STUDY PERFORMANCE REPORT

State: Michigan

Project No.: F-53-R-14

Study No.: 482

Title: Investigations into causes of, and solutions for, variable survival of chinook salmon stocked into Lake Huron

Period Covered: April 1, 1997 to March 31, 1998

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, 1996, and 1997 study fish were marked, reared, and stocked at Oscoda, Swan River, and Harbor Beach as planned. Quality control was conducted for mark quality and fish health for all study groups. During 1995-97, the stocking sites were netted to measure relative abundance of predator and prey fish and the composition of predator diets. In 1997, a total of 198 predator fish was netted or electrofished from the study sites. These fish had consumed 125 alewives, 22 rainbow smelt, 53 age-0 chinook, and 1 steelhead yearling. As with 1995 and 1996, walleyes were the most significant predator of stocked salmonids. At the Swan River mouth, lake trout were relatively abundant in the beach zone and 11 age-0 chinook were found in lake trout stomachs there. Two roving “head hunters” were employed in 1997 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, test (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. Returns of Swan River stockings declined sharply after 1994 from the relatively high return rates experienced with the 1991-94 cohorts. Wild age-0 chinook were observed in seine samples taken near the AuSable River in earlier segments of this study, but there was no evidence that natural reproduction was contributing to the spawning run there, based on examination of oxytetracycline marks. Biological data for the Swan and AuSable River spawning runs were summarized. Growth was significantly slower at both sites in 1997 than in 1996. The 1995 and 1996 year classes from Swan River appear to be unusually weak. All data processing and reporting requirements for this study were met.

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

Findings: From 1995-97, the harvest pen at the VanEtten Weir was 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 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 near 400,000 chinook which were planted directly by truck. Similarly, at Harbor Beach, one lot of pen-reared chinook was paired with the release of a second lot stocked directly from the hatchery from 1995-98. The Harbor Beach fish were penned and reared by the Thumb Steelheaders. Swan River, near Rogers City, had 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 1997 stockings of chinook at Lake Huron research sites is given in Table 1.

Fish marking and handling, quality control, feed, transport, and advice to the pen-culture cooperators were supplied by DNR personnel.

Pen rearing at Harbor Beach and Oscoda was relatively uneventful and the fish were released from the pens without loss. The spring rearing period at Oscoda was unseasonable cold, however, and pen temperatures there never reached 10 C, causing growth to be slower than usual. The Harbor Beach pen is in a power plant thermal discharge. The warm pen temperatures there caused the penned fish to be larger at stocking than the conventional plant (Tables 1 and 2).

Job 2. Title: Fish quality control.

Findings: Coded-wire tags were read from samples taken from the two VanEtten (Oscoda) raceways, which revealed significant mixing of the two study groups. One of 65 fish (2%) sampled from the raceway designated for river (upstream) stocking was found to have the beach (downstream) tag. Six of 59 fish (10%) sampled from the beach (downstream) sample bore river (upstream) tag numbers. Apparently, the screen dividing the two groups was not fully sealed. Future returns will have to be corrected to account for this problem. Coded-wire tag retention and adipose clip quality for the Oscoda groups were measured from a sample of 198 fish. Quality control for Harbor Beach and Swan sites was conducted by hatchery and district management personnel. Estimated tag retention and clip quality rates are given in Table 2.

At Oscoda, fish health 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. Sample size of 100 from each group was used for measurement of length, weight, and condition factor. Fish health monitoring for chinook destined for stocking at Swan and Harbor Beach was conducted by hatchery personnel. Health data from Oscoda chinook were summarized using methods of Goede (1993) (Table 3). The study group destined for beach stocking was slightly, but significantly ($p<0.05$), larger in length and weight than the upstream group. The beach group also carried significantly ($p<0.05$) more fat in the foregut and hindgut areas of the viscera (Table 3). In past years, there were no significant differences between mean lengths, weights, or condition factors of chinook in the test and control pens at Oscoda. Evidently, the downstream pen produced somewhat better growth in 1997. We have alternated placement of test groups, placing the beach and river lots in reverse order in the raceway in successive years. The purpose of this plan is to compensate for any advantage of rearing position on overall returns during the course of the study.

