STUDY PERFORMANCE REPORT

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

Study No.: 495 **Title:** Assessment of lake trout populations in Michigan waters of Lake Superior

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

Cooperators: Bay Mills Indian Community, Brimley, Michigan; Biology Department, Northern Michigan University; Chippewa Ottawa Resource Authority (CORA; formerly called Chippewa-Ottawa Treaty Fisheries Management Authority, Sault Ste. Marie, Michigan; Department of Fisheries and Wildlife, Michigan State University; Great Lakes Indian Fish and Wildlife Commission, Odanah, Wisconsin; Isle Royale National Park, National Park Service; Peterson Fisheries, Hancock, MI; Keweenaw Bay Indian Community, Baraga, Michigan; Sivertson Fisheries, Duluth, Minnesota; Red Cliff Band of Lake Superior Chippewas, Bayfield, Wisconsin; and U. S. Geological Survey, Biological Research Division, Ashland, Wisconsin.

Study Objectives: (1) To annually (or semi-annually) determine relative abundance, length and age composition, sex and maturity, sea lamprey wounding, growth rate, and mortality rate for lean and siscowet lake trout in Michigan's Lake Superior lake trout management units. (2) To periodically determine relative abundance, diet, and biological variables (age, growth rate, etc.) of lake trout varieties, other predator fish, and forage fish at various depth strata in Lake Superior. (3) To calculate total allowable catch (TAC) for lake trout in Michigan's Lake Superior management units.

Summary: Compared to 2000, spring survey relative abundance of lean lake trout in 2001 increased in MI-3, MI-4, and MI-6 and declined in MI-5 and MI-7. Siscowet relative abundance as indexed in spring surveys remained relatively constant in all areas and was less than lean lake trout relative abundance. Pre-recruit lean lake trout relative abundance declined in all management areas sampled during 2001. Relative abundance in 2001 of pre-recruit siscowets increased in MI-3, MI-4, MI-6, and MI-7 and declined in MI-2 and MI-5. Pre-recruit siscowet relative abundance was higher than lean values in MI-2, MI-3, MI-6, and MI-7. During the spring of 2000 and 2001, rainbow smelt were the dominant prey fish observed in the diet of lean lake trout. Coregonines were the next most frequently observed prey fish followed by sculpins. Insects were observed in over 30% of stomachs in MI-6 and over 10% of stomachs in MI-5 during the springs of 2000 and 2001. Wild lake trout statistical catch-at-age models for MI-5, MI-6, and MI-7 were used to estimate recommended lake trout harvest quotas for state and tribal fisheries for 2001 in support of the mandates of the 2000 Consent Decree of the 1836 Great Lakes Fishing Treaty. Average total annual mortality rates (1998-2000) for ages 6 to 11 were 28% in MI-5, 38% in MI-6, and 32% in MI-7. Spawning stock biomass per recruit values for MI-6 were below the reference value for a stable population indicating excessive mortality rates. In MI-5 and MI-7, spawning stock biomass per recruit values were above the reference values indicating endurable mortality rates.

Job 1. Title: Assess commercial-sized lake trout.

Findings: On October 23, 24, 25, 26, and 27, 2001, Marquette Fisheries Research Station (MFRS) personnel conducted a lean lake trout (*Salvelinus namaycush namaycush*) spawning survey in Presque Isle Harbor, Marquette, MI (MI-5). This was part of an ongoing cooperative study with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) to index spawner relative abundance. Furthermore, this survey had an objective to tag lake trout to study movement patterns in support of the lake trout stock assessment models. The total number of lake trout caught was 552 with 87% being of wild origin. There were 478 lake trout tagged with anchor tags and 10 recaptures from previous years. Otoliths were archived and weights were recorded for dead lake trout. Eggs were collected from gravid or ripe dead female lake trout to assess fecundity.

Commercial-sized lean lake trout were sampled in the spring starting on April 30 and ending June 08, 2001. A contracted commercial fisher (Peterson Fisheries) under permit from GLIFWC fished five stations in Management Unit MI-3 (Figure 1). Marquette Fisheries Research Station (MFRS) personnel aboard the R/V Judy sampled 11 stations in MI-4, six stations in MI-5, and nine stations in MI-6. Chippewa Ottawa Resource Authority personnel sampled eight stations in MI-7. The total number of fish sampled was 4,309, including 3,470 lake trout.

All spring and fall data collected during this performance period were entered into a computer database and proofed for errors by MFRS personnel. Stratified-random subsamples of the total fish catch for each management unit from the spring survey will be assessed for age using scales or otoliths collected from each fish.

During this performance period, commercial-sized lean lake trout were also sampled in MI-1 (Isle Royale) by the National Park Service (June-August 2001) and Sivertson Fisheries (September-October 2000). These data have not been processed due to staff shortages at MFRS.

