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CHAPTER THREE

STATUS OF SELECTED STOCKS IN LAKE HURON AND RECOMMENDATIONS FOR COMMERCIAL HARVEST

TECHNICAL REPORT: 73-32

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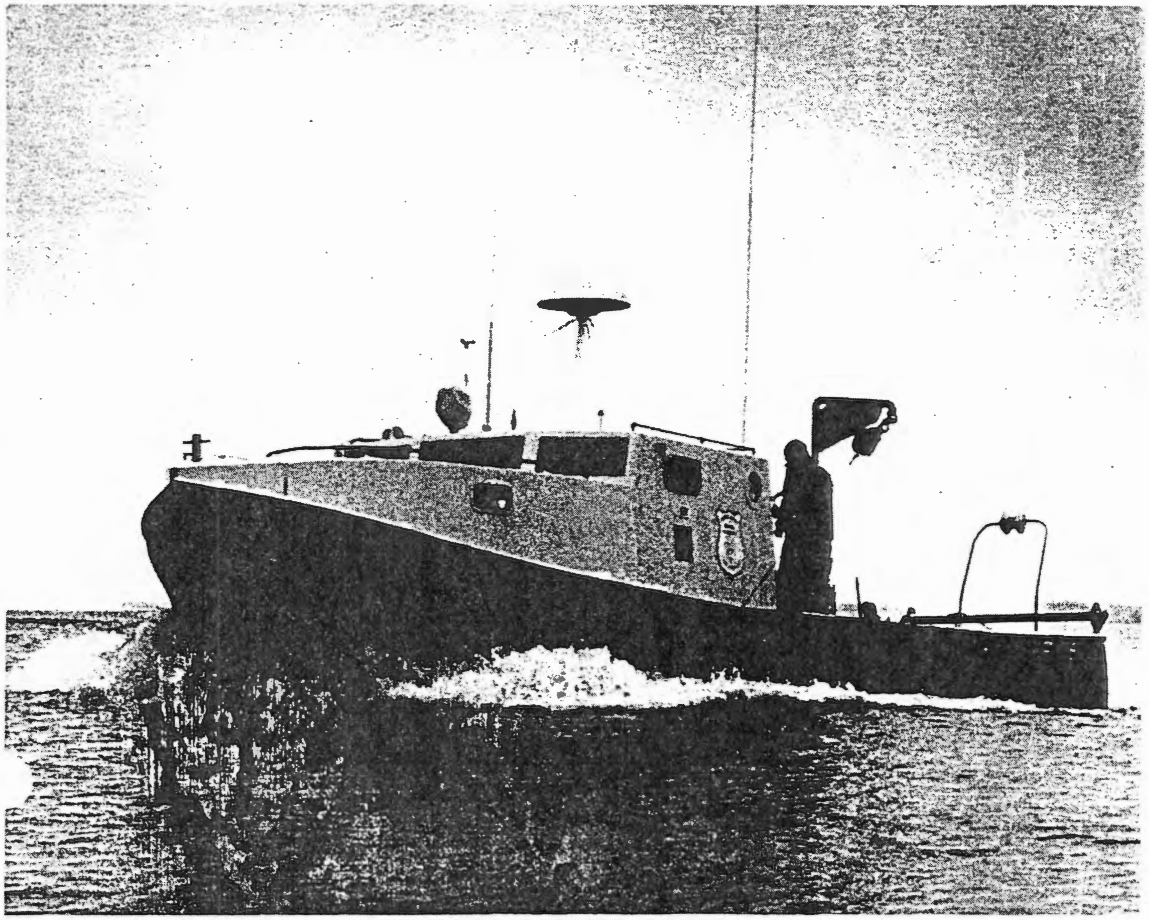
Editor's Note: Unless otherwise noted, common names used in the text conform to those established in The List of Common and Scientific Names of Fishes from the United States and Canada, (3rd Edition). American Fisheries Society, Special Publication No. 6, Washington D.C., 1970. 150p.



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STATUS OF SELECTED STOCKS IN LAKE HURON

AND RECOMMENDATIONS FOR COMMERCIAL HARVEST

OVERVIEW

Excessive exploitation is increasingly acknowledged in fisheries publications as a contributor to the depletion of native salmonid and percid fish stocks in the Great Lakes (Berst and Spangler, 1972; Lawrie and Rahrer, 1972; Regier et al, 1969; Smith, 1968 and 1972; Wells and McLain, 1972). Elimination of the terminal piscivores, particularly lake trout, has had a de-stabilizing effect on the fish community and encouraged the proliferation of exotics at the expense of valuable native fishes (Smith, 1972). Scientists do not agree on the primary mechanism involved in the decline of the lake trout, but Smith (1968) has demonstrated that they were being overfished in all the upper Great Lakes before sea lampreys became abundant. Commercial fishing, therefore, has had a great impact on the Great Lakes fish communities, and some perspective of its role in the past is desirable in understanding recent management policy. The following discussion will center on the fisheries in Michigan waters of Lake Huron.

Lake Huron has supported a substantial commercial fishery since the middle 1800's, and the premium species were lake trout, lake whitefish, ciscoes (chubs), and (in Saginaw Bay) walleye and lake herring. The ciscoes, an association of seven distinct species, were the first coregonines (subfamily consisting of lake whitefish, round whitefish, lake herring and ciscoes in the Great Lakes) to experience a lake-wide depletion. The two largest species of chubs were fished heavily (Smith, 1968) by the early fishery, and were greatly reduced by the turn of the century. Smaller chubs apparently replaced the larger species, and some overlap in the niches of the various chubs is now evident. A pattern of intense fishing coupled with interspecific competition thus emerged as a potentially destructive force early in the development of the Great Lakes commercial fishery. The consequences of this pattern were to become much more severe with the introduction of exotic species.