Fish health parameters were acceptable for both lots. The unusually cold spring caused growth of both study groups to be less than expected.

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

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 have been met; thus, there was no beach seining scheduled for 1996 or 1997

Predators of age-0 chinook salmon: From 1995-97, predator fish abundance was indexed and diets were recorded at Oscoda, Harbor Beach, and Swan Bay. At Oscoda, the beach zone near the stocking sites was surveyed in 1997 using 12 sets of 76-m gill nets, each composed of 15-m panels of 38-mm to 114-mm stretch-measure multi-filament mesh. Four 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 198 predator fish was sampled in 1997, of which 68 were walleyes. For the combined collections, 125 alewives, 53 age-0 chinook, 1 age-1 rainbow trout, 75 invertebrates, 22 smelt, and 18 trout-perch were identified from the stomach contents. In addition, there were 68 other or unidentified fish remains. Walleyes accounted for 49% of the age-0 chinook eaten and 100% of the age-1 rainbow trout. Lake trout contained 28% of the age-0 chinook observed in stomachs. Smallmouth bass contained 9% of the chinook eaten. These results are consistent with those collected in 1995 and 1996, with the exception that alewife and walleye catch rates were lower in 1997. 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, where alewives were scarce, than for walleyes from the lake, where alewives and smelt appeared to be more abundant. During the three years of sampling, walleyes collected along the beach zone of Lake Huron at Oscoda, where study fish had recently been stocked, consumed alewives almost exclusively. The consumption rate by walleyes on salmonids was lower in 1996 and 1997 than in 1995. In 1995 the number of salmonids per walleye stomach averaged 1.18; the ratio was 0.31 chinook per walleye in 1996 and 0.38 in 1997. 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. In 1997, lake trout were also common but consumption of chinook declined to 0.21 per lake trout. Only one lake trout was collected in 1995. The higher catch of lake trout in 1996 and 1997 was probably due to later spring warming in those years, which resulted in cooler than normal water temperatures in the beach zone through early June. As in 1995 and 1996, there was evidence that switching to stocked salmonids as prey was an individually-based behavioral trait. Most walleyes and lake trout ate exclusively alewives and smelt. However, certain fish had switched to predominantly salmonid prey and these few individuals accounted for most of the salmonid consumption measured. For example, in 1997 a single walleye at Harbor Beach contained 23 age-0 chinook. One walleye taken in 1996 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, 1994-96, fishing 38-mm and 51-mm mesh 4.6-m deep gill nets in the littoral zone. A total of 1,077 age-0 chinook was sampled during the three years. The purpose of the survey was to estimate relative first-summer survival of each of the study groups and contribution of wild, unmarked chinook to Michigan's chinook fishery. However, in 1997 marking with oxytetracycline ceased, which brought an end to this study element. One measure of the contribution of wild chinook is the incidence of adipose fin clips in the net catch. The number of fin clipped fish was close to that expected if no wild recruitment occurred in each of the three years of the survey (Table 5). An analysis of origin of the age-0 catch will be provided in the final report.

In 1997, graded-mesh gill nets were built and deployed to sample for all ages of chinook. The purposes of this sampling effort were to: 1) further document distribution and seasonal prey of chinook and other pelagic predators, and 2) to provide diet and tissue samples for bioenergitics modeling being conducted by Michigan State University at the request of the Lake Huron Committee. This first year of work was designed as a "shakedown" of the technique and to determine the feasibility of setting such gear with the Alpena Station's vessel as presently equipped.

In 1997 all effort set was "jugged" to fish 3 to 10 m below the surface. Each net was 244 m long and 6.1 m deep (from float to lead line) when deployed. Mesh sizes ranged from 76 to 152 mm in 17.7-mm increments plus one panel of 178-mm mesh. These nets were deployed in statistical districts 1-6 from May through August.

A summary of the 1997 catch is given in Table 6. Chief pelagic predators were chinook, walleye, and lake trout. The catch was immediately frozen and shipped to MSU for caloric analysis or stomachs were removed and shipped to the lab in Alpena for analysis. The PERM Unit at Michigan State University used this catch data, fish samples from Alpena's Study 451, and data contributed by other agencies on Lake Huron to produce a bioenergetics model of Lake Huron. The model is based upon chinook salmon, lake trout, burbot, and walleye as the principal predators and alewife, smelt, and bloater chub as the prey base. The model is being used to evaluate stocking and management strategies to optimize use of the lake's prey base.

