STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-53-R-13

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

Period Covered: April 1, 1996 to March 31, 1997

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

Summary: The project design was modified in 1995 to accommodate more stations, as required for the Lake Huron Technical Committee's movement studies. During the spring of 1996, index sampling for lake trout in U.S. waters of Lake Huron was conducted with graded, large-mesh gill nets at 10 sites. Four of these index sites have been sampled annually since the mid-1970's. Annual mortality estimates from the 1996 spring assessment catch curves were: 81% at MH-1 (9-Mile Pt., the northern-most station); 55% at MH-2 (Thunder Bay); 54% at MH-3 (Oscoda); and 53% at MH-4 ("Thumb" area of south-central Lake Huron). Excessive mortality rates in northern Lake Huron appear to preclude lake trout rehabilitation there. Mortality rates rose at all stations in 1996; none were below the 45% target level set by the Lake Huron Technical Committee. Currently, sea lamprey predation is a leading cause of mortality, especially in the north. Lamprey wounding rates from the 1995 season ranged from 75 type A1-A3 wounds/100 for lake trout > 629 mm (TL) in the north to 34.7 wounds/100 fish > 629 mm in the south. Annual mortality attributable to sea lamprey for fish over 630 mm was estimated to range from 56% in the north to 33% in the south. Growth rates and body condition were greater in the south, with lake trout lengths from the northern station averaging 46 mm less at age 5 than the average of all stations. There was no clear difference in growth parameters from previous years. Smelt and alewives have consistently made up about 98% of the spring diet.

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

Findings: Six assessment stations were added to the study design in 1995. Therefore, a total of 10 assessment stations was sampled in 1996. One of these stations, Adams Point, was sampled by the Biological Resources Division of the Geological Survey, U.S. Dept. Interior, (BRD) the balance by the DNR Alpena Fisheries Station. Lake trout marked with coded wire tags are being stocked at each of four sites along the Michigan coastline; returns of the coded wire tags will be used by the Lake Huron Technical Committee to document movement and will become the basis for delineation of lake trout management unit boundaries. The additional assessment stations were designed to document distribution of these marked lake trout on and between the four stocking sites. The data from all assessment sites within each statistical district were combined for the purpose of estimating area stock parameters.

Survival–Age-specific catch per 1,000 ft of gill net from the 1996 spring assessment, adjusted for stocking rate, was calculated for each of four statistical districts (Table 1). Mortality rates were estimated using the methods of Robson and Chapman (1961) for catch-at-age data (Table 2).

The assessment stations in MH-1 (northern Lake Huron) were Nine-Mile Point and Adams Point. The National Biological Survey netted Adams Pt. in 1996 and conveyed the data to Alpena for analysis. Catch of lake trout older than age four in MH-1 continued to be extremely low (Table 1). This area, which included waters deferred from lake trout rehabilitation by the 1985 consent decree, contains some grids that receive no lake trout stockings. Yet, the tribal commercial catch of lake trout ranged from 78 to 232 thousand pounds from 1985 to 1996. With the closure of Hammond Bay (immediately south of Nine-Mile Pt.) to commercial fishing in 1990, annual commercial harvest dropped to below 100,000 pounds during 1991, and 1992, but gradually rose again to 202,000 pounds in 1996. Barely enough older fish were available from MH-1 to permit computation of mortality rates (tables 1 and 2) or indexing of lamprey wounding. It appears that lamprey-induced mortality, in combination with fishing, is suppressing the number of older fish available in MH-1.

