STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-53-R-14

Study No.: 471 **Title:** Chinook salmon population dynamics in Michigan's waters of the Great Lakes

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

Study Objectives: (1) To assemble the volumes of data collected on all life stages of chinook salmon (*Oncorhynchus tshawytscha*) since the inception of the salmon program in Michigan; (2) to capture these data into computerized databases to allow for a) management and update of such data, b) analysis, c) development of predictive capabilities for future management of chinook salmon, and d) easier dissemination of these data to other interested researchers; (3) to develop information and mathematical models from these data which will allow managers to predict, with some predetermined level of certainty, the outcome of various management strategies on chinook salmon; and (4) to begin the process of a holistic approach to the management of the Great Lakes through the development of mathematical models to predict, with some predetermined level of certainty, the outcome of various management scenarios on the Great Lakes' ecosystem.

Summary: The number of chinook salmon harvested at weirs located on tributaries to Lake Michigan decreased by approximately 28% from 1996 to 1997. This decrease was observed at all four Lake Michigan weirs. Bacterial kidney disease (BKD) incidence at all Lake Michigan weirs combined (based on visual signs) was 7.7%. Historic (1985-96) weir harvest data was summarized for a presentation at the 1997 Midwest Fish and Wildlife Conference. Percent return of chinook salmon to Lake Michigan weirs ranged from 1 to 2%, while returns to the Swan River weir (Lake Huron) ranged from 2 to almost 5%. Significant shifts in age structure and sex ratio of returning fish were observed between 1985 and 1996.

Data analysis and reporting on biological data from tagging and oxytetracycline marking has been shifted (in part) from Study 464 to this study (471). An amended study design has been submitted to reflect this change. Return rates of coded wire tagged (CWT) fish per 100,000 fish stocked at 5 Lake Michigan and 3 Lake Huron planting sites were generally highest for the northern-most planting site in both lakes. Rate of straying is, in most cases, less than 10%, although a slightly higher rate (23%) was observed in 1997 for fish stocked in Kids Creek. Comparisons of survival between CWT chinook salmon that were direct planted versus net-pen cultured were conducted in the Grand River (Lake Michigan) and in the AuSable River (Lake Huron). Net-pen culture appeared to be the more effective method of stocking chinook salmon in both rivers. In the Grand River, chinook salmon stocked directly near the mouth of the river (downstream) performed better (with the exception of the 1991 year class) than fish stocked upstream. In 1997, 48% of the chinook salmon collected in MDNR assessment netting on Lake Michigan appeared to be from natural reproduction.

Job 1. Title: Compile data on chinook salmon culture techniques and create a computer database.

Findings: Responsibility for database management has been transferred to MDNR Fisheries Division database personnel.

Job 2. Title: Analyze data on chinook salmon hatchery culturing techniques.

Findings: No work on this job was accomplished during 1996-97.

Job 3. Title: Compile data on stocking and release techniques of chinook salmon and create a computer database.

Findings: Data on stocking and release of chinook salmon is now being compiled in a stocking database created and maintained by MDNR Fisheries Division personnel in Lansing, Michigan. Additions to this database, describing stocking of chinook salmon throughout the state, are ongoing.

Job 4. Title: Analyze data on stocking and release techniques of chinook salmon.

Findings: I reviewed literature on salmonine stocking as part of the analysis of stocking and release techniques in Michigan. While work has been conducted to evaluate salmonine hauling techniques (Carmichael and Tomasso 1988, McDonald et al. 1993) and temperature tolerance (Brett 1952), there is little information available for chinook salmon on the extent of mortality directly resulting from stocking stress. This could account for significant losses of just-stocked chinook salmon fingerlings (10-20% based on work with other species) and will be an important area for evaluation using data from MDNR historic records.

Job 5. Title: Make recommendations and write technical and research reports.

Findings: Collection, compilation, and analysis of stocking and release data for chinook salmon are in various stages of completion. Results will be presented in future reports.

Job 7. Title: Analyze weir harvest and biological data.

Findings: The number of chinook salmon harvested at weirs located on tributaries to Lake Michigan decreased by approximately 28% from 1996 to 1997 (Table 1). This decrease was observed at all four Lake Michigan weirs, and ranged from 10% at the Little Manistee River weir to 60% at the Platte River. Returns to Swan River (Lake Huron) declined approximately 33%, from 25,615 fish in 1996 to 17,219 fish in 1997. The harvest weir at Van Ettan Creek was not operated during 1997.