Job 2. Title: Assess pre-recruit lake trout.

Findings: Pre-recruit lake trout were sampled in the summer starting on July 31 and ending September 11, 2001. Marquette Fisheries Research Station personnel aboard R/V Judy sampled four stations in MI-2, seven stations in MI-3, eight stations in MI-4, four stations in MI-5, four stations in MI-6, and two stations in MI-7 (Figure 1). The total number of fish sampled was 2,769, including 999 lake trout. Stomach samples were collected from 1,149 fish and will be analyzed during the winter months. All data have been entered into a computer database and were proofed for errors. Fish ages will be assessed during the winter months using scales or otoliths collected during sampling.

Job 3. Title: Assess lake trout variety composition.

Findings: No fieldwork was done for this job during this performance period. Marquette Fisheries Research Station personnel participated in a Lake Superior lake trout and deepwater coregonine workshop sponsored by the Lake Superior Technical Committee of the Great Lakes Fishery Commission. The purpose of the workshop was to evaluate and coordinate the identification of the lake trout morphotypes (i.e., lean lake trout, siscowet *Salvelinus namaycush siscowet*, and humper lake trout) and the various deepwater coregonines (i.e., lake herring *Coregonus artedi*, bloater, *C. hoyi*, shortjaw cisco *C. zenithicus*, and kiyi *C. kiyi*).

Job 4. Title: Analyze assessment data.

Findings: *Spawner survey*-Average wild lean lake trout relative abundance (CPUE= catch per unit effort) in Presque Isle Harbor was 196 fish/km/day and average hatchery lake trout CPUE was 27 fish/km/day. Only one ripe female siscowet was captured on the spawning reefs. The percentage of the daily catch of wild lake trout that were females ranged from 16% on 23 October to 37% on 27 October. Percentage females caught for hatchery lake trout ranged from 20% on 23 October to 67% on 26 October. There were no hatchery female lake trout caught on 27 October. The percentage of wild lean lake trout females that were ripe averaged 42.3%.

Spring survey–During 2001, relative abundance (GMCPUE= Geometric Mean Catch Per Unit Effort) of lean lake trout was higher than during 2000 in MI-3, MI-4, and MI-6 (Figure 2a). Lean lake trout GMCPUE declined in MI-5 and MI-7. Siscowet GMCPUE has remained relatively constant during the last two years (Figure 2b). Siscowet GMCPUE was highest in MI-7. Overall, wild lake trout composed more than 75% of all lean lake trout catch (not adjusted for sampling effort). Spring sea lamprey wounding rates for 534-635 mm lean lake trout were lower than in 2000. Wounding rate was highest in MI-6 at 7 wounds (Type A1-A3) per 100 fish and was less than 4 wounds per 100 fish in all other management units.

Pre-recruit survey–Pre-recruit lean lake trout GMCPUE in 2001 declined in all management units from 2000 (Figure 3a). Pre-recruit siscowet GMCPUE was higher than lean GMCPUE in MI-2, MI-3, MI-6, and MI-7. Pre-recruit siscowet relative abundance declined from 2000 values in MI-2 and MI-5 (Figure 3b).

Job 5. Title: Analyze diet data.

Findings: Diet data for fish sampled in MI-7 during 2000 and 2001 were not available from CORA at the time of this report.

2000 Spring Survey–In general, rainbow smelt *Osmerus mordax* were the most frequently observed prey fish in lean lake trout stomachs in all management units sampled (Table 1). Coregonines (lake herring *Coregonus artedi*, bloater, *C. hoyi*, shortjaw cisco *C. zenithicus*, and kiyi *C. kiyi*) were the next most frequent fish in lean stomachs, followed by sculpins (slimy sculpin *Cottus bairdi*, mottled sculpin *C. cognatus*, and deepwater sculpin *Myoxocephalus thompsoni*). Insects were observed in 33.3% of lean stomachs in MI-6 and 10.6% of lean stomachs in MI-5. Nearly all these insects were terrestrial, indicating that lean lake trout were foraging at the lake surface during the spring. The percentage of lean lake trout stomachs that were empty ranged from 7.1% in MI-3 to 28.7% in MI-6.

In general, fishes were the most frequent prey items observed in siscowet stomachs with the exception being MI-6 where insects were observed in stomachs almost as frequently as fishes (Table 1). The most frequent prey fish observed in siscowet stomachs were rainbow smelt in MI-4, coregonines in MI-5, and sculpins in MI-6. Percent frequency of empty stomachs ranged from 0% in MI-5 to 15.8% in MI-6.