Three stations were netted in MH-2 (north-central L. Huron): Presque Isle, Rockport, and Thunder Bay. Catch rates for age 3, 4, and 5 fish increased sharply in 1996. As in past years, there was a pronounced decline in catch rate between age 5 and age 6 (Table 1). Swink (1990 and 1991) reported that vulnerability of lake trout to sea lamprey attack increases sharply at about 635 mm in length. In 1996, lake trout from MH-2 averaged 596 mm at age 6 and 665 mm at age 7. The high losses of lake trout between age 5 and 8 in Thunder Bay may be partly due to size-specific lamprey effects. Annual mortality since 1988 has ranged near or above Lake Huron Committee guidelines (Table 2). There is no commercial fishery for lake trout in MH-2. The sport harvest in 1993 (Study 427) was less than 1,000 lake trout at Alpena and Rockport, combined, but rose somewhat to 2,091 in 1994, 4,893 in 1995, and 10,958 in 1996, suggesting a recovery is occurring. Until recently, lamprey-induced mortality has been the chief cause of the high mortality rates in MH-2. The relatively high harvest in 1996 indicates the recreational fishery has also become a significant source of mortality.

Two assessment sites were used to represent MH-3: Sturgeon Pt. and Oscoda. Mortality, which has ranged near 45% since 1982, exceeded target levels in 1996 (Table 2). Like MH-2, there was a sharp decline in catch rate for fish older than age 6 (Table 1).

Assessment sites in MH-4,5 ("Thumb" area) were at Pte. aux Barques, Harbor Beach north, and Harbor Beach south. Survey catch rates and number of age groups sampled there have consistently been higher than in the north and, therefore, have allowed more accurate estimation of survival. Mortality estimates for the Thumb area have, until 1996, ranged much lower than in the north. In 1996, however, the mortality estimate exceeded the 45% target level for the first time since the assessment began (Table 2). The apparent increase may be due in part to low survival of the 1989 year class, which was stocked from shore as fall fingerlings. Although a correction factor was applied to convert this year class to “yearling equivalents”, the year class almost completely failed (Table 1). To compensate for this year class failure, the actual catch rate was replaced with an interpolated value for purposes of mortality estimation. Offshore stocking began in 1990, and this may have increased survival of more recent year classes, which in turn, would increase apparent mortality (by violating the assumption of equal recruitment rates over time

Mortality rates increased from 1995 through 1996 in all statistical districts (Table 2). With increasing recreational and commercial harvest, further regulation of fishing and increased control of sea lampreys will be required to attain target survival levels.

Movement–In 1992, the Lake Huron Technical Committee initiated a lake trout movement study with the stocking of 60,000 coded-wire-tagged lake trout at each of 4 sites: Adams Pt., Rockport, Sturgeon Pt., and Pte. aux Barques. In addition, coded-wire-tagged lake trout have been stocked at Drummond Island and 6-Fathom Bank since 1985. To capture information on distribution of these marked fish, we increased the number of stations along the Michigan shore of Lake Huron such that one station was on each stocking site and other stations were located equal distances between them.

Lake trout originating from all the research stocking sites were sampled in 1995 and 1996 (Table 3). 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 in the northern stations. A total of 273 coded-wire tagged lake trout have been taken (124 in 1995 and 149 in 1996). These sample sizes indicate the number of marked fish deployed and the survey effort are both adequate to meet study objectives. Eighty-three lake trout from 6-Fathom Bank were taken at the near-shore sites (40 in 1995 and 43 in 1996), and they appeared at all 10 stations (Table 3). Stockings at 6-Fathom have been equally divided between three strains. However, for fish age 7 and older, twice as many Seneca strain were taken at the near-shore sites than the other two strains (Table 4). Assessment nettings by the National Biological Survey on 6-Fathom Bank have likewise found that Seneca strain composes the majority of older fish on this mid-lake reef.

Lamprey wounding–Lamprey-induced mortality was estimated using rates of A1-A3 wounds from spring assessment netting, survival rates from laboratory studies by Swink (1990), and the equation:

$$ZL=W(1-P)/P,$$

after Koonce and Pycha (unpublished) where ZL = instantaneous lamprey-induced mortality, W = the number of A1-A3 type wounds (King and Edsall 1979) per lake trout, and P = probability of surviving a single lamprey attack (Swink 1990).

