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LAKE TROUT POPULATIONS IN MICHIGAN WATERS OF LAKE MICHIGAN, 1976-1982[1]

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Abstract

Lake trout populations in Michigan waters of Lake Michigan continue to remain dependent upon the hatchery product for recruitment. However, the proportion of unclipped trout has increased in the index catch in Grand Traverse Bay, which suggests natural recruitment is developing. The percentage of unmarked trout has doubled annually since 1980, and was 5.7% of the index catch in 1983. Ages of unmarked trout caught in Grand Traverse Bay in 1983 ranged from yearlings to 8 years old.

Little progress was made during 1976-82 in increasing stock density or number of year classes of adult lake trout. The standing stock of mature trout in 1982, as compared to the peak population density during 1976-81 in each statistical district, registered decreases of 79% in MM1, 48% in MM3, 70% in MM4, 52% in MM5, 40% in MM6, and 31% in MM7. Only in MM8 has the trout population steadily increased. In most statistical districts only five year classes of mature trout were observed in the 1982 index samples, which is equal to or less than that observed in 1976. For practical purposes the 1964-71 year classes are now extinct. Because there are few trout older than age VIII, reproductive potential is virtually dependent upon just three age groups -- VI through VIII.

Total annual mortality during 1976-82 nearly always was greater than the 40% rate recently recommended by the Lake Michigan Lake Trout Technical Committee to enhance trout rehabilitation prospects.

Although mean length within an age group varied between years, no change in growth of trout was found during 1975-82.

Introduction

For nearly two decades lake trout populations in Lake Michigan have been artificially sustained by large plantings of hatchery-reared fish. From 1965 to 1982, 19.3 million trout were planted in Michigan's waters of Lake Michigan for the purpose of rehabilitating the species.

Lake trout populations had been annihilated by the early 1950's as the result of lamprey predation and over-fishing (Smith 1968). Reconstruction of trout stocks, through the liberal planting of hatchery fish, has supported a highly successful sport fishery and, more recently, a treaty fishery. Although there is a variety of factors (contaminants; genetics; planting sites; over-fishing) which potentially could inhibit significant natural reproduction by lake trout, over-fishing may be one of the most important. Certainly fishing is the most readily controllable aspect.

Despite the often repeated commitment to creating a self-sustaining lake trout population, catch quotas recommended by an interagency (state, federal, and tribal) task force have been routinely ignored. The result has been a depletion of the lake trout resource in much of the lake, and a set back for the rehabilitation of trout stocks.

The primary purpose of this report is to describe the trends in numbers and growth of the lake trout populations in Lake Michigan during 1976-82.

Methods

Index stations and gear

Lake trout populations were fished experimentally at numerous index stations during 1976-82 (Fig. 1). Because statistical district MM3 is very large and only one index station (Little Traverse Bay) was established, references in this report to MM3 pertain only to the area south of Dahlia

Shoal and east of Beaver Island, and is designated as lower-nearshore. Statistical district MM2 was not indexed. Experimental gill nets were used throughout the duration of the investigation. The descriptive statistics of gear are:

Mesh size:	64 to 152 mm, on an interval of 13 mm. Each mesh size in panels of 30.5 m.
Net depth:	1.8 m.
Net length:	731.5 to 1,463 m.
Material:	Nylon.

Survival

Survival rates for lake trout were computed from catch curves using the technique of Robson and Chapman (1961). Since lake trout recruitment in Lake Michigan is dependent on the stocking of hatchery-reared fish, year class frequencies in the experimental gill net catches were converted to a frequency per 100,000 planted. The purpose of this conversion was to remove catch curve distortion due to variable planting rates.

Although most index catches were made during the spring or early summer, stations in MM5 and MM8 were fished either partially or totally during the fall. Survival rates estimated from the autumn samples were back-calculated to the preceding May for trout in MM8, and to the preceding June in MM5. The back-calculation method assumed that monthly natural mortality was equally distributed over the year, and that all fishing mortality in MM8 occurred during May-October, and in MM5 during June-October. In the latter statistical district some fishing mortality likely occurred during the winter in recent years, but the monthly distribution of the lake trout catch by treaty fishermen was unknown.

Natural mortality for age-V and older lake trout was estimated to have been 25% (M=0.284) in an earlier report by Rybicki and Keller (1978). However, that estimate has since

been updated to 30% (M=0.357) by Richard Hatch (personal communication). A natural mortality rate of 37% (M=0.462) was used for yearling through age-IV trout (Rybicki and Keller 1978).

Standing stock

Estimates of standing stock in the spring of the year were obtained by multiplying the number of trout stocked in each year class by an annual survival rate of 0.63 through age IV; thereafter, the number in each age group was multiplied by the prevailing survival rate in the appropriate year. An exception was made in MM1 where the stock was considered fully vulnerable at age IV. Population estimates prior to 1977 were not made for this area because of gaps in the data base, and for the same reason I could not estimate the contribution of the 1968-70 year classes to that population of adult trout. In those districts where the adult year classes were present in the 1981 catches but absent in 1982, an estimate was made because they could possibly show up in the 1983 index sample. The estimated standing stock in numbers for each year class in each statistical district from 1976 to 1982 is given in Appendices A1-A8.

Growth

Mean lengths for age groups V, VI, and VII in the index catches were compared between statistical districts and between index years. A two-way ANOVA model designed to accommodate unequal subclass frequencies, as described by Walker and Lev (1953), was used in the comparative analysis.

Results and Discussion

Recruitment

Recruitment has been and presently is dependent upon the hatchery product. Small quantities of naturally produced lake trout fry at the swim-up stage were found by

Madsen (1977) in 1977 and Wagner (1980) in 1978 and 1979 in the west arm of Grand Traverse Bay. Dorr et al. (1981) also reported capturing trout fry in southern Lake Michigan on the power plant crib at Port Sheldon in 1980. Since 1975 small numbers of unclipped lake trout, usually less than 1% of the catch, have been taken at one time or another at all of the index stations (Table 1). On occasion the index catch has consisted of as much as 3% unmarked trout, but was not sustained in subsequent years. These unmarked fish have always been regarded as either having been missed during the fin clipping process in the hatchery, or as having regenerated fins.

However, an encouraging trend in the proportion of unclipped lake trout in the index catch has developed in Grand Traverse Bay, which suggests reproduction and survival to maturity has been occurring. Since 1980 the percentage of unclipped trout has doubled each year, and in 1983 comprised a significant 5.7% of the index catch (Table 1). Prior to 1981 unmarked trout accounted for less than 1% of the index catch in this area.

The unclipped lake trout in the June 1981-83 index catches in Grand Traverse Bay consisted of older and larger fish because of gear selectivity. Trout captured in experimental gill nets in this area typically have a modal age of 5 or 6 years. The age distribution of the unclipped fish in the June 1983 index catch from the Bay was:

Age group	Number	Percent of age group
V	4	7.8
VI	1	2.6
VII	3	25.0
VIII	1	12.5

To complete the record for unclipped juvenile trout, extensive trawling and some gill netting were done in the Bay in September 1983 (sites shown in Fig. 2). The numbers of unclipped trout caught in the September operation were: age-I (6), age-II (6), and age-III (3). Total catches of unclipped lake trout in Grand Traverse Bay by gear and age group are summarized in Table 2.

