STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-81-R-2

Study No.: 451 **Title:** Evaluation of lake trout stocks in Lake Huron

Period Covered: October 1, 2000 to September 30, 2001

Study Objective: To determine stock parameters for lake trout in Lake Huron from index sampling.

Summary: Index sampling for lake trout in U.S. waters of Lake Huron was conducted with graded, large-mesh gill nets during the spring of 2000 at 12 sites. Four of these index sites have been sampled annually since the mid-1970s. Statistical-catch-at-age (SCAA) model results show that, in general, mortality rates are too high to allow spawning stocks to build. Commercial fishing and sea lampreys are the most prominent sources of mortality in the north, while lampreys and recreational fishing are the most prominent sources in the south. Further suppression of sea lampreys and significant reductions in fishing effort are needed to allow the main basin lake trout population to advance towards rehabilitation. Weight-length regressions and lake trout body condition were similar across statistical districts. Smelt and alewives comprised 96.9% of the spring diet in 2000. Fall gill net catches on spawning reefs near Alpena yielded low catches of wild spawning lake trout. For the first time since 1985, no age-0 lake trout were sampled in trawling at the annual North Point index station.

Job 1. Title: Fish graded-mesh, experimental gill nets at assessment stations.

Findings: Two assessment stations were added to the study design in 2000 to increase spatial coverage in northern Lake Huron. Therefore, a total of 12 assessment stations were sampled in 2000. Lake trout marked with coded-wire tags were stocked at each of four sites along the Michigan coastline; returns of the coded-wire tags will be used by the Great Lakes Fishery Commission (GLFC), Lake Huron Technical Committee (LHTC) to document movements and create a lakewide movement matrix used for modeling lake trout population dynamics. The locations of assessment stations were designed to document distribution of these marked lake trout at and between the four stocking sites. Data from all assessment sites within each statistical district were combined for the purpose of estimating area stock parameters using SCAA models. SCAA models for northern (MH-1 and adjacent Canadian waters) and north-central (MH-2 and adjacent Canadian waters) Lake Huron are updated yearly by the Modeling Subcommittee of the Technical Fisheries Committee (TFC) as mandated by the Year 2000 Consent Decree. The southern (MH-3,4,5 and adjacent Canadian waters) Lake Huron SCAA model is updated periodically and was last updated in 1999.

Survival–Instantaneous mortality rates have been variable and relatively high in northern Lake Huron (Figure 1). From 1977 to 1990, commercial fishing mortality was the leading source of lake trout mortality. After 1990, commercial fishing mortality decreased as lamprey-induced mortality increased. Lampreys were the largest source of lake trout mortality in the 1990s. From 1990 to 1998, lamprey-induced instantaneous mortality averaged 0.26/year and commercial fishing instantaneous mortality averaged 0.14/year. Recreational fishing mortality was low in all years relative to commercial fishing mortality in northern Lake Huron (Figure 1).

The high rates of both lamprey-induced and commercial fishing mortality caused the age structure in northern Lake Huron to be truncated just before the age of first maturity. As a result, spawning stock biomass is extremely low in northern Lake Huron and total lake trout biomass remains stable, oscillating around a 20 year average of 518,000 kg (Figure 2).

The dominant source of mortality for lake trout in north-central Lake Huron was lamprey-induced mortality (Figure 3). Lamprey-induced mortality was greater than all other mortality sources from 1984-2000 with the exception of 1986, 1987, and 1990, when natural mortality was the largest single mortality source (Figure 3). Sea lamprey mortality rates have been cyclic in north-central Lake Huron, reaching peaks in 1989, 1994, and 1997 (Figure 3). From 1990 to 2000, lamprey-induced mortality averaged 0.30/year. Recreational and commercial fishing mortality were low in all years relative to lamprey-induced mortality (Figure 3).

The high rate of lamprey-induced mortality caused the lake trout age structure in north-central Lake Huron to be truncated at the age of first maturity. As a result, spawning stock biomass is low in north-central Lake Huron (Figure 4). Total lake trout biomass has steadily increased since 1984, averaging 759,000 kg in the 1990s (Figure 4); however, the majority of this biomass is young, immature, hatchery fish. Spawning stock and total biomass are higher in north-central Lake Huron (Figure 4) than in northern Lake Huron (Figure 2). This larger spawning stock might contribute to the wild recruitment documented at North Point off Alpena (Johnson and VanAmberg 1995).