2001 Spring Survey–Overall, rainbow smelt were the most frequent prey fish in lean lake trout stomachs in all management units that were sampled except in MI-3 where coregonines were most frequently observed (Table 1). Coregonines were the next most frequent fish in lean stomachs followed by sculpins and then burbot *Lota lota*. Insects were observed in 39.5% of lean stomachs in MI-6 and 21.8% of lean stomachs in MI-5. Nearly all these insects were

terrestrial, indicating that lean lake trout were foraging at the lake surface during spring. The percentage of lean lake trout stomachs that were empty ranged from 13.1% in MI-4 to 28.7% in MI-5.

In general, fishes were the most frequent prey items observed in siscowet stomachs, with the exception being MI-6 where insects were observed in 52.8% of the stomachs (Table 1). The most frequent prey fish observed in siscowet stomachs were coregonines in MI-3, coregonines and smelt in MI-4, and sculpins in MI-5 and MI-6. Percent frequency of empty stomachs ranged from 10.8% in MI-4 to 27% in MI-3.

2000 Pre-recruit survey– Diet samples collected during the summer of 2001 will be processed this winter. Stomach samples from 2000 were collected from 104 leans and 86 siscowets in MI-3, and from 124 leans and 78 siscowets in MI-6. MFRS personnel and volunteer students from Northern Michigan University analyzed stomach samples.

Overall, fishes were the most frequent prey item observed in both pre-recruit (total length <432 mm) lean and siscowet stomachs except for MI-6 siscowets where crustaceans (*Diporeia* spp., *Mysis relicta*) were the dominant prey items (Table 2). The most frequent fish species observed in lean lake trout were sculpins in MI-3 and rainbow smelt in MI-6. The major fish in siscowets were sculpins in both MI-3 and MI-6. In comparing invertebrate prey items, crustaceans were observed more frequently than insects in MI-6 for both leans and siscowets while the inverse occurred in MI-3.

Job 6. Title: <u>Model lean lake trout populations.</u>

Findings: Statistical catch-at-age models have been developed for wild lake trout populations in MI-5, MI-6, and MI-7 (Figure 1). These models have been used to develop harvest quotas (also termed Total Allowable Catch or TAC) for lake trout in accordance with the 2000 Consent Decree of the 1836 Great Lakes Fishing Treaty between the State of Michigan and Native American Tribes. Overall, model results indicated abundant wild lake trout populations in MI-5 and MI-7 with mortality rates below the target maximum rate established by the Great Lakes Fishery Commission (target maximum A=40%). The model for MI-6 indicated that the population is suffering mortality rates slightly above the target maximum rate. The status of the lake trout populations was indexed by comparing Spawning Stock Biomass produced per Recruit (SSBR) values with the target value. This index is a measure of the reproductive capacity of the population in the context of mortality rates. The SSBR for each population is the sum of the mature female biomass produced per recruit under recent mortality rates (mean of 1998-2000 rates). The target SSBR is the theoretical amount of SSBR produced if all fish older than age 7 suffer the target maximum total annual mortality rate of 40%. This method of indexing population health accounts for the age-specific differences in mortality rates from fishing and sea lamprey predation and incorporates the reproductive capacities of each population.

Recent total abundance (mean of 1998-2000) of ages 3 to 15 wild lake trout was estimated to be about 1.1 million fish in MI-5; 160,000 fish in MI-6; and 690,000 fish in MI-7 (Figure 4). Mean total annual mortality rates during 1998 - 2000 for ages 6 to 11 wild lake trout were 0.28 $year^{-1}$ in MI-5, 0.38 $year^{-1}$ in MI-6, and 0.32 $year^{-1}$ in MI-7 (Figure 5). Recreational fishing mortality was the dominant mortality source in MI-6 during 1998-2000. Sea lamprey mortality was the dominant mortality source in MI-5 and MI-7. The SSBR values were above the target in MI-5 and MI-7 (Figure 6). In MI-6, SSBR was 15% below the target value.

These modeling results have been used to estimate lake trout harvest quotas for 2001. Currently, hatchery lake trout models have been partially developed for MI-5, MI-6, and MI-7. Data have been partially assembled for MI-2, MI-3, and MI-4 wild and hatchery lake trout models.

Job 7. Title: Prepare reports.

Findings: Draft reports on lake trout TAC recommendations for 2001 have been written for the 1836 Treaty Technical Fisheries Committee, and this progress report was prepared.

