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EVALUATION OF COHO SALMON (Oncorhynchus kisutch)
AS A SPORT FISH IN MINNESOTA

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EVALUATION OF COHO SALMON (Oncorhynchus kisutch)
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BY

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ABSTRACT

Four plants of yearling coho salmon were made in Lake Superior from 1969 to 1972. The number of coho stocked annually ranged from 62,650 to 121,000 and produced returns (angler plus spawning escapement) of 1 to 5 percent. At maturity these fish averaged 21.5 inches in length and 3.5 pounds in weight.

The majority of the returning coho appeared at the release site in late October and November and availability to the angler was largely limited to the fall. The four year angling catch rate was 0.216 fish per man hour for fall fishing and 0.01 fish per man hour during the summer.

The sex ratio of returning coho ranged from 0.7 to 1.1 males per female. All returning coho showed varying degrees of thyroid hyperplasia and a low incidence of furunculosis and kidney disease.

Straying of spawning adults was noted in other streams and evidence of limited natural reproduction was found in some years.

Stomach samples indicated coho fed mostly on insects and crustacea during their first year in the lake and chiefly on smelt during their second year.

One yearclass of coho salmon was stocked in two inland lakes. Hare Lake produced angler returns of 21 percent of the plant and the fishery attracted over 2,000 anglers who caught an estimated 14.9 pounds per acre of coho salmon mostly during January and June. Growth, food and angler utilization of the Hare Lake stock are reported.

In Greenwood Lake no coho were taken by anglers, apparently because the fish emigrated at smolting.

Comparison of coho and rainbow trout in small lakes managed for salmonids suggests rainbow trout are a better choice for this management program.

INTRODUCTION

The success of the State of Michigan with the introduction of the coho salmon (Oncorhynchus kisutch) in Lake Michigan is well known, and has attracted considerable attention among anglers and other state agencies. Their experience in Lake Superior with the initial five year classes (1966-1970) of coho salmon has been less spectacular. Rybicki (1973) reported that although coho in Lake Superior do not attain the large size (15 to 20 pounds) they do in Lake Michigan, they do become a respectable game fish (2 to 6 pounds) attractive to anglers.

Based on the Michigan experience in Lake Superior, Minnesota introduced the coho salmon into its waters to determine its potential as a sport fish. In evaluating the sport fishing potential, four basic questions were considered; (1) whether, in these cold waters, coho would return to the streams in time to be available during the traditional angling season, (2) whether they would bite well on hook and line as they concentrated near spawning streams, (3) whether, in the face of a critical shortage of small boat facilities and harbors of refuge on Minnesota's rocky coast they could be effectively harvested by anglers and (4) whether they would reproduce in the streams in significant numbers to become competitors for lake-run rainbow trout presently established there.

Another potential use of these fish was in inland lakes capable of supporting trout where barriers at the outlet prevent downstream movement (Klein and Finnel, 1969). This use of coho salmon in inland waters would be similar to the management of rainbow trout in reclaimed lakes of Minnesota (Micklus and Johnson, 1965).

This report covers the returns of four year classes of coho salmon stocked in Lake Superior, and one year class stocked in two inland lakes.

METHODS

The initial year class of coho (1968) was obtained from the state of Oregon (Columbia River stock) who supplied 200,000 eggs. Subsequent year classes (1969-1971) of coho were obtained as eggs from Oregon, the state of Michigan (Lake Michigan stock), and from spawn taken from Lake Superior stock returning to Minnesota at French River.

The eggs were hatched and reared in the Lanesboro hatchery. Those destined for inland waters were retained at Lanesboro until fall when they achieved a size of approximately 40 fish per pound at which time they were stocked in Hare Lake, Lake County, Minnesota, and Greenwood Lake, Cook County, Minnesota. The coho intended for the Lake Superior plant were transferred to outdoor rearing facilities at Spire Valley, Minnesota, where they were raised to yearling size (15 to the pound). These fish were stocked in the spring (May) in French River near Lake Superior.

The numbers of yearling coho planted in French River were 115,000 in 1969; 62,650 in 1970; 121,000 in 1971; and 110,000 in 1972. Stocking of fall fingerling coho in the inland lakes numbered 3,800 in Hare Lake and 66,700 in Greenwood Lake.

The inland lake plants were made during the first week of October, 1968.

Approximately 35,000 of those stocked in French River in 1969 were marked with the removal of the adipose fin and an additional 600 were marked with the removal of the right ventral fin. All coho planted in 1969 (110,000) and 1970 (62,650) were marked internally with tetracycline for identification. The use of tetracycline for marking salmon and subsequent identification of the marks has been described by Weber and Ridgway (1967). Subsequent plants of coho were not marked.

Samples of coho from Lake Superior during the summer months were obtained from incidental catches by commercial fishermen and exploratory gillnets set by the Department of Natural Resources. Inland lakes stocked with coho were sampled during the spring and fall from 1969 to 1971 with experimental gillnets of five mesh sizes (1.5, 2.0, 2.5, 3.0 and 4.0 inches stretch measure). All the coho were examined for length and weight, and stomachs were preserved in 10 percent formalin for later identification of food items.

