STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-53-R-15

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

Period Covered: April 1, 1998 to September 30, 1999

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 for 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 44% from 1997 to 1998. This decrease was observed at all Lake Michigan weirs except the Platte River. Returns to Swan River (Lake Huron) declined approximately 32% from 1997 to 1998. Weir sampling was also used to obtain information on disease incidence, trends in percent return, age and sex composition of returning chinook salmon, and average length and weight at age; these data are still being analyzed.

In 1998, information from CWT returns was used to make decisions about allocating lakewide chinook salmon stocking cuts among 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). In making decisions about how to allocate chinook salmon stocking reductions, we used a factor of from 0 (south) to 2.0 (north) to adjust stocking numbers. Net-pen culture appeared to be the more effective method of stocking chinook salmon. For all years and sites combined, the average difference in CWT returns between net pen and direct plants on Lake Michigan was approximately 2% (net pen > direct), but increased to 22% if "catastrophic" net pen failures were removed from the data. In making decisions about how to allocate chinook salmon stocking reductions, we used a factor of +20% to characterize the increase in survival likely to be associated with net pen stocked fish. While net pens may increase return rates, there is also an increased risk associated with their use.

During 1998, caudal vertebrae from 157 age 3 – age 4 chinook salmon were collected in MDNR assessment netting on Lake Michigan. Of these, almost 69% appeared to be from natural reproduction. However, these data are not yet corrected for non-marked fish stocked in other states and mark retention rates estimated from hatchery quality control checks. Corrected estimates will be presented in subsequent reports.

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

Findings: I began work on a review paper examining the effects of size at stocking and rearing density on short- and long-term survival of salmonids as well as other fish. This paper will combine previously published literature with data on current MDNR hatchery practices (Job 1 of this study), and serve as the starting point for a joint hatchery / research section study on chinook salmon and steelhead size at stocking and rearing density, to begin in October 2000.

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

Findings: No work on this job was accomplished during 1998-99.

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. This progress report was completed as scheduled.

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 44% from 1997 to 1998 (Table 1). This decrease was observed at all Lake Michigan weirs except the Platte River. Returns to Swan River (Lake Huron) declined approximately 32% from 1997 to 1998. The harvest weir at Van Ettan Creek has not been operated since 1994.

In addition to compiling harvest estimates, weir sampling was also used to obtain information on disease incidence (bacterial kidney disease – BKD), trends in percent return, age and sex composition of returning chinook salmon, and average length and weight at age. These data are still being analyzed and will be presented in subsequent reports.

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

Findings: Data analysis and reporting on biological data from tagging and oxytetracycline marking has been shifted from Study 464 to this study (471). Objectives of the chinook salmon coded-wire tag program (Study 464) 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.

Coded-wire tag returns. - Numbers of recoverable coded wire tagged (CWT) chinook salmon stocked during 1990-1994 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 cases, there was an increase in return rates from 1990-1994, probably due to increased angler

knowledge and acceptance of the study. In 1998, information from CWT returns was used to make decisions about allocating lakewide chinook salmon stocking cuts among sites.

Spatial patterns in tag returns. – Return to the Great Lakes chinook salmon fishery varies significantly for fish stocked at different locations. 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 2). In making decisions about how to allocate chinook salmon stocking reductions, we used a factor of from 0 (south) to 2.0 (north) to adjust stocking numbers (see N:S ratio, Table 2).

These return rates have not yet been adjusted for spatial and temporal differences in tag recovery efficiency. However, correcting return rates using human population density as a surrogate for effort would lead to the same results; the differences would, in fact, be magnified (greater N-S difference in return rates) relative to those reported here.

Survival from holding pens versus direct stream plants. – Paired 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; 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 (see previous reports for detailed results).

Additional (non-paired) net pen stockings were conducted in the St. Joseph River and Medusa Creek. Using data from all net pen plants combined, an increase in return rate from south to north was observed, similar to that seen with direct plants (Table 3). For all years and sites combined, average difference between direct and net pen plants on Lake Michigan was approximately 2% (net pen > direct), but increased to 22% if "catastrophic" net pen failures were removed from the data. For Lake Huron (AuSable River), average returns from direct plants (160.9 $\pm$ 44.9 fish per 100,000 stocked) were actually 9% higher than for net pen plants (147.3 $\pm$ 147.3 fish per 100,000). However, 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. If this stocking event is not included, returns from net pen plants (N=2; 211.5 $\pm$ 125.3 fish per 100,000) were approximately 31% higher than for direct plants.