Smelt were first recorded in Lake Huron in 1925 (Smith, 1972). They expanded rapidly, underwent a massive die-off in the early 1940's (Van Oosten, 1947), recovered, and today are probably the dominant species in northern Lake Huron. Smelt inhabit inshore areas, the most productive portion of the basin. Published food studies indicate that smelt are primarily invertebrate feeders in the Great Lakes (Baldwin, 1950; Gordon, 1961; Anderson and Smith, 1971). The areal distribution and diet of smelt suggest a competitive relationship with the native coregonines, especially the lake herring and whitefish.

Lake whitefish was the next premium species to suffer lake-wide depletion in Michigan waters. Van Oosten et al (1946) showed that this decline, which occurred in the 1930's, resulted from excessive landings made possible by the introduction of a new gear, the deep trap net. Whitefish landings varied between 1 and 2 million lb. annually before employment of deep trap nets and declined to a level of 100,000-200,000 lb. in most years thereafter (Appendix B). To this date, whitefish stocks have not recovered from the depletion of the 1930's. Whitefish stocks also were depleted in the 1940's in Ontario waters, especially Georgian Bay. However, Georgian Bay stocks recovered to record levels in the early 1950's only to again decline sharply by the late 1950's. Deep trap nets were not implicated in the whitefish depletion in Ontario as the gear could not be legally fished there. Berst and Spangler (1972) identify the whitefish declines in Ontario with an intensive lake trout fishery, which exploited whitefish as an incidental species.

Loss of lake trout in the 1940's crippled the commercial fishery and stimulated effort towards other less-valuable species. Without the restraint of predation the alewife increased in numbers and became a major component in the fish community. In this era the lake herring fisheries collapsed. Lake herring yield reached a maximum in Saginaw Bay, the center for herring fishing in Lake Huron, in the 1920's. Van Oosten (1929) noted that improvements in fishing technology and increased effort did not improve the catches. By the 1940's the sustainable yield of lake herring in Saginaw Bay must have been declining because of habitat deterioration associated with increased war demands for agricultural and industrial products and the emergence of smelt and alewife as cohabiting species. Exploited herring stocks outside of Saginaw Bay also collapsed in the 1940's and 1950's but there are large, unexploited herring stocks today, evidence that exploitation was a major factor in the loss of the lake herring fisheries.

Walleye were a prized commercial species in Saginaw Bay. The stock collapsed abruptly in the 1940's, leaving the fishery without a high-value species. Several explanations of the walleye collapse in Saginaw Bay have been tendered including lamprey predation, closing of the Bay City hatchery, environmental degradation and overfishing. Lamprey predation has never been substantiated as a cause for walleye declines in the Great Lakes. Published observations indicate a low incidence of lamprey wounds on Great Lakes walleyes at times when lampreys were known to have been abundant (Ryder, 1968). Evidence of lamprey predation on Saginaw Bay walleyes was lacking at a time when the stock was near collapse and fish were being examined by biologists (Hile, 1954). Regarding the hatchery closure, the stock collapsed well before the closure could have influenced landings. Fishing and environmental degradation, therefore, remain as possible explanations. The exploitation of walleyes in the years preceding the collapse was heavy. Record landings were achieved only three years before the collapse occurred. The size limit was lowered twice in the years 1932-38, and published growth data from Hile showed that growth was increasing between 1930 and 1943. The age at recruitment was lowered by regulation at a time when it was effectively being lowered by a change in growth, thereby compounding the effect.

As was the case for lake herring, environmental degradation in the late 1930's and early 1940's might have adversely influenced walleye reproduction, and made the stock less resilient to exploitation. The evidence suggests, then, that fishing intensity was increasing at a time when the sustainable yield was likely decreasing, and this situation could not long be maintained as evidenced by the landing records. This anomaly was exceeded only by the failure to close the fishery after the collapse was very evident in 1947. No attempt was made to salvage any brood stock until the advent of zone management in 1970, and by then it was too late.

The most recent lake-wide disruption of an important commercial species was the expansion of the chub fishery. Beginning in 1957, chub fishermen from the upper Great Lakes converged on Lake Huron. Michigan chub landings prior to 1957 averaged approximately 200,000 lb. per year. With a massive increase in effort chub landings reached 3 million lb. in 1960 and 1961. This proved to be the peak because landings were nearly nonexistent by 1968 (Appendix B).

The chub fishery in 1957-66 was based largely on the smallest species, the bloater. Lamprey abundance continued to climb well after lake trout were eliminated and lampreys are known to feed on chubs (Smith, 1970), especially the larger species. Lampreys may have modified the species composition within the chub stocks, as detailed by Smith (1968) for Lake Michigan, but obviously did not greatly inhibit the stocks overall or the recent surge in landings would not have been possible. There are now few chubs in Lake Huron's main basin (Smith, 1968), and this condition is clearly a function of excessive fishing. Chubs remain abundant in Georgian Bay where they are lightly exploited.

All of the premium species were either extinct or greatly reduced by the late 1960's. Few fishermen could be found in once thriving fishing ports, and those that remained either turned to species of lower value such as yellow perch and carp or continued to fish the reduced whitefish stocks. Yellow perch landings peaked in 1966 following a surge in effort but recent changes in the Saginaw Bay stock prompted stringent regulations there. Also, the stocking of salmonids followed initiation of sea lamprey control measures in the late 1960's, and this led to the closure of the large-mesh, gill-net fishery as a protective measure.

Smelt and alewives now dominate the main basin and are likely too abundant but there is not, as yet, an ample stock of piscivores. Percids and centrarchids probably suffer from the lack of balance in the present fish fauna, as suggested by Smith (1970). Although these fishes have minor commercial importance, they are important sport fishes. Restoration of a functional balance in the fish community is a highly desirable goal. The commercial fishery, as it existed in the past, contributed to depletion of premium species and favored the proliferation of unexploited species. Commercial fishing in the future must not be allowed to exert the de-stabilizing influence of the past. Hence, landings must be consistent with projections of sustained yields for target species, and the fishery must be conducted in keeping with the management objective of piscivore restoration. Selective gear and quota management can establish the framework within which the commercial fishery should be regulated if the state is to realize the potential benefits from a balanced and productive fish community in Lake Huron. Accordingly, we present our recommendations for quotas and gear in Table 1. The reasoning and data to support these recommendations follow in the subsequent pages.