The dominant source of mortality for lake trout in southern Lake Huron from 1984 to 1998 was lamprey-induced mortality (Figure 5). Recreational fishing mortality increased from 1994 to 1998 but was still secondary to lamprey-induced mortality (Figure 5). Commercial fishing mortality was uniformly low in all years. From 1990 to 1998, lamprey-induced mortality averaged 0.34/year.

Total lake trout biomass and spawning stock biomass are higher in southern Lake Huron than in northern or north-central Lake Huron (Figure 6). From 1990 to 1998, spawning stock biomass in southern Lake Huron averaged 168,000 kg versus 63,000 kg in north-central Lake Huron and 10,000 kg in northern Lake Huron. The higher levels of spawning stock biomass in southern Lake Huron are encouraging, but the majority of the historic lake trout spawning habitat is located in northern and north-central lake Huron (Ebener 1998; Eshenroder et al. 1995). The presence of a moderate number of spawners but limited spawning habitat, combined with high rates of lamprey-induced mortality on adult lake trout and lower stocking rates after 1985, may explain why both total and spawning stock biomass steadily declined from 1984 to 1998 for lake trout in southern Lake Huron (Figure 6).

Chemical control of sea lampreys began in 1998 on the St. Marys River. Because most sea lampreys are believed to originate there, the St. Marys treatment is expected to significantly enhance lake trout survival, particularly in northern Lake Huron. In anticipation of this effect, the Lake Huron Committee resumed stocking lake trout in some of the northern grids of Lake Huron in 1998. With increasing recreational and commercial harvest, further regulation of fishing will be required to attain target survival levels. The Year-2000 Consent Decree recently signed by the State of Michigan, the federal government, and 5 Chippewa/Ottawa tribes limits commercial harvest of lake trout and stipulates new recreational size limits in north and north-central Lake Huron. Similar regulations are needed for southern Lake Huron to control lake trout mortality.

Movement–In 1992, the LHTC initiated a lake trout movement study with the stocking of 60,000 coded-wire tagged lake trout at each of 4 sites: Adams Point, Middle Island, Sturgeon Point, and Point aux Barques. Sixty thousand coded-wire tagged lake trout were annually planted at each of these four sites in 1994, 1996, and 1998. In addition, coded-wire tagged lake trout have been stocked at Drummond Island and 6-Fathom Bank since 1985.

Tagged lake trout originating from all research stocking sites were represented in each year's samples from 1995 through 2000 (Table 1). Although some lake trout had moved considerable distances, there was a tendency for those lots stocked from Sturgeon Pt. south to be sampled in the south and those stocked north of Sturgeon Pt. to be found at the northern stations (Table 1). A total of 1,038 coded-wire tagged lake trout have been taken in this assessment since 1995 (Table 1). This sample size indicates the number of marked fish and the survey effort deployed were both adequate to meet study objectives.

One hundred seventy-seven lake trout stocked at 6-Fathom Bank were taken at the near-shore sites from 1995 to 2000, and they appeared at all 10 movement study stations (Tables 1 and 2). Stockings at 6-Fathom have been equally divided between three lake trout strains. However, for fish age-7 and older, nearly 2 and 4 times as many Seneca strain were taken at the near-shore sites than either Marquette or Jenny/Lewis strains respectively (Table 2). Assessment nettings by the United States Geological Survey Biological Resource Division on 6-Fathom Bank have likewise found that Seneca strain composes the majority of older fish on this mid-lake reef.

A more in-depth analysis of lake trout movements based on coded-wire tag data was conducted as part of the SCAA modeling done by the Modeling Subcommittee of the TFC. In 1998, the LHTC designed a common lake trout coded-wire tag data base for Lake Huron that contained data from Michigan Department of Natural Resources (MDNR), United States Fish and Wildlife Service (USFWS), United States Geological Survey Biological Resource Division (BRD), Chippewa/Ottawa Resource Authority (CORA) and Ontario Ministry of Natural Resources (OMNR). I worked with the USFWS to analyze the common database and determine the extent of lakewide lake trout movement. These movement data were developed into a lakewide movement matrix that was included in the SCAA models.

Growth–Parameters of weight-length regressions and condition factors for the assessment stations were fairly similar across statistical districts in 2000 (Table 3), suggesting uniform lake trout body condition across statistical districts. Average total length at age five followed a north-south gradient for the Michigan assessment stations (Table 4), likely reflecting the colder, less productive conditions of northern Lake Huron.

