STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-81-R-5

Study No.: 230451 **Title:** Evaluation of lake trout stocks in Lake Huron

Period Covered: October 1, 2003 to September 30, 2004

Study Objective: To estimate stock parameters for lake trout in Lake Huron based on surveys.

Summary: This year we were able to summarize all data collected through August 2004 for this report. Changes in the ecosystem of Lake Huron indicated a need to modify sample designs such that consistency of the long-term study will be maintained, new problems can be addressed, and requirements of various modeling analyses will be met. We extended sample depths to beyond 150 feet in our spring survey, and found that catch rate increased with depth. Our major finding was that lake trout have been moving to deeper waters. Catch per unit effort for young age groups continued to decrease, probably due to changes in their distribution and vulnerability to gillnets. Catch per unit effort for older age groups has continued to increase. Lake trout catch-at-age modeling was accomplished for all Main Basin management units based on our surveys and coordination with other agencies. Estimated abundance for age-4 and older lake trout remains relatively high; and estimated abundance for age 6 and older has increased. Sea-lamprey-induced mortality is the highest in northern Lake Huron, and fishing mortality is the highest in southern Lake Huron. Observed sea lamprey wounding rates have remained relatively low since the lamprey population of the St. Marys River came under control. Contribution of alewives to diet of lake trout declined sharply in 2003, but alewives were still dominant prey in northern Lake Huron. Rainbow smelt were dominant prey in southern Lake Huron. Modeling analyses of annual growth variation indicated that there has been continuous decline in lake trout asymptotic length. In 2004, we had the highest annual catch of age-0 wild lake trout in bottom trawls since 1995, and we caught them in a much wider range of depths than our surveys in previous years. All job requirements for 2004 were met.

Findings: Jobs 1 through 6 were scheduled for 2003-04, and progress is reported below.

Job 1. Title: Spring assessment using gillnets.–A total of 877 lake trout (*Salvelinus namaycush*) were caught during the 2004 survey, including 27 non-clipped lake trout and 55 samples with coded-wire tags (CWT). These CWT samples and related information on catches and survey effort will be sent to USGS Great Lakes Science Center for a cooperative study on lake trout movement. There were sufficient samples (477 lake trout) in southern Lake Huron for reliable age assignment and estimates of age distribution. Sample sizes in northern Lake Huron (109) may be slightly short for estimating age composition, although they should be sufficient for estimating average size at age.

Sea lamprey wounding rates (Table 1) were similar during the past three years for lake trout in southern Lake Huron and consistently below levels that prevailed prior to treatment of sea lampreys in the St. Marys River. In central Lake Huron, they were slightly lower in 2004 than 2003, but higher than 2002. In northern Lake Huron, they were similar to 2002, but lower than 2003.

A total of 150 lake trout stomachs were analyzed in the laboratory, the balance of stomachs from the 855 lake trout sampled were checked in the field. Alewife (*Alosa pseudoharengus*) were still

dominant in the lake trout diet in central and northern Lake Huron, and rainbow smelt (*Osmerus mordax*) were the dominant diet item in southern Lake Huron (Table 2). Other prey commonly observed included round goby (*Neogobius melanostomus*) and ninespine stickleback (*Pungitius pungitius*).

In the very early years of this long-term survey, very large amounts of effort were used to cover a wide range of depth strata; the objective during that time was to find lake trout when their density was very low. In the past decade, we reduced gillnet effort in response to substantial increases in lake trout density. The remaining effort was concentrated on depth strata where catch rates were highest. A shortcoming of this reduction in effort was that the survey no longer represented variations in lake trout distribution. There were indications that depth distributions were changing over years, but the survey was not designed to adequately document these changes in distribution.

In 2004, we improved the sample design to provide more regular and complete coverage of depth strata at the 12 fixed stations, using almost the same gillnetting effort as recent years (Table 3). We found that catch per unit effort increased with depth. The highest catch rates were at the deepest strata (150-200 feet), a distribution patter never observed before. This change in depth distribution might be a year-specific phenomenon, or reflect changes in the lake ecosystem. Our findings in 2004 suggested the need to further improve survey design to provide sufficient coverage over the depth range of 30-200 feet.

