STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-53-R-14

Study No.: 473 **Title:** Assessment of lake trout populations in Michigan waters of Lake Superior

Period Covered: April 1, 1997 to March 31, 1998

Cooperators: Thill Fisheries, Marquette, Michigan; Brey Fisheries and Vanlandschoot Fisheries, Munising, Michigan; United States Geological Service - Biological Resources Division (USGS-BRD), Ashland, Wisconsin; Chippewa/Ottawa Treaty Fisheries Management Authority (COTFMA), Sault Ste. Marie, Michigan; Red Cliff Fisheries Department, Bayfield, Wisconsin.

Study Objective: (1)To annually determine relative abundance, length and age composition, sex and maturity, sea lamprey wounding rates, growth, mortality rates, and total allowable catches (TACs) for hatchery (fin clipped) and wild (not fin clipped) lean-variety and siscowet-variety lake trout in Michigan's Lake Superior lake trout management areas. (2)To utilize these parameters in assessing effectiveness of sea lamprey control and progress of lean lake trout rehabilitation efforts in Michigan waters of Lake Superior. (3)To periodically determine what lake trout are eating, especially to document the switch from rainbow smelt to lake herring, and to determine if competition for food exists between the lean and siscowet varieties of lake trout. (4)To monitor lake herring abundance and age composition in lake trout habitat.

Summary: Abundance, as measured by CPE (number of fish per 1,000 feet of gill net per 72-hour set) of commercial sized (≥17 in, total length), wild lean lake trout (leans) in 1997 ranged from 6.2 in MI-3 to 35.9 in MI-5. Wild fish made up 85-94% of lean lake trout populations. Abundance of mature wild leans (≥25 in, total length) in 1997 ranged from 2.2 in MI-3 to 5.9 in MI-5. Sea lamprey wounding (number of wounds per 100 fish) on the size group that represented most mature leans (25.0-28.9 in, total length) ranged from 6.0 in MI-3 to 35.0 in MI-6, and compared to 1996, represented an increase in wounding in all areas except MI-3. Siscowet lake trout outnumbered all other fish and were over forty times more abundant than leans in a special assessment done in MI-5 in September 1997. Sea lamprey wounding was 16.2 for siscowets 25- to 28-inches long. Age of leans in the 1997 commercial-sized assessment ranged from 4 to 20 years and modal age ranged from 7 to 8 years among management areas. Total annual mortality rates of 9- to 15-year-old wild leans in the commercial-sized assessment ranged from 0.37 in MI-3 to 0.45 in MI-5. Commercial-sized lean lake trout weight-length regression coefficients were not significantly different among management areas. Age of siscowets ranged from 3 to 30 years with a modal age of 16. Siscowet total mortality for ages 16 to 30 was 0.48. Siscowet weight-length coefficients were significantly greater than for leans. The siscowet diet consisted mainly of coregonines (deepwater ciscoes and lake herring).

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

Findings: Assessment fishing for commercial-sized (≥17 inches, total length) lean lake trout (hereafter referred to as leans) was done by a contracted commercial fisher at two stations in MI-5 (Big Bay and Marquette), by Marquette Fisheries Station at three stations in MI-4 (Bete Grise,

