STUDY PERFORMANCE REPORT

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

Study No.: 482 **Title:** Investigations into causes of, and solutions for, variable survival of chinook salmon stocked into Lake Huron

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

Objective:

(1) To develop methods for documenting the lacustrine early life history of stocked salmonids, with emphasis upon an understanding of factors influencing mortality of chinook salmon in Lake Huron during their first year at large.

(2) To identify the cause of low returns in chinook salmon stocked into the AuSable River.

(3) To determine if there is a significant difference in return rates for chinook salmon stocked in three different regions of Lake Huron: North, Central, and South.

(4) To determine the relative contributions of wild- and hatchery-produced chinook to Lake Huron's Fisheries.

Summary: Since 1993, a salmon harvest raceway on the AuSable River near Oscoda has been used as a rearing pen for chinook parr. In 1995 the raceway was divided to permit the rearing of two test lots of chinook. In 1995 and 1996, study fish were marked, reared, and stocked at Oscoda as planned. Other study fish at Swan River and Harbor Beach also were marked and stocked as planned. Quality control was conducted for mark quality and fish health for all study groups. A total of 208 predator fish was netted or electrofished from the study sites. These fish had consumed 204 alewives, 66 rainbow smelt, 58 age-0 chinook, and 7 steelhead yearlings. Walleyes were the most significant predator of stocked salmonids. At the Swan River mouth, lake trout were relatively abundant in the beach zone and 21 age-0 chinook found in lake trout stomachs there. Small-mesh gill netting produced a total catch of 193 age-0 chinook. All study groups were represented, but only 21 coded-wire tagged fish were identified. Two roving "head hunters" were employed in 1996 on Lake Huron. Angler awareness was heightened using signing of access sites and by networking with fishing groups. Sportfishing groups sponsored reward programs to stimulate returns. Coded-wire tags from chinooks were processed and the data entered. Tag recovery rates from the sportfishery suggest survival of penned groups from Oscoda have performed nearly twice as well as conventionally planted fish. Weir collections and fall electrofishing were used to assess imprinting and return to the study site for mature fish. In the AuSable River, (penned) fish were observed more than 5 times as frequently as the control (conventionally stocked) groups in the spawning runs, suggesting pen culture enhances both survival and homing. There was no evidence that natural reproduction is contributing to the spawning run in the AuSable River, based on examination of oxytetracycline marks. Biological data for the Swan and AuSable River spawning runs were summarized. All data processing and reporting requirements for this study were met.

Job 1. Title: Mark, imprint, and evaluate quality of the stocked fish.

Findings: Since 1995, the harvest pen at the VanEtten Weir has been divided into two equal sections to permit rearing of two lots of 100,000 fish each. Lake Huron Sportfishing Inc. reared and fed the penned fish, and assisted with with pen maintenance, draining, and stocking. Each lot of fish was marked with adipose fin clips and coded wire tags before delivery to the pens. In addition to the study lots, the AuSable River received 400,666 chinook which were planted directly by truck on May 30. At Harbor Beach, one lot of pen-reared chinook was paired with the release of a second lot stocked from the hatchery by truck. The Harbor Beach fish were penned an reared by the Thumb Steelheaders. Swan River, near Rogers City, has been Lake Huron's most successful stocking site in terms of return to creel, and a group of marked fish was stocked there as a benchmark for comparison with the study sites. A listing of 1996 stockings of chinook at Lake Huron research sites is given in Table 1.

Pen rearing at Harbor Beach and Oscoda was relatively uneventful and the fish were released from the pens without loss. The only potential problem was a power outage at Oscoda, which was dealt with by the cooperators by calling in a pumping unit from the local fire department until power was restored. There was no loss of fish. Marked fish, feed, fish loading and transport, quality control, and advice to the cooperators were supplied to the cooperators by DNR personnel.

Job 2. Title: Fish quality control.

Findings: A total of 60 coded wire tags were read from the two VanEtten (Oscoda) raceways, which revealed no mixing of the two study groups. Coded-wire tag retention and adipose clip quality for the VanEtten groups were measured from a sample of 198 fish. Estimated tag retention and clip quality rates are given in Table 2.

