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LAKE TROUT FISHERY ON THE CARIBOU ISLAND GROUNDS [1]

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Introduction

There are offshore stocks of native lake trout in Lake Superior which might be able to sustain a small commercial fishery because they are not subject to severe lamprey predation and are inaccessible to sport fishermen. One of these fishing areas is near Caribou Island which is 35-40 miles north of Grand Marais, Michigan. The grounds consist of several submerged, uplifted plateaus (locally known as "banks") which lie offshore around the island in both Canadian and U.S. waters. An assessment program for the stocks in American waters was started in 1967 when four commercial fishermen were contracted by the Michigan Department of Natural Resources to fish these grounds under an annual quota of 60,000 pounds. The Great Lakes unit in the Research and Development Division was asked to review the data and prepare recommendations for a quota in 1970. This report was prepared to show the results of a detailed analysis of these data in which Ricker's yield equation was used to estimate an optimum level of harvest.

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Methods

All fish were caught by commercial fishermen using nylon gill nets of 4.5-inch stretch measure. These fish were identified by the fishermen who classify these lake trout into four types: leans, fats, humpers, and half-breeds. Leans are either native or hatchery-reared and are the type commonly caught by anglers in inland lakes and inshore waters of the Great Lakes. Fats are the siscowet (Salvelinus naymacush siscowet), a recognized subspecies of lake trout. The fat (siscowet) has a flesh fat content approximately 2-3 times that of the lean trout which is not a function of diet and appears to be genetically determined (Eschmeyer and Phillips, 1965). The humper, although not a recognized subspecies, is the most abundant variety on these offshore grounds. The humper is found only on these offshore areas. It seldom grows to 25 inches and attains sexual maturity at 13-16 inches whereas leans and fats seldom attain sexual maturity at less than 20 inches. The humper's small size protects it from severe sea lamprey predation. As determined by Eschmeyer and Phillips, the flesh fat of the humper is higher than leans but much lower than fats, Khan and Qadri (1970) recognized the humper as distinct from the lean and siscowet (fat) varieties based on morphological differences.

Half-breeds are believed to be immature fats by many fishermen and field biologists. Considerable evidence, both circumstantial and factual, has been amassed to support this contention. For example, no mature half-breeds have been found

and few trout over 22 inches were identified as half-breeds. Furthermore, preliminary examinations of electrophoretic patterns of blood samples taken from Caribou Island trout revealed only three distinct patterns for the LDH enzyme (lacto dehydrogenase)--lean, humper, and fat (siscowet). Patterns for fats and half-breeds were identical. Hence, all data for half-breeds and fats were lumped together for the final calculations and are referred to as siscowets in the remainder of the text.

Nearly all trout were measured to the nearest 0.1 inch (total length) by the fishermen. However, an unmeasured catch of 268 humpers from Red George Bank in 1968 was assigned the same length distribution as the measured catches of the other three fishermen from this Bank in 1968.

Before converting the catches to a number/age/variety basis, certain assumptions had to be made concerning the identity of some catches to surmount the tendency of some fishermen to lump their catches under the general heading of "lake trout." This problem was particularly troublesome for the 1967 catches. The following assumptions were made after confirming that the depth of sets was approximately the same:

(1) If one fisherman failed to identify his catch but others fishing the same bank did so, the unidentified catch was apportioned according to the species composition of the others.

(2) When the 1968 catches from the same grounds were identified, the 1967 catches were grouped in like manner.

(3) Where there was a choice, the most reliance on identification was placed on the judgment of the most experienced fisherman.

One fisherman was discovered to have intentionally used the name lean trout for humpers to get a better market price, in both 1967 and 1968.[2] Since few humpers exceed 22 inches, all of his "lean" trout under 22 inches were assumed to be humpers.

Length frequencies (by inch group and variety) for all catches each year were tabulated for each fishing ground. Only fish at least 16.0 inches long were included. Age-length frequency tables were prepared from which the total catches were apportioned into age groups, thereby giving the estimated age structure of the catches each year for each variety (Table 1). However, for comparative purposes only the data for seven fishing grounds fished each of the 3 years were used for the yield calculations. These banks are known as Red George, Klondike, Preachers, Caribou, West Patch, Southwest, and Southeast.

Plastic impressions were made from over 3,100 lake trout scales collected by DNR personnel during 1967-69. Back calculations of humper growth rates were based on Rahrer's equation for Isle Royale populations (Rahrer, 1965). The direct-proportion method without any correction had to be employed for the lean, "half-breed," and fats.

