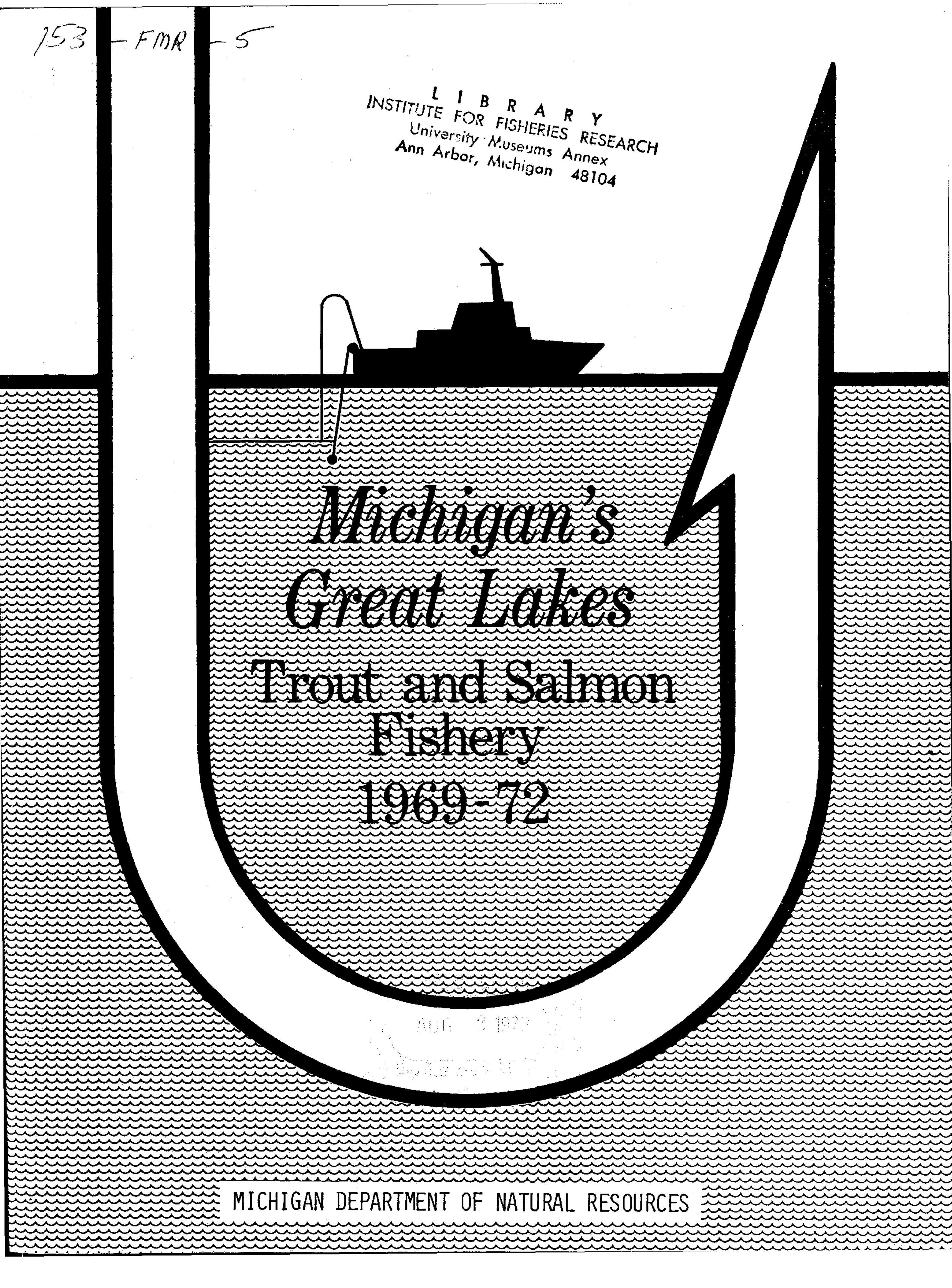


Michigan's Great Lakes Trout and Salmon Fishery 1969-72

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

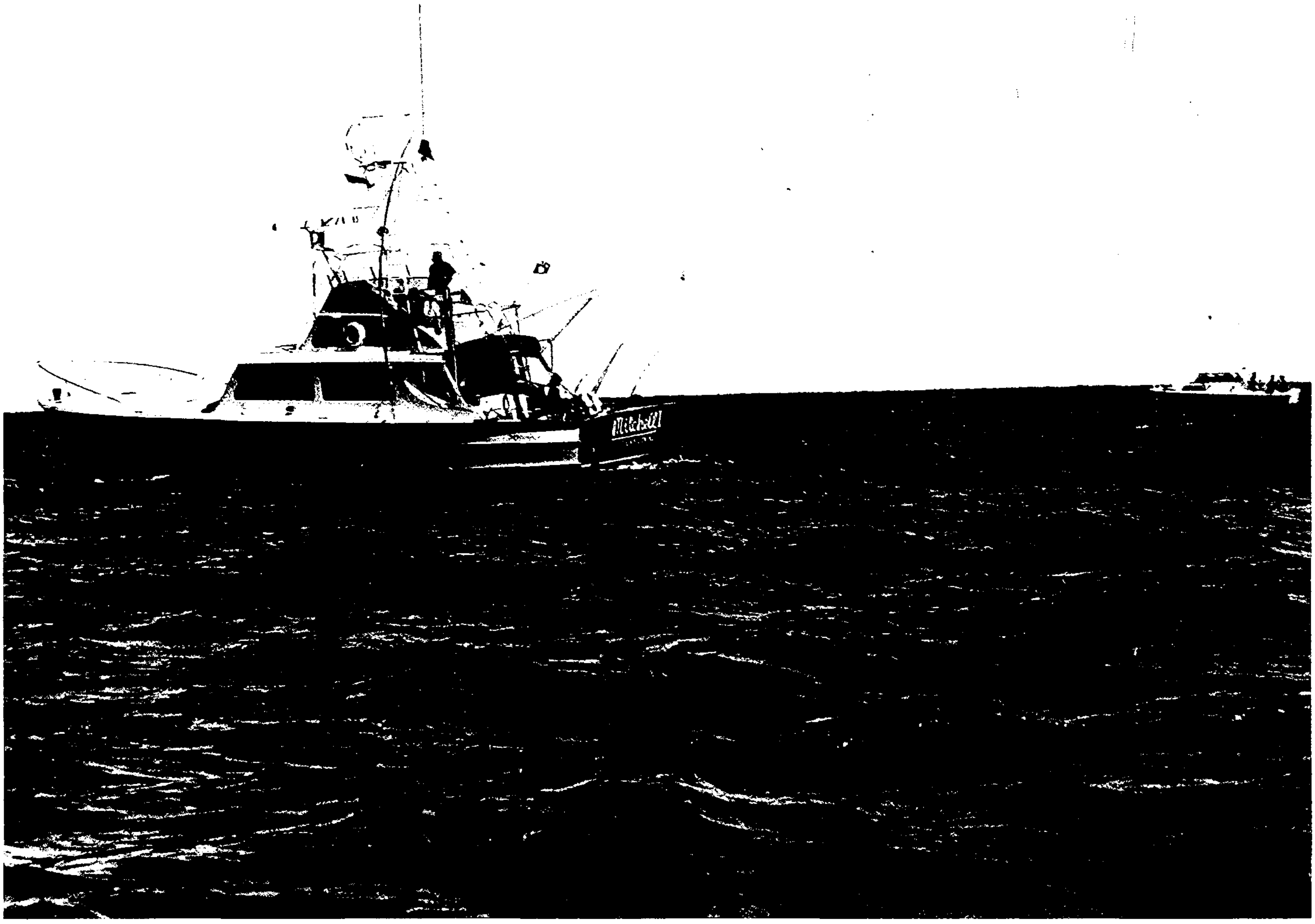
Fisheries Management Report No. 5

June, 1973

MICHIGAN'S GREAT LAKES TROUT AND SALMON FISHERY

(1969 - 1972)

Partially supported by the Bureau of Sport Fisheries and Wildlife and the National Marine Fisheries Service - Great Lakes Fish Resource Development Study AFSC-8



ACKNOWLEDGEMENTS

"Much of the work reported here has been funded under the Anadromous Fish Act as has much of the program under discussion. Michigan is grateful to the United States government and the Fisheries and Wildlife Service for supporting these studies. There is no longer any question that the eight Great Lakes states and all their people working cooperatively with the United States and Canadian governments can complete the total job of fisheries restoration in the Great Lakes."

Wayne H. Tody
Fisheries Chief
Michigan Department of Natural Resources

CONTENTS

PREFACE

In 1966 the State of Michigan made a major policy decision to mount a full-scale program to rehabilitate the fisheries resource of its Great Lakes waters. To supplement the sea lamprey control and lake trout rehabilitation programs then in progress by the United States and Canadian governments, Michigan introduced coho and chinook salmon from the Pacific. It also revamped its entire hatchery system to produce these new species along with steelhead, rainbow and brown trout in sufficient quantities to restructure the fish populations in these huge inland seas. After the early success of the coho salmon in 1967, optimism for the total success of the program ran extremely high.

In a report to Michigan people in 1967, I made the following comments.

"The 50 million acres of the upper Great Lakes have been (and the process is continuing) dealt a series of staggering blows. We have felt the effects of overexploitation of the fisheries, an invasion of a super parasite--the sea lamprey, a population explosion of still another invader--the small but pestilential alewife, and worst of all, the start of a degrading of these sparkling, deep blue waters by pollution.

"To save, restore, and enhance the fisheries of the Great Lakes we must apply positive action--research, planning, investment, and management. The rewards can be great from a resource with the magnitude of the Great Lakes. The product will be an assurance now and for the future of food, recreational opportunity, and a large economic gain. Perhaps tens or even hundreds of millions of dollars will be added to Michigan's economy in the next few years if a trout and salmon recreational fishery can be developed to meet an overwhelming public demand."

During the past two years a close look has been taken at both the economic and biological impact of this fisheries restoration program. This report is a careful appraisal of the value created by the new Great Lakes fishery to the people of Michigan and the surrounding areas. The net economic worth of this program, as will be shown, has indeed surpassed some 20 million dollars a year, and has a benefit-cost ratio of greater than 10 to 1. The effort expended has been great, but the rewards have been many times greater.

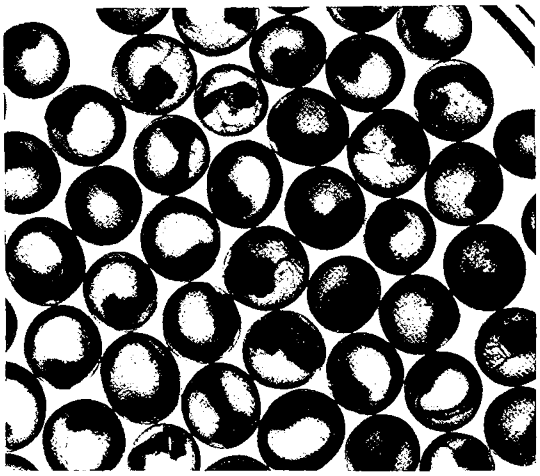
However, there also have been other important benefits. Once considered a nuisance and a liability, the alewives are now a major source of food for the highly prized and valuable trout and salmon. The Great Lakes are being restored to a higher level of improved water quality each succeeding year; the new fishery has exerted considerable influence in this most gratifying trend. The net effect of these factors has been a tremendous enhancement of the Great Lakes' recreational opportunities.

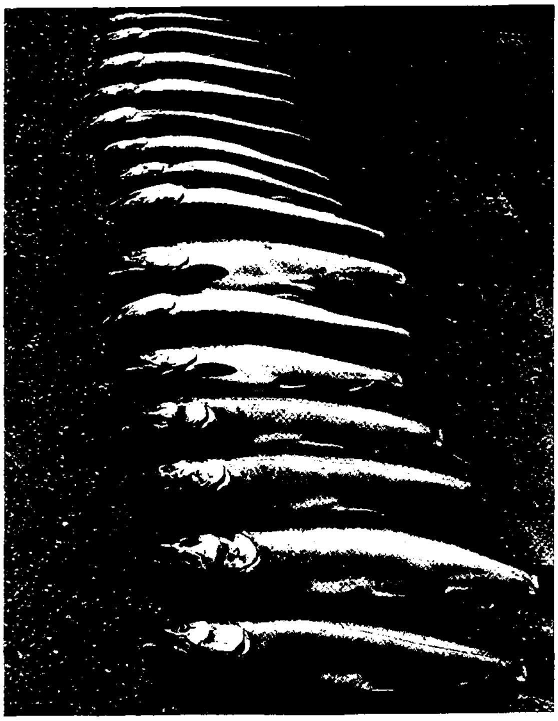
Much of the work reported here has been funded under the Anadromous Fish Act as has much of the program under discussion. Michigan is grateful to the United States government and the Fisheries and Wildlife Service for supporting these studies.

There is no longer any question that the eight Great Lakes states and all their people working cooperatively with the United States and Canadian governments can complete the total job of fisheries restoration in the Great Lakes.

WAYNE H. TODY
Chief
Fisheries Division
Department of Natural Resources

Biological Evaluation Of The Trout And Salmon Resource





A SUMMARY OF THE SALMONID PROGRAM (1969-1971)

by Ronald W. Rybicki[1]

INTRODUCTION

Sport fishing for salmonids in Michigan's waters of the Great Lakes and tributary streams has expanded from insignificance in 1965 to over three million angler days in 1971. The revolution in Great Lakes angling activity occurred because of intensive management efforts--control of the parasitic sea lamprey, introduction of Pacific salmon to the Great Lakes, rehabilitation of lake trout stocks, increased plantings of rainbow trout (steelhead), and controls on commercial gill nets.[2]

It was the successful introduction of coho and chinook salmon which triggered the intense interest of anglers and fisheries workers alike in the Great Lakes (Table 1). The story of Michigan's coho salmon program from 1966 through 1968 has been documented by Tody and Tanner (1966), Borgeson and Tody (1967), and Borgeson (1968). Chinook salmon were introduced into lakes Michigan and Superior in 1967, and Lake Huron in 1968. Although the chinook salmon has not received the publicity that the coho salmon has, the introduction has been equally successful.

This report is an account of the progress of coho salmon, chinook salmon, and steelhead (rainbow trout) programs in Michigan's waters of the Great Lakes from 1969 through 1971.

LAKE MICHIGAN

Spring and autumn upstream migrations of anadromous salmonids in the Platte and Little Manistee rivers have been intercepted at harvest weirs since 1968. The purposes of blocking these runs have been to obtain spawn and establish the status of the stocks based on index of abundance, growth, and incidence of Lamprey wounding. Other streams supporting anadromous salmonids but lacking weirs have been "spot checked" to determine the relative success of salmon plantings.

Coho and Chinook Salmon

Growth

Coho salmon grow very well in Lake Michigan. The mean weight of 3-year-old fish taken at the weirs since 1967 has ranged from 8.0 to 10.1 pounds (Table 2), and appears to have stabilized at a healthy 8.0 to 9.0 pounds.

---

[1] Management Evaluation Specialist, Fisheries Division, Michigan Department of Natural Resources

[2] Scientific names of all species of fish referred to in this and subsequent papers are presented in Appendix A.

Table 1. Great Lakes salmonid plantings in Michigan (1966-1972).

		Species			
Great Lake	Year	Lake trout	Steelhead trout	Coho salmon	Chinook salmon
	1966	956,000	127,000	659,000	0
	1967	1,118,000	0	1,732,000	802,000
	1968	855,000	157,000	1,179,000	687,000
Michigan	1969	876,000	171,000	3,043,000	650,000
	1970	875,000	284,000	3,155,000	1,674,000
	1971	1,195,075	197,000	2,410,000	1,864,000
	1972*	1,600,000	615,000	2,520,000	1,950,000
	1966	2,216,000	48,000	193,000	0
	1967	2,059,000	0	467,000	34,000
	1968	2,251,375	60,000	382,000	50,000
Superior	1969	1,859,698	57,000	526,000	50,000
	1970	1,944,390	32,000	507,000	150,000
	1971	1,000,000	73,000	405,000	252,000
	1972*	1,000,000	125,000	160,000	450,000
	1968	0	45,000	402,000	200,000
	1969	0	144,000	667,000	250,000
Huron	1970	43,000	709,000	571,000	603,000
	1971	74,000	96,000	976,000	840,000
	1972**	300,000	235,000	380,000	600,000

* Proposed plantings
** Lake trout X splake

Table 2. Mean total length and weight of age 3 coho sampled in the fall at the Platte and Little Manistee river weirs, 1967-1971

Stream	Year	Length (Inches)	Weight (Pounds)
Platte	1967	28.9	10.1
	1968	29.0	9.0
	1969	29.0	9.0
	1970	27.6	8.2
	1971	28.4	8.7
Little Manistee	1968	28.1	8.7
	1969	27.5	8.8
	1970	26.7	8.0
	1971	28.5	8.7

The largest coho caught by hook and line weighed 30.5 pounds and was taken from the east arm of Grand Traverse Bay (Lake Michigan) in 1971. A Michigan record coho--weighing 33.2 pounds--was captured at the Little Manistee River weir in 1970.

Growth of chinook has been excellent and consistent--average weight of age II's ranged from 5.0-6.3 pounds, age III's at 15.0-16.6 pounds, and age IV's from 22.7 to 23.0 pounds (Table 3).

Table 3. Mean weights and lengths of chinook salmon captured at the Little Manistee River weir during the fall of the year.

Age group	Statistic*	Year sampled 1968	1969	1970	1971
II	Length	25.2	24.9	24.7	24.1
	Weight	5.9	6.1	6.3	5.0
III	Length		34.2	34.7	34.2
	Weight		15.9	16.6	15.0
IV	Length			38.8	38.9
	Weight			23.0	22.7

* Total length in inches; weight in pounds.

The largest verified chinook taken in Michigan by hook and line was 42.8 pounds and came from the Pere Marquette River in 1971.

Stomach Contents

Feeding habits of salmon have not been studied systematically. However, some data were collected on the contents of coho and chinook stomachs in 1969 and 1971 and do provide a clue as to their diet. Alewife and smelt were the dominant forage species found in coho and chinook stomachs in 1969 and 1971 (Table 4); only five percent or less of the stomachs contained sticklebacks and sculpins. If other fish species were consumed by the salmon, they could not be identified as such. The shift from alewife in 1969 to smelt in 1971 does not necessarily signify a shortage of alewife as a forage species, but, rather, might reflect variation in time and locations of sampling.

Table 4. Stomach contents of Lake Michigan coho and chinook salmon expressed as a percentage of the stomachs containing the item.

Species	Year sampled	Alewife	Smelt	Stick-leback	Sculpins	Unident.	Void	Number stomachs examined
Coho	1969	27	5	5	0	18	50	273
	1971	10	11	1	2	0	68	89
Chinook	1969	29	3	3	0	26	42	141
	1971	18	30	0	0	0	23	44

Catch and Escapement

The statewide sport fisheries for Great Lakes salmon and trout have been censused annually since 1969 by mail surveys (Jamsen, 1969, 1970, 1971). Catch data obtained for Lake Michigan and tributary streams from these surveys are summarized in Table 5.

Table 5. Sport catch of salmon and lake trout from Lake Michigan and tributary streams by salmon-trout anglers only.

Year	Water type	Number caught Coho	Chinook	Lake trout
1969	Open water	139,000	18,000	92,000
	Tributaries	131,000	91,000	0
	Total	270,000	109,000	92,000
1970	Open water	374,000	36,000	245,000
	Tributaries	160,000	143,000	0
	Total	534,000	179,000	245,000
1971	Open water	452,000	46,000	311,000
	Tributaries	160,000	198,000	0
	Total	610,000	234,000	311,000

Numerically, the sport catch from the open water of Lake Michigan has been sustained largely by coho (46% - 52%) and lake trout (31% - 33%), followed by rainbow trout (11% - 17%) and chinook (5%). The annual catch composition from tributary streams has changed from predominantly coho (39%) in 1969 to rainbow trout (41%) in 1971. Of the total chinook catch, the stream fishery has been far more productive than the open-water fishery, accounting for 83 percent of the harvest.

Commercial fishing for salmon in Michigan's waters of the Great Lakes is prohibited. However in 1967 and 1968, salmon harvested at weirs were disposed of through the commercial market for human consumption and, as the quality of the product deteriorated, for pet food. The sale of salmon for human use was prohibited in 1969-71 because of low-level pesticide contamination.

In 1969, 295,000 pounds of excess coho and 259,000 pounds of surplus chinook were sold at three cents per pound to a packing firm which utilized only the eggs. In the autumn of 1970, the packer received 1.8 million pounds of coho and 481,000 pounds of chinook in exchange for processing and delivering up to 40,000 salmon for free distribution to the public at the weir sites. For an individual to receive one free fish, he needed a valid Michigan fishing license which was punched to prevent abuse of acquiring "free" fish. Some 70,000 fish were distributed in this manner in 1969-70. The program was enthusiastically endorsed by the fishermen--a welcomed change from the animosity of the anglers in 1968 when the fish were harvested at the weirs for commercial purposes only. The practice was discontinued in 1971 because of low-level contamination with DDT and poly-chlorinated biphenyls. However, 1.5 million pounds of surplus salmon were again sold at seven cents per pound for the eggs.

The percentage returns of planted coho to the weirs on the Platte and Little Manistee rivers from 1967 through 1971 are given in Table 6.

Table 6. Percentage returns of coho salmon harvested at the weirs, 1967-71.

Year	Stream: Platte River	Stream: Little Manistee River
1967	19.7	----
1968	22.3	14.0
1969	11.4	15.6
1970	13.7	15.0
1971	11.2	10.7

The range of future weir returns is expected to fluctuate between 11 and 15 percent. Estimated returns in 1971 from other streams planted with coho ranged from 1.5 percent in the Menominee River to 22 percent at Thompson Creek. Lake-wide total catch and escapement is estimated to be on the order of 20-25 percent.

That the chinook are highly adaptable to Lake Michigan is demonstrated not only by an excellent rate of growth but also by a high rate of survival. Cumulative returns to the Little Manistee River weir for two year classes that had completed their life cycles were 8.3 and 7.4 percent (Table 7). Catch and escapement for these two year classes is believed to be from 10 to 15 percent. West Coast chinook catch and escapement average around 2 percent.

Table 7. Percentage returns of chinook planted in and harvested from the Little Manistee River weir, 1968-1971; age is in parentheses.

Brood year	Year: 1968	Year: 1969	Year: 1970	Year: 1971	Year class return
1966	(II) 2.0	(III) 3.3	(IV) 3.0		8.3
1967		(II) 2.1	(III) 3.3	(IV) 2.0	7.4
1968			(II) 1.5	(III) 4.0	
1969				(II) 0.9	

Fecundity

Lake Michigan coho produce more eggs than do West Coast coho of comparable size. The number and average diameter of coho eggs have ranged from 2,229 and 0.27 inch in diameter for a 21.6-inch female to 3,812 and 0.31 inch in diameter for a 30.8 inch female coho (Stauffer, 1970). The average size of the female coho was 26.7 inches and 7.8 pounds; the mean number of eggs per fish was 3,109, and the ova accounted for 24 percent of the whole body weight. Hatching success has been about 50 percent of the fertile eggs. Survival rate of coho from eye-up to planting (18 months) has averaged 75 percent.

Chinook average approximately 280 eggs per pound of female, with a hatching success of 78 percent of the fertile eggs. Survival of chinook from eye-up to planting has been about 70 percent. There have been no significant differences in the quality of spawn between three and four-year-old females insofar as fertility, hatching or fry survival are concerned.

Straying of Lake Michigan coho to other than those streams into which they were released is commonplace; however, the magnitude of natural reproduction from these strays is poorly known. Taube (1971) has demonstrated that coho spawned successfully in experimental sections of the Platte River, although densities of young-of-the-year coho were only from two to eleven fish per 100 square meters.

A qualitative electro-fishing survey of the Muskegon River in 1971 indicated that natural reproduction of chinook salmon did indeed occur. The extent of that reproduction and its contribution to the salmon program has not yet been assessed.

Lamprey Wounding

The number of coho bearing lamprey marks (fresh wounds and scars combined) continues to remain low at 1.5% (Table 8). Total wounding incidence on age-IV chinook declined from 8.3% in 1970 to 2.8% in 1971.

Table 8. Percentage of chinook and coho sampled at the Little Manistee weir which bore lamprey marks (1968-1971).

Species	Age group	Year 1968	1969	1970	1971
Coho	III	4.3	2.5	1.0	1.5
Chinook	II	3.7	0.0	1.1	2.2
	III		4.7	3.0	2.9
	IV			8.3	2.8

Kidney Disease

Kidney disease in Michigan coho was discovered in 1967 when dead or moribund fish were found drifting along the beaches of Lake Michigan. Kidney disease in Michigan salmon has been described by MacLean and Yoder (1968) and is believed to be caused by the bacterium *Cornybacterium*. The disease is not considered to be a threat because less than one percent of the coho sampled in both lakes Michigan and Superior were infected in 1971.

Steelhead Trout

Abundance

Indices of abundance of steelhead (lake rainbow trout) migrating during the spring and autumn in the Little Manistee and Platte rivers have been calculated since 1968 (Table 9). The abundance index is expressed as catch per day of weir operation.

Although substantiating data are lacking, it is generally agreed that the steelhead populations are now above the level of the pre-lamprey era. The run of steelhead in the spring of 1971 was the largest since the weir operation began in 1968.

Table 9. Steelhead catch and catch per weir day at the Little Manistee River and Platte River weirs.

Stream	Year	Season	Number of days weir in operation	Number of steelhead trapped	Catch/ weir day
Platte					
	1968	Fall*	44	888	20.2
	1969	Fall*	45	587	13.0
	1970	Fall*	93	2,746	29.5
	1971	Fall*	27	715	26.5
Little Manistee					
	1968	Spring	15	1,640	109.3
	1969	Spring	15	996	66.4
	1970	Spring	16	1,405	87.8
	1971	Spring	35	5,011	143.2
	1968	Fall*	110	1,297	11.8
	1969	Fall*	70	2,987	42.7
	1970	Fall*	92	7,322	79.6
	1971	Fall*	119	7,523	63.2

* Count began on September 15 and ended upon day of weir removal. This corresponds to the salmon runs.

The age composition and mean length of steelhead sampled from the Little Manistee River have stabilized since 1968 (Table 10).

Sport Catch

Michigan's trout fishermen have been ecstatic over the resurgence of the steelhead. And well they should be as the estimated catch has spiraled from 166,000 in 1969 to 347,000 in 1971 (Table 11).

The steelhead provides primarily a stream fishery of varying quality--65 to 70 percent of the catch is from streams--during early spring and mid to late fall from the State's southern border to the Straits of Mackinac.

Table 10. Percentage age distribution and mean lengths of steelhead in the Little Manistee River during the spring of the year.

Year	Statistic	Age III	IV	V	VI	VII	VIII	Mean age and length
1966	%	40%	41%	19%				3.8
	Length	18.8	25.4	28.8				23.4
1968	%	3%	29%	55%	13%			4.8
	Length	19.4	27.2	30.0	32.3			29.2
1969	%	5%	41%	42%	9%	2%	1%	4.6
	Length	23.5	27.2	28.5	30.9	32.1	34.0	28.0
1970	%	2%	58%	38%	2%			4.4
	Length	26.2	27.3	28.2	30.2			27.7
1971*	%	18%	34%	38%	10%			4.4
	Length	25.0	27.2	29.9	32.7			27.9

* Approximate age distribution based on length frequencies.

Table 11. Estimated catch of steelhead from Lake Michigan and tributary streams by salmon-trout anglers.

Year	Open water	Tributaries	Total
1969	52,000	114,000	166,000
1970	95,000	189,000	284,000
1971	94,000	253,000	347,000

LAKE HURON

The first plants of coho and chinook salmon in Lake Huron were made in 1968. In spite of a potentially hostile environment--a large lamprey population and a Canadian commercial fishery--the salmon have done unexpectedly well.

Coho and Chinook Salmon

Growth

The growth of Lake Huron coho and chinook has been comparable to that of Lake Michigan salmon--the average weights of three-year-old coho have ranged from eight to nine pounds; chinook at age II ranged from 6.5 to 7.9 pounds; age III at 15.5 pounds (Table 12).

Table 12. Mean length and weight of Lake Huron salmon sampled during the fall of the year.

		1969		1970		1971	
Species	Age	Length	Weight	Length	Weight	Length	Weight
Coho	III	27.4	9.1	26.8	8.5	26.4	8.4
Chinook	II	24.9	6.6	25.5	7.9	23.7	6.5
	III	--	--	33.5	15.5	33.2	15.5

Smelt and alewife were the forage fishes found in the stomachs of Lake Huron coho and chinook (Table 13). These two forage species also were the dominant food items found in Lake Michigan salmon.

Table 13. Stomach contents of Lake Huron coho and chinook salmon expressed as a percentage of stomachs containing the item.

Species	Year sampled	Alewife	Smelt	Insects	Void	Number stomachs examined
Coho	1969	7	29	1	63	338
	1970	22	29	0	49	125
Chinook	1969	11	29	0	60	45
	1970	14	29	0	57	7

Catch and Escapement

Even though Lake Huron is the nearest of the upper Great Lakes to densely populated southeastern Michigan, the amount of effort (615,000 angler days) expended on Lake Huron in pursuit of salmon and trout in 1971 was only about one-third of the effort spent on Lake Michigan. Three factors act to discourage a Lake Huron open-water fishery which is potentially equal to or greater than that on Lake Michigan--(1) uncertainty of the survival rate of salmon due to lamprey depredations, (2) a paucityoof knowledge on the whereabouts of the stocks, and (3) the absence of lake trout to fall back on when salmon are unavailable. By international agreement, splake rather than lake trout are being planted in Lake Huron. At this time splake are largely an unknown quantity but ultimately may serve the sport fishery well. Meanwhile, large numbers of brown and rainbow trout are being planted to narrow the gap. Even though modest, this beginning of an open-water fishery on Lake Huron for salmonids is a vast improvement over the previous void.

The coho catch in the Lake Huron watershed declined from 83,000 in 1970 to 66,000 in 1971 (Table 14). The decrease in coho catch was due in part to the 15 percent reduction in the number of coho planted between 1969 and 1971.

Table 14. Sport catch of salmon and trout from Lake Huron and tributary streams by salmon-trout anglers only.