Food habits–The stomach contents of all gill-netted lake trout were examined, and a sub-sample of stomach contents was brought back to the lab to obtain lengths and weights of individual prey items. A summary of stomach contents from 2000 spring index netting is given in Table 5. As with past years, smelt and alewives comprised the majority (96.9%) of the diet lakewide. Alewives were the dominant prey in all statistical districts and were more frequently found in stomachs in southern statistical districts. Average weights of prey items are also given (where possible) in Table 5. Approximately 15% of the lake trout sampled in 2000 had void stomachs (Table 5). This is near the long-term average (12.7%) of void stomachs in the spring lake trout survey. In 1998, the percent of void stomachs reached an all time high of 27.7%, but recent strong year classes of alewives have bolstered the forage base.

Job 2. Title: Net for adults on spawning reefs.

Findings: In 2000 we sampled reefs at 3 nearshore sites (Rockport, Middle Island, Cement Plant) in and around Thunder Bay and at one offshore reef site (Monrovia wreck) to index the incidence of wild spawning lake trout. A few wild lake trout were captured at Rockport, Cement Plant Reef, and the Monrovia wreck. 51 lake trout (3 wild and 48 hatchery) were captured in 9 lifts at the nearshore sites, and 26 lake trout (1 wild and 25 hatchery) were captured in one set at the offshore reef. The average CPE of wild lake trout was 1.1 per 305 m at the nearshore sites and 1.7 per 305 m at the offshore site. This is much lower than the 1998 and 1997 wild lake trout catch rates of 26.7 and 21.7 per 305 m at Mischley's Reef, one of our nearshore index stations. We did not sample Mischley's Reef in 2000. All fish caught were released or sent to the International Joint Commission for contaminant analysis.

Job 3. Title: Analyze field data and coordinate with other agencies. Participate in interagency planning and management of lake trout.

Findings: I updated and scrubbed the Alpena Station lake trout database to include all spring and fall gill net data from 1970-2000. We prepared analyses for the coordinated interagency studies of the LHTC, presented lake trout status reports at the annual Upper Lakes meetings, presented a rehabilitation status report to the GLFC Board of Technical Experts task area meeting, and presented lake trout population dynamics to the Lake Huron Fisheries Advisory Committee. We also attended the summer and winter LHTC meetings where updates on lake trout progress and technical reports were presented. I co-authored the lake trout section of the GLFC report, *State of Lake Huron in 1999*. I am also a member of the Modeling Subcommittee of the TFC and compiled Lake Huron lake trout biological data, coded-wire tag movement data, and guided lake trout stock assessment model development for Lake Huron. I attended 2 GLFC sponsored SCAA modeling training sessions. We designed 2000 and 2001 stocking plans for Lake Huron and began work on long-term stocking strategies in conjunction with the Year-2000 Consent Decree.

Job 4. Title: Write annual and final reports.

Findings: The required reports and documents were completed as scheduled.

Job 5. Title: Trawl for age-0 wild lake trout in Thunder Bay and monitor for other evidence of lake trout reproduction.

Findings: Trawling to sample age-0 lake trout was completed as scheduled at the annual index station near North Point of Thunder Bay. A semi-balloon otter trawl with a 23-m bridle, 11-m foot rope, and 13-mm mesh (stretch measure) cod-end liner was used. Age-0 wild lake trout were taken in bottom trawls every year at the North Point station from 1986 through 2000. Trawl catches have been steadily dropping since the early 1990s, and no age-0 lake trout were caught in 2001 (Table 6).

The number of unclipped lake trout at spring assessment stations has been used as another index of reproduction. The contribution of unclipped, potentially wild, lake trout to the assessment catch in MH-2 was 10-18% for the 1984, 1985, and 1986 year classes (Johnson and VanAmberg

1995). In 2000, however, the contribution of unclipped fish, averaged over all year classes, was only 4.1%, 3.5%, 1.6%, and 1.2% for MH-1, 2, 3, and 4,5 respectively. There was no evidence that unclipped fish composed a larger than expected proportion of any one year class. Although reproduction continues, its contribution to the fishery is almost too weak to be measurable.

Literature Cited:

Ebener, M.P. [ED.]. 1998. A lake trout rehabilitation guide for Lake Huron. Great Lakes Fish. Comm. 48 p.

Eshenroder, R.L., N.R. Payne, J.E. Johnson, C.B. Bowen, and M.P. Ebener. 1995. Lake trout rehabilitation in Lake Huron. J. of Great Lakes Res. 21(Supplement 1):108-127.

