STUDY PERFORMANCE REPORT

State: Michigan

Project No.: F-80-R-7

Study No.: 230703

Title: Lakewide assessment of the contribution of natural recruitment to the Chinook salmon population of Lake Huron.

Period Covered: October 1, 2005 to September 30, 2006

Study Objective:

(1) To estimate annual natural recruitment of Chinook salmon to Lake Huron for the 2000 to 2004 year classes;

(2) To determine contributions from natural reproduction to the spawning populations of selected tributaries to Lake Huron;

(3) To refine recruitment modules of Lake Huron's bioenergetics and catch-at-age models, which will, in turn, be used to prescribe stocking levels for Lake Huron.

Summary: This was the fifth year of funding for this project. All Chinook salmon *Oncorhynchus tshawytscha* from 2000–03 stocked in lakes Huron and Michigan, except those stocked by Ontario, were marked using oxytetracycline administered in feed. In addition, all Chinooks stocked by Michigan were marked with oxytetracycline in 2004. All Chinook salmon stocked in Ontario waters of Lake Huron from 2000–03 were fin clipped. In 2004, Wisconsin, Illinois, Indiana, and Ontario decided not to mark Chinook salmon they stocked. Thus, the marking phase of this study ended in 2004. We used ultraviolet microscope equipment to detect marks and imaging software to enhance reproducibility and specimen processing speed. Vertebrae images and biological data from the Chinook salmon sampled were electronically archived in a database developed cooperatively with Ontario Ministry of Natural Resources. These data were shared with other cooperating agencies on the Lake Huron Technical Committee. Alpena Fishery Station provided staff to collect vertebrae at fishing tournaments at Port Huron, Alpena, Rogers City, Cheboygan, St. Ignace, and Detour. Volunteer groups assisted in many collections. The "Thumb Steelheaders" collected nearly 100 vertebrae each year (2002, 2003, and 2004) using the prescribed methodology. Lake Superior State University collected vertebrae each year from the St. Marys River and in 2005 collected additional vertebrae from the Garden and Carp rivers. Ontario Ministry of Natural Resources collected vertebrae from Georgian Bay, North Channel, and the main basin of Lake Huron. Mark composition of age-1, -2, and -3 Chinook salmon from 2005 suggested 10.5% of these year classes were of hatchery origin (89.5% wild born). At Swan Weir, where we believe there is no reproduction, we could not detect marks on 9.7% of fish sampled, suggesting mark loss is nearly 10%. Correcting for this level of mark loss, 88.5% of fish sampled in the offshore fisheries were wild born. This level of Chinook salmon reproduction is a sharp increase since the early 1990s. Maturing salmon returning to the St. Marys River were approaching 90% wild born, considerably higher than in 2004. For the Carp River, located between two major stocking sites, the spawning run was composed of about 34% wild-born (unmarked) fish. Chinook salmon returning to two lower peninsula Michigan stocking sites (Swan Weir and Au Sable River), on the other hand, were approximately 92% of hatchery origin. In all, the Alpena Fishery Research Station laboratory analyzed 2,188 fish samples collected during 2005 for age and OTC marks. Lake Superior State University analyzed an additional 192

specimens. Size and condition of Chinook salmon at the two Michigan stocking sites reached record lows in 2004 and remained low in 2005. Sea lamprey wounding rates on larger Chinooks remained relatively low.

Findings: Jobs 2–5 were scheduled for 2005-06 and progress is reported below.

Job 2. Title: Monitoring of composition of open-water Chinook harvest.–A database for storage of Chinook salmon biological data and laboratory results of vertebrae analysis was designed in 2001 and refined in 2002–05 in collaboration with Ontario Ministry of Natural Resources, as were field data sheets and instructions for field collections. These products were shared with other cooperating agencies on the Lake Huron Technical Committee. The 2005 field season was the fourth and last year of collections. Coded-wire tag recovery personnel and volunteers from organized recreational fishing groups were trained in gathering vertebrae for the recruitment study. Alpena Fishery Station provided staff to collect vertebrae at fishing tournaments at Port Huron, Alpena, Rogers City, Cheboygan, St. Ignace, and Detour. Volunteer groups assisted in some collections. Ontario Ministry of Natural Resources collected vertebrae from Georgian Bay, North Channel, and the main basin of Lake Huron. A summary of vertebrae collections is given in Table 1. Sample size fell short of quotas in several units in Michigan waters of Lake Huron and in some Ontario waters because some locations were distant from agency offices and recreational catches of Chinook salmon were very low this year. Incidence of unmarked (wild origin) Chinook salmon has been higher (see Job 4) than anticipated in the study design, thus it may prove that sample size targets in the study plan were higher than necessary.