		Number caught			
Year	Location	Coho	Chinook	Steelhead	Brown trout
1969	Open Lake	20,000	400	2,500	No
	Tributaries	14,000	100	18,500	Data
	Total	34,000	500	21,000	
1970	Open Lake	42,000	15,000	18,000	3,600
	Tributaries	41,000	4,000	28,000	7,300
	Total	83,000	19,000	46,000	10,900
1971	Open Lake	25,000	10,000	28,000	10,000
	Tributaries	41,000	37,000	47,000	8,200
	Total	66,000	47,000	75,000	18,200

Returns of adult salmon planted in the Lake Huron watershed have been imprecisely monitored. However, catch and escapement is judged to be on the order of 15 to 20 percent. Straying of Lake Huron coho into Lake Erie is well documented.

The percentage return of chinook to the Ocqueoc River has been good. In 1969 approximately 4,000 (two percent of the plant) age II fish returned to the river. Chinook returns to the Thunder Bay River have been disappointing.

Lamprey Wounding

Although still severe, the incidence of lamprey attack on Lake Huron coho has declined considerably--from 72 percent in 1969 to 36 percent in 1971. Likewise, 18 percent of the age II and 35 percent of age III chinook bore lamprey marks in 1971, whereas the two year olds showed attack incidences of 63 percent in 1969 and 53 percent in 1970. Clearly, the continuation of intensive control programs is needed to bring Lake Huron's lamprey population down to levels where it is no longer a threat.

Rainbow Trout

Rehabilitation of Lake Huron's sport fisheries has been given a boost with plantings of nearly two million rainbow trout. The results of these plantings are evident in the creel: 21,000 in 1969, 46,000 in 1970, and 75,000 in 1971.

Both domesticated hatchery rainbows and wild rainbows (offspring from steelhead) were planted directly into Lake Huron in 1970, to establish an inshore salmonid population available to anglers during the spring and summer months when salmon are scarce. Spring and summer netting surveys in 1971 produced only insignificant catches from these plants; however, by autumn a buildup of the rainbow populations was found at all the 1970 release sites. These facts indicate that both the domestic and steelhead strains of rainbow trout are highly migratory, but that they will home to the inshore planting site. Consequently, rainbows did not fulfill the objective of providing an inshore summer fishery, although angling for this species was good on streams and inshore areas during the autumn.

Only sketchy growth data for rainbows were available in 1971 because of the variation in planting sizes (fall fingerling, spring fingerling, and yearling) and difficulty in separating domestic and steelhead strains. Most of the rainbows returning in the fall of 1971 weighed from 3.5 to 5.5 pounds.

Brown Trout

A total of 91,000 brown trout were planted in Lake Huron in 1970 to establish an inshore salmonid fishery. The density of brown trout in Thunder Bay was greatest within four miles of the planting site during both the summer and fall of 1971, indicating a far lesser degree of emigration than was shown by rainbow trout. Experimental netting indicated these browns preferred depths of 10 - 40 feet.

Thunder Bay brown trout reached an average, back-calculated length of 14.4 inches at the end of their first year in the lake. By the following June, these fish averaged 17.5 inches and 3.2 pounds. Stomachs from brown trout examined in June were found to contain mostly alewives.

The characteristics of low emigration from the planting site during the summer, good growth rate, and low vulnerability to lamprey (one percent of the trout showed lamprey marks) make this species an attractive choice for intensive management in Lake Huron.

LAKE SUPERIOR

Lake Superior coho and chinook have not been monitored as closely as were Lake Michigan salmon because weir facilities were lacking. Most of the data have been obtained by qualitatively surveying Lake Superior tributaries during the autumn when the salmon were spawning.

Coho and Chinook Salmon

Growth

Mean lengths and weights of Lake Superior coho have been remarkably consistent over the past five years--20.1 - 21.2 inches and 2.8 - 3.1 pounds, respectively (Table 15).

Table 15. Mean lengths and weights of three-year-old coho salmon from Lake Superior tributaries sampled during the autumn of the year.

Year	Length (inches)	Weight (pounds)
1967	20.2	2.8
1968	21.1	3.1
1969	20.6	2.9
1970	20.1	2.8
1971	21.2	3.1

Because of Lake Superior's relatively low productivity, the weight of three-year-old coho is considerably less than the eight to nine pounds of three-year-old coho from lakes Michigan and Huron.

Lake Superior chinook also show a slower rate of growth--about one-half that of chinook from Lakes Michigan and Huron--but nevertheless attain respectable weights of eight to nine pounds at age III and ten to eleven pounds at age IV (Table 16).

Table 16. Mean length and weight of spawning chinook salmon from Lake Superior tributaries sampled during the autumn of the year.

Age		Year sampled		
group	Statistic*	1969	1970	1971
II	Length	20.0	--	20.6
	Weight	3.2	--	2.8
III	Length	25.6	26.3	28.5
	Weight	7.8	8.9	8.0
IV	Length	--	30.6	30.3
	Weight	--	11.8	10.7

* Total length in inches; weight in pounds.

Catch and Escapement

Although somewhat imprecise, lake-wide catch and escapement of planted Lake Superior coho has been estimated at:

Year returned	Percent catch and escapement
1967	16
1968	3
1969	8
1970	6
1971	5

Returns in 1971 to the six streams planted in 1970 were estimated to have ranged from less than one percent to seven percent. The Sucker River coho plant provided the greatest returns--22 percent in 1969 and 30 percent in 1970, but dropped sharply to five percent in 1971.

Returns of the 1967 year class of chinook salmon to the Marquette Hatchery totaled 200 fish, or about 0.4 percent of the plant. Catch and escapement of this year class probably was not more than five percent.

The coho catch declined sharply from 60,000 in 1969 to 41,000 in 1970 and 44,000 in 1971 (Table 17). The decrease occurred despite increased planting densities from 382,000 coho in 1968 to 526,000 in 1969 and 506,000 in 1970. Chinook catches have been rather small but the annual stocking densities have been light--34,000 in 1967; 50,000 in 1969; 150,000 in 1970.

Table 17. Estimated catch of salmon and trout from Lake Superior and tributary streams by salmon-trout anglers.

Year	Water type	Number caught Coho	Chinook	Steelhead	Lake Trout
1969	Open lake	50,000	6,300	14,000	171,000
	Tributaries	10,000	400	23,000	0
	Total	60,000	6,700	37,000	171,000
1970	Open lake	31,000	2,000	19,000	172,000
	Tributaries	10,000	800	50,000	0
	Total	41,000	2,800	69,000	172,000
1971	Open lake	36,000	1,100	15,000	138,000
	Tributaries	8,000	4,500	60,000	0
	Total	44,000	5,600	75,000	138,000

Natural Reproduction

Coho planted in Lake Superior streams have strayed to numerous other tributaries. In 1967-68 Peck (1969) examined five of these streams for reproduction of coho. He found densities of young-of-the-year coho ranging from 2 to 95 salmon per 100 square meters of stream area. In comparison, density in a good western stream was 150 young-of-the-year coho per square meter (Chapman, 1965). The only known significant run of naturally recruited adult coho in 1971 occurred in the Big Huron River and consisted of approximately 1,000 three-year-old fish.

Lamprey Wounding and Kidney Disease

None of the Lake Superior coho showed lamprey marks. The incidence of total lamprey marks on chinook decreased from 16.5 percent in 1970 to 1.2 percent in 1971.

No coho were observed to have kidney disease in 1971, as compared to a 14 percent incidence in 1967. Nearly 7 percent of the chinook sampled in 1970 had kidney disease, but no infected fish were found in 1971.

Pink Salmon

A spawning run of pink salmon occurred in several Lake Superior tributaries again in 1971. This species of salmon has continued to increase in numbers since the original release was made by Ontario in 1965. The number of pinks in the 1971 run was much larger than any previously observed and were seen in many more streams than ever before. These fish first begin to appear in the streams in early September, and peak by mid-September. They ranged in size from 16 to 18 inches.

SALMON MANAGEMENT PRACTICES

Success of the Great Lakes salmon program has brought about a change in attitudes to both the angling fraternity and the Michigan Department of Natural Resources (DNR). The "new breed" of fishermen do not seem to mind crowded conditions if fishing is good and are very insistent upon being permitted to harvest salmon. In 1967-68, heavy runs of spawning salmon attracted hordes of anglers. This, in turn, caused numerous law enforcement problems and some destruction of habitat in relatively small streams. Many fishless anglers became frustrated because regulations prohibited the keeping of foul-hooked fish when, right beneath their noses, tons of weir-harvested coho were being loaded aboard refrigerated trucks for the market.

Thus, two refinements in the salmon management program quickly emerged: (1) maximize angling opportunity and the sport harvest of salmon, and (2) minimize destruction of stream habitat caused by intensive angler use. The first refinement has been largely achieved by permitting the foul-hooking (popularly called "snagging") of coho and chinook, and the second by stocking large rivers in the southern part of the State where the population centers exist. This has resulted in substantial river fisheries where little or none previously occurred during the fall months. Many of these rivers are large enough to accommodate angler demands with minimum environmental damage. Also, most of these southern streams at best support only minor populations of migratory populations of rainbow and brown trout so that illegal snagging of these species is minimized.

Although snagging has proved to be an effective and popular method of harvesting salmon, particularly where the fish are concentrated, there is a growing conflict between snaggers and steelhead fishermen where the two fisheries overlap. Continuous refinement in salmon planting quotas and regulations are needed to minimize damage to the trout populations. Thus the DNR has proposed (1) to allow snagging only on those rivers having large salmon runs and on rivers and lakes where a conflict with migratory rainbow trout or other species does not exist; and (2) snagging of salmon on rivers having important runs of steelhead to be allowed only during September and October (existing season is September-February 15) and only in specified areas below dams and bridges.

The Sable River coho fishery in 1971 deserves special mention because it demonstrated that a well regulated "quality" snag fishery was possible. A section of the river in the Ludington State Park was opened to fall fishing but under special regulations. The daily fishery was by permit only and was divided into A.M. and P.M. periods, with no more than 100 permits outstanding during one period. The free permit consisted of a colored arm band. An angler turned in his valid fishing license when he obtained the permit. At the termination of fishing, he returned the permit and recovered his fishing license. The hook size was restricted to 3/8 inch or less from point to shank but hooks specially designed for snagging were prohibited. It did not take long for the anglers to discover that snagging with conventional gear was not prohibited. By the end of the second week of the fishery, the majority of anglers were using a 3/8 inch treble hook with heavy sinkers attached four to eight inches below the hook and deliberately and legally snagging salmon. Park records showed that 8,268 permits were issued and 8,722 salmon were creeled from September 25 through November 14. Park personnel observed that the permit system was well received by the anglers, and that spectators frequently outnumbered the participants. The future might well see the permit system extended to other waters of the State.

The planting of coho in Lake Superior was reduced from 507,000 in 1970 to 405,000 fish in 1971 because their growth, survival and contribution to the creel have not met expectations. Future management emphasis will be placed on greater use of hatchery-produced rainbow trout and chinook salmon as well as the continued use of lake trout.

Experimental plantings of coho were made in the open water of Lake Michigan in 1971. Whether or not this becomes a permanent management practice is dependent upon homing behavior and contribution made to the creel. Thus far, Lake Michigan chinook have not provided the open-water fishery that the coho have; on the other hand, the chinook has produced a better stream fishery than the coho. For the time being, the coho will be managed for the Lake Michigan open-water fishery and the chinook for the stream fishery.

Lake Huron will continue to receive plantings of both coho and chinook but at a somewhat reduced level. Releases of salmon will be concentrated in a few streams tributary to southern Lake Huron.

Atlantic salmon were introduced into lakes Michigan (8,000 smolts planted in the Boyne River) and Huron (8,000 planted in the Au Sable River) in 1972. If successful, it is anticipated that this species will be managed for a unique recreational fishery rather than being brought to the abundance of other salmon and trout.

SUMMARY

1. Coho salmon have thrived in lakes Michigan and Huron. Average weights of this species from both lakes ranged between 8 and 9 pounds. Lakewide catch and escapement was estimated at 20-25 percent for the Lake Michigan stocks, and 15-20 percent for the Lake Huron coho. Comparatively speaking, the performance of Lake Superior coho has been less than spectacular. Lake Superior coho attained an average size of only 3 pounds, and lakewide catch and escapement only ranged from 3 percent to 8 percent during the past four years.

2. Chinook salmon were introduced into lakes Michigan and Superior in 1967, and into Lake Huron in 1968. This species, too, has prospered in its new habitat. Mean weights for spawning chinook from lakes Michigan and Huron at age II ranged from 5 to 8 pounds; at age III were 15 pounds; and at age IV were 23 pounds; catch and escapement of Lake Michigan chinook was on the order of 10 to 15 percent, and Lake Huron returns were pegged at about 5 to 10 percent. Mature Lake Superior chinook averaged 3 pounds at age II, 8 pounds at age III, and 11 pounds at age IV. Catch and escapement is believed to have been roughly 5 percent.

3. About 2,000,000 angler days were expended by salmon-trout fishermen on Lake Michigan and tributaries in 1971 and they caught 610,000 coho, 234,000 chinook, 347,000 steelhead, and 270,000 lake trout. Lake Huron anglers fished 615,000 days in 1971, and harvested 66,000 coho, 47,000 chinook, and 75,000 steelhead. On Lake Superior and tributaries in 1971, anglers took 44,000 coho, 5,600 chinook, 75,000 steelhead, and 138,000 lake trout in 401,000 man days of fishing.

4. Lake Michigan steelhead populations have increased in abundance since lamprey control began in 1963. The mean age and length of spawning steelhead intercepted in the Little Manistee River has increased from 3.8 years and 23.4 inches in 1966 to 4.4 years and 27.9 inches in 1971.

5. Lake Michigan coho produced an average of 3,000 eggs per female. About 50 percent of the fertilized eggs hatched, on the average, and survival from eye-up to planting averaged 75 percent. Lake Michigan chinook average 280 eggs per pound of female. Hatching success has been 78 percent, and survival to plantout is about 70 percent.

6. Coho and chinook are reproducing naturally in streams tributary to lakes Michigan and Superior but the quantity of that reproduction is not known.

7. Lamprey wounding incidence on Lake Michigan coho (age III) and chinook (age IV) was low at 1.5 percent and 2.8 percent, respectively, in 1971. None of the Lake Superior coho bore lamprey marks, but 1.2 percent of the chinook were scarred in 1971. Lake Huron coho showed a severe incidence of lamprey attack of 36 percent in 1971. Age III chinook were hit equally hard, but for both species the incidence of lamprey wounding had decreased by one-half or more from previous years.

LITERATURE CITED

Borgeson, D. P. and W. H. Tody. 1967. Status Report on Great Lakes Fisheries. Michigan Department of Conservation, Fisheries Management Report No. 2.

Chapman, D. W. 1965. Net Production of Juvenile Coho Salmon in Three Oregon Streams. Transactions of the American Fisheries Society, 94 (1):40-52.

Jamsen, G. C. 1969. Michigan's 1969 Salmon and Trout Sport Fishery. Michigan Department of Natural Resources, Research and Development Report No. 203.

Jamsen, G. C. 1972. Michigan's 1971 Sport Fishery. Michigan Department of Natural Resources, Research and Development Report No. 268.

Jamsen, G. C. and P. V. Ellefson. 1970. Michigan's 1970 Sport Fishery, January 1-April 24. Michigan Department of Natural Resources, Research and Development Report No. 211.

Jamsen, G. C. and P. V. Ellefson. 1970. Michigan's 1970 Sport Fishery, April 25-August 31. Michigan Department of Natural Resources, Research and Development Report No. 234.

Jamsen, G. C. and P. V. Ellefson. 1970. Michigan's 1970 Sport Fishery, September 1-December 31. Michigan Department of Natural Resources, Research and Development Report No. 235.

MacLean, D. G. and W. G. Yoder. 1968. Kidney Disease Among Michigan Salmon in 1967. Michigan Department of Conservation, Research and Development Report No. 144.

Peck, J. W. 1969. Straying and Reproduction of Coho Salmon, *Oncorhyncus kisutch*, Planted in a Lake Superior Tributary. Michigan Department of Natural Resources, Research and Development Report No. 177.

Stauffer, Thomas M. 1970. Fecundity of Coho Salmon from Lake Michigan. Michigan Department of Natural Resources, Research and Development Report No. 212.

Taube, C. M. 1971. Competition Among Coho Salmon, Steelhead, and Brown Trout. Michigan Department of Natural Resources, Research and Development Job Progress Report F-31-R-4, Job No. 5.

Tody, W. H. and H. A. Tanner. 1966. Coho Salmon for the Great Lakes. Michigan Department of Conservation, Fisheries Management Report No. 1.

Sport Fishing Activity In 1971

INTRODUCTION

by Gale C. Jamsen[1]

In the past, Michigan used a statewide creel census of fishermen to determine fishermen success rates. Conservation officers conducted those interviews as a part of their regular duties. Severe biases existed in this system and, after a careful review in 1962, it was discontinued. Some fishing activity on relatively small lakes and stream stretches of special interest still is routinely measured in the state as it was done in the past.

In recent years, the regional assessment of sport fishing for Great Lakes salmon and trout has been conducted by a field creel census. However, prohibitive costs prevented a thorough coverage of the area and fishing activity outside of the peak period. In 1968 and 1969, experimental mail surveys were also conducted to establish the feasibility of this approach. A statewide postcard survey was conducted in 1969 with a sample of licensed fishermen eligible to fish for salmon and trout. In 1970 and 1971, statewide mail surveys were carried out from samples of all licensed fishermen who were queried about all types of fishing in the state.

Our experience over the past few years has convinced us that mail surveys of sport fishermen are an inexpensive and valuable means of collecting sport fishing statistics. Hunting and hunter statistics have been routinely collected for more than 20 years in Michigan by the use of sample surveys.

The two papers in this section discuss in considerable detail the methodology and results of the 1971 sport fishing surveys.

---

[1] Biometrician, Research and Development Division, Michigan Department of Natural Resources

ASSESSMENT OF THE 1971 SPORT FISHERY

by Gale C. Jamsen

INTRODUCTION

The intent of the mail creel census surveys was to measure the dimensions of the fishery for the purpose of guiding public and private investment in fishing and related programs. Reports on sport fishery assessment in previous years as well as numerous other reports resulting from the Great Lakes Fish Resource Development Study (AFSC-8) are cited in Appendix B.

SURVEY PROCEDURES

Sport fishermen licensed in Michigan were surveyed twice by mail and once by telephone about their fishing activity during the 1971 season. The first mail survey sample was selected from carbon copies of fishing licenses sold through June 30, 1971. The sample was selected systematically with a random start and the sampling rate was 2.0 percent. The telephone survey sample for this period was selected in a similar manner. The sampling rate for this survey was 0.2 percent, making it one-tenth the size of the mail survey sample. The second mail survey sample was selected at a 1.0 percent rate from all of the 1.1 million fishermen licensed to fish after July 1, 1971.

The three samples did not include (a) wives of licensed fishermen who fish under authority of their husband's license, (b) fishermen under 17 years of age who may legally fish without a license, (c) fishermen who fish only on private lakes where a license is not needed, and (d) fishermen who are resident members of the armed services in possession of furlough papers. The catch and fishing effort of these individuals are not represented in our estimates. Since most of them are casual fishermen, our catch estimates are not expected to be significantly affected by this omission.

Up to three reminders were sent to those fishermen not responding to the original mailing. The reminders were sent at three-week intervals. A 70 percent response of delivered questionnaires was obtained with two reminders from those surveyed about their fishing during the first half of 1971. The survey covering the second half of 1971 achieved a 79 percent response with three reminders.

The original intent of the telephone survey was to provide statewide and regional sport catch and effort estimates within three to four weeks after the survey period ended. First, telephone numbers were obtained for 52 percent of the Michigan residents in the sample. Listings could not be found for an additional 34 percent with the remaining 14 percent residing in rural areas not included in our file of directories. After three weeks of calling by telephone, 43 percent of those on our list of telephone numbers were successfully interviewed. At this point it was decided to survey the remainder of the sample, including all non-residents, by mail. Two reminders were sent to non-respondents in two-week intervals after the original mailing. By early September the survey was terminated and estimates of catch and effort were generated by computer. The final response was 73 percent of the fishermen who were either contacted by telephone or had the questionnaire delivered to their home. In contrast, preliminary mail survey estimates for the same period and based on a sample of more than 10,000 fishermen were not available until mid-November.

METHODOLOGY COMPARISONS

As mentioned earlier, fishermen were surveyed by two different methods about their fishing activity during the first six months of 1971. The mail survey sample was ten times as large as the telephone sample. The statewide catch and effort estimates (Table 1) are surprisingly close with 14 of the 16 mail survey estimates falling within the 95 percent confidence limits of the telephone survey estimates.

The second half of the 1971 fishing season was assessed by sending a mail questionnaire to nearly 10,000 fishermen asking them to report on their fishing activity after July 1, 1971. The confidence limits of the results (Table 2) which are presented as a percentage of the estimates are similar to those obtained for the first half. This is not unexpected, since both samples were approximately the same size.

Table 1. Estimated numbers of fish caught and effort in the first half of 1971 computed from surveys by mail and telephone.

Species caught	Mail Survey*	Telephone Survey*
Perch	11,744,600 ± 9%	9,358,000 ± 23%
Walleye	421,800 ± 17%	455,000 ± 47%
Bass	1,840,300 ± 13%	2,180,000 ± 36%
Panfish	21,006,700 ± 7%	22,368,000 ± 22%
Muskellunge	6,300 ± 85%	33,000 ± 182%
Northern Pike	903,400 ± 17%	996,000 ± 36%
Suckers	1,753,000 ± 20%	1,501,000 ± 57%
Smelt	12,829,700 ± 14%	9,678,000 ± 44%
Lake Trout	203,100 ± 23%	212,000 ± 105%
Rainbow Trout	496,000 ± 16%	448,000 ± 43%
Brown Trout	416,300 ± 18%	294,000 ± 60%
Brook Trout	876,500 ± 16%	492,000 ± 44%
Coho Salmon	140,100 ± 30%	109,000 ± 59%
Chinook Salmon	3,900 ± 67%	8,000 ± 137%
Other	1,894,100 ± 21%	2,377,000 ± 54%
Angler-days	8,134,800 ± 3%	8,460,000 ± 12%

* Confidence limits (95 percent) are presented as a percentage of the estimate.

Table 2. Estimated numbers of fish caught and effort in the second half of 1971.

Species	Estimate*
Perch	14,301,120 ± 9%
Walleye	869,920 ± 17%
Bass	3,336,480 ± 13%
Panfish	25,421,280 ± 8%
Muskellunge	11,360 ± 53%
Northern Pike	1,136,000 ± 10%
Suckers	863,360 ± 23%
Smelt	47,040 ± 102%
Lake Trout	275,680 ± 25%
Rainbow Trout	529,440 ± 15%
Brown Trout	449,120 ± 21%
Brook Trout	1,008,320 ± 19%
Coho Salmon	599,200 ± 17%
Chinook Salmon	299,680 ± 30%
Other	2,439,360 ± 19%
Angler-days	13,676,480 ± 3%

* Confidence limits (95 percent) are presented as a percentage of the estimate.

Early in 1971 a decision was made to measure sport fishing activity during the first half of 1971 by conducting both a telephone and mail survey of representative samples of licensed fishermen. One weakness in the mail survey is the long time lag that occurs from the time the fishing period ends to the time the results are available. Without a timely report, the fishery statistics can become "stale" and lose some of their value. We viewed our telephone survey as a pilot project for determining whether or not it could function as a useful alternative to the mail survey and eliminate the problem of a time lag.

Our telephone survey experience indicates that we can locate telephone numbers for approximately 60 percent of those listed in a sample of fishing license holders. However, because of our lack of success in achieving a reasonable percentage of successful interviews, we conclude that our telephone survey experiment was a failure. We still consider the telephone survey a useful means of assessing sport fishing but at considerable time and expense.

The best uses for a telephone survey would probably be for rapid assessment of big game seasons such as deer or bear. It might also prove of value in assessing the catch of prized sport fish, such as salmon, when a list of the names and addresses of only the participants seeking such fish is available. Using the entire population of fishing license holders as a sampling frame would be very inefficient since we know that less than one out of five anglers fish for salmon in Michigan.

The mail survey appears to be the most efficient means of collecting sport fishery statistics on a statewide basis. Our cost per usable response is approximately two dollars. The decision maker requires relatively precise estimates at the county and multi-county level. A relatively large sample of around 10,000 is needed to provide good estimates at this level.

The mail survey is not faultless. One problem is non-response bias. We assume that the 20 percent who do not respond to our questionnaires are not different from the respondents in regard to their fishing activity. If they are less active then the catch and effort estimates are biased upwards. A second problem is concerned with the sampling frame. It is not complete by excluding wives of licensed fishermen and children under 17 years of age. The effect of this is to bias our estimates downward. We do not view these two biases as having a serious effect on our estimates. Third, there is the problem of inaccurate reporting by those who have difficulty recalling their fishing experiences, and those who intentionally falsify their reports. Lastly there is the problem of improperly identifying the species of fish caught. The nature of these biases is unknown. However, in the past we have conducted numerous telephone interviews with fishermen reporting a catch of more than 50 salmon or trout on their mail questionnaire. These interviews have convinced us that we are getting accurate reports from most of the fishermen selected in the surveys.

SURVEY RESULTS

Sport Fishermen by Area of Residence

Approximately 1.1 million individuals aged 17 or over purchased one of seven different Michigan sport fishing licenses in 1971. Eighteen percent of the total were purchased by non-residents. Wives of licensed fishermen and all children under the age of 17 do not need to purchase a license to fish in Michigan. To estimate the size of this group, licensed fishermen were queried as to whether or not their wives had fished and how many of their children had fished. The size of this combined group was slightly larger than the group of license holders, indicating a total resident fishing population of about 1.8 million. This means that more than one out of five people in the state fished in 1971.

One out of three persons in the entire population north of a line from Bay City to Muskegon did some fishing in 1971 (Table 3). Less than one out of five of those living south of this line fished in the state. However, the bulk of the state's licensed fishermen (81 percent) came from this southern region. This is not surprising since 89 percent of the state's 1970 population (8,898,655) resides in counties of southern Michigan that are approximately below a line between Muskegon and Bay City (Region III in Fig. 1).

Non-residents resided primarily in Ohio, Indiana, Illinois, and Wisconsin. Sixty-six percent of all the non-residents were from the adjacent states of Ohio and Indiana. Illinois and Wisconsin accounted for an additional 21 percent with the remaining 13 percent well distributed among residents of the remaining states and Ontario. A smattering originated from other sections of Canada and Western Europe.

Ice fishermen were also censused in relation to their area of residence (Table 4). This was the first time an estimate of the number of participants in this chilling form of recreation had been obtained. We discovered that one out of four license holders fished through the ice for an average of nearly 11

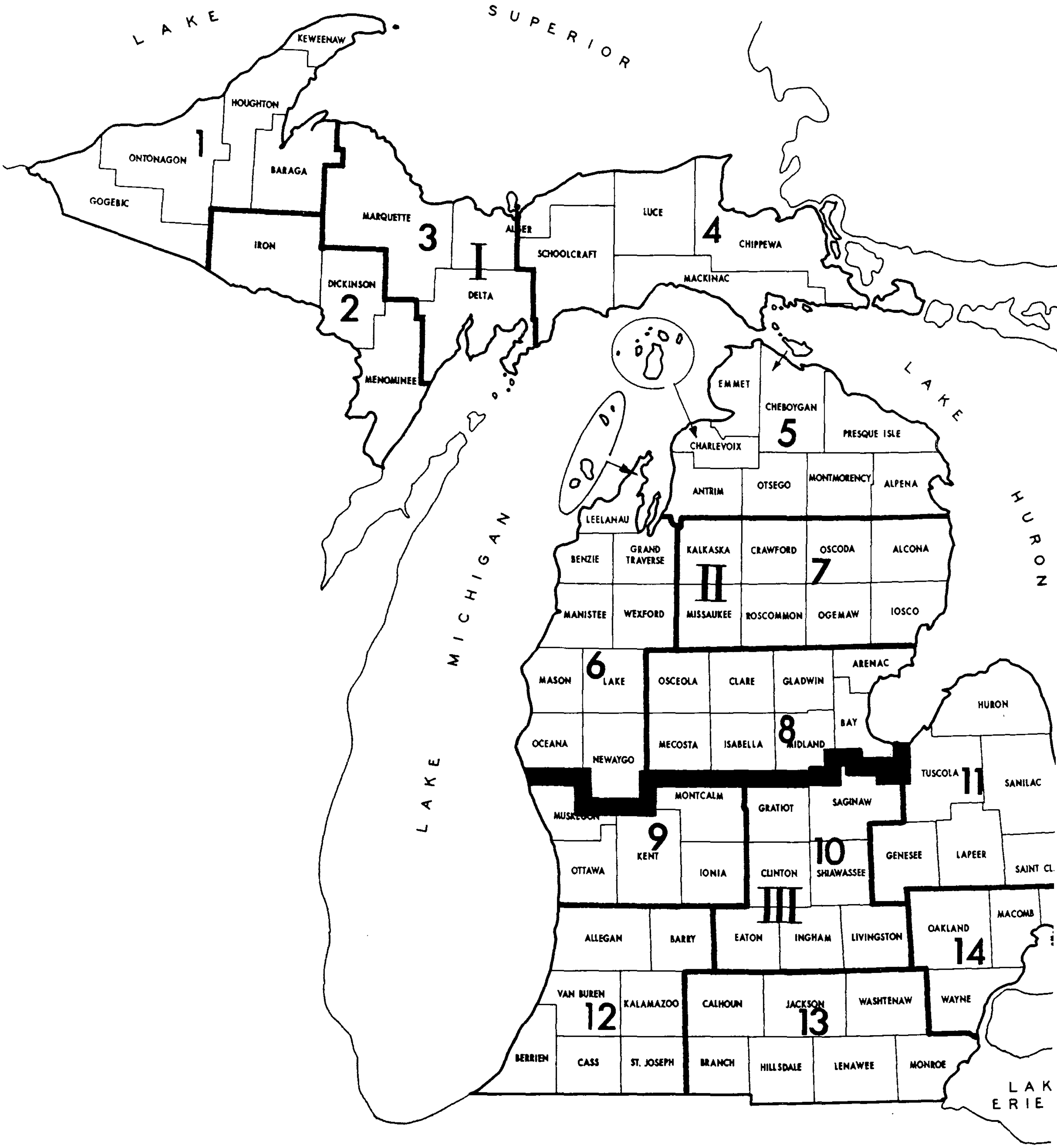


Figure 1. A map of Michigan showing the regions (Roman numerals) and fish management districts (Arabic numerals) of the Michigan Department of Natural Resources.

days. Ice fishing days accounted for 12 percent of the total fishing activity in the state in 1971.

Table 3. Residence and number of sport fishermen in Michigan in 1971.