Johnson, J.E., and J.P. VanAmberg. 1995. Evidence of natural reproduction of lake trout in western Lake Huron. Journal of Great Lakes Research 21 (Supplement 1):253-259.

Prepared by: Aaron P. Woldt and James E. Johnson
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Table 1.–Total gill net catch and catch per effort (number per 3,050 m of net) of coded-wire-tagged lake trout at 10 near-shore Michigan stations in Lake Huron, spring, 1995-2000.

	Survey station and effort (combined 1995-2000 m of net in parenthesis)										
	S. Harbor Beach (8,779)	N. Harbor Beach (9,328)	Grindstone (6,587)	AuSable Pt. (10,698)	Sturgeon Pt. (9,876)	Thunder Bay (8,504)	Nordmeer (7,956)	Presque Isle (7,956)	Adams Pt. (13,200)	Nine-mile Pt. (25,240)	Total by stocking site
Catch by stocking site:											
Drummond Island	0	0	0	0	1	1	5	5	7	5	24
Adams Pt.	1	1	6	3	4	14	27	29	132	64	281
Middle Island	0	0	4	10	6	18	61	47	54	16	216
Six-Fathom	11	17	28	12	20	17	44	5	17	6	177
Sturgeon Pt.	7	9	17	22	29	41	22	8	2	5	162
Pt. Aux Barques	20	58	70	11	7	5	4	3	0	0	178
Total by station	39	85	125	58	67	96	163	97	212	96	1038
Catch/3,050 m net by stocksite:											
Drummond Island	0.00	0.00	0.00	0.00	0.31	0.36	1.92	1.92	1.62	0.60	6.72
Adams Pt.	0.35	0.33	2.78	0.86	1.24	5.02	10.35	11.12	30.50	7.73	70.27
Middle Island	0.00	0.00	1.85	2.85	1.85	6.46	23.38	18.02	12.48	1.93	68.83
Six-Fathom	3.82	5.56	12.96	3.42	6.18	6.10	16.87	1.92	3.93	0.73	61.48
Sturgeon Pt.	2.43	2.94	7.87	6.27	8.96	14.70	8.43	3.07	0.46	0.60	55.75
Pt. Aux Barques	6.95	18.96	32.41	3.14	2.16	1.79	1.53	1.15	0.00	0.00	68.10
Total	13.55	27.79	57.88	16.54	20.69	34.43	62.49	37.19	48.98	11.60	

Table 2.–Age composition, by strain, of coded-wire-tagged lake trout stocked on 6-Fathom Bank, Lake Huron and sampled at nearshore stations, spring gill netting, 1995-2000.

	Strain		
Age	Seneca/Ontario	Marquette	Jenny/Lewis
2	0	0	0
3	1	4	2
4	3	12	7
5	14	15	15
6	14	12	16
7	4	8	5
8	9	3	3
9	11	4	1
10	1	1	0
11	6	0	0
12	3	0	0
13	1	1	0
14	0	0	0
15	0	1	0
Totals	67	61	49
Age >=7	35	18	9

Table 3.–Condition factors, weight-length regressions at assessment stations, and estimated weight (g) at 600 mm total length from 2000 index netting in Michigan waters of Lake Huron.

Statistical District	Area	Ktl @600 mm	a	b	R squared	Wt (g) @600 mm
MH-1	North	1.029	4.8E-06	3.118	0.974	2223
MH-2	North Central	1.033	9.3E-06	3.016	0.954	2231
MH-3	Central	1.015	1.3E-05	2.967	0.948	2192
MH-4,5	"Thumb"	1.014	1.3E-05	2.959	0.930	2190

$Ktl=(W/L^3)*10^5$

Length-weight regression: $W=aL^b$

Table 4.–Mean total lengths (mm) at age-5 of lake trout sampled from 5 statistical districts of Lake Huron, 2000.

Statistical district	Mean	Standard deviation	N
MH-1	504	45	65
MH-2	545	44	93
MH-3	545	44	78
MH-4,5	560	43	109

Table 5.–Lake trout stomach contents (number consumed, % of total identifiable prey, and average weight of prey) by statistical districts in Lake Huron from MDNR 2000 assessments. Sample sizes for prey weights are in parentheses.

