STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-80-R-6

Study No.: 230703 **Title:** Lakewide assessment of the contribution of natural recruitment to the Chinook salmon population of Lake Huron. Huron

Period Covered: October 1, 2004 to September 30, 2005

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 fourth year of funding for this project. All Chinook salmon from 2000–2003 stocked in lakes Huron and Michigan, except those stocked by Ontario, were marked using oxytetracycline administered in feed. In addition, all Chinook salmon stocked by Michigan were marked with oxytetracycline in 2004. All Chinook salmon stocked in Ontario waters of Lake Huron from 2000–2003 were fin clipped. In 2004, Wisconsin, Illinois, Indiana, and Ontario decided not to mark Chinook salmon they stocked. Quality control samples received from Michigan hatcheries after marking in 2004 were generally not readable, perhaps because the fish were too small or sampled too soon after marking. For mark detection, we used ultraviolet microscope equipment 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 Alpena, Cheboygan, St. Ignace, and Rogers City. 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 over 300 vertebrae each year from the St. Marys River and in 2004 collected additional vertebrae from the Garden and Carp rivers. Ontario Ministry of Natural Resources collected vertebrae from Georgian Bay, North Channel, the main basin of Lake Huron, and the Saugeen River, a Main Basin tributary. Mark composition of age-1, -2, and -3 Chinook salmon from 2004 suggested close to 83% of these year classes originated from natural reproduction. If sustained, this level of Chinook salmon reproduction would represent a sharp increase since the early 1990s. Chinook salmon escapement to two Ontario tributaries, the Garden and Saugeen rivers, was composed of more than 80% wild, unmarked fish. Returns to two upper peninsula Michigan tributaries, the St. Marys and Carp rivers, were composed of about 68% wild-born fish. Chinook salmon returning to two lower peninsula Michigan stocking sites, on the other hand, were approximately 97% of hatchery origin. Size and condition of Chinook salmon at the two Michigan stocking sites reached the

lowest on record in 2004. Sea lamprey wounding rates were the lowest since the beginning of the time series.

Findings: Jobs 2–5 were scheduled for 2004-05 and progress is reported below.

Job 2. Title: Monitoring of composition of open-water Chinook salmon harvest.–A database for storage of Chinook salmon biological data and laboratory results of vertebrae analysis was designed in 2001 and refined in 2002–2004 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 fourth year of field collections was 2005. 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. The "Thumb Steelheaders" collected approximately 100 vertebrae in each year, 2002–2004, using the prescribed methodology. 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. Vertebrae samples from 2005 were still being received from cooperators by the Alpena Fishery Station at the time of this report. Sample size quotas were met in 2005 for north-central Lake Huron, but as with 2002 and 2003, collections fell short in southern Lake Huron and in some Ontario waters as a consequence of the remoteness of these locations from agency offices and very low numbers of Chinook salmon in the catch 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 2004 by electrofishing. Biological samples of escaping Chinook salmon were taken at Swan River in October 2004 by sampling the harvest weir. Both of these efforts were conducted according to the study plan. Lake Superior State University (LSSU) collected 274 Chinook salmon from the upper St. Marys River, 57 from the Garden River, a tributary to the Ontario side of the St. Marys River, and 81 returning spawning-phase fish from the Carp River, a Main Basin tributary in Michigan's upper peninsula in 2004. LSSU aged their catch and examined the samples for OTC using their own lab. Ontario Ministry of Natural Resources sampled the Denny's Dam Fishway of the Saugeen River, a tributary to the south-central Main Basin of Lake Huron. Sample sizes are given in tables 1 and 2.

Job 4. Title: Laboratory analysis.–We employed 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 cross sections. The new technology allowed archiving and peer review of our image analysis, using electronically saved images. OTC mark composition and ages were determined for all 2,015 vertebrae samples received (Table 1) from May 2004–April 2005. Most 2005 samples collected by the Alpena Fishery Research Station have been analyzed. Samples collected by the Ontario Ministry of Natural Resources will be received and analyzed by the Alpena laboratory this winter. Ages for the 2003 and 2004 specimens have not been verified and the aged data given 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 1991–1994, 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 2001–2003 year classes, as represented by the combined incidence of fin clips and OTC-marked vertebrae in samples from the summer 2004, open water, recreational fishery. Marks and/or fin clips were detected on only 17% of these samples (Table 2). Three quarters or more of Chinook salmon sampled from the various open-water sites were evidently of wild origin. Combined fin-clip and OTC marking rates averaged only 9% and 19% for Ontario's Saugeen and Garden rivers, respectively. The Saugeen River is a stocking site and the Garden River is near a stocking site, yet the large majority of escaping fish were of wild origin. Approximately one third of Michigan's Carp River's spawning run had detectable hatchery marks. By contrast, OTC marks were detected on 96.7% of samples from two Michigan stocking sites, Swan Weir and Au Sable River, where reproduction is known to be minimal or nonexistent (Table 2). The high incidence of marking in the Au Sable and Swan systems is also an indication the quality and durability of the OTC marks has been acceptable.