The weir and fish trap as described by Hassinger, Hale and Woods (1974), was operational in French River during the fall (September 1 to November 30) for the years 1969 to 1973 to monitor the mature salmon returning to the river for spawning. The trap was checked at least once daily and all fish were counted and a portion were sampled for length, weight, sex, degree of maturity, finclips and tetracycline marks. Stream and lake temperatures were recorded and staff gauge readings made as an index to flow in the stream.

A creel census to determine angler utilization of the coho was conducted on Lake Superior and the two inland lakes. The census methods followed those described by Schupp (1964). The Lake Superior census sampled anglers at major landings between Duluth and Hovland and was designed to contact a majority of the anglers during the sampling period. The census on the inland lakes contacted virtually all anglers on the lakes during the sampling days. Information collected included the number of fishermen in the party, number of hours fished, and number, length, and weight of fish by species in the catch.

Coho entering North Shore streams for spawning in the fall were detected by observation and angler interrogation. Angler-caught fish were examined for marks indicating origin of the fish. Streams in which spawning coho were detected were electrofished during August of the following summer with 110 volt A. C. generator to determine the extent of natural reproduction. All fingerling fish were identified as to species, counted and measured for length.

Lake Superior Coho

Distribution, Size and Food

Michigan coho salmon planted from 1966 to 1971 are first reported in Minnesota waters of Lake Superior in April when they are taken in pound nets set for smelt in the St. Louis River estuary at Duluth. These coho are apparently

following smelt into the shallows during their spawning in the spring. No further reports of Michigan coho salmon are usually received until July, after which occasional catches are reported by anglers and commercial fishermen. The Michigan coho are most numerous in the Duluth to Beaver Bay area during July and August. As catch reports decline in the Duluth area, increased catches are reported in the Grand Marais to Grand Portage area during September. Other scattered reports of Michigan coho salmon are received along the entire shore, suggesting wide distribution.

In contrast to frequent reports of Michigan stocked coho, reports of catches of Minnesota coho salmon stocked at French River during May from 1969 to 1972, were few and widely scattered until spawning time in their second year of life in the lake. Little information was obtained on distribution or movement of Minnesota coho during their lake life. Reports from other states and provinces bordering Lake Superior indicate very few observations of Minnesota coho in their water (per. comm: A. Lawrie, Ontario; G. King, Wisc.; A. Wright, Michigan). First reports of returning Minnesota coho occurred during the first part of September when finclipped and tetracycline marked coho were being caught in the Beaver Bay area. As the fall season progressed, Minnesota coho moved inshore chiefly from Beaver Bay to Duluth and concentrated in the French River area.

Judging from reports of capture by anglers and commercial fishermen the salmon appear to be pelagic during the summer of their two years of life in Minnesota waters with most caught from one to five miles offshore and at depths of less than 10 fathoms. During the latter part of their second summer in the lake, the mature salmon begin to move inshore where they are taken in one to four fathoms of water.

The size of coho salmon from the Michigan and Minnesota plants of smolts (mean length 5.5 inches at planting) recovered during the summer in Minnesota waters are shown in Table 1. The mean length of the salmon captured during their first summer in the lake has ranged from 11.9 to 13.5 inches for the seven year classes (1965 to 1971). Those salmon captured during their second summer in the lake have ranged from 20.1 to 21.9 inches mean total length.

The stomachs of 108 coho salmon were examined for food habit data from samples collected during July, August and September 1966 to 1970. The food items are shown in Table 2, expressed as the percentage occurrence of major food items for the two important size groups. Salmon during their first summer in the lake (size group 10.0 to 15.0 inches) fed mostly on crustacea and insects, which occurred in 50 and 73 percent of the stomachs respectively. Mysis was the most important crustacean while Diptera and Lepidoptera were the most important insects in this size group. During their second summer in the lake (size 15.1 to 21.0 inches) the coho appeared to feed chiefly on fish, which were found in 74 percent of the stomachs in this size group. All identifiable fish in the diet were smelt. Insects and crustacea made up a minor portion of the diet of this size group.

Table 1: Total length of coho salmon captured during their first and second summer in Minnesota waters of Lake Superior

Year Class	Length (Inches)	First Summer	Second Summer
1965 a/	Mean Range	13.5(24)c/ 12.4-14.6	20.6(113) 15.5-23.0
1966 a/	Mean Range	12.1(7) 10.5-14.2	21.0(34) 15.6-23.5
1967 a/	Mean Range	11.9(18) 8.5-13.5	20.3(31) 16.5-23.5
1968 b/	Mean Range	11.9(7) 8.9-13.7	21.1(41) 15.5-26.0
1969 b/	Mean Range	13.2(4) 11.5-14.7	20.8(12) 15-25.0
1970 b/	Mean Range	12.1(1) --	21.9(26) 18.7-24.0
1971 b/	Mean Range	12.6(3) 10.5-14.7	20.1(8) 18.0-23.0

a/ Michigan planted year class

b/ Michigan and Minnesota planted year classes

c/ Number of fish measured in parenthesis

Table 2: Percentage occurrence of food items in stomachs of coho salmon caught in Minnesota waters of Lake Superior during the summers of the five year period, 1966-1970