The relatively low catch rate in Thunder Bay was because the sample strata chosen were found in a very small area; future surveys will be designed to better reflect site-specific conditions. The very low catch rates in northern Lake Huron, particularly stations 10, 11 and 13, were partly due to high winds prior the survey days, and gillnets were almost buried by high density of algae at the lake bottom. To minimize the chance for similar events in future, the spring survey should start in early May and finish by the end of May. Station 13 had a high catch rate of young lake whitefish, and caught very few lake trout, just as in most previous years. The bottom type at this sample site was predominately composed of muck. An alternative sample site should be considered in future surveys.

Job 2. Title: **Net for adults on spawning reefs.**–Fall netting for spawning lake trout is not required every year. We are focusing on alternative methods for non-lethal sampling, such as sampling with trap nets. In 2002, nearly half of our fall catch in Thunder Bay was composed of unclipped, presumably wild lake trout. Gillnetted lake trout experience high mortality rates and we were reluctant to set such lethal gear in light of this evidence of wild lake trout in Thunder Bay. Several dozen trapnet days were fished in Thunder Bay during October and November 2003, but we were largely unsuccessful in designing nets that were efficient in trapping lake trout. We learned from this experimentation that throat openings need to be 10 to 15 inches in diameter and that we need tunnels and leads at least 8 feet deep. This work will continue in 2004-05.

Job 3. Title: **Data analyses and coordination with other agencies in Lake Huron lake trout management.**–Usually age determinations of lake trout from the spring assessment are not available until the following winter, but this year all age determinations from spring 2004 collections were completed in time for inclusion in the annual report. Catch per unit effort (CPUE) was the highest for age-4 lake trout in northern Lake Huron, and for age 6 in central and southern Lake Huron (Figures 1-3). In central and southern Lake Huron, CPUE continued to decrease for ages 2-4, but has been increasing for older ages. There is larger uncertainty in estimating abundance of young lake trout than estimating abundance of older age groups. In southern Lake Huron, CPUE for age-5 lake trout also decreased in recent years. One possibility for the decline is that young lake trout vulnerability to gillnets has changed because of changes in

depth distribution. This hypothesis will be supported if CPUE for older age groups continues to increase or remain high.

Catch-at-age modeling has used Michigan DNR spring survey data, Chippewa/Ottawa Resource Authority fishery independent data, US Fish and Wildlife Service stocking data, and recreational and commercial fisheries data. Estimated abundance of age-4 and older has remained high, and abundance of age 6 and older has been increasing (Figure 4). Sea-lamprey-induced mortality continued to be the highest in northern Lake Huron; and fishing mortality was the highest in southern Lake Huron (Figure 5). Statistical catch-at-age modeling for northern and central Lake Huron was accomplished in conjunction with the Modeling Subcommittee of the Technical Fisheries Committee as mandated by the Year-2000 Consent Decree for 1836 Treaty Waters. Total Allowable Catch estimates for these two management units were made using the models. Similar modeling efforts for southern Lake Huron were coordinated with Ontario Ministry of Natural Resources, US Fish and Wildlife Service, Chippewa/Ottawa Resource Authority, and Michigan State University.

Annual variations in lake trout size at age have been interpreted by modeling cohort-specific growth with year-specific von Bertalanffy growth parameters (Figure 6). This modeling work was done by cooperating with Jim Bence at Michigan State University. We found that size at younger ages, such as age-4, has been relatively stable, but size at older ages has experienced dramatic decreases. Our model interpretation was that there has been a continuous decline in asymptotic length. As a consequence, the recovery of spawning biomass was much slower than the recovery of mature female abundance (Figure 7). We hypothesize that the decline in growth of older lake trout was driven by declining numbers of large alewives: prey size in Lake Huron appears to be less than optimal for larger-sized mature lake trout.

Job 4. Title: Reports.–The required reports and documents were completed as scheduled. We have reported our findings to Technical Fisheries Committee of the Year 2000 Consent Decree for 1836 Treaty Waters. We also reported our results at the Lake Huron Technical Committee 2004 summer meeting; the American Fisheries Society 2004 annual meeting at Madison, Wisconsin; and in the native fish workshop of the Great Lakes Fisheries Commission, at Ann Arbor. Lake trout samples with coded-wire tags were sent to USFW Fishery Resource Office at Alpena for processing and reading tags. The complied data set will be sent to USGS Great Lakes Science Center, and the completed central database will be used for studying lake trout movement patterns in Lake Huron. Sea lamprey wounding rates and survey CPUE will be reported to the Great Lakes Fisheries Commission.