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[2] This misrepresentation was brought to our attention by the field biologist (Asa T. Wright) some time after the preparation of the 1968-1969 annual D-J Progress Report. Hence, summary tables given here will not agree with tables in the earlier report.

Growth calculations, assumed to be representative of all populations, were derived from 590 humper lake trout caught in 1969; 280 half-breeds from Red George Bank in 1968; 309 lean trout caught on the West Bank in 1967; and all fat trout (116 fish) scale sampled in 1967 and 1968. Empirical length-weight curves (mean weight in ounces per inch group) were prepared using all available data, from which instantaneous growth rates were derived.

Total mortality was obtained by comparing CPE's for successive years for each fully vulnerable age class.[3] This method was preferred over using catch curves because it gives the mortality rates in effect for the year in question, not for some previous year. Fishing mortality was calculated from the 4% exploitation rate described by Pycha in the minutes of the 1969 annual report of the Lake Superior Committee, from tag recoveries for lean trout in Wisconsin waters. He felt that these rather small rates were also applicable to Michigan waters. Quite likely Caribou exploitation rates are small for humpers and siscowets because the CPE has either risen both years since 1967 or remained stable. The relationship used was $p = \frac{iu}{a}$, from Ricker (1958). Natural mortality was obtained by subtraction of fishing mortality from total mortality.

Ricker's yield-per-recruit equation was used to calculate optimum yield points, using the computer program described by Paulik and Bayliff (1967). Because of the instability of the native and hatchery

[3] CPE = Catch per unit of effort (number per 1,000 feet gill net).

lean trout populations, yield analyses were performed only for the humper and siscowet populations.

Results

The estimated age structure, total effort, and CPE (by number) for each variety of native trout caught on the seven fishing banks for the three years are shown in Table 1. Despite the decline in effort, the CPE for siscowets and hatchery lean trout continued to rise, whereas catches of humper trout remained fairly stable. There was a drastic decline in the catches of native lean trout. No tabulation of the age structure of planted trout was made, but most of them were from 1962 and 1963 plants. Humpers appear to be fully vulnerable to the 4 1/2-inch gill net at age IX, whereas siscowets are fully vulnerable at age VIII, and native lean trout at age VI.

The assumption that mean growth rates from either several banks (humpers) or from one bank (siscowets) are representative of growth rates of lake trout on all the banks in this Caribou Island area may not be strictly true, but for purposes of this analysis the assumption was deemed adequate. An analysis of variance was done, by James R. Ryckman, for growth rates calculated for humper lake trout taken from six banks in 1969. The resulting contrasts (comparisons of mean calculated lengths among banks for four different years of life) disclosed that humpers grow significantly faster on Preachers and Southwest banks than on the other four banks (Table 2). Fish from Klondike Bank were

consistently longer than those from Red George, West Patch, and Big Flats, but the differences were not significant.

Using the values shown in Table 3, both yield and production per 1,000 recruits were calculated for various multiples of 'p' (instantaneous fishing mortality rate) calculated for 1967 when there was an assumed 4% rate of exploitation. The 1967 season was used instead of 1968 because data were available for more age groups. The results are presented in Figures 1 and 2, along with similar results had the rate of exploitation been either 5 or 10 times the assumed rate (20% and 40%, respectively).

Under the 4% rate of exploitation the optimum points, where harvest balances production, occur at about 4p for humpers and 4 1/2p for siscowets. At face value this could be interpreted to mean that a four-fold increase in the 1967 quota was permissible. However, in view of the uncertainty of some of the data inserted in the equation, it would be much better to take a conservative approach. Also, on the average, 41% of the total catch of each variety in the 3 years was comprised of younger fish for which no calculations were possible because of the lack of mortality data. These fish were not fully vulnerable to the gill nets. Quotas probably could be safely increased 50-100% (1 1/2p-2p) without harm to these stocks.

The only drawback would be the incidental catches of planted trout. In 1969 there was one hatchery plant caught for every 7 humpers. An estimated 53,900 pounds of humpers and siscowets were caught on the seven banks in 1967 (the base year used for 'p'). A 50% increase in

catch (1 1/2p) would permit a harvest of 80, 850 pounds in 1970. This would be a conservative increase because under those harvest conditions, production of fish (growth in weight) would exceed the yield by some 2 1/2 times (2100 pounds vs. 800 pounds per 1, 000 fish entering the fishery at ages VIII (siscowets) and IX (humpers). However, such an increase of 26, 950 pounds amounts to an increase of about 8, 500 fish. If the 1969 ratio of 1 hatchery trout to 7 humpers and siscowets held in 1970, this would mean an increase of some 1, 200 hatchery trout caught incidentally--or a total estimated catch of approximately 2, 800 planted lake trout.