Traverse Island, Point Abbaye) and two stations at Munising (Munising-west and Munising-east), by the Red Cliff Fisheries Department (RCFD) of the Red Cliff Band of Lake Superior Chippewas at one station in MI-3 (Upper Entry), and by Chippewa/Ottawa Treaty Fisheries Management Authority (COTFMA) at one station in MI-7 (Grand Marais) during 28 April to 5 June 1997. Assessment nets were 1,500- or 3,000-foot gangs of 4.5-inch stretched mesh multifilament gill net fished 72 hours on the bottom in 120-240 feet of water. In general, successive net sets were made at sites associated with each station until the quota of commercial-sized lake trout was captured. Fish quotas were 500 fish per station in management area MI-5 (Big Bay and Marquette), and 400 fish per station in area MI-6 (Munising-west and Munising-east). Time constraints prevented collecting a quota of 500 lake trout at each of the five stations included in areas MI-3 and MI-4, so an amount of gill-net effort (feet) based on time constraints has been fished at each station annually in recent years as follows: 45,000 at Upper Entry (MI-3), 15,000 at each of MI-4 stations Bete Grise, Traverse Island and Point Abbaye. Personnel from COTFMA fished 24,000 feet of net at Grand Marais (MI-7) in 1997. Marquette Fisheries Station personnel collected data from all assessment catches in MI-4, MI-5, and MI-6, RCFD collected data from catches in MI-3, and COTFMA personnel collected data from catches in MI-7. Data consisted of the following for commercial-sized leans captured in each 1,500 feet of net: number, fin clip, total length, sex, number of sea lamprey wounds (combined total of stages A1, A2, and A3) and scars (combined total of stages A4, B1, B2, B3, and B4). Scale samples were taken from all leans less than 23 inches long and otoliths from all leans 23 inches and longer. Total weights and diet data were obtained for 100 net-run leans from each management area. Data from these assessments were either collected by or turned over to Marquette Fisheries Station personnel for analysis. Marquette Fisheries Station personnel determined the number of leans per 1,000 feet of net per 72-hour set (CPE) as a measure of abundance, determined age from scales and otoliths, calculated mortality rates from age composition, and summarized sea lamprey wounding. USGS-BRD personnel from the Ashland Biological Station in Ashland, Wisconsin analyzed diet data. Commercial-sized leans were assessed in MI-2 in 1997 by the RCFD who retained the data for analysis

The CPE of hatchery leans was highest in MI-5 (3.3) and lowest in MI-3 (0.6) (Table 1). Wild fish made up 85-94% of lean lake trout assessment samples, and were most abundant in MI-5 (CPE=35.9) and least abundant in MI-3 (CPE=6.2). The CPE of mature ($\geq$25 inches, total length) wild leans ranged from 2.2 in MI-3 and MI-7 to 5.9 in MI-5. Compared to 1996, CPE of wild leans in 1997 was down in MI-3, MI-6 and MI-7, and up in MI-4 and MI-5.

Sea lamprey wounding (number of wounds per 100 fish) on leans in the inch group that represented most mature fish (25.0-28.9 in) ranged from 6.0 in MI-3 to 35.0 in MI-6 (Table 1). Compared to 1996, wounding on this size group in 1997 increased in all areas except MI-3. Wounding was lower on smaller lean lake trout, ranging from 1.7 (MI-4) to 8.0 (MI-7) for the 21.0-24.9 inch group, and 0.0 (MI-3, MI-5, and MI-7) to 3.1 (MI-7) for the 17.0-20.9 inch group.

Job 2. Title: <u>Assess pre-recruit lake trout</u>.

Findings: No pre-recruit lake trout assessment was done in 1997 due to retirement of the Marquette Fisheries Station boat captain and a hiring freeze which prevented filling that position in time to do the assessment. Since monitoring lake herring abundance was part of this assessment, these data were not obtained in 1997.

Marquette Fisheries Station personnel with assistance from Charlevoix Fisheries Station personnel did conduct an assessment of siscowet lake trout in MI-5 during 15-24 September

1997. This was part of an inter-agency lakewide assessment of the relative abundance of siscowets and other predator fish in U. S. waters of Lake Superior. Graded-mesh gill nets consisting of 300-ft panels of 2.0-, 2.5-, 3.0-, 3.5-, 4.0-, 4.5-, 5.0-, 5.5-, and 6.0-inch multifilament nylon mesh were fished one to two nights on the bottom within 120-foot depth intervals out to 714 feet. All fish were identified, checked for fin clip, measured (total length, inches), and weighed (grams). Sea lamprey wounding and scarring and sex and maturity were recorded, and scales or otoliths obtained for aging. Scales were collected from all fish except that otoliths were collected from all siscowets, all burbot, and leans 23 inches and longer. Stomachs from all lake trout and burbot were preserved for subsequent diet analysis. Egg samples from six mature siscowets were collected for thiamin analysis by Department of Fisheries and Oceans, Canada, and tissue samples were obtained from lake trout and burbot for stable-isotope analysis by University of Wisconsin, Madison.