Job 5. Title: Bottom-trawl survey for age-0 wild lake trout.–A total of 32 bottom trawl tows were conducted in Thunder Bay and Black River areas in 2004. A total of 11 wild age-0 lake trout were caught at depths 40, 50, 60, 70, 80, and 90 feet. This is the highest annual catch since 1995. All lake trout were caught at the end of July (July 26-29). Only 10 days later, replications at the same locations caught nothing. In early years, lake trout were caught from June to October in Thunder Bay area, at fixed locations with depths of 60, 70, and 80 feet. During the 1990s, annual catch decreased, and only one age-0 wild lake trout was caught from 2000-2003. It was not clear if the decrease in annual catch mostly reflected declining lake trout reproduction or was also an indication of changes in seasonal depth distribution of wild age-0 lake trout caused by changes in the lake ecosystem during the past decade. We are redesigning details of the trawling surveys to have fewer replicates but cover much wider depth strata within the best time window, in comparison with the previous years that had a relatively narrow range of "best" depth strata, but had many replicate tows per site.

Job 6. Title: Publish report (data up through 2001-02).–The following paper summarized the 1973-2002 data set using catch-at-age models. Results of the models are summarized for each management unit and implications to management of our data and modeling results are given. The proceedings will be published in early 2005.

Johnson, J. E., J. X. He, A. P. Woldt, M. P. Ebener, and L. C. Mohr. In press. Lessons in rehabilitation stocking and management of lake trout in Lake Huron. Pages xxx-xxx *in* M. Nickum, P. Mazik, J. Nickum, and D. MacKinlay, editors. Role of Propagated Fish in Resource Management. American Fisheries Society, Symposium 44, Bethesda, Maryland.

Prepared by: Ji X. He and James E. Johnson
Date: September 30, 2004

Table 1.–Sea lamprey wounding rates of lake trout in northern (MH1), central (MH2), and southern (MH3) Lake Huron, 2002-04.

Size	2002			2003			2004		
group	MH1	MH2	MH3	MH1	MH2	MH3	MH1	MH2	MH3
<430	0.00	0.00	na	0.00	0.00	na	0.00	0.00	0.00
430-529	4.31	2.78	0.00	7.14	0.00	0.00	0.00	0.00	0.00
530-629	5.13	5.15	10.28	12.50	7.84	10.50	0.00	10.75	11.26
630-734	6.67	3.92	8.36	5.00	14.62	8.03	6.52	7.75	7.63
735-835	0.00	0.00	9.52	100.00	0.00	9.68	25.00	21.43	10.71
836-963	na	na	100.00	na	na	na	na	na	0.00
Total	4.55	4.05	8.88	9.43	10.27	8.28	3.67	8.55	8.39

Table 2.–Diet composition (proportion of diet items) in lake trout stomachs. Stations 1-5 represent southern Lake Huron. Stations 6-8 represent central Lake Huron, and stations 9-13 represent northern Lake Huron.

Station number	Station	Rainbow smelt	Alewife	Round goby	Sticklebacks	Other
1	Sucker Creek	0.829	0.000	0.171	0.000	0.000
2	Hardwood Point	0.928	0.000	0.038	0.000	0.034
3	Port Austin	0.878	0.024	0.098	0.000	0.000
4	Oscoda	0.988	0.000	0.000	0.012	0.000
5	Harrisville	0.856	0.006	0.065	0.000	0.073
6	Thunder Bay	0.042	0.000	0.875	0.083	0.000
7	Rockport	0.059	0.588	0.000	0.235	0.118
8	Presque Isle	0.061	0.303	0.545	0.061	0.030
9	Adams Point	0.095	0.495	0.019	0.371	0.019
10	Hammond Bay	0.161	0.484	0.097	0.226	0.032
11	Spectacle Reef	0.143	0.429	0.000	0.143	0.286
13	Rabbit Back	0.676	0.162	0.000	0.135	0.027
	All	0.672	0.129	0.100	0.079	0.020

Table 3.–Sampling designs and results in 2003 and 2004. The design of 2003 was consistent with previous years, except for the three strata in Harrisville. The year 2004 represents the effort toward a new design that will maintain fixed sample sites and have more regular and complete coverage across depth strata.

