STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-80-R-5

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

Period Covered: October 1, 2003 to September 30, 2004

Study Objective:

(1) To estimate annual natural recruitment of chinook salmon to Lake Huron for the 2000 to 2003 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 third year of funding for this project. All chinook salmon stocked in lakes Huron and Michigan, except those stocked by Ontario, were marked using oxytetracycline administered in feed. All chinook salmon stocked in Ontario waters of Lake Huron were fin clipped. Quality control samples of vertebrae were received during May and June 2003 from Michigan, Illinois, Indiana, and Wisconsin hatcheries and the samples were checked for quality of the oxytetracycline mark. 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. This year was the third year of field collections and creel clerks and coded-wire tag recovery personnel were trained in gathering vertebrae for the recruitment study. 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", in particular, 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. 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 from 2003 suggested close to 80% 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 three Ontario tributaries was composed of more than 80% wild, unmarked fish. Chinook salmon returning to two 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 were relatively low in 2002 and 2003. Sea lamprey wounding rates were the lowest since the beginning of the time series.

Findings: Jobs 2, 3, 4, and 5 were scheduled for 2003-04, and progress is reported below.

Job 2. Title: <u>Monitoring of composition of open-water chinook harvest.</u>–A database for storage of chinook salmon biological data and laboratory results of vertebrae analysis was designed in 2001 and refined in 2002-2003 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. This was the third year of field 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 Alpena, Rogers City, Cheboygan, and St. Ignace. Volunteer groups assisted in some collections. The "Thumb Steelheaders", in particular, collected approximately 100 vertebrae in each year, 2002-2004, using the prescribed methodology. Ontario Ministry of Natural Resources collected vertebrae from Georgian Bay, North Channal, and the main basin of Lake Huron. Lake Superior State University (LSSU) collected 339 Chinook salmon from the upper St. Marys River in 2003. LSSU aged their catch and examined the samples for OTC using their own lab. LSSU also collected Chinook salmon from the St. Marys River in fall 2004. A summary of vertebrae collections is given in Table 3. Vertebrae samples from 2004 were still being received from cooperators by the Alpena Fishery Station at the time of this report. Sample size quotas were met in 2004 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. 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. Volunteer groups did not fill out the fin clip spaces on the data forms and it was apparent they were not uniformly looking for fin clips. We therefore used fin clip composition data from adjacent units monitored by agency personnel to estimate fin clip incidence for samples collected by volunteers. A sample of 96 chinooks from North Channel was examined for fin clips by Ontario Ministry of Natural Resources but insufficient numbers of vertebrae were submitted to determine OTC composition; thus we used OTC incidence from the adjacent Mississagi Straits to represent OTC incidence in the North Channel samples.

Job 3. Title: Monitoring of composition of spawning escapement chinook salmon on selected spawning tributaries.–Escapement was sampled in the AuSable River in October 2003 by electrofishing. Biological samples of escaping chinook salmon were taken at Swan River in October 2003 by sampling the harvest weir. Both of these efforts were conducted according to the study plan. Lake Superior State University sampled the St. Marys River. Ontario Ministry of Natural Resources sampled the Nottawasaga, Beaver, and Sydenham rivers in southern Georgian Bay. Sample sizes are given in tables 3 and 4.

Job 4. Title: Laboratory analysis.–We employed a florescence dissecting stereoscope and imaging software to detect OTC marks. We aged Chinooks 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 1,818 vertebrae samples received (Table 3) from May 2003-March 2004. In addition, 456 quality control specimens 2003 were inspected. Ages for 2002 samples were verified by second readings. Ages for the 2003 specimens have not been verified and any 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 2000, 2001, and 2002 year classes, as represented by the combined incidence of fin clips and OTC-marked vertebrae in samples from the summer, open water, recreational fishery. Marks and/or fin clips were detected on only 14.1% of these samples (Table 4). 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 6.6% for three Ontario tributaries to southern Georgian Bay, suggesting these escaping fish were nearly all of wild origin. The Nottawasaga River Chinook salmon, thought to be Ontario's largest spawning population, displayed no fin clips or OTC marks. By contrast, OTC marks were detected on 96.8% of samples from two Michigan stocking sites, Swan Weir and AuSable River, where reproduction is known to be minimal or nonexistent (Table 4). The high incidence of marking in the AuSable and Swan systems is also an indication of the quality and durability of the OTC marks.