At Oscoda, quality control samples were taken by Alpena station personnel from samples of 60 fish each from test and control groups at the time they were stocked out. Quality control for chinook destined for stocking at Swan and Harbor Beach was conducted by hatchery personnel. Health data from Oscoda chinook were summarized using the AUSUM fish health summary template (Goede 1993) (Table 3). As in 1995, there were no significant differences between mean lengths, weights, or condition factors of chinook in the test and control pens at Oscoda (t test, $P>0.17$). However, the hind gut fat levels of fish destined for the beach site were higher ($P\leq0.05$, Table 3) than in the fish stocked in the river. Fish health parameters were acceptable for both lots and size and quality criteria for the study were met.

Job 3. Title: Evaluate predator distribution at time of stocking, and relative abundance and returns of test fish following stocking.

Findings: *Beach Seining:* Night beach seining was conducted from 1992-95. During this period all stocked chinook were marked with tetracycline and the number of wild (unmarked) fish was estimated from the seine catch. The use of tetracycline ceased in 1996. Objectives of the beach seining had been met; thus, there was no beach seining scheduled for 1996 or 1997.

Predators of age-0 chinook salmon: Predator abundance was indexed and diets were recorded at Oscoda and Harbor Beach. At Oscoda, the beach zone near the stocking sites was surveyed

using 10 sets of 76-m gill nets, each composed of 15-m panels of 38-mm to 114-mm stretch-measure multi-filiment mesh. Three such sets were made at Harbor Beach and 6 at Swan Bay in the vicinity of the stocking sites. In addition, electrofishing was used to capture predators at Harbor Beach and at two locations in the AuSable River; one river site was at Whirlpool, where pen reared fish were released, and a second river site was near the mouth. Diets of fish of a size capable of eating chinook are summarized in Table 4.

A total of 208 predator fish were sampled in 1996, of which 108 were walleyes. For the combined collections, 204 alewives, 58 age-0 chinook, 7 age-1 rainbow trout, 9 invertebrates, 66 smelt, and 1 trout-perch were identified from the stomach contents. In addition, there were 65 unidentified fish remains, many of which were similar in length to the age-0 chinook. Walleyes accounted for 47% of the age-0 chinook eaten and 100% of the age-1 rainbow trout. Lake trout contained 43% of the age-0 chinook observed in stomachs. Smallmouth bass from the AuSable River had also eaten chinook. The total number of chinook and rainbow trout consumed cannot be estimated without predator population estimates, and measurements of consumption and digestive rates. These collections suggest, however, that where alewives are abundant there may be less consumption of stocked salmonids. For example, salmonids were more important to the diet of walleyes collected from the AuSable River than for walleyes from the lake, where alewives and smelt appeared to be more abundant. The walleyes collected along the beach zone of Lake Huron at Oscoda, where 100,000 study fish had recently been stocked, had eaten alewives almost exclusively. The consumption rate by walleyes on salmonids was lower in 1996 than in 1995. In 1995 the number of salmonids per walleye stomach averaged 1.18; in 1996 the ratio dropped to 0.31. In 1996, lake trout were commonly taken in nets at Oscoda and Swan Bay, and the consumption of age-0 chinook averaged 0.60 chinook per lake trout; only one lake trout was collected in 1995. The higher catch of lake trout was probably due to later spring warming in 1996, which resulted in cool water temperatures in the beach zone through early June. There was evidence that diets of predator fish varied between individuals. For example, most walleyes and lake trout ate exclusively alewives and smelt. Only 15 of the predators had eaten chinook, but they had consumed 65 salmonids, for a consumption rate of 4.3 salmonids per predator. One walleye had eaten 14 age-0 chinook.

Small-mesh gill netting to index age-0 chinook: Relative abundance of age-0 chinook was measured in July and August fishing 3.8-cm and 5.1-cm mesh 4.6-m deep gill nets in the littoral zone. A total of 11,975 m of net was fished during the period in two statistical districts of Lake Huron and 193 age-0 chinook were captured. The purpose of the survey was to estimate relative first-summer survival of each of the study groups, as measured in relative abundance in the gill-net catch. However, the metal detector failed while we were extracting coded-wire tags from the catch and a large percentage of the catch was discarded before the problem was discovered. The result was that recoveries were too low to meet minimum sample size criteria. Only 21 coded-wire tags were recovered, but all study groups were represented in the sample. Chinook from penned study groups composed 71% of the marked sample; the expected incidence based on number stocked was 60% (Table 5). The most productive sampling site was Thunder Bay. Interestingly, all the Harbor Beach fish sampled were from nets set in Thunder Bay.