Station number	Station	2003			2004			
		Strata 1	Strata 2	Strata 3	Strata 1	Strata 2	Strata 3	Strata 4
				Depth range (ft.)				
1	Sucker Creek	32-43	67-83	–	40-45	70-76	100-104	130-133
2	Hardwood Point	47-55	60-74	–	57-60	83-90	113-119	143-148
3	Port Austin	36-53	75-90	–	40-60	70-77	100-109	130-136
4	Oscoda	34-41	82-110	–	59-65	84-89	110-120	140-150
5	Harrisville	32-40	64-68	90-96	40-48	70-78	100-109	130-137
6	Thunder Bay	40-84	–	–	40-60	70-77	100-105	130-134
7	Rockport	37-88	–	–	40-58	77-90	94-118	120-148
8	Presque Isle	40-101	–	–	43-55	70-84	101-119	130-137
9	Adams Point	37-115	50-95	–	40-74	85-101	130-146	160-184
10	Hammond Bay	42-96	–	–	63-70	100-110	149-159	186-191
11	Spectacle Reef	40-129	–	–	50-71	110-139	174-211	230-275
13	Rabbit Back	36-71	–	–	61-64	64-71	71-89	89-229
				Effort (ft.)				
1	Sucker Creek	2700	2700	–	900	900	900	900
2	Hardwood Point	1800	1800	–	900	900	900	900
3	Port Austin	1800	1800	–	900	900	900	900
4	Oscoda	2700	2700	–	900	900	900	900
5	Harrisville	900	900	900	900	900	900	900
6	Thunder Bay	3600	–	–	900	900	900	900
7	Rockport	2700	–	–	900	900	900	900
8	Presque Isle	2700	–	–	900	900	900	900
9	Adams Point	3600	3600	–	900	900	900	900
10	Hammond Bay	5400	–	–	900	900	900	900
11	Spectacle Reef	5400	–	–	900	900	900	900
13	Rabbit Back	5400	–	–	900	900	900	1800
				Catch per unit effort (catch per 1000 ft.)				
1	Sucker Creek	15.56	21.48	–	5.56	35.56	28.89	25.56
2	Hardwood Point	2.22	11.11	–	10.00	43.33	31.11	24.44
3	Port Austin	24.44	101.11	–	7.78	12.22	26.67	26.67
4	Oscoda	29.63	52.96	–	40.00	25.56	25.56	27.78
5	Harrisville	10.00	35.56	28.89	15.56	21.11	40.00	56.67
6	Thunder Bay	33.89	–	–	7.78	1.11	0.00	31.11
7	Rockport	24.81	–	–	8.89	16.67	36.67	65.56
8	Presque Isle	27.41	–	–	23.33	35.56	42.22	30.00
9	Adams Point	9.44	11.39	–	23.33	7.78	12.22	38.89
10	Hammond Bay	14.07	–	–	4.44	0.00	2.22	8.89
11	Spectacle Reef	0.93	–	–	0.00	1.11	0.00	1.11
13	Rabbit Back	0.56	–	–	1.11	2.22	4.44	6.67