The weakest parameter in the data is the assumed fishing mortality rate. The calculations were extended to include a 10% and 20% rate of exploitation (Figs. 1 and 2). At a 10% rate the optimum level for both varieties is reached at only a 60-70% increase in fishing mortality; a 20% rate of exploitation suggests the 1967 quota of 60, 000 pounds was too high. Fishing mortality rates on the Caribou grounds could be better estimated either from a tagging program on those banks or by using the method of Paloheimo (1958). The latter method requires a series of data on annual catches by number and age class plus data on effective effort. To date there are only 3 years of such data available.

Table 1.--Fishing intensity and age frequency distribution of the catches from seven fishing grounds around Caribou Island, 1967-1969

Year	Effort[1]	Number caught[2]	V	VI	VII	VIII	IX	X	XI	XII	XIII
HUMPER											
1967	1465.6	12,055 (8.23)	-	96	749	4981	4330	1545	279	55	20
1968	1088.1	9,693 (8.91)	-	-	420	2649	3909	2349	351	13	2
1969	770.0	6,474 (8.41)	-	30	627	2098	2705	892	99	23	-
SISCOWET (Half-breed and fats)											
1967	1465.6	7,327 (5.00)	29	211	1720	2289	1474	1440	110	54	-
1968	1088.1	6,255 (5.75)	113	1286	1925	1752	852	263	64	-	-
1969	770.0	5,183 (6.73)	-	1033	1207	1539	766	483	88	67	-
LEAN (Native)											
1967	1465.6	3,943 (2.69)	1391	1529	650	251	110	12	-	-	-
1968	1088.1	852 (0.78)	406	282	118	27	11	8	-	-	-
1969	770.0	116 (0.15)	7	38	40	24	7	-	-	-	-
LEAN (Hatchery)											
1967	1465.6	820 (0.56)									
1968	1088.1	1,086 (1.00)				(Mostly 1963 and 1962 plants)					
1969	770.0	1,633 (2.12)									

[1] Thousands of feet.

[2] C.P.E. in parentheses.

Table 2.--Contrasts in mean calculated lengths ($\bar{x}$) at the end of four different years of life among humper lake trout captured on Red George (RG), West Patch (WP), Big Flats (BF), Southwest (SW), Preacher's (P), and Klondike (K) banks in 1969

Year of life	Bank						'F' value	Significance
	RG	WP	BF	SW	P	K		
FIRST								
$\bar{x}$	3.55	3.52	3.54 vs.	3.73	3.77	-	9.96	*
	(RG, WP, and BF < SW and P)							
$\bar{x}$	3.55	3.52	3.54	- vs.	-	3.67	2.53	NS
$\bar{x}$	-	-	-	3.73	3.77 vs.	3.67	0.82	NS
THIRD								
$\bar{x}$	6.63	6.64	6.66 vs.	7.07	7.16	-	22.44	*
	(RG, WP, and BF < P and SW)							
$\bar{x}$	6.63	6.64	6.66	- vs.	-	6.71	0.29	NS
$\bar{x}$	-	-	-	7.07	7.16 vs.	6.71	9.60	*
	(SW and P > K)							
FIFTH								
$\bar{x}$	9.82	9.37	9.72 vs.	10.67	10.90	-	21.86	*
	(RG, WP, and BF < SW and P)							
$\bar{x}$	9.82	9.37	9.72	- vs.	-	9.83	0.40	NS
$\bar{x}$	-	-	-	10.67	10.90 vs.	9.83	8.86	*
	(SW and P > K)							
SEVENTH								
$\bar{x}$	14.42	13.12	14.34 vs.	16.10	16.16	-	72.40	*
	(RG, WP and BF < SW and P)							
$\bar{x}$	14.42	13.12	14.34	- vs.	-	14.54	3.14	NS
$\bar{x}$	-	-	-	16.10	16.16 vs.	14.54	21.30	*
	(SW and P > K)							

Table 3.--Total mortality (a) and instantaneous rates of growth (g), total mortality (i), fishing mortality (p) and natural mortality (q) for humpers and siscowets from the Caribou Island grounds in 1967 ('p' derived from an assumed exploitation rate of 4%)

Item	Age group			
	VIII	IX	X	XI
HUMPER [1]				
g	-	0.19	0.35	0.24
a	-	0.27	0.70	0.95
i	-	0.32	1.20	2.99
p	-	0.05	0.07	0.12
q	-	0.27	1.13	2.87
SISCOWET [2]				
g	0.42	0.12	0.07	-
a	0.50	0.76	0.94	-
i	0.69	1.43	2.81	-
p	0.06	0.08	0.12	-
q	0.63	1.35	2.69	-

[1] Mean weight at age of full recruitment (IX) = 29.5 ounces.