<u>Size Group</u>	<u>10.0 - 15.0 (Inches)</u>	<u>15.1 - 21.0 (Inches)</u>
Number of coho examined	34	74
Number with food	22	34
<u>Items</u>	<u>Percentage Occurrence</u>	
Crustacea	50	15
Cladocera	5	-
Amphipoda	5	12
Mysidacea	41	6
Insects	73	18
Ephemeroptera	14	-
Diptera	41	-
Lepidoptera	32	12
Tricoptera	14	9
Unidentified	23	6
Fish	32	74
Smelt	5	71
Unidentified	27	1

Time and Size of Spawning Runs and Biological Features of Spawning Salmon

The weir catch of adult salmon returning to French River in the fall for spawning (spawning escapement) ranged from 434 to 3,218 for the years 1970 to 1973 (Table 3).

During all years coho first entered the river during the first week of September and continued to run until freeze-up about the last week of November or first week of December. Peak returns of each of the four year classes ranged from the last week of October to the last week of November. The major run of spawning salmon, combining the four years, came during November with 69 percent of the total catches occurring in this period.

Movements of spawning salmon into French River during the fall appeared to be associated with stream temperatures and flow. During most of the years large runs of salmon into the trap were associated with stream temperatures above 40° and increases in stream water level (flow) of the stream of approximately two feet.

Table 3: Temporal distribution of spawning run coho salmon taken in French River weir 1970-1973, with percentage return of initial stocking (spawning escapement)

<u>Date</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>Total</u>
Sept. 1-5	1	1	0	5	7
6 - 12	0	0	2	0	2
13 - 19	3	4	13	3	23
20 - 26	0	8	27	14	49
27 - Oct. 3	1	128	24	36	189
4 - 10	1	14	41	62	118
11 - 17	0	8	68	6	82
18 - 24	1	101	16	469	587
25 - 31	363	69	179	285	896
Nov. 1-7	26	5	1,269	440	1,740
8 - 14	99	88	965	361	1,513
15 - 30	0	8	402	1,239	1,649
Dec. 1-7	0	0	0	298	298
	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
TOTAL	495	434	3,006	3,218	7,153
Spawning escape- ment as percentage of initial stocking	0.43%	0.69%	2.48%	2.92%	1.75%

Gillnets of $4\frac{1}{2}$ inch stretch mesh were set in Lake Superior off French River each December for the years 1970 to 1973 to determine whether substantial numbers of coho had not entered the river. The catch of coho ranged from 6 in 1971 to 395 in 1970 and was indicative that a substantial number of coho had returned and remained in the lake after the river had frozen over.

Returns of jack coho salmon (precocious males) to the weir after one summer in the lake ranged from 12 to 729 for the four year classes (Table 4). Although the samples for some years are small, there is some indication the jack coho salmon tended to return earlier in the season than the adults. Combining the four year classes of returning jack coho indicated 73 percent returned during the month of October (Table 4). Returns to the weir of jack coho salmon as a percentage of the stocking ranged from 0.02 percent to 0.60 percent for the four year classes. These jack coho (one summer in the lake) taken as mature fish in the trap during October and November ranged from 13.2 inches to 14.9 inches in mean total length and 1.0 to 1.2 pounds in weight for the four year classes (Table 5).

Size of adult salmon at maturity (two summers in the lake) taken in the weir at French River ranged from 14 to 28 inches in total length (Table 6). The mean length and weight for the four year classes combining sexes was 21.5 inches and 3.5 pounds respectively. Females tended to be slightly longer and heavier than the males at maturity although the difference in mean length and weight between the sexes was not significant at the .05 level (Paired observations, Steel and Torrie, 1960). Rybicki (ibid) reported mature coho from Michigan waters of Lake Superior ranged in size from 20.1 to 21.2 inches in length and 2.8 to 3.1 pounds in weight when examined at maturity in the fall.

The sex ratio of adult salmon in the spawning run for the four year classes was quite similar (Table 6). The ratio of males to females ranged from 0.7 males to 1 female in 1971 to 1.1 males to 1 female in 1970. Maturity of the salmon in most years occurred during the last of November and first part of December when eggs were collected for propagation purposes.

Egg production from the French River spawning run has ranged from 270,000 to 1,400,000 eggs (Table 7). The average number of eggs per female was 2,320 combining all years. During the egg-take operations observations were made on the incidence of furunculosis and kidney disease. Less than 1 percent of the coho examined had furunculosis and about 2 percent had kidney disease during 1970 and 1971. The incidence of kidney disease in coho salmon from Michigan waters of Lake Superior during 1967 amounted to 14.2 percent while Lake Michigan coho had an incidence of 1.5 percent (MacLean and Yoder, 1970).

During the course of the spawning run, coho were examined by personnel from the National Water Quality Laboratory at Duluth, Minnesota for iodine deficiency. Thyroid hyperplasia or goiter was evident in varying degrees on all the salmon examined (Per. Comm. James Tucker). The tumors in the adult salmon appeared in the floor of the mouth and secondary growths occurred on the gills and lower jaw. Robertson and Chaney (1953) found marked hyperplasia of the thyroid in spawning rainbow trout in Lakes Michigan and Superior. They suggested the thyroid hyperplasia in the spawning rainbow trout was associated with the low iodine content of Great Lakes waters.