Siscowets outnumbered leans at all depths except in the shallowest set and were 46 times more abundant than leans in all sets combined (Table 2). Abundance increased 40-fold between the 36-60 foot set and the 210-234 foot set, then continued to increase in sets out to 534 feet. Abundance decreased somewhat in the deepest set (618-648 ft). Lean lake trout were present in the four shallowest sets but absent in deeper ones. Burbot were infrequently caught in three of the four deepest sets. Bloaters were the most abundant species other than lake trout, mainly within depths of 210 to 288 feet. Lake herring and kiyi were captured in sets at 210 feet and deeper but were not abundant. Longnose suckers were abundant in the shallowest set (36-60 ft) but absent in deeper sets.

Siscowets collected in this assessment ranged in total length from 9 to 30 inches with 22 and 23 inches tied for the modal inch group and a median length of 21 inches. Sea lamprey wounding rate increased from 1.3 wounds per 100 fish for 17-to 20-inch fish to 16.2 for 25- to 28-inch fish. The only siscowet larger than 28 inches was not wounded.

Job 3. Title: <u>Assess spawning lake trout</u>.

Findings: No work was done on this job.

Job 4. Title: <u>Determine age, growth, mortality, total allowable catch (TAC), and food habits</u>.

Findings: Marquette Fisheries Station personnel determined age of wild leans in the commercial-sized assessment from a subsample of 20 fish per inch group from scales or otoliths. Age composition in each inch group subsample was applied to the total number of wild leans in those inch groups to estimate total age composition. Ages were determined for commercial-sized hatchery leans based on fin clip with scale or otolith age used to verify fin-clip age. Ages were determined for all fish captured in the siscowet assessment. Otoliths were used to age all siscowets, burbot, and leans 23 inches and larger, and scales were used to age all other fish. Confidence intervals (±95%) were determined for mean age, mean weight, mean total length, and weight-length coefficients for weights and lengths transformed to natural logarithms. Some means and coefficients were compared between leans and siscowets and among management areas, with non-overlapping confidence intervals indicating a significant difference ($P \leq 0.05$). Total mortality rates for commercial-sized wild leans and siscowets were derived from survival rates estimated by the method described by Robson and Chapman (1961). These survival rates were based on coded age frequencies of fish in age groups on the descending limb of the catch curve that were judged to be fully vulnerable to the gill nets. Chi-square values were calculated

to compare two separate estimated survival rates in the Robson Chapman method. According to Robson and Chapman (1961), a chi-square in excess of 3.84 indicated that there was greater than a 5% chance that factors other than sampling error were compromising validity of survival rates estimated from the age composition data. These factors could include variable recruitment, variable survival among ages, or unequal vulnerability to sampling gear.

Total allowable catches (TACs) for commercial-sized leans in Lake Superior management areas are being updated but are not available for this report.

Age distribution of wild leans in the 1997 commercial-sized assessment ranged from 4 to 20 years (Table 3). Age 7 was modal in MI-3 and MI-4 and age 8 was modal in MI-5, MI-6, and MI-7. The Great Lakes Fishery Commission's Lake Superior Technical Committee has elected to use mean total length at age 7 as an annual index of wild lean growth. Mean total length of age-7 wild leans ranged from 21.3 inches in MI-4 to 22.5 inches in MI-3. Age 8 has been determined to be the youngest age fully vulnerable to the 17-inch minimum size limit in the commercial-sized assessment. To insure vulnerability and comparability among management areas and years, ages 9-15 were selected for mortality rate calculations. Total annual mortality rates ranged from 0.37 in MI-3 to 0.45 in MI-5 (Table 3). Compared to 1996, mortality rates from ages 9-15 in 1997 decreased in all areas except MI-5. Mean weight of commercial-sized leans ranged from 3.36 pounds in MI-4 to 4.67 pounds in MI-3, and mean total length ranged from 21.7 inches in MI-6 to 24.0 inches in MI-3 (Table 4). Weight-length coefficients for commercial-sized lean lake trout were not significantly different ($P \leq 0.05$) among the areas.