[2] Mean weight at age of full recruitment (VIII) = 45.0 ounces.

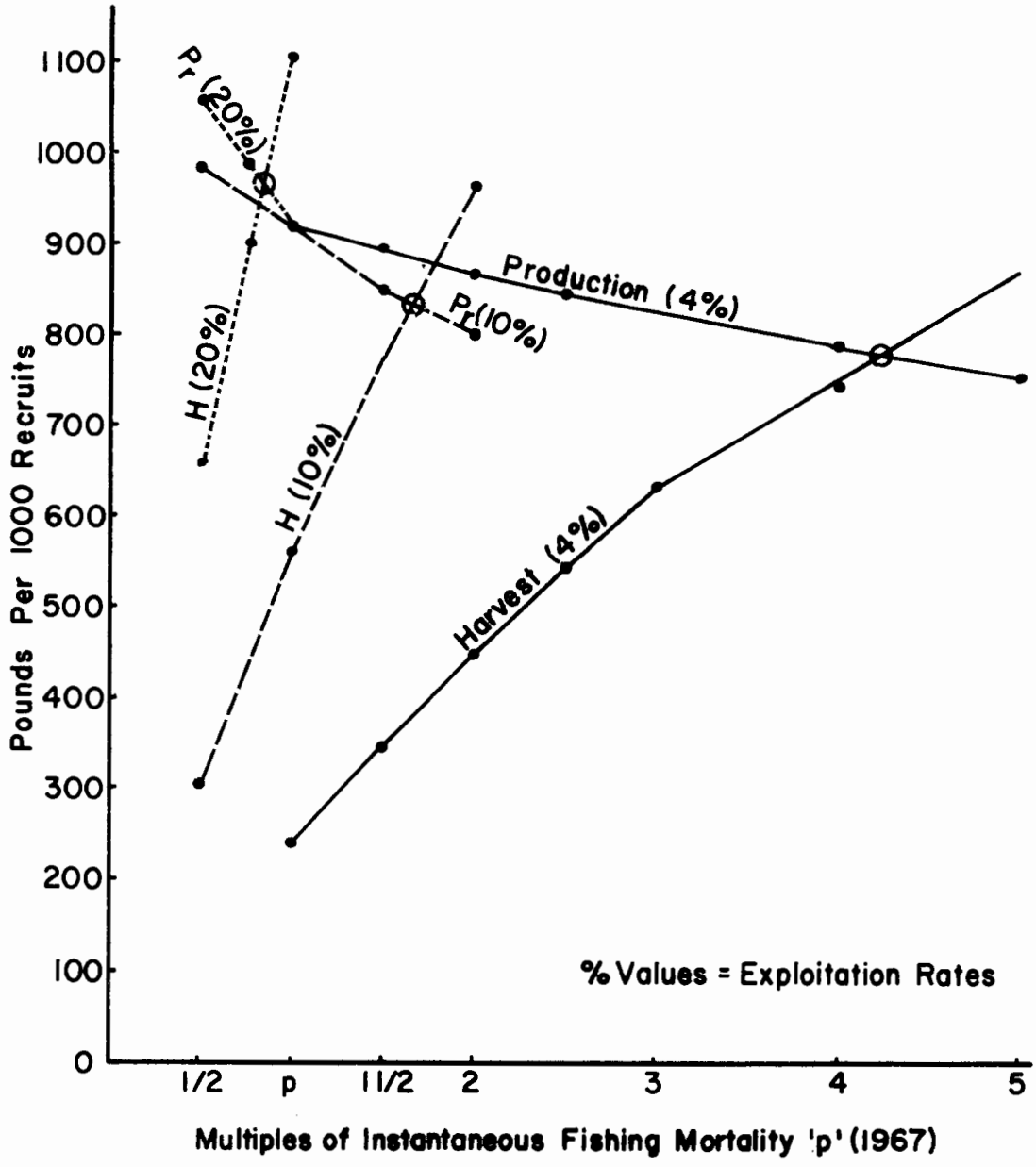

Figure 1. --Estimated equilibrium harvest and production (pounds per 1,000 recruits) of humper lake trout on the Caribou Island fishing grounds at various multiples of the 1967 instantaneous rate of fishing mortality, based on three rates of exploitation.