Job 3. Title: Monitoring of composition of spawning escapement Chinook salmon on selected spawning tributaries.–Escapement was sampled in the Au Sable River in October 2005 by electrofishing. Biological samples of escapement Chinook salmon were taken at Swan River weir in October 2005 by sampling at the harvest weir. Both of these efforts were conducted according to the study plan. Lake Superior State University (LSSU) collected Chinook salmon in 2005 from the upper St. Marys River, the Garden River, a tributary to the Ontario side of the St. Marys River, and from the Carp River, a Main Basin tributary in Michigan's Upper Peninsula. LSSU aged their catch and examined the samples for OTC marks using their own lab. Sample sizes are given in tables 1 and 3.

Job 4. Title: Laboratory analysis.–We used a florescence dissecting stereoscope and imaging software to detect OTC marks. We aged Chinook salmon by counting annuli on both scales and on the vertebrae. The imaging technology allowed archiving and peer review of our image analysis, using electronically saved images. OTC mark composition and ages were determined for 2,184 vertebrae samples received from May 2005–April 2006 (Table 3). Lake Superior State University analyzed an additional 192 specimens. Only 4 samples had unusable vertebrae. Ages and marks for the 2003-05 specimens have not all been verified so the data presented here are preliminary.

Job 5. Title: Data analysis, preparation of annual and final reports, report layout and publication, and presentation of findings at technical and public meetings.–During the period from 1991 to 1994, the last time all Chinook salmon were OTC marked, approximately 85% of vertebrae displayed a mark, suggesting natural reproduction contributed no more than 15% of recruitment at that time. Surprisingly, the opposite was true for the 2001–2004 year classes, as represented by the combined incidence of fin clips and OTC-marked vertebrae in samples from the summer 2005 open water recreational fishery. From 77% to 98% of Chinook salmon sampled from the various open-water sites were evidently of wild origin (Table 3). Approximately one third of Michigan's Carp River's spawning run had detectable hatchery marks. By contrast, OTC marks were detected on an average of 92.3% of spawning run samples from two Michigan stocking sites, Swan Weir and Au Sable River, where reproduction is known to be minimal or nonexistent (Table 3). The high incidence of marking in the Au Sable and Swan systems indicates that the quality and durability of the OTC marks has been acceptable.

The open-water recreational fisheries were sampled during mid-summer when Chinook salmon were presumably of mixed origin. Thus, Chinook salmon from a variety of stocking and reproduction sites should have been represented in each of these samples. The low incidence of OTC marks in the open-water recreational fisheries indicates high contributions from natural reproduction to the 2001–2004 year classes (Table 3). At Swan Weir, where we believe there is no reproduction, we could not detect marks on 9.7% of fish sampled, suggesting mark loss is nearly 10%. Correcting for this level of mark loss, 88.5% of fish sampled in the offshore fisheries of Lake Huron, all sites combined, were wild born.

Fall sampling of Chinook salmon escapement to the Swan Weir and Au Sable River provided the opportunity to continue collecting growth and condition information previously collected under Study 230482 and previous studies. Size-at-age data from the two sites are presented in Table 4. Size and Ktl for age-2, -3, and -4 salmon were low at both sites in 1997 and 1998, years of low adult alewife *Alosa pseudoharengus* abundance. Size and Ktl recovered in 1999 but Ktl again declined from 2000 to 2004, and remained low in 2005, which corresponds with more recent declines in alewives in Lake Huron. Alewives almost disappeared in 2004 and have not recovered (J. Schaeffer, USGS Great Lakes Science Center, unpublished data). Incidence of age-4 Chinook salmon in the two spawning runs declined sharply after 2000, but recovered somewhat in 2005. In Table 5, growth and condition of age-3 Chinook salmon from the Au Sable River in 1996–2005 are compared with data collected there from 1973–1981. Length, weight, and Ktl were lower in the latter period ($P < 0.01$), suggesting declining prey availability may be affecting these parameters in recent years. Sea lamprey wounding is given in Table 6 for both sampling sites. In 2004, incidence of Type A-1, A-2, and A-3 wounds, which in fall represent wounds of the current year, was lowest of the 1996–2005 time series, but marking rates rose somewhat in 2005.