With the exception of Georgian Bay, 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 is indicative of high contributions from reproduction to the 2001, 2002, and 2003 year classes (Table 2).

Fall sampling of Chinook salmon escapement to the Swan Weir and Au Sable River provided the opportunity to continue collecting growth and condition information that had been collected by Study 482 and previous studies. Size-at-age data from the two sites are presented in Table 3. Size and Ktl for age-2, -3, and -4 salmon were low at both sites in 1997 and 1998, years of low adult alewife abundance. Size and Ktl recovered in 1999 but Ktl again declined from 2000 to 2004, which corresponds with more recent declines in alewives in Lake Huron. Alewives almost disappeared in 2004 (Jeffery Schaeffer, USGS Great Lakes Science Center, unpublished data). Incidence of age-4 Chinook salmon in the two spawning runs appears to have declined sharply after 2000. Ktl from the recreational catch, as represented by our vertebrae collection data of 2004, was also very low, averaging 0.82 and 0.85 for age-2 and age-3 Chinook salmon, respectively. In Table 4, growth and condition of age-3 Chinook salmon from the Au Sable River in 1996–2004 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 5 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, were lowest of the 1996–2004 time series.

The annual progress report for October 2004–September 2005 was prepared. Data from this study were presented at the Upper Lakes Meeting of the Great Lakes Fishery Commission, the Lake Huron Technical Committee, Michigan DNR Lake Huron Basin Team meetings, the Lake Huron Citizen Fishery Advisory Committee, the Fisheries Division Management Team, and a variety of recreational fishing forums and workshops during 2005. The data were used by the Lake Huron Basin Team to formulate a 50% stocking reduction for Chinook salmon in Lake Huron, which will be implemented for 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.

Prepared by: James E. Johnson and Steven P. DeWitt,
assisted by Dave Gonder, Ontario Ministry Natural Resources

Date: September 30, 2005

Table 1.–Numbers of Chinook salmon vertebrae collected by basin or lake area, 2004, for Jobs 2 and 3 (summer and fall collections).

Area	Targeted	Analyzed to date
Swan Weir	150	141
Au Sable River (fall)	215	281
Carp River (fall, LSSU)	–	81
Garden River, Ontario (fall, LSSU)		57
Mich. North Main Basin	200	0
Mich. N. Central Main Basin	300	218
Thumb	300	44
St. Marys (LSSU [1], fall)	200	274
Ontario Main Basin	300	811
North Channel/Mississagi straits	100	27
Georgian Bay	250	828
Lake Michigan offshore	–	125
Big Manistee River	–	103
Total	2,015	1,978

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

Table 2.–Incidence of marked (OTC marked or fin clipped or both) Chinook salmon from Lake Huron, 2004, by capture location, ages 1–3 combined (2001–03 cohorts). St. Marys River and Georgian Bay samples included escapement, and were in proximity both to stocking sites and locations thought to be reproduction sites. Swan River and Au Sable River are major stocking sites.

Basin	Sample size	% OTC Marked or fin-clipped	% wild (lacking OTC or fin-clip)
Georgian Bay	828	4	96
North Channel	27	36	65
Main Basin, Ont.	811	15	85
South Basin, Mich.	105	19	81
North-Central, Mich.	218	12	88
All open water sites	1,989	17	83
Fall escapement to stocking sites:			
Saugeen River	298	9	91
Garden River (Ontario)	57	19	81
St. Marys River	274	33	67
Carp River	81	31	69
Au Sable River	281	95.7	4.3
Swan Weir	141	97.8	2.2

Table 3.–Lengths (mm), weights (gm), and condition factors for Chinook salmon spawning runs in Swan and Au Sable rivers, September–October, 1996–2003.

		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
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
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
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

[a] $Ktl = (Weight/Length^3) X10^5$

Table 4.–Summary of lengths, weights, and condition factors of age-3 Chinook salmon, Au Sable River, 1973–2004.

Year	Length (mm) Mean	Length (mm) Std. dev.	Weight (g) Mean	Weight (kg) Std. dev.	Condition (Ktl [a]) Mean	Condition 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	766	80	4,070	1,540	0.86	0.12

[a] $Ktl = (Weight/Length^3) X10^5$

Table 5.–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