Area of residence	Fishermen aged 17 and over	Wives	Children under 17	Total
Upper Peninsula	59,680	15,200	25,600	100,480
Northern Lower Peninsula	115,040	39,840	72,160	227,040
Southern Lower Peninsula	722,400	247,360	500,320	1,470,080
Michigan total	897,120	302,400	598,080	1,797,600
Non-Residents	164,320	65,120	100,640	330,080
Grand total	1,061,440	367,520	698,720	2,127,680

Ice fishing is well distributed over Michigan's lakes. Protected areas of the Great Lakes also attract thousands of fishermen. The lake trout triggers most of the activity on areas such as Keweenaw Bay on Lake Superior and Grand Traverse and Little Traverse bays on Lake Michigan. Saginaw Bay and Lake St. Clair are other important ice fishing areas on the Great Lakes. The species of primary interest is the yellow perch. The residence of ice fishermen (Table 4) reflects fairly closely the residence of the entire population of licensed fishermen. Fishermen in the northern Lower Peninsula (Region II of Fig. 1) are the most active. One out of three in this group ice-fish while one out of five in the Upper Peninsula and one out of four in the southern Lower Peninsula are active ice fishermen.

Table 4. The number and amount of fishing by Michigan's ice fishermen in 1971, according to area of residence.

Area of residence	Number of fishermen	Percentage	Angler-days	Percentage
Upper Peninsula	12,000	5	132,900	5
Northern Lower Peninsula	37,000	15	432,100	16
Southern Lower Peninsula	190,300	75	2,007,600	75
Michigan Total	239,300	95	2,572,600	96
Non-residents	12,300	5	106,800	4
Grand total	251,600		2,679,400	

The Distribution of Fishing Activity and Catch

Licensed resident anglers fished nearly 20 million days in 1971 (Table 5). This is an average of 22 days per fisherman. Non-residents of Michigan fished over 1.9 million days for an average of 11 days per fisherman.

Over half of the fishing effort takes place in southern Lower Michigan (Region III in Figure 1). This is explained primarily by the above mentioned statistic that 81 percent of the resident fishermen live in this area. The enormous impact of the fishing effort from these fishermen on the fishing resource in their own region as well as other regions of the state is clearly observed in Table 5.

Table 5. The number of angler-days in each region in 1971 and their origin by area of residence.

	Destination*			
Residence	Region I	Region II	Region III	Total
Upper Peninsula (Region I)	1,396,160	19,340	36,580	1,452,080
Northern Lower Peninsula (Region II)	100,960	2,619,020	141,480	2,861,460
Southern Lower Peninsula (Region III)	547,280	4,180,880	10,841,780	15,569,940
Non-Michigan	321,800	491,260	1,114,740	1,927,800
Total	2,366,200	7,310,500	12,134,580	21,811,280

* See Figure 1 for map of regions.

The large amount of good fishing water in the northern Lower Peninsula (Region II in Figure 1) probably accounts for the fact that nearly two-thirds of the fishing effort in this region originated from non-residents of the region. An explanation for this is clearly evident in an examination of the catch statistics in each Fisheries Management District (Table 6). The majority of the state's salmon and trout catch in 1971 (58 percent) occurred in Region II (districts 5, 6, 7, and 8). In contrast, visitors to the Upper Peninsula account for 41 percent of the fishing effort in that region and only a meager 11 percent of the fishing activity in the southern Lower Peninsula.

Their distance from Michigan appears to have a significant effect on where non-residents expend their fishing effort. Fifty-eight percent of the non-resident fishing effort was reported in the southern Lower Peninsula.

Many have wondered how Michigan fishermen view their fishing. To learn how the various species ranked in importance, each fisherman in the survey sample was asked to check each species he was seeking and to report the number of days fished for each species sought. Panfish (mostly bluegills), bass, and perch were the top three species, respectively. Just under one-half million fishermen were estimated as seekers of each of these species.

Table 6. Statewide sport fish catch and effort by Fisheries Management District in Michigan, 1971

Districts*	Perch	Walleye	Bass	Panfish	Muskel-lunge	Northern pike	Suckers	Smelt
1	253,100	97,820	53,200	282,060	780	76,700	55,740	873,200
2	316,220	48,960	79,500	449,940	0	53,600	31,580	158,000
3	575,000	30,460	84,220	156,340	160	70,900	95,440	857,500
4	2,131,060	151,320	136,100	399,000	320	256,740	116,260	2,365,700
5	1,373,320	152,740	311,060	1,148,960	740	197,280	184,440	522,340
6	2,126,660	89,820	467,740	3,513,540	2,760	165,900	217,120	791,500
7	1,688,880	115,700	341,860	2,014,540	200	390,320	147,500	2,238,000
8	2,199,240	22,440	250,480	3,199,580	520	180,060	287,520	2,418,900
9	1,520,900	18,960	382,280	4,808,540	320	141,700	311,720	198,200
10	233,440	3,780	266,560	2,814,640	1,280	74,980	195,640	10,000
11	2,976,640	265,420	402,800	2,629,580	3,760	141,840	373,960	1,574,800
12	3,062,940	26,240	1,067,680	12,917,900	0	127,140	381,180	590,600
13	3,534,180	21,380	738,140	7,953,460	1,060	84,440	146,320	16,300
14	4,054,140	246,680	595,160	4,139,900	5,760	77,800	71,940	261,700
Totals	26,045,720	1,291,720	5,176,780	46,427,980	17,660	2,039,400	2,616,360	12,876,740

Districts	Lake trout	Rainbow trout	Brown trout	Brook trout	Coho salmon	Chinook salmon	All Other Species	Angler-days
1	72,980	81,300	28,760	232,120	21,740	4,580	37,460	537,840
2	740	11,260	14,280	178,860	1,480	0	42,440	344,880
3	57,740	69,140	37,700	324,300	35,840	1,140	91,880	720,620
4	17,440	57,460	16,260	122,660	38,560	13,280	275,560	762,860
5	67,700	123,300	70,740	284,460	50,060	27,940	123,420	1,427,540
6	216,500	346,120	263,900	271,700	313,660	168,700	164,540	2,775,300
7	7,380	115,300	247,160	262,400	33,100	25,600	134,500	1,788,640
8	160	29,020	61,160	93,700	0	160	170,620	1,319,020
9	22,800	56,200	62,060	77,460	80,160	57,800	377,540	2,009,260
10	0	15,580	4,300	2,600	7,520	0	256,920	938,660
11	2,460	22,980	5,000	6,260	9,060	160	418,880	1,524,520
12	12,880	55,680	42,480	22,380	148,120	4,220	930,280	3,438,700
13	0	11,720	5,120	3,720	0	0	841,260	2,319,600
14	0	30,380	6,500	2,200	0	0	468,160	1,903,840
Totals	478,780	1,025,440	865,420	1,884,820	739,300	303,580	4,333,460	21,811,280

* See Figure 1 for map of Fisheries Management Districts.

The northern pike followed with nearly 300,000 enthusiasts. Tops for the salmonids was the coho salmon with 168,000 followers. Each of the remaining trout and salmon listed had about 100,000 fans (Table 7). The estimates in Table 7 are not additive. If a fisherman fished for more than one species at a time, he or she would be counted as a fisherman under each species sought and the fishing effort would be counted in a similar fashion.

Table 7. Statewide estimates of fishermen and fishing effort according to species sought in Michigan during 1971.

Species sought	Number of fishermen*	Angler-days*
Great Lakes perch	190,720 ± 5%	1,663,360 ± 10%
Inland perch	278,880 ± 4%	3,086,080 ± 7%
Walleye	190,560 ± 5%	1,748,000 ± 8%
Bass	463,360 ± 3%	5,314,720 ± 5%
Panfish	487,840 ± 3%	7,090,240 ± 5%
Muskellunge	26,240 ± 15%	228,000 ± 30%
Northern pike	294,400 ± 4%	2,862,400 ± 7%
Suckers	86,720 ± 8%	745,280 ± 15%
Smelt	90,880 ± 8%	286,400 ± 19%
Lake trout	104,800 ± 7%	729,760 ± 14%
Steelhead trout	96,480 ± 8%	707,040 ± 14%
Rainbow trout	106,400 ± 7%	917,760 ± 13%
Brown trout	101,440 ± 8%	917,440 ± 13%
Brook trout	124,160 ± 7%	1,045,440 ± 11%
Coho salmon	168,000 ± 6%	978,080 ± 9%
Chinook salmon	97,120 ± 8%	646,560 ± 12%
Other	58,720 ± 10%	764,960 ± 18%

* Confidence limits (95 percent) are presented as a percentage of the estimate.

Another way of looking at fishing in Michigan is to view its distribution over time (Figure 2). Fishing pressure is greatest in July and August, which also reflects the pattern of many other outdoor recreation activities in Michigan.

Salmon and Steelhead Fishing

Salmon and steelhead fishing deserve special mention since the emphasis of this report series is on the economic appraisal of the value of this fishery to the people of Michigan in 1970 (see next section).

In 1971 the number of fishermen seeking salmon and steelhead has increased substantially from 1965 when only a few thousand fishermen (nearly all in the Lake Superior area) were fishing for lake trout and steelhead. Mature salmon were first available to the sport fishery in 1967.

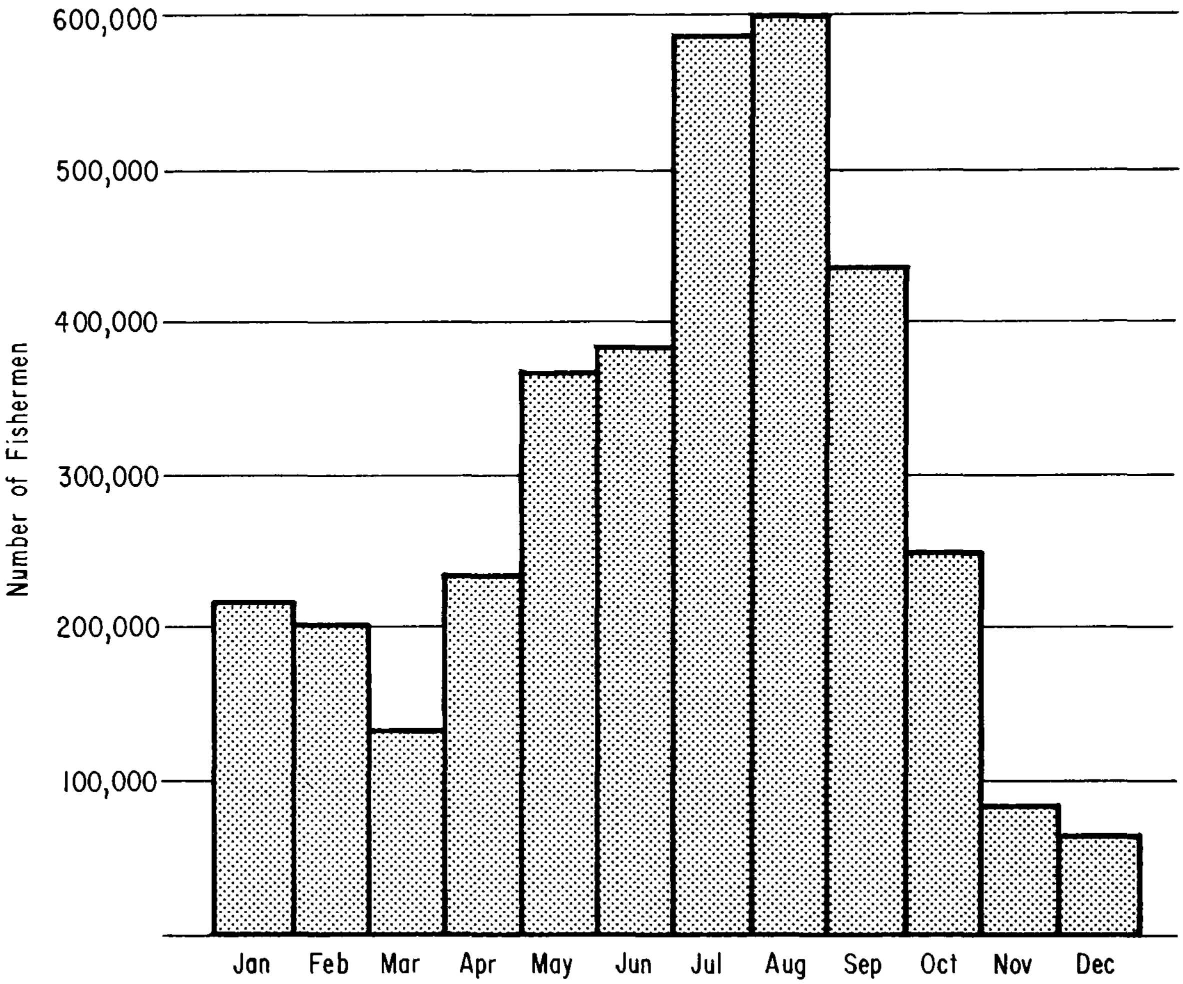


Figure 2. Monthly distribution of Michigan fishermen in 1971.

Nearly 200,000 fishermen fished over two million days for Great Lakes salmon and steelhead in 1971. This is 10 percent of the total angler-days estimated for licensed fishermen in Michigan. Seventy-eight percent of the salmon and steelhead effort was on Lake Michigan and its major tributary streams. The Lake Huron and Lake Superior areas accounted for 12 and 10 percent, respectively, of the remaining effort. In terms of fish caught, fairly substantial increases were registered in 1971 over those recorded in 1970 (Table 8), even though there was only a moderate increase in angling effort.

Table 8. The numbers of salmon, steelhead, and lake trout caught in the Michigan waters of the upper Great Lakes and their major tributaries in 1970 and 1971.

	Lake trout		Steelhead trout		Coho salmon		Chinook salmon	
Open lake:	1970	1971	1970	1971	1970	1971	1970	1971
Michigan	238,490	303,240	95,410	99,940	374,260	459,080	36,400	48,200
Superior	171,400	143,640	18,590	20,060	30,610	41,460	2,020	1,140
Huron	560	2,820	17,970	29,500	41,940	25,540	14,560	10,240
Total	410,450	449,700	131,970	149,500	446,810	526,080	52,980	59,580
Major tributaries of:								
Michigan	6,400	7,800	189,450	286,520	159,690	163,780	143,510	199,680
Superior	980	0	50,480	87,900	10,420	8,480	840	4,480
Huron	0	0	28,150	52,680	40,970	40,800	4,200	39,840
Total	7,380	7,800	268,080	427,100	211,080	213,060	148,550	244,000
Total catch:								
Michigan	244,890	311,040	284,860	386,460	533,950	622,860	179,910	247,880
Superior	172,380	143,640	69,070	107,960	41,030	49,940	2,860	5,620
Huron	560	2,820	46,120	82,180	82,910	66,340	18,760	50,080
Grand total	417,830	457,500	400,050	576,600	657,890	739,140	201,530	303,580

Lake Michigan's dominant role is explained by the relatively large numbers of salmon, lake trout and steelhead planted, the abundant food supply of alewives available to these fish, and its easy accessibility from the large urban areas in Michigan and the Midwest.

Areas of residence of anglers who fished for salmon and steelhead in 1971 are shown in Table 9. Out-of-state salmon fishermen nearly equaled the number of residents who live in the northern two-thirds of the state (Regions I and II of Fig. 1). Southern Lower Peninsula fishermen (mostly urban dwellers) composed nearly two-thirds of the salmon and steelhead fishermen in the state. Even though most of the resource is in northern Michigan, many fishermen were willing to spend time and money to enjoy this high quality recreation.

In terms of participation, coho salmon fishermen outnumbered steelhead fishermen by two to one in Regions I and III and Region II hosted five coho salmon fishermen for every four steelhead fishermen. In absolute numbers, one out of five fishermen in Region I was a salmon fisherman, one out of four in Region II, and one out of seven in Region III.

Table 9. Residence of Michigan's salmon and steelhead trout fishermen in 1971.

Area of residence	Steelhead trout	Coho salmon	Chinook salmon
	--------------	Number of fishermen	--------------
Upper Peninsula	6,560	11,840	2,720
Northern Lower Peninsula	19,040	24,640	14,880
Southern Lower Peninsula	60,320	100,000	62,080
Michigan total	85,920	136,480	79,680
Non-residents	10,560	31,520	17,440
Grand total	96,480	168,000	97,120

SUMMARY

Michigan fishermen who fished in 1971 were surveyed twice by mail and once by telephone. The objective of the surveys was to measure the recreational benefits of the sport fishery for the purpose of guiding public and private investment in fishing and related programs. The telephone survey was conducted parallel to the first mail survey to test out this method of assessing the sport fishery. Statewide estimates of sport catch by the two methods were similar for the period surveyed (the first half of 1971). However, the telephone survey estimates lacked the precision necessary to meet management requirements for estimates at the county and multi-county level.

Licensed fishermen were estimated to have spent nearly 22 million days fishing in 1971. The average licensed fisherman fished 21 days. Fishing wives of license holders and children under the age of 17 who fished totaled slightly more in number than licensed fishermen. This means that one out of five Michigan residents spent some time fishing in 1971. The top three fish groupings in order of preference were panfish (mostly bluegills), bass, and yellow perch. The favorite among salmon and trout fishermen was the coho salmon, followed by brook trout. The peak months of fishing were July and August. About 600,000 participants fished in each of these months. November and December were the low points in the fishing year with 84,000 and 65,000 active fishermen, respectively.

Ice fishing, one of the leading winter recreational activities in the state, attracted 251,600 fishermen who fished a total of 2,679,400 days. Fishing activity was well distributed over the state because Michigan is ringed by 3,200 miles of Great Lakes shoreline, has 38,000 miles of streams, and contains over 10,000 lakes.

Salmon, lake trout, and steelhead trout fishing, essentially new or revived activities since the first run of jack salmon in 1966, is an important piece of the sport fishing package in Michigan. Over two million of these Great Lakes salmon and trout were taken in Michigan during 1971. Two hundred thousand fishermen are presently enjoying two million days of sport fishing yearly for these species. This is ten percent of the total fishing activity in the state. Lake Michigan and its major tributary streams account for nearly 80 percent of the salmon and steelhead fishing effort. This is explained by the huge natural and hatchery-raised supply of sport fish in the lake which primarily utilizes an excellent forage base of alewives and smelt. A slow but steady growth in the amount of sport fishing devoted to Great Lakes salmon and trout is expected over the next few years.

THE 1971 SPORT TROLLER PROJECT

by Ronald W. Rybicki

INTRODUCTION

In 1971, a group of sport fishermen and licensed charterboat operators voluntarily submitted records on their Great Lakes salmon and trout fishing activities to the Fisheries Division. The purpose of the project was to economically obtain accurate biological information on Great Lakes salmonids in the sport catch. This report summarizes the catch, effort and biological data provided by the sport trollers.

METHODS

One-hundred and eleven expert anglers and licensed charterboat operators were asked to voluntarily maintain and submit records on their daily Great Lakes salmon-trout fishing trips.

Each participant was provided with a packet containing data forms, an instruction sheet, and pre-addressed stamped envelopes. For each fishing trip, the cooperator was instructed to report the area in which he fished, depth at which most salmonids were caught, offshore distance where most fish were caught, numbers of anglers in the party, and hours fished. For each salmonid caught, they were to record the species, length, fin clip, tag origin and number, and the number of fresh lamprey wounds and the number of scars.

For convenience, the results from the sport troller reports for each port area are combined to represent larger statistical areas as shown in Figures 1-3.

RESULTS AND DISCUSSION

Lake Michigan

Effort and Catch

Thirty-seven sport-troller cooperators on Lake Michigan reported 812 fishing trips in 1971. These trips generated 2,806 days of angling and catches of 2,677 lake trout, 2,368 coho, and 189 chinook, rainbow and brown trout (Table 1).

The best catches of lake trout came from the northern statistical districts MM-1, MM-3, and MM-4 (Fig. 1). These areas traditionally have been the most productive sport fishing grounds for lake trout. Grand Traverse Bay is particularly favored by anglers because it offers an excellent lake trout population, protection from prevailing westerly winds and short runs to the fishing grounds.

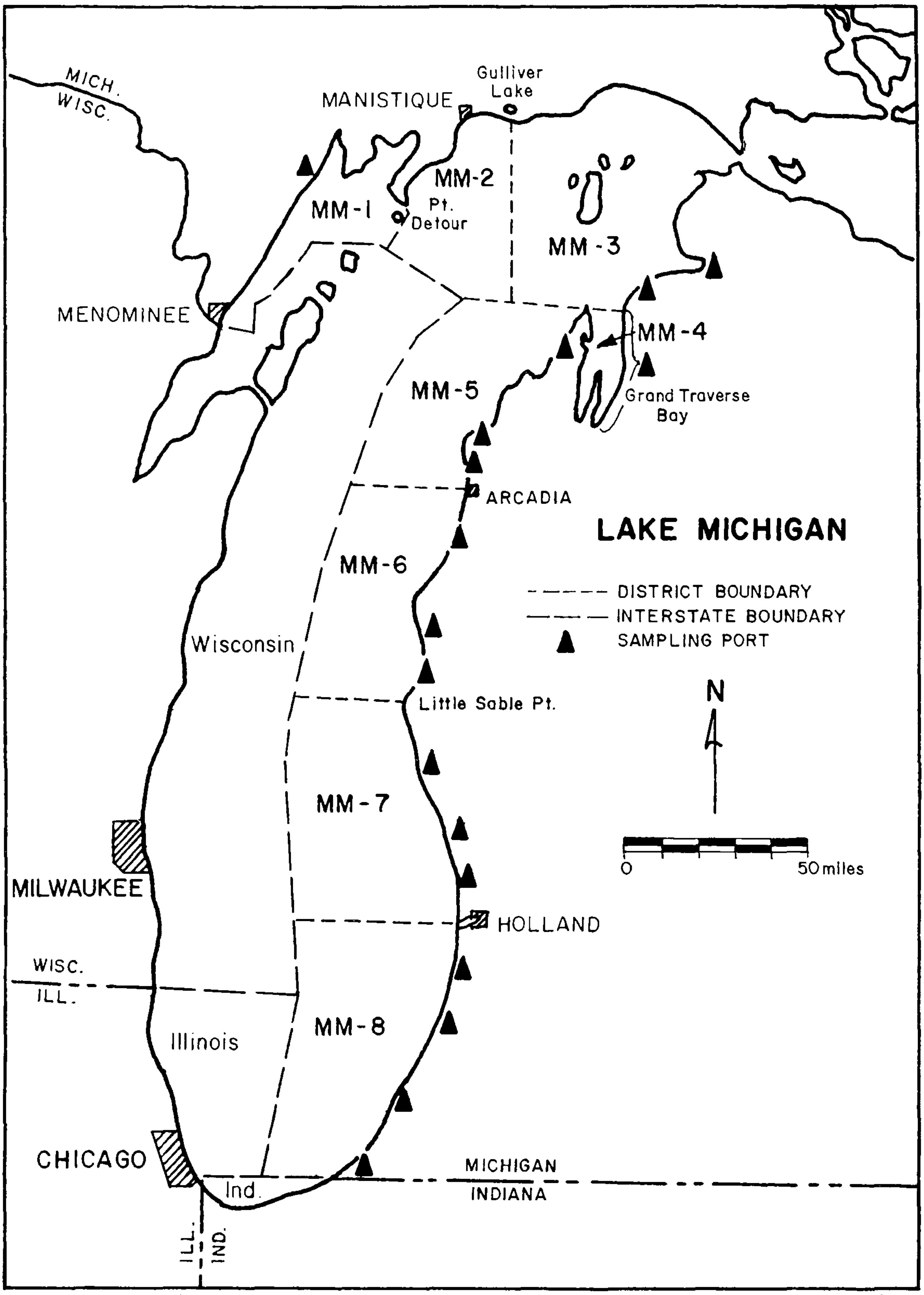


Figure 1. Michigan statistical districts of Lake Michigan and port areas of volunteer sport troller activity.

Table 1. Effort, catch and catch per angler day by Lake Michigan volunteer sport trollers in 1971.

Stat. dist.	Boat trips	Angler days	Number caught and mean catch per angler day (in parentheses)					
			Lake trout	Rainbow trout	Brown trout	Coho salmon	Chinook salmon	Total salmonids
MM-1	7	42	117	---	---	---	---	117
			(2.8)					(2.8)
MM-3	42	89	236	1	---	24	---	261
			(2.7)	(<0.1)		(0.3)		(2.9)
MM-4	244	878	1642	6	4	55	22	1729
			(1.9)	(<0.1)	(<0.1)	(0.1)	(<0.1)	(2.0)
MM-5	10	29	7	---	---	88	---	95
			(0.2)			(3.0)		(3.3)
MM-6	253	913	400	26	1	1480	54	1961
			(0.4)	(<0.1)	(<0.1)	(1.6)	(0.1)	(2.2)
MM-7	153	524	224	31	2	293	25	575
			(0.4)	(0.1)	(<0.1)	(0.6)	(<0.1)	(1.1)
MM-8	103	339	51	7	1	428	6	493
			(0.2)	(<0.1)	(<0.1)	(1.3)	(<0.1)	(1.5)
Totals	812	2814	2677	71	8	2368	107	5231
			(1.0)	(<0.1)	(<0.1)	(0.8)	(<0.1)	(1.9)

Coho catch rates tend to be greatest in MM-5 through MM-8. During midsummer in MM-6, when the coho were distributed from 10 to 20 miles off-shore, lake trout seemed to be the bread-and-butter species--accounting for 46-80 percent of the catch in July. The spring salmon fishery is concentrated almost exclusively in MM-8, but districts MM-5 and MM-6 support the bulk of the important salmon fishing. Neither chinook, rainbows nor brown trout contributed significantly to the open-water catch.

Not surprisingly, the volunteer group was much more successful than the rest of the angling population--1.86 salmonids per angler day on the average, versus 0.74 salmonids per angler day observed in the 1971 field survey. The volunteers are known to be good fishermen with much more sophisticated fishing gear.

Average lengths (inches) of salmon and trout in the volunteers' catches for the season were:

Species	Mean	Range
Coho salmon	26.8	12-36
Chinook salmon	29.0	14-46
Lake trout	24.8	12-36
Rainbow trout	25.0	14-32

Depth Distribution

The depths where Great Lakes salmonids are caught are largely dependent upon the temperature preferences of the various species, which are 49° F. for lake trout, 53° F. for salmon, and 55° F. for rainbows. The daily depth ranges at which salmonids were caught by the Lake Michigan cooperators were so extremely variable that the data are meaningless. The depths at which salmonids were found changed almost daily, depending upon how wind velocity and direction affected the temperature regimes and baitfish distribution. Onshore winds tend to lower the thermocline, pushing the fish deeper and farther offshore, while offshore winds cause cold water upwellings which bring the fish closer to shore.

Age Composition of Lake Trout

Nearly all (97%) of the lake trout caught were fin clipped. Since there has been no evidence of natural reproduction by lake trout in Lake Michigan to date, the unmarked fish likely either bore regenerated clips, were unmarked hatchery fish, or the clip simply was missed by the observer. Lake trout were assigned to year classes on the basis of the fin clip. However, considerable judgment was needed because the size of the fish frequently failed to correspond to the age prescribed by the clip. It is likely that the discovery of one clipped fin sometimes precluded the search for others. The adjusted year-class composition and mean length of lake trout in the volunteers' catches is given in Table 2. The 1966 and 1967 year classes dominated the catches from statistical districts MM-3 through MM-7. In 1967, 285,000 fingerling lake trout (76 fish to the pound) were planted in the Ludington-Manistee area of MM-6. Twenty percent of the lake trout catch in MM-6 was from the fingerling release as compared to 29 percent of the 1967 class planted as yearlings in the same area one year later. However, the percentage of the fingerling plant caught by the volunteers was only 0.02 percent while 0.12 percent of the yearling plant was caught, which suggests a greater survival rate for the fish released as yearlings.

Table 2. Percentage year-class composition of fin-clipped lake trout in the volunteer sport troller catches from Lake Michigan in 1971.

Statistical district	Year class 1964	1965	1966	1967	1968	1969	1970	Sample size
MM-1	54.8	18.3		11.1	9.5	----	----	118
MM-3	1.0	22.8	46.5	27.2 1.0*	1.5	----	----	206
MM-4	6.5	20.1	44.3	20.6 0.4*	7.5	0.3	0.3	1609
MM-5	----	100.0	----	----	----	----	----	7
MM-6	7.3	14.9	17.1	29.0 19.9*	11.8	----	----	357
MM-7	17.0	11.2	36.2	23.4 8.5*	3.7	----	----	188
MM-8	2.9	48.5	2.9	31.4 2.9*	11.4	----	----	35
Mean length	27.5	27.4	24.4	22.7	21.3	14.7	14.5	

* Planted as fingerlings (76/lb.) in MM-6 in 1967.

Lamprey Wounding in Lake Trout

Lamprey wounding data provided by the sport trollers also are uncertain. Percentages of Lake Michigan lake trout bearing lamprey marks were consistently and considerably less than those obtained from departmental netting surveys (Table 3). It is not known whether the disagreement in these data between the two sources reflects differences in fishing gear selectivity, differences in locations within a statistical area, or perhaps the professionally trained eye detects nearly invisible scars which others fail to see.

Table 3. Comparison between incidences of lamprey wounding (%) on Lake Michigan lake trout (≥21.0 inches) as determined from department surveys and volunteer sport troller reports, September - October, 1971.

Statistical district	Data source	Sample size	Fresh wounds	Healed wounds	Total wounds
MM-3	Volunteers	33	0.0	33.3	33.3
	Fisheries Division	838	1.5	48.9	49.6
MM-4	Volunteers	102	0.0	24.5	24.5
	Fisheries Division	438	1.8	48.9	50.7
MM-6	Volunteers	26	3.8	15.4	19.2
	Fisheries Division	371	9.7	62.5	68.7
MM-7	Volunteers	13	0.0	11.1	11.1
	Fisheries Division	155	1.3	18.1	18.1

Lake Superior

Effort and Catch

Nearly all of the 144 fishing reports received from the five sport troller volunteers pertained to the western half of Michigan's waters of Lake Superior (Fig. 2). Even so, the statistical districts are so large and the fishery so localized that the data are not necessarily indicative of the fish stocks in a given statistical sector.

Lake trout were by far the dominant species in the volunteers' catches--ranging from 88 percent to 100 percent of the total catch within a statistical district. The best mean catch of 1.8 lake trout/angler day came from the Isle Royale area of MS-1 (Table 4), falling short of the top catch rates of 2.8 and 2.7 lake trout per angler day reported by Lake Michigan volunteers for statistical areas MM-1 and MM-3, respectively.