A second candidate site for intensive experimental fishing effort to search for naturally recruited lake trout is Good Harbor Bay area of MM5 (Fig. 1). The Good Harbor Reef has been planted annually since 1972 with yearling lake trout, and was also stocked in 1966-68. Unclipped trout accounted for 2.1 and 3.8% of the index catch in 1982 and 1983, respectively (Table 1). In 1983, three (4.8%) of 63 age IV trout were unclipped, and one unmarked trout was found for age V and one for age VI.

Survival

Survival rate may well be a key factor limiting reproductive success of lake trout in Michigan waters of Lake Michigan. Healey (1978) concluded that self-sustaining trout populations with natural mortality rates in the 20-30% range could withstand fishing which would push the annual total mortality to 50%; however, where total mortality was in excess of 50% the trout populations were in serious difficulty. Pycha (1980) also suggested that a total mortality in excess of 50% may preclude restoration of spawning stocks in Lake Superior. It is now widely speculated that a hatchery-sustained lake trout stock may have a lower spawning efficiency than does a self-sustaining population. Thus a 50% total mortality may not allow adequate escapement of hatchery-maintained stocks, and the Lake Michigan Lake Trout Technical Committee (1983) decreased the target mortality to 40% annually.

If a minimum annual survival rate of 60% (annual total mortality rate of 40%) of the adult stock is essential to

creating a self-sustaining trout population, then, in retrospect, virtual reproductive failure is not surprising. Rarely during 1976-82 did survival approach 60% (Table 3).

Sharply decreasing survival rates of lake trout in MM1 in 1981 and 1982, a direct result of intensified commercial exploitation (the sport catch of lake trout in MM1 is insignificant), precluded whatever chance there might have been for recovery in that area. With the low rates of survival and the relatively small amount of lake trout habitat available in MM1, attempting trout restoration in this district is highly questionable. The selection of Little Bay de Noc as the planting location is inappropriate. If MM1 must receive lake trout, then releases should be made on Minneapolis Shoal, south of Peninsula Point. However, it is recommended that lake trout plants be discontinued in MM1.

Notable declines in lake trout survival rates coincided with the advent of the treaty fishery in MM3 and MM4 in 1978, and in MM5 in 1979. Differences between pre- and post-tribal fishery survival and exploitation rates, expressed as averages, are given in Table 4.

From 1977 to 1980 survival rates for trout in MM6 consistently were above 50%. However, lower survival rates during 1981 and 1982, due to increased fishing, may signal a departure from the relatively high survival sustained during the previous 4 years.

A sport fishery can exert considerable pressure on a trout population. In MM7, where annual survival rates were in the 0.39-0.49 range, annual exploitation rates (u) were calculated to range from 26 to 38% annually, and averaged 32% for the period 1976-82.

Only in MM8 has the trout population sustained a relatively high rate of survival (50% and greater) in 6 out of 7 years. The positive impact of high survival rate also showed in the age structure of the 1982 index catch where

trout in the XII-XIV age category were represented, albeit sparsely.

Clearly, much more restrictive measures controlling the withdrawal of lake trout by both the sport and commercial fisheries are needed, if the minimum recommended survival rate of 60% is to be achieved.

Standing stock

In statistical districts MM3-MM7 there are negative trends in the standing stocks of adult lake trout (age VI and older) which, if not reversed, could very well preempt rehabilitation efforts in Michigan's waters of Lake Michigan. Generally there was a period during which the adult populations increased in number, followed by a decline and in MM3-MM5 resulted in the lowest stock density since 1975 (Fig. 3).

The standing stocks of adult trout in 1982, compared to the peak year in each district, registered decreases of 79% in MM1, 48% in MM3, 70% in MM4, 52% in MM5, 40% in MM6, and 31% in MM7. Only district MM8, the southern most area, showed a progressively building stock of mature trout, and although the trend was encouraging, the standing stock was not as large as were those in MM3 and MM4 during peak years. Reductions in planting rates or increases in fishing mortality could easily reverse the expanding trout stock in MM8. A lack of meaningful protection will be particularly devastating to the small wild stock which appears to be developing in Grand Traverse Bay.

A second set of standing stock estimates for lake trout in the treaty-ceded waters of Lake Michigan in 1982 was published in Status of the Fishery Resource 1982 (Tripartite Technical Working Group 1982). Standing stock estimates of adult trout (age VI and older) given in the tripartite report differed markedly from those presented in this paper for several statistical districts. In MM1 and MM4 the tripartite estimates were 14.9 and 1.7 times greater,

respectively, than those given in this report (Table 5). The degree of discrepancy, or similarity, of the results given in Table 5 is a reflection of the difference in survival rates used to compute the two sets of estimates. In the tripartite report, exploitation rates were based on sport catch (adjusted for over-reporting by a factor of 5) estimated from the annual mail creel survey, and on catches reported by the treaty and state-regulated commercial fisheries. If the catch figures from one or both user groups are in error, then biased survival rates will result and, ultimately, faulty standing stock estimates. A case in point is MM1, where there exists an intensive commercial fishery (angler catch of lake trout is insignificant). Survival rates based on reported catch ranged from 0.61 to 0.67 during 1976-82 (Richard Hatch, personal communication) as compared to 0.17-0.53 based on catch curves for the same period. High survival rates, and hence a large standing stock, are inconsistent with the trend of the abundance index shown in Figure 4. A reasonable explanation for the extreme difference between the standing stock estimates from the two sources is that the fishery under-reported the yield.

The figures given for MM3 in Table 5 are not directly comparable because the tripartite stock estimates were based on survival and planting rates in MM2 and all of MM3, whereas those in this paper were based on survival and stocking rates in the lower-inshore area of MM3 only.

Although lake trout have been planted since 1965 and 1967 in most statistical districts, little progress has been made in expanding and sustaining the number of adult year classes. As compared to 1976, there was either little change in the number of year classes of mature trout, or there was a loss (Table 6). The notable exception was MM8 where the year classes have steadily increased in both age and number. It is also evident from the data in Table 6 that for practical purposes the 1964-71 year classes are now

extinct. There presently are few trout older than age VIII, so that reproductive potential is virtually dependent upon just three age groups, VI-VIII.

Growth

Occasionally, the question is asked as to whether or not the relatively high rate of growth of lake trout noted in past years is being sustained. To answer that question, length-at-age data for lake trout in statistical districts MM3-MM6 were examined for trends in growth patterns (Table 7). Differences between mean lengths attributable to statistical district (rows), index years (columns), and interaction effects were statistically significant at each age ($P<0.01$). Year (column) means for age group-V showed the greatest differences, while differences between year means for each age VI and VII were of minor proportions. However, no consistent pattern in mean lengths emerged over years to suggest that the growth of lake trout had been reduced. Indeed, the mean length for each age group in 1982 was the largest observed in several years.

For reference, coefficients for the von Bertalanffy growth curve, and length-weight regressions for lake trout are given in Appendices B and C; predicted length-at-age and weight-at-age are also given in Appendix D. Analysis of covariance of the length-weight regression for lake trout in each statistical district MM3-MM7 indicated no significant difference between slopes; however the intercepts differed significantly ($P<0.01$). Hence, the length-weight regression coefficients are presented by statistical district rather than as a lake-wide entity.