Table 4: Temporal distribution of coho salmon jacks (precocious males) taken in French River weir 1969-1973 with percentage return of initial stocking

<u>Date</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>Total</u>
Sept. 1-5	0	0	0	0	0
6 - 12	0	0	3	0	3
13 - 19	0	0	5	4	9
20 - 26	3	0	84	2	89
27 - Oct. 3	4	0	328	11	343
4 - 10	1	0	16	7	24
11 - 17	0	0	17	7	24
18 - 24	2	0	152	1	155
25 - 31	0	6	39	7	52
Nov. 1-7	8	6	1	14	29
8 - 14	6	0	83	4	93
15 - 30	<u>1</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>2</u>
TOTAL	25	12	729	57	823
Return as percentage of stocking	0.02%	0.02%	0.60%	0.05%	0.20%

Table 5: Length frequency distribution and average weight of coho salmon jacks (precocious males) taken in French River weir, 1969-1972

<u>Length (Inches)</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>TOTAL</u>
8.0 - 8.9	-	-	-	-	-
9.0 - 9.9	1	-	-	-	1
10.0-10.9	1	-	2	1	4
11.0-11.9	1	-	3	2	6
12.0-12.9	4	-	20	5	29
13.0-13.9	5	1	45	6	57
14.0-14.9	5	5	38	6	54
15.0-15.9	8	4	10	4	26
16.0-16.9	-	2	1	4	7
17.0-17.9	-	-	-	-	-
TOTAL	25	12	119	28	184
Mean Length (Inches)	13.7	14.9	13.2	13.9	13.9
Mean Weight (Pounds)	1.0	1.0	1.2	1.1	1.1

Table 6: Length frequency distribution average weight and sex ratio of mature adult coho salmon taken in the weir and testnets at French River 1970-1973

	NUMBER OF FISH								
Length (Inches)	1970		1971		1972		1973		TOTAL
	M	F	M	F	M	F	M	F	
14-14.9	0	0	0	0	0	1	0	2	3
15-15.9	0	0	5	1	7	2	6	4	25
16-16.9	1	2	8	7	28	3	9	3	50
17-17.9	5	3	8	6	55	21	13	9	120
18-18.9	22	10	4	7	100	61	25	19	248
19-19.9	43	22	12	11	117	102	41	32	380
20-20.9	61	51	18	25	163	146	45	64	573
21-21.9	66	76	18	27	120	174	60	48	589
22-22.9	70	74	24	41	77	177	54	44	561
23-23.9	65	72	12	47	45	95	29	24	389
24-24.9	44	61	9	21	10	26	16	21	208
25-25.9	37	31	4	7	1	2	9	7	98
26-26.9	19	12	1	-	-	1	5	3	41
27-27.9	8	1	-	-	-	-	1	-	10
28-28.9	2	-	-	-	-	-	-	-	2
TOTAL	443	415	125	201	723	811	280	313	3,297
Mean Length (Inches)	22.4	22.6	20.3	21.4	21.2	21.3	21.2	21.2	21.5
Mean Weight (Pounds)	4.1	4.0	3.1	3.7	3.2	3.0	3.2	3.5	3.5
Sex ratio Males to Females	1.1 to	1.0	0.7 to	1.0	0.9 to	1.0	0.9 to	1.0	

Table 7: Egg production of coho salmon taken in French River spawning run 1970-1972

<u>Year</u>	<u>Dates Stripped</u>	Mean Temp.		<u>Males</u>	<u>Females</u>	<u>Total Eggs</u>	<u>Eggs/Female</u>
		<u>Lake</u>	<u>Stream</u>				
1970	Nov. 5 - Dec. 29	-	45 ⁰	335	286	642,303	2,246
1971	Nov. 1 - Dec. 14	47 ⁰	48 ⁰	74	115	269,584	2,344
1972	Oct. 23 - Nov. 21	44 ⁰	42 ⁰	522	592	1,392,000	2,351
				931	993	2,303,887	2,320

The incidence of lamprey marks on coho salmon from the four year classes was less than 4 percent. This is in sharp contract to the lamprey marked rate on rainbow trout which ranged from 18 to 27 percent, and on lake trout which ranged from 23 to 37 percent during the 1969 to 1973 period in Minnesota waters. The short life span in the lake (18 months) and habitat preference of the coho likely make them less vulnerable to lamprey attacks. Rybicki (ibid) reported no lamprey marks on coho from Michigan waters of Lake Superior in the years 1967 to 1971.

Straying and Natural Reproduction

Straying of mature adult coho salmon from the four year classes into streams other than the stream of release was rather extensive although the total numbers of straying coho in any one stream was usually less than 100 fish. Straying coho were observed or reported in 2 streams west of French River and 6 streams east of French River. These observations are considered minimal and it is likely some coho entered most streams along the Minnesota coast during the spawning period. Peck (1970) reported extensive straying of Michigan planted coho in Lake Superior during the fall of 1967. Here straying was related to a lack of imprinting at the release site prior to movement into the lake.