The average mean lengths (inches) of Lake Superior salmonids creeled by the sport troller volunteers were:

Species	Length	Range
Lake trout	22.1	10.0 - 33.0
Rainbow trout	22.3	16.0 - 30.0
Coho salmon	19.1	17.0 - 21.0

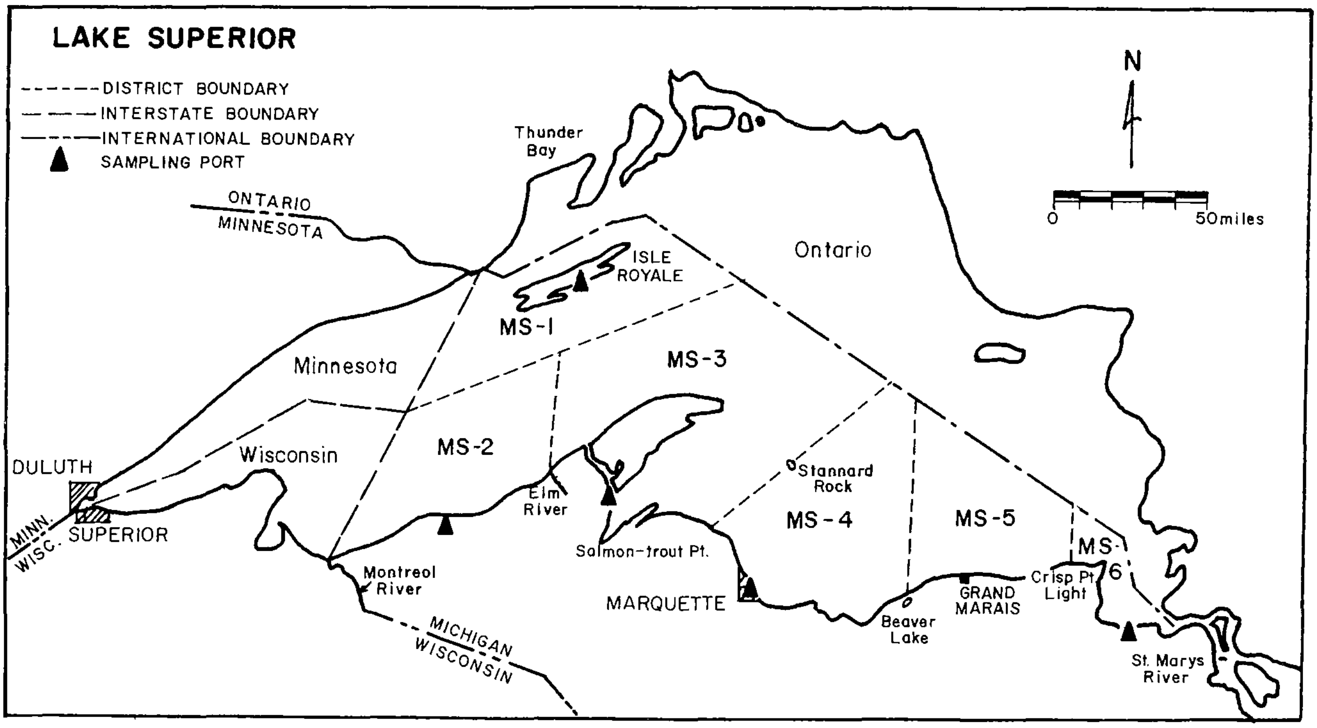


Figure 2. Michigan statistical districts of Lake Superior and port areas of volunteer sport troller activity.

Table 4. Effort, catch and mean catch per angler day by Lake Superior volunteer sport trollers in 1971.

			Number and mean catch/angler day (in parentheses)					
Stat. dist.	Boat trips	Angler days	Lake trout	Rainbow trout	Brown trout	Chinook salmon	Coho salmon	Total salmonids
MS-1	73	197	106 (0.5)	---	---	---	---	106 (0.5)
MS-2	48	264	473 (1.8)	37 (0.1)	8 (<0.1)	---	24 (0.1)	542 (2.0)
MS-3	20	94	97 (1.0)	---	---	---	12 (0.1)	109 (1.1)
MS-4	2	11	2 (0.2)	---	---	---	---	2 (0.2)
MS-5	1	2	---	---	---	---	---	---
Totals	144	568	680 (1.2)	37 (0.1)	8 (<0.1)	---	36 (0.1)	761 (1.3)

Age Composition of Lake Trout

None of the lake trout taken from MS-1 (Isle Royale) were fin clipped, indicating all of the offshore stocks were from natural recruitment. Twenty-two percent and six percent of the lake trout caught in MS-2 and MS-3, respectively, were reported unmarked.

The 1963 year class accounted for 24 percent of the catch in MS-2 (Table 5), while the lake trout catch from Keweenaw Bay (MS-3) consisted of three principal year classes--1963 (21%), 1964 (33%), and 1965 (25%).

Table 5. Percentage year-class composition of fin-clipped lake trout in the volunteer sport troller catches from Lake Superior in 1971.

Stat.	Year class									Sample
dist.	1961	1962	1963	1964	1965	1966	1967	1968	Unknown*	size
MS-1	--	--	--	--	--	--	--	--	100%	106
MS-2	0.6	3.5	24.1	14.9	15.8	7.0	12.1	--	22.0	312
MS-3	1.0	1.0	21.0	33.0	25.0	5.0	--	7.0	6.0	100

* Not clipped

Lamprey Wounding on Lake Trout

Lamprey attacks on lake trout, as reported by the volunteers, apparently are still quite severe, ranging from an incidence of 14 percent to 40 percent (Table 6). Total wounding on steelhead (>17.0 inches) from MS-2 was 8 percent.

Table 6. Percentage of Lake Superior lake trout (>17.0 inches) bearing lamprey marks in 1971 as reported by volunteer sport trollers.

Statistical district	Sample size	Fresh wounds	Healed wounds	Total wounded
MS-1	68	4.8	13.2	14.7
MS-2	318	35.8	19.5	40.6
MS-3	104	4.8	9.6	14.4

Lake Huron

Effort and Catch

Of the 46 fishing trips reported by the volunteer sport trollers on Lake Huron, 90 percent were made in the St. Martin's Bay area in MH-1 (Fig. 3). The total catch consisted of 71 salmonids, of which 17 percent were coho, 39 percent were brown trout, and 44 percent were rainbow trout. This is an average catch rate of 1.1 salmonids per angler day.

The mean lengths (inches) of the salmonids in the volunteer sport troller catch were:

Species	Mean	Range
Coho salmon	25.2	23-30
Rainbow trout	20.2	16-24
Brown trout	20.1	16-22

Lamprey Wounding

Lamprey preyed heavily on Lake Huron rainbow and brown trout. Seventeen percent of the rainbows and seven percent of the brown trout bore fresh lamprey wounds. The wounding incidence on brown trout as reported by the volunteers is unexplainably at variance with the one percent wounding frequency observed in departmental netting surveys.

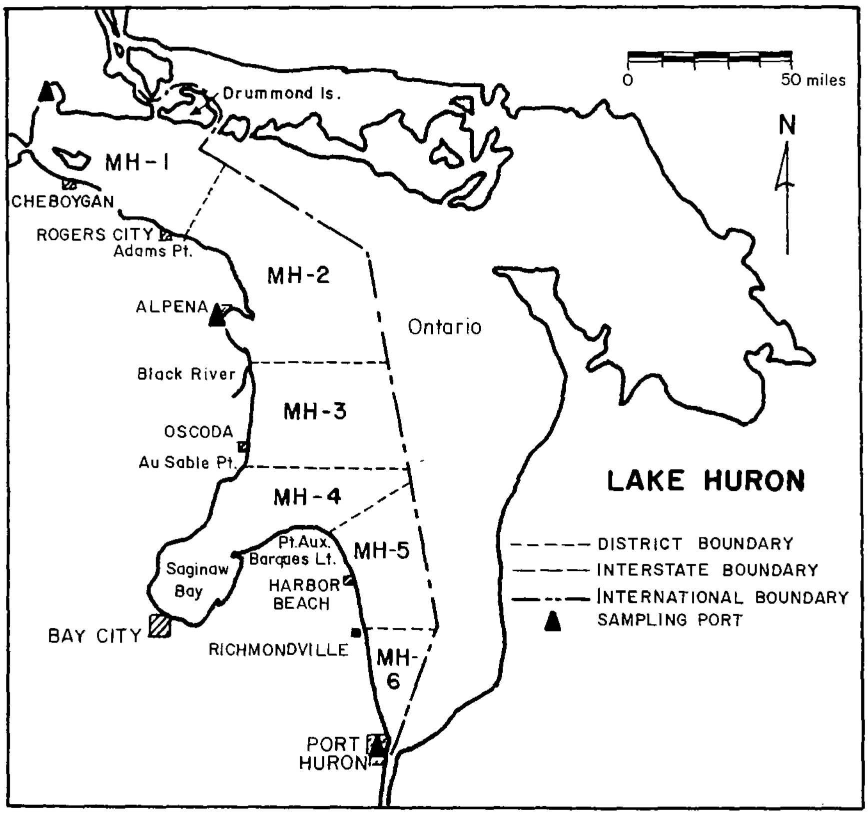


Figure 3. Michigan statistical districts of Lake Huron and port areas of volunteer sport troller activity.

SUMMARY

1. The objective of the volunteer sport troller project was to obtain biological data on the sport catch as a supplement to other data sources.

2. Forty-five Great Lakes sport trollers volunteered to maintain records on their fishing activities in 1971.

3. Thirty-seven Lake Michigan cooperators reported 812 fishing trips and catches of 2,677 lake trout, 2,368 coho salmon, and 189 chinook salmon, rainbow trout and brown trout.

4. Lake Michigan catch rates were greatest for lake trout (1.0/angler day) and coho salmon (0.8/angler day).

5. Mean lengths of salmonids in the Lake Michigan volunteers' catches were: coho salmon--26.8"; chinook salmon--29.0"; lake trout--24.8"; rainbow trout--25.0".

6. All of the Lake Michigan lake trout in the volunteers' catch were hatchery fish. The 1966 and 1967 year classes occurred with the greatest frequency.

7. Volunteer anglers on Lake Superior reported 144 trips.

8. Catches from Lake Superior consisted of from 88 to 100 percent lake trout.

9. The mean catch rate for Lake Superior lake trout was 1.2 fish per angler day.

10. The mean length of Lake Superior salmonids in the volunteers' catches were: lake trout--22.1"; rainbow trout--22.3"; coho salmon--19.1".

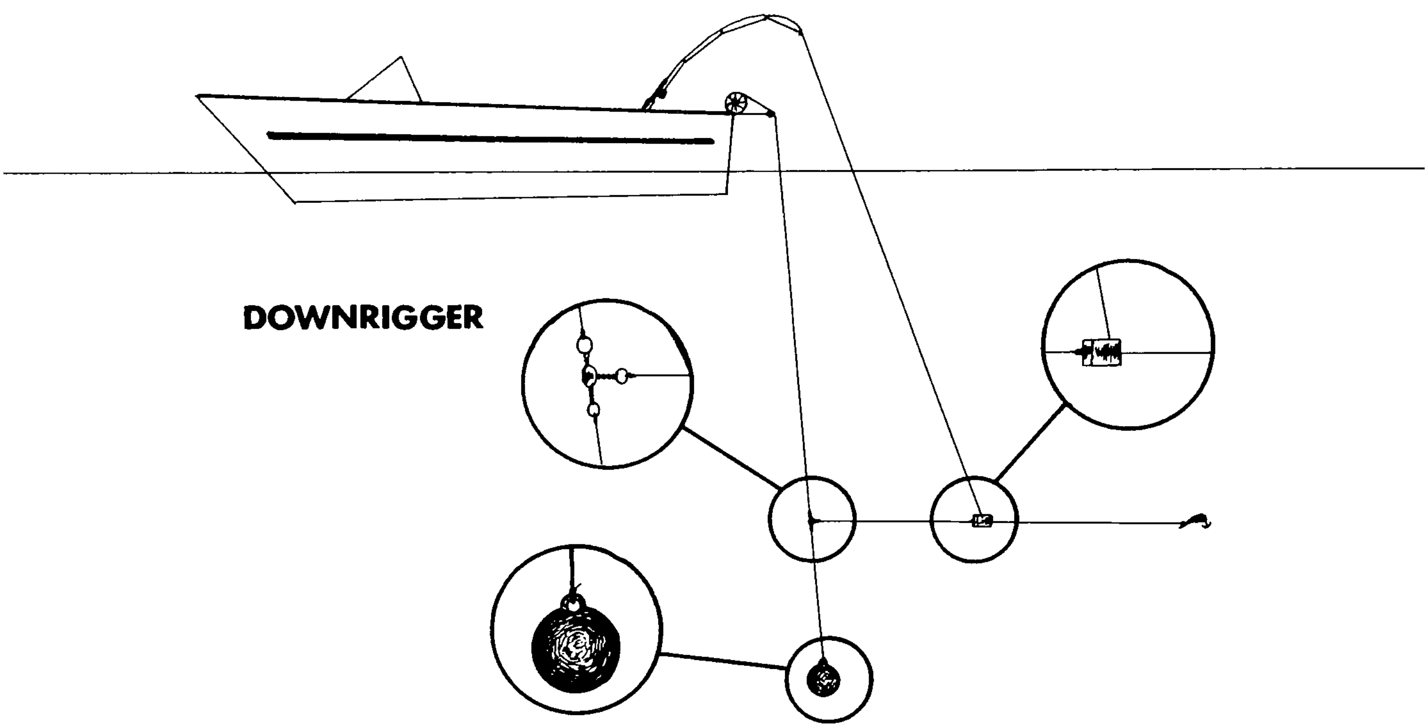
11. All of the Lake Superior lake trout from the Isle Royale area were from natural reproduction, while 22 percent of the Black River Harbor and 6 percent of the Keweenaw Bay catches were not fin clipped.

12. Forty-six fishing trips were reported by Lake Huron volunteer sport trollers. Their catch consisted of 71 salmonids, of which 17 percent were coho salmon, 39 percent were brown trout, and 44 percent were rainbow trout.

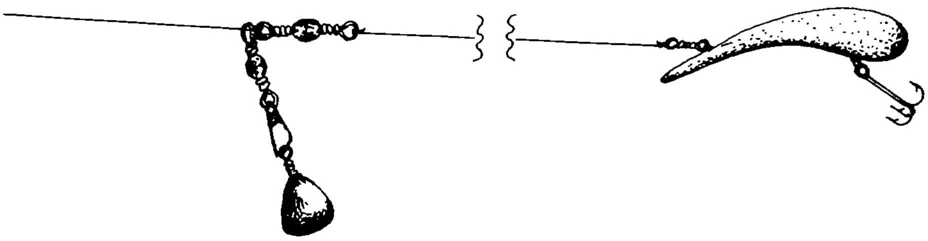
13. The catch rate of the Lake Huron volunteers was 1.1 salmonids per angler day.

14. The mean lengths of salmonids in the Lake Huron volunteers' catches were: coho salmon--25.2"; rainbow trout--20.2"; brown trout--20.1".

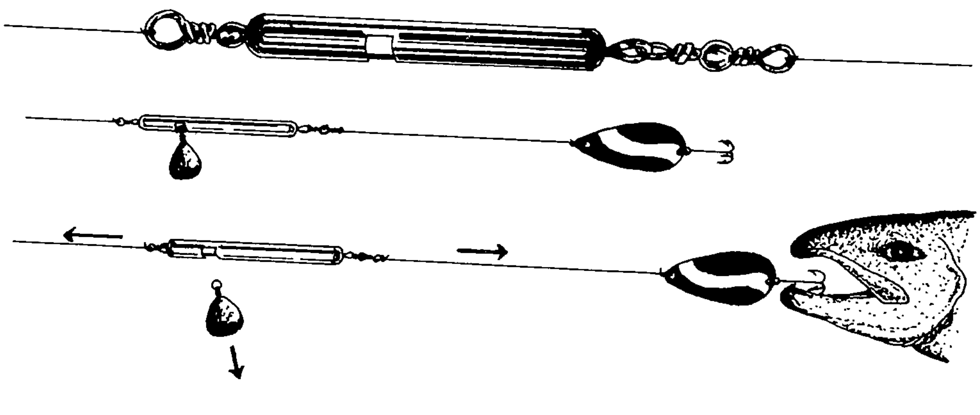
DOWNRIGGER



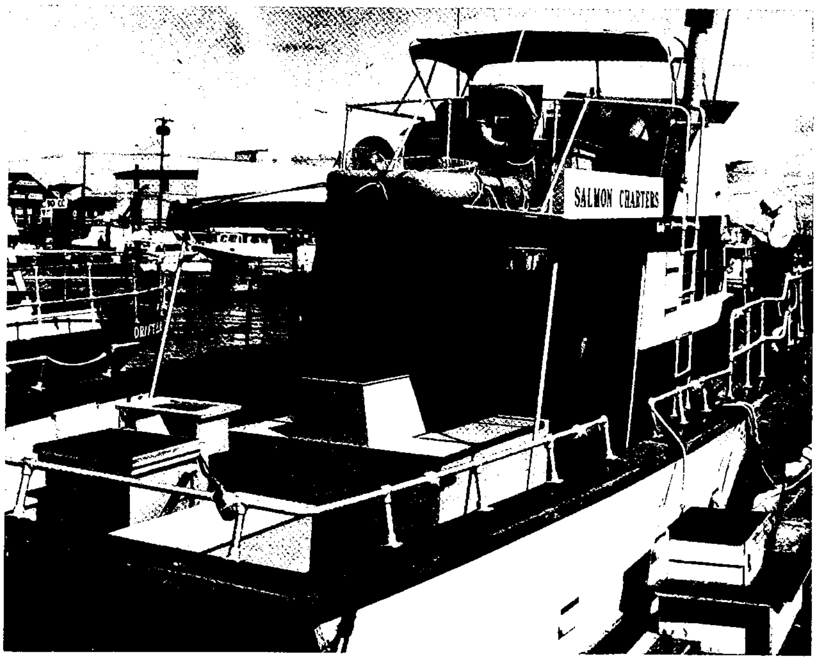
CONVENTIONAL TROLLING

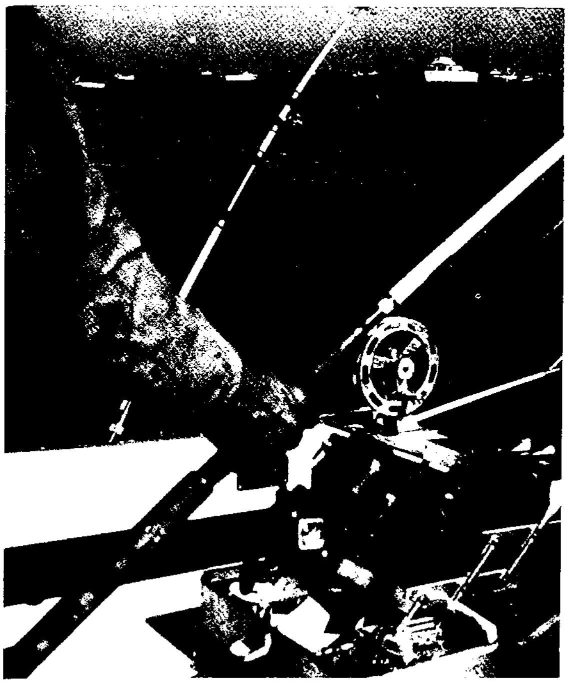


SINKER RELEASE METHOD



Economic Evaluations Of The Sport Fishery





INTRODUCTION AND SUMMARY

by Daniel R. Talhelm[1] and Paul V. Ellefson[2]

The unprecedented and widely recognized success of Michigan's salmon and steelhead trout program has been truly remarkable. Anglers currently spend nearly two million days annually fishing for salmon or steelhead in Michigan.[3] Surely the program is a classic example of innovation and wise use of public resources for the public good. As with any public program questions regarding its direction and efficiency must inevitably be raised. For example: Are public monies invested in the program returning values of comparable magnitude? Will additional dollars invested in the program bring greater or less return to the public than dollars previously invested? What other opportunities exist for investment of public monies and should some of the funds be diverted to or from these opportunities? How many citizens are being served by the program, who are they, and where do they reside? Should other uses of the fishery resource--e.g., commercial fishing--become active and integral parts of the program? Certainly there are some similar questions, all of which must at some time during the life of the program be coped with by policymakers and administrators.

Answers to questions about public investment in Michigan's salmon and steelhead sport fishery are not easy to come by. They are dependent upon thorough knowledge of complex economic and biological systems distinctive of the sport fishery. In particular they rest on an awareness of how these complex systems respond to management alternatives and which responses are truly in the public interest. Such knowledge is essential to the continued success of the program. As ever increasing demands are placed on the fishery resource, managers will inevitably be faced with an ever growing number of economic and biological questions, answers to which will require far more knowledge about systems which comprise the sport fishery as well as further development of more reliable economic and biological guides for use in making decisions in the public interest.

This study of Michigan's 1970 salmon and steelhead sport fishery program was initiated with the aim of securing much needed information required for better guidance of public investment in the salmon and steelhead sport fishery program and related programs. The economic studies focused attention on the costs and the benefits of the program, its efficiency, and the nature of the people being served.

The primary economic studies were begun by Ellefson and continued by Talhelm. Those studies investigated the demand, supply, costs, benefits and related aspects of the anadromous fishery. Other studies were conducted by

---

1 Resource Economist, Office of Planning Services, Michigan Department of Natural Resources.

2 Director, Environmental Programs, Society of American Foresters.

3 "Days" refers to angling participation by one person on any part of one day.

Pearce, and Kapetsky and Ryckman, as part of independent investigations for other purposes. They were assisted in their work by the Anadromous Fish Study investigators, and since the studies are relevant to the overall investigation, they are included with this report. Pearce estimated the value of angling (primarily inland trout angling) on the Au Sable River, and Kapetsky and Ryckman estimated the economic impact of salmon, steelhead and (primarily) lake trout angling in Grand Traverse Bay upon the local economy.

The objectives of the studies by Ellefson and Talhelm were quite similar. Both estimated the benefits of the anadromous fishery and compared the benefits with costs to evaluate the efficiency of the program. The difference was that Ellefson used a well-known technique to determine the total benefits in one sense, whereas Talhelm used a new, more flexible technique to estimate total benefits in two other senses. Talhelm also established and utilized a procedure for estimating the benefits of certain hypothesized changes in the Anadromous Program at particular locations.

The studies showed that the value of salmon-steelhead angling to anglers was nearly $30 million annually. In other words, anglers would be willing, if necessary, to contribute or pay a maximum of nearly $30 million annually (not including any of their present $15.5 million expenditures) to prevent the total loss of the opportunity for salmon-steelhead angling.

Establishing and maintaining the fishery has required a considerable investment in money and manpower for hatchery facilities and for continuous annual stocking and other management efforts. On an annual basis, these costs are about $1.6 million, including payments that would recover the initial investments plus interest. Consequently, the ratio of benefits to costs is about 30 to 1.6, or roughly 18 to 1. There is no question that the net public welfare was increased with the advent of the fishery.

In Talhelm's analysis, the estimate that anglers would be willing to contribute a maximum of about $30 million to prevent the loss of the opportunity for salmon-steelhead angling, was based on the assumption that all other kinds of angling would remain available under the same conditions as existed in 1970. Talhelm also estimated that anglers would be willing to contribute or pay about $23 million to prevent the loss of salmon-steelhead angling opportunity, under the assumption that anglers would simultaneously face an equivalent loss of all other kinds of angling opportunity. Ellefson estimated that Michigan residents would be willing to contribute or pay between $18 and $24 million (depending upon the value of leisure time), under the implicit assumption that anglers would simultaneously face a roughly equivalent loss in Great Lakes lake trout angling opportunity and some loss of other kinds of trout angling opportunity. The exact assumptions are uncertain because of the methodology used. If nonresidents had been added to the total willingness to contribute, Ellefson's estimate would probably have been $24 to $30 million.

The three net value estimates are all estimates of the net benefits to anglers of salmon-steelhead angling. They estimate the degree to which anglers are better off with the fishery than without it. For this reason, they may be termed the "all-or-none" values of angling opportunity, and may appropriately be used for cost/benefit analysis of the program.

However, the figures should be used with caution. They represent the "social" value of the fishery to anglers, and are considerably different from the market value of the sport fishery: the amount anglers would be willing to pay in an actual market situation for the opportunity to participate in the sport. The market value would be only about one-third of the total "social" value, and since most goods and services are allocated based upon market value, the market value may be considered to be the more appropriate value for many purposes. In particular, a "value per angler day" figure derived from the market value would more closely approximate the value of increased or decreased angler days resulting from incremental changes in the anadromous program.

The most accurate procedure for estimating the benefits of incremental changes in the program (e.g., stocking fish in new locations, or changing the number or species of fish stocked) is to utilize the demand and supply information in a "simulation model". This procedure takes into account (1) the fact that different anglers have different preferences, (2) the availability of the different kinds of angling,[4] (3) the willingness of anglers to substitute one kind of salmon-steelhead angling for other kinds of salmon-steelhead angling, and (4) the probability that any change that is beneficial to some may be detrimental to others (depending upon personal preferences), and vice versa. The procedure is to estimate both the willingness of anglers to contribute or pay to promote a change, and the willingness of anglers to contribute to prevent the change. Trial evaluations using a simulation model developed by Talhelm showed that additional stocking of salmon or steelhead would be more beneficial in certain locations than in others, but in general the program should be expanded. The simulation model could be used to help reshape the program to the maximum benefit of the people.

Ellefson, and Kapetsky and Ryckman showed that the Anadromous Program has considerable impact upon the communities near the angling locations. Ellefson found that 60 percent of the $15.5 million spent by anglers was spent in or near the location fished. Kapetsky and Ryckman found that $419 thousand was spent in the Grand Traverse Bay area by anglers who live elsewhere and whose primary purpose was angling in the Bay. An estimated 21.5 full-time equivalent jobs in the area were attributable to the fishery.

Pearce conservatively estimated that the value of sport fishing on the Au Sable River was $536 thousand in 1970 and $836 thousand in 1971.

---

[4] Different kinds of angling were defined in Talhelm's study. There were four kinds of non-anadromous angling (lake trout, inland trout, other game fish, and perch-panfish) and several kinds of anadromous angling, each with a different combination of catch rates for the various anadromous species.

ECONOMIC APPRAISAL OF THE RESIDENT SALMON AND STEELHEAD SPORT FISHERY OF 1970

by Paul V. Ellefson

INTRODUCTION

This study of Michigan's 1970 salmon and steelhead sport fishery program was initiated with the aim of securing much needed information required for better guidance of public investment in the salmon and steelhead sport fishery program and related programs. The study focused attention on both the costs and benefits of the program. Program efficiency was examined as was the nature of the people being served.

Decisions as to how public monies are to be used to achieve specified objectives are essentially economic. They are limited only by the physical (or biological) and political framework in which a public program is operated. Ideally, managers would like to put each unit of land, water and public funds to that use, or combination of uses, which yields the greatest net benefit to the people in whose interest decisions are made. Where the value of goods and services and the cost of using land, water and public monies to produce them are adequately reflected by market prices, it is possible to compare the benefits and costs of alternative uses and determine the best use--that alternative which exhibits the greatest excess of benefits over costs. Procedures for evaluating benefits and costs of resource use are well developed in most agricultural and industrial sectors of our society. This is not so in the recreation sector.

The value ascribed by the public to benefits received when resources are used for recreation purposes is usually not reflected by a price which is determined in the market place. Without a price which reflects the value of using resources for various recreation purposes, managers are left without a rational and consistent method of judging between the many uses which compete for land and water resources and public monies. Consequently, they must rely instead on subjective judgment. In response to this problem, economists have recently directed attention to developing methods of evaluating non-priced recreational opportunities in an attempt to narrow the range of guesswork involved in recreation resource planning.

The evaluation of benefits flowing from Michigan's salmon and steelhead sport fishery program is founded on analysis of demand curves (Clawson and Knetsch, 1966). The procedure and the values that result rest on the following propositions: (1) a fisherman's willingness to sacrifice a portion of his income and time is a measure of the value placed on resources used to produce the sport fishing opportunities they consume; and (2) the number of angler days varies inversely with the price paid by the fisherman per angler day. An "angler day" is used as a measure of all or part of a day's fishing effort and represents the satisfaction or pleasure received by the fisherman for his fishing effort.

The evaluation procedure follows three major steps. First, a demand curve for the <u>whole recreation experience</u> is determined. This represents the demand situation for the entire sport fishing package, i.e., travel to and from the site, activity at the site, and recollection that occurs once the fisherman returns home.

Second, from the demand curve for the whole recreation experience, a recreation resource demand curve is determined. This relationship illustrated the fisherman's desire for various amounts of enjoyment produced by the salmon and steelhead resources themselves at various prices. The quality as well as the quantity of the fishing experience is reflected by the recreation resource demand curve.

Third, based on the resource demand curve, the value or worth of the fishing resources to the sport fisherman is determined. This value is termed the "net economic value" of the fishery and represents the degree to which fishermen are better off with the sport fishery than without it. It is the new or additional recreation produced by the salmon and steelhead program in contrast to that which might have existed without the program.

STATEWIDE VALUE

Demand Curve for the Whole Recreation Experience

Construction of the demand curve for the whole recreation experience requires the following: (1) travel distance between the fisherman's home and a fishing site; (2) money spent by the fisherman for various goods and services; and (3) number of days fished per 1000 population. A portion of this information was obtained from a survey of Michigan's 1970 salmon and steelhead fishermen, e.g., money spent and days fished. Only the fishermen's variable costs were used in constructing the demand curve, e.g., expenses such as gas, oil, food, lodging, bait, and rental fees. Fixed or durable costs were not used in the analysis.

The State of Michigan was divided into five distance zones, each based on the average distance traveled to a fishing site (Figure 1). Fishermen originating in Zone I traveled the greatest distance and, as expected, had the highest variable cost per angler day (Table 1). Fishermen from Zone V traveled the least distance and incurred the lowest cost per angler day.

Table 1. Demand situation for Michigan's resident salmon and steelhead sport fishery, 1970.

Distance zone	Mean distance traveled (miles)	Average variable cost per angler day (dollars)	Zone population (1,000's)	Sample angler days	Total angler days per 1000 population*
I	241	18.51	4914	1377	42.03
II	144	13.82	2064	2121	154.14
III	78	9.09	972	2593	400.15
IV	48	7.00	315	2013	958.57
V	20	3.08	515	3601	1048.84

* Total angler days = (Sample angler days) x (Expansion factor)

Figure 1. Geographic location of five distance zones in Michigan.

The demand curve for the whole salmon and steelhead recreation experience is presented in Figure 2. It depicts the relationship between the average variable cost per angler day and the number of angler days fished per 1000 population.