Summary

Hatchery-maintained lake trout populations in most statistical districts of Lake Michigan have dropped sharply from peak standing stocks as compared to those in 1982. Survival rates usually were less than the 60% believed

necessary to build a self-sustaining lake trout population. Despite these adversities, a population of wild trout appears to be emerging in Grand Traverse Bay, where unclipped yearling through age-VIII fish were found in 1983. Growth patterns of lake trout in the northern half of Lake Michigan showed no decrease in average length-at-age.

Table 1. Percent of unclipped lake trout in index catches in experimental gill nets, by station and year. N is total number of fish in catch.

Index station		Index year								
		1975	1976	1977	1978	1979	1980	1981	1982	1983
Little Traverse Bay	%	0.0	0.0	1.6	0.0	0.0	0.0	0.0	3.1	0.0
	N	40	120	123	102	101	111	224	65	24
Grand Traverse Bay	%	0.5	0.2	0.1	0.2	0.0	0.8	1.5	2.9	5.7
	N	196	624	725	649	275	118	205	170	159
Good Harbor Bay	%	0.0	0.0	0.8	0.0	0.6	3.4	0.0	2.1	3.8
	N	101	263	640	214	519	118	41	119	130
Frankfort	%	0.9	0.5	1.3	0.0	0.0	0.8	0.7	1.6	1.7
	N	113	211	159	319	414	357	678	188	118
Manistee	%	0.7	0.0	0.0	0.0	0.0	0.0	1.2	n.s.[a]	n.s.[a]
	N	144	94	250	508	301	363	407	n.s.	n.s.
Little Sable Point	%	1.0	0.3	0.4	0.0	0.0	3.3	0.7	1.0	1.1
	N	408	315	478	82	81	481	557	630	449

[a] n.s. indicates not sampled.

Table 2. Number (N) and percentage of unclipped lake trout in experimental catches in Grand Traverse Bay, in June-September 1983, by age group and gear.

Age group		All gill net[a]	All trawls[b]	Total
I	N	0	6	6
	%	0	1.2	1.2
II	N	1	5	6
	%	16.7	38.5	31.6
III	N	3	0	3
	%	2.1	0.0	1.0
IV	N	0	0	0
	%	0.0	0.0	0.0
V	N	4	0	4
	%	6.5	0.0	6.5
VI	N	1	0	1
	%	2.3	0.0	2.3
VII	N	3	0	3
	%	18.8	0.0	18.8
VIII	N	1	0	1
	%	12.5	0.0	12.5
IX	N	0	0	0
	%	0.0	0.0	0.0
Total	N	13	11	24
	%	3.5	1.6	2.3

[a] Total gill net effort was 33,600 feet lifted. Unclipped lake trout taken at the Elk Rapids and Marion Island stations only.

[b] Trawling effort was 7 hours.

Table 3. Annual survival rate (S) for lake trout (age V and older) in statistical districts of Lake Michigan with 95% confidence limits in parentheses and age segments of catch curve used, 1976-82.

Statistical district		Years			
		1975-76	1976-77	1977-78	1978-79
MM1	S	0.423 (0.123)	0.454[a] ---	0.485 (0.202)	0.530 (0.321)
	Age	IV-VII	---	V-VII	VI-IX
MM3	S	0.596 (0.071)	0.495 (0.114)	0.469 (0.035)	0.415 (0.156)
	Age	V-XI	VI-X	VIII-XII	V-VIII
MM4	S	0.482 (0.048)	0.523 (0.040)	0.528 (0.037)	0.474 (0.053)
	Age	VII-XI	VII-XII	VII-XII	VII-XIII
MM5	S	0.587[b] ---	0.517 ---	0.500 ---	0.522 ---
	Age	IV-VI	V-VI	VI-VIII	VII-X
MM6	S	0.404 (0.223)	0.539 (0.044)	0.588 (0.027)	0.515 (0.068)
	Age	VI-VIII	VII-XI	V-XI	VI-X
MM7	S[c]	0.42 ---	0.46 ---	0.46 ---	0.39 ---
	Age	---	---	---	---
MM8	S[d]	0.506 ---	0.546 ---	0.437 ---	0.513 ---
	Age	V-VII+	VI-VIII+	VI-VIII	VI-VIII

Table 3. Continued:

Statistical district		Years		
		1979-80	1980-81	1981-82
MM1	S	0.460 (0.146)	0.275 (0.232)	0.167 (0.441)
	Age	IV-VII	V-VII	IV-V
MM3	S	0.346 (0.126)	0.428 (0.084)	0.375 (0.215)
	Age	VI-IX	VI-X	V-VII
MM4	S	0.295 (0.137)	0.453 (0.109)	0.293 (0.101)
	Age	VII-IX	VII-X	VI-VIII
MM5	S	0.416[b] ---	0.385 ---	0.322 ---
	Age	VI-XI	VI-XII	VI-X
MM6	S	0.576 (0.025)	0.476 (0.044)	0.466 (0.092)
	Age	V-XIV	VI-X	VII-XI
MM7	S[c]	0.488 (0.078)	0.474 (0.059)	0.400 (0.213)
	Age	V-X	VI-X	VII-IX
MM8	S[d]	0.591 ---	0.562 ---	0.518 ---
	Age	VII-X	VI-XI	VII-XII

[a] Not sampled in 1977. Survival assumed equal to the mean of the rates in 1975-76 and 1977-78.

[b] Confidence intervals not calculated as survival was back-calculated from September to preceding June.

[c] Not indexed from 1976-79. Survival rates estimated by Richard Hatch (personal communication) from sport catch for 1975-76 and 1978-79.

[d] Age frequencies provided by Great Lakes Fishery Laboratory, U.S.F.W.S., Ann Arbor. Survival back-calculated from September to preceding May.

Table 4. Mean survival and exploitation rates for lake trout in statistical districts, and MM5 of Lake Michigan, during pre- and post-tribal fishing periods 1976-82.

Statistical district		Years	Survival rate[a] ($\bar{s}$)	Exploitation rate[b] ($\bar{u}$)
MM3	Pre-tribal	1976-78	0.517	0.221
	Post-tribal	1979-82	0.390	0.379
MM4	Pre-tribal	1976-78	0.511	0.229
	Post-tribal	1979-82	0.369	0.405
MM5	Pre-tribal	1976-78	0.531	0.205
	Post-tribal	1979-82	0.372	0.401

[a] Mean survival is the geometric mean of the survival rates given in Table 1 for the given years.

[b] Mean exploitation rate was calculated from the relation $\bar{u}=\bar{F}\bar{A}/\bar{Z}$, where: instantaneous natural mortality rate $M=0.357$; mean instantaneous fishing rate $\bar{F}=\bar{Z}-M$; mean instantaneous total mortality rate $\bar{Z}=Ln(1/\bar{s})$; and mean total mortality rate $\bar{A}=1-\bar{s}$.

Table 5. Estimates of the standing stock (number) of adult lake trout in 1982, based upon two methods of estimating survival rates, and the ratio of the catch curve to the reported catch method for each statistical district.

Statistical district	Catch curve	Reported catch	$\frac{RC}{CC}$
MM1	2,302	34,290	14.9
MM3	18,040	38,920	---[a]
MM4	11,510	19,060	1.7
MM5	8,413	6,200	0.7
MM6	20,055	19,030	0.9
MM7	21,778	22,970	1.1

[a] Not comparable; see text for explanation.

