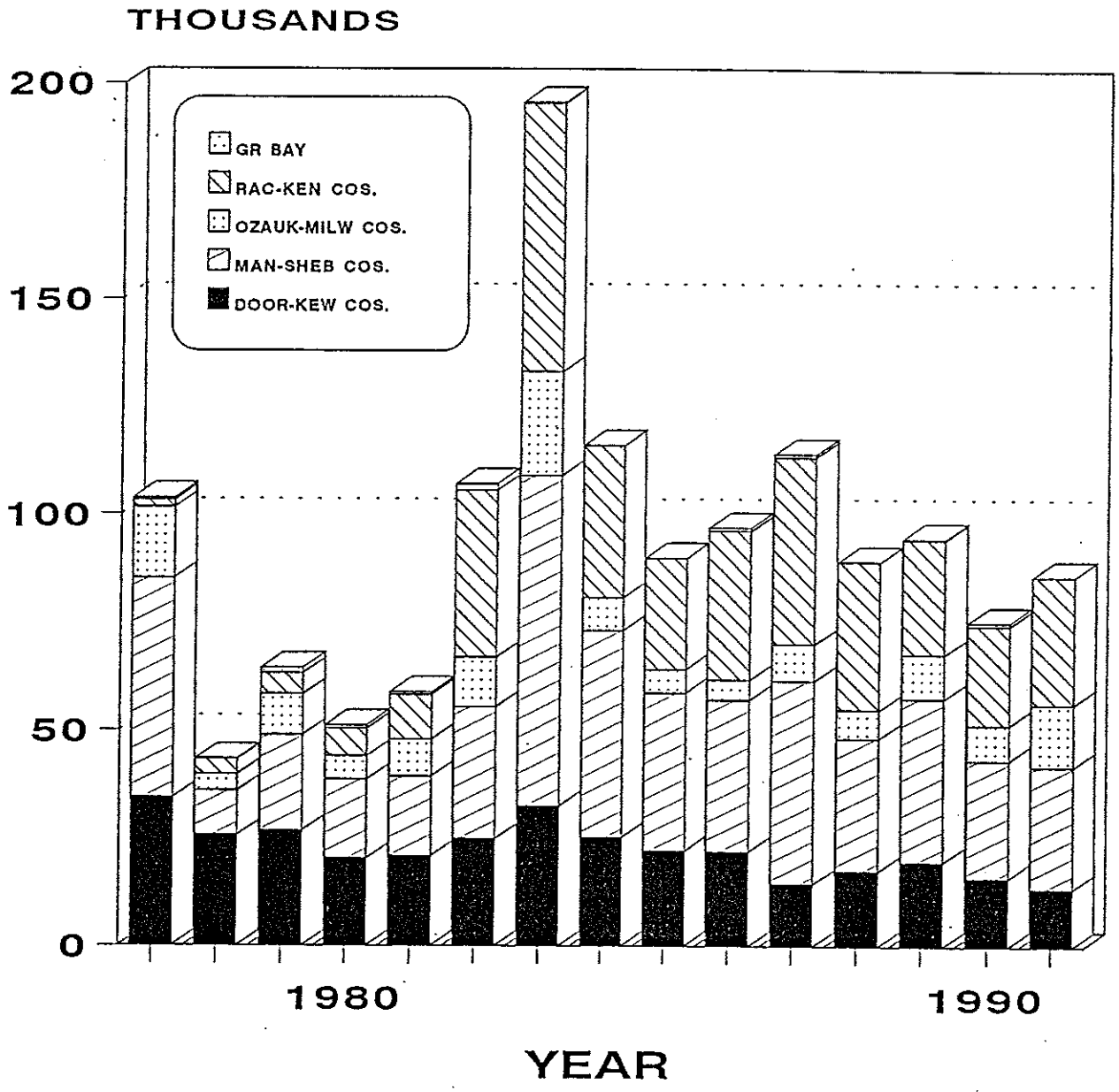


Figure 8. Estimated numbers of lake trout killed annually from 1977 through 1991 by sports fishermen in five areas of Wisconsin waters of Lake Michigan.

stocking of fertilized eggs is currently being tried by WDNR on the Jacksonport Deep Reef, it is premature to judge its effectiveness. However, in 1991 and 1992 we received reports of unclipped lake trout in the nets of commercial chub fishers in the Baileys Harbor area. Those immature lake trout could have been survivors of eggs stocked on the Jacksonport Deep Reef in 1989 and 1990. Fry stocking was attempted on a limited scale by Dr. Ross Horrall, but has not been adequately tested. Trap and transfer of wild adult spawners has been discussed but not tested.

**Habitat degradation.** Our knowledge of the location and gross features of possible spawning areas is growing (Coberly and Horral 1980, Edsall et al. 1992), but we lack adequate knowledge of what constitutes good lake trout spawning habitat. Most of the present knowledge about where native lake trout spawned in Lake Michigan prior to their extinction is based on interviews with commercial fishermen (Coberly and Horrall 1980). Present knowledge of the spawning habitat requirements of lake trout is inadequate to allow us to know whether or not traditional spawning areas have been degraded to the point where they will not support reproduction.

**Genetics.** The possible importance of genetic adaptations has been recognized for many years. However, we have not been able to assess strains other than the Marquette domestic strain on a meaningful scale, largely because disease problems in the federal hatcheries that supply lake trout for stocking have limited production of the strains that were called for by the Plan.

**Toxic contaminants.** Regarding the effects of contaminants on lake trout reproduction the data are equivocal. Some studies (Stauffer 1979, Edsall et al. 1992) have indicated that eggs from lake trout in Lake Michigan survive well when incubated and hatched in Lake Michigan, while other studies (Mac et al. 1985) suggest that there is a contaminant problem.

Table 4. Timetable illustrating the minimum time needed for stocked lake trout to produce offspring that can be detected as yearlings or as spawning adults. This time table pertains to nearshore waters of Lake Michigan where lake trout reach sexual maturity at the age of six.

| | year | age of stocked fish | age of youngest offspring |
|---|---|---|---|
| Stocking of yearlings | 1 | 1+ | |
| First spawning by stocked fish | 6 | 6+ | |
| Offspring of stocked fish detectable as yearlings | 8 | 8+ | 1+ |
| Offspring of stocked fish detectable as spawning adults | 13 | 13+ | 6+ |

## Conclusions

Efforts to restore self-sustaining populations of lake trout in Lake Michigan have not yet succeeded and, although reductions in the use of large mesh gill nets, the institution of the Clay Banks Refuge and, possibly, other regulations have protected stocked lake trout and allowed the development of large spawning populations, it is not clear that those measures are sufficient to allow restoration of natural reproduction. The goal of restoring natural reproduction by lake trout in Lake Michigan and the appropriate methods for achieving that goal should be reviewed during the process of developing the new **Lake Michigan Integrated Fisheries Management Plan.**

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**Acknowledgments**

The work reported here would not have been possible without the perseverance and dedication of the captains and crew of the Barney Devine; we thank Frank Schmidt, Dick Pagel and numerous crew members. We thank the professional, technical, and seasonal staffs of the Sturgeon Bay and Milwaukee Field Offices (especially those who ventured out to the Sheboygan Reef in November) for their expertise, hard work, and dedication in collecting the data required for this report. Pat McKee deserves special recognition for his service since 1975. He summarized and analyzed data presented here and provided thoughtful advice to lake trout researchers within WDNR and other research agencies over the years.

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