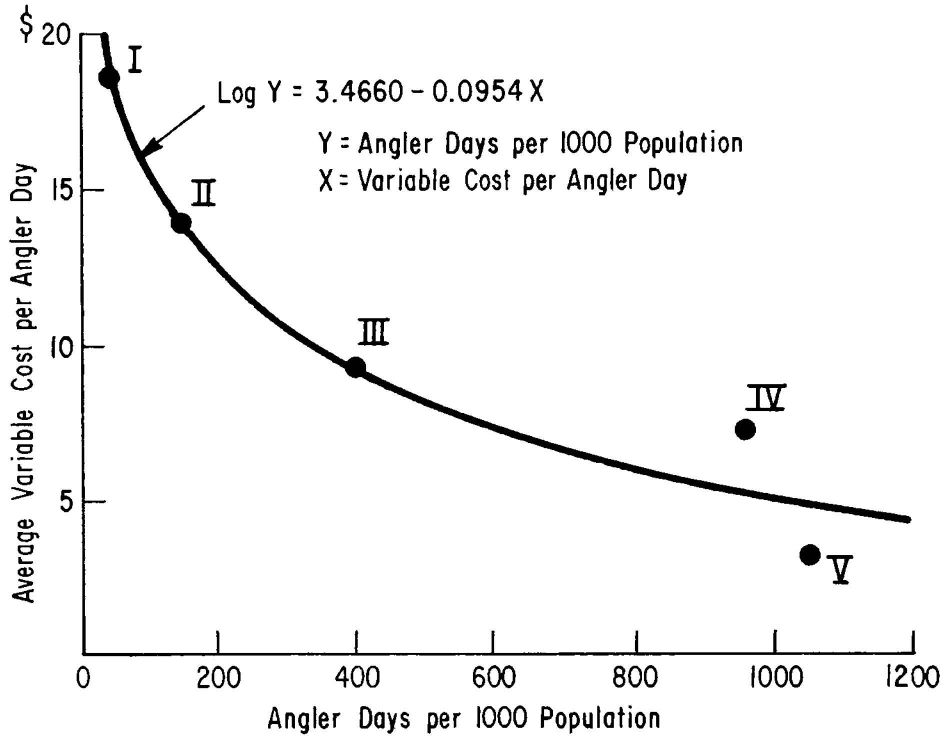


Figure 2. Demand curve for the whole Michigan salmon and steelhead recreation experience, 1970.

The demand curve for the whole recreation experience oversimplifies a very complex system which determines the number of angler days consumed by fishermen. First, there are factors other than variable cost which determine the number of angler days consumed. This is especially true for fishermen located in the greater distance zones (Zones I and II). For these fishermen, the level of fishing activity is not always a question of the money that must be spent in order to get to a fishing site. Rather, the constraint on their fishing activity is the amount of time available for travel to the site. In this light, the demand curve portrayed by Figure 2 is probably situated to the left of the true demand curve, especially in its upper reaches.

The demand curve is simplistic in yet another manner. It fails to portray in an explicit manner the impact that other supply and demand variables have on fishing activity. By not relating angler days per 1000 population to such variables as fishermen income, catch, weather, etc., the demand curve may be incorrectly located and, consequently, may provide inaccurate estimates of fishing activity at various costs per day. Unfortunately, the direction of this bias is unknown.

Demand Curve for the Recreation Resource

The demand curve for the salmon and steelhead recreation resource was derived from the demand curve for the whole recreation experience. It was determined from estimates of the angler days consumed by fishermen if the fishermen were faced with unit increases in the price of an angler day.

The demand curve for the salmon and steelhead resource is presented in Figure 3. It depicts the relationship between increases in daily fishing costs and the total number of angler days consumed by resident Michigan fishermen.

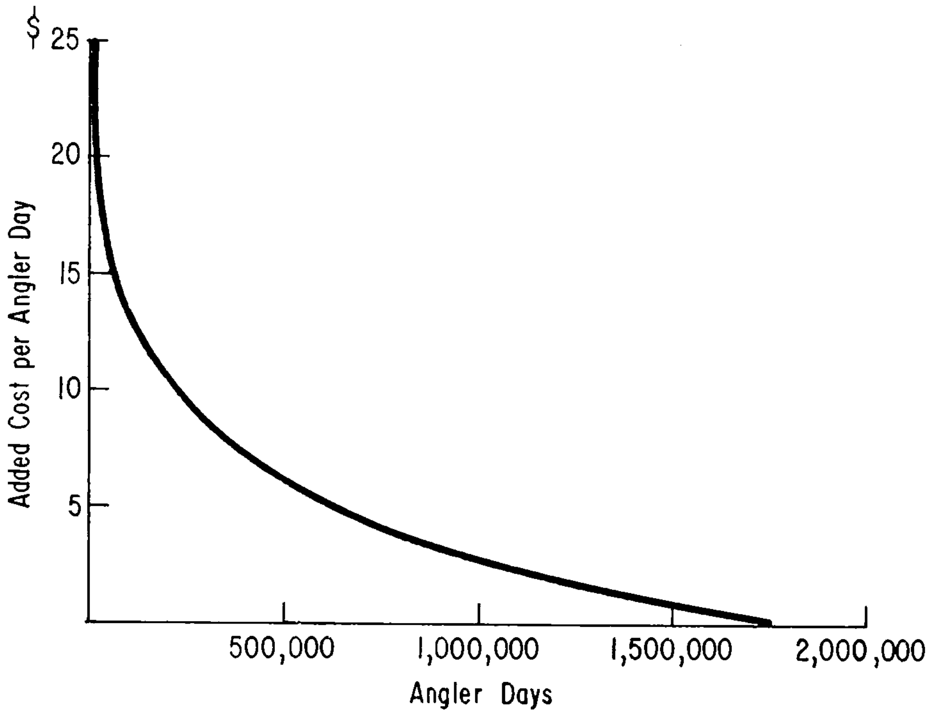


Figure 3. Demand curve for Michigan's salmon and steelhead recreation resources, 1970.

Net Economic Value

The value of Michigan's salmon and steelhead sport fishery lies in its ability to produce recreational opportunities demanded by the public. Furthermore, the relevant measure of the fishery's worth is the new or additional recreation that was produced relative to that which might have been produced without the fishery, i.e., net economic value.

The net economic value of Michigan's 1970 salmon and steelhead sport fishery to resident fishermen is estimated to be $8.34 million and is portrayed by the area under the resource demand curve (Figure 3). Had the salmon and steelhead sport fishing resources been eliminated in 1970 (1.76

million angler days), and resident fishermen allowed to substitute an alternative recreation activity, the value of the sport fishing foregone by the resident fishermen would equal the fishery's net economic value, namely, \$8.34 million.

Capitalized at 7 percent rate of interest, the value of the sport fishery is estimated to be \$119 million. This is the value of the fishery if its net economic value were allowed to accumulate annually for an infinite period of time.

The net economic value of an angler day is estimated to be \$4.75. Again, this is the worth of the salmon and steelhead resources used to produce an angler day. It represents the value of the recreation that would be lost had the sport fishermen been denied an opportunity to fish one day for salmon and steelhead although allowed to partake of other recreation activities for one day.

The estimated value of the fishery is conservative. Three considerations lead to this conclusion. First, the value reflects the worth of the fishery to Michigan residents; the value to non-residents is not included. Second, the estimate does not include the value of time which must be spent by the fishermen in order to partake of the fishery. An attempt at adjusting this bias is discussed later. Third, the estimate of net economic value does not reflect the impact of the fishery on local economies (new jobs, added income).

Statewide Value Adjusted for Time Bias

The price the sport fisherman pays for an angler day includes both his out-of-pocket expenses and the time spent getting to and from the fishing site. The demand curves for the statewide salmon and steelhead fishery include only the former, i.e., money expenses (Figures 2 and 3). Consequently, the demand curve is biased to the left and therefore underestimates the true net economic value of the fishery.

Three alternative estimates of the fishery's net economic value were determined from demand curves adjusted to include the value of time. Three different time values were used, namely, \$1 per hour, \$2 per hour and \$3.42 per hour. The latter was the statewide average hourly wage rate in 1969.[1] By applying these rates to the travel time required to get to and from the fishing site, new costs per angler day, which include time, were calculated (Table 2). These values when related to angler days consumed per 1000 population for each zone resulted in revised estimates of the demand curves for the entire recreation experience:

Time value = \$1 per hour
$$\log Y = 3.3683 - 0.0608X$$
Time value = \$2 per hour
$$\log Y = 3.3202 - 0.0445X$$
Time value = \$3.42 per hour
$$\log Y = 3.2831 - 0.322X$$

Y = Salmon and steelhead angler days per 1000 population
X = Variable cost per angler day

[1] Michigan Employment Security Commission, Research and Statistics Division, Detroit, Michigan

Table 2. Demand situation for Michigan's resident salmon and steelhead sport fishery, adjusted for value of time, 1970.

Distance zone	Mean round trip distance traveled	Mean time traveled at 50 miles per hour	Average dollar cost per angler day	Total average dollar cost per angler day at various time values* $1	$2	$3.42	Angler days per 1000 population
	(Miles)	(Hours)					
I	482	9.64	18.51	28.15	37.79	51.48	42.03
II	288	5.77	13.82	19.59	25.36	33.55	154.14
III	156	3.12	9.09	12.21	15.34	19.77	400.15
IV	96	1.91	7.00	8.91	10.82	13.54	958.57
V	40	0.79	3.08	3.87	4.66	5.79	1048.84

* Total average cost per angler day = (Dollar cost per angler day) + (Time cost per angler day)

Revised demand curves for the sport fishery resource were calculated for each time valuation (Fig. 4). Based on these demand curves revised estimates of the net economic value of Michigan's salmon and steelhead sport fishery for 1970 were calculated (Table 3).

Table 3. Net economic value (dollars) of the 1970 Michigan resident salmon and steelhead sport fishery, adjusted for the value of time.

Time value per hour	Net economic value (millions)	Net economic value per angler day	Capitalized net economic value* (millions)
0.00	8.3	4.75	119
1.00	12.8	7.28	183
2.00	17.5	10.00	250
3.42	23.8	13.55	340

* 7 percent interest

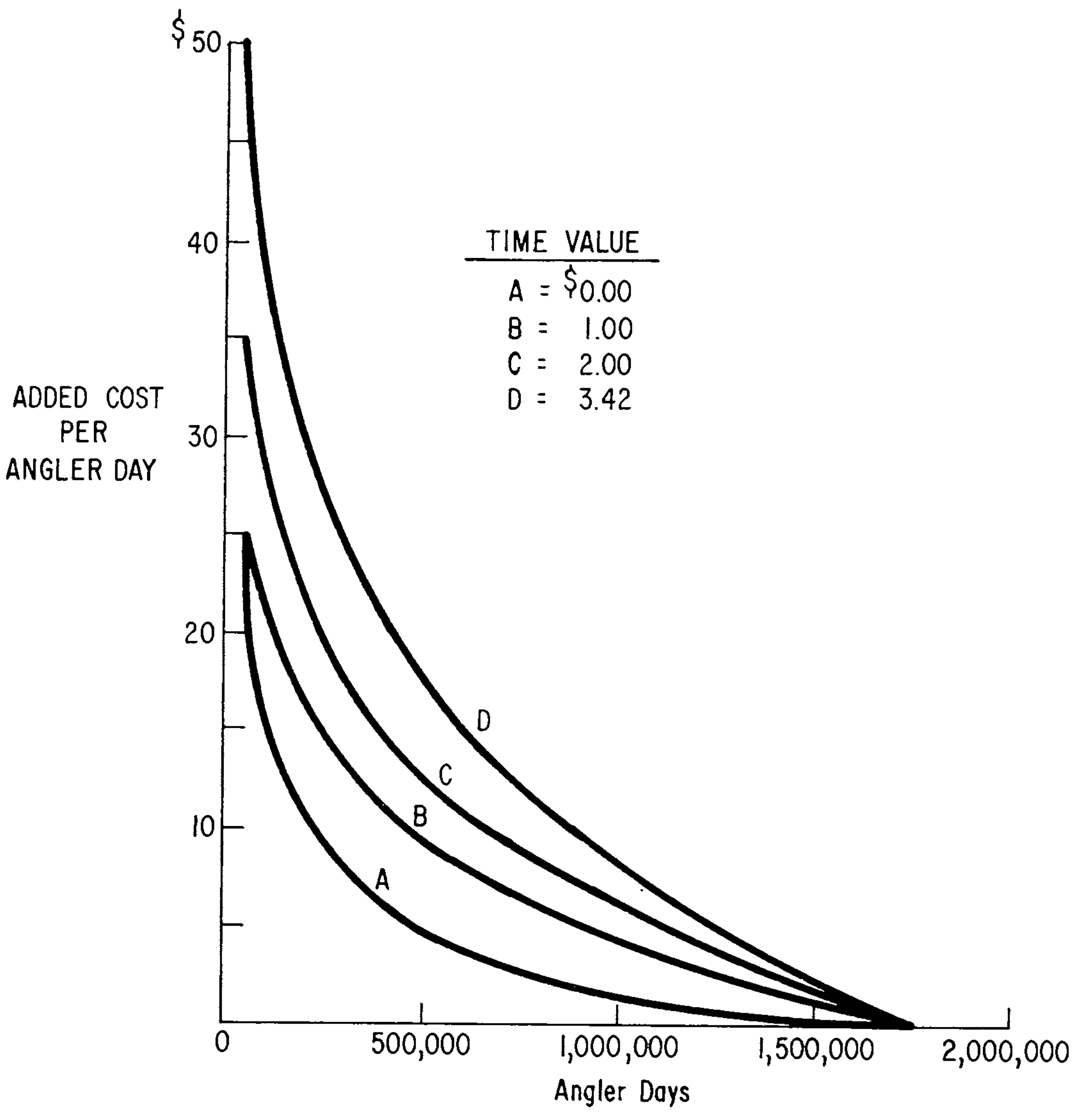


Figure 4. Demand curves (time adjusted) for Michigan's salmon and steelhead sport fishing resource, 1970.

Economic Value of Watersheds

The net economic value of each Great Lake and its tributary streams was also calculated (Table 4). The procedure followed was identical to that used in calculating the statewide net economic value of the salmon and steelhead sport fishery. Lake Michigan and its tributary streams accounted for 88 percent of the total statewide net economic value of the salmon and steelhead sport fishery. Lakes Superior and Huron accounted for 6 percent each.

Table 4. Angler days and net economic value of Michigan's salmon and steelhead sport fishery by watershed, 1970.

Watershed	Angler days	Net economic value
		(Dollars)
Lake Michigan	1,377,000	6,197,000
Lake Superior	168,000	446,000
Lake Huron	210,000	437,000

PROGRAM EFFICIENCY

Information about program benefits is vital to any resource planning effort. In addition, an equally important element of planning is program cost. Adequate knowledge about both program benefits and costs allows consideration of the program's efficiency relative to other opportunities which may exist for the same public resources.

The efficiency with which public resources are being invested in Michigan's salmon and steelhead fishery can be analyzed if certain assumptions are made about current and future program benefits and costs. These assumptions are:

1. The net economic value of the program to Michigan resident fishermen will continue at a rate of $17.5 million (value of fishermen's time = $2.00/hour) for the next 30 years. This is a conservative estimate of the value of the recreation that will be produced over the next three decades since it is based on the program's current production of 1.76 million angler days per year for Michigan residents. The latter will undoubtedly rise to at least 2 million angler days per year as the fishery is intensified in lakes Superior and Huron.

2. Total capital investment in the program is $10.93 million dollars. This includes $8.69 million (state and federal funds) for an anadromous fish hatchery and an additional $2.24 million in improvements such as fishing piers, fish passageways, dam removal, land acquisition, etc. Not included are capital costs which must be invested by local governments.

3. Total cost of operating and maintaining the program per year will be $1.62 million for the next 30 years. This includes $430,000 for hatchery operation. Again, operation and maintenance costs incurred by local governments are not included.

4. A discount rate of 7 percent is available.

With these assumptions, a benefit-cost ratio can be calculated. Discounting benefits and costs over a 30 year period, the benefit-cost ratio is calculated to be 11 to 1, a benefit to Michigan resident fishermen of $11 worth of recreation enjoyment for every $1 invested by state government agencies.

The benefit-cost ratio of 11 to 1 is based on a number of heroic assumptions. However, it is entirely adequate for making general assessments about the overall efficiency of the program relative to other investment opportunities which might exist in the public sector.

Future studies of the sport fishery should give high priority to more thorough analyses of program efficiency. Consideration should be given to a wide range of benefits not specified here, such as the value of the program to local communities as reflected by new jobs created, additional income and economic stability, and the value of salmon as predators on alewife because the latter can adversely affect Michigan's recreation industry. Future analyses should also focus greater attention on program costs, especially the cost of capital, the cost of operating and maintaining the program, and the costs which must be incurred by local governments. Furthermore, a wide range of "environmental costs" should be assessed, e.g., public displeasure with dead and dying salmon, stream bank erosion resulting from large numbers of fishermen concentrated in one area, etc.

Additional consideration should also be given to the scale or size of the salmon and steelhead program. Are the additional public dollars being invested in the program returning more or less fishing enjoyment than dollars previously invested? Furthermore, will these same additional dollars bring greater returns if invested in other programs, e.g., inland fishing and small game programs? These are important questions, each of which deserves more than passing attention.

VARIABLES AFFECTING PARTICIPATION

The salmon and steelhead sport fishery is a complex system composed of many elements, all of which have some relevance in determining the amount of recreation that will be produced. In an attempt to better understand the influence of these elements, data were subjected to regression analysis.

A number of variables were hypothesized as playing a significant role in determining the number of angler days that fishermen spent during 1970 (Table 5). Unfortunately, many variables could not be included since data were not available to represent them. This was especially true for abstract variables such as "peaceful and serene surroundings" and "scenic attractiveness" of the fishing site. However, a reasonable cross section of the supply and demand variables which determine the level of fishing activity was specified and analyzed.

Table 5. Variables used in analyzing Michigan's salmon and steelhead sport fishery, 1970.

Notation	Variable
Y	Angler days of salmon and steelhead fishing per fisherman
X_1	Cost per angler day
X_2	Fisherman's family income in hundreds of dollars
X_3	Per capita income in fisherman's county of origin
X_4	Household income in fisherman's county of origin
X_5	Fisherman's age
X_6	Number of salmon and steelhead caught
X_7	Population of the fisherman's home county in thousands
X_8	Number of private and public boat launching sites in county fished
X_9	Number of private and public camp sites in county fished
X_{10}	Number of motel rooms in county fished
X_{11}	Number of salmon and steelhead planted in or near county fished

The first step in the analysis was that of defining the relationship between the amount of recreation consumed by the sport fishermen and each of the demand and supply variables considered (Table 5). To this end, the simple correlations between angler days and the various independent variables were calculated (Table 6). In general, these relationships were very poor. The only relationship found to have any merit was between angler days and the number of fish caught by fishermen.

Table 6. Simple correlation coefficients for salmon and steelhead angler days and various independent variables, 1970.

R	Variable
-0.0705	X_1 = Cost per day
-0.0827	X_2 = Fisherman's family income
-0.1504	X_3 = Per capita income in county of origin
-0.1471	X_4 = Household income in county of origin
0.0117	X_5 = Fisherman's age
0.5514	X_6 = Fish caught
-0.1030	X_7 = Population in county of origin
0.0494	X_8 = Boat sites
0.0363	X_9 = Camp sites
0.0692	X_{10} = Motel rooms
-0.0745	X_{11} = Salmon and steelhead planted

The supply and demand variables also were analyzed as a group; the intent being to specify explicitly that group of variables which play a dominant role in determining the amount of recreation by fishermen. A stepwise process was employed for this analysis. Each variable was examined for its ability to explain the number of days fished by salmon and steelhead fishermen during 1970. If a variable was judged significant, it was added to the group (equation) while those which were superfluous were deleted. The process continued until a pre-set level of significance was reached. The result of this process was the following multiple linear regression equation:

$$Y = 4.34464^* - 0.02290X_1^* - 0.00592X_2^*$$

$$- 0.48898X_6^* - 0.00043X_7^*$$

$$- 0.06511X_8^* - 0.00192X_{11}^*$$

Y = angler days per fisherman

X_1 = cost per angler day
X_2 = fisherman's family income
X_6 = salmon and steelhead catch
X_7 = population in fisherman's county of origin
X_8 = boat sites in county fished
X_{11} = salmon and steelhead planted
$R^2 = 0.3285$

* Significant at the 0.05 probability level.

The estimated equation includes only those variables which were statistically significant at the 0.05 probability level. The variables which entered the equation explained slightly more than 32 percent of the variation in the number of days fished. Almost 68 percent remained unaccounted for.

An analysis also was made of the additional variation in angler days explained by adding additional variables to the regression. Of the somewhat more than 33 percent of the variation in angler day explained when all variables are included in the regression, the vast majority of this variation--more than 30 percent--is explained by the number of salmon and steelhead caught (Table 7).

Table 7. Additional amount of variation in angler days explained by independent variables, Michigan's salmon and steelhead sport fishery, 1970.

Step number	Variable entered	Increase in R^2
1	X_6 = Salmon and steelhead catch	0.3088
2	X_1 = Cost per day	0.0091
3	X_{11} = Fish planted	0.0067
4	X_8 = Boat sites	0.0055
5	X_2 = Fishermen's income	0.0034
6	X_7 = Origin county population	0.0014
7	X_5 = Fishermen's age	0.0005
8	X_{10} = Motel rooms	*
9	X_9 = Camp sites	*

* Less than 0.0001

FISHERMEN EXPENDITURES

Resident Michigan salmon and steelhead fishermen spent an estimated \$15.5 million during 1970. This estimate includes those added expenses that fishermen were willing to incur in order to partake of the salmon and steelhead sport fishery, e.g., gas and oil, food and lodging, bait, rental fees, and the like. Sixty percent of all the fishermen's expenditures were made at or near the location fished. Expenditures of the latter type totaled \$9.4 million. The remaining portion, \$6.1 million, was spent for goods and services either before or while the fishermen were en route to a fishing site.

Nearly \$86 was spent by each fisherman on all fishing trips taken during 1970 (Table 8). Expenditures for all trips were greatest (\$89.90) for Lake Michigan fishermen.

Table 8. Angler days and expenditures of Michigan salmon and steelhead fishermen on all trips by watershed and statewide, 1970.

Watershed	Angler days per fisherman	Expenditures per angler day	Expenditures per fisherman: Spent at fishing location	Spent en route	Total
Lake Michigan	9.7	$9.27	$55.32	$34.58	$89.90
Lake Superior	11.6	$6.83	$42.52	$36.67	$79.19
Lake Huron	8.8	$7.70	$40.08	$27.70	$67.78
Statewide	9.8	$8.77	$52.06	$33.84	$85.90

Salmon and steelhead fishermen spent an average of $8.77 on each day fished during 1970 (Table 8). This varies from a low of $6.83 per day for Lake Superior fishermen to a high of $9.27 per day for Lake Michigan fishermen. Only one out of every ten fishermen reported spending more than $30 per day fished while nearly 60 percent indicated expenses of $10 per day or less (Figure 5).

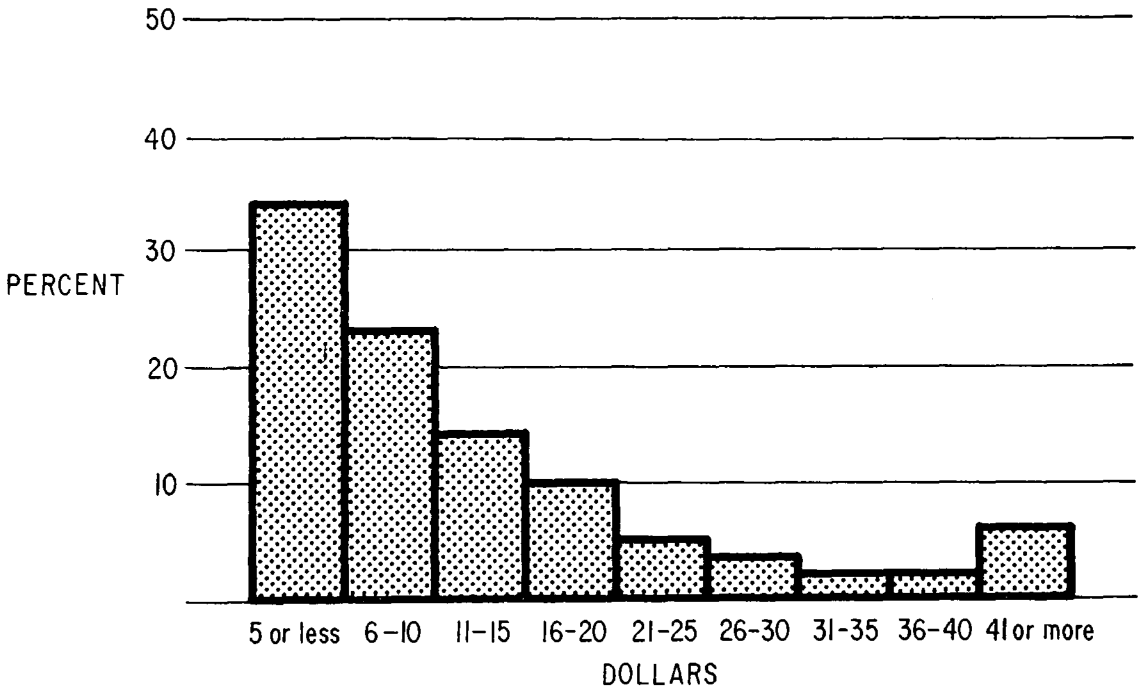


Figure 5. Distribution of expenditures per day made by Michigan salmon and steelhead fishermen on all trips, 1970.

FISHERMEN CHARACTERISTICS

Michigan's salmon and steelhead fishermen fished an average of 9.8 days on all fishing trips during 1970 (Table 8). Lake Superior fishermen appear to be the most ardent when days fished are considered. During 1970 they spent an average of 11.6 days fishing for salmon and steelhead. Lake Michigan fishermen were next in line with more than 9.5 angler days per fisherman, while Lake Huron fishermen spent 8.8 days fishing for salmon and steelhead during 1970.

The median family income of salmon and steelhead fishermen for 1970 is estimated to be $10,413. This estimate is approximately $400 more than that attributed to families residing in the North Central Region during 1969.[2] Those reporting annual incomes greater or equal to $15,000 per year accounted for 17 percent of all salmon and steelhead fishermen (Figure 6). Six percent of the fishermen reported incomes less than $3,000 per year.

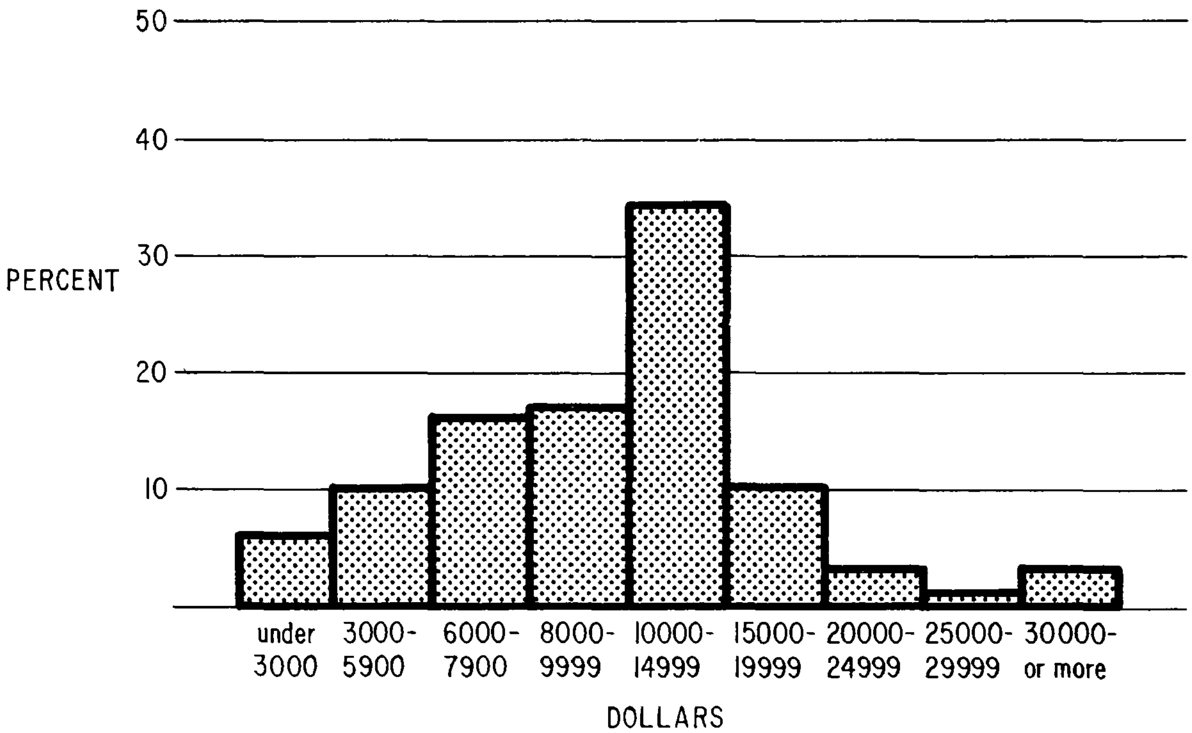


Figure 6. Distribution of Michigan salmon and steelhead fishermen family income, 1970.

LITERATURE CITED

Clawson, M. and J. L. Knetsch. 1966. Economics of outdoor recreation. The John Hopkins Press, Baltimore.

[2] The median income of North Central Region families was $10,020 in 1969 (Source: U. S. Bureau of the Census, Current Population Reports, Consumer Income, Series P-60, No. 60, 1970).

EVALUATION OF THE DEMANDS FOR THE SALMON AND STEELHEAD SPORT FISHERY OF 1970 -- A Condensed Report[1] --

by Daniel R. Talhelm

Michigan's salmon and steelhead sport fishery produces nearly two million angler days annually.[2] Establishing and maintaining the fishery has required a considerable investment in hatchery facilities and continuous stocking thereafter. On an annual basis, these costs are about $1.6 million, including payments that will recover the initial investments plus interest. An analysis was undertaken to quantify the benefits produced by the fishery, to estimate the efficiency of the Anadromous Program and to evaluate the prospects and desirability of changes in the program. In the process, additional information was generated about (1) the cost to anglers or angling, (2) the attributes of angling that anglers consider important, and (3) the willingness of anglers to substitute one kind of angling for another.

The analysis showed that the value of salmon-steelhead angling to anglers (not including their present expenditures) was nearly $30 million annually, and that additional stocking of salmon and/or steelhead in certain locations would be more valuable than the additional costs. The analysis also showed that many qualifications and considerations are necessary to properly interpret and use the results of the study for evaluating fisheries management decisions.