Natural reproduction of coho salmon in Minnesota was detected in 5 of 12 streams sampled in 1971 and 2 of 20 streams sampled in 1972. No reproduction was found in 9 streams sampled in 1973. The young-of-the-year salmon sampled in 1971 averaged 2.9 inches in total length and ranged from 2.6 to 3.2 inches (Table 8). Young-of-the-year sampled in 1972 ranged from 2.5 to 4.0 inches in total length and averaged 3.3 inches. Density of coho in the five streams sampled during 1971 ranged from 1 to 750 fish per acre. In most streams density of young coho was less than the density of steelhead rainbow trout which also spawn in these streams (Hassinger et al. ibid). Natural reproduction of coho salmon in Michigan streams tributary to Lake Superior has been reported by Peck (ibid). He found densities of young coho in five Michigan streams ranging from 81 to 3,845 per acre. These young-of-the-year coho ranged from 2.5 to 3.9 inches in length during late summer and fall. The only known run of significance of naturally recruited adult coho occurred in 1971 in Michigan waters of Lake Superior where approximately 1,000 three-year-old coho returned to the Big Huron River (Rybicki, ibid). To what extent the naturally recruited coho from Minnesota tributaries contributed to subsequent spawning runs of adults is not known, but based on numbers of young observed in the streams their contribution appears minimal.

Utilization by Anglers

An estimated 46,123 angler days (trips) were spent on Lake Superior in Minnesota during the four years in which adult salmon returned (1970 to 1973). These anglers fished 113,566 manhours and caught 5,361 coho salmon, 2,642 lake trout, 8,432 rainbow trout, 862 brook trout, 28 brown trout and 13 chinook salmon. The estimated angler participation and catch by year and season are shown in Table 9.

Table 8: Size, number and number per acre of naturally produced young-of-the-year coho salmon sampled in five Lake Superior tributaries during August 1971 with comparative catches of rainbow trout young-of-the-year

<u>Length (Inches)</u>	<u>Schmidt Creek</u>	<u>Sucker River</u>	<u>Talmadge River</u>	<u>Stewart River</u>	<u>Silver Creek</u>
2.6	-	-	-	1	1
2.7	-	-	-	-	2
2.8	1	-	1	1	6
2.9	1	-	-	2	3
3.0	4	1	-	-	3
3.1	6	-	-	-	3
3.2	3	-	-	-	1
TOTAL	15	1	1	4	19
Mean Length (inches)	3.1	3.0	2.8	2.8	2.9
Coho salmon per acre	750	1	10	22	158
Rainbow trout per acre	250	65	980	411	316
Total acres sampled	.02	.84	.10	.18	.12

Table 9: Estimated angler participation and salmonid catch by year and season from Minnesota waters of Lake Superior, 1970-1973

	<u>1970</u>		<u>1971</u>		<u>1972</u>		<u>1973</u>		<u>TOTAL</u>	
	<u>Summer^{1/}</u>	<u>Fall^{2/}</u>	<u>Summer</u>	<u>Fall</u>	<u>Summer</u>	<u>Fall</u>	<u>Summer</u>	<u>Fall</u>	<u>Summer</u>	<u>Fall</u>
Angler days	5502	1462	6267	2114	8591	2177	17,287	2723	37,647	8476
Manhours	14,542	2770	15,661	4646	23,739	5951	38,937	7320	92,879	20,687
<u>CATCH</u>										
Coho	222	413	61	166	281	2305	338	1575	902	4459
Lake trout ^{3/}	239	-	109	13	875	46	1346	14	2569	73
R'Bow trout	164	29	213	246	343	12	7405	20	8125	307
Brook trout	9	-	-	-	655	-	162	-	826	-
Brown trout	16	-	12	-	-	-	-	-	28	-
Chinook salmon	3	-	-	-	5	-	5	-	13	-

1/ Summer season includes months of June through September

2/ Fall season includes months of October through December

3/ Lake trout season closed October 10 to November 5

The annual number of angler days ranged from 6,964 in 1970 to 20,010 in 1973, increasing each year during the four years of census. The catch of coho salmon ranged from 227 in 1971 to 2,586 in 1972. Most of the angling pressure (81 percent) occurred during the summer months (June through September) and in the Duluth-Two Harbors area (70 percent). The bulk of the coho catch occurred in the fall near French River (the release site) where 19 percent of the angler days produced 84 percent of the total coho catch (Table 10).

Angling success for coho salmon as measured by the catch per manhour averaged .010 during the summer and .216 during the fall for the four years of census. The best summer fishing for coho occurred in 1970 when .015 coho per manhour were caught and the best fall fishing success occurred in 1972 when .387 coho per manhour were caught. Lake trout, rainbow trout, and brook trout angling success was higher during the summer than for coho but was not as high as in the fall when the mature coho concentrated near the spawning stream (Table 11).

The large catch of rainbow trout during 1973 and the high catch rate (.19 fish per manhour) were the result of a large plant of rainbow trout at French River. The large catch of brook trout in 1972 and the high catch per manhour (.61) were the result of a plant of brook trout in the Grand Marais harbor area.