TABLE 1. - COMMERCIAL FISHERIES RECOMMENDATIONS FOR LAKE HURON[1]
(DEPTHS IN FATHOMS; QUOTAS IN THOUSANDS OF POUNDS)

Item	Statistical District				
	MH 1	MH 1	MH 2	MH 3	MH 4
Whitefish[2]					
Grids	304-306	301,302 401-404 504	- -	1210	1309,1310 1409
Gear	Pound and Trap	Pound and Trap	- -	Trap	Trap
Depth	<15	<15	- -	<15	<15
Quotas:					
1974	100	90	- -	40 (Both Districts)	
1977	100	150	- -	40 " "	
1980	200	200	- -	80 " "	
Round Whitefish[2]					
Grids	(Zones 17 and 19 not otherwise closed)				
Gear	Trap	Trap	Trap	Trap	Trap
Depth	<15	<15	<15	<15	<15
Quotas:					
1974	10 (Four Districts Combined)				
1977	10 " "				
1980	10 " "				
Channel Catfish[2]					
Grids	- -	- -	- -	- -	Zone 22
Gear	- -	- -	- -	- -	Trap, Seine, Set Line
Depth	- -	- -	- -	- -	All
Quotas:					
1974	- -	- -	- -	- -	150
1977	- -	- -	- -	- -	250
1980	- -	- -	- -	- -	300

[1]Seasons:
Lake whitefish and round whitefish: April - October
All other species: None

[2]Minimum size limits:
Lake whitefish (MH 1): 19.0"
" " (MH 3 & 4): 20.0" in 1974; 22.0" in 1977 and 1980
Channel catfish: 17.0"
Yellow perch: 8.5"

Table 1. (Cont'd)

Item	Statistical District				
	MH 1	MH 1	MH 2	MH 3	MH 4
Yellow Perch[2]					
Grids	- -	- -	- -	- -	Zone 22
Gear	- -	- -	- -	- -	Trap
Depth	- -	- -	- -	- -	All
Quotas:					
1974	- -	- -	- -	- -	150
1977	- -	- -	- -	- -	150
1980	- -	- -	- -	- -	150
Carp					
Grids	- -	- -	- -	- -	Zone 22
Gear	- -	- -	- -	- -	Trap, Seine, Gill
Depth	- -	- -	- -	- -	All
Quotas:					
1974	- -	- -	- -	- -	Unlimited
1977	- -	- -	- -	- -	"
1980	- -	- -	- -	- -	"
Suckers					
Grids	- -	- -	- -	- -	Zone 22
Gear	- -	- -	- -	- -	Trap, Seine
Depth	- -	- -	- -	- -	All
Quotas:					
1974	- -	- -	- -	- -	Unlimited
1977	- -	- -	- -	- -	"
1980	- -	- -	- -	- -	"

LAKE WHITEFISH

Whitefish landings from northern Lake Huron (MH 1) averaged 200,000 lb. in 1971-72 and accounted for 80% of Michigan's Lake Huron whitefish landings in those years. Previously, annual landings from MH 1 in 1891-1908 averaged 550,000 lb. and amounted to 57% of the lake-wide harvest; in 1929-39, they averaged 463,000 lb. and comprised 22% of the Michigan catch (Van Oosten, 1946). Although the catch in 1971-72 was less than one-half of that recorded in earlier eras, the whitefish stocks in MH 1 presently are the strongest of those in Michigan's waters. There has been steady improvement since 1967, possibly in response to sea lamprey control which was initiated in northern Lake Huron in 1966.

Fishing effort in MH 1 is now confined to two distinct areas which support discrete stocks. The easterly stock is fished between Port Dolomite and Detour and will be referred to here as the Detour stock. The westerly stock is fished mainly in St. Martin Bay but may extend as far south as Nine Mile Point, some 12 miles southeast of Cheboygan. Whitefish from Cheboygan are similar in growth and age composition to those of St. Martin Bay, and may be from a common stock. Whitefish from the west shore of MH 1 will be referred to as the St. Ignace stock. Detour whitefish exhibit pronounced differences in growth, age composition and age at maturity from those at St. Ignace. Accordingly, the stocks will be treated separately in the following discussion of catch quotas for whitefish in MH 1.

The rationale employed here in selecting catch quotas consisted of applying Ricker's yield-per-recruit model for various combinations of size limits and mortality rates (Ricker, 1958). Regressions were compared to select a size limit which would ensure adequate escapement at an optimum rate of fishing. Size limits between 17.0 and 21.0 inches were employed in the yield models. Instantaneous fishing rates ranged between 0.2 and 1.4, and the rate for each year of life for a year class was adjusted to compensate for changes in vulnerability with age. Vulnerability was estimated from a length-frequency distribution of age groups in the catch and fishing gear (deep trap nets) was assumed to be fully efficient for 17-inch whitefish. This assumption is reasonably consistent with observations made on the length frequencies of whitefish taken in experimental gill nets and deep trap nets fished together on the same grounds at the same time. Fishing mortality within a year was proportioned to reflect the seasonal distribution of the 1970-72 catches.

Natural mortality rates for whitefish stocks in MH 1 are unknown. Cucin and Regier (1965) estimated an instantaneous rate of 0.41 for southern Georgian Bay whitefish. In the models developed here, constant natural mortality rates of 0.3, 0.4 and 0.5 were employed with the objective of bracketing their value. Little change was noted between yield regressions computed for specific size limits using different natural mortality rates.

Hence, approximations of the true value of natural mortality were adequate for our analysis. The model depends mostly on natural mortality not changing with age.