Swan River has been considered to be Lake Huron's consistently most productive stocking site, in terms of return to creel. consistent with that assumption, in 1994 catch rates were highest for Swan River chinook (Study 469, 1994 performance report). In both 1995 and 1996, however, catch rates for chinook from the Swan River were among the lowest of the 5 study groups. Overall catches of study fish in 1995 were low: adipose fin clips were observed on only 7.2% (40) of the age-0 chinook gill netted. In contrast, 21.4% of the 1994 age-0 gill-net catch had

adipose clips and 16.5% had clips in 1996. These departures from expected values (Table 6) suggest site- and year- specific differences in post stocking survival may be occurring. The pronounced decline in 1995 corresponds with a reduction in the number of clipped chinook stocked at Rogers City (a site where stocking success has been high) and an increase in number of clips allocated to Harbor Beach (where stocking success had been thought to be low). Only one Harbor Beach fish was sampled in 1995, and no age-0 Harbor Beach chinook were netted in 1994. The increase in number of chinook sampled from the Harbor Beach pen group in 1996 is likely due to earlier release of these fish; in 1995, the Harbor Beach pen fish were released after water temperatures had reached critical levels and large numbers of the penned fish were probably lost to temperature stress.

As in previous years, especially productive netting sites for Age-0 chinook were sandy bays, such as Thunder Bay, Tawas Bay, and Saginaw Bay. Most productive depths were 8- to 11-m. Temperatures at the netting sites usually ranged from 15 C to 18 C, considerably warmer than temperatures typical of adult distributions.

Return to creel: Ultimately, return to creel is the most important measure of performance of the experimental groups. Coded wire tags were collected using two summer fisheries assistants, who examined angler catches and worked with project cooperators, and by soliciting cooperation of bait and tackle vendors. Signs were posted at all fish cleaning stations and public launch ramps notifying anglers of the study and instructing them on how to identify study fish and how to remove and return snouts to the DNR. Local interest groups have sponsored a reward program for return of coded-wire-tags. Rewards range from free fishing lures to drawings for cash and other prizes. Creel survey clerks (Study 427) were also instructed to collect snouts from all study fish encountered.

During 1996, a total of 836 coded-wire-tags were recovered from chinook salmon taken by the recreational fishery on Lake Huron. In addition, other coded-wire tags were taken from survey and weir catches at the AuSable River and Swan weir. Tags from 1996 are still being received from cooperating agencies and vendors. Most of the tags have been processed.

Tag recovery rates for each of the study lots stocked since 1993 are summarized in Table 7. For each cohort stocked in the AuSable River, test groups have returned at higher rates than control groups. For 1993 and 1994, when the control groups were conventionally (direct from hatchery) planted fish, the respective penned fish have returned 1.8 and 3.3 times better than control lots to date. For 1995, penned fish were used for both the upriver and the beach plant. Only age 1 fish have returned to date. In this case, the test (beach stocked) group has thus far returned 1.7 times better than the control.

During September and October, the AuSable River was electrofished weekly to determine relative contributions of study fish to the spawning run. The hypothesis was that pen culture would better imprint the fish and thus enhance returns to the AuSable River. A total of 438 salmon was collected from the AuSable, of which 137 (31%) bore coded-wire tags (Table 8). For the 1993 and 1994 year classes, test groups were observed more than 5 times more frequently than control lots, consistent with the imprinting hypothesis. The difference was much less pronounced with the 1995 year class, for which both the test and control groups were imprinted in the pen.

One hundred chinook salmon were sampled from the spawning run at Swan Weir during October 1996. Because the Swan run is thought to be almost entirely supported by stocking, we used this

run as a "benchmark" with which to evaluate the contribution of wild fish in the AuSable River's run. All chinook stocked in 1992-95 were marked with oxytetracycline; thus a significantly higher rate of unmarked fish in the AuSable River would indicate reproduction was contributing to that spawning population. The catch was aged using vertebrae. Biological data, including oxytetracycline mark rates, are given in Table 8 for both locations. The percentage of unmarked fish was not significantly different between the two runs in 1996 (in fact, the incidence of unmarked chinook was slightly higher in the Swan run), suggesting reproduction contributed little to the AuSable River spawning population. Sea lamprey wounding was similar for the two sites and averaged 9.3 A1-A3 type wounds per 100 fish for ages 3 and 4 combined. The contribution of age 1 fish to the spawning run was higher at the AuSable River than at Swan, which is consistent with other results from Study 482 that suggest, at least for the marked study groups, the 1995 year class was relatively strong from the AuSable River but weak from the Swan.