This annual progress report for October 2005–September 2006 was prepared. Data from this study were presented at the Upper Lakes Meeting of the Great Lakes Fishery Commission State of Lake Huron Symposium, the Lake Huron Technical Committee, Michigan DNR Lake Huron Basin Team meetings, the Lake Huron Citizen Fishery Advisory Committee, the Fisheries Division Management Team, the American Fisheries Society annual meeting in Lake Placid, and a variety of recreational fishing forums and workshops during 2006. The data were used by the Lake Huron Basin Team to formulate a 50% stocking reduction plan for Chinook salmon in Lake Huron, which was implemented in the 2006 stocking year. Coordination was carried out with the Lake Huron Technical Committee on Chinook salmon marking and stocking, data collection, and data management.

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Table 1.–Numbers of vertebrae collected by basin or lake area, 2005, for Jobs 2 and 3 (summer and fall collections).

Area	Number Targeted	Number Sampled
Swan Weir	150	150
Au Sable River (fall)	200	178
MI. North Main Basin	200	73
MI. N. Central Main Basin	300	174
Thumb	300	90
St. Marys (LSSU[1], fall)	200	120
Garden River, Ontario (LSSU, fall)	–	18
Carp River (fall)	–	54
Ontario Main Basin	300	469
North Channel/Mississagi straits	100	104
Georgian Bay	250	457
Lake Michigan offshore	–	128
Lake Michigan tributaries	–	365
Total	2,015	2,188[2]

[1] LSSU = Lake Superior State University, courtesy Roger Greil and others; additional samples of juvenile Chinooks were collected by LSSU but are not shown here.

[2] Four of these vertebrae could not be read in the lab.

Table 2.–Oxytetracycline mark quality on Chinook salmon returning to Swan Weir (site with no reproduction), 2005.

			Mark quality, count				Mark quality percent			
Age	Year class	Sample size	Excellent	Good	Poor	No mark	Excellent	Good	Poor	No mark
1	2004	10		7	3	0	0.0	70.0	30.0	0.0
2	2003	67	1	31	29	6	1.5	46.3	43.3	9.0
3	2002	59	11	24	18	6	18.6	40.7	30.5	10.2
4	2001	14		4	8	2	0.0	28.6	57.1	14.3

Table 3.–Incidence of marked (OTC marked or fin clipped or both) Chinook salmon from 2005, by capture location, 2001–2004 cohorts.

Basin	Sample size	% OTC Marked or fin-clipped	% wild (lacking OTC or fin-clip)
Lake Huron			
Georgian Bay	457	7	93
North Channel	104	2	98
Main Basin, Ont.	469	11	89
South Basin, Mich.	90	12.2	87.8
North-Central, Mich. [a]	170	7.6	92.4
North, Mich.	73	23.3	76.7
All open water sites	1,363	10.5	89.5
Lake Michigan			
Big Manistee River	146	2.1	97.9
Little Manistee River	189	25.4	74.6
Grand River	30	13.3	86.7
Ludington	26	46.2	53.8
Manistee	11	45.5	54.5
South Haven	31	64.5	35.5
Saugatuck	29	48.3	51.7
St. Joseph	31	65.9	34.1
Fall escapement to stocking sites:			
Garden River (Ontario)	18	0	100
St. Marys River	120	7.5	92.5
Carp River	54	66.0	34.0
Au Sable River	178	93.8	6.2
Swan Weir	150	90.7	9.3

[a] 4 vertebrae could not be analyzed.

Table 4.–Lengths (mm), weights (gm), and condition factors for Chinook salmon spawning runs in Swan and Au Sable rivers, September–October, 1996–2005.