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, worked with agency project cooperators, and solicited 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. In addition, other coded-wire tags were taken from survey and weir catches at the AuSable River and Swan weir. Tags from 1997 are still being received from cooperating agencies and vendors. Most of the tags have been processed.

Tag recovery rates in the recreational fishery 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, 1996, and 1997, penned fish were used for both the upriver (control) and the beach (test) plant. Only age 1 and 2 fish have returned to date from this study element. In this case, the 1995 test (beach stocked) group has thus far returned 1.4 times better than the control. First-year returns for the 1996 cohort from the Oscoda study were identical (Table 7). The first year of the Harbor Beach comparison (1995), the penned fish were exposed to water temperatures that exceeded 21 C and significant mortality resulted. Because of that mishap, it was decided to extend the study period at Harbor Beach to 1998. The 1996 rearing period went well and there were no significant losses. To date, returns of penned and conventionally stocked fish from the 1995 Harbor Beach comparison have been similar but pen-cultured fish composed the majority of first-year returns of the more successful 1996 rearing effort (Table 7). Return rates in the recreational fishery for chinook stocked at Swan River declined sharply after 1994. Lower than expected returns were first measured in small-mesh netting of age-0 Swan River fish in 1995 and 1996. More recently, recreational catch of the 1995 and 1996 year classes originating at Swan has been approximately half the rate of previous years, and are now trailing all other experimental stocking sites.

Measurement of biological data and composition of spawning escapement: During September and October, 1996 and 1997, 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 499 salmon was collected during fall 1997 from the AuSable, of which 115 (23%) bore coded-wire tags (Table 8). For the combined 1993 and 1994 year classes, test groups were observed 5.9 times more frequently than control lots (Table 9), which is much higher than the rate expected based upon returns to creel. Thus, the test groups appeared to benefit from a combination of improved post-stocking survival and enhanced imprinting. For the 1995 and 1996 year classes, combined, penned fish transported to the beach were sampled 3.6 times the rate of pen-cultured fish transported upriver for stocking (Table 9). Because both groups were imprinted in the pen, the difference in returns for the 1995 and 1996 year classes could represent survival costs of river migration in the upstream stocking group in the AuSable. Differences in the 1995 and 1996 study groups' lake catch in the 1997 recreational fishery were less pronounced (Table 7) than in fall escapement, however. Sample sizes for recent age groups are sparse, but will become more robust with subsequent years of sampling.

As in 1996, chinook salmon were sampled from the spawning run at Swan Weir during October 1997. 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 and fin clip 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 or 1997, suggesting reproduction contributed little to the AuSable River spawning population. Wild smolts were measured during earlier segments of this study by seining beaches near the AuSable River. Although wild smolts were abundant, sometimes composing near 50% of the catch, they were significantly smaller than stocked smolts and did not leave the beach zone until late June. This slower development may have exposed the wild recruits to higher predation levels and water temperatures than the larger stocked fish experienced.

Sea lamprey wounding was lower for both sites in 1997 than in fall 1996, averaging 4.8 A1-A3 type wounds per 100 fish for ages 3 and 4 combined (Table 8). The marking rate in 1996 was 9.3 per 100 for ages 3 and 4. The contribution of age 1 fish to the spawning run was much lower at the AuSable River in 1997 than in 1996 (Table 10), which is consistent with other results from Study 482 that suggest the 1995 pen-cultured cohort from the AuSable River was relatively strong.

At both Swan and the AuSable, weight and length of most age groups declined significantly from 1996 to 1997 fall sampling periods (Table 10). Overall condition factor also was significantly lower in 1997. The change in growth was most pronounced in older age groups. Weight of age 4 salmon from the AuSable River, for example, declined 1.7 kg between 1996 and 1997.