The full report, condensed here, is actually five semi-independent reports (sections) on different aspects of the evaluation. The first section is a discussion of the nature of the demand and supply of angling and the significance of those concepts to management decisions. The second section describes the cost of angling as related to travel distance and other factors. Section three examines several attributes of salmon-steelhead angling and describes the different kinds of angling in terms of those attributes. Each kind of salmon-steelhead angling has a unique set of attributes. The fourth section estimates and analyzes the demand for each of these kinds of salmon-steelhead angling and the willingness of anglers to substitute one kind of angling for another. The last section estimates the total value of the fishery to anglers and describes a simulation model with which many hypothetical changes in the fishery may be evaluated. Each section is summarized in turn below.

---

1 Condensed from: Talhelm, D. R. 1973. Evaluation of the demands for Michigan's salmon and steelhead sport fishery of 1970. Michigan Dept. Nat. Res., Fisheries Division, Fisheries Research Rept. 1797.

2 An angler day is a unit of angling activity representing participation by one person on any part of one calendar day.

DEMAND AND SUPPLY

The demand for angling is a relationship between the amount of angling and the cost of angling (to anglers). More precisely, the demand for angling is the schedule of the amount of angling that would take place at each given level of cost, other factors being constant. As the cost to anglers increases, the amount of angling decreases. The cost of angling includes not only the monetary costs of travel, equipment, lodging, and various kinds of fees but also the time anglers must take from other activities in order to go angling. These costs are the resources anglers give up for angling: the "price" of angling to anglers.

The demand relationship is important because it measures the willingness of anglers to exchange their resources for angling. It illustrates the social preference for angling relative to other goods.

The supply of angling to anglers is the relationship describing the "prices" at which given amounts of angling are available to anglers. In any one year the potential for angling for anadromous fish is predetermined by biological factors and previous management activities, so there is only "one" price (per day) at which angling is available at any location: the cost to anglers of going angling at that location.[3] In other words, there is no way in a short period to legally change the number of salmon or steelhead available or the locations at which they are available, so the only way price is related to the amount of angling supplied is through the cost of going angling. For anglers residing at any given location (e.g., county), the supply of a particular kind of angling may be described by specifying only the "price" (per day) to those anglers of that kind of angling, determined by the distance from that county to the nearest location where the kind of angling is available. In other words, to those residents the potential is available for any amount of angling at that price.

This concept of supply indicates the resources anglers must give up if they wish to participate in any kind of angling. It also permits us to estimate the demand for each kind of angling, utilizing knowledge about (1) the kinds of angling available at various locations, (2) the cost to anglers of angling as related to travel distance and (3) the amount of angling at each destination by anglers from each origin. From the demand estimates we may derive the value to anglers of particular management activities at any location.

ANGLING COST

Costs incurred on angling trips to Michigan were determined on the basis of questionnaire responses. The principal kinds of costs for angling are (1) fees, equipment, and other direct costs, (2) the monetary costs necessary for transportation, food and lodging, and (3) the value of the

---

3 Angling costs vary considerably between individuals, so the cost referred to here and elsewhere is the average cost, based upon the equations developed in Section II of the full report.

time spent to facilitate the recreation and transportation.[4] Equations were developed (illustrated in figures 3, 4, and 5 in the full report) that related costs per angler day to travel distance for Michigan residents and nonresidents for salmon-steelhead angling and for other angling in each of three periods in 1970.

KINDS OF ANGLING

In defining the kinds of angling, the attributes of "species combination" (i.e., various combinations of steelhead trout, coho salmon and chinook salmon) and "catch rates" of each species were chosen for the basic description of the kinds of angling. For each period, a county was rated as to the catch rates for each species--i.e., high catch rate, moderate catch rate, low catch rate, or not available. Each unique set of catch rates defines one "character" or kind of angling. For example, one character has a moderate catch rate for steelhead, high catch rate for coho and no chinook; another character has moderate catch rates for steelhead, coho and chinook.

The characters (or kinds) of angling are analogous to the different makes and models of automobiles. Anglers have different preferences for the various characters of angling, just as people have different preferences for the several makes and models of automobiles. The attributes of catch rates and species were chosen as character determinants because it was felt that they are of primary importance to anglers. They are also extremely important in management decision-making. Limitations in the data on angling effort prevented separating steelhead angling effort from salmon angling effort. Separate data probably would have permitted a simpler, more meaningful classification of characters and analysis of results.

The above two attributes appeared to explain over 90 percent of the angling effort, but in some cases other factors were also important to many anglers. These were (1) publicity, (2) timing of the salmon run, (3) the kinds of streams in which the fish run, (4) urban or non-urban surroundings, (5) the availability of complementary types of recreation in the vicinity, and (6) weather.

DEMAND ANALYSIS

The demand equations were estimated in such a way that they would not only indicate the total preference for each kind of angling, holding constant the availability of other kinds of angling and some other factors, but also indicate (1) anglers' willingness to exchange one kind of angling for the others and (2) to what extent their preference for one kind of angling is affected by the presence of other kinds of angling. The findings tend to confirm some commonly held ideas of angler behavior and give these ideas

---

[4] In this analysis, time value is equated to the respondent's wage rate. It is true that one's wage rate is not equal to the value of his leisure time "for all the people some of the time, and for some of the people all of the time." However, it represents the most unbiased, easily attainable figure available, and in the context used here is considered quite accurate.

quantified expression. The quantitative results are given in the full report but the principal conclusions are presented here.

In general, the kinds (characters) of salmon-steelhead angling with higher catch rates are preferred over those with lower catch rates. This is indicated by (1) a "greater" demand for the former, (2) a positive willingness to switch from lower-catch-rate angling locations to higher-catch-rate locations, but not vice-versa, and (3) the fact that the positive relationship between the personal income per capita in the angler's origin county and the demand for angling was stronger for higher-catch-rate angling.

Although some kinds of salmon-steelhead angling have a negative relationship to county income per capita, particularly the lower-catch-rate angling, most are positively related to county income. This positive relationship between income and angling effort (holding other factors constant) indicates that salmon-steelhead angling may be considered a "normal" or even a "luxury" item. In other words, it is one of the goods people choose to consume more as their income increases. However, since the average income reported by Michigan anglers is very similar to the statewide average, this conclusion is uncertain.

The preference patterns of salmon-steelhead anglers reveal how their preferences for salmon-steelhead angling relate to other kinds of angling. The principal conclusions are: (1) since these anglers fish jointly for salmon and lake trout for at least part of the year, the presence of lake trout enhances the desirability of angling for salmon, and probably vice-versa; (2) salmon-steelhead anglers consider inland trout angling as roughly equivalent to salmon-steelhead angling and are more willing to go to a location with low catch rates for salmon-steelhead if inland trout are also available, particularly in fall; (3) salmon-steelhead anglers strongly prefer high-catch-rate salmon-steelhead angling to other game fish angling (bass, pike, walleye and muskellunge), but are somewhat indifferent between low-catch-rate, salmon-steelhead angling and other game fish angling; (4) the preference for high-catch-rate chinook angling over other game fish angling is particularly strong in the fall; and (5) salmon-steelhead anglers strongly prefer high-catch-rate salmon-steelhead angling to perch-panfish angling, particularly during summer, and are somewhat indifferent between low-catch-rate salmon-steelhead angling and perch-panfish angling.

ANGLING VALUE

What is Value?

The demand schedule for any kind of angling indicates the willingness of anglers to exchange their resources (measured in terms of dollars) for various amounts of that kind of angling. From the demand schedule and knowledge about the present costs to anglers (based upon travel distance), we may predict (1) additional amounts anglers would be willing to pay (or contribute) if additional costs were imposed upon them, (2) any savings to anglers from reductions in their present costs, and (3) the change in the amount of angling that would accompany any change in angling costs or availability. Such changes in angling costs may result either from additional costs (or savings) imposed upon anglers, such as changes in license fees, user fees, transportation costs, etc., or from a change in travel costs resulting from a change in the location of the angling. In any case, an increase in cost represents a decrease in supply (i.e., a shift in the supply schedule) and some loss of angling, whereas a decrease in costs represents an increase in supply and some increase in angling.

Therefore, with the proper analysis, we may estimate anglers' willingness to pay or contribute (beyond their present costs) to prevent a decrease in supply or to promote an increase in supply. Since the demand schedule measures social preferences, willingness-to-pay may be estimated in such a way that it summarizes social preferences in given circumstances.

Calculated Total Values

The total value of the 1970 salmon-steelhead sport fishery is the maximum net willingness of anglers to pay or contribute (beyond their present costs) either to prevent the total loss of their participation in the fishery, or, conversely, to promote the gain of the existing fishery if one didn't already exist. Assuming all other fisheries continue to exist in their present form at their present costs, anglers would be willing to pay or contribute to the state (or anyone who controls angling rights) a maximum of about $30 million per year to prevent the total loss of their participation in the salmon-steelhead fishery.[5] This $30 million value could be appropriately called the "all-or-none" value of the salmon-steelhead fishery, since it represents an evaluation of an all-or-none choice for society. The value is also called "consumer's surplus." It gives us very little insight about whether the level of development of the fishery was the most appropriate one or whether the Anadromous Program should be increased or decreased in any or all locations. The simulation model discussed below should help evaluate those questions.

Two other analyses were used to estimate the all-or-none value of the fishery using different assumptions about the availability of other kinds of angling. First, assuming that the costs to anglers of all kinds of angling were increased simultaneously with the costs of salmon-steelhead angling, anglers would only be willing to pay about $23 million to prevent the loss of the salmon-steelhead fishery. Michigan residents would be willing to pay about $17 million of that amount. In other words, it was assumed that anglers would face equivalent losses of all kinds of angling opportunity simultaneously. Thus, as we analyze how salmon-steelhead anglers would act as the salmon-steelhead angling supply is reduced, we assume that they are acting in response to a decrease in supply of all kinds of angling. It is as if a surcharge were levied upon all kinds of angling simultaneously.

The second analysis is that presented previously by Ellefson which assumes (roughly) that the costs of lake trout angling in the Great Lakes and inland trout angling (to a lesser extent) increase simultaneously with the

---

[5] All estimates given in this paper pertain to the circumstances that existed in 1970. No attempt has been made to estimate values for later years. It should be pointed out, however, that the amount of salmon-steelhead angling has apparently increased in 1971 and again in 1972. The monetary expenditures (none of which are a part of the all-or-none value) were about $15.5 million in 1970. The value of leisure time expended was roughly $50 million (none of which was included in the all-or-none value).

cost of salmon-steelhead angling, but other kinds of angling remain at about the same cost (or supply). Under those conditions he predicted that Michigan residents would be willing to pay $18-$24 million to prevent the loss of the salmon-steelhead f shery, depending upon the value of leisure time. Results mentioned in the previous paragraph suggested that non-residents of Michigan would be willing to pay an additional $6 million or more.

Meaning of Results

The all-or-none value measures the total benefits to buyers of having the opportunity to purchase a good, as opposed to not having that opportunity. The all-or-none value of the fishery, or any other kind of good, could almost certainly never be actually collected by the state or anyone else. For most practical purposes, such an all-or-none value is imaginary. It is never found in a real market situation and the concept has limited usefulness. Only a perfectly discriminating monopolist could collect that amount by collecting every increment in willingness to pay as price increased to the maximum possible. Geometrically it is equivalent to the entire area under the demand curve and above the price at which the supply curve intersects the demand curve.

In the real world, only one or, at most, a few different prices could be charged to anglers at various locations and times. The most revenue a real owner (or controller) of the salmon-steelhead fishery could recover from anglers would be about one-half to one-third of the maximum willingness to pay. This value, minus the cost of administering such charges, would be the market value of control over fishing rights. The total amount an owner could recover from anglers is equivalent to the sales revenue of any market good, such as automobiles or apples. For example, the all-or-none value of water is extremely high, since without it we would be dead; but its sales value is low because it is so easily obtainable.

Just as the cost of shopping is not included as part of sales price of automobiles or apples, the present costs to anglers of angling, with the possible exception of license fees, are not included as any part of the willingness of anglers to pay or contribute to an owner for angling. The shopping and angling costs are important to shopper behavior and angler behavior (we use them for calculating demand), but are eliminated in calculating all-or-none value.

If a decision-maker is faced with an all-or-none choice--either provide the opportunity to "purchase" a good or provide no opportunity--the most appropriate value to use (from the public's point of view) would be the all-or-none value. It may also be used in comparison with other values calculated in a similar manner to judge between mutually exclusive choices of resource utilization. For lesser choices, however, the revenue that could actually be recovered by an owner would be a more realistic value, since almost all goods are allocated on that basis in this country by private enterprise.

Considering the fact that the annual cost of providing the fishery is in the neighborhood of $1.6 million, whereas the annual value of the fishery is nearly $30 million, there is no question that the net public welfare was increased with the advent of the fishery. It should be pointed out that the values presented in this paper do not include any present payment for licenses. Those payments attributable to salmon-steelhead angling, amounting to approximately $650 thousand annually, should be added to the above all-or-none values in calculating total benefits.

Value of Incremental Changes

Incremental changes in the opportunities for various characters of salmon-steelhead angling (such as changes in catch rates of one or more species at certain locations, changes in the locations where fish may be caught, or regional changes in catch rates) may best be evaluated by using a simulation model based on known behavior patterns to predict angler response. Any change in the character of angling at any location will likely produce a complex reaction by anglers. For example, a significant change in the catch rate of one species of salmon or steelhead at one location will change the character (as previously defined) of angling at that location. Various anglers would have different reactions to that change: they could either (1) stop angling, (2) start angling, (3) switch their angling effort from one location to another, (4) fish less at the changed location and/or more at others, or (5) fish more at the changed location and/or less at the others. In particular, some anglers may decide to fish less and travel farther to another location where they can still find angling of the character that had existed at the previous location, and other anglers may increase their angling of the new character because the changed location is closer than where they previously went for angling of that character. An individual's reaction depends upon the nature of the change, his alternatives, and his tastes and preferences.

The net results of an incremental change would likely be some or all of the following: (1) some willingness of certain anglers to pay or contribute to prevent the change, (2) some willingness of certain anglers to pay or contribute to promote the change, and (3) minor or major changes in the location of angling effort. The full report describes how a computer-based simulation model may predict those results in detail and illustrates the use of such a model that was constructed for the 1970 salmon-steelhead fishery.

Basically, the total value to anglers of such a change is computed by estimating the willingness of anglers to pay to promote the change (based upon their savings in travel costs, including time), and subtracting from that the willingness of anglers to pay to prevent the change (based upon their increase in travel costs). The changes in travel costs represent the increase in supply (decrease in costs) of the newly created character of angling and the decrease in supply (increase in costs) of the old character of angling. The resulting value may be interpreted as the maximum all-or-none value of the incremental change to anglers.

Usefulness of Incremental Values

The all-or-none value of an incremental change in salmon-steelhead angling differs somewhat from that of the whole fishery.[6] The calculations

[6] The all-or-none value of one unit of a good, such as an automobile or an apple, is essentially equal to the market price of the good, since "identical" automobiles or apples are available elsewhere at that price, except for the cost of transportation to other market locations.

for an incremental change are based upon location advantages of certain "market" areas, and the calculated value could largely be recovered by a monopolist discriminating among users based upon their place of residence. Even without discrimination much of the value of such a change could likely be collected by an owner. The all-or-none value of an incremental change in salmon-steelhead angling character measures the maximum amount of resources anglers would be willing to exchange to promote the character change, and roughly equals the actual revenue that could be collected. Therefore, it would usually be the best value to use in evaluating such changes. It is particularly useful in comparing alternative incremental changes.

Results of Incremental Evaluation

Using the simulation model, values were computed for several hypothetical changes in salmon-steelhead catch rates. Tentative conclusions from the simulations (assuming that increases in stocking will increase catch rates) are: (1) general increases in salmon-steelhead stocking rates would probably have higher benefits than costs, (2) additional stocking of certain salmon-steelhead species at certain locations would have even greater benefits than the same amount of stocking increase spread over a wider area, and (3) stocking rates for some salmon-steelhead species at some locations may be reduced without important losses in benefits.

These conclusions should be qualified by two other considerations. First, because of the uneven distributions of angling effort and biological conditions, the degree of management effort required to produce a significant change in salmon or steelhead catch rates varies considerably throughout Michigan. Therefore, the management costs and feasibility are equally as important in determining the distribution of management effort as the values produced. Management effort should be allocated so as to produce the maximum benefits with a given amount of resources. Second, the values of alternative activities of the Department, particularly fisheries management for non-anadromous species, have not been determined. Such evaluations may indicate that greater or lesser benefits are produced by other programs, so the anadromous program should be decreased or increased to shift resources to or from other programs. Moreover, the budget for any programs should be increased when it can be shown that the public benefits would be increased more than the public costs, as appears to be the case in the Anadromous Program.

Other Conclusions

This analysis suggests several factors that should be taken into consideration when evaluating the kinds of recreation that might be provided at various locations. First, the rarer any kind of recreation is, the more valuable an additional unit of that kind would be to the users, or, conversely, the more available any kind is, the smaller the value of an additional unit. Second, since different people have different preferences, each different kind of recreation may be viewed as serving a different segment of the population. Third, since one of the primary costs of recreation is for transportation, each unit of a kind of recreation (e.g., each county that has a particular character of salmon-steelhead angling) serves a fairly unique geographic market area. Each angler belongs to the market area of the closest unit of a kind of recreation, so the size of each market area depends upon the locational advantage of the unit.[7] Fourth, the larger the population of the market area, and the closer the population is to the recreation, the greater is the value. The simulation procedure uses all of these factors and others in calculating benefits.

The average all-or-none value of salmon-steelhead angling is $10 to $15 per angler day, but it should be abundantly clear that every increase or decrease in angler days should not be evaluated at $15 per angler day or any other fixed figure. In general, changes in angler days that are the indirect result of changes elsewhere (e.g., increased angling effort at stream A caused by pollution in stream B) should be given zero value. Otherwise, angler days may be valued up to as high as $20 or $30, or even more per angler day, depending upon the above circumstances and other factors. The simulation techniques could quantify such values in many situations.

It is recommended that further work of this type be carried out for Michigan's fisheries resources because of its potentially great usefulness in fisheries management and planning. With sufficient data acquisition and analysis, computerized simulation models could become highly accessible and easily used management tools.

---

7 Recall that a "character" of recreation is defined in such a way that users are indifferent between any two locations of the same character.

A STATEWIDE ECONOMIC DEMAND ANALYSIS OF THE AU SABLE RIVER SPORT FISHING RESOURCE[1]

by James W. Pearce[2]

INTRODUCTION

Natural resources management decisions are most frequently made with respect to relatively small geographic areas. One technique which can be utilized in the decision making process is the Clawson-type economic demand analysis for non-market (non-priced) recreational use of natural resources (Clawson, 1959). The Au Sable River sportfishing resource was subjected to a three-phase economic demand analysis utilizing existing statewide fishery survey data collected during 1970 and 1971. The applicable extracted data for this analysis were limited; hence, the results drawn from it should be viewed with caution.

This analysis proceeds generally along the same lines as does that of the parent 1970 survey study (Ellefson and Jamsen, 1971). On a county basis, 1970 and 1971 statewide, sportfishing survey data were extracted which were applicable specifically to fishing on the river within the six counties (Fig. 1). This amounted to a very small proportion of the overall statewide sample of sport fishermen in each of the study years; hence, this analysis is necessarily less definitive than was the Ellefson and Jamsen study cited above.

Inherent to the study is the assumption that, while the sampling frames of the parent survey(s) were designed to statistically support analysis on a large scale (Lake Michigan, all inland waters, etc.), segments of those samples applicable to small areas or specific fishery resources would also be reasonably descriptive for an individual river. Although there are strong arguments against such an assumption, this study was done on the basis that it has merit and offered potential for other applications during future surveys.

The objectives were to estimate:

a) the economic value to the State of Michigan of resident sport fishing on the Au Sable River during the years 1970 and 1971;
b) the comparative angler effort exerted on the river;
c) the aggregate resident angler expenditure patterns in the six counties of destination and while traveling to and from these counties.

---

1 The material contained in this report is a part of the "Three River Study" supported by the Institute of Water Research, Michigan State University. Technical and administrative cooperation was provided by Gale C. Jamsen (Research and Development Division, Michigan Department of Natural Resources), Ronald W. Hodgson (Department of Park and Recreation Resources, Michigan State University), and Richard E. Esch (Transportation Planning Division, Michigan Department of State Highways).

2 Graduate research assistant, Department of Park and Recreation Resources, Michigan State University.

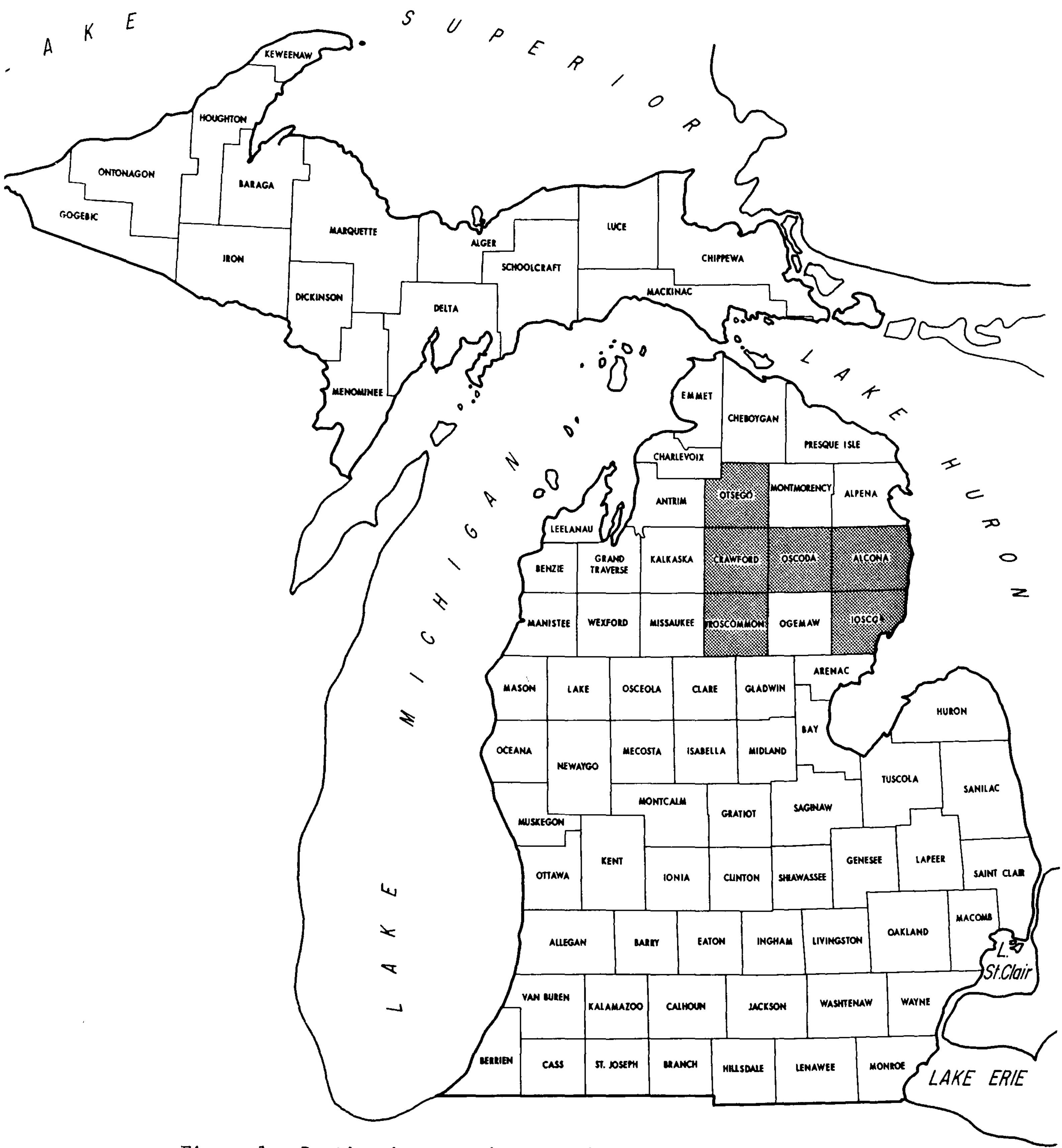


Figure 1. Destination counties comprising the Au Sable River Study area.

METHODS

The methodology utilized is that of analyzing market demand (willingness to pay) for varying quantities of fishing (angler days) at various prices to geographically separated segments of the potential consumer market (licensed sport fishermen throughout the state). The chief proponent of this method was Marion Clawson (1959). Others have since modified and expanded upon Clawson's basic proposal and several of these efforts have been applied to economic evaluation studies of fishery resources (Smith and Kavanaugh, 1969; Brown, et. al., 1964; Ellefson and Jamsen, 1971).

Demand for the Entire Recreation Experience

A three-part approach was utilized. First, the demand curve for the entire recreation experience (Clawson, 1966) was determined (Table 1 and Figure 2). This experience, applying Clawson's definition, includes the anticipation of the fishermen, their travel to the site, the fishing experience itself, the return trip, and the post-experience recollections.

Table 1. Demand for the entire experience of sport fishing on the Au Sable River, 1970.

Time zone	Mean driving time (Minutes)	Average variable cost per angler day (Dollars)	Zone population[1] (1000's)	Ave. 1969 per capita (family) income in zone (Dollars)[1]	Total angler days[2]	Angler days per 1000 population
I	2	2.2	249	7,537	64,260	258.1
II	95	7.9	876	8,036	49,870	56.9
III	149	11.3	3,135	8,771	61,280	19.5
IV	211	14.3	7,415	7,415	45,550	6.1
V	253	13.5	5,900	9,590	26,340	4.5

[1] U. S. Bureau of Census; Census of Population, 1970.

[2] Total angler days = (sample angler days) x (expansion factor)

People who take part in the whole experience of going to the Au Sable River to fish incur costs (some measurable and some not). These are comprised of prices they would actually pay in dollars, plus the "intangible costs" knowingly sustained as a result of foregoing opportunities to do other things with their leisure time. The aggregate costs, as viewed by these consumers, are an important determinant of the amount of fishing they will do on the Au Sable River at any given instant.

In order to ensure coverage of the statewide (potential) Au Sable sport fishing market area, the state was divided into five zones (groups of counties) delineated by driving time band widths. Each zone was one hour in width (i.e., Zone II in Figure 2 comprises all counties 60 to 120 driving minutes from each of the six destination counties along the river). Table 1 shows the average one-way driving times of all surveyed Au Sable anglers residing in counties within the zone from their county of origin to the reported county of destination.[3] The five zones established in this manner result in overlap because nearly every one of Michigan's 83 counties lie within more than one time zone, but was unavoidable because of the linear configuration and size of the destination--a group of six counties. To reduce this six-county area to an effective point resource for purposes of statewide county analysis on a concentric zone basis, it was important to include all "eligible" counties within each zone. A true concentric pattern could thus be described. To exclude a potential origin county (after it was first accounted for within a "closer" time band) would have been to deny that any potential, licensed (but non-surveyed), resident angler who lived within 60 to 120 minutes of Otsego

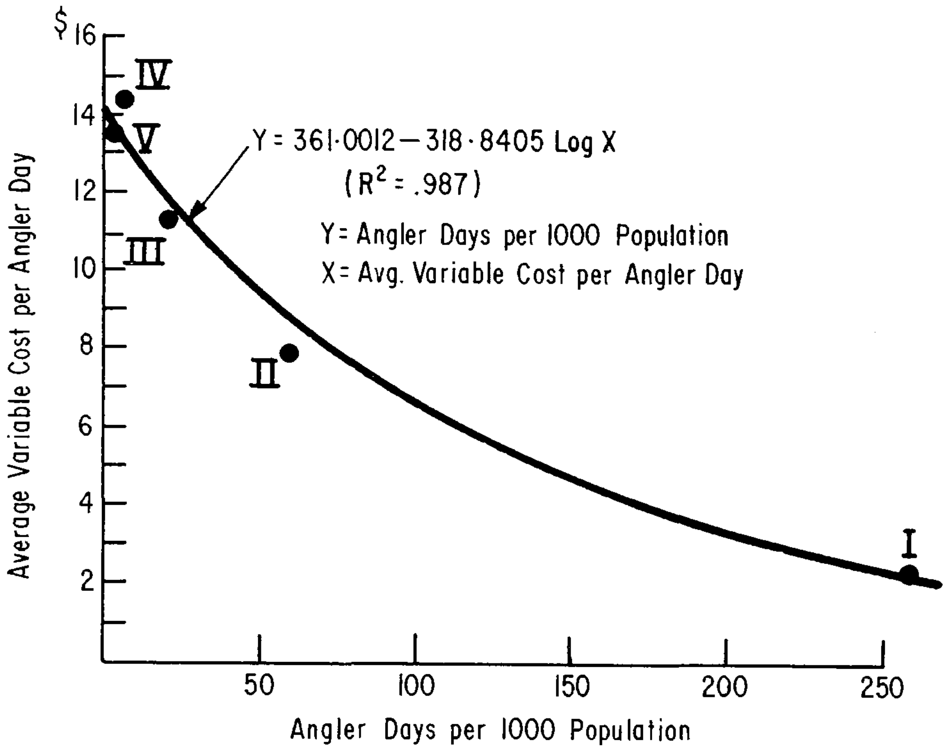


Figure 2. Demand curve for entire Au Sable River sport fishing experience in Michigan, 1970.

---

[3] The consecutive zone numbering system (Figure 2 and Table 1) is opposite from that used by Ellefson; i.e., Zone I in this analysis comprises all counties closest to the river (0 to 60 minutes).

County could not just as well have fished the Au Sable River in Iosco County. In this latter case, his county of origin might also lie within the 180 to 240 minute time band.[4]

As a result of the foregoing, the zone populations in Table 1 are not additive for purposes of obtaining the total state population. The method in no way affected the actual count of angler days since these were considered, in each individual's case, only with respect to his county of origin and stated county of destination. The count is thus made only in the appropriate zone in which the fishing trip took place.

The average variable costs for an angler day on the Au Sable were computed (Table 1). These were based upon actual reported dollar costs. Reported angler days were expanded to represent the estimated statewide effort of the known population of resident licensed anglers. The expanded days for each zone were then divided by the zone population (in thousands) in order to eliminate differentials in zone population sizes, thus equating the values on a "per-capita" basis.

Each zone--defined by its average total variable costs (site plus travel dollars) per angler day, along with its consumption in angler days per thousand--was plotted and the coordinates for each zone were subjected to simple regression analysis. The "best fit" curve--having the highest coefficient of correlation (r)--was selected. The resulting curve in Figure 2 is representative of an empirical estimate of the 1970 statewide demand for the entire experience of sport fishing on the Au Sable. It does not include specification (in dollars) of the value of the users' time and foregone opportunities, nor does it include wives of licensed fishermen, non-residents, or children under 17. Therefore, it represents a conservative estimate of the shape and location of the "actual" demand curve and is probably situated downward and to the left of its true location.