		Swan River				Au Sable River			
Age group	Sample year	Length	Weight	Condition (Ktl[a])	Sample size	Length	Weight	Condition*	Sample size
1	1996	569	1,773	0.95	10	543	1,727	1.05	126
	1997	507	1,372	1.05	6	528	1,580	1.08	34
	1998	509	1,470	1.13	7	561	1,970	1.06	11
	1999	629	2,468	0.98	46	608	2,464	1.07	40
	2000	593	2,250	1.06	58	572	2,003	1.09	186
	2001	591	2,120	1.01	68	594	2,160	1.02	40
	2002	563	1,812	0.98	44	535	1,564	1.00	76
	2003	561	1,510	0.85	2	589	2,065	0.98	31
	2004	674	2,680	0.82	17	622	2,070	0.86	3
	2005	575	1,810	0.95	10	530	1,480	0.97	3
2	1996	776	4,414	0.93	52	766	4,590	1.00	124
	1997	840	4,040	0.74	3	724	3,730	0.97	190
	1998	691	3,150	0.95	61	710	3,300	0.92	95
	1999	789	5,025	0.99	52	771	4,627	0.99	56
	2000	824	5,705	1.00	37	786	4,799	0.97	96
	2001	820	5,592	1.00	86	775	4,538	0.96	55
	2002	806	4,893	0.92	143	763	4,161	0.91	110
	2003	784	4,585	0.93	98	743	3,732	0.88	178
	2004	739	3,510	0.82	32	716	3,220	0.84	30
	2005	747	3,740	0.89	64	695	2,960	0.87	61
3	1996	852	5,769	0.92	25	857	6,246	0.98	149
	1997	822	4,973	0.89	40	827	5,260	0.92	239
	1998	846	5,610	0.90	86	783	4,490	0.92	310
	1999	864	6,365	0.97	91	847	6,092	0.99	278
	2000	915	7,577	0.98	89	875	6,545	0.97	114
	2001	917	7,399	0.95	37	839	5,567	0.93	41
	2002	891	6,823	0.95	61	855	5,798	0.91	66
	2003	914	7,137	0.92	43	869	6,037	0.89	69
	2004	793	4,550	0.86	187	789	4,420	0.87	94
	2005	826	4,990	0.87	61	759	3,910	0.87	110
4	1996	967	8,886	0.97	13	911	7,513	0.98	27
	1997	860	5,706	0.88	16	858	5,830	0.91	92
	1998	866	5,860	0.88	56	825	4,840	0.85	33
	1999	864	6,257	0.96	10	863	6,233	0.96	136
	2000	921	7,182	0.91	16	899	6,862	0.94	38
	2001	865	6,051	0.91	9	917	6,775	0.87	2
	2002	–	–	–	0	815	4,960	0.92	1
	2003	915	6,465	0.84	4	750	3,080	0.73	1
	2004	748	–	–	1	–	–	–	0
	2005	804	4,350	0.81	14	779	3,870	0.80	4

[a] Ktl = $(\text{Weight}/\text{Length}^3) \times 10^5$

Table 5.–Summary of lengths, weights, and condition factors of age-3 Chinook salmon, Au Sable River, 1973–2005.

	Length (mm)		Weight (g)		Condition	
Year	Mean	Std. dev.	Mean	Std. dev.	(Ktl[a]) Mean	Std. dev.
1973	886	54	8,685	1,540	1.24	0.09
1974	909	53	9,276	1,554	1.23	0.11
1975	952	50	10,719	1,265	1.25	0.14
1976	904	48	8,850	1,382	1.19	0.09
1977	888	51	8,298	1,421	1.18	0.08
1978	887	50	8,424	1,442	1.20	0.10
1979	899	34	8,785	1,401	1.20	0.10
1980	882	52	7,946	1,386	1.15	0.10
1981	897	47	8,425	835	1.17	0.11
1996	857	63	6,246	1,529	0.99	0.11
1997	827	60	5,265	1,320	0.92	0.13
1998	783	72	4,492	1,304	0.92	0.17
1999	847	61	6,092	1,449	0.99	0.12
2000	875	63	6,545	1,537	0.96	0.12
2001	840	60	5,567	1,336	0.93	0.10
2002	855	61	5,798	1,516	0.91	0.10
2003	869	75	6,037	1,958	0.89	0.12
2004	770	69	3,978	1,522	0.83	0.13
2005	759	74	3,910	1,244	0.87	0.10

[a] Ktl = $(\text{Weight}/\text{Length}^3) \times 10^5$

Table 6.–Number of A1-A3 (fresh) wounds per 100 chinook salmon ≥700 mm total length, Au Sable and Swan Rivers, combined fall spawning escapement collections.

Year	Wound rate	Sample size
1996	6.4	535
1997	3.6	611
1998	2.0	662
1999	5.1	710
2000	2.5	635
2001	3.5	339
2002	1.6	505
2003	2.6	431
2004	1.4	367
2005	2.92	240