In addition to compiling harvest estimates, we also use weir sampling to obtain information on disease incidence in chinook salmon populations. In 1997, bacterial kidney disease (BKD) incidence at all Lake Michigan weirs combined (based on visual signs) was 7.7% (Table 2). This is higher than that observed in 1996 (3.5%), but still within the range observed since control measures were instituted in 1992 (Range=3.5-7.8%).

Historic (1985-96) weir harvest data was summarized for a presentation at the 1997 Midwest Fish and Wildlife Conference. Trends in percent return, age and sex composition of returning chinook salmon, and average length and weight at age were examined for trends that could be used in improving management of chinook salmon. Percent return of chinook salmon to Lake Michigan weirs ranged from 1 to 2%, while returns to the Swan River weir (Lake Huron) ranged from 2 to almost 5% (Table 3). The majority of fish returning to harvest weirs are age 0.2 and 0.3 chinook salmon. Prior to 1991, age 0.2 and 0.3 chinook salmon made up 17 and 50 percent of fish returning to weirs, respectively. Beginning in 1991, a dramatic shift was observed in age structure of returning fish. Age 0.2 chinook salmon made up from 38-45% of fish returning in 1991-96, whereas return of age 0.3 fish declined to approximately 30% (Table 4). Sex ratio also changed over the years examined; percent of females declined from approximately 40% in 1985 to just over 20% in 1996 (Table 5).

Job 8. Title: <u>Compile data on egg-take operations and create a computer database.</u>

Findings: Responsibility for database management has been transferred to MDNR Fisheries Division database personnel.

Job 9. Title: <u>Analyze data on chinook salmon egg-take operations.</u>

Findings: Work on this job was completed as part of Julie Weeder's Masters of Science thesis at Michigan State University and will be presented in Weeder (1998).

Job 11. Title: <u>Integrate data from coded-wire tag, assessment, and creel studies of chinook salmon in the Great Lakes.</u>

Findings: Data analysis and reporting on biological data from tagging and oxytetracycline marking has been shifted (in part) from Study 464 to this study (471). Objectives of the chinook salmon coded-wire tag program were to determine (1) movement, (2) growth, (3) exploitation/survival, (4) survival from holding pens versus direct stream plants, (5) survival from upstream versus downstream plants, (6) incidence of bacterial kidney disease (BKD) in hatchery versus naturally produced stocks, and (7) contribution of natural reproduction to the catchable stocks of chinook salmon in lakes Michigan and Huron.

<u>*Coded-wire tag returns.*</u> - Numbers of recoverable coded wire tagged (CWT) chinook salmon stocked during 1990-94 were presented in previous reports. We determined return rates of CWT fish per 100,000 fish stocked at 5 Lake Michigan and 3 Lake Huron planting sites. In most years, CWT returns per 100,000 fish planted were highest for the northern most planting site in both Lake Michigan (Medusa Creek) and Lake Huron (Swan River - Table 6). These return rates have not yet been adjusted for spatial and temporal differences in tag recovery efficiency.

<u>*Movement.*</u> - Chinook salmon returns to harvest weirs and their contribution from various planting sites are presented in Table 7. The highest percentage of CWT fish recovered at harvest weirs were fish planted at or near the location of the weir. In general, rate of straying is low

(<10%), although a slightly higher rate was observed in 1997 for fish stocked in Kids Creek (approximately 23%).

Survival from holding pens versus direct stream plants. - Comparisons of survival between CWT chinook salmon that were direct planted versus net-pen cultured were conducted in the Grand River, Lake Michigan and in the AuSable River, Lake Huron. Net-pen culture appeared to be the more effective method of stocking chinook salmon in both the Grand (Table 8) and AuSable (Table 9) Rivers. Net-pen cultured fish provided higher returns per 100,000 fish planted for all year classes at the Grand River and for 3 of 4 year classes at the Au Sable River. Most of the 1992 year-class fish cultured in the net pen on the AuSable River may have been lost due to a collapse of the pen, resulting in a lower than expected return of these fish.

Survival from upstream versus downstream plants. - At the Grand River, net-pen cultured fish provided better returns than either directly-planted group. However, chinook salmon stocked directly near the mouth of the Grand River (downstream) performed better than fish stocked upstream at Grand Rapids (Table 8). This pattern was apparent in all year classes except 1991, when fish stocked upstream provided higher return rates.