Age of siscowets assessed in MI-5 in September 1997 ranged from 3 to 30 years and modal age was 16 (Table 5). Total annual mortality rate estimated for ages 16-30 was 0.48. Siscowet weight-length coefficients were significantly greater than for leans (Table 4). Siscowet mean total length-at-age increased from 10.0 inches for age 3 to 24.4 inches for age 20 (Table 5). Length-at-age of older siscowets fluctuated considerably.

Deepwater ciscoes (chubs) and lake herring contributed most to the diet of siscowets sampled in MI-5 in September 1997, especially at depths greater than 40 fathoms (Table 6). Burbot and sculpins were also important prey items. Siscowets sampled at depths less than 40 fathoms were feeding mainly on crustaceans (Amphipoda) and terrestrial insects. Diet data from the few lean lake trout and burbot captured in this assessment has not yet been summarized.

Job 5. Title: <u>Prepare reports</u>.

Findings: Data from this study were used to prepare the annual report to the Lake Superior Committee of the Great Lakes Fishery Commission, and to prepare this Federal Aid to Sport Fish Restoration Annual Performance Report.

Literature Cited:

Robson, D. S. and D. G. Chapman. 1961. Catch curves and mortality rates. Transactions of the American Fisheries Society 90:181-189.

Table 1.–Commercial-sized (≥17 in, total length) lean lake trout assessment effort, abundance (CPE)[a] and sea lamprey wounding[b] at stations in Michigan's Lake Superior management areas 3-7 during 28 April-5 June 1997.

Management area and station	Effort (ft x 1,000)	CPE				Wounds per 100 lake trout and number of fish in parentheses			
			Wild		Total	Total length (in) groups			
		Hatchery	All	≥ 25in	(% wild)	17.0-20.9	21.0-24.9	25.0-28.9	≥29.0
MI-3									
Upper Entry	45.0	0.6	5.6	2.2	6.2 (91)	0.0 (32)	2.2 (138)	6.0 (84)	0.0 (23)
MI-4									
Bete Grise	15.0	3.5	14.9	3.0	18.4 (81)	0.0 (132)	2.1 (96)	15.0 (40)	37.5 (8)
Traverse Island	15.0	4.6	14.5	1.3	19.1 (76)	0.0 (107)	1.3 (153)	4.0 (25)	0.0 (2)
Point Abbaye	15.0	0.9	21.7	3.1	22.5 (96)	1.6 (125)	1.8 (165)	11.1 (45)	33.3 (3)
Area total	45.0	3.0	17.0	2.5	20.0 (85)	0.6 (364)	1.7 (414)	10.9 (110)	30.8 (13)
MI-5									
Big Bay	18.0	3.8	28.5	6.7	32.3 (88)	0.0 (68)	2.4 (367)	8.0 (137)	0.0 (9)
Marquette	12.0	2.4	38.8	4.8	41.2 (94)	0.0 (132)	2.7 (300)	10.3 (58)	20.0 (5)
Area total	30.0	3.3	32.6	5.9	35.9 (91)	0.0 (200)	2.6 (667)	8.7 (195)	7.1 (14)
MI-6									
Munising-west	6.0	2.7	27.8	5.0	30.5 (91)	1.9 (53)	1.0 (95)	26.9 (26)	44.4 (9)
Munising-east	12.0	1.8	16.4	3.0	18.2 (90)	4.4 (45)	9.8 (133)	41.2 (34)	66.7 (6)
Area total	18.0	2.1	20.2	3.7	22.3 (91)	3.1 (98)	6.1 (228)	35.0 (60)	53.3 (15)
MI-7									
Grand Marais	24.0	0.7	10.7	2.2	11.4 (94)	0.0 (64)	8.0 (149)	17.9 (56)	25.0 (4)

[a] Number of commercial-sized lean lake trout per 1,000 feet of 4.5-inch multifilament-mesh gill net.
[b] Number of stage A1, A2, and A3 sea lamprey marks per 100 lake trout.