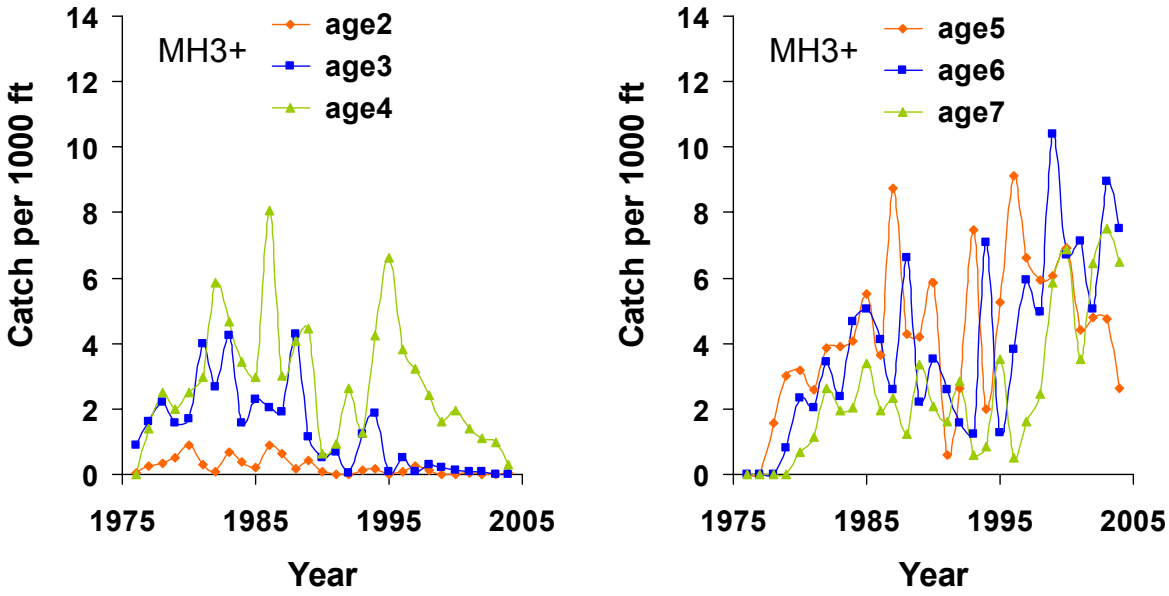

Figure 1.–Catch per unit effort of lake trout age groups in southern Lake Huron (MH3+).

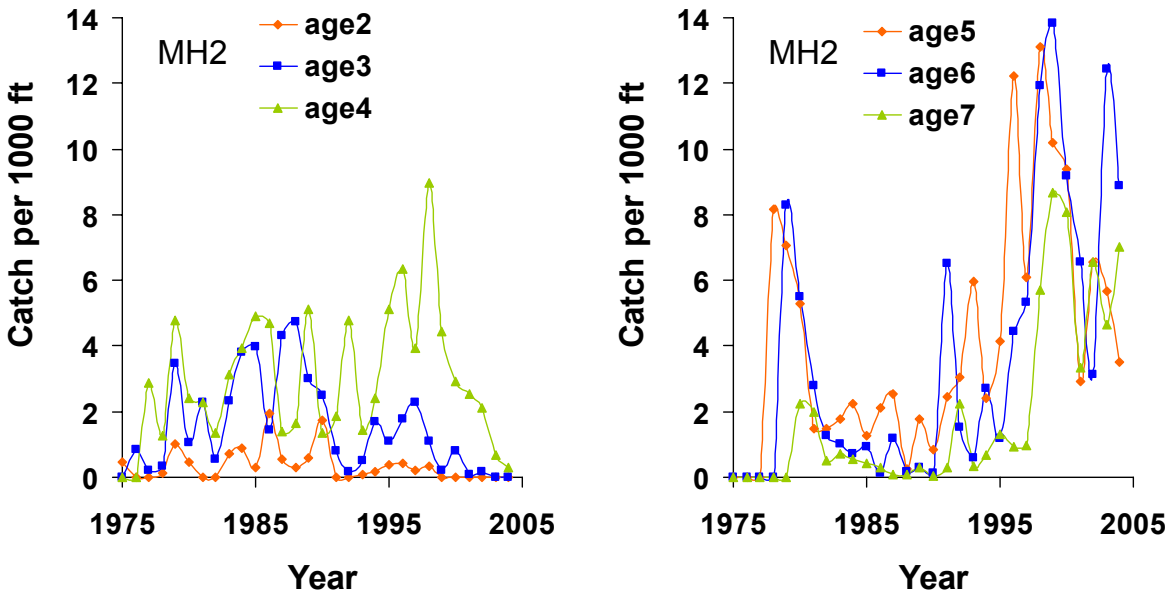

Figure 2.–Catch per unit effort of lake trout age groups in central Lake Huron (MH2).