Theoretical yields can be generated after a range of fishing and natural mortality rates are selected, together with the corresponding instantaneous rates of growth. Growth rates were estimated either from grand averages of back-calculated lengths for age groups in recent commercial catches or from length-at-capture data in assessment catches. Lengths were converted to weight using individual length-weight data for each stock.

Each year of life for a year class was divided into time segments wherein rates of growth and mortality were fairly consistent in relation to each other. Yields were then calculated for selected natural and fishing mortality rates at different size limits. Calculations were performed by computer as the number of variables employed in the model precluded a manual approach. In addition to calculating yields the program calcululated the standing crop at the beginning of each time division for a year class. Estimates of spawning escapement at the various fishing rates and size limits thus were available for consideration.

Detour Stock. - The yield calculations for Detour whitefish encompassed ages IV (when whitefish first contributed significantly to the fishery), to VII, the oldest age observed. Each year of a year class was divided into three periods and the instantaneous rates of growth, fishing mortality and natural mortality were proportioned within these segments (Table 2).

Exponential (instantaneous) growth rates for Detour whitefish were calculated from samples of the 1972 spring catch. Back-calculated lengths and estimated weights used in determining exponential growth are provided in Table 3.

The proportion of fish vulnerable to the fishery at a particular age and size was estimated from a length frequency distribution by age groups for fish collected in 1970-72, as shown in Table 4.

Theoretical yields at various minimum size limits for a series of fishing rates were plotted for the three values of natural mortality used in the model. As stated earlier, there was little change between yield regressions over the range of natural mortality rates (0.3 through 0.5) employed in the model. The specific yield values do change somewhat with different natural mortality rates because the yields are higher with lower rates of natural mortality. However, the curves for each size limit maintain their configuration under all three natural mortality rates and only the yield curves for the natural mortality rate of 0.4 will be presented here. These regressions are given in Fig. 1 where yield is expressed as pounds per 1,000 recruits at age IV.

Several inferences can be made from the yield curves in the figure from noting effects of different fishing rates (a measure of effort). Increases in these rates up to 0.8 generate proportionate increase in catch. Beyond 0.8, increases produce sharply reduced catch increments. For size limits between 17.0 and 20.0 inches, fishing rates greater than 0.8, which is equivalent to an annual fishing mortality of 55% on fully recruited fish,

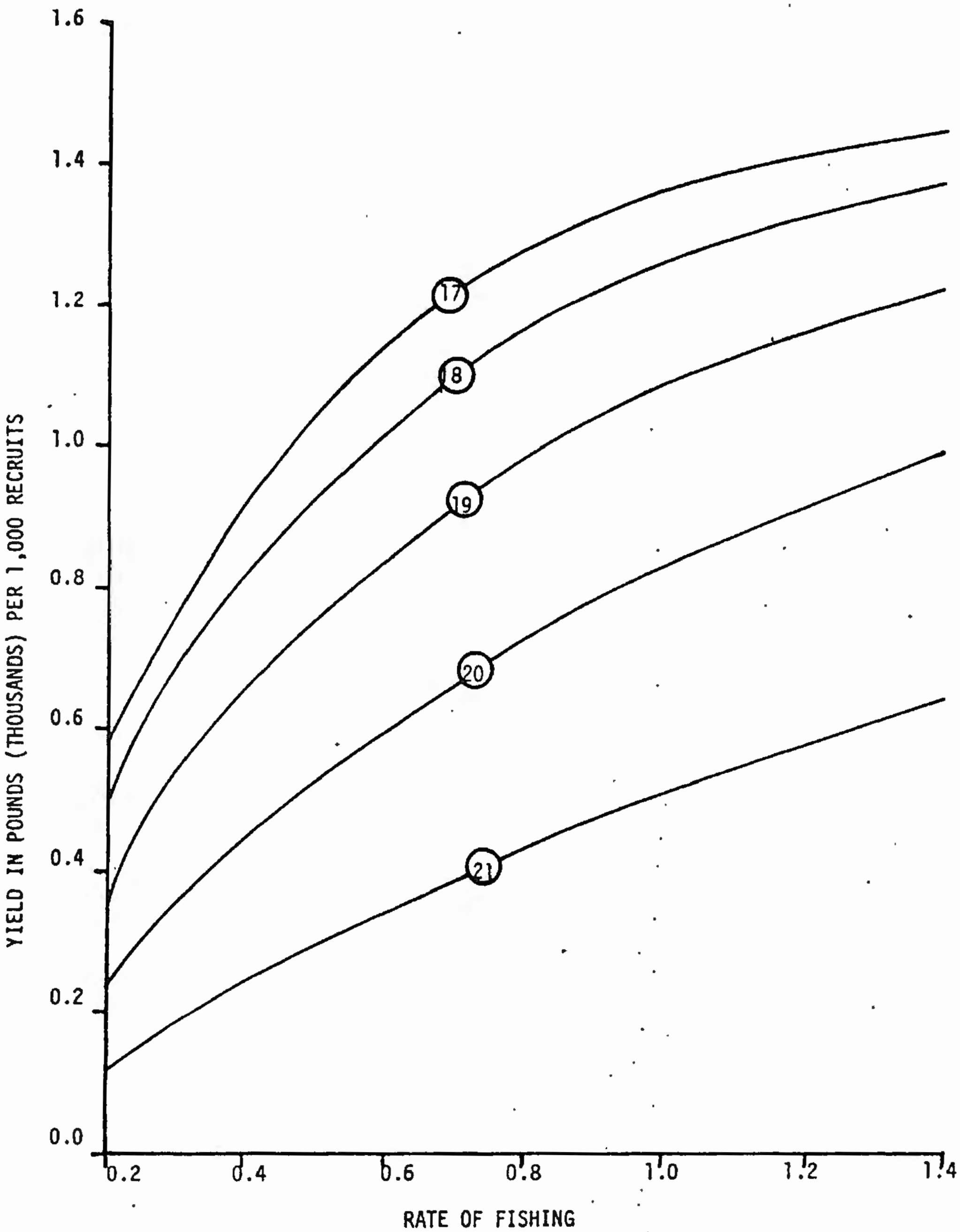

FIG. 1-YIELD PER 1,000 RECRUITS FOR DETOUR WHITEFISH VS. RATES OF FISHING FOR 5 SIZE LIMITS AND AN INSTANTANEOUS NATURAL MORTALITY RATE OF 0.4. SIZE LIMITS ENCIRCLED.