Table 6. Percentage age composition of adult lake trout in the index catches in 1976 and 1982, by year class, age, and statistical district, Lake Michigan.

Year class	MM3, MM4			
	1976		1982	
	Age	Percent	Age	Percent
1976	---	---	VI	57.9
1975	---	---	VII	18.4
1974	---	---	VIII	7.0
1973	---	---	IX	9.7
1972	---	---	X	7.0
1971	---	---	XI	0.0
1970	VI	47.5	XII	0.0
1969	VII	27.8	---	---
1968	VIII	9.7	---	---
1967	IX	4.1	---	---
1966	X	9.1	---	---
1965	XI	1.9	---	---
1964	XII	0.0	---	---
Number	320		114	

Year class	MM5			
	1976		1982	
	Age	Percent	Age	Percent
1976	---	---	VI	32.1
1975	---	---	VII	42.6
1974	---	---	VIII	16.1
1973	---	---	IX	7.4
1972	---	---	X	1.9
1971	---	---	XI	0.0
1970	VI	34.7	XII	0.0
1969	VII	47.2	XIII	0.0
1968	NP[a]	---	---	---
1967	IX	0.0	---	---
1966	X	18.1	---	---
1965	XI	0.0	---	---
1964	NP	---	---	---
Number	72		162	

Table 6. Continued:

Year class	MM6			
	1976		1982	
	Age	Percent	Age	Percent
1976	---	---	VI	29.7
1975	---	---	VII	45.1
1974	---	---	VIII	4.4
1973	---	---	IX	9.9
1972	---	---	X	0.8
1971	---	---	XI	2.2
1970	VI	16.7	XII	0.0
1969	VII	22.6	---	---
1968	VIII	25.8	---	---
1967	IX	29.0	---	---
1966	X	5.4	---	---
1965	XI	0.5	---	---
1964	NP	---	---	---
Number	186		91	

Year class	MM7			
	1976[b]		1982	
	Age	Percent	Age	Percent
1976	---	---	VI	38.1
1975	---	---	VII	33.3
1974	---	---	VIII	19.1
1973	---	---	IX	9.5
1972	---	---	X	0.0
1971	---	---	XI	0.0
1970	VI	18.2	XII	0.0
1969	VII	63.6	---	---
1968	VIII	9.1	---	---
1967	IX	9.1	---	---
1966	X	0.0	---	---
1965	XI	0.0	---	---
1964	NP	---	---	---
Number	11		21	

Table 6. Continued:

Year class	MM8			
	1976		1982	
	Age	Percent	Age	Percent
1976	---	---	VI	24.0
1975	---	---	VII	43.6
1974	---	---	VIII	13.6
1973	---	---	IX	9.2
1972	---	---	X	6.9
1971	---	---	XI	0.9
1970	VI	49.1	XII	1.4
1969	NP	---	---	---
1968	VIII	22.3	XIV	0.3
1967	IX	22.3	---	---
1966	X	6.2	---	---
1965	NP	---	---	---
1964	NP	---	---	---
Number	291		346	

[a] NP = not planted.

[b] Not sampled 1976-1979.

Table 7. Mean total length (mm) of lake trout at ages V, VI, and VII, by statistical district and index year, with sample size in parentheses, Lake Michigan, 1975-82.

Age group	Statistical district	Year								
		1975	1976	1977	1978	1979	1980	1981	1982	All
V	MM3	584 (8)	580 (30)	592 (58)	603 (15)	575 (28)	556 (25)	577 (47)	844 (17)	614
	MM4	521 (44)	565 (93)	564 (298)	551 (36)	586 (20)	528 (9)	563 (58)	585 (49)	558
	MM5	540 (19)	626 (32)	641 (20)	612 (71)	603 (73)	593 (142)	577 (125)	584 (33)	597
	MM6	540 (70)	598 (39)	588 (161)	604 (151)	573 (82)	558 (352)	537 (220)	628 (4)	578
	All	546	592	596	593	584	559	564	660	
VI	MM3	686 (8)	640 (20)	643 (71)	660 (22)	660 (6)	655 (36)	625 (61)	670 (10)	655
	MM4	650 (39)	627 (82)	631 (179)	632 (312)	627 (64)	603 (28)	620 (26)	647 (62)	630
	MM5	604 (33)	666 (21)	658 (18)	667 (99)	666 (98)	664 (49)	642 (297)	634 (37)	650
	MM6	664 (91)	646 (31)	647 (68)	671 (204)	650 (77)	613 (104)	604 (251)	659 (27)	644
	All	651	645	645	658	651	634	623	653	
VII	MM3	775 (7)	665 (6)	672 (37)	704 (6)	665 (5)	696 (11)	670 (19)	691 (11)	692
	MM4	716 (18)	689 (73)	662 (130)	666 (173)	661 (120)	653 (41)	658 (41)	674 (19)	672
	MM5	643 (15)	702 (33)	688 (15)	714 (54)	689 (106)	694 (34)	694 (50)	673 (62)	687
	MM6	710 (74)	698 (35)	675 (73)	710 (52)	680 (68)	655 (64)	656 (43)	696 (41)	685
	All	711	689	674	699	674	675	670	684	