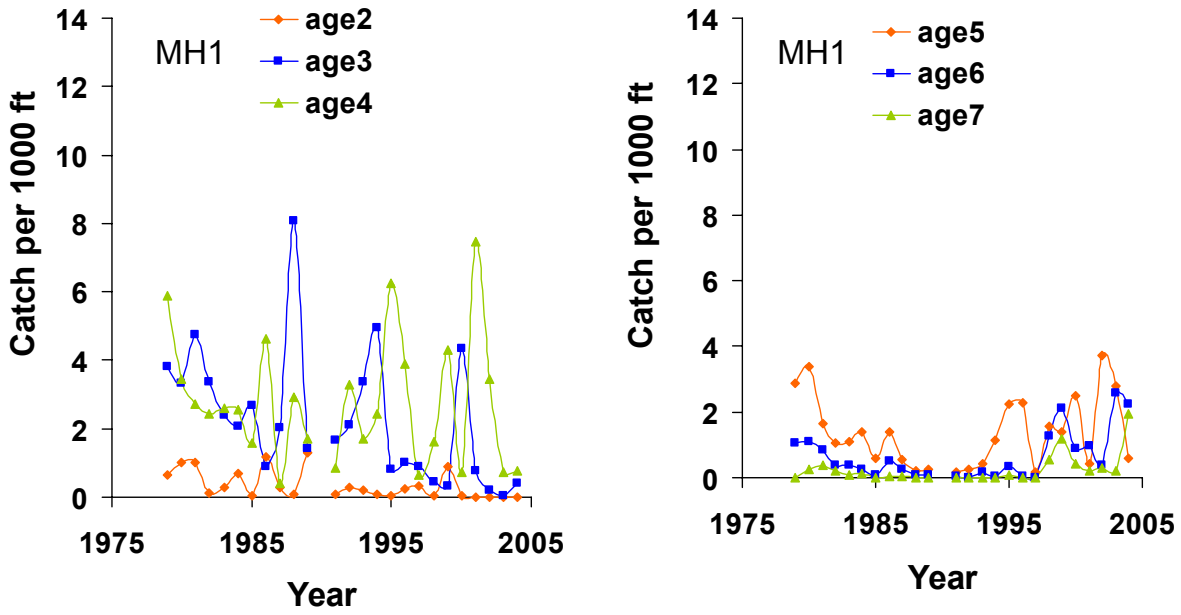

Figure 3.–Catch per unit effort of lake trout age groups in northern Lake Huron (MH1).

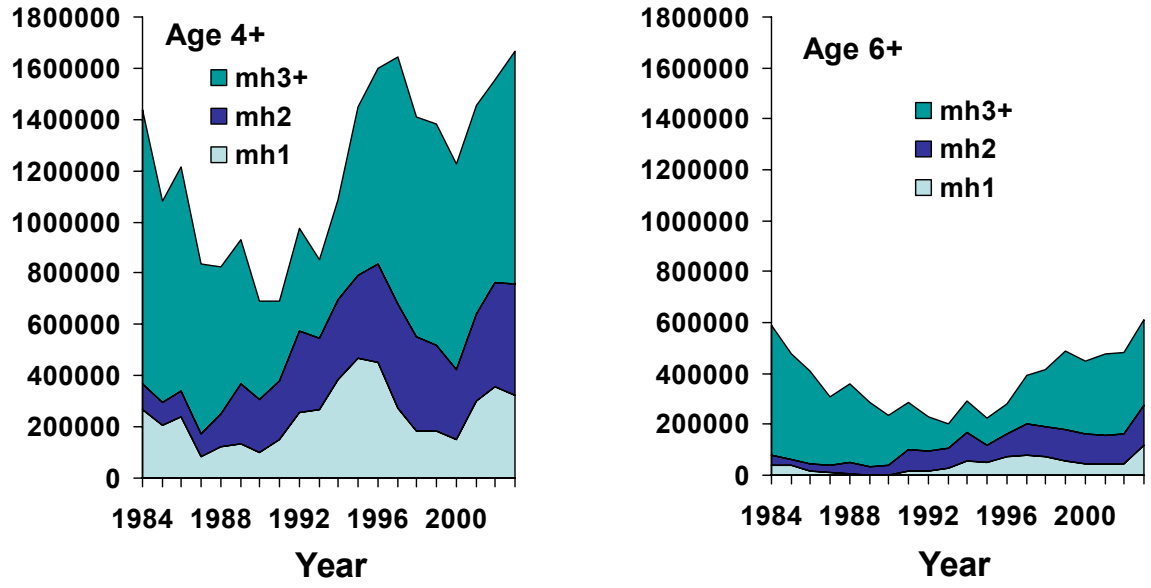

Figure 4.–Estimated population abundance based on catch-at-age models, and fisheries and survey data up to 2003.