Prepared by: S.P. Sitar
Dated: September 27, 2001

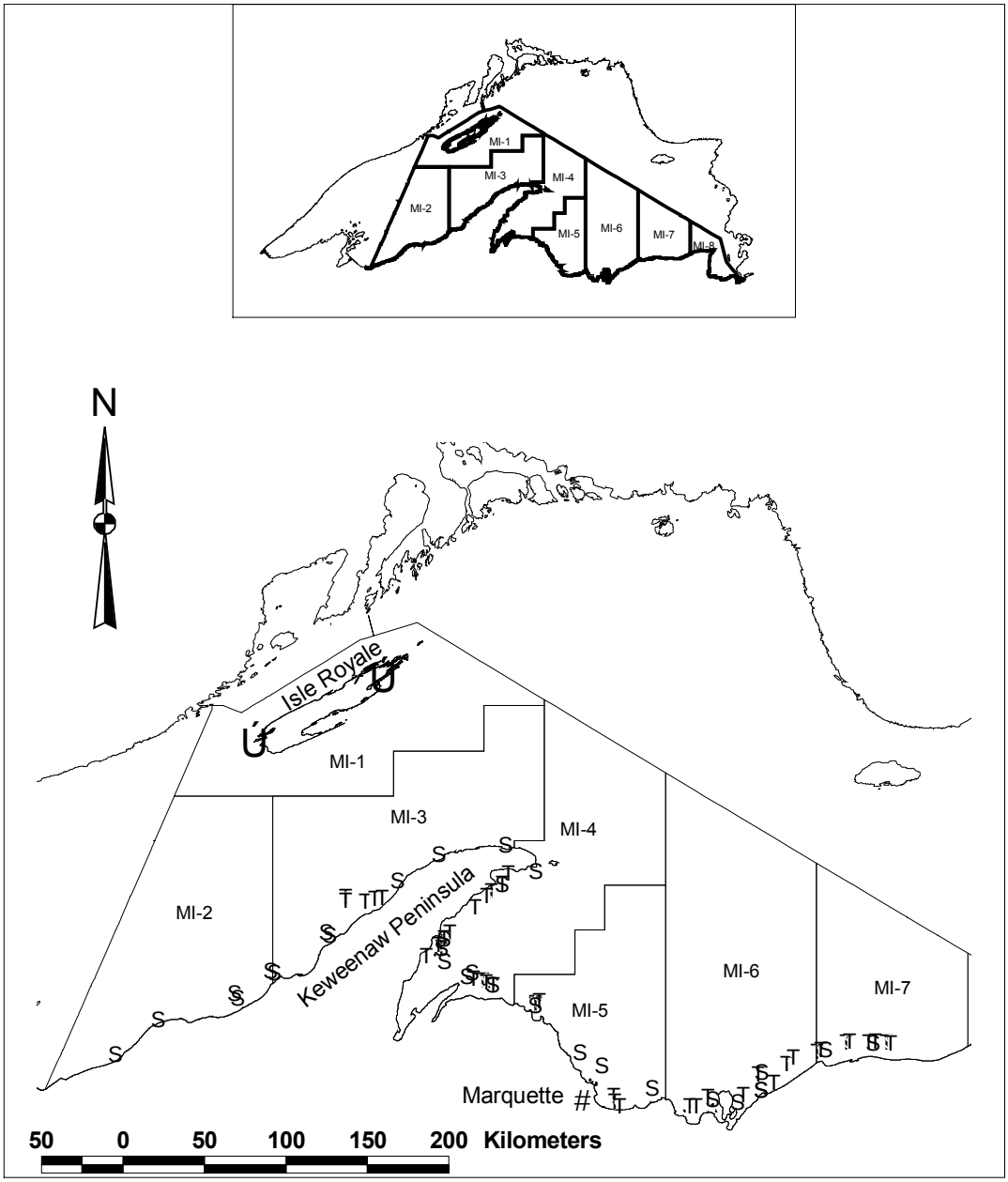

Figure 1.–Lake trout management units and lake trout survey sampling stations in Michigan waters of Lake Superior for 2001. Triangles represent spring survey stations, circles represent summer pre-recruit survey stations, and stars represent Isle Royale survey stations.