With the exception of Georgian Bay and St. Marys River, the 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 2000, 2001, and 2002 year classes (Table 4). This result is supported by analysis of the incidence of fin clips among harvested Chinooks. For the 2000-2002 year classes combined, 24.9% of all Chinook salmon stocked by Ontario and Michigan were fin clipped. Thus, if the fishery were supported entirely by stocking, the expected incidence of fin clips in the recreational harvest would be 24.9%. In contrast to this expected value, incidence of fin clips in the recreational harvest ranged from 4.2% to 6.4% and averaged 5.2% (Table 5). In all areas of Lake Huron sampled, the incidence of fin clips was far below the expected value. Based on incidence of fin clips alone (exclusive of OTC marks) an estimated 79.1% of harvested Chinook salmon originated from natural reproduction (Table 5), which was only a slightly lower than the estimate of 85.9% produced using the combination of OTC marks and fin clips (tables 4 and 5).

Fall sampling of Chinook salmon escapement to the Swan Weir and AuSable 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 6. 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 shows indications of decline from 2000 to 2003, which corresponds with more recent declines in alewives in Lake Huron (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 2003, was also relatively low, averaging 0.89 and 0.93 for age-2 and age-3 Chinook salmon, respectively. In Table 7, growth and condition of age-3 Chinook salmon from the AuSable River in 1996-2003 are compared with data collected there from 1973-1981. Length, weight, and Ktl were lower in the latter period ($P < 0.01$), suggesting prey availability may be affecting these parameters in recent years. Sea lamprey wounding is given in Table 8 for both sampling sites. In 2003, incidence of Type A-1, A-2, and A-3 wounds, which in fall represent wounds of the current year, were lowest of the 1996-2003 time series.

The annual progress report for October 2003-September 2004 was prepared. Data from the first years of 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, and a variety of recreational fishing forums during 2004. 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.–Summary of quality control data by hatchery, 2001, 2002, and 2003.

					Numbers					Percent				
Station	State	Year	Lot	Sample size	Excellent	Good	Fair	Poor	Negative	Excellent	Good	Fair	Poor	Negative
Keewanee	Wisconsin	2001		25	0	4	13	5	3	0	16	52	20	12
Manitowac	Wisconsin	2001		25	0	7	15	1	2	0	28	60	4	8
Westfield	Wisconsin	2001		25	0	0	10	13	2	0	0	40	52	8
Wild Rose	Wisconsin	2001		25	0	0	14	6	5	0	0	56	24	20
Jake Wolf	Illinois	2001		50	37	13	0	0	0	74	26	0	0	0
Thompson	Michigan	2001		50	50	0	0	0	0	100	0	0	0	0
Wolf Lake	Michigan	2001		100	61	28	11	0	0	61	28	11	0	0
Platte	Michigan	2001		40	34	4	1	0	1	85	10	2.5	0	2.5
Bodine	Indiana	2001		50	7	17	22	4	0	14	34	44	8	0
Mixsawbah	Indiana	2001		50	1	11	33	5	0	2	22	66	10	0
Keewanee	Wisconsin	2002	1	65	8	8	22	0	27	12	12	34	0	42
Westfield	Wisconsin	2002	2	74	55	10	6	0	3	74	14	8	0	4
Wild Rose	Wisconsin	2002	1	51	43	5	2	0	1	84	10	4	0	2
Jake Wolf	Illinois	2002	1	48	28	18	2	0	0	58	38	4	0	0
Jake Wolf	Illinois	2002	2	52	47	5	0	0	0	90	10	0	0	0
Mixsawbah	Indiana	2002		59	50	6	2	0	1	85	10		3	2
Thompson	Michigan	2002	1	101	81	16	4	0	0	80	16	4	0	0
Platte	Michigan	2002	LM	19	8	10	1	0	0	42	53	5	0	0
Platte	Michigan	2002	Sable Pen	19	12	5	2	0	0	63	26	11	0	0
Westfield	Wisconsin	2003		30	0	0	0	0	30	0	0	0	0	100
Wild Rose	Wisconsin	2003		46	0	10	23	13	0	0	22	50	28	0
Jake Wolf	Illinois	2003		30	0	10	23	13	0	0	22	50	28	0
Wolf Lake	Michigan	2003	L. Huron	30	19	10	1	0	0	63	33	3	0	0
Wolf Lake	Michigan	2003	L. Mich.	30	28	2	0	0	0	93	7	0	0	0
Platte	Michigan	2003	L. Huron pens	60	8	40	7	5	0	13	67	12	8	0
Platte	Michigan	2003	L. Mich. pens	80	31	6	6	24	13	39	8	8	30	16
Platte	Michigan	2003	L. Mich direct plant	30	16	14	0	0	0	53	47	0	0	0
Platte	Michigan	2003	L. Huron direct plant	90	50	35	5	0	0	56	39	6	0	0