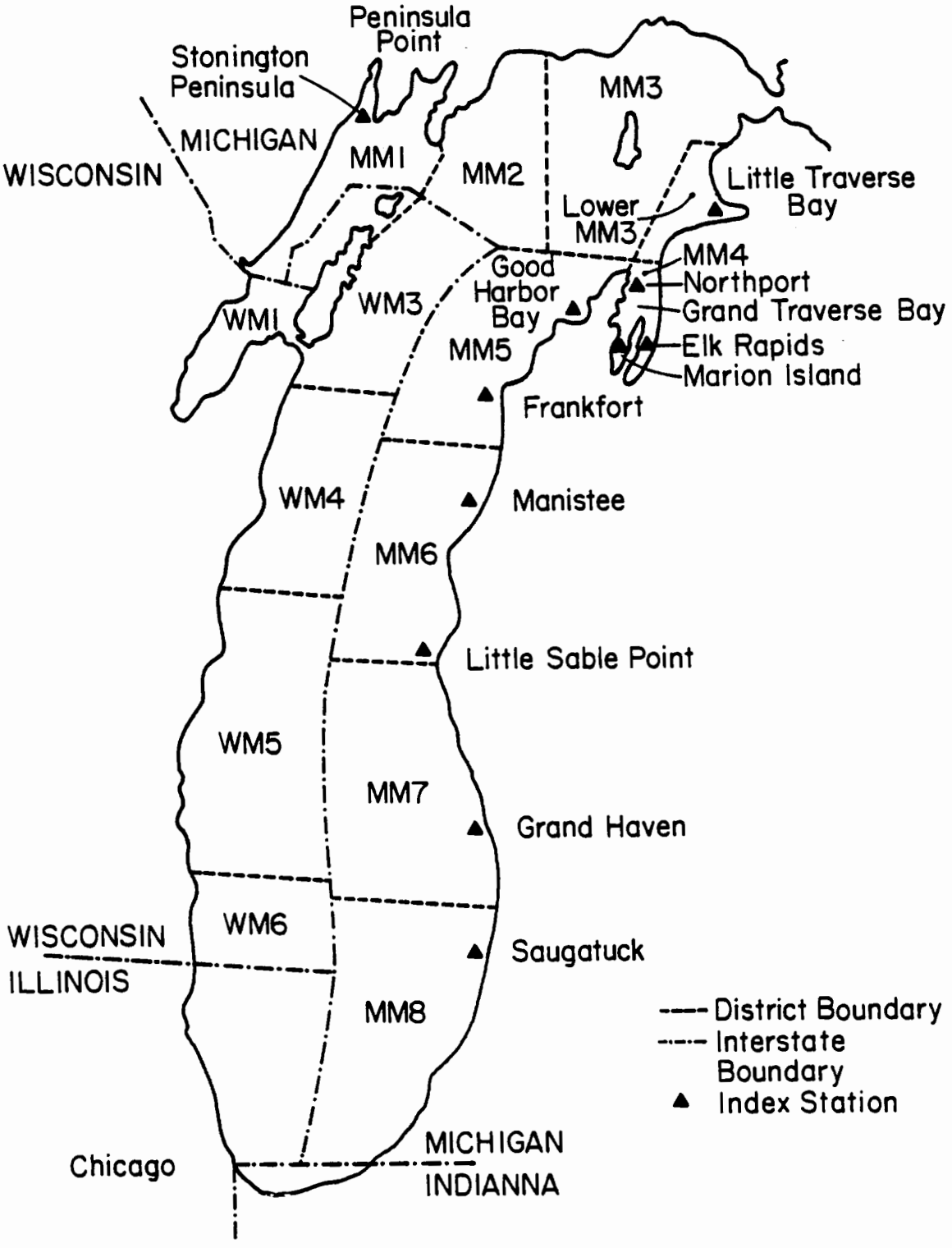

Figure 1. Fisheries statistical boundaries in Lake Michigan and locations of lake trout index stations.

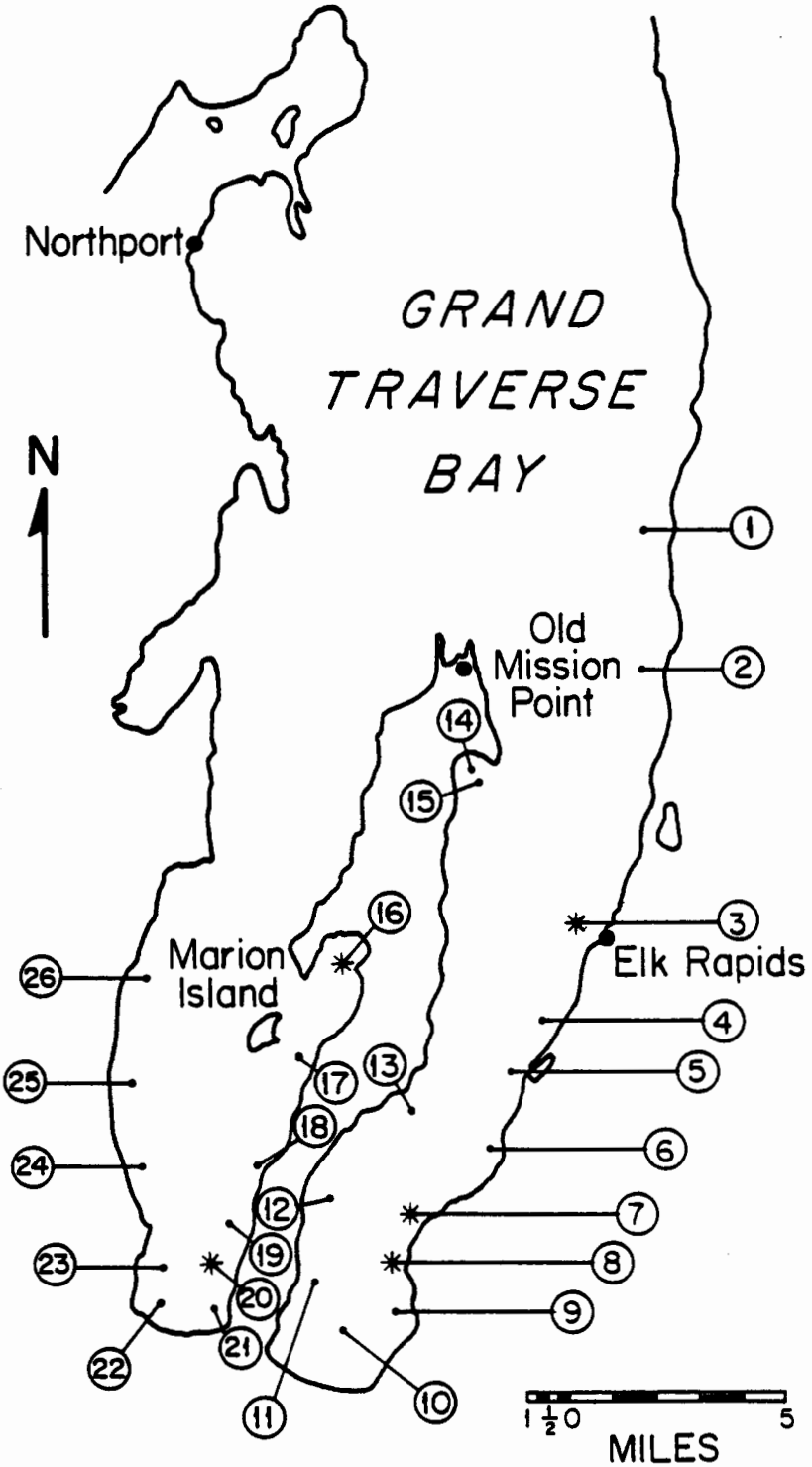

Figure 2. Numbered locations of trawling sites in Grand Traverse Bay, September 1983. Stars are where unclipped lake trout were found.