Demand for the Au Sable Sportfishery Resource

The second step in the analysis was to estimate the demand curve for the resource (per se)--the sport fishery. This step required the assumption that each aggregate segment (zone) of the statewide market would react to increased costs for fishing on the Au Sable by taking fewer angler days. The degree to which each zone reacted was determined by its location with respect to the demand curve in Figure 2, and by the slope of the curve at that point. For example, as Zone I is located in a relatively flat area of the curve, an increase in observed cost to that zone would result in a proportionately greater reduction in angler days taken than would the same increase at Zone V.

Costs were artificially imposed in increments of one dollar and the resultant angler days per thousand population for each zone multiplied by its base population (in thousands) were determined. All the results from each

---

4 Construction of driving time zone matrices was carried out using the Michigan Department of State Highways' traffic forecasting model--the 580 zone system. For further details see: R. E. Esch and L. J. Swick, Michigan's Statewide Traffic Forecasting Model, Vol. II, Michigan Department of State Highways, Lansing, 1971. 46 pp.

zone were summed and these sums (total angler days in Table 2) were plotted against their respective increments of cost increase to define the curve in Figure 3. This is the curve which depicts the estimated statewide demand situation for the Au Sable sport fishery resource (per se).

Table 2. Total number of angler days and the added cost (dollars) of an angler day for the Au Sable River sport fishery, 1970.

Added cost of an angler day (Dollars)	Total angler days
0	247,300
1	143,161
2	86,936
3	59,524
4	42,812
5	27,869
6	17,340
7	13,372
8	9,815
9	6,590
10	3,641
11	925
12	0

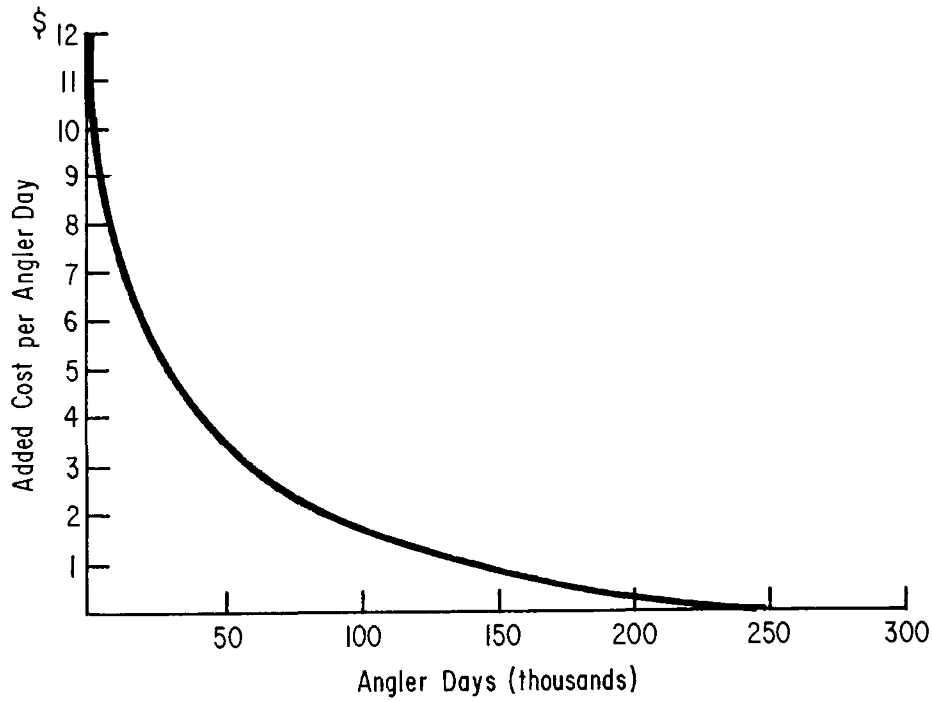


Figure 3. Demand curve for the Au Sable River sportfishery resource in Michigan, 1970.

Economic Value of the Resource

The final step in the analysis was to determine the area under the curve in Figure 3. This area estimates the dollar value of the resource to the state of Michigan as a result of sport fishing on the Au Sable during 1970.

RESULTS AND DISCUSSION

A few of the gross estimates based upon this analysis are summarized in Table 3. The economic value per angler day ($2.18) is fairly close to the value ($2.95) estimated by Ellefson and Jamsen (1971) for inland sport fishing.

Table 3. Statewide socio-economic summary of the Au Sable River sport fishing resource.

	1970	1971
Economic value ($)/year	535,640	846,290*
Economic value of an angler day ($)	2.18	**
Per cent of statewide resident angling effort	1.6	2.1
Per cent of statewide non-resident angling effort	0.4	0.6
Average reported resident fisherman income ($)/year	11,200	**
Statewide resident sample for this study***	263	442

* Represents estimated economic value for 1971 based upon 1970 expenditure averages applied to 1971 effort from the same zones.

** Expenditure data and income not requested in 1971 survey.

*** Parent survey effective (statewide) sample 1970: (Jan.-April) 845, (May-Aug.) 3750, (Sept.-Dec.) 1650. sample 1971 (approx.): (Jan.-June) 4000, (July-Dec.) 4000.

There are several plausible explanations for the difference. First, the Ellefson method utilizes a different zone construction rationale. For purposes of determining angler days per thousand base population, only those counties in which fishermen were actually reported by the survey were included by Ellefson for a base population count. The value being sought, then, was that accruing to the statewide population of licensed fishermen rather than to the population of both fishermen and non-fishermen as a whole. This smaller base population suggests a greater demand (consumption) of angler days per thousand at a given price than if those same angler days, at that same price, were equated to all counties of the state within the same distance of the type of resource being evaluated. Secondly, those characteristics peculiar to the Au Sable River alone, as opposed to the aggregate effect upon demand for all inland lakes and streams, could easily have accounted for the difference. The nature and extent of this effect is not readily identifiable. Thirdly, the \$2.18 value herein represents an estimate over the entire year 1970; whereas Ellefson's \$2.95 estimate was based only upon the first four months of the year. Finally, the paucity of the data base for this study could, of itself, have accounted for the difference.

The results of a comparative analysis of resident sport fishing effort on the Au Sable as exerted upon individual counties are summarized in Table 4. Counties were combined in order to have sufficient data for the analyses of economic value. Even when combined, the data were, in most instances, so few in numbers of observations per time zone for a given county (or county group), that subjective analyses were necessary in locating (hand fitting) the demand curves. As indicated by reported angler days, the relative pressures on particular counties should be representative (within the limitations of this overall analytical effort) of reasonably accurate descriptions.

Assuming that subjective analyses were not necessary (in this case) to compute economic value, and that sufficient data were available to statistically support all the findings presented in Table 4, certain observations are of interest to resource management.

Of primary concern to resource management agencies are the relative values ascribed to different segments of the river starting at upstream in Crawford, Otsego and Roscommon counties. Table 4 shows a successive decline in the "value per angler day." A great many factors could be contributing to this apparent effect: water quality, the availability of public access, crowding, scenery, types of fish available, accessibility to population centers, etc.

Certain questions arise such as:

1) Why, when the greatest overall pressure in angler days is exerted on the lower two counties, do they exhibit the lowest economic value? The highest ascribed value exists in the upper two counties where considerable controversy exists between canoeists and fishermen.

2) Is the greater downstream fishing pressure (where canoeing is not so much a problem) a direct result of the upstream controversy?

3) Is the "value" of the river in these lower two counties a function of the nature and condition of the river? The major impoundments occur here and overall water quality must certainly affect its aesthetic attraction to fishermen. Furthermore, there is more space available for fishermen. Another possible explanation is a longer season than upstream and there is a greater variety of angling over this longer period of time than upstream, such as fishing for walleye, perch, bass and salmon, and ice fishing.

Table 4. Au Sable River economic demand analysis; summary of county of destination results (resident fishermen - statewide survey).

1970 (1971)		County(s) of destination: Crawford-Otsego	Roscommon	Oscoda	Alcona-Iosco	Totals
Average, one-way driving time (min.) from origin to destination on river - all zones included.		155	111	163	132	---
		(152)	(102)	(138)	(131)	---
Total number of fisherman days (on the Au Sable).		72,380	17,220	33,290	124,410	247,300
		(91,800)	(14,220)	(57,980)	(260,380)	(424,380)
Percent of total fishing days on the river.		29	8	13	50	---
		(22)	(3)	(14)	(61)	---
Total dollars spent at the fishing location.	(%)	--- 37	7	15	41	100
		$462,376	$87,235	$183,242	$510,288	$1,243,081
Total expenditures of fishermen (includes travel and other costs enroute to site).	(%)	--- 33	8	16	43	100
		$737,883	$168,794	$362,256	$940,114	$2,209,047
Economic value of the river	Year (70) (%)	--- 39	7	14	40	100
		$233,350*	$45,820*	$80,760*	$239,450*	$599,380*
	Angler day	$3.22*	$2.66*	$2.42*	$1.92*	$2.42*

* Each county/county group was subjected to demand analysis in the same manner as was the overall river (Fig. 2, 3). As a result of much fewer available observations on a county basis; however, it was necessary to employ subjective analysis in "fitting" the curves. It is chiefly for this reason that the economic value for the year ($599,380) differs by 11% from that ($535,640) determined by simple regression.

The "total dollars spent at the fishing location" category indicates little with respect to the economic impact of sport fishing upon the local communities. Economic impact is a complex function involving the tracing of "imported" dollars once they are spent in the community. The paths taken by the dollars and the number of times they are re-spent within the community determines the "multiplier effect" and, consequently, the aggregate impact upon the community in terms of net income and new jobs created, etc. Insofar as the sport fishermen's impact is concerned, one assumes that it must amount to at least the sum of their initial expenditures at the site. Thus, it represents a minimum economic impact.

One final observation should be made with respect to the "economic values" reported in both Tables 3 and 4. This value is really the gross worth of the river to the state as a whole. The method of determining zones and base populations ensures that eligible resident anglers in the state represent the population to which the value is ascribed. In this case, then, the economic value should be adjusted downward to reflect the state's (DNR) investment and depreciation costs for the Au Sable River during 1970 and 1971.

As has already been pointed out, the limited amount of data available for this study precluded the conduct of economic demand analyses of individual types of sport fishing such as salmon and steelhead fishing and fishing for warmwater species.

The anadromous fishery on the Au Sable River comprises only the lower 10 miles in Iosco County from Foote Dam to its mouth. From 1968 through 1971 approximately 100,000 steelhead trout, 1.3 million coho salmon, and 700,000 chinook salmon have been planted near the mouth of the river. Through 1971, over 20,000 steelhead, 40,000 coho, and 20,000 chinook have been taken by Au Sable River sport fishermen.

This catch of anadromous species undoubtedly accounts for a significant proportion of both the total angler pressure and the economic value ascribed to Alcona-Iosco counties in Table 4. It can be expected that the effects of anadromous fishing upon the river's overall "value" and producing greater numbers of fishing opportunities, will increase in future years. The chinook plantings, for example, will be returning to the river in substantial numbers, for the first time, during the 1972 fall season.

MANAGEMENT IMPLICATIONS

The results of this study are perhaps more illustrative than definitive. There are several implications to be considered insofar as its methods may commend themselves to application in the decision process in natural resources management.

The limitations of the general methodology are well documented in the literature cited in this paper (Clawson, Brown, Ellefson, Smith). Further limitations imposed on this particular study result from the size of the available sample. If a three or four percent statewide sampling effort could be economically and administratively accommodated on an annual basis, and if basic expenditure questions could be included within the questionnaire, then a broader base for comparative analyses of individual resources (lakes, streams, rivers, bays, etc.) would be readily available.

Results of such analyses might be of assistance in the decision process for determining the relative allocation of natural resource dollars among alternative fisheries projects within the state. The efforts--in terms of trends in economic values for specific fishery resource projects from annual estimates--might be used as justification for curtailment or expansion in individual program/project spending. With the advent of the Planning, Programming and Budgeting systems (PPBS) at the state level, the difficulty of analyzing costs vs. benefits among "non-market" resource management program inputs and outputs has increased. Clawson-type, economic demand analyses have significant potential for further refinement and application within the PPBS framework. In any case, the method clearly represents a potential avenue of approach to finding an acceptable answer for the crucial question so often asked in budgetary hearings..."How much is this program worth relative to that one?"

SUMMARY

The best estimate of the economic value to the state of Michigan from sport fishing on the Au Sable River by Michigan residents was $535,640 in 1970. Since economic information was not requested of fishermen surveyed in 1971, expenditure data from the 1970 analysis were extrapolated to the angling pressure (angler days) reported during 1971. This gave an estimated overall economic value for the resource of $836,290 in 1971.

In analyzing both years' results, all types of fishing were combined. Thus, no distinction was made between inland and anadromous fishing effort. A substantial increase in angling pressure during 1971 took place over 1970. Consequently, there was a similar increase in estimated economic value of the resource. During 1970, the Au Sable River sport fishery accounted for 1.6 percent of all resident statewide angling pressure and 0.4 percent of all non-resident statewide effort. In 1971, it accounted for 2.1 percent of resident and 0.6 percent of non-resident statewide effort. Resident anglers using the river spent approximately 60 percent of their total reported expenditures at the fishing location.[5] In 1970, approximately 80 percent of the total annual effort in angler days was exerted during the months of May through August.

[5] For purposes of clarity, the term "resident" refers to state as opposed to local residents.

LITERATURE CITED

Brown, W. G., A. Singh, and E. N. Castle. 1964. An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fishery. Oregon Agr. Exp. Sta. Tech. Bull. 78. 47 pp.

Clawson, M. 1959. "Methods of Measuring the Demand for and Value of Outdoor Recreation," Reprint No. 10, Resources for the Future, Inc. Washington, D.C.

Clawson, M. and J. L. Knetsch. 1966. Economics of Outdoor Recreation. Johns Hopkins Press, Baltimore. 328 pp.

Ellefson, P. V., and G. C. Jamsen. 1971. Economic Appraisal of Michigan's Sport Fishery. Michigan Dept. Nat. Res., Research and Development Reports 227, 243 and 244.

Smith, R. J., and N. J. Kavanaugh. 1969. The Measurement of Benefits of Trout Fishing: Preliminary Results of a Study at Grafham Waters, Great Ouse Water Authority, Huntingdonshire. J. Leisure Res. 2(4): 316 - 332.

ECONOMIC IMPLICATIONS FROM THE GRAND TRAVERSE BAY SPORT FISHERY[1]

by James M. Kapetsky[2] and James R. Ryckman[3]

INTRODUCTION

The University of Michigan Sea Grant Program has as its ultimate objective the definition of the consequences of various alternatives in long-term development of water and land resources of the Great Lakes and the presentation of this knowledge to society as a basis for rational choice.

Grand Traverse Bay was selected as the focus of pilot efforts to develop a complete model of a small part of the Great Lakes ecosystem. The bay provides a microcosm of the problems and processes encountered in Lake Michigan.

In 1966, the State of Michigan established a fishery management policy which clearly recognized the economic and recreational benefits that would accrue from a developed fishery on the Great Lakes. Furthermore, in recent years all fisheries agencies on the Great Lakes have become increasingly aware of the need to obtain better statistical information on the sport fishery for both biological and socio-economic reasons.

Consultations between representatives of The University of Michigan Sea Grant Program and the Michigan Department of Natural Resources disclosed mutual interest in the sport fishery aspects of Grand Traverse Bay. The two agencies agreed to initiate a cooperative project in accordance with the overall informational requirements of the Sea Grant Program in its efforts to model physical, biological, sociological, and economic aspects of the Grand Traverse Bay area, and in line with the on-going activities of the State of Michigan in evaluating the biological and socio-economic characteristics of its sport fishery.

Recognizing the opportunity to define and evaluate the role of a developing recreational fishery in a localized area, the project, as conceived, had three objectives:

---

[1] This report is an edited version of a report prepared for The University of Michigan Sea Grant Program. This work is a result of research sponsored by NOAA Office of Sea Grant, Department of Commerce, under Grant #04-3-158-23. The U. S. Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notation that may appear hereon.

[2] Principal investigator, The University of Michigan Sea Grant Project R/EMD-18.

[3] Biometrician, Research and Development Division, Michigan Department of Natural Resources

1. Measure the use of the Grand Traverse Bay fishery resource in terms of the fishing activity engaged in by community residents and visitors to the bay area.

2. Identify the source and quantify the seasonal and annual revenue flows stemming from various kinds of fishing activity associated with the Grand Traverse Bay fishery.

3. Measure the economic benefits accruing to the Grand Traverse Bay community related to sport fishing activity on Grand Traverse Bay.

The Grand Traverse Bay Community

The Grand Traverse Bay community comprises the three-county area adjacent to the bay (Fig. 1). Included in the community are Antrim, Grand Traverse, and Leelanau counties, with a combined population of nearly 63,000. Traverse City, located at the southern end of the bay with a population of about 18,000, is the economic and cultural center of the community (U. S. Bureau of Census, 1970).

The northwest section of the lower peninsula of Michigan, in the center of which lies the bay area, is one of the most popular tourist areas in the state. Water and related resources are the major natural assets of the area. Availability of unspoiled water and land resources, agreeable climate, and the natural beauty of the region attract visitors on a year-round basis. Tourism and recreation rank with manufacturing as leading economic activities in the region (NMEDDC, 1968).

The Grand Traverse Bay Sport Fishery

The popularity of sport fishing in Grand Traverse Bay is not a recent phenomenon but dates back to the late 1860's. Just after the turn of the century a nationally known sport fishing camp was established at Northport and provided "deep sea trolling" for lake trout. Charter fishing in those days was available on a "no catch, no charge" basis (Colby, 1971), attesting to the abundance of the fishery resources.

From the mid-1940's to the early 1960's, certain fish populations declined due to the parasitic sea lamprey which was first reported in Lake Michigan in 1936 (Wells and McLain, 1972), and perhaps because of intensive commercial fishing. During depression years attempts to limit commercial fishing were made but were unsuccessful (Colby, 1971). In 1945 the lower portion of the bay was closed to commercial fishing and in 1970 the entire bay was set aside exclusively for sport fishing.

Through the 1950's sport fishing remained at low ebb. In the 1960's, as a result of the increasing success of the lamprey control program and advent of fish stocking, sport fishing activity began to increase. Lake trout were planted in the bay in 1966 and coho salmon were first introduced in 1968. Indicative of the growth of sport fishing activity on Grand Traverse Bay in recent years is the rebirth of the charter fishing industry. In 1966 there were no active charter operations on the bay; during the 1971 season there were 22.

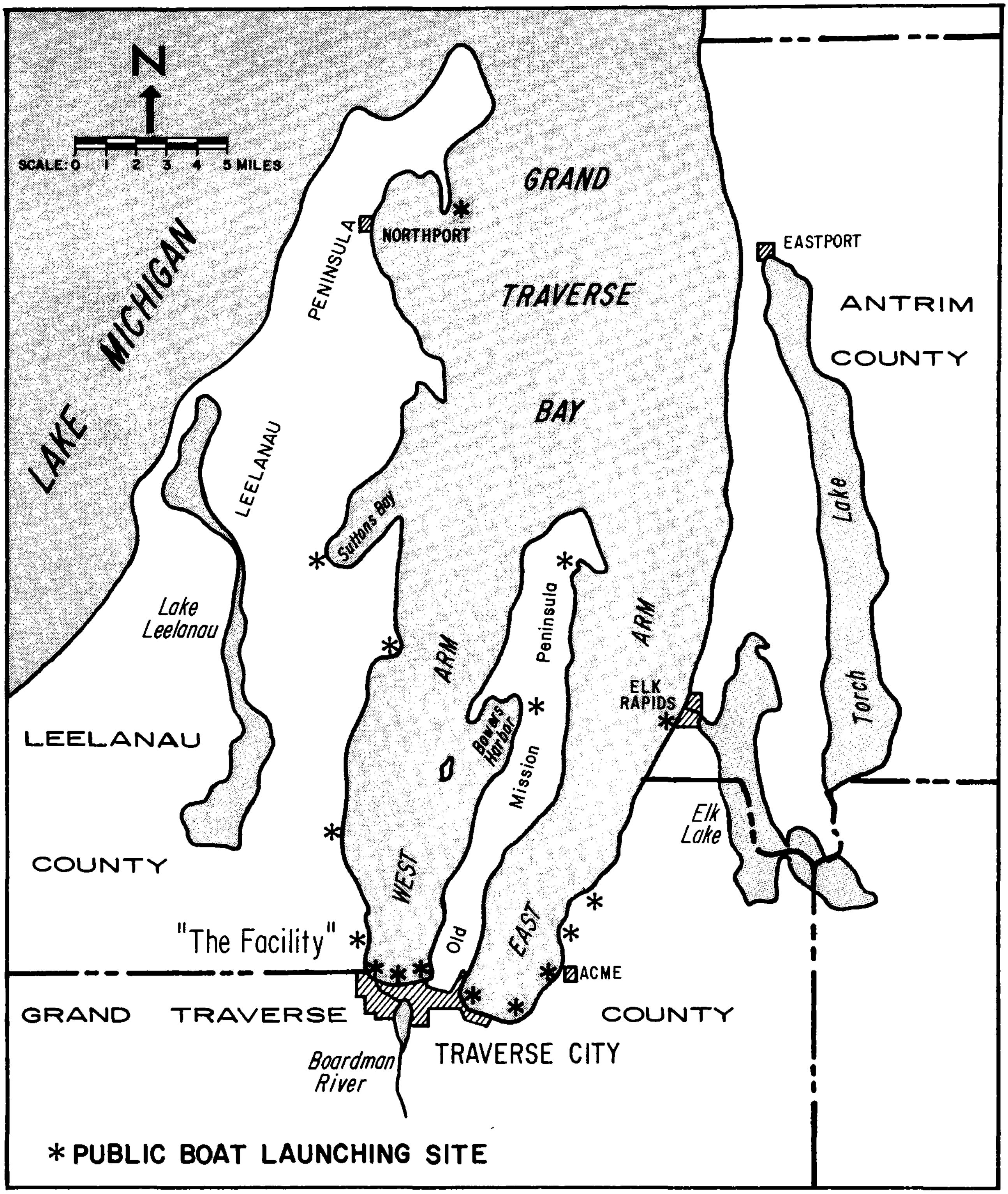


Figure 1. Public boat launching sites on Grand Traverse Bay

Although the successful introduction of coho salmon has received wide publicity in recent years, the sport fishery on the Bay is based primarily on lake trout. Lake trout accounted for about two-thirds of the estimated 87,000 salmon and trout caught in Grand Traverse Bay in 1969, while coho salmon accounted for less than 20 percent of the total catch (Jamsen et al., 1970). Lake trout are available to the fishery on an almost year-round basis, whereas coho and chinook salmon and steelhead trout are available only seasonally. In addition to the salmon and trout mentioned above, brook trout, smallmouth bass, rock bass, and yellow perch are caught in inshore areas. Smelt are dipped during their spawning runs.

SPORT FISHING ACTIVITY ON GRAND TRAVERSE BAY

Sport fishing activity on Grand Traverse Bay for a one-year period (May 1971 to May 1972) was estimated at 61,847 (±5%) angler days (Table 1). An angler day is the recreational fishing activity engaged in by one individual at any time during one calendar day and as such is an appropriate measure of the recreation provided by the fishery resource. Because of repeat fishing trips, especially by local residents, the actual number of individuals who utilized the resource is considerably less than the fishing activity expressed in angler days. Estimates of non-resident fishing activity were based on the proportions of visitors encountered during interviews with sample fishermen.

Angling effort on Grand Traverse Bay was divided into five categories: (1) boat fishing originating at public access sites in 1971; (2) charter fishing in 1971; (3) shore fishing in the late summer and fall of 1971; (4) ice fishing in the winter of 1971-72; and (5) shore fishing in the spring of 1972. Counts of boat fishing and charter fishing began in May, 1971; however, no estimates were made for spring shore fishing in 1971. In 1972, spring shore fishing estimates were made through May 31 to compensate for the spring shore fishing activity not monitored during 1971.

Several techniques were used to measure angler activity. A regression model was developed to estimate boat fishing effort. From the launching activity which occurred at the principal launching site on the bay as input, the daily fishing effort originating at 11 other access sites could be predicted. Angler days expended by shore and ice fishermen were estimated from an expansion of periodic once-daily observations. Angler counts were made during times of peak fishing activity. The estimate of charter fishing activity was based on extrapolation of the total number of angler days reported by 80 percent of the charter operators.

The model for boat fishing activity does not incorporate effort originating from five public access sites on the bay; however, in terms of parking capacity, these five sites account for less than 15 percent of all public boat-trailer parking spaces at public access sites. Furthermore, no attempt was made to estimate angling effort originating from private bay-front properties or that associated with boats permanently moored at marinas. Nevertheless, it is believed that these sources of fishing activity are quite small in relation to that originating from public launching sites.

Fishing pressure estimates for shore and ice fishing are conservative because the daily counts on which the estimates were based were of an "instantaneous" nature. Although counts were made during peak fishing hours, angling activity that ended before the counts were made or began after the counts were concluded was not observed. It is believed that charter fishing effort was not underestimated. The statistic of 61,847 angler days must be considered as the minimum point estimate of angler activity expended on the bay during the period over which sport fishing activity was measured.

In terms of angler activity, boat fishing originating at public launching sites was the most important source of fishing activity on Grand Traverse Bay, and accounted for an estimated two-thirds of all fishing effort. Ice fishing was second in importance with 18 percent of the total activity. Charter and shore fishing amounted to about 15 percent of the total (Table 1).

More than 70 percent of all fishing took place during the warmer months of the year, June through September; however, some fishing occurred on an almost year-round basis, with a minimum amount in December and January.

Visitors to the bay area used the fishery resource more than the residents. Overall, an estimated 69 percent of angler activity was accounted for by visitors. Charter fishing and boat fishing originating at public launching sites attracted the largest proportions of non-residents. Ice fishing was the only activity in which residents used the resource more extensively than did visitors to the bay area (Table 1).

Table 1. Summary of sport fishing activity on Grand Traverse Bay, May 1971 - May 1972.

Category of fishing activity	Total angler days	Percentage of total angler days	Non-resident angler days	Percentage from non-residents
1971				
Boat	41,279 (±4%)	67	33,073 (±7%)	80
Charter	4,030 (±4%)	6	3,430 (±11%)	85
Shore	4,192 (±25%)	7	2,815 (±27%)	67
1972				
Ice	11,055 (±23%)	18	2,787 (±32%)	25
Spring shore	1,291 (±27%)	2	773 (±30%)	60
Totals	61,847 (±5%)	100	42,878 (±7%)	69

SPORT FISHING REVENUE

During the period from May, 1971, to May, 1972, an estimated $419,000 in revenue attributable to the Grand Traverse Bay fishery resource accrued to the bay-area community. This gross income stemmed from the spending of non-resident anglers who visited the bay-area primarily for fishing in Grand Traverse Bay. The spending by anglers whose fishing was incidental to the primary purpose of their visits and the expenditures of fishermen who would have been equally satisfied to fish elsewhere in the bay-area were omitted. Expenditures by resident fishermen provided no new source of income for the community and was also excluded. Thus, the revenue attributable to the fishery resource is an estimate of the amount of gross income which would be lost to the bay community if the Grand Traverse Bay fishery were to suddenly disappear.

Boat fishermen contributed approximately one-half of the revenue attributable to the fishery resource (Table 2). Although numerically small in terms of fishing activity, charter fishermen provided 38 percent of the gross income from fishing, by virtue of their large daily spending (Table 2). Because boat and charter fishing are seasonal, more than three-fourths of the total revenue attributable to the fishery resource accrued to the community during the warmer months of the year.

Table 2. Non-resident sport fishing revenue, attributable to the Grand Traverse Bay fishery resource, generated from one-day fishermen and those staying overnight.

Category of fishing activity	One-day trip		Overnight trip		Total	
	$$	%	$$	%	$$	%
1971						
Boat	28,662 (±33%)	14	175,880 (±15%)	86	204,542 (±13%)	49
Charter	38,902 (±22%)	24	120,051 (±13%)	76	158,953 (±11%)	38
Shore	3,448 (±48%)	28	8,967 (±40%)	72	12,415 (±32%)	3
1972						
Ice	2,966 (±60%)	8	35,285 (±38%)	92	38,251 (±36%)	9
Spring shore	821 (±50%)	19	3,519 (±45%)	81	4,340 (±38%)	1
Totals	74,799 (±17%)	18	343,702 (±10%)	82	418,501 (±9%)	100

Fishermen on one-day trips are in the bay area for a relatively short time and usually acquire their supplies at home. Thus the revenue accruing to the community from these anglers is small compared with that from anglers staying in the area more than one day. For all categories of fishing, revenue from overnighters accounted for 82 percent of the total; from one-day fishermen, 18 percent (Table 2).

ECONOMIC IMPACT OF THE GRAND TRAVERSE BAY SPORT FISHERY

From the economic viewpoint of the bay community, the impact of the fishery amounts to increased income and employment in the community. In most cases not all of the goods and services required by a small community can be produced within its confines. Therefore, a large proportion of the gross income which the community receives must eventually leave the area as payment for imported goods and services. The remaining income (net income) is divided among salaries and wages to local workers, profits to area industries, interest, and rent.

The direct community income from revenue attributable to the fishery resource was estimated as $136,000, based on an income component of sales of 30 percent in the local retail trade and service industries. Some of the necessary data on which estimates of economic impact were based were unobtainable from local sources or from published state and federal documents. In the absence of these data, pertinent values have been selected from the literature. Although literature values have been selected with care, the resulting economic impact estimates must not be rigidly interpreted, but are meant to convey only an approximation of the values which actually obtain. Income components of sales have been found to range between 28 percent (Pearse and Laub, 1969) and 51 percent (derived from information presented by Kalter and Lord, 1968). Consistent with estimates previously made in this report, a conservative value for the income component of sales has been utilized.

In addition to the direct effect on the bay community income, this revenue attributable to the fishery resource also exerts a multiplying effect on income in the area. Simply stated, additional income available in the community will result in increased spending. Money spent by one individual becomes, in part, income to the person or business making the sale. Thus, successive rounds of spending, beginning with sport fishermen and continuing with community residents, exert a multiplying effect on community income. However, the effect is progressively reduced as some of the income is used to pay for imported goods and services and some is saved.