TABLE 2. - ESTIMATED PERCENTAGES OF THE INSTANTANEOUS RATES OF GROWTH AND MORTALITY WITHIN VARIOUS PERIODS OF A YEAR FOR RECRUITED DETOUR WHITEFISH.

Period	Growth	Fishing mortality	Natural mortality
June 1 - Aug. 15	50	30	25
Aug. 16 - Oct. 31	50	70	25
Nov. 1 - May 31	0	0	50

TABLE 3. - AVERAGE BACK-CALCULATED LENGTHS (INCHES) AND ESTIMATED WEIGHT (POUNDS) FOR 208 WHITEFISH TAKEN AT DETOUR IN THE SPRING OF THE YEAR, AND THE ANNUAL EXPONENTIAL GROWTH RATES.

	Age				
	IV	V	VI	VII	VIII
Length	15.5	18.1	19.7	21.1	22.3
Weight	1.23	2.18	3.04	3.76	4.36
Exp. growth rate	0.570	0.332	0.213	0.148	----

TABLE 4. - LENGTH-FREQUENCY DISTRIBUTIONS WITHIN FIVE AGE GROUPS OF DETOUR WHITEFISH IN SPRING COMMERCIAL SAMPLES IN 1970-72.

Inch group	III	IV	V	VI	VII
10	1				
11	1				
12	2				
13		2			
14	4	10			
15	4	47	9		
16	3	57	35	1	
17	3	39	114	8	
18	1	30	104	42	1
19		6	88	58	2
20		4	43	54	11
21		1	8	30	11
22				2	7
23					1
Totals:	19	196	401	195	33

provide a diminishing economic return and will not be recommended. Note also that the yield declines at an increasing rate with increases in size limit. Maximum yield for a given level of recruitment is obtained at the 17.0" size limit. If recruitment were constant and not some function of the size limit and the rate of fishing, a 17.0" size limit would be optimum.

The historical record of the whitefish fishery in Lake Huron and the maturity characteristics of the Detour stock do not, however, favor a 17.0" size limit. Whitefish stocks in MH 1 are just now showing signs of recovery from the depletion caused by the introduction of deep trap nets in the early 1930's (Van Oosten, 1946). Fishing effort and catch are currently on the increase at Detour. Catch samples indicate that 60% of the females mature at age IV, and female whitefish in the Detour catch have completed only an average of 0.6 spawnings. A higher size limit would decrease the yield for a given level of recruitment but increase the standing crop of spawners and provide for a greater egg deposition. This greater egg deposition might produce larger year classes than heretofore and hence the potential yield could be greater.

The relationship between standing crop of repeat spawners (females) in November and size limit is plotted in Fig. 2 for a fishing rate of 0.8 and a natural mortality rate of 0.4. A plot of yield at these rates is included. These curves demonstrate that increases in size limit up to 19.0" will generate an increase in standing crop of spawners (per 1,000 recruits) greater than that harvested. Specifically, increasing the size limit from 17.0 to 19.0 inches would immediately decrease yield by 23% but double the standing crop of spawners. Cucin and Regier (1965) found egg production for whitefish to be directly proportional to weight. Presumably this relationship is true for Detour whitefish so that egg deposition would be doubled at Detour with a 19.0" size limit. Furthermore, the number of repeat spawners versus first-time spawners would be substantially increased. With a 19.0" size limit and an 0.8 rate of fishing, the average number of completed spawnings per female in the catch would increase to 1.4.

There is increasing evidence that the number of repeat spawners is a factor in determining year-class strength for salmonids. Christie (1963) suggested that Lake Ontario whitefish might require more than one spawning per female for stock replacement and Christie and Regier (1972) calculated that Lake Ontario whitefish should spawn an average of 1.5 times for stock replacement. Numann (1970) demonstrated that the number of repeat spawners in the population of Lake Constance Blaufelchen (a species similar to lake herring) was a factor in determining year class strength. Ayles and Berst (1973) have demonstrated that the survival of splake from egg to yolk-sac absorption increases as the age of the female parent increased. The above arguments strongly suggest that an increase in size limit for whitefish is warranted, and the data presented here indicate that a 19.0" size limit would be reasonable. The potential long-term benefits of increased recruitment and stability are great compared to the relatively small and short-term loss in yield.

Estimation of a catch quota for 1974 and beyond involves determining a yield which would require a rate of fishing of 0.8, with a 19.0" size limit. Such a quota can be approximated by estimating the current rate of fishing and adjusting the quota to reflect the differences in calculated