The average size of coho in the anglers creel was similar to the average size observed in the weir catches (Table 6). The largest coho examined during the study was angler caught near the Baptism River during November of 1970. This coho, with a Minnesota clip from the 1969 plant, was 27.5 inches long and weighed 10 pounds 6 ounces.

In all years the French River was closed to angling to permit captures in the trap for spawn-taking purposes. After the river froze over in 1972 the stream was opened to angling to determine angler utilization and catch of the late returning salmon. The stream was open to angling for 12 days from November 27 to December 8th. During this period 799 angler trips were recorded in which 2,479 manhours were fished catching 1,143 coho. This catch represents approximately 44 percent of the total angler recoveries during 1972. The fishing success rate during the 12 day period was 0.5 coho per manhour. The coho were caught chiefly by angling or snagging through the ice and were in a deteriorated condition characteristic of spawning salmon.

Angler returns as a percentage of the coho stocked in Minnesota waters of Lake Superior has ranged from .4 percent to 2.1 percent for the four year classes. The total estimated return to the angler of 5,361 coho from a total plant of 408,650 for the four years represents an angler return of approximately 1.3 percent (Table 10).

Table 10: Estimated angler participation and coho salmon catch by location and season from Minnesota waters of Lake Superior, 1970-1973

	1970		1971		1972		1973		TOTAL	
	Angler Days	Coho Catch	Angler Days	Coho Catch	Angler Days	Coho Catch	Angler Days	Coho Catch	Angler Days	Coho Catch
Duluth to Two Harbors June thru Sept.	5502	222	6267	61	7139	213	13,556	273	32,464	769
Grand Marais to Hovland June thru Sept.	-	-	-	-	1380	12	3,731	65	5,111	77
French River Area October thru December	1462	413	2114	166	2249	2361	2,723	1575	8,548	4515
TOTAL	6964	635	8381	227	10,768	2586	20,010	1913	46,123	5361
Angler recoveries as a percentage of the total stocked		0.6%		0.4%		2.1%		1.7%		1.3%

Table 11: Salmonid catch per manhour by year and season in Minnesota waters of Lake Superior, 1970-1973

	<u>1970</u>		<u>1971</u>		<u>1972</u>		<u>1973</u>		<u>TOTAL</u>	
	<u>Summer^{1/}</u>	<u>Fall^{2/}</u>	<u>Summer</u>	<u>Fall</u>	<u>Summer</u>	<u>Fall</u>	<u>Summer</u>	<u>Fall</u>	<u>Summer</u>	<u>Fall</u>
Manhours	14,542	2770	15,661	4646	23,739	5951	38,937	7320	92,879	20,687
<u>Catch per Manhour</u>										
Coho	.015	.149	.004	.036	.012	.387	.009	.215	.010	.216
Lake trout ^{3/}	.016	-	.007	.003	.037	.008	.035	.002	.028	.004
R'Bow trout	.011	.010	.014	.053	.014	.002	.190	.003	.087	.015
Brook trout ^{4/}	Tr.	-	-	-	.607	-	.070	-	.456	-
Brown trout	.001	-	.001	-	-	-	-	-	Tr.	-
Chinook salmon	Tr.	-	-	-	Tr.	-	Tr.	-	Tr.	-

1/ Summer season includes the months of June through September

2/ Fall season includes the months of October through December

3/ Lake trout season closed October 10 to November 5

4/ Catch rate based on shore fishing in Grand Marais area only

INLAND LAKE COHO

Description of the lakes and stocking

Coho salmon of one year class (1968) were stocked as fall fingerlings in two inland trout lakes, Hare Lake, Lake County and Greenwood Lake, Cook County. These lakes are within the Lake Superior watershed of the Superior National Forest in Northeast Minnesota. The plants totaled 3,800 coho in Hare Lake and 66,700 coho in Greenwood Lake.

Hare Lake is a bog-type lake with a surface area of 38 acres and a maximum depth of 18 feet. The littoral area comprises a major portion of the lake with 97 percent less than 15 feet deep. A barrier to fish movement is located in the outlet which is the Two Island River. Total alkalinity of Hare Lake ranges between 20 and 30 ppm, secchi disc readings average 7.4 feet and the lake stratifies during the summer with oxygen depletion in the deeper water (Micklus 1961). Hare Lake was rehabilitated with Fintrol (Antimycin) in August of 1968 prior to stocking with coho salmon. Methods used to rehabilitate the lake with Fintrol have been described by Hassinger and Woods (1974). Previous management of Hare Lake had included stocking of rainbow and brook trout (Micklus 1960).

Greenwood Lake is a 2,078 acre lake having a maximum depth of 112 feet. It is typical of the large oligotrophic lakes of Northeast Minnesota with dissolved oxygen below the thermocline during the summer, a secchi disc reading of 25 feet and total alkalinity of 10 ppm. The most abundant fish species present are lake herring (Coregonus artedii), common sucker (Catostomus commersoni), and yellow perch (Perca flavescens). Lake trout (Salvelinus namaycush), walleye (Stizostedion vitreum), and green sunfish (Lepomis cyanellus) are also present, but are not abundant. The lake has a barrier to fish movement at the outlet, the Greenwood River, which flows to Lake Superior via the Brule River.