The annual mortality rate for lake trout attributable to lamprey ranged from 56% for lake trout over 629 mm in MH-1 to as low as 19% for lake trout over 734 mm in MH-2 (Table 5). Indexing of lamprey wounding on lake trout requires large samples of fish larger than 535 mm. Unfortunately, few lake trout of larger size groups were available from spring assessments at MH-1. A larger sample size from MH-1 was gained by combining DNR assessment data with those from the Chippewa-Ottawa Treaty Fishery Management Authority (COTFMA) and the Biological Resources Division, Geological Survey. Even this combined sample inadequately represented larger lake trout in the most northerly unit. The high loss to lampreys, in combination with natural mortality, leaves little, if any, surplus production for harvest in any of the Lake Huron statistical districts. Wounding generally increased with host size and was most pronounced in fish over 629 mm (Table 5). This pattern is consistent with laboratory observations of Swink (1991).

Growth–Parameters of weight-length regressions for the assessment stations have varied little in recent years. Lake trout from northern stations have consistently demonstrated lower body condition, as reflected by their lower calculated weight at 600-mm total length (Table 6). Average length at age five has consistently been greatest in the south (Table 7). Growth rates follow a north-south gradient for the Michigan assessment stations, probably reflecting the colder, less productive conditions of northern Lake Huron.

Food habits–Stomach contents (number of items by species of prey) were examined during the spring index sampling. A summary of stomach contents from 1996 spring index netting is given in Table 8. As with past years, smelt and alewives composed over 95% of the diet lakewide. Alewife have been the dominant prey in MH-4 since the early 1980s; however, in 1996 they were second to smelt in terms of number consumed. In MH-2, alewife were the dominant prey. In 1995, 9-spine stickleback dominated the diet in MH-1. In 1996, the diet was divided between smelt and alewife, and 45% of the stomachs observed in MH-1 were empty.

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

Findings: No netting for spawning lake trout was scheduled for 1996.

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

Findings: All data from the 1996 surveys were checked and entered into the Alpena Station data base. Analysis included preparation of findings for the coordinated interagency studies of the Lake Huron Technical Committee, presentation of lake trout status reports at the annual Upper Lakes meetings, refinement and updating of the Lake Huron Lake Trout Virtual Population Model, and application of the data base for a Lake Huron bioenergetics model. I also prepared the annual lake trout stocking plan for Michigan waters of Lake Huron and attended the summer and winter Lake Huron Technical Committee and annual Lake Huron Committee meeting, where updates on lake trout progress and technical reports were presented. I also participated as a member of the St. Marys River Control Task Force, where I provided lake trout data for modeling population responses to sea lamprey control options under consideration for the St. Marys River.

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 other evidence of lake trout reproduction.

Findings: Trawling 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 to sample age-0 lake trout. Age-0 wild lake trout were taken in bottom trawls every year at the North Point station from 1986 through 1996, but the catch decreased to the lowest levels of the study in 1995 and 1996 (Table 9).

The number of unclipped lake trout in 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 1996, however, the contribution of unclipped fish, averaged over all year classes, was only 1.1% in MH-2 and 0.0%, 5.0%, and 3.1% for MH-1 ,3, and 4 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:

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

Swink, W. D. 1991. Host size selection by parasitic sea lampreys. Transactions of the American Fisheries Society. 120:637-643.

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Table 1.–Annual age-specific lake trout catch, adjusted for stocking and effort, by statistical district, Michigan waters of Lake Huron, 1996.