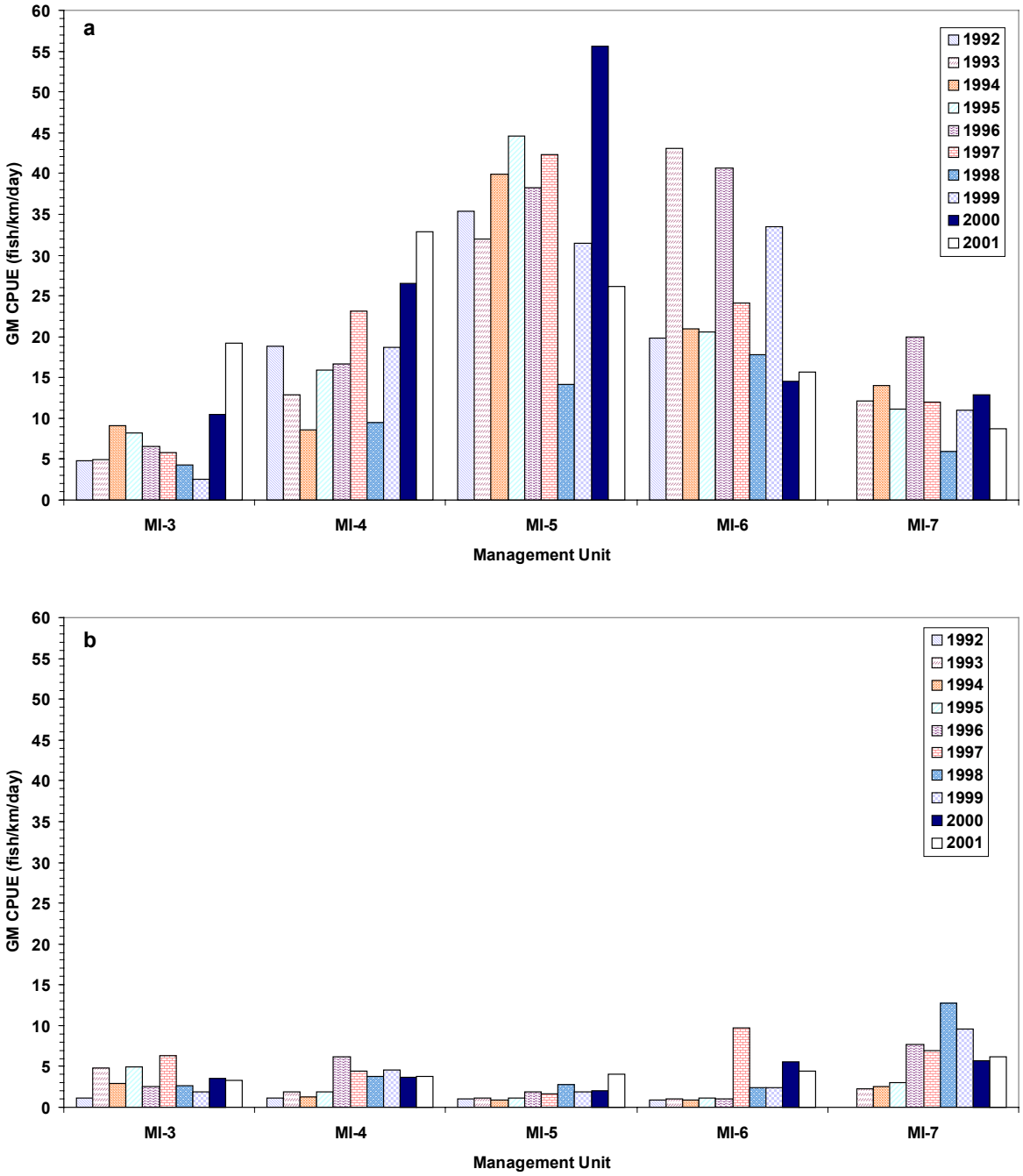

Figure 2.– Relative abundance of (a) lean and (b) siscowet lake trout during spring surveys from 1992 to 2001 in Michigan waters of Lake Superior. Data expressed as geometric mean catch per unit effort (GMCPUE) based on 11.4 cm stretched-mesh bottom gill nets. No survey was conducted in MI-7 during 1992.