Typically, mature salmon cannot be aged with scales or otoliths due to erosion and opaqueness, respectively, of these bony structures. Vertebrae aging has proved to be a viable alternative. Collection of biological date and vertebrae from approximately 100 salmon per week from each major spawning run appears to be sufficient to describe age-specific biological parameters of annual chinook escapement.

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 in Michigan with the 1995 year class. Ontario Ministry of Natural Resources continued 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: Enter and analyze data, read coded-wire tags and tetracycline marks, and prepare annual reports and publications

Findings: Data entry for all 1997 collections is complete. Oxytetracycline and coded-wire tag processing is continuous and on schedule. The 1997-98 annual performance report was prepared. Data from this study was used by the Lake Huron Technical Committee in the development of the Lake Huron bioenergetics model. Results of Study 482 were presented at the annual Upper Lakes / Lake Huron Committee Meeting in Thunder Bay Ontario in March, 1998. The paper "Predation by walleyes and other predator fish on stocked salmonids in Lake Huron" was presented at the Annual Meeting of the American Fisheries Society in Monterey, August, 1997. The paper "Predation by walleyes and other native predator fish on stocked chinook salmon, Lake Huron" was presented at the Midwest Fish and Wildlife Conference in Milwaukee, December, 1997.

Literature Cited:

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

Table 1.–Chinook salmon stocking in Lake Huron study sites, 1997.

Location	Date	Mark[1]	Average Length (mm)	Method	Number
Rogers City					
Swan River	May 29	None	81	truck	783,807
Swan River	May 29	AD-CWT	84	truck	102,314
Oscoda					
AuSable River, Oscoda	June 2-4	None	85	truck	342,322
AuSable River, Whirlpool	May 20	AD-CWT	77	pen	102,793
Beach	May 20	AD-CWT	80	pen	101,270
Harbor Beach					
Power Plant	June 2	AD-CWT	104	pen	103,036
Marina	June 3	AD-CWT	82	truck	103,076
Marina	June 3	None	81	truck	239,598

[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, 1997.

	Swan	Oscoda pens		Harbor Beach	
	Truck	Stocked on beach	Stocked in river	Pen	Truck
Stocking date:	May 29	May 20	May 20	June 2	June 3
CWT number	59-49-11	59-49-04	59-49-08	59-49-07	59-49-02
Number stocked	102,314	101,270	102,720	103,036	103,156
Proportion with CWT	0.903	0.904	0.95	0.936	0.872
Proportion with AD clip	0.981	0.875	0.89	0.961	0.991
Number stocked with clip & CWT	90,587	80,105	86,947	92,680	89,084
Number died in pen	---	67	67	0	---
Number stocked with both tag & clip	90,587	80,038	86,880	92,680	89,084
Number per kg when stocked out	221	190	198	111	217
Average total length (mm)	84	80	77	104	82

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, 1997.

Criteria	River plant Mean	River plant N	River plant SD	Beach plant Mean	Beach plant N	Beach plant SD
Means						
Total length (mm)	77[1]	101	6.4	80[1]	104	6.9
Weight (g)	4.8[1]	60	1.1	5.7[1]	60	1.3
Ktl	1.02	60	0.07	1.06	60	0.16
Foregut fat index[2]	0.2[3]	60	0.42	0.5[3]	60	0.6
Hindgut fat index[2]	1.5[3]	60	0.54	1.9[3]	60	0.7
Percent "normal" (N = 60 for each group):						
Eye		100			100	
Pseudobranchs		100			100	
Thymus		80			82	
Spleen		100			100	
Hind gut		100			100	
Kidney		100			100	
Liver		100			100	
Fins		100			100	
Gills		100			88	
Opercle		100			100	

[1] Significant difference between study groups (t=test; P<0.05).
[2] 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.
[3] 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, 1997.