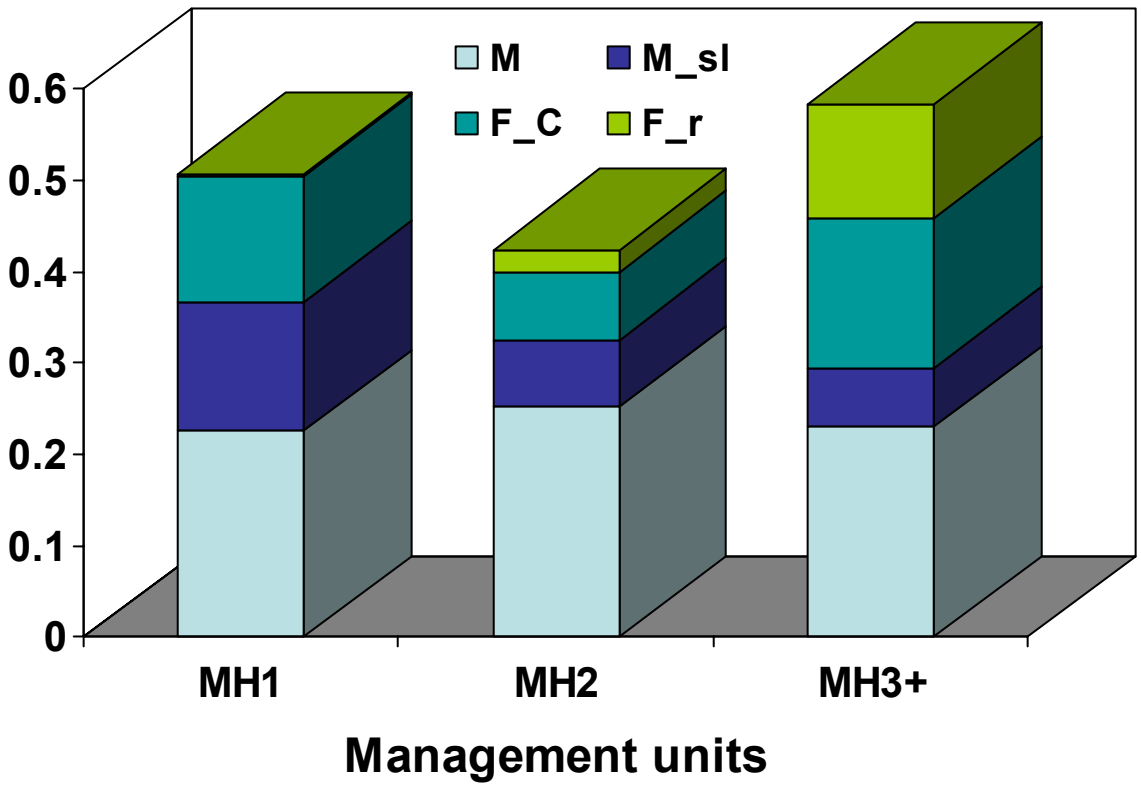

Figure 5.–Estimated lake trout 2003 mortalities in northern (MH1), central (MH2), and southern (MH3+) Lake Huron. F_r is recreational fishing mortality, F_c is commercial fishing mortality, M_sl is sea lamprey induced mortality, and M is natural mortality.