	MH-1			MH-2			MH-3			MH-4, 5			Total		
Prey	No.	%	Avg. weight (g)	No.	%	Avg. weight (g)	No.	%	Avg. weight (g)	No.	%	Avg. weight (g)	No.	%	Avg. weight (g)
Alewife	204	45.4	8.2 (42)	846	56.4	5.7 (149)	627	59.8	6.3 (122)	776	67.1	12.4 (161)	2453	59.1	8.4 (474)
Smelt	199	44.3	6.6 (33)	642	42.8	6.7 (60)	419	40.0	7.0 (48)	311	26.9	4.6 (26)	1571	37.8	6.4 (167)
Round goby	1	0.2	–	0	0.0	–	0	0.0	–	58	5.0	–	59	1.4	–
9-spine stickleback	34	7.6	1.7 (1)	2	0.1	–	1	0.1	0.6 (1)	0	0.0	–	37	0.9	1.2 (2)
Slimy sculpin	8	1.8	–	1	0.1	–	0	0.0	–	4	0.3	16.2 (3)	13	0.3	16.2 (3)
Lake whitefish	1	0.2	–	2	0.1	–	1	0.1	14.0 (1)	1	0.1	–	5	0.1	14.0 (1)
Bloater chub	1	0.2	–	0	0.0	–	0	0.0	–	0	0.0	–	1	0.02	–
Trout perch	0	0.0	–	0	0.0	–	0	0.0	–	2	0.2	17.1 (1)	2	0.05	17.1 (1)
Yellow perch	0	0.0	–	0	0.0	–	0	0.0	–	2	0.2	37.0 (1)	2	0.05	37.0 (1)
Crayfish	0	0.0	–	0	0.0	–	0	0.0	–	1	0.1	–	1	0.02	–
Zebra mussels	0	0.0	–	0	0.0	–	0	0.0	–	1	0.1	2.0 (1)	1	0.02	2.0 (1)
Terrestrial insects	1	0.2	–	6	0.4	1.0 (6)	0	0.0	–	0	0.0	–	7	0.2	1.0 (6)
Total identifiable	449	100		1499	100		1048	100		1156	100		4152	100	
Unidentifiable fish	164	–		213	–		221	–		475	–		1073	–	
Void	44	18.3		42	12.3		22	8.8		90	18.8		198	15.1	
Number examined	241			342			250			481			1314		

Table 6.–Trawl catch of age-0 lake trout from Thunder Bay, Lake Huron, 1984-2001.

	North Point			Mischley Reef			Black River		
Year	Tows	Catch	CPE	Tows	Catch	CPE	Tows	Catch	CPE
1984	0	–	–	0	–	–	13	9	0.69
1985	8	0	0.00	0	–	–	2	2	1.00
1986	19	41	2.16	0	–	–	0	–	–
1987	23	19	0.83	0	–	–	0	–	–
1988	33	43	1.30	0	–	–	0	–	–
1989	63	39	0.62	0	–	–	0	–	–
1990	54	44	0.81	0	–	–	24	0	0.00
1991	39	6	0.15	0	–	–	0	–	–
1992	36	7	0.19	6	1	0.17	0	–	–
1993	35	13	0.37	11	1	0.09	0	–	–
1994	36	21	0.81	4	2	0.50	3	0	0.00
1995	36	4	0.11	0	–	–	0	–	–
1996	36	2	0.06	0	–	–	0	–	–
1997	48	5	0.10	0	–	–	0	–	–
1998	40	3	0.08	0	–	–	0	–	–
1999	38	2	0.05	0	–	–	0	–	–
2000	36	1	0.03	0	–	–	0	–	–
2001	36	0	0.00	0	–	–	0	–	–