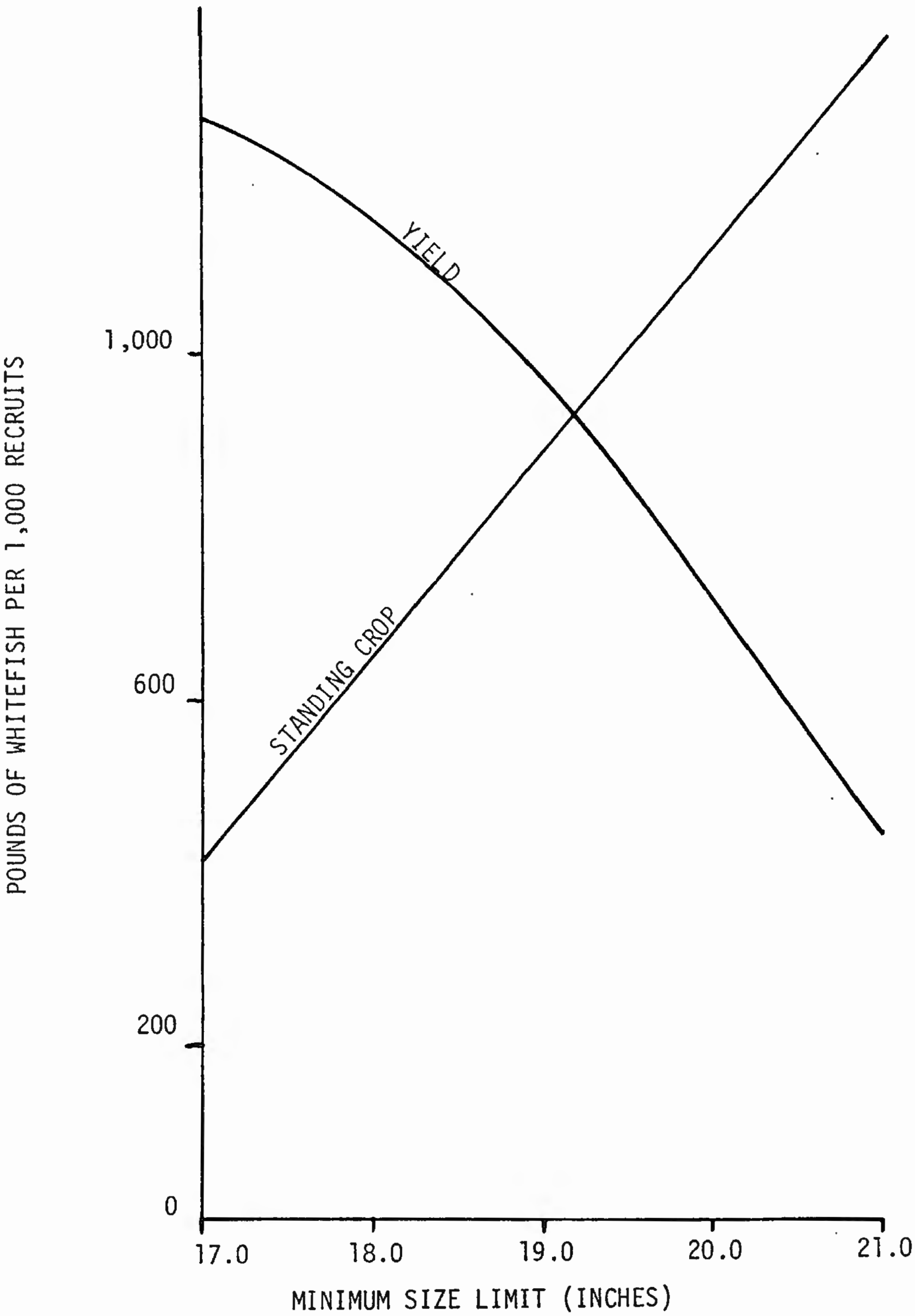

FIG. 2-RELATIONSHIP BETWEEN SIZE LIMIT, YIELD AND STANDING CROP OF REPEAT FEMALE SPAWNERS IN NOVEMBER PER 1,000 RECRUITS FOR DETOUR WHITEFISH. (P=0.8; Q=0.4).

yield per recruit shown in Fig. 1. The current rate of fishing can be estimated by comparing the mean age composition and mean landed weight of fish with the expected age composition and mean landed weight at various levels of fishing at the 17.0" size limit. These comparisons are given in Table 5.

The data in Table 5 suggest that the current rate of fishing is very high and may approach 1.2 even if natural mortality is as high as 0.5. Referring to Fig. 1, the yield per 1,000 recruits is 1,400 lb. at a fishing rate of 1.2 and a size limit of 17.0". At an 0.8 rate of fishing and a 19.0" size limit the yield-per-1,000 recruits is 1,000 lb. Therefore, the current yield must be reduced by 28% to effect an 0.8 rate of fishing at the 19.0" size limit. Yield at Detour during the 1972 fishing season was 142,000 lb. Accordingly, the catch quota for 1974 should be approximately 100,000 lb. with a 19.0" size limit.

The implementation of the above conditions in 1974 should double the egg deposition and increase markedly the number of repeat spawners. Increases in recruitment would not affect the fishery until 1980 because the 1975 year class would be the first to benefit from the increased size limit and would not show up prominently in the catch until 1980. Therefore, the catch quota should not be increased until 1980, assuming the expected increase in recruitment occurs. At the present time we can assume higher yields by then, and suggest a projected quota of 200,000 lb. for that year.

The validity of the above analysis is dependent on continuity in the current level of recruitment through 1974. Catch sampling in MH 1 and Ontario indicated that the 1966-1968 year classes were strong but Ontario biologists are forecasting weaker 1969 and 1970 year classes (1973 Lake Huron Committee report to Great Lakes Fishery Commission). Whitefish sampling at Detour to date has been confined to commercial catches, and hence reliable indices of year-class strength for unrecruited year classes are not now available. If the Ontario predictions apply to stocks in MH 1, a 100,000 lb. quota in 1974 may not be attainable. Nevertheless, implementation of the 19.0" size limit should insure greater carry-over of brood stock. Efforts are currently underway to establish an index of abundance for young whitefish at Detour. If successful this information should provide better information on the status of the stocks and potential yield.

St. Ignace Stock. - Fishing effort and catch at St. Ignace occur at a different time than at Detour. At St. Ignace the largest catches are made in the spring so that the apportioning of fishing mortality and the divisions within a year were somewhat different than at Detour. The percentages of the annual instantaneous values of growth and mortality for each interval for these whitefish are given in Table 6.