The study plan calls for collection of vertebrae (for measurement of oxytetracycline mark rates) of chinook salmon caught in the Ontario commercial and sport fisheries. Funding constraints and reductions in force in Ontario have, however, caused this work to be canceled. Oxytetracycline marking was terminated with the 1995 year class. Ontario Ministry of Natural Resources continued in 1996 to search sport and commercially caught salmonids for coded-wire-tags and is processing and sharing that information with the Michigan DNR.

Job 4. Title: Read coded-wire-tags and tetracycline marks, enter and analyze data, and prepare annual reports and publications.

Findings: Data entry for all 1996 collections is complete. Oxytetracycline and coded-wire-tag processing is continuous and on schedule. The 1996-97 annual performance report was prepared.

Literature Cited:

Goede, R.W. 1993. Fish health/condition assessment procedures. Utah Division of Wildlife Resources, Fisheries Experiment Station, Logan.

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Table 1.–Chinook salmon stocking in Lake Huron study sites, 1996.

Location	Date	Mark[1]	Method	Number
Rogers City				
Swan River	June 5		truck	797,598
Swan River	June 5	AD-CWT	truck	103,140
Oscoda				
AuSable River, Oscoda	May 30		truck	400,666
AuSable River, Whirlpool	May 21	AD-CWT	pen	103,651
Beach	May 21	AD-CWT	pen	102,558
Harbor Beach				
Power Plant	May 29	AD-CWT	pen	103,738
Marina	May 29	AD-CWT	truck	102,145
Marina	May 29		truck	198,007

[1] AD=adipose clip; CWT=coded wire tag.

Table 2.–Estimates of proportion marked, number, and size at stocking, five chinook salmon study groups, Lake Huron, 1996.

	Swan	Oscoda pens		Harbor Beach	
	Truck	Stocked on beach	Stocked in river	Pen	Truck
Stocking date:	June 5	May 21	May 21	May 29	May 29
CWT number	59-47-56	59-47-61	59-47-62	59-19-01	59-47-59
Number stocked	103,140	102,558	103,651	103,788	102,145
Proportion with CWT	0.929	0.816	0.890	0.914	0.860
Proportion with AD clip	0.963	1.000	0.990	0.980	0.990
Number stocked with clip & CWT	92,272	83,687	91,327	92,965	86,966
Number died in pen	–	312	77	50	–
Number stocked with both tag & clip	92,272	83,375	91,250	92,915	86,966
Number per kg when stocked out	307	280	214	190	280
Average total length (mm)	78	95	95	105	83

Table 3.–Summary of fish quality criteria for two lots of chinook salmon reared in the VanEtten pens at time of their stocking at Oscoda, 1996.

	River plant			Beach plant		
Criteria	Mean	N	SD	Mean	N	SD
Means (N=60 unless indicated otherwise)						
Total length (mm)	95	126	7.5	95	99	6.4
Weight (g)	7.4	126	1.6	7.3	99	1.4
Ktl	0.86	126	0.07	0.85	99	0.07
Foregut fat index[2]	1.7			1.6		
Hindgut fat index[2]	2.2[2]			2.6[1]		
Percent "normal" (N = 60 for each group):						
Eye		100			100	
Pseudobranchs		100			100	
Thymus		75			73	
Spleen		100			100	
Hind gut		100			100	
Kidney		100			100	
Liver		90			83	
Fins		100			100	
Gills		100			100	
Opercle		100			100	

[1] Percent pyloric caeca or hindgut obscured by fat: 0=no visible fat; 1=less than 50% of caeca or hindgut covered; 2=50% covered; 3=75% covered; 4=caeca or hindgut obscured by fat.
[2] Significant difference between study groups (Mann-Whitney U; $P<0.05$).

Table 4.–Number of prey in stomachs of predator fish sampled near chinook salmon stocking sites, 1996.