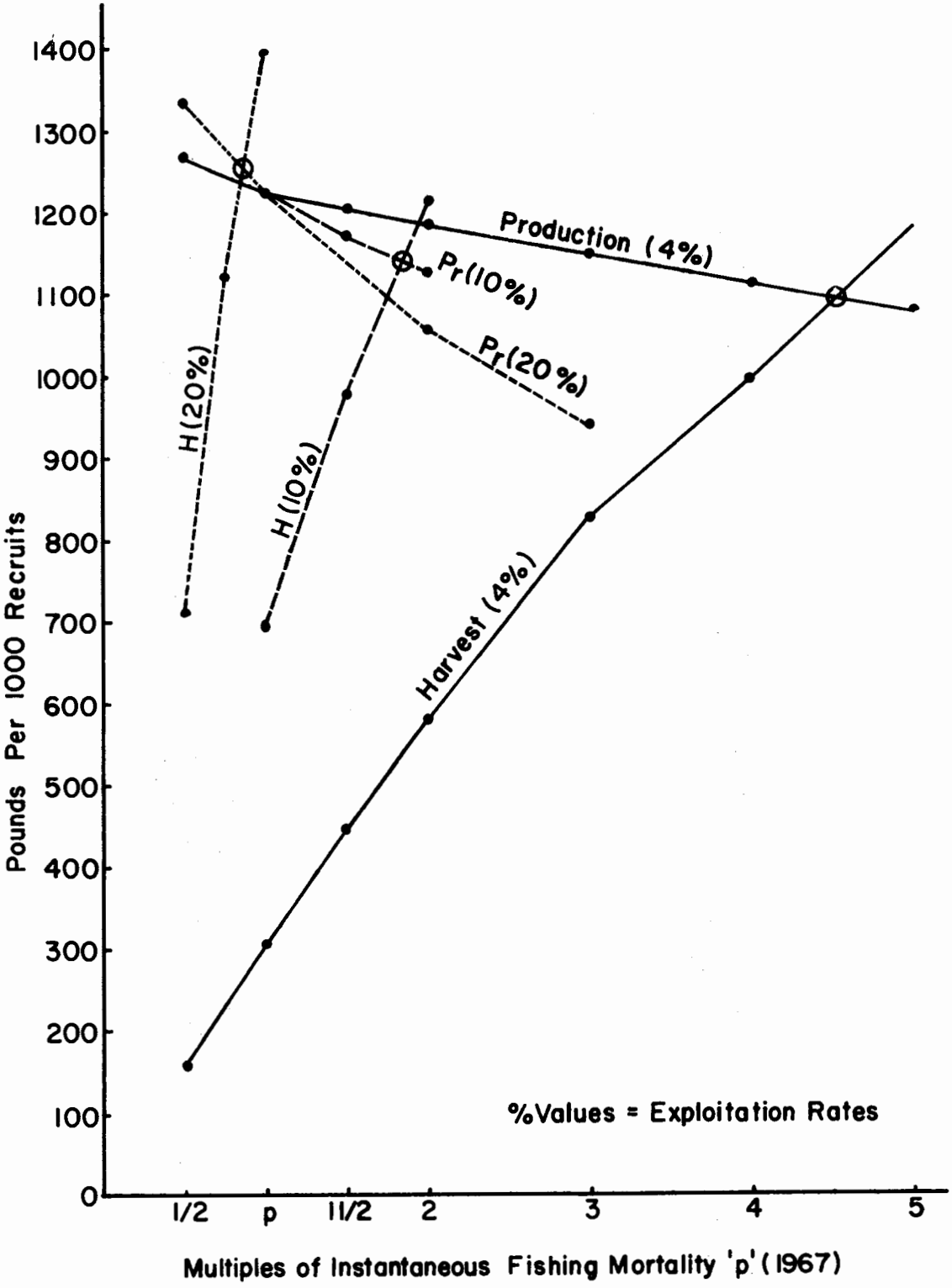

Figure 2. --Estimated equilibrium harvest and production (pounds per 1,000 recruits) of siscowets on the Caribou Island fishing grounds at various multiples of the 1967 instantaneous rate of fishing mortality, based on three rates of exploitation.

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