Whitefish at St. Ignace grow faster than at Detour and are recruited to the fishery at an earlier age. The yield model for St. Ignace whitefish applies to ages III-VII. Growth values used for the St. Ignace population are given in Table 7. Vulnerability to commercial nets for these fish was estimated from an age-length frequency of the 1972 spring assessment catch (Table 8).

TABLE 5. - EXPECTED AGE COMPOSITION AND MEAN LANDED WEIGHT UNDER ACTUAL AND VARIOUS CALCULATED RATES OF FISHING AND NATURAL MORTALITY, AND SIZE LIMITS FOR DETOUR WHITEFISH.

Restrictions	Mean Weight	Percentage at age III	IV	V	VI	VII
Actual (1971-72)	2.48	5.0	47.4	35.8	10.1	1.7
Calculated: *						
17" Size limit, q = 0.4:						
p = 0.4	2.94	---	20.1	39.8	27.3	12.9
p = 0.8	2.78	---	26.0	44.1	22.0	7.9
p = 1.2	2.63	---	32.2	46.9	17.1	3.7
17" Size limit, q = 0.5:						
p = 1.2	2.59	---	35.0	46.5	15.5	3.0
19" Size limit, q = 0.4:						
p = 0.8	3.28	---	7.4	31.2	38.8	22.6

* q = Instantaneous natural mortality rate;
p = Instantaneous fishing mortality rate

TABLE 6. - ESTIMATED PERCENTAGES OF THE INSTANTANEOUS RATES OF GROWTH AND MORTALITY WITHIN VARIOUS PERIODS OF A YEAR FOR RECRUITED ST. IGNACE WHITEFISH.

Period	Growth	Fishing mortality	Natural mortality
May 1 - June 30	0	60	10
July 1 - Oct. 31	100	40	40
Nov. 1 - Apr. 30	0	0	50

TABLE 7. - AVERAGE LENGTH AT CAPTURE (INCHES), ESTIMATED WEIGHT (POUNDS) AND EXPONENTIAL GROWTH RATES FOR 305 ST. IGNACE WHITEFISH TAKEN IN THE SPRING, 1972.

	Age					
	III	IV	V	VI	VII*	VIII*
Length	16.0	18.8	20.9	22.4	23.7	24.7
Weight	1.37	2.29	3.01	3.87	4.50	5.45
Exp. growth rate	0.513	0.273	0.251	0.151	0.192	----

* Estimated by projecting a regression of length and age.

TABLE 8. - LENGTH-FREQUENCY DISTRIBUTION WITHIN FIVE AGE GROUPS OF ST. IGNACE WHITEFISH BASED ON THE INDEX GILL-NET CATCH IN THE SPRING, 1972.

Inch group	III	IV	V	VI	VII
12	3				
13	2				
14	8	1			
15	11	2			
16	28	5			
17	11	26	1		
18	1	45	4		
19		52	24		
20		17	44	1	
21		1	49	9	1
22			14	13	5
23			4	9	
24					2
Totals:	64	149	140	32	8

Yield regressions for an instantaneous natural mortality rate of 0.4 are given in Fig. 3. There are only small differences in yield between the 17.0-, 18.0- and 19.0-inch size limits. This fact suggests a minimum size limit of 19" could be implemented with practically no loss in yield. Whitefish fishermen in MH 1 now move back and forth between the two stocks and a difference in size limit between St. Ignace and Detour is not practical.

As a device to protect immature fish, the 19.0" size limit would have nearly the same effect at St. Ignace as at Detour under comparable rates of fishing. With a 19.0" size limit, a natural mortality rate of 0.4 and a fishing rate of 0.8, female whitefish in the St. Ignace catch could spawn an average of 1.3 times. The comparable figure for Detour was 1.4. This similarity may seem inconsistent as St. Ignace whitefish are recruited at an earlier age because of faster growth. However, St. Ignace whitefish mature a full year earlier than at Detour and therefore this earlier recruitment is offset by advanced maturity.

Estimates of age composition and mean landed weight for the St. Ignace catch at various rates of fishing were made for the 17.0" size limit to determine the position of the present fishery on the yield curve shown in Fig. 3. These estimates are given in Table 9. A comparison of age composition and mean landed weight between observed values in the fishery and calculated values indicates a low rate of fishing. This is expected as the implementation of zone management in 1970 eliminated the extensive gill net fishery there and reduced the annual catch by more than one-half in 1970 and 1971. Assessment netting at St. Ignace in the years 1970-72 indicated that the 1969 and 1970 year classes may be weaker than their predecessors and accordingly the difference in observed and calculated values for low fishing rates in Table 9 is not as severe as indicated. The present fishery at St. Ignace is thought to be fishing near the 0.4 rate, which is equivalent to a 33% annual fishing mortality on the fully recruited age groups.

The St. Ignace fishery has served as an experimental area since 1970 in that the stock has been monitored to determine any changes that might result from the reduction in landings accompanying the gill-net closure. Observations to date indicate there is an increase in trap-net fishing success and a shift in age composition towards older fish. It will be several years before the assessment can be completed which will demonstrate whether or not the closure benefited reproduction and enhanced recruitment. If these observations are to be continued to a time when an evaluation can be made, landings through 1976 should not be increased over the 1972 level of 90,000 lb. After 1976 the quota could be increased by 20% if no increase in recruitment has occurred. This figure is the difference in yield per recruit for a 0.4 rate of fishing at a 17.0" size limit and an 0.8 rate of fishing under a 19.0" size limit. If recruitment increases in the interim, a higher quota could be set for 1977 and 1980. A quota as high as 200,000 lb. may be reasonable after 1980 if there is substantial improvement in recruitment.