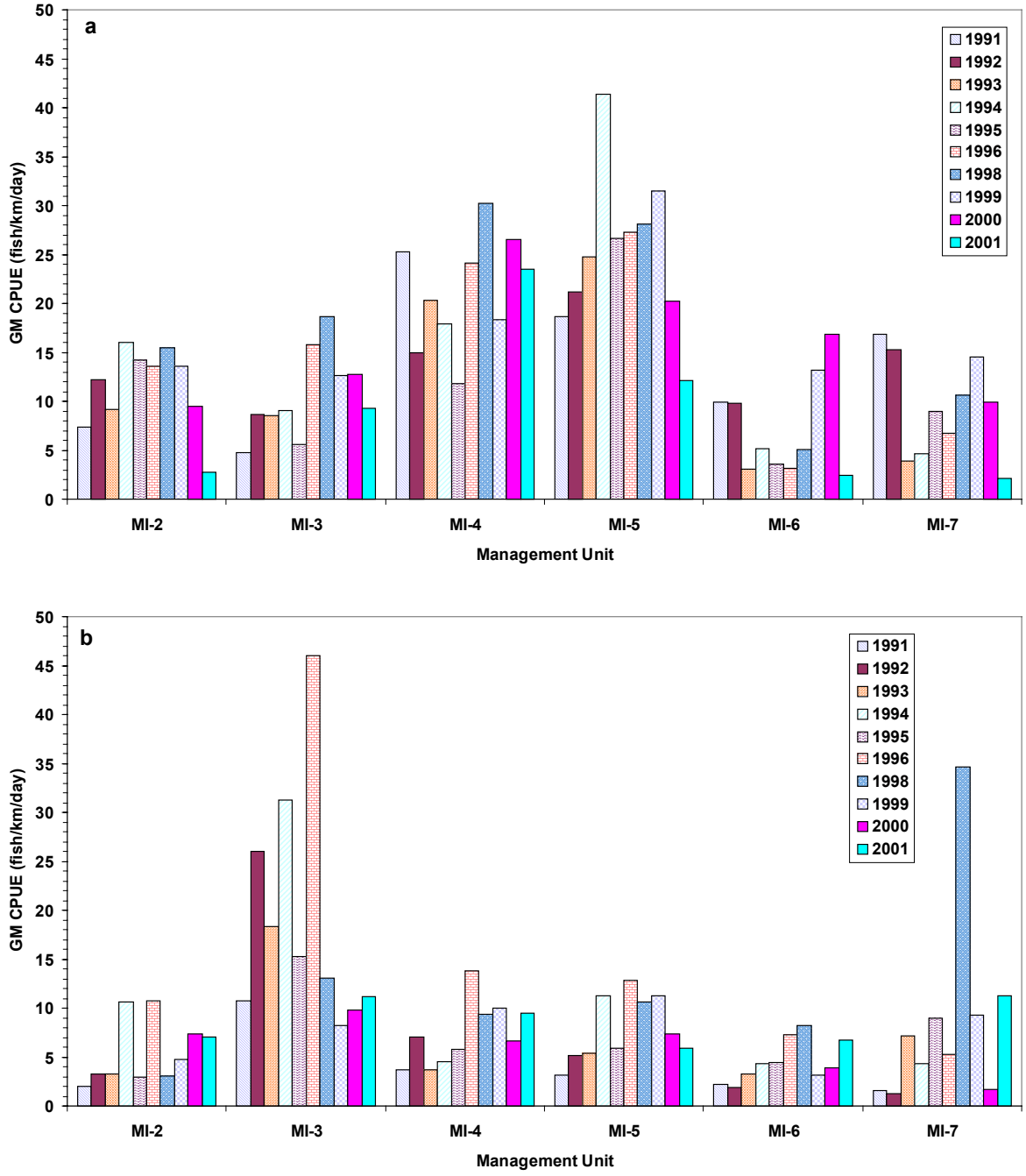

Figure 3.–Relative abundance of pre-recruit (< 432 mm total length) (a) lean and (b) siscowet lake trout during summer surveys from 1991 to 2001 in Michigan waters of Lake Superior. Data expressed as geometric mean catch per unit effort (GMCPUE) based on graded-mesh bottom gill nets (stretched mesh sizes=5.1, 5.7, 6.4, 7.0, 7.6, 8.9 cm). No pre-recruit survey was conducted in 1997.

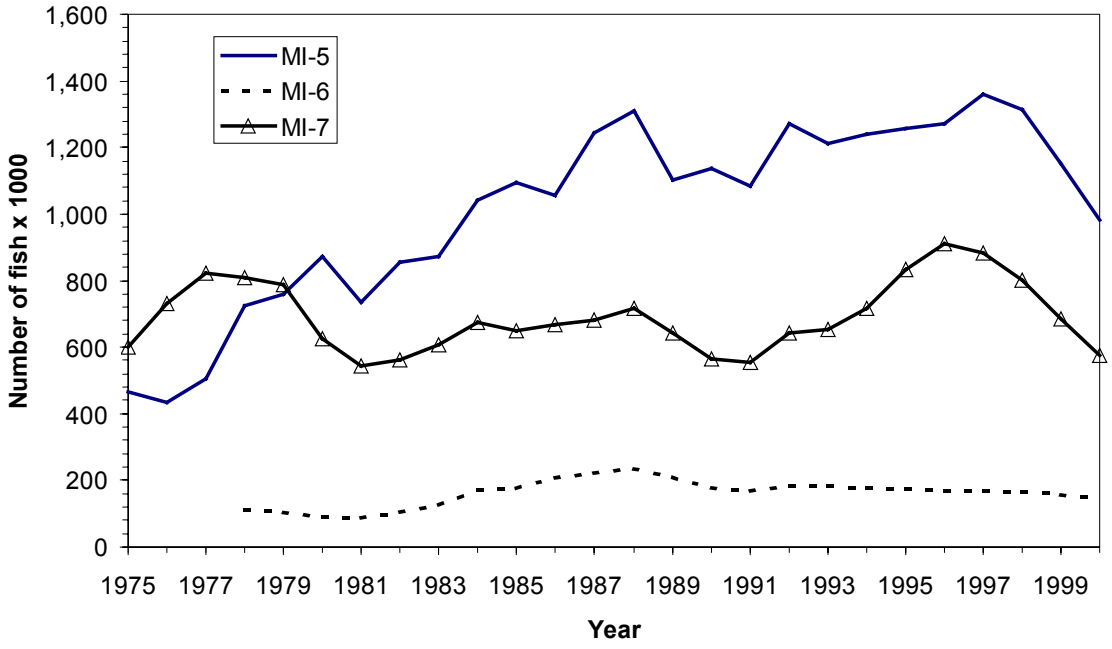

Figure 4.–Annual abundance of ages 3-15 wild lake trout in MI-5, MI-6, and MI-7 based on estimates from statistical catch-at-age models.