In making decisions about how to allocate chinook salmon stocking reductions, we used a factor of +20% to characterize the increase in survival likely to be associated with net pen stocked fish. However, it is important to remember that while net pens may increase return rates, there is also an increased risk associated with their use.

Survival from upstream versus downstream plants. - Chinook salmon stocked directly near the mouth of the Grand River (downstream) performed better than fish stocked upstream at Grand Rapids. This pattern was apparent in all year classes except 1991, when fish stocked upstream provided higher return rates (see previous reports for additional details).

Contribution of natural reproduction. - During 1998, caudal vertebrae from 157 age 3 – age 4 chinook salmon were collected in MDNR assessment netting on Lake Michigan. Of these, almost 69% appeared to be from natural reproduction (Table 4). This is a significant increase

over previous years estimates (32-48% in 1994-97); however, age 1 fish were not included in the 1997 estimate, and age 1 and age 2 fish were not included in the 1998 estimate (oxytetracycline marking was discontinued in 1995). In addition, these data are not yet corrected for non-marked fish stocked in other states (>10% of fish stocked in last 2 years of study) and mark retention rates estimated from hatchery quality control checks. Corrected estimates will be presented in subsequent reports.

Prepared by: David F. Clapp, John Clevenger, and Donna Wesander-Russell.
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Table 1.–Estimated total number of chinook salmon harvested from weirs on tributaries to lakes Michigan and Huron each fall from 1986-1998.

	Weir							
Sample year	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
1998	2,665	7,3	1,277	2,380	13,64	11,654		11,65

Table 2.–Average returns per 100,000 chinook salmon from direct plants at various sites in Lake Michigan and Lake Huron, 1990-1993. Two standard errors are shown in parentheses. "N:S ratio" shows the change in return rates (relative to the southern-most site) when moving from the southern- to northern-most stocking site on each lake.

Lake	Year / Site	Number of plants	Average returns	N:S ratio
Michigan	1990	3	25.4 (11.7)	NA
	1991	5	47.1 (36.3)	NA
	1992	4	57.5 (18.2)	NA
	1993	4	55.6 (22.0)	NA
	Medusa Creek	2	75.6 (79.9)	1.98
	Boardman River	3	65.4 (24.7)	1.71
	Little Manistee River	4	37.3 (14.6)	0.98
	Grand River	7	38.2 (17.2)	1.00
Huron	1990	0	---- (----)	NA
	1991	2	180.6 (106.3)	NA
	1992	2	260.8 (114.4)	NA
	1993	3	144.3 (72.4)	NA
	Swan River	3	251.6 (68.7)	3.22
	AuSable River	3	160.9 (44.9)	2.06
	Harbor Beach	1	78.2 (---)	1.00

Table 3.–Average returns per 100,000 chinook salmon from net pen plants at various sites in Lake Michigan and Lake Huron, 1990-1993. Two standard errors are shown in parentheses. "N:S ratio" shows the change in return rates (relative to the southern-most site) when moving from the southern- to northern-most stocking site on each lake.

Lake	Year / Site	Number of plants	Average returns	N:S ratio
Michigan	1990	1	48.0 (----)	NA
	1991	2	19.4 (20.9)	NA
	1992	3	63.7 (9.4)	NA
	1993	3	85.8 (58.0)	NA
	Medusa Creek	2	90.6 (41.7)	2.97
	Grand River	4	65.6 (38.0)	2.15
	St. Joseph River	3	30.5 (26.3)	1.00
Huron	1990	0	(----) (----)	NA
	1991	1	148.8 (----)	NA
	1992	1	18.9 (----)	NA
	1993	1	274.1 (----)	NA
	AuSable River	3	147.3 (147.3)	1.00

Table 4.–Number and percent of chinook salmon from hatchery and wild sources collected by MDNR assessment netting in eastern Lake Michigan, 1994-1998. Fish were considered to be from hatchery sources if they displayed a fin clip, coded-wire tag, or oxytetracycline (OTC) mark. Eight fish could not be classified as hatchery or wild fish. Data are not corrected for non-marked fish stocked in other states and mark retention rates estimated from hatchery quality control checks.

Collection year	Source	Age 1	2	3	4	Total	%
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	Hatchery	---	90	77	4	171	51.2
	Wild	---	103	54	5	162	48.5
	Other	---[1]	1	0	0	1	0.3
1998	Hatchery	---	---	22	25	47	29.9
	Wild	---	---	46	62	108	68.8
	Other	---[1]	---[1]	1	1	2	1.3

[1] OTC marking was discontinued in 1995; age 1 fish collected in 1997 and age 1 and age 2 fish collected in 1998 would not be expected to have an oxytetracycline mark.