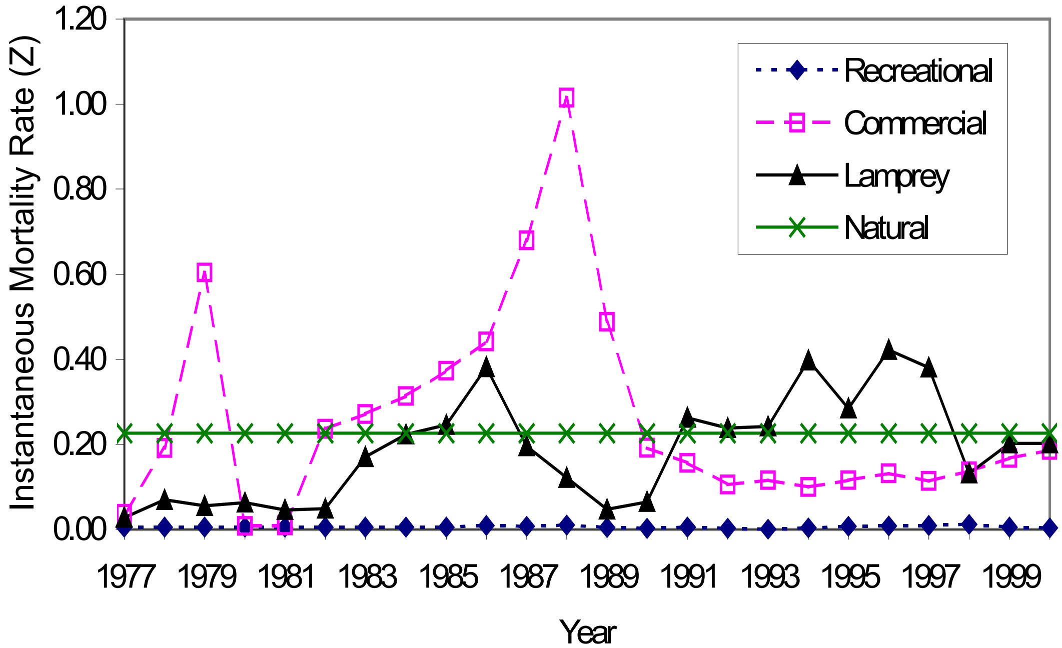

Figure 1.–Statistical-catch-at-age (SCAA) model estimates of average instantaneous mortality rates for age 3-13 lake trout in northern Lake Huron (MH-1 and adjacent Canadian waters).

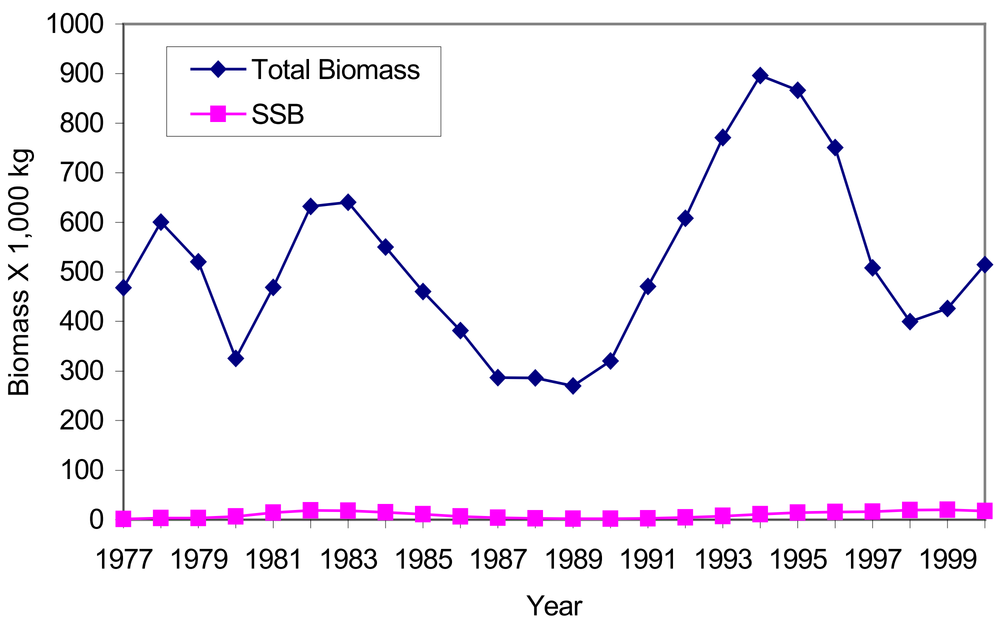

Figure 2.–Statistical-catch-at-age (SCAA) model estimates of lake trout biomass and spawning stock biomass (SSB) in northern Lake Huron (MH-1 and adjacent Canadian waters).