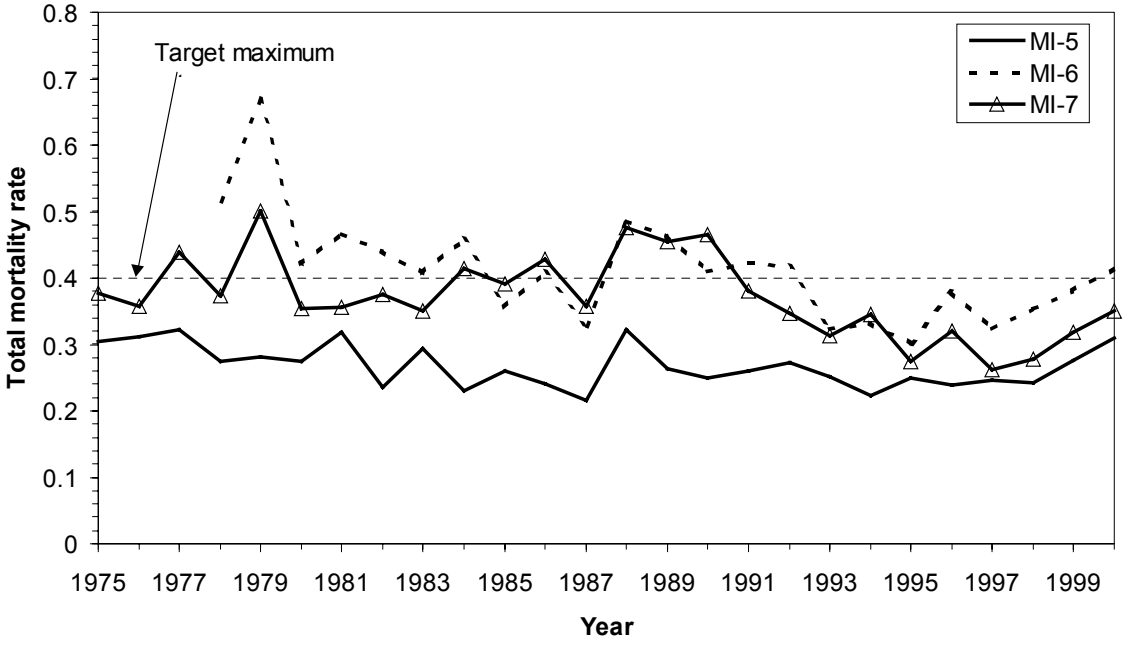

Figure 5.–Total annual mortality rates for wild lake trout (average of ages 6 to 11 fish) during 1975-2000 in MI-5, MI-6, and MI-7 based on statistical catch-at-age models. The thin dashed line indicates the Great Lakes Fishery Commission's lake trout rehabilitation target maximum mortality rate of 0.4.