Table 2.–Number of fish per 1,000 ft of graded-mesh gill nets[a] (CPE)[b] in 2,700-ft gangs fished on the bottom within 120-ft depth intervals to assess relative abundance of siscowet lake trout in Michigan's Lake Superior management area MI-5 during 15-24 September 1997.

		Number of fish and number per 1,000 ft of net (CPE)						
Depth (ft)	Nights fished	Siscowet lake trout	Lean lake trout	Burbot	Lake herring	Bloater	Kiyi	Longnose sucker
36-60	1	2 (0.7)	5 (1.8)	0	2 (0.7)	0	0	282 (104.4)
210-234	2	80 (29.6)	3 (1.1)	0	2 (0.7)	19 (7.0)	1 (0.4)	0
258-288	2	98 (36.3)	2 (0.7)	3 (1.1)	1 (0.4)	17 (6.3)	0	0
402-414	2	139 (51.5)	2 (0.7)	0	0	2 (0.7)	2 (0.7)	0
510-534	2	170 (63.0)	0	1 (0.4)	1 (0.4)	2 (0.7)	2 (0.7)	0
618-648	1	60 (22.2)	0	2 (0.7)	0	0	1 (0.4)	0
Total		549 (33.9)	12 (0.7)	6 (0.4)	6 (0.4)	40 (2.5)	6 (0.4)	282 (17.4)

[a] Assessment gill nets were made up of 300-foot panels of 2.0-, 2.5-, 3.0-, 3.5-, 4.0-, 4.5-, 5.0-, 5.5-, and 6.0- inch multifilament nylon mesh.

[b] Number of lake trout per 1,000 feet of gill net not adjusted for number of nights fished.

Table 3.–Age composition (number), mean total length at age 7 with ±95% confidence intervals (CI), and total annual mortality (A) of wild lean lake trout captured in the assessment[b] of commercial-sized lean lake trout (³17 in, total length) in Michigan's Lake Superior management areas 3-7 during 28 April-5 June 1997.

Age (year)	Management area				
	MI-3	MI-4	MI-5	MI-6	MI-7
4		24	8		
5	11	80	47	16	2
6	45	207	208	68	36
7	70	256	245	92	64
8	38	132	313	96	81
9	46	81	100	46	38
10	15	52	85	28	20
11	17	17	29	29	11
12	10	20	12	6	10
13	14	21	4	11	5
14	5	4	7	3	3
15	4	2	11	5	1
16	1		5	1	2
17		1			
18					
19		3			
20			1	1	
Total	277	900	1,075	401	273
Age-7 length	22.5	21.3	21.4	20.6	21.0
CI	0.6	0.5	0.7	0.6	0.6
Mortality					
Ages	9-15	9-15	9-15	9-15	9-15
A	0.37	0.43	0.45	0.40	0.44
Chi-square	1.2019	0.3912	4.8471	1.2236	0.0062

[a] Mortality determined by the method described in Robson-Chapman (1961).
[b] Assessment nets were 4.5-inch multifilament nylon mesh gill nets.

Table 4.–Mean weight, mean total length, and the weight-length regression coefficients for commercial-sized (³17 in, total length) lean lake trout captured during 28 April-5 June 1997[a], and for siscowets captured during 15-24 September 1997[b] in Michigan's Lake Superior management areas (±95% confidence intervals (CI) on means and coefficients).