Distribution, Growth, and Food

Recoveries of coho salmon in experimental gillnets set in Hare Lake during the spring and fall of the 3 years of the coho life cycle indicated distribution throughout the lake during the netting periods. The salmon averaged 6.7 inches in total length in the spring following planting (May 1969) and 10.0 inches in the fall (one year in the lake). Captures the following spring as 2 year old fish (May 1970) averaged 11.6 inches and one coho captured in the fall of 1970 was 14.5 inches in length (Table 12). Two coho were recovered during July of 1971 as 3 year old fish and averaged 15.0 inches in length. No coho were captured during the fall of 1971 from the 1968 plant. Annual average increases in length for these salmon taken in experimental gillnets was about 5.5 inches after the first year in the lake and about 4.5 inches after the second year in the lake. These growth rates were quite similar to the growth of coho in Parvin Lake, Colorado (Klein and Finnel, *ibid*).

Table 12: Age and size of coho salmon recovered in experimental gillnets in Hare Lake 1968 to 1971

<u>Date</u>	<u>Age</u>	<u>Length (Inches)</u>		<u>Sample Size</u>
		<u>Mean</u>	<u>Range</u>	
October 1968 (Stocking)	0	4.5	4.0-5.0	11
May 1969	I	6.7	6.3-7.2	22
November 1969		10.0	9.7-10.4	3
May 1970	II	11.6	10.8-14.0	8
October 1970		14.5	-	1
July 1971	III	15.0	14.0-16.0	2
November 1971		None		

Food habits of 36 of the coho captured in the experimental nets in Hare Lake indicated a diet of crustaceans and insects during the first year in the lake (size range 6.3 to 10.4 inches) and insects and fish during the second year in the lake (size range 11.3 to 14.5 inches (Table 13). The crustacea were all Daphnia, the insects included mayflies and midge larva. The fish were not identifiable but presumed to be minnows which had become reestablished in the lake. McKnight and Serns (1974) found insects the most frequent food item by occurrence and fish the most frequent food by volume in 185 coho stomachs from Stormy Lake in Wisconsin. They suggested that supplies of forage fish in prospective inland coho lakes may be less important than previously assumed.

Table 13: Food habits of five sizes of coho salmon from Hare Lake expressed as percentage of occurrence and percentage total volume.

<u>Date</u>	<u>May 10, 1969</u>		<u>Nov. 6, 1969</u>		<u>Jan. 7, 1970</u>		<u>May 16, 1970</u>		<u>Oct. 21, 1970</u>	
Size range (inch)	6.3-7.2		9.7-10.4		11.3-13.0		10.8-14.0		14.5	
No. examined	22		3		2		8		1	
No. with food	15		3		2		8		1	
<u>ITEMS</u>	<u>Occur.</u>	<u>Vol.</u>	<u>Occur.</u>	<u>Vol.</u>	<u>Occur.</u>	<u>Vol.</u>	<u>Occur.</u>	<u>Vol.</u>	<u>Occur.</u>	<u>Vol.</u>
<u>Crustacea</u>	40	10								
Daphnia	40	10								
<u>Insects</u>	87	90	100	100	50	-	88	95		
Hexogenia	40	35	33	10	-	-	50	56		
Charborus	60	35	100	90	50	-	50	29		
Chirononius	13	Tr.	-	-	-	-	-	-		
Tendipes	-	-	-	-	-	-	12	10		
<u>Fish</u>	-	-	-	-	50	-	12	5	100	100

The incidence of insects in the diet of Hare Lake coho (50 to 100 percent by occurrence and 90 to 100 percent by volume) tend to support this conclusion. However, the maximum growth potential of the coho has only been realized where adequate fish forage has been available (Rybicki, *ibid*), (Wigglesworth and Rawstron 1974).

Recoveries of coho from the plant in Greenwood Lake occurred only in the spring following stocking. Experimental gillnets set throughout the lake as bottom sets and float sets captured salmon only at the outlet of the lake during May of 1969. These salmon averaged 6.7 inches and ranged from 6.2 to 7.6 inches in total length. The food of 29 of these salmon consisted entirely of insects (100 percent by occurrence and volume). The insects included midge larva and mayfly larva. Observations on the Greenwood River downstream from the lake indicated large numbers of the salmon had left the lake during smolting in the spring when the barrier at the outlet was inundated by high water. Subsequent testnetting during 1970 and 1971 failed to capture any coho.

Klein and Finnel (*ibid*) also reported extensive downstream migration of coho salmon from Parvin Lake, Colorado, where a total of 1,183 coho from a plant of 2,000 were initially captured in a downstream trap during the spring following planting.

Utilization by Anglers

Fingerling coho salmon stocked in the fall of 1968 in Hare Lake became acceptable to anglers during the winter of 1970 (approximately 15 months after stocking). During the winter season (January 3 to January 25, 1970), considerable fishing pressure occurred on Hare Lake. An estimated 300 anglers fished 600 manhours and caught 200 coho. These salmon ranged in size from 10 to 13 inches in length with the larger salmon weighing about one pound.