Contribution of natural reproduction. - During 1997, 334 age 0.2-0.4 chinook salmon were collected in MDNR assessment netting on Lake Michigan. Of these, 48% appeared to be from natural reproduction (Table 10). This is a significant increase over previous years estimates (approximately 35% in 1994-96); however, Age 0.1 fish were not included in the 1997 estimate since oxytetracycline marking was discontinued in 1995. There was significant year-to-year variation in the contribution of natural reproduction (Table 11). For example, contribution at age 0.1 ranged from 17.8% for the 1993 year class to 47.0% for the 1995 year class.

Literature Cited:

Brett, J.R. 1952. Temperature tolerance in young Pacific salmon, genus Oncorhynchus. Journal of the Fisheries Research Board of Canada 9:265-323.

Carmichael, G.J., and J.R. Tomasso. 1988. Survey of fish transportation equipment and techniques. The Progressive Fish-Culturist 50:155-159.

McDonald, D.G., M.D. Goldstein, and C. Mitton. 1993. Responses of hatchery-reared brook trout, lake trout, and splake to transport stress. Transactions of the American Fisheries Society 122:1127-1138.

Weeder, J.A. 1998. Population genetics of Lake Michigan chinook salmon. Michigan Department of Natural Resources, Fisheries Research Report 2032, Ann Arbor.

Table 1.–Estimated total number of chinook salmon harvested from weirs on tributaries to lakes Michigan and Huron each fall from 1986-97.

Sample year	Weir							
	Boardman	Little Manistee	Medusa	Platte	Total (Lake Michigan)	Swan	Van Ettan	Total (Lake Huron)
1986	0	22,131	0	2,678	24,809	38,781	12,733	51,514
1987	4,902	31,841	11,230	7,787	55,760	51,447	12,472	63,919
1988	6,129	12,519	2,353	4,649	25,650	30,830	9,081	39,911
1989	5,809	18,338	3,040	1,899	29,086	30,119	3,891	34,010
1990	6,236	19,499	6,533	1,761	34,029	19,521		19,521
1991	5,556	21,062	2,127	4,398	33,143	23,048	8,319	31,367
1992	3,139	15,747	4,038	4,171	27,095	37,862	7,913	45,775
1993	2,299	12,911	3,021	3,109	21,340	34,994	2,300	37,294
1994	3,025	11,888	3,030	1,162	19,105	19,771	1,218	20,989
1995	4,547	13,079	4,714	3,943	26,283	30,320	0	30,320
1996	5,705	17,120	6,548	4,145	33,518	25,615	0	25,615
1997	3,040	15,443	4,036	1,659	24,178	17,219	0	17,219

Table 2.–Incidence (percent of fish sampled) of bacterial kidney disease (BKD) among chinook salmon sampled from Lake Michigan weirs, 1991-97. Visual estimates are for fish harvested at all weirs, whereas FELISA estimates are for fish sampled at the Little Manistee weir egg-take operation.

	Type of estimate	
Sample year	Visual	FELISA
1991	12.3	----
1992	6.2	----
1993	7.8	----
1994	6.0	17.4
1995	7.5	5.2
1996	3.5	14.4
1997	7.7	12.0

Table 3.–Percent return of chinook salmon to weirs on Lake Michigan and Lake Huron. Data are for 1985-92 year classes, ages 0.0-0.4 combined.

	Lake	
Year class	Michigan	Huron
1985	2.3	4.8
1986	2.1	3.8
1987	1.8	2.1
1988	1.4	1.8
1989	2.1	2.7
1990	1.3	3.9
1991	1.2	3.2
1992	1.1	2.6
Average	1.7	3.1

Table 4.–Age composition (percent of fish returning) of chinook salmon at Michigan harvest weirs, 1985-96.

Sample year	Age			
	0.0-0.1	0.2	0.3	0.4-0.5
1985	14	19	50	16
1986	4	22	60	14
1987	15	14	49	22
1988	14	19	57	11
1989	16	13	47	25
1990	27	15	40	17
1991	30	41	24	5
1992	20	43	29	8
1993	14	41	36	9
1994	33	38	27	2
1995	18	45	34	2
1996	17	45	34	4
Average	19	30	41	11

Table 5.–Percent of female and male chinook salmon returning to Michigan harvest weirs, 1985-96.

Sample year	Sex	
	Female	Male
1985	36	64
1986	41	59
1987	36	64
1988	39	61
1989	37	63
1990	30	70
1991	28	72
1992	36	64
1993	42	58
1994	24	76
1995	25	75
1996	23	77
Average	33	67

Table 6.–Chinook salmon sport catch returns (number per 100,000 planted) of chinook salmon planted in Michigan waters of Lake Michigan (MI) and Lake Huron (HU) and tributary rivers.