An income multiplier of 1.5 has been selected as applicable to the economy of the bay community.[4] Using this value, it is estimated that the revenue attributable to the Grand Traverse Bay fishery resource increased community income by a total of $204,000 ($136,000 x 1.5) during the period from May, 1971 to May, 1972.

---

4 Use of this value is based on the apparent similarities between economic profiles of Walworth County, Wisconsin, and Antrim, Grand Traverse and Leelanau counties taken together. Kalter and Lord (1968) have calculated an income multiplier of 1.52 for Walworth County.

Similarly, this revenue from the fishery exerts both a direct and multiplying effect on community employment. Fishery-related employment was estimated separately for the charter fishing industry and for the largest boat launching facility on the bay. Sport fishing income provided the full-time equivalent of 4.0 jobs in the charter industry and 0.7 jobs at the launching facility. Additional direct employment not identified with any specific industry was estimated at 9.6 full-time equivalent jobs. This is based on the ratio of one individual employed for every $35,912 in sales in the retail and service industries in this community, as derived from the 1967 Survey of Business. Direct community employment generated by the revenue attributable to the fishery resource was thus estimated at 14.3 full-time equivalent jobs.

As community income originating from the spending of sport fishermen is increased through successive rounds of re-spending, additional employment is required to handle the increased volume of sales. Thus there is a community-wide increase in employment in addition to that directly generated by anglers' spending. An employment multiplier of 1.5, coincidentally the same as the income multiplier, was selected as indicative of the total effects of the bay fishery resource on community employment.[5] Applying the multiplier to the 14.3 jobs directly generated by the spending of sport fishermen, this results in an estimate of 21.5 full-time equivalent jobs in the Grand Traverse Bay community which were attributable to the fishery resource.

Neither the revenue estimates nor the estimates of economic impact should be construed as representative of the total value of the Grand Traverse Bay sport fishery. On the one hand, the fishery has, as yet, unmeasured recreational value to its non-resident users; on the other hand, the value of the fishery to local residents, whether they engage in fishing or not, may far surpass the value estimated for it in terms of increased employment and income accruing to the community.

Furthermore, the sport fishery may have still other unquantified impacts. Colby (1971) has suggested that the first visitors to the bay area were sport fishermen and the fishery resource may have stimulated the creation of additional recreational facilities and activities. It is likely that the rebirth of sport fishing in the last decade has had a similar effect.

SUMMARY

As part of the University of Michigan Sea Grant Program, an investigation was conducted on Grand Traverse Bay in 197 -1972 to measure the use of the fishery resource, quantify the flow of revenue, and determine the economic impact of the fishery on a three-county area adjacent to the bay.

From May, 1971 to May, 1972, nearly 62,000 angler days of fishing activity were expended on the bay. Boat fishing from boats originating at public launching sites was the most important category of activity, accounting for 67 percent of the total angler days of recreational fishing. Visitors to

---

[5] An employment multiplier of 1.5 was associated with the spending of recreationists in Walworth County, Wisconsin (Kalter and Lord, 1968).

the bay area used the resource more heavily than did residents. Overall, an estimated 69 percent of total angler activity was expended by non-residents. More than three-fourths of the annual fishing activity was done from June through September; however, some fishing occurred on a year-round basis.

The spending of non-resident anglers, attributable to the Grand Traverse Bay fishery resource, provided an estimated $419,000 of gross income to the bay community. Boat fishermen using public launching sites contributed the largest amounts of revenue. Charter fishermen, although small numerically, accounted for the second largest flow of revenue to the community.

The economic impact of the fishery resource was measured in terms of income and employment generated by the spending of non-resident sport fishermen which could be attributed to the fishery. Total community income was increased by an estimated $204,000. Full-time equivalent employment attributable to the fishery resource was estimated at 21.5 jobs.

LITERATURE CITED

Colby, L. 1971. Grand Traverse Bay in the Great Lakes Basin. Univ. of Michigan Sea Grant Program. 112 pp.

Jamsen, G., J. Ryckman and F. Jamsen. 1970. Michigan's 1969 Salmon and Trout Sport Fishery. Research and Development Report No. 203. Michigan Department of Natural Resources. Appendices A-1, A-2 and A-3. 10 pp.

Kalter, R. and W. Lord. 1968. Measurement of the Impact of Recreation Investments on a Local Economy. Am. J. Agr. Econ. 50 (2), pp. 243-256.

Pearse, P. and M. Laub. 1969. The value of the Kootenay Lake Sport Fishery: An Economic Analysis. Fish and Wildlife Branch, Dept. of Recreation and Conservation, Victoria, B. C., Canada. 60 pp.

NMEDDC. 1968. Prelogue for Accelerated Growth of the Economy. The Northwestern Michigan Economic Development District Commission.

U. S. Bureau of Census. 1972. Census of Agriculture, 1969. Vol. I. Area Reports, Part 13. Michigan Section 2. County Data. U. S. Govt. Printing Office, Washington, D.C.

U. S. Bureau of Census. 1970. Census of Business, 1967. Vol. II, Retail Trade--Area Statistics, Part 2, Iowa to North Carolina. U. S. Govt. Printing Office, Washington, D.C.

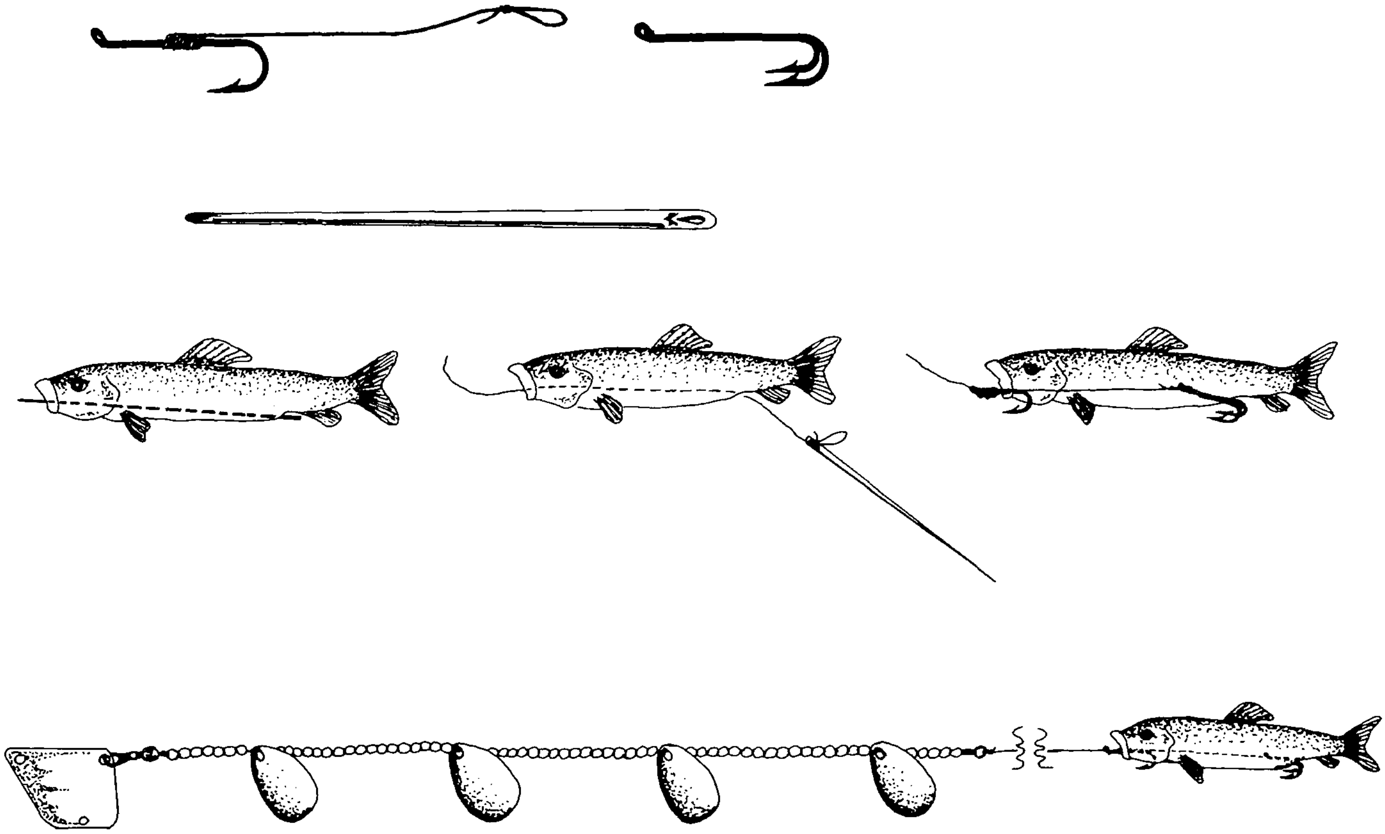
U. S. Bureau of Census. 1970. Census of Business, 1967. Vol. V. Selected Services - Area Statistics, Part 2, Iowa to North Carolina. U. S. Govt. Printing Office, Washington D.C.

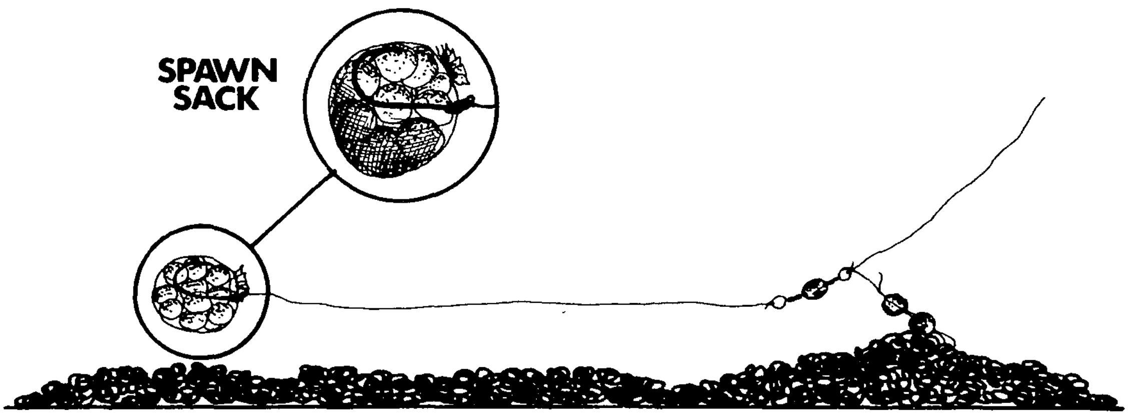
U. S. Bureau of Census. 1971. Census of Manufacturers, 1967. Vol. III, Area Statistics, Part 1, Alabama to Montana. U. S. Govt. Printing Office, Washington, D.C.

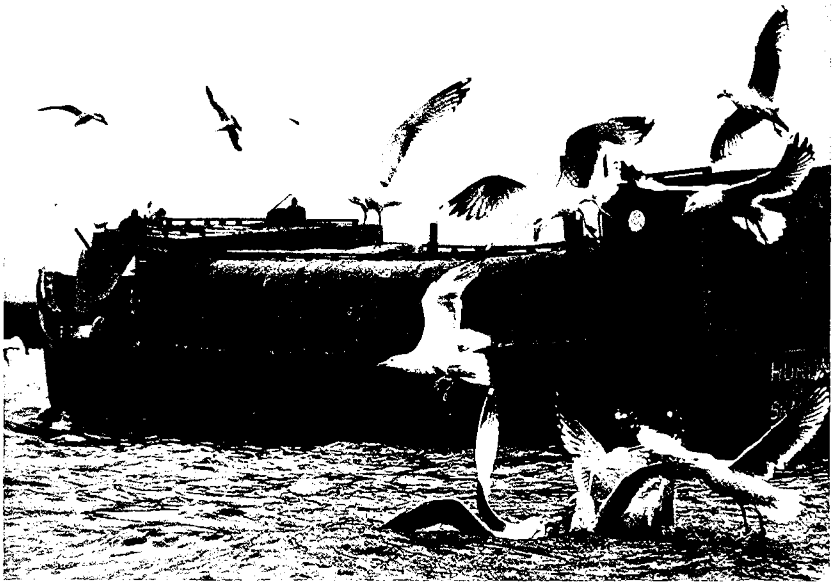
U. S. Bureau of Census. 1972. Census of Population: 1970. Vol. I, Characteristics of the Population, Part A, Number of Inhabitants Section 1 - U. S., Alabama - Mississippi. U. S. Govt. Printing Office, Washington, D.C.

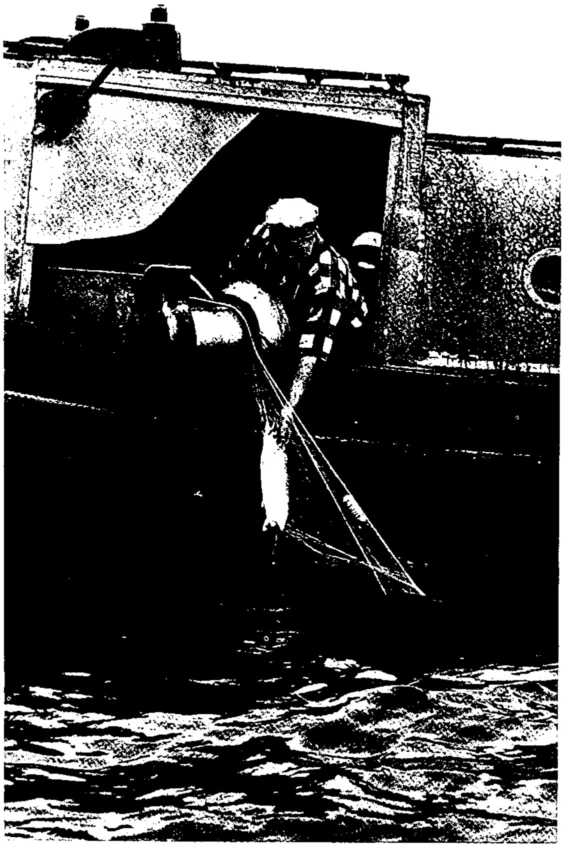
Wells, L. and A. McLain. 1972. Lake Michigan: Effects of Exploitation, Introductions, and Eutrophication on the Salmonid Community. J. Fish. Res. Bd. Canada, 29: 889-898.

TROLLING WITH BAIT









Non-Recreational Use Of Salmon And Trout In Michigan's Great Lakes

COMMERCIAL AND INDIAN FISHING FOR GREAT LAKES SALMON AND TROUT

by Ned E. Fogle[1]

The first substantial commercial fishing venture on the Great Lakes was initiated by the American Fur Company early in the 19th century. This activity was centered in western Lake Superior and gradually moved to all portions of the Great Lakes. Since then and continuing through 1969, the fishery resources in Michigan waters of the Great Lakes were openly pursued by an aggressively exploitive commercial fishery. Limited commercial fishing ventures were already underway by various Indians upon the arrival of the white man, although most Indian fishing was for personal food needs.

The composition of the present fish stocks show little resemblance to that which existed historically. As one stock was fished down, the fishermen shifted their emphasis to a new species or to another area. Peak fishing production occurred around the turn of the century. However, even by this time, certain important commercial species such as sturgeon and muskellunge were nearly gone.

Improved equipment such as the gas engine, gill net lifter, nylon gill nets and freezers allowed the fishermen to greatly increase their pursuit, and this resulted in near depletion of the stocks of lake herring, chubs, yellow perch, walleye, and whitefish in many areas of the lakes.

Continued exploitation by commercial fishing, combined with the effects of the invading predatory sea lamprey, brought about the near total destruction of lake trout and other remnant species of high commercial value in the upper Great Lakes by the mid-1950's. By this time, the depressed economics of the fishery resulted in the number of commercial fishermen falling from approximately 1,100 in 1950 to approximately 300 in 1969. During this period, from 1950 to 1969, fishing by Indians was practically non-existent except for those few who held commercial fishing licenses.

By the early 1960's lamprey control was a reality and fish restoration in the Great Lakes was initiated in lakes Superior and Michigan under the auspices of the Great Lakes Fishery Commission, by the Michigan Conservation Department (now the Michigan Department of Natural Resources). Lake trout, the first species to be re-stocked, were planted first in Lake Superior and then in Lake Michigan. In 1966 another species, the coho salmon, was stocked in lakes Superior and Michigan by the Michigan Department of Natural Resources, and in 1967 chinook salmon were stocked in Lake Michigan.

It soon became obvious to state fishery managers that hatchery plants of lake trout stocks were being harvested by the commercial fishery in large numbers. Lake trout had been given sport fish status in 1962, i.e., were no longer considered a commercial species. This, however, did not alleviate the

---
[1] Great Lakes Specialist, Fisheries Division, Michigan Department of Natural Resources

high numbers of trout being taken by commercial fishing incidental to fishing for a commercial species such as whitefish. Similarly, newly planted salmon also were vulnerable to nets being set for other species.

New state legislation in 1968 gave the Director of the Department of Natural Resources the authority to regulate commercial fishing on the Great Lakes. In 1970, under this authority, a zone management program and limited entry were put in effect in an attempt at effective control of the commercial harvest. Under these new regulations, part-time fishermen were eliminated from the fishery and the number of licensed commercial fishermen reduced from approximately 300 to 188.

The present day commercial fishery is substantially different from what it was in the past. The proportion of low-value species in relation to high-value species has increased significantly. Today the fishery primarily concentrates its efforts on alewives, chubs, whitefish, and carp. In 1971, the percentages by weight of these species in the commercial catch was 25, 20, 19, and 10, respectively. The dockside value for the entire commercial catch was $2.7 million, with whitefish and chubs accounting for 73 percent of the total value.

Lake trout harvest occurs primarily from assessment fishing under permit from the state, although some continues to occur from illegal fishing. The incidental catch of lake trout was highest in 1968, when it was estimated that over 70,000 fish from Lake Michigan and over 17,000 fish from Lake Superior were landed. Although the 1969 and 1970 incidental catches in Lake Michigan were substantially lower (22,000 and 20,000 respectively), it was estimated that, by 1970, 80 percent of the 1965 plant had been killed, and meaningful reproduction from this plant was nil. Assessment fishing by commercial fishermen for research purposes is permitted only in Lake Superior and accounts for about 10,000 fish annually.

Salmon are reserved exclusively for sport fishing. Under the present commercial fishing rules, salmon generally are not vulnerable to netting and there is no problem with incidental net mortality as with the lake trout. The sale of excess salmon at harvest weirs, however, has been prevented by contamination of DDT and polychlorinated biphenyls (PCB's) in excess of the level (5 ppm.) set by the U. S. Food and Drug Administration (FDA). The present utilization of salmon is restricted to the sale of eggs for bait. Lake trout, although still being marketed by the fishing industry, are also coming under closer scrutiny by the FDA because of contamination levels.

Present-day fishing by Indians, other than the few holding commercial fishing licenses, is relatively limited. There are some problems in localized areas where the Indian fishery tends to be of an exploitive nature. By an 1854 treaty, Indians of the L'Anse and Lac Vieux DeSert bands were given fishing rights in the Keweenaw and Huron Bay area of Lake Superior. These rights were upheld in 1971 by the Michigan State Supreme Court (People vs Jondreau, 384 Mich. 539), which ruled that Indians residing on tribal lands in the Keweenaw Bay Area were exempt from the state's hunting and fishing laws. Confusion over the court decision resulted temporarily in Indians fishing throughout the state. This burst of fishing proved to be quite exploitive and is estimated to have taken in excess of 150,000 pounds of trout and salmon in

1972, which was a significant percentage of the fish being stocked. Eventually the decision was clarified to the effect that only specific Indians, i.e., from the Lac Vieux DeSert and L'Anse bands were covered by the treaty. In the interim, the Michigan United Conservation Clubs sought and obtained an injunction (Mich. United Cons. Clubs vs Anthony, et. al.) against all other unlawful fishing by Indians. The only other fishing by Indians occurs under the authority of several tribal fishing permits issued by the Michigan Department of Natural Resources. This particular fishing, however, is for commercial species and does not significantly affect the trout and salmon populations of the respective areas.

The future holds some radical changes for commercial fishing in Michigan. The Department of Natural Resources is proposing that gill net fishing (except for carp) be prohibited by 1974, and that all fishing be done with impounding gear, i.e., trap and pound nets, trawls, etc. It is further proposed that all fishing be done under some form of contract. The contract form of management will reduce the number of operators to about 40, and should put the industry on a sound economic basis. Provisions probably will be made to allow some fishing in the future by Indians.

SELECTED REFERENCES ON GREAT LAKES COMMERCIAL FISHING

Baldwin, N. S., and R. W. Saalfeld. 1962. Commercial fish production in the Great Lakes, 1867-1960. Great Lakes Fishery Commission Technical Rept. No. 3. 166 pp.

Berst, A. H., and G. R. Spangler. 1972. Lake Huron: effects of exploitation, introductions, and eutrophication on the salmonid community. J. Fish. Res. Bd. Canada. 29(6): 877-887.

Borgeson, D. P. (Editor). 1972. Status of Michigan's fisheries management 1971. Michigan Dept. Nat. Res., Fish. Div., Fish. Mgmt. Rept. 4. 37 pp.

Buettner, H. J. 1968. Commercial fisheries of the Great Lakes 1879-1966. U. S. Fish Wildl. Serv. Historical Fishery Statistics 13 (C.F.S. No. 4825). 22 pp.

Christie, W. J. 1972. Lake Ontario: effects of exploitation, introductions, and eutrophication on the salmonid community. J. Fish. Res. Bd. Canada. 29(6): 913-929.

Frick, H. C. 1965. Economic aspects of the Great Lakes fisheries of Ontario. Fish. Res. Bd. Canada Bull. 149. 160 pp.

Hartman, W. L. 1972. Lake Erie: effects of exploitation, environmental changes and new species on the fishery resources. J. Fish. Res. Bd. Canada. 29(6): 899-912.

Koelz, W. 1926. Fishing industry of the Great Lakes. Rep. U. S. Comm. Fish. 1925: 553-617.

Lawrie, A. H., and J. F. Rahrer. 1972. Lake Superior: effects of exploitation and introductions on the salmonid community. J. Fish. Res. Bd. Canada. 29(6): 765-776.

Nute, G. L. 1926. The American Fur Company's fishing enterprises on Lake Superior. Mississippi Valley Historical Review. 12(4): 483-503.

Rakestraw, L. 1968. Commercial fishing on Isle Royale. Isle Royale Natural History Association, Houghton. 24 pp.

Smith, S. H. 1968. Species succession and fishery exploitation in the Great Lakes. J. Fish. Res. Bd. Canada. 25(4): 667-693.

Smith, S. H. 1972. Destruction of the ecosystem in the Great Lakes and possibilities for its reconstruction. Univ. of Washington, Pubs. in Fisheries, New Series, Vol. 5.

Tody, W. H. 1970. Zones for the big lakes. Michigan Nat. Res. 39(2): 3-9.

Van Oosten, J. 1938. Michigan's commercial fisheries of the Great Lakes. Michigan History 22: 107-145.

Wells, L., and A. McLain. 1972. Lake Michigan: effects of exploitation, introductions, and eutrophication on the salmonid community. J. Fish. Res. Bd. Canada 29(6): 889-898.

SELECTED REFERENCES ON INDIAN FISHING
IN THE GREAT LAKES

Burroughs, R. D. 1961. They made their own tackle. Michigan Conservation, 30(3): 24-27.

Kinietz, W. V. 1965. The Indians of the Western Great Lakes, 1615-1760. University of Michigan Press. Ann Arbor.

Martin, P. S., G. I. Quimby and D. Collier. 1947. Indians before Columbus; twenty thousand years of North American history revealed by archeology. University of Chicago Press. Chicago.

Mason, P. P. (Editor) 1958. Schoolcraft's expedition to Lake Itasca; The discovery of the source of the Mississippi. Michigan State University Press. East Lansing.

Mason, P. P. 1960. Michigan's first outdoorsmen. Michigan Conservation, 29(2): 40-45 and 29(3): 26-29.

Quimby, G. I. 1960. Indian life in the upper Great Lakes, 11,000 B.C. to A.D. 1800. University of Chicago Press. Chicago.

Rankin, E. H. 1966. The Indians of Gitchigumee. Marquette County Historical Society. Marquette, Michigan.

Ritzenthaler, R. E. and P. Ritzenthaler. 1970. The Woodland Indians of the Western Great Lakes. Natural History Press. Garden City, New York.

Thwaites, R. G. (Editor). 1959. The Jesuit relations and allied documents; travels and explorations of the Jesuit missionaries in New France, 1610-1791. 73 Vol. Pageant Book Co., New York.

U. S. Bureau of American Ethnology Annual Reports. 1879-Present.

Warren, W. W. 1970. History of the Ojibway nation. Ross and Haines. Minneapolis, Minn.

APPENDICES

APPENDIX A

Common and scientific fish names

1971 Fishing Survey Questionnaire List	Common name	Scientific name
Perch	Yellow perch	*Perca flavescens*
Walleye	Walleye	*Stizostedion vitreum*
Bass	Largemouth bass	*Micropterus salmoides*
	Smallmouth bass	*Micropterus dolomieui*
	White bass	*Roccus chrysops*
Panfish (mainly the following members of the family Centrarchidae)		
	Bluegill	*Lepomis macrochirus*
	Pumpkinseed	*Lepomis gibbosus*
	Black crappie	*Pomoxis nigromaculatus*
	Rock bass	*Ambloplites rupestris*
Musky	Muskellunge	*Esox masquinongy*
Northern pike	Northern pike	*Esox lucius*
Suckers	Suckers	Catostomidae
Smelt	Rainbow smelt	*Osmerus mordax*
Lake trout	Lake trout	*Salvelinus namaycush*
Rainbow trout	Rainbow trout (steelhead)	*Salmo gairdneri*
Brown trout	Brown trout	*Salmo trutta*
Brook trout	Brook trout	*Salvelinus fontinalis*
Coho salmon	Coho salmon	*Oncorhynchus kisutch*
Chinook salmon	Chinook salmon	*Oncorhynchus tshawytscha*
	Pink salmon	*Oncorhynchus gorbuscha*
	Lake sturgeon	*Acipenser fulvescers*
	Carp	*Cyprinus carpio*
	Lake whitefish	*Coregonus clupeaformis*
	Sea lamprey	*Petromyzon marinus*
	Alewife	*Alosa pseudoharengus*
	Chub	*Coregonus* spp.
	Sticklebacks	Gasterosteidae
	Sculpins	Cottidae

APPENDIX B

Documents Produced Under AFSC-8.

Ellefson, Paul V. 1971. Estimating user benefits of public recreation areas by demand curve analysis. Michigan Dept. Nat. Res., Research and Development Rept. 228. 14 pp.

Ellefson, Paul V., and Gale C. Jamsen. 1971a. Economic appraisal of Michigan's sport fishery, January 1 - April 24. Michigan Dept. Nat. Res., Research and Development Rept. 227. 36 pp.

Ellefson, Paul V., and Gale C. Jamsen. 1971b. Economic appraisal of Michigan's salmon and steelhead sport fishery, April 25 - August 31, 1970. Michigan Dept. Nat. Res., Research and Development Rept. 243. 21 pp.

Ellefson, Paul V., and Gale C. Jamsen. 1971c. Economic appraisal of Michigan's salmon and steelhead sport fishery, September 1 - December 31, 1970. Michigan Dept. Nat. Res., Research and Development Rept. 244. 12 pp.

Ellefson, Paul V., and Gale C. Jamsen. 1971d. Michigan's salmon-steelhead trout fishery: an economic evaluation. Michigan Academician, IV(2): 237-244.

Fox, James Edward. 1970. Socio-economic characteristics, use patterns, and expenditures of Michigan salmon and trout anglers in 1967. M.S. Thesis, Michigan State University. East Lansing. 160 pp.

Jamsen, G. C. 1971. Michigan's mail creel census methodology. Michigan Dept. Nat. Res., Research and Development Rept. 252. 5 pp.

Jamsen, G. C. 1972. Michigan's 1971 sport fishery. Michigan Dept. Nat. Res., Research and Development Rept. 268. 7 pp.

Jamsen, G. C., and J. R. Ryckman. 1969a. Mail survey of trout and salmon sport fishermen in Michigan, 1968 - preliminary report I: April 1 - June 30, 1968. Michigan Dept. Nat. Res., Research and Development Rept. 159. 7 pp.

Jamsen, G. C., and J. R. Ryckman. 1969b. Mail survey of salmon and trout sport fishermen in Michigan, 1968 - preliminary report II: July 1 - September 30, 1968. Michigan Dept. Nat. Res., Research and Development Rept. 168. 9 pp.

Jamsen, G. C., and J. R. Ryckman. 1969c. Mail survey of salmon and trout sport fishermen in Michigan, 1968 - preliminary report III: October 1 - December 31, 1968. Michigan Dept. Nat. Res., Research and Development Rept. 172. 9 pp.

Jamsen, G. C., J. R. Ryckman, and J. E. Fox. 1969. Participation and socioeconomics of salmon and trout fishermen in Michigan. Michigan Dept. of Nat. Res., Research and Development Rept. 158. 31 pp.

Jamsen, G. C., and L. A. Ryel. 1969. Studies of mail survey response rates: II. - the effect of enclosing a popularized reprint. Michigan Dept. Nat. Res., Research and Development Rept. 163. 1 p.

Jamsen, G. C., J. R. Ryckman, and F. W. Jamsen. 1970a. Salmon, steelhead and lake trout sport fishing in Michigan from January 1 - June 30, 1969. Michigan Dept. Nat. Res., Research and Development Rept. 198. 3 pp.

Jamsen, G. C., J. R. Ryckman, and F. W. Jamsen. 1970b. Michigan's 1969 salmon and trout sport fishery. Michigan Dept. Nat. Res., Research and Development Rept. 203. 10 pp.

Jamsen, G. C., and Paul V. Ellefson. 1970. Michigan's 1970 sport fishery, January 1 - April 24. Michigan Dept. Nat. Res., Research and Development Rept. 211. 4 pp.

Jamsen, G. C., and Paul V. Ellefson. 1971a. Economic evaluation of Michigan's salmon-trout fishery. Trans. N. A. Wild. and Nat. Res. Conf., 36: 397-405.

Jamsen, G. C., and Paul V. Ellefson. 1971b. Michigan's 1970 sport fishery, April 25 - August 31. Michigan Dept. Nat. Res., Research and Development Rept. 234. 5 pp.

Jamsen, G. C., and Paul V. Ellefson. 1971c. Michigan's 1970 sport fishery, September 1 - December 31. Michigan Dept. Nat. Res., Research and Development Rept. 235. 5 pp.

SPECIAL CREDIT...

for the making of this publication goes to Gale C. Jamsen (editorial supervision and planning); Mercer H. Patriarche (editing); Gerry Ream (cover art and picture layouts); Dean Armstrong (maps, charts, and graphs); and Sue Kingsland (typing).