During their second summer in the lake the salmon entered the fishery in May and continued to be caught until October. A total of 608 coho were estimated to have been caught during the summer of 1970 by an estimated 1,732 anglers. Heaviest fishing pressure and largest catch came during June when 492 coho were caught (Table 14). A total of 14.9 pounds per acre of coho salmon were removed by anglers in 1970. Fishing pressure on the lake amounted to 126 manhours per acre with an overall catch rate of 0.17 fish per manhour.

The coho taken by anglers during the summer of 1970 ranged from 10 to 17 inches in length (Table 15). The average size was 12.6 inches in length and 0.7 pounds in weight. The largest coho examined from anglers catches was 17 inches in length and 1.7 pounds in weight. An estimated 21 percent of the stocking was harvested by anglers during the 3 year life of the coho in Hare Lake.

Creel census on Greenwood Lake during the summer of 1970 indicated very light fishing pressure and no coho were reported or observed.

Table 14: Angling pressure and harvest of coho salmon from Hare Lake, 1970

<u>Month</u>	<u>Estimated Number Anglers</u>	<u>Estimated Manhours</u>	<u>Estimated Coho Catch</u>	<u>Catch per Manhour</u>
January	300	600	200	.33
May	160	228	28	.12
June	872	2,218	492	.22
July	262	504	24	.05
August	256	694	32	.05
September	170	496	30	.06
October	12	32	2	.06
TOTAL	2,032	4,772	808	.17

Table 15: Length-frequency distribution of angler caught coho salmon from Hare Lake, Summer 1970

<u>Length (Inches)</u>	<u>Number</u>
10 - 10.9	5
11 - 11.9	87
12 - 12.9	101
13 - 13.9	29
14 - 14.9	19
15 - 15.9	11
16 - 16.9	6
17 - 17.9	1
TOTAL	259

An estimated 216 anglers fished 745 manhours from May through August and caught 34 lake trout. The absence of the coho in the anglers catches from Greenwood Lake confirmed the observations that virtually all the coho had migrated downstream during the spring.

DISCUSSION

The returns of coho salmon from the Minnesota plants in Lake Superior were slightly less than reported from Michigan waters where catch plus spawning escapement has ranged from 3 to 16 percent of the plant (Rybicki, *ibid*). The coho compared favorably with rainbow trout planted in Lake Superior which have had angler returns of 1 to 3 percent (Hansen and Stauffer 1971) (Hassinger et al. *ibid*). The returns of coho were also similar to natural recruited rainbow trout (steelhead) of equivalent smolting size from Minnesota streams (Hassinger et al. *ibid*). However, the returning salmon were less available to the anglers and the catch rates were lower during the traditional angling season. The quality of the coho fishery, i.e.: ice fishing for deteriorated spawning coho late in the fall, did not compare with a similar fishery in the spring for spawning rainbow (steelhead) trout nor compare with the summer open-water fishery for other salmonids.

The Hare Lake coho fishery was quite similar to that reported on Parvin Lake, Colorado (Klein and Finnel, *ibid*) where an estimated 33 percent of a stocking was harvested by anglers, chiefly during the month of May. They suggested the coho population was probably almost exhausted by the extensive harvest in May and this is probably also true for Hare Lake following the large catch in June.

In contrast to the less than satisfactory results obtained from plants of coho salmon in small inland lakes, are the results of plants of coho in large reservoirs (7,000 to 20,000 acres). Coho compared favorable to rainbow trout in Granby Reservoir, Colorado, with superior growth, survival to catchable size and seasonal contribution to the fishery especially in their second summer (Klein and Finnel, *ibid*).

Wigglesworth and Rawstron (*ibid*) found coho salmon in Lake Berryessa, a large reservoir in California, to compare favorable to the most economical strain of rainbow stocked in cost per pound to the anglers creel. The coho salmon also demonstrated less initial vulnerability to fishing than most domestic strains of rainbow stocked.

The coho fishery on Hare Lake compared favorably with a rainbow trout fishery on Kimball Lake in Northeast Minnesota under similar management conditions (Micklus and Johnson, *ibid*). Plants of fingerling rainbow trout in Kimball Lake produced returns to the angler of 4.2 to 16.4 percent of the stocking. Fishing pressure during 3 years of census ranged from 43 to 78 manhours per acre, catch rates ranged from .12 to .40 rainbow per manhour and the total harvests ranged from 5.0 to 13.5 pounds per acre. Size of the rainbow trout in the anglers catches were also similar. The only difference occurred in the seasonal distribution of the catch. Rainbow trout were available to anglers for at least 3 years providing angling opportunities

throughout the summer. The coho fishery on Hare Lake during the 3 year life of the salmon occurred principally during two months, January and June.

Klein and Finnel (ibid), when comparing matched plants of rainbow trout and coho salmon in Parvin Lake, found the rainbow trout to be superior in growth, contribution to the creel, and seasonal pattern of fishing recreation. Similar conclusions can be drawn for the Hare Lake coho fishery.

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