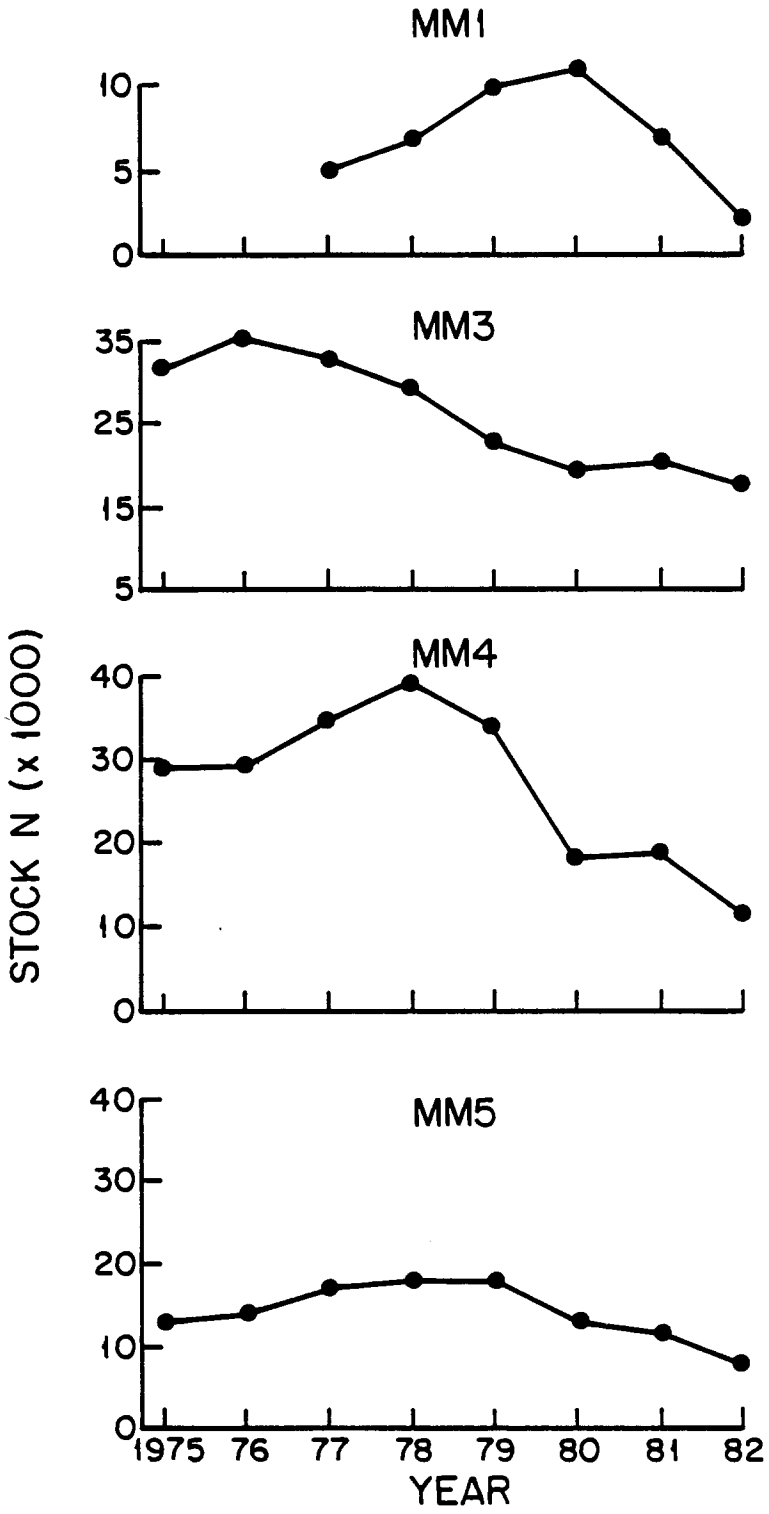

Figure 3. Estimated number of adult lake trout (age VI and older) in Michigan waters of Lake Michigan, 1976-82, by statistical district.

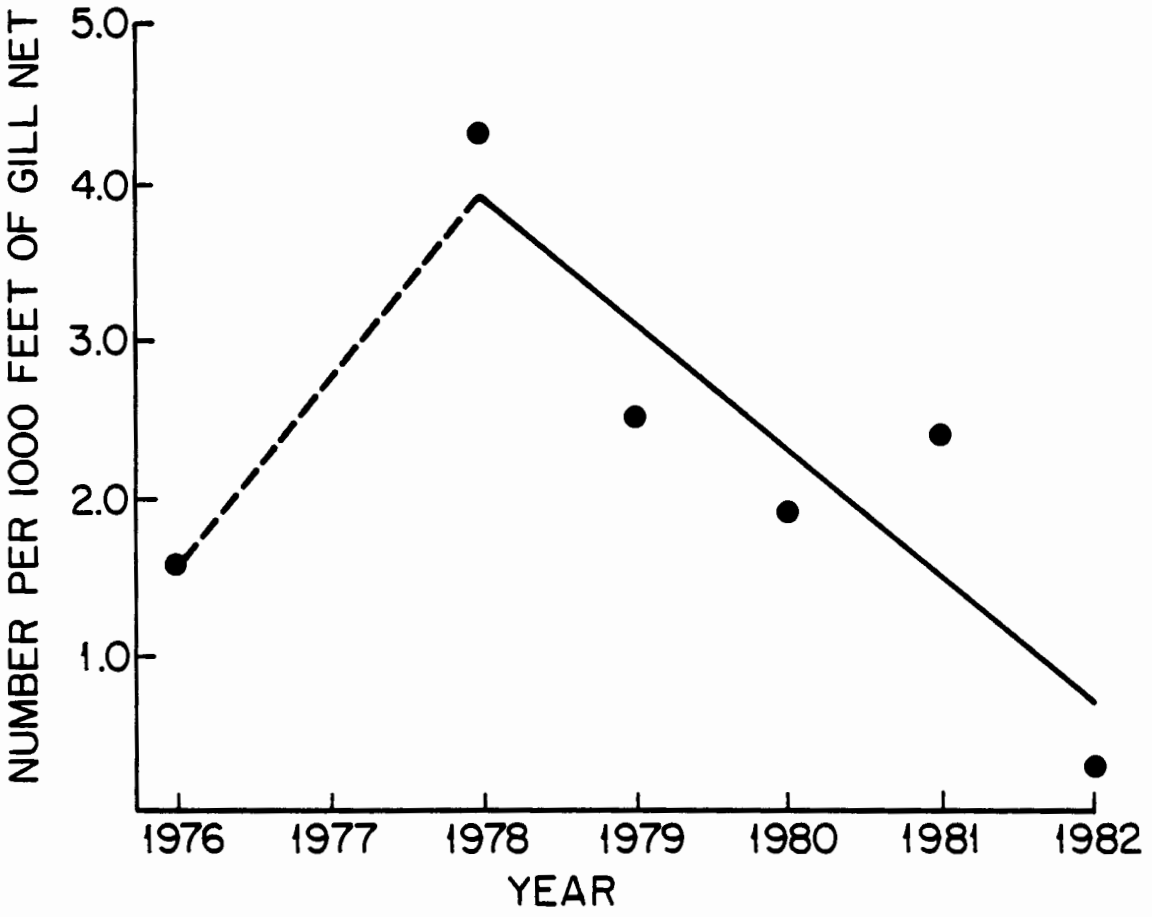

Figure 4. Yearly trend of lake trout number per 1,000 feet of experimental gill net lifted in MM1, Lake Michigan, 1976-82.

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Report approved by W. C. Latta

Typed by G. M. Zurek

Appendix A1. Estimated standing stock (number) of lake trout in the lower inshore of statistical district MM1, by year class, age group, and year.

Year class[a]	Month and year							
	May, 1976		May, 1977		May, 1978		May, 1979	
	Age	Number	Age	Number	Age	Number	Age	Number
1977	---	---	---	---	---*	---	II	63,000
1976	---	---	---	---	II	63,000	III	39,690
1975	---	---	II	78,750	III	49,613	IV	31,256
1974	II	79,821	III	50,287	IV	31,681	V	16,791
1973	III	40,722	IV	25,655	V	12,443	VI	6,595
1972	IV	21,254	V	9,649	VI	4,680	VII	2,480
1971	V	11,074	VI	5,028	VII	2,439	VIII	1,293
Total		152,871		169,369		163,856		161,105

Year class[a]	Month and year					
	May, 1980		May, 1981		May, 1982	
	Age	Number	Age	Number	Age	Number
1978	II	47,250	III	29,768	IV	18,754
1977	III	39,690	IV	25,005	V	4,176
1976	IV	25,005	V	6,876	VI	1,148
1975	V	14,378	VI	3,954	VII	660
1974	VI	7,724	VII	2,124	VIII	355
1973	VII	3,034	VIII	834	IX	139
1972	VIII	0	IX	0	X	0
1971	IX	0	X	0	XI	0
Total		137,081		68,561		25,232

[a] Year classes 1968-70 not included because no survival data were available.