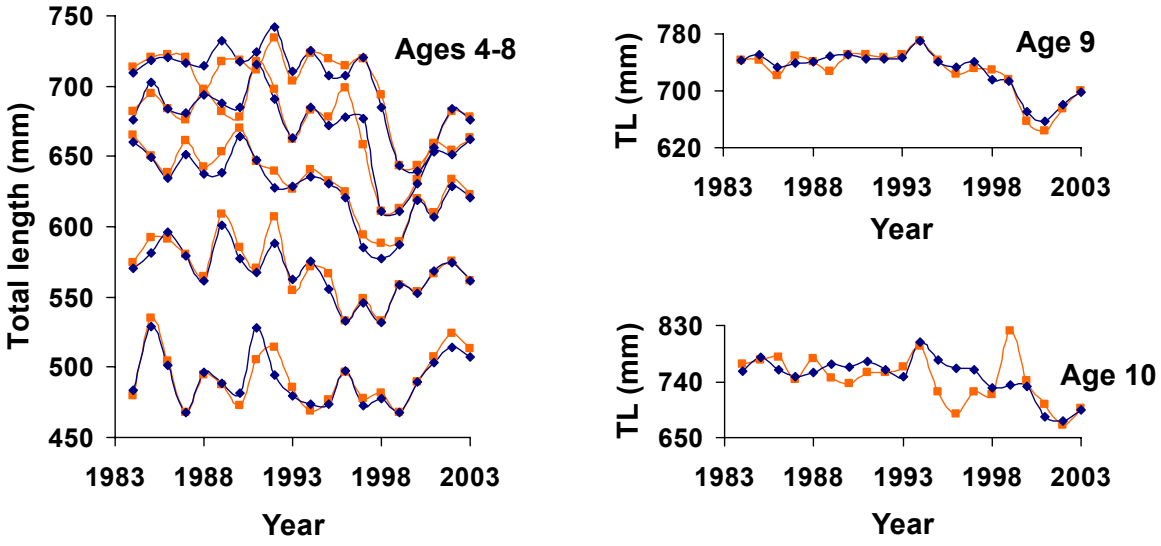

Figure 6.–Observed and estimated size-at-age over years, for lake trout in southern Lake Huron.

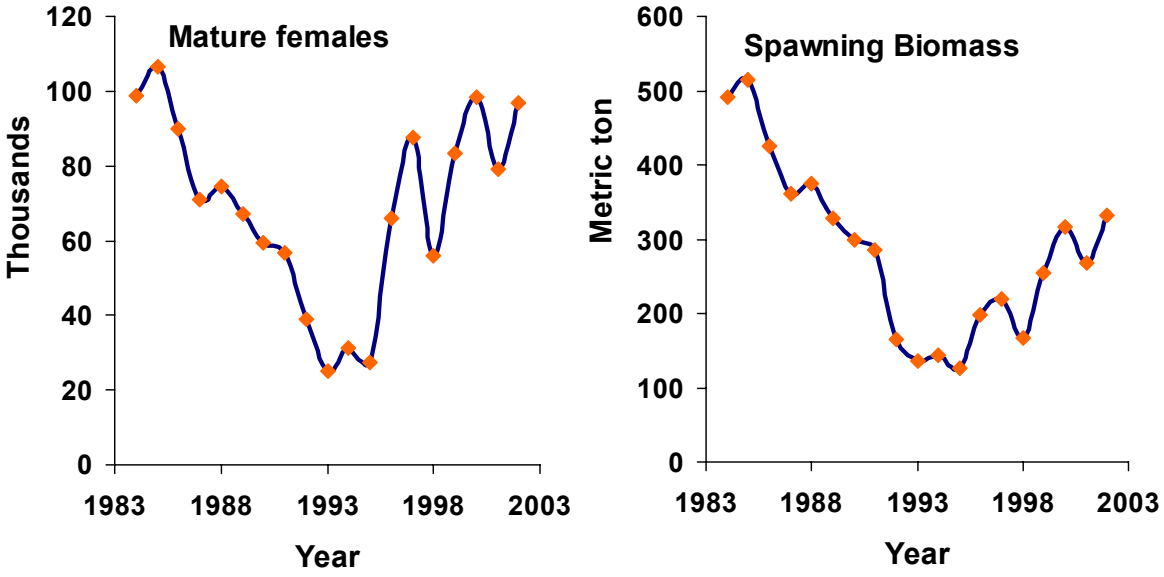

Figure 7.–Comparison between the two time trends for estimated recent recoveries of mature female abundances and spawning biomass in southern Lake Huron. See related growth declines in Figure 6.