Species	Length range (mm)	Sample size	Number void	Invertebrate	Age-0 chinook	Age-1 steelhead	Alewife	Smelt	Trout perch	Unidentified fish
Oscoda										
Beach zone (effort=ten 76 m gill nets)										
Rainbow trout	167-622	5	0	0	0	0	0	0	0	0
Brown trout	470-633	4	1	0	0	0	15	0	0	0
Lake trout	509-671	15	0	0	4	0	18	12	0	1
Walleye	243-732	68	26	0	0	0	86	0	0	2
Chinook	252-354	5	5	0	0	0	0	6	0	1
AuSable River (effort=176 minutes electrofishing)										
Rainbow trout	212-837	9	5	0	0	0	0	0	0	0
Walleye	365-721	30	6	0	20	7	36	0	0	24
Smallmouth bass	269-420	4	2	0	6	0	0	0	0	3
Rock bass	191-230	5	1	7	0	0	0	0	0	0
Atlantic salmon	560	1	1	0	0	0	0	0	0	0
Brown trout	436	1	0	0	0	0	0	0	0	0
Harbor Beach										
Gill-nets (effort=three lifts, 76 m nets)										
Walleye	314-749	10	3	0	7	0	9	0	0	9
Northern pike	558-703	3	1	0	0	0	9	0	0	1
Chinook	264-327	5	1	0	0	0	0	6	0	1
Brown trout	500	1	0	0	0	0	0	0	0	3
Smallmouth bass	334-416	5	3	0	0	0	0	0	0	2

Table 4 - (Continued).

Species	Length range (mm)	Sample size	Number void	Invertebrate	Age-0 chinook	Age-1 steelhead	Alewife	Smelt	Trout perch	Unidentified fish
Harbor Beach										
Electrofishing (effort=88 minutes)										
Walleye	–	0	0	0	0	0	4	0	0	0
Northern pike	–	0	0	0	0	0	0	0	0	0
Smallmouth bass	262-410	7	4	2	0	0	4	0	1	3
Chinook	320	1	0	0	0	0	0	1	0	0
Swan Bay (Rogers City)										
Gill-nets (effort=six lifts, 76 m nets)										
Burbot	503-616	3	0	1	0	0	3	0	0	9
Lake trout	403-639	27	1	0	21	0	23	41	0	12
Totals										
Rainbow trout		14	5	0	0	0	0	0	0	0
Brown trout		6	1	0	0	0	15	0	0	3
Lake trout		42	1	0	25	0	41	53	0	13
Walleye		108	35	0	27	7	135	0	0	35
Northern pike		3	1	0	0	0	9	0	0	1
Channel catfish		11	6	0	0	0	0	13	0	2
Burbot		3	0	0	0	0	0	0	0	3
Smallmouth bass		16	9	2	6	0	4	0	1	8
Rock bass		5	1	7	0	0	0	0	0	0
All species		**208**	**59**	**9**	**58**	**7**	**204**	**66**	**1**	**65**

Table 5.–Catch of age-0 chinook salmon in small-mesh gill nets, by statistical district, August and September 1996, Michigan waters of Lake Huron.

Statistical District	Effort (m)	Total age-0 chinook	Site and number coded-wire tagged				
			Swan Creek 92,272	Oscoda Beach 83,375	Oscoda River 91,250	Harbor Beach direct plant 86,966	Harbor Beach pen plant 92,915
MH-1	0						
Total catch		–	–	–	–	–	–
Adjusted catch[1]		–	–	–	–	–	–
MH-2	5,806						
Total catch		105	1	2	3	4	7
Adjusted catch[1]		18.08	0.19	0.41	0.57	0.79	1.30
MH-3	0						
Total catch		–	–	–	–	–	–
Adjusted catch[1]		–	–	–	–	–	–
MH-4	6,169						
Total catch		88	1	3	0	0	0
Adjusted catch[1]		14.27	0.18	0.58	0.00	0.00	0.00
Totals	11,975						
Total catch		193	2	5	3	4	7
Adjusted catch[1]		16.12	0.18	0.50	0.27	0.38	0.63

[1] For total age-0 chinook, adjusted catch is catch per 1000 m net fished. For site-specific catch, adjusted catch is catch per 1,000 m standardized to stocking rate of 100,000.