Area	N	Mean weight (lb) ±95% CI	Mean total length (in) ±95% CI	Log_e total weight (lb) log_e total length (in) coefficients ±95% CI a	b	R^2
Commercial-sized lean lake trout						
MI-3	99	4.67±0.39	24.0±0.6	3.06±0.14	-8.23±0.46	0.95
MI-4	102	3.36±0.24	22.1±0.5	3.05±0.18	-8.25±0.56	0.92
MI-5	109	3.78±0.23	23.2±0.5	2.86±0.16	-7.70±0.52	0.92
MI-6	109	3.52±0.25	21.7±0.4	2.94±0.29	-7.83±0.88	0.79
MI-7	273	4.03±0.17	22.8±0.3	2.90±0.10	-7.70±0.32	0.92
Commercial-sized siscowet lake trout						
MI-5	444	3.85±0.15	22.1±0.2	3.41±0.11	-9.28±0.35	0.89
All siscowet lake trout						
MI-5	549	3.27±0.16	20.6±0.3	3.33±0.06	-9.02±0.17	0.96

[a] Commercial-sized assessment gill nets were 4.5-inch multifilament nylon mesh.
[b] Siscowet assessment gill nets were made up of 300-foot panels of 2.0-, 2.5-, 3.0-, 3.5-, 4.0-, 4.5-, 5.0-, 5.5-, and 6.0-inch multifilament nylon mesh.

Table 5.–Age composition (number) and total annual mortality rate[a] of siscowet lake trout captured in graded-mesh gill nets[b] in management area MI-5 of Lake Superior during 15-24 September 1998.

Age (year)	Number	Length (in ±95%CI)	Weight (lb ±95%CI)
3	2	10.0 (1.8)	0.29 (0.20)
4	6	11.8 (1.3)	0.48 (0.12
5	14	12.0 (1.0)	0.53 (0.15)
6	14	13.7 (1.0)	0.70 (0.14)
7	14	14.0 (1.4)	0.89 (0.43)
8	6	16.2 (2.9)	1.50 (0.92)
9	18	16.2 (1.0)	1.30 (0.38)
10	29	17.9 (0.9)	1.87 (0.42)
11	23	18.2 (1.3)	2.06 (0.61)
12	26	20.1 (1.4)	3.04 (0.79)
13	51	20.6 (0.8)	2.96 (0.36)
14	64	21.7 (0.7)	3.64 (0.43)
15	75	22.4 (0.6)	4.04 (0.37)
16	76	22.6 (0.6)	4.12 (0.35)
17	55	22.8 (0.6)	4.17 (0.41)
18	26	23.4 (0.8)	4.41 (0.59)
19	9	23.8 (1.4)	4.91 (0.77)
20	4	24.4 (1.3)	4.96 (0.77)
22	1	30.1	10.89
23	1	21.7	4.05
25	1	24.5	4.85
30	1	18.3	3.05
Total mortality (A)	0.48		
Ages	16-30		
Chi-square	2.70		

[a] Mortality determined by the method decribed in Robson-Chapman (1961).

[b] Assessment nets were made up of 300-ft panels of 2.0-, 2.5-, 3.0-, 3.5-, 4.0-, 4.5-, 5.0-, 5.5-, and 6.0-inch multifilament nylon mesh.

Table 6.–Percentage by weight of prey items eaten by siscowets captured in Michigan's Lake Superior management area MI-5, 15-24 September 1997.

		Percentage of total prey weight								
Depth (fathoms)	No. fish	Chubs and herring	Burbot	Sculpins	Stickle-back	Amphi-poda	Mysis	Terres-trial insects	Other	Total prey weight (g)
0-19	2			100.0						7
20-39	80			5.8		51.4		31.4	11.4	35
40-59	98	49.6	32.0	5.7	0.9	5.7	0.4	3.5	2.2	228
60-79	139	80.0		9.4		4.4		0.6	5.6	160
80-99	170	75.0	12.1	6.0		4.5	0.1	0.7	1.6	688
100-119	60	73.0		27.0						171
Total	549	68.4	12.1	9.6	0.2	5.4	0.2	1.9	2.2	1,289

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