Species	Length range (mm)	Sample size	No. void	Invertebrates	Age-0 chinook	Age-1 steelhead	Alewife	Smelt	Trout-perch	Other fish
Oscoda										
Beach zone (effort=twelve 76 m gill nets)										
Rainbow trout	563-775	3	3	0	0	0	0	0	0	0
Brown trout	412-504	4	1	0	3	0	0	0	8	0
Lake trout	470-656	18	1	20	4	0	16	8	10	3
Walleye	407-723	33	27	0	0	0	3	0	0	0
AuSable River (effort=170 minutes electrofishing)										
Walleye	510-712	16	11	0	10	1	0	0	0	4
Harbor Beach										
Gill-nets (effort=four lifts, 76 m nets)										
Walleye	398-700	15	7	0	26	0	9	0	0	3
Northern pike	512-884	20	4	0	1	0	23	0	0	1
Chinook	346-522	7	4	0	0	0	4	0	0	1
Channel catfish	592	1	0	0	0	0	2	0	0	1
Freshwater drum	362-380	3	3	0	0	0	0	0	0	0
Rock bass	225	1	1	---	---	---	---	---	---	---
Smallmouth bass	410	1	0	0	0	0	0	0	0	1
Harbor Beach										
Electrofishing (effort=114 minutes)										
Walleye	---	0	---	---	---	---	---	---	---	---
Northern pike	435	1	0	0	1	0	0	0	0	2
Smallmouth bass	265-422	11	2	5	7	0	0	0	0	14
Rock bass	260	1	0	0	0	0	0	0	0	1
Freshwater drum	350-433	4	1	50	0	0	0	0	0	2

Table 4. continued

Species	Length range (mm)	Sample size	No. void	Invertebrates	Age-0 chinook	Age-1 steelhead	Alewife	Smelt	Trout-perch	Other fish
Swan Bay (Rogers City)										
Gill-nets (effort=six lifts, 76 m nets)										
Burbot	458-595	2	0	0	0	0	1	0	0	1
Walleye	356-666	4	3	0	0	0	2	0	0	0
Brown trout	412	1	0	0	0	0	1	0	0	0
Lake trout	436-688	55	8	0	11	0	67	14	0	38
Totals										
Rainbow trout		3	3	0	0	0	0	0	0	0
Chinook		7	4	0	0	0	4	0	0	1
Brown trout		5	1	0	3	0	1	0	8	0
Lake trout		73	9	20	15	0	83	22	10	41
Walleye		68	48	0	26	1	11	0	0	3
Northern pike		21	4	0	2	0	23	0	0	3
Channel catfish		1	0	0	0	0	2	0	0	1
Burbot		2	0	0	0	0	1	0	0	1
Freshwater drum		4	1	50	0	0	0	0	0	2
Smallmouth bass		12	2	5	7	0	0	0	0	15
Rock bass		2	1	0	0	0	0	0	0	1
All species		**198**	**73**	**75**	**53**	**1**	**125**	**22**	**18**	**68**

Table 5.–Proportion of age-0 chinook with adipose fin clips captured during August and September, 1994-96 in small mesh gill nets, with respect to proportion stocked.

Year	Total no. stocked	No. adipose clipped stocked	Expected ratio clipped/no clip	Gill net ratio Clip/no clip
1994	3,572,559	467,270	0.131	21.4
1995	3,829,957	486,325	0.127	7.2
1996	3,471,523	507,023	0.146	16.5

Table 6.–Catch per 1,000 feet of high gill nets, by species and month, Lake Huron, 1997.

	Effort (feet)	Chinook catch	Chinook CPE	Lake trout catch	Lake trout CPE	Walleye catch	Walleye CPE
May	6,750	17	2.52	3	0.44	4	0.59
June	10,400	16	1.54	24	2.31	1	0.10
July	12,800	22	1.72	7	0.55	15	1.17
August	16,000	16	1.00	1	0.06	35	2.19

Table 7.–Number of lake sport-caught coded-wire tagged chinook salmon returns at age per 100,000 planted, Lake Huron stocking method studies, 1993-97.