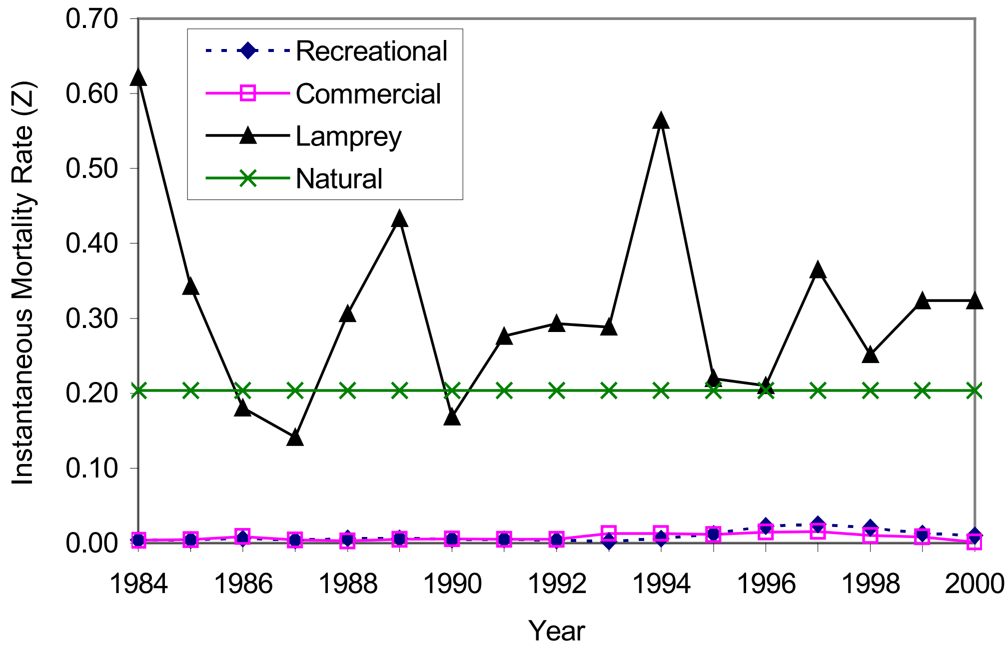

Figure 3.–Statistical-catch-at-age (SCAA) model estimates of average instantaneous mortality rates for age 3-13 lake trout in north-central Lake Huron (MH-2 and adjacent Canadian waters).

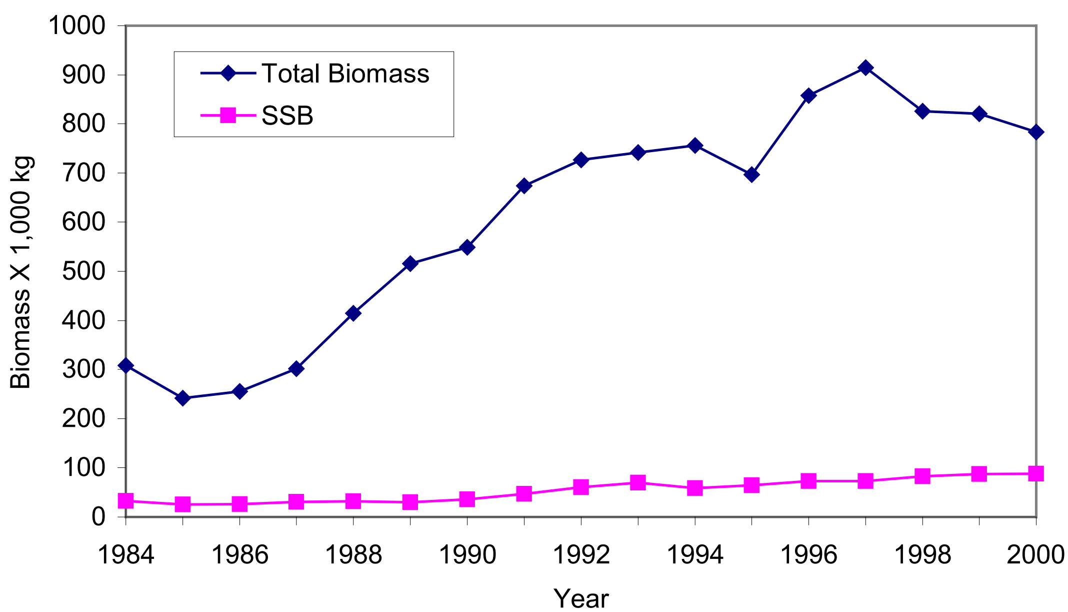

Figure 4.–Statistical-catch-at-age (SCAA) model estimates of lake trout biomass and spawning stock biomass (SSB) in north-central Lake Huron (MH-2 and adjacent Canadian waters).