Table 2.–Oxytetracycline mark quality on Chinook salmon returning to Swan Weir (site with no reproduction), 2003.

			Mark quality counts					Mark quality percent				
Age	Year class	Sample	Excellent	Good	Fair	Poor	No mark	Excellent	Good	Fair	Poor	No mark
1	2002	30	16	9	4	1	0	53.3	30.0	13.3	3.3	0.0
2	2001	180	24	74	54	24	4	13.3	41.1	30.0	13.3	2.2
3	2000	72	7	26	23	4	12	9.7	36.1	31.9	5.6	16.7

Table 3.–Numbers of vertebrae collected by basin or lake area, 2003, for Jobs 2 and 3 (summer and fall collections).

Area	Targeted	All Ages	< Age-4
Swan Weir	150	141	137
AuSable River (fall)	200	281	280
Mich. North Main Basin	200	79	79
Mich. N. Central Main Basin	300	471	469
Thumb	300	105	105
St. Marys (LSSU, fall)	200	339	293
Ontario Main Basin	300	342	NA
North Channel/Mississagi straits	100	130	NA
Georgian Bay	250	60	NA
Total	2,000	1,818	

Table 4.–Incidence of marked (OTC marked or fin clipped or both) Chinook salmon from Lake Huron, 2003, by capture location, ages 1-3 combined (2000-2002 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 based on OTC or fin-clips
Georgian Bay	60	5.0	95.0
Mississagi Straits[a]	115	9.4	90.6
North Channel[b]	96	9.4	90.6
Main Basin, Ont.	342	8.1	91.9
South Basin, Mich. [c]	105	18.9	81.1
North-Central, Mich.	471	20.6	79.4
North, Mich.	79	29.1	70.9
St. Marys River	293	14.3	85.7
All sites	1,561	14.1	85.9
Fall escapement to stocking sites:			
Nottawasaga River	161	0.0	100.0
Sydenham River	90	6.9	93.1
Beaver River	23	13.0	87.0
AuSable River	281	95.7	4.3
Swan Weir	141	97.8	2.2

[a]Fin clips were not professionally observed; used finclip data from North Channel.
[b]Inadequate vertebra samples; used OTC results from Mississagi Straits.
[c]Fin clips were not professionally observed; used fin clip incidence from North-Central Michigan unit.

Table 5.–Incidence of fin-clipped Chinook salmon from Lake Huron, 2003, by capture location, ages 1-3 combined (2000-2002 cohorts). Lakewide, 24.9% of stocked 2000-2002 cohorts were fin clipped (expected value). Georgian Bay samples included escapement, and were in proximity both to stocking sites and locations thought to be reproduction sites.

Basin	Sample size	% Fin Clipped	Expected % fin clipped	% wild based in fin clips
Georgian Bay	90	5.0	24.9	79.9
North Channel	96	4.2	24.9	83.1
Main Basin, Ont.	1,164	5.6	24.9	77.5
South Basin, Mich.	105	NA [a]	24.9	NA [a]
North-Central, Mich.	471	4.8	24.9	80.7
North, Mich.	79	6.4	24.9	74.3
All sites	2,005	5.2	24.9	79.1

[a] Fin clips were not professionally observed (volunteers used).

Table 6.–Lengths (mm), weights (gm), and condition factors for Chinook spawning runs in Swan and Au Sable rivers, September-October, 1996-2003.

		Swan River				AuSable 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
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
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
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

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

Table 7.–Summary of lengths, weights, and condition factors of age-3 Chinook salmon, Au Sable River, 1973-2003.

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

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

Table 8.–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	8.0	375
1997	3.4	523
1998	2.4	544
1999	5.5	605
2000	3.2	381
2001	5.3	225
2002	1.9	362
2003	2.7	330
2004	1.0	296