Age	Year class	Stocking adjustment factor[1]	Count	Adjusted catch[2]	Adjusted CPE[3]
		Statistical District MH-1: Effort=36,000'			
2	1994	1.03	8	8.24	0.23
3	1993	1.03	19	19.60	0.54
4	1992	0.70	94	65.80	1.83
5	1991	0.52	100	52.00	1.44
6	1990	0.53	13	6.90	0.19
7	1989	1.00	2	4.00	0.11
		Statistical District MH-2: Effort=16,200'			
2	1994	1.03	12	24.00	1.48
3	1993	1.03	23	23.69	1.46
4	1992	0.70	107	74.90	4.62
5	1991	0.52	192	99.84	6.16
6	1990	0.53	71	37.63	2.32
7	1989	1.00	19	19.00	1.17
8	1988	0.83	17	14.11	0.87
9	1987	0.79	3	2.37	0.15
10	1986	1.33	2	2.66	0.16
		Statistical District MH-3: Effort=10,800'			
2	1994	0.60	2	1.20	0.11
3	1993	0.57	3	1.71	0.16
4	1992	0.80	18	14.40	1.33
5	1991	0.73	60	43.80	4.01
6	1990	0.83	38	31.54	2.92
7	1989	0.94	12	11.28	1.04
8	1988	0.67	5	3.35	0.31
9	1987	1.07	3	3.21	0.30
		Statistical District MH-4, 5: Effort=14,400'			
2	1994	0.60	1	0.60	0.04
3	1993	0.57	8	4.56	0.32
4	1992	0.80	89	71.20	4.94
5	1991	0.73	158	115.34	8.01
6	1990	0.83	66	54.78	3.80
7	1989	0.94	4	3.76	0.26
8	1988	0.67	26	17.42	1.21
9	1987	1.07	1	1.07	0.74
10	1986	0.93	2	1.86	0.13
11	1985	0.62	1	0.62	0.04

[1]Adj. factor = no. stocked/500,000
[2]Adj. catch = count x adj. factor
[3]Adj. CPE = adj. catch/1,000'

Table 2.–Mortality rates (%) by station and agency, from spring gill-net assessments, Michigan waters of Lake Huron.

Year	"Thumb" (MH-4) MDNR	Central(MH-3) MDNR	N. Central (MH-2) MDNR	North (MH-1) MDNR & BRD
1982-86 (average)	28	42	49	76
1986-87	36	NA	NA	87
1987-88	40	43	NA	76
1988-89	37	43	52	89
1989-90	46	47	52	NA
1990-91	31	43	35	>70
1991-92	27	48	42	>70
1992-93	28	62	69	>70
1993-94	32	51	55	>70
1994-95	37	49	52	74
1995-96	53	54	55	81

Table 3.–Total gill net catch and catch per effort during 1995 and 1996 of coded-wire-tagged lake trout at 10 near-shore Michigan stations.

	Survey station and effort (in parenthesis)										
	S. Harbor Beach (9,900)	N. Harbor Beach (9,900)	Grindstone (8,100)	AuSable Pt. (9,900)	Sturgeon Pt. (9,900)	Thunder Bay (10,800)	Nordmeer (10,800)	Presque Isle (10,800)	Adams Pt. (31,600)	Nine-mile Pt. (39,600)	Total by stocking site
Catch by stocking site:											
Pt. Aux Barques	4	3	13	2	3	0	0	1	0	0	26
Sturgeon Pt.	6	1	8	7	11	6	4	4	2	2	51
Middle Island	0	0	1	0	2	3	10	7	7	6	36
Adams Pt.	0	0	3	0	0	0	7	6	31	15	62
Six-Fathom	5	6	21	5	11	4	18	4	7	3	84
Drummond Island	0	0	0	0	0	0	2	4	5	4	15
Total by station	15	10	46	14	27	13	41	26	52	30	274
Catch/10,000' by stocksite:											
Pt. Aux Barques	4.04	3.03	16.05	2.02	3.03	0.00	0.00	0.93	0.00	0.00	29.10
Sturgeon Pt.	6.06	1.01	9.88	7.07	11.11	5.56	3.70	3.70	0.63	0.51	49.23
Middle Island	0.00	0.00	1.23	0.00	2.02	2.78	9.26	6.48	2.22	1.52	25.50
Adams Pt.	0.00	0.00	3.70	0.00	0.00	0.00	6.48	5.56	9.81	3.79	29.34
Six-Fathom	5.05	6.06	25.93	5.05	11.11	3.70	16.67	3.70	2.22	0.76	80.25
Drummond Island	0.00	0.00	0.00	0.00	0.00	0.00	1.85	3.70	1.58	1.01	8.15
Total	15.15	10.10	56.79	14.14	27.27	12.04	37.96	24.07	16.46	7.58	

Table 4.–Age composition, by strain, of coded-wire-tagged lake trout stocked on 6-Fathom Bank and sampled at 10 nearshore stations, 1995 and 1996 spring gill-netting. MDNR and BRD.