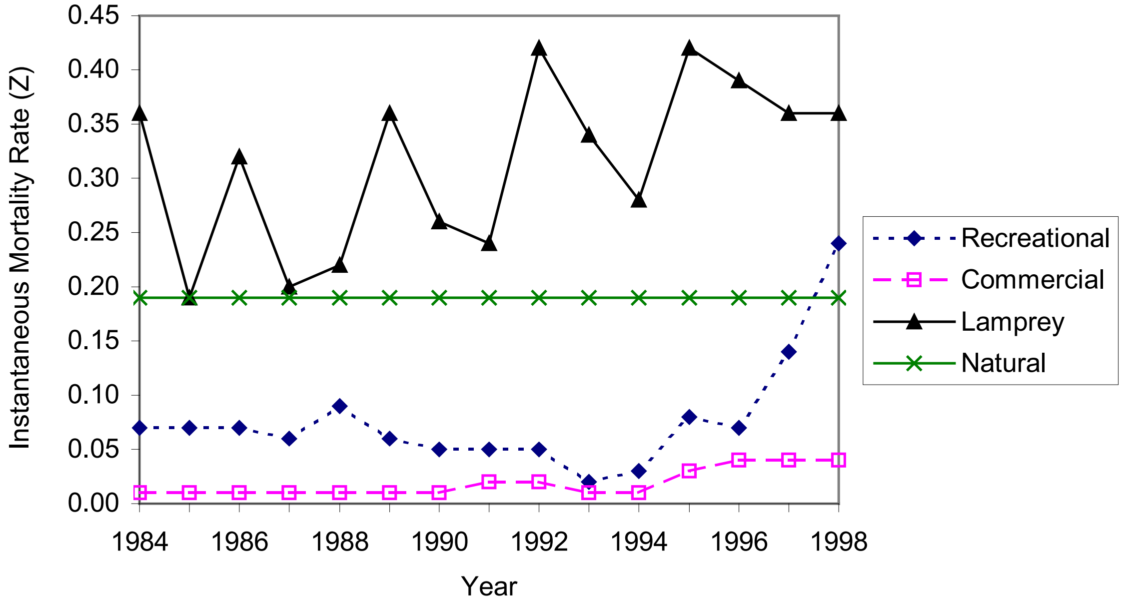

Figure 5.–Statistical-catch-at-age (SCAA) model estimates of average instantaneous mortality rates for age 3-13 lake trout in southern Lake Huron (MH-3, MH-4, MH-5 and adjacent Canadian waters).

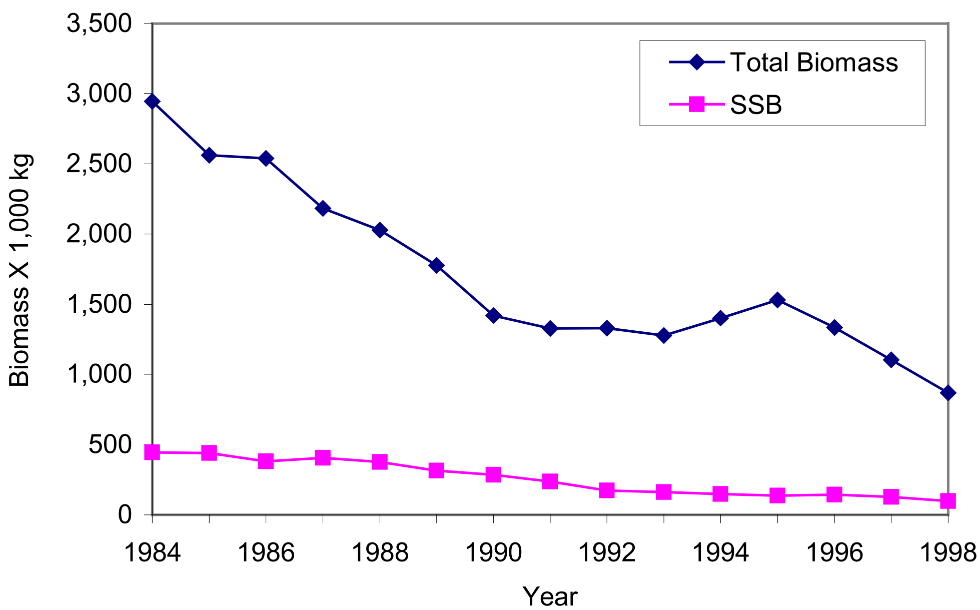

Figure 6.–Statistical-catch-at-age (SCAA) model estimates of lake trout biomass and spawning stock biomass (SSB) in southern Lake Huron (MH-3, MH-4, MH-5 and adjacent Canadian waters).