Appendix A2. Estimated standing stock (number) of lake trout in the lower inshore of statistical district MM3, by year class, age group, and year.

Year class	Month and year							
	May, 1976		May, 1977		May, 1978		May, 1979	
1977	---	---	---	---	---	---	II	173,250
1976	---	---	---	---	II	112,140	III	70,648
1975	---	---	II	113,400	III	71,442	IV	45,008
1974	II	121,653	III	76,641	IV	48,284	V	30,419
1973	III	66,282	IV	41,758	V	26,308	VI	10,918
1972	IV	52,085	V	32,814	VI	15,390	VII	6,387
1971	V	31,506	VI	15,595	VII	7,314	VIII	3,035
1970	VI	16,149	VII	7,994	VIII	3,749	IX	1,556
1969	VII	7,774	VIII	3,848	IX	1,805	X	749
1968	VIII	5,264	IX	2,606	X	1,222	XI	507
1967	IX	2,369	X	1,173	XI	550	---	---
1966	X	1,743	XI	863	XII	405	---	---
1965	XI	1,256	XII	622	---	---	---	---
Total		306,081		297,314		288,609		342,477

Year class	Month and year					
	May, 1980		May, 1981		May, 1982	
	Age	Number	Age	Number	Age	Number
1980	---	---	---	---	II	137,340
1979	---	---	II	148,680	III	93,668
1978	II	94,500	III	59,535	IV	37,507
1977	III	109,148	IV	68,763	V	43,321
1976	IV	44,508	V	28,040	VI	10,515
1975	V	28,355	VI	12,136	VII	4,551
1974	VI	10,525	VII	4,505	VIII	1,689
1973	VII	3,778	VIII	1,617	IX	606
1972	VIII	2,210	IX	946	X	355
1971	IX	1,050	X	449	XI	168
1970	X	538	XI	230	XII	86
1969	XI	259	XII	111	XIII	42
1968	XII	175	XIII	75	XIV	28
Total		295,046		325,087		329,876

Appendix A3. Estimated standing stock (number) of lake trout in the lower inshore of statistical district MM4, by year class, age group, and year.

Year class	Month and year							
	June, 1976		June, 1977		June, 1978		June, 1979	
	Age	Number	Age	Number	Age	Number	Age	Number
1977	---	---	---	---	---	---	II	94,500
1976	---	---	---	---	II	82,530	III	51,994
1975	---	---	II	96,390	III	60,726	IV	38,257
1974	II	110,250	III	69,458	IV	43,759	V	27,568
1973	III	83,369	IV	52,522	V	33,089	VI	15,684
1972	IV	62,962	V	39,666	VI	20,944	VII	9,927
1971	V	35,665	VI	18,653	VII	9,849	VIII	4,668
1970	VI	15,186	VII	7,942	VIII	4,193	IX	1.987
1969	VII	6,811	VIII	3,562	IX	1,881	X	892
1968	VIII	1,874	IX	980	X	517	XI	245
1967	IX	2,874	X	1,503	XI	794	XII	376
1966	X	1,573	XI	823	XII	435	XIII	206
1965	XI	947	XII	495	---	---	---	---
Total		321,511		291,994		248,747		246,304

Year class	Month and year					
	June, 1980		June, 1981		June, 1982	
	Age	Number	Age	Number	Age	Number
1980	---	---	---	---	II	195,993
1979	---	---	II	163,233	III	102,837
1978	II	78,750	III	49,613	IV	31,256
1977	III	59,535	IV	37,507	V	23,629
1976	IV	32,756	V	20,636	VI	6,046
1975	V	24,102	VI	10,918	VII	3,199
1974	VI	8,133	VII	3,684	VIII	1,079
1973	VII	4,627	VIII	2,096	IX	614
1972	VIII	2,928	IX	1,326	X	389
1971	IX	1,377	X	624	XI	183
1970	X	586	---	---	---	---
1969	XI	0	---	---	---	---
1968	XII	72	---	---	---	---
Total		212,867		289,637		365,225

Appendix A4. Estimated standing stock (number) of lake trout in the lower inshore of statistical district MM5, by year class, age group, and year.

Year class[a]	Month and year							
	June, 1976		June, 1977		June, 1978		June, 1979	
	Age	Number	Age	Number	Age	Number	Age	Number
1977	---	---	---	---	---	---	II	65,520
1976	---	---	---	---	II	57,330	III	36,118
1975	---	---	II	69,930	III	44,056	IV	27,755
1974	II	53,550	III	33,737	IV	21,254	V	13,390
1973	III	42,389	IV	26,705	V	16,824	VI	8,782
1972	IV	31,468	V	19,825	VI	9,913	VII	5,175
1971	V	19,691	VI	10,180	VII	5,090	VIII	2,657
1970	VI	6,473	VII	3,347	VIII	1,647	IX	874
1969	VII	2,816	VIII	1,456	IX	728	X	380
1967	IX	2,444	X	1,264	XI	632	XII	330
1966	X	1,297	XI	671	XII	336	XIII	175
1965	XI	775	---	---	---	---	---	---
Total		160,903		167,115		157,837		161,156

Year class[a]	Month and year					
	June, 1980		June, 1981		June, 1982	
	Age	Number	Age	Number	Age	Number
1980	---	---	---	---	II	47,313
1979	---	---	II	73,679	III	46,418
1978	II	63,504	III	40,008	IV	25,205
1977	III	41,278	IV	26,006	V	16,383
1976	IV	22,754	V	14,335	VI	4,616
1975	V	17,486	VI	6,732	VII	2,168
1974	VI	5,570	VII	2,144	VIII	690
1973	VII	3,653	VIII	1,406	IX	453
1972	VIII	2,153	IX	829	X	267
1971	IX	1,105	X	425	XI	137
1970	X	364	XI	140	XII	45
1969	XI	158	XII	61	XIII	20
1967	XIII	137	XIV	53	XV	17
Total		158,162		165,818		143,732

Appendix A5. Estimated standing stock (number) of lake trout in the lower inshore of statistical district MM6, by year class, age group, and year.

Year class	Month and year							
	June, 1976		June, 1977		June, 1978		June, 1979	
	Age	Number	Age	Number	Age	Number	Age	Number
1977	---	---	---	---	---	---	II	91,350
1976	---	---	---	---	II	84,420	III	53,185
1975	---	---	II	94,500	III	59,535	IV	37,507
1974	II	56,700	III	35,721	IV	22,504	V	14,178
1973	III	38,102	IV	24,004	V	15,123	VI	7,788
1972	IV	57,511	V	36,231	VI	21,304	VII	10,972
1971	V	23,629	VI	12,736	VII	7,489	VIII	3,857
1970	VI	4,773	VII	2,573	VIII	1,513	IX	779
1969	VII	6,110	VIII	3,293	IX	1,936	X	997
1968	VIII	1,466	IX	790	X	465	XI	239
1967	IX	2,048	X	1,104	XI	649	XII	334
1966	X	341	XI	184	XII	108	XIII	57
1965	XI	351	---	---	---	---	---	---
Total		191,031		211,136		215,046		221,243

Year class	Month and year					
	June, 1980		April, 1981		April, 1982	
	Age	Number	Age	Number	Age	Number
1980	---	---	---	---	II	132,300
1979	---	---	II	127,355	III	80,234
1978	II	113,400	III	71,442	IV	45,008
1977	III	57,551	IV	36,257	V	22,842
1976	IV	33,507	V	21,109	VI	9,837
1975	V	23,629	VI	11,247	VII	5,241
1974	VI	8,167	VII	3,887	VIII	1,811
1973	VII	4,486	VIII	2,135	IX	995
1972	VIII	6,320	IX	3,008	X	1,402
1971	IX	2,222	X	1,058	XI	493
1970	X	449	XI	214	XII	100
1969	XI	574	XII	273	XIII	127
1968	XII	138	XIII	0	XIV	0
1967	XIII	192	XIV	91	XV	42
1966	XIV	32	XV	15	XVI	7
Total		250,667		278,091		300,439

Appendix A6. Estimated standing stock (number) of lake trout in the lower inshore of statistical district MM7, by year class, age group, and year.