		Plant site							
Plant year	Age	Medusa Creek (MI)	Board-man River (MI)	Little Manistee River (MI)	Grand River[1] (MI)	St. Joseph River (MI)	Swan River (HU)	Au Sable River[2] (HU)	Harbor Beach (HU)
1990	0.0	0.00	-	0.00	0.00	-	-	-	-
	0.1	7.12	-	8.76	6.14	-	-	-	-
	0.2	18.30	-	10.92	10.94	-	-	-	-
	0.3	9.15	-	5.02	4.03	-	-	-	-
	0.4	1.02	-	0.52	0.00	-	-	-	-
	Total	35.59	-	25.21	21.11	-	-	-	-
1991	0.0	0.00	0.00	0.27	0.00	0.00	0.00	0.00	-
	0.1	78.56	29.32	27.83	9.86	6.03	41.92	10.34	-
	0.2	26.50	8.38	9.11	8.53	1.00	65.60	43.20	-
	0.3	10.41	3.14	7.31	2.73	2.01	97.66	74.21	-
	0.4	0.00	0.00	1.32	0.00	0.00	28.61	10.32	-
	Total	115.47	40.84	45.82	21.12	9.04	233.79	138.07	-
1992	0.0	2.99	5.13	1.08	0.75	1.03	0.00	0.00	-
	0.1	33.90	33.86	21.58	24.99	25.70	22.48	12.98	-
	0.2	23.93	21.55	20.38	16.24	16.45	88.32	50.94	-
	0.3	7.98	18.47	11.03	11.71	10.28	170.22	44.19	-
	0.4	1.00	0.00	0.51	1.04	1.03	36.94	3.13	-
	Total	69.80	79.01	53.49	54.72	54.49	317.96	111.23	-
1993	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.1	36.00	26.29	9.87	19.49	8.50	38.45	42.06	10.20
	0.2	36.00	29.87	10.40	30.87	18.21	76.37	90.20	26.06
	0.3	36.00	17.92	2.67	27.59	1.21	55.31	70.47	33.99
	0.4	3.48	2.39	1.87	1.76	0.00	32.66	9.62	7.93
	Total	111.48	76.47	24.80	79.71	27.92	203.32	212.85	78.18
1994	0.0	1.18	3.31	0.00	0.00	0.00	0.00	0.59	0.00
	0.1	18.92	24.24	9.76	20.85	29.51	38.80	49.96	12.09
	0.2	63.85	84.84	19.84	69.78	86.49	82.99	65.42	20.88
	0.3	50.84	29.75	13.78	21.72	27.47	127.72	109.49	64.85
	0.4								
	Total	133.6	138.83	43.37	112.35	143.47	249.51	224.86	97.82

[1] See Table 8 for breakdown of return rates from the different plants on the Grand River.
[2] See Table 9 for breakdown of return rates from the different plants on the Au Sable River.

Table 7.–Returns of chinook salmon to rivers with harvest weirs, 1997. Data are percent of total run at each weir originating from various planting sites. Percentages were determined from coded wire tagged salmon returning to each river during 1997.

			Plant Site							
Harvest Weir	Chinook sampled (CWT found)	Total number harvested	Kids Creek	Medusa Creek	Little Manistee River	Swan River	Au Sable River[1]	Other Michigan rivers	Wisconsin rivers	Ontario rivers
Boardman River	546 (35)	3,040	77.1	5.7	0.0	5.7	8.6	0.0	2.9	0.0
Little Manistee R	2,294 (133)	15,443	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Medusa Creek	720 (68)	4,036	1.5	95.5	1.5	1.5	0.0	0.0	0.0	0.0
Platte River	523 (18)	1,659	5.6	11.1	50.0	33.3	0.0	0.0	0.0	0.0
Swan River	2,428 (315)	17,219	0.6	0.0	0.0	98.1	1.3	0.0	0.0	0.0
Thompson Creek	45 (5)	112	20.0	0.0	0.0	40.0	0.0	0.0	40.0	0.0
Au Sable River	500 (115)	500	0.0	0.0	0.0	8.7	91.3	0.0	0.0	0.0
Total	7,056 (689)	42,009								

[1] No harvest weir was operated on the Au Sable River during 1997. The Au Sable River fish were collected by electro-fishing.

Table 8.–Chinook salmon sport catch returns (number per 100,000 planted) from various planting sites in the Grand River.