	Strain					
	Seneca/Ontario		Marquette		Jenny/Lewis	
Age	1995	1996	1995	1996	1995	1996
2	0	0	0	0	0	0
3	0	0	0	1	0	0
4	1	1	5	3	5	0
5	2	3	2	3	1	4
6	6	3	3	5	0	3
7	0	2	1	1	0	3
8	5	1	1	0	0	0
9	6	2	0	2	1	0
10	1	3	0	1	0	1
11	0	2	0	0	0	0
Totals	21	17	12	16	7	11
Older than age 7	12	10	2	4	1	4

Table 5.–Estimated mortality attributable to sea lamprey attacks, Lake Huron, 1995-96, based on wounding rates measured in 1996.

Length group (mm)	Probability of survival	Marks per fish (M)	Sample size (N)	Lamprey instantaneous (ZL)	Annual lamprey (AZ)
MH-1: Drummond Island to Rogers City (combined DNR, BRD & COTFMA)					
430-529	0.35	0.053	217	0.10	0.094
530-629	0.45	0.325	40	0.40	0.328
630-734	0.45	0.667	3	0.82	0.557
735+	0.55	1.000	1	0.82	0.559
MH-2: North-Central					
430-529	0.35	0.030	202	0.06	0.054
530-629	0.45	0.123	122	0.15	0.140
630-734	0.45	0.327	49	0.40	0.329
735+	0.55	0.250	4	0.20	0.185
MH-3,4,5: "Thumb" & Central					
430-529	0.35	0.047	192	0.09	0.083
530-629	0.45	0.209	163	0.25	0.225
630-734	0.45	0.347	95	0.42	0.346
735+	0.55	0.345	12	0.28	0.246

Table 6.–Condition factors and length-weight regressions at assessment stations and estimated weight (gm) at 600 mm total length from 1996 index netting in Michigan.

Statistical district	Area	Ktl @600 mm	a intercept	b slope	r squared	Wt (gm) @600 mm
MH-1	North Central	1.000	4.30E-06	3.132	0.956	2161
MH-2	North Central	1.037	4.60E-06	3.127	0.978	2239
MH-3	Central	1.048	6.76E-06	3.070	0.963	2265
MH-4,5	"Thumb"	1.053	1.00E-05	3.008	0.961	2273

$Ktl=(W/L^3)*10^5$
Length-weight regression: $W=aL^b$

Table 7.–Mean total lengths (mm) at age-5 of lake trout sampled from 4 statistical districts of Lake Huron, 1996.

Statistical district	Mean	Standard deviation	N
MH-1	467	50	46
MH-2	516	48	201
MH-3	543	64	63
MH-4	531	59	168

Table 8.–Lake trout stomach contents (number consumed and % of total identifiable prey consumed) by statistical district from MDNR 1996 spring assessments.

	MH-1		MH-2		MH-3		MH-4		Total	
Prey	No.	%	No.	%	No.	%	No.	%	No.	%
Alewife	43	41.3	1071	87.5	226	63.0	367	30.3	1707	58.9
Smelt	52	50.0	146	11.9	132	36.8	841	69.5	1171	40.4
Slimy sculpin	4	3.8	1	0.1	1	0.3	0	0.0	6	0.2
9-spine stickleback	5	4.8	6	0.5	0	0.0	0	0.0	11	0.4
Lake whitefish	0	0.0	0	0.0	0	0.0	1	0.1	1	0.0
Spottail shiner	0	0.0	0	0.0	0	0.0	1	0.1	1	0.0
Total identifiable	104		1224		359		1210		2897	
Number void	53	45.3	43	11.6	11	7.8	15	4.2	122	12.4
Number examined	117		371		140		358		986	

Table 9.–Trawl catch of age-0 lake trout from Thunder Bay, 1984-96.

	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	–	–

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