		AuSable River		Harbor Beach		Swan
Year Class	Age	Test (Released at pen or beach)	Control (Whirlpool)	Study (pen)	Control (conventional Truck)	(benchmark)
1993[1]	1	55.4	29.7		10.2	38.4
	2	116.9	63.5		26.1	76.9
	3	87.7	53.6		34.0	55.3
	4	14.1	5.1		7.9	32.7
	Total	274.1	151.6	---	78.2	203.3
1994[2]	1	79.4	20.5		12.1	38.8
	2	102.8	28.1		20.9	83.0
	3	169.3	49.7		64.9	127.7
	Total	352.6	98.3	---	97.9	249.5
1995[3]	1	78.6	53.4	33.1	36.5	18.9
	2	116.1	87.3	108.3	101.5	44.5
	Total	194.8	140.7	142.5	138.0	64.5
1996						
	1	40.4	40.5	37.7	19.6	12.6
	Total	40.4	40.5	37.7	19.6	12.6

[1] Pen fish released directly from pen versus conventional truck plant in 1993.
[2] Pen fish trucked to beach versus conventional truck plant in 1994.
[3] Pen fish trucked to beach versus pen fish trucked up river in 1995, 1996 and 1997.

Table 8.–Biological data from chinook salmon sampled from the spawning runs in AuSable River and Swan Weir during fall, 1997.

Age	Number	Percent of aged catch	Mean length (mm)	Mean weight (kg)	% marked with OTC or fin clip	Lamprey wounds per 100
AuSable River (electrofishing)						
1	29	5.9	532	1.629	Not marked	0.00
2	189	38.4	724	3.729	94.7	2.84
3	197	40.2	828	5.322	99.5	3.87
4	76	15.4	856	5.860	98.7	8.22
Unknown	8				33.3	
Total	499					
Swan River (weir harvest)						
1	6	9.2	507	1.372	Not marked	0.00
2	3	4.6	840	4.040	100.0	0.00
3	40	61.5	822	4.973	100.0	5.00
4	16	24.6	860	5.709	100.0	0.00
Unknown	1					
Total	66					

Table 9.–Return of study groups of chinook to AuSable River at maturity, fall 1997, electrofishing samples of 100 fish per week for 5 weeks. Total sample=499 fish, 76% of sample was unmarked (lacked finclip or coded-wire tag).

Study group	CWT number	Site code	Clip adj. factor	Tagging adj. factor	Recoverable stocked	Age	Number	Corrected number	Percent	Ratio test/control
1993 VanEtten Pen	594404	350001	0.993	0.917	93,139	4	3	2.79	60	1.50
1993 conventional	594413	350106	0.999	0.962	97,641		2	1.95	40	
1994 Pen, 3 Mile Park	594455	350004	0.997	0.920	92,594	3	44	40.74	88	7.33
1994 conventional	594456	350106	0.997	0.858	85,648		6	5.14	12	
1995 Pen, beach	594752	350004	0.955	0.868	84,574	2	33	27.91	79	3.67
1995 Pen, upstream	594750	350106	0.980	0.835	84,575		9	7.61	21	
1996 Pen, beach	594761	350004	0.990	0.820	83,375	1	7	5.84	78	3.50
1996 pen, upstream	594762	350106	0.980	0.890	91,250		2	1.83	22	
Other CWT lots						4	0			
(3 were from Swan)						3	8			
						2	0			
						1	1			
Total number with CWT							114			

Table 10.–Lengths (mm), weights (gm), and condition factor for chinook spawning runs in AuSable River and Swan River, September-October, 1996 and 1997.

Site	Age group	Sample year	Length	Weight	Condition [2]	Sample size
Swan River	1	1996	569[1]	1773[1]	0.95	10
		1997	507[1]	1372[1]	1.05	6
	2	1996	776	4414	0.93	52
		1997	840	4040	0.74	3
	3	1996	852[1]	5769[1]	0.92	25
		1997	822[1]	4973[1]	0.89	40
	4	1996	967[1]	8886[1]	0.97	13
		1997	860[1]	5706[1]	0.88	16
AuSable River	1	1996	543	1727	1.06	126
		1997	532	1629	1.09	29
	2	1996	766[1]	4638[1]	1.01	124
		1997	724[1]	3719[1]	0.97	188
	3	1996	857[1]	6246[1]	0.98	149
		1997	828[1]	5324[1]	0.92	199
	4	1996	911[1]	7513[1]	0.98	27
		1997	856[1]	5860[1]	0.93	76

[1] Significantly smaller in 1997 ($p<0.05$).
[2] Condition was function of age, year, and interaction of age and year (ANOVA, $p<0.05$), with overall condition significantly smaller in 1997.

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