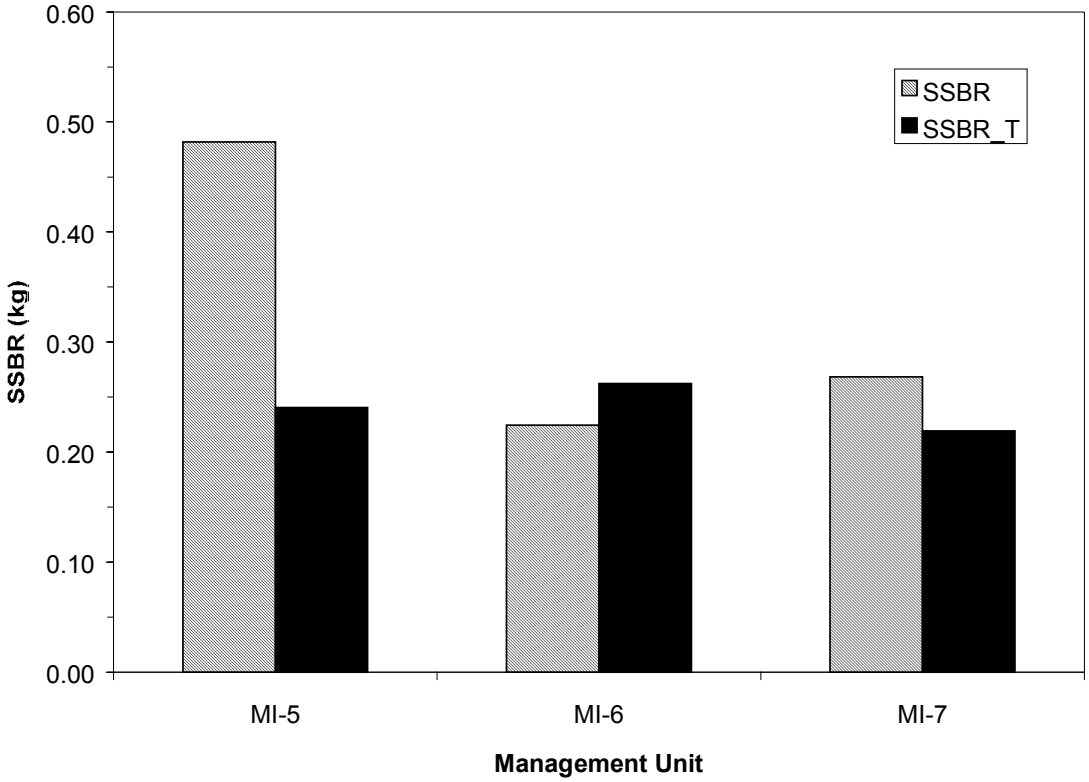

Figure 6.– Reproductive index of wild lake trout populations in MI-5, MI-6, and MI-7 based on results from statistical catch-at-age models. Reproductive index was measured using Spawning Stock Biomass produced per Recruit (SSBR) values. SSBR was based on the average of 1998-2000 mortality rates and female maturity schedules for each management unit. SSBR_T was the target SSBR value based on the Great Lakes Fishery Commission target maximum total annual mortality rate of 40%.

Table 1.–Spring lean and siscowet lake trout diet compositions for Michigan waters of Lake Superior in 2000 and 2001. Data expressed as percent frequency occurrence among sampled stomachs in each management unit. Prey category "other fish" comprised mainly unidentified fish remains, which were assumed to be composed of species in the same proportion as identified fishes. Prey category "other" included plant material, stones, sand, and other unidentifiable biological matter. Diet data for MI-7 were not available at the time of this report.

		Lean lake trout				Siscowet			
Year	Prey category	MI-3	MI-4	MI-5	MI-6	MI-3	MI-4	MI-5	MI-6
2000	Smelt	77.6	68.0	72.1	10.1		35.6		6.1
	Sculpin	1.0	2.0	5.8	3.1		2.2	51.3	10.5
	Coregonine	16.3	6.0	8.7	7.8		20.0	53.8	7.0
	Burbot						12.2	5.1	4.4
	Other fish	23.5	31.0	26.0	21.7		40.0	2.6	36.0
	Insect	3.1	2.0	10.6	33.3		2.2		36.8
	Crustacean		6.0	2.9	14.7		13.3		14.0
	Bird								1.8
	Mollusk								0.9
	Other	1.0	3.0	2.9	7.0		6.7		13.2
	Empty	7.1	9.0	9.6	28.7		11.1		15.8
	n	98	100	104	129		90	39	114
2001	Smelt	18.1	50.5	15.8	8.9	1.4	30.4	3.1	3.7
	Sculpin	1.1	1.9	5.0	4.8	4.1	6.9	13.8	14.8
	Coregonine	43.6	21.5	12.9	6.5	28.4	30.4	6.2	0.9
	Burbot	2.1	1.9		2.4	1.4	9.8	9.2	5.6
	Other fish	25.5	20.6	29.7	28.2	35.1	20.6	38.5	42.6
	Insect	1.1	6.5	21.8	39.5	9.5	4.9	23.1	52.8
	Crustacean		4.7	6.9	10.5		8.8	10.8	8.3
	Bird					1.4			
	Mollusk					1.4		1.5	0.9
	Other		1.9	2.0	3.2	9.5	2.9	6.2	7.4
	Empty	25.5	13.1	28.7	21.0	27.0	10.8	15.4	11.1
	n	94	107	101	124	74	102	65	108

Table 2.–Summer pre-recruit (<432 mm) lean and siscowet lake trout diet compositions for Michigan waters of Lake Superior in 2000. Data expressed as percent frequency occurrence among sampled stomachs in each management unit. Prey category "other fish" comprised sticklebacks (threespine *Gasterosteus aculeatus*, ninespine *Pungitius pungitius*), trout-perch *Percopsis omiscomaycus*, and unidentified fish remains, which were assumed to be composed of species in the same proportion as identified fishes. Prey category "other" included plant material, stones, sand, and other unidentifiable biological matter.

	Lean lake trout		Siscowet	
Prey category	MI-3	MI-6	MI-3	MI-6
Smelt	7.58	13.48		6.25
Sculpin	31.82	11.24	40	12.5
Coregonine	3.03	2.25		3.13
Other fish	27.27	33.71	38.18	21.88
Insect	7.58	15.73	5.45	18.75
Crustacean	4.55	30.34	1.82	43.75
Other	7.58	4.49	9.09	9.38
Empty	24.24	14.61	20	9.38
n	66	89	55	32