		Planting site		
Year class	Ages	Grand Haven (net pen)	Grand Haven (direct plant, downstream)	Grand Rapids[1] (direct plant, upstream)
1990	0.0	0.00	0.00	-
	0.1	12.27	6.14	-
	0.2	25.66	7.16	-
	0.3	10.04	2.05	-
	0.4	0.00	0.00	-
	Total	47.97	15.35	-
1991	0.0	0.00	0.00	0.00
	0.1	10.30	7.21	12.08
	0.2	14.42	4.12	7.05
	0.3	5.15	1.03	2.01
	0.4	0.00	0.00	0.00
	Total	29.87	12.36	21.14
1992	0.0	1.19	1.05	0.00
	0.1	27.39	27.40	20.18
	0.2	15.48	22.13	11.10
	0.3	22.62	9.48	3.03
	0.4	0.00	2.11	1.01
	Total	66.68	62.17	35.32
1993	0.0	0.00	0.00	0.00
	0.1	29.23	14.66	14.58
	0.2	49.79	23.04	19.79
	0.3	36.80	24.09	21.87
	0.4	2.16	2.09	1.04
	Total	117.98	63.88	57.28
1994	0.0	0.00	0.00	0.00
	0.1	36.73	15.91	9.92
	0.2	109.13	70.46	29.76
	0.3	33.58	23.86	7.71
	0.4			
	Total	179.44	110.23	47.39

[1] In 1991, no coded-wire tagged chinook were released near Grand Rapids.

Table 9.–Chinook salmon sport catch returns (number per 100,000 planted) from planting sites in in the Au Sable River. In 1993 and 1994 net pens were located in Van Ettan Creek. In 1994 net pen fish were trucked to the river mouth at release.

		Planting site	
Year class	Ages	Net-pen plant	Direct river plant
1991	0.0	0.00	0.00
	0.1	10.23	10.45
	0.2	47.42	38.97
	0.3	79.04	69.38
	0.4	12.09	8.55
	Total	148.78	127.35
1992	0.0	0.00	0.00
	0.1	0.00	25.96
	0.2	8.40	93.47
	0.3	8.40	79.97
	0.4	2.10	4.15
	Total	18.90	203.55
1993	0.0	0.00	0.00
	0.1	55.43	29.70
	0.2	116.90	63.50
	0.3	87.67	53.26
	0.4	14.11	5.12
	Total	274.11	151.58
1994	0.0	1.17	0.00
	0.1	79.39	20.52
	0.2	102.75	28.08
	0.3	169.30	49.68
	0.4		
	Total	352.61	98.28

Table 10.–Number and percent of chinook salmon from hatchery and wild sources collected by MDNR assessment netting in eastern Lake Michigan. Fish were considered to be from hatchery sources if they displayed a fin clip, coded-wire tag, or oxytetracycline (OTC) mark. Six fish could not be classified as hatchery or wild fish. Data are not corrected for mark retention rates estimated from hatchery quality control checks.

		Age					
Year	Source	1	2	3	4	Total	Percent
1994	Hatchery	152	262	79	0	493	67.6
	Wild	33	150	47	4	234	32.1
	Other	0	1	0	1	2	0.3
1995	Hatchery	161	368	51	2	582	64.7
	Wild	47	231	38	0	316	35.1
	Other	1	1	0	0	2	0.2
1996	Hatchery	63	291	311	19	684	65.7
	Wild	56	112	171	17	356	34.2
	Other	1	0	0	0	1	0.1
1997 [1]	Hatchery	---	90	77	4	171	51.2
	Wild	---	103	54	5	162	48.5
	Other	---	1	0	0	1	0.3

[1] OTC marking was discontinued in 1995; age 1 fish collected in 1997 would not be expected to have a oxytetracycline mark.

Table 11.–Percent of wild chinook salmon from four year classes (1992-95). Fish were collected by MDNR assessment netting in eastern Lake Michigan. N is the number of fish examined for oxytetracycline (OTC) marks in each age and year class. Data are not corrected for mark retention rates estimated from hatchery quality control checks.

	Age					
	0.1		0.2		0.3	
Year class	N	Percent wild	N	Percent wild	N	Percent wild
1992	---	---	412	36.4	89	42.7
1993	185	17.8	599	38.6	482	35.5
1994	208	22.6	403	27.8	13	41.2
1995	119	47.0	193	53.4	---	---
Average	512	29.1	1,607	39.0	584	39.8

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