Year class	Month and year							
	April, 1976		April, 1977		April, 1978		April, 1979	
	Age	Number	Age	Number	Age	Number	Age	Number
1977	---	---	---	---	---	---	II	160,650
1976	---	---	---	---	II	118,440	III	74,617
1975	---	---	II	126,000	III	79,380	IV	50,009
1974	II	93,240	III	58,741	IV	37,007	V	23,314
1973	III	78,983	IV	49,759	V	31,348	VI	12,226
1972	IV	64,805	V	40,827	VI	18,708	VII	7,324
1971	V	44,681	VI	20,553	VII	9,454	VIII	3,687
1970	VI	10,617	VII	4,884	VIII	2,247	IX	876
1969	VII	3,555	VIII	1,635	IX	752	X	293
1968	VIII	1,394	IX	641	X	295	XI	115
1967	IX	588	X	270	XI	124	XII	48
1966	X	274	XI	126	XII	58	XIII	23
1965	XI	105	XII	48	XIII	22	XIV	9
Total		298,242		303,484		297,907		333,191

Year class	Month and year					
	April, 1980		April, 1981		April, 1982	
	Age	Number	Age	Number	Age	Number
1980	---	---	---	---	II	145,341
1979	---	---	II	138,600	III	87,318
1978	II	170,730	III	107,560	IV	67,763
1977	III	101,210	IV	63,762	V	40,170
1976	IV	47,009	V	29,616	VI	11,846
1975	V	31,506	VI	14,934	VII	5,974
1974	VI	11,377	VII	5,393	VIII	2,157
1973	VII	5,966	VIII	2,828	IX	1,131
1972	VIII	3,574	IX	1,694	X	678
1971	IX	1,799	X	853	XI	341
1970	X	429	XI	0	XII	0
1968	XII	56	XIII	27	XIV	11
Total		373,656		365,267		362,730

Appendix A7. Estimated standing stock (number) of lake trout in the lower inshore of statistical district MM8, by year class, age group, and year.

Year class[a]	Month and year							
	May, 1976		May, 1977		May, 1978		May, 1979	
	Age	Number	Age	Number	Age	Number	Age	Number
1977	---	---	---	---	---	---	II	120,960
1976	---	---	---	---	II	85,050	III	53,582
1975	---	---	II	94,500	III	59,535	IV	37,507
1974	II	93,240	III	58,741	IV	37,007	V	23,314
1973	III	39,690	IV	25,005	V	15,753	VI	8,081
1972	IV	45,008	V	28,355	VI	12,391	VII	6,357
1971	V	23,629	VI	12,901	VII	5,638	VIII	2,892
1970	VI	11,956	VII	6,528	IX	2,853	IX	1,464
1968	VIII	1,665	IX	909	X	397	XI	204
1967	IX	761	X	416	XI	182	XII	93
1966	X	355	XI	194	XII	85	XIII	44
Total		216,304		227,549		218,891		254,498

Year class[a]	Month and year					
	May, 1980		May, 1981		May, 1982	
	Age	Number	Age	Number	Age	Number
1980	---	---	---	---	II	126,000
1979	---	---	II	119,700	III	75,411
1978	II	119,700	III	75,411	IV	47,509
1977	III	76,205	IV	48,009	V	30,246
1976	IV	33,757	V	21,267	VI	11,016
1975	V	23,629	VI	13,279	VII	6,879
1974	VI	13,779	VII	7,744	VIII	4,011
1973	VII	4,776	VIII	2,684	IX	1,390
1972	VIII	3,757	IX	2,111	X	1,093
1971	IX	1,709	X	960	XI	497
1970	X	865	XI	486	XII	252
1968	XII	121	XIII	68	XIV	35
1967	XIII	55	XIV	31	---	---
1966	XIV	25	XV	14	---	---
Total		278,378		291,764		304,339

[a] Year class 1969 not planted in this area.

Appendix B. Constants in the von Bertalanffy growth curve (length) for lake trout in Lake Michigan, 1981-82, by statistical district.

Statistical district	Month	Ages	K	L_∞	T_o
MM3	May	3-10	0.145	1,025	-0.497
MM4	June	3-10	0.136	1,009	-0.891
MM5[1]	June	3-10	0.136	1,012	-1.299
MM6	April	3-11	0.111	1,145	-0.813
MM7	April	2-10	0.100	1,100	-1.649
MM8	September	2-10	0.184	799	-0.269

[1] Frankfort index station only

Appendix C. Length-weight regression coefficients for lake trout in Lake Michigan, 1981-82, by statistical district.

Statistical district	Month	Intercept[a] (A)	Slope (B)
MM3	May	-12.1675	3.1166
MM4	June	-12.3422	3.1404
MM5	June	-12.1622	3.1068
MM6	April	-12.2511	3.1176
MM7	April	-12.8251	3.2077

[a] $\log_e Y = \log_e A + B (\log_e X)$, where X is total length in millimeters, Y is weight in grams, and A and B are constants.

Appendix D. Predicted mean total length in millimeters (L) and weight in grams (W) for lake trout in Lake Michigan, 1981-82, by age group and statistical district.

Age group		District and month					
		MM3 (May)	MM4 (Jun)	MM5 (Jun)	MM6 (Apr)	MM7 (Apr)	MM8[b] (Sep)
II	L	311[a]	328[a]	366[a]	307[a]	335	355
	W	305	347	481	271	339	---
III	L	408	415	447	396	408	459
	W	711	727	895	600	637	---
IV	L	491	490	519	474	474	539
	W	1,267	1,225	1,340	1,051	1,031	---
V	L	563	556	581	545	533	600
	W	1.941	1,822	2,022	1,623	1,502	---
VI	L	626	613	636	608	587	647
	W	2,701	2,475	2,678	2,283	2,047	---
VII	L	680	664	683	665	637	683
	W	3,496	3,181	3,342	3,019	2,661	---
VIII	L	726	708	725	715	680	710
	W	4,287	3,891	4,023	3,784	3,281	---
IX	L	767	748	761	760	720	731
	W	5,087	4,624	4,676	4,578	3,941	---
X	L	801	779	793	801	756	747
	W	5,823	5,253	5,315	5,392	4,609	---
XI	L	831[a]	809[a]	822[a]	837	789[a]	760[a]
	W	6,531	5,915	5,942	6,184	5,285	---

[a] Projected beyond data range.

[b] Weight data not available.