Oscoda Stock. - Michigan has one whitefish fishery in Lake Huron south of statistical district MH 1. This fishery operates in the outer waters of Saginaw Bay in the vicinity of Tawas and Au Sable Points and will be referred to as the Oscoda fishery. At present two operators are licensed to fish deep trap nets from the ports of Oscoda and East Tawas in statistical

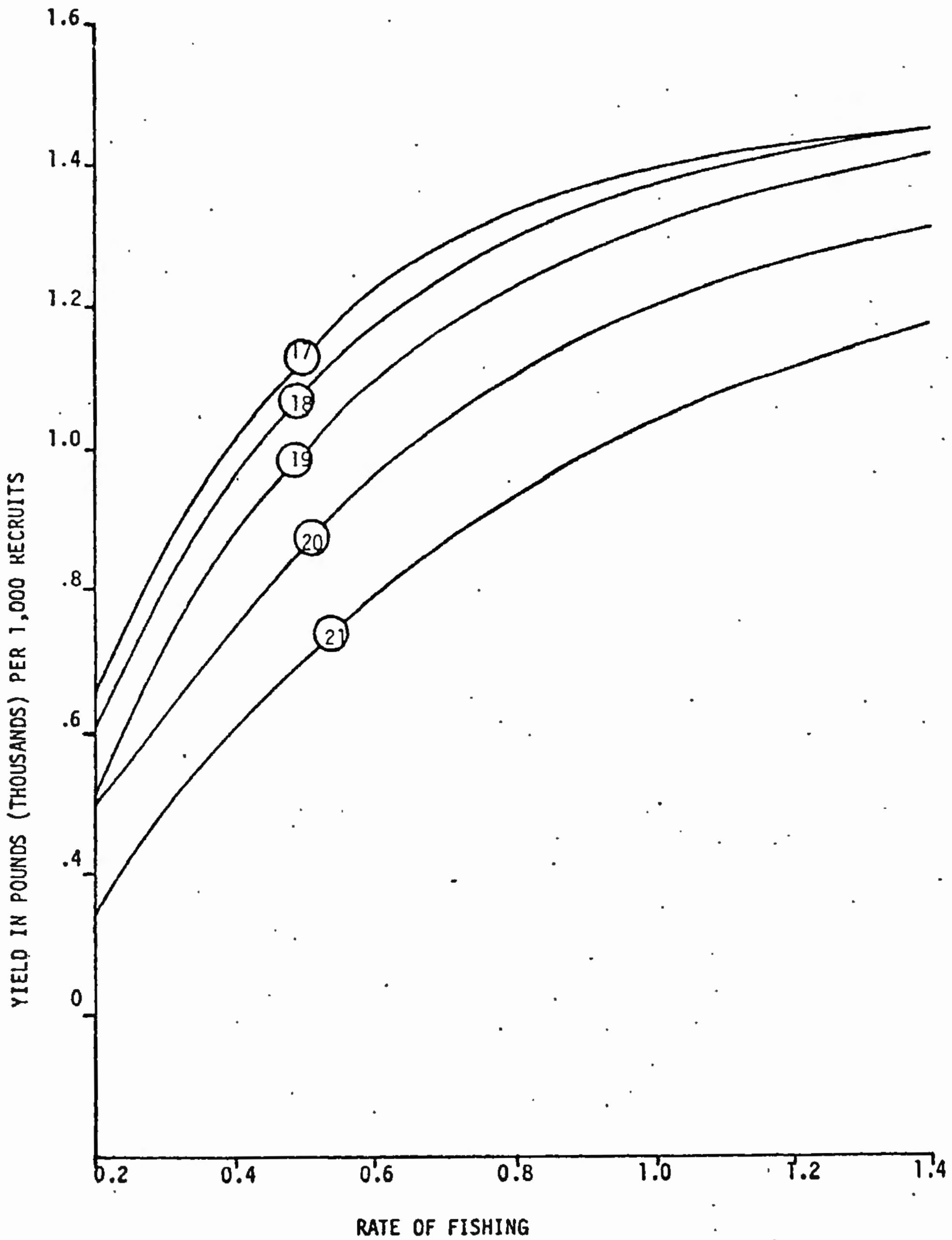

FIG. 3-YIELD PER 1,000 RECRUITS FOR ST. IGNACE WHITEFISH VS. RATES OF FISHING FOR 5 SIZE LIMITS AND AN INSTANTANEOUS NATURAL MORTALITY RATE OF 0.4. MINIMUM SIZE LIMITS ENCIRCLED.

TABLE 9. - EXPECTED AGE COMPOSITION AND MEAN LANDED WEIGHT UNDER ACTUAL AND VARIOUS CALCULATED RATES OF FISHING AND NATURAL MORTALITY, AND SIZE LIMITS FOR ST. IGNACE WHITEFISH.

Restrictions	Mean Weight	Percentage at age III	IV	V	VI	VII
Actual (1971-72)	2.90	12.8	43.1	28.4	14.2	1.5
Calculated: *						
17" Size limit, q = 0.4:						
p = 0.4	2.60	24.7	42.8	19.1	8.7	4.7
p = 0.6	2.46	29.3	45.1	16.6	6.1	2.9
p = 0.8	2.34	33.5	46.4	14.0	4.2	1.8
19" Size limit, q = 0.4:						
p = 0.8	2.82	10.4	46.3	30.0	9.4	4.0

* q = Instantaneous natural mortality rate;
p = Instantaneous fishing mortality rate

districts MH 3 and MH 4. Age and growth data from their catches indicate a common stock in the adjacent statistical districts and these populations will be referred to as the Oscoda stock. Grids 1409, 1309, 1310 and 1210 encompass the fishing grounds of this fishery.

Quota recommendations for the Oscoda fishery are based on the same approach used for whitefish in statistical district MH 1. A yield-per-recruit model was constructed utilizing current age and growth data. Several fishing rates were used with a series of whole-inch size limits, ranging between 17.0 and 22.0 inches. An instantaneous rate of natural mortality of 0.4 was employed for Oscoda whitefish for the reasons given above. Each year of life for a year class was divided into three segments, and the proportions of the annual values of growth, fishing and natural mortality rates were assigned as given in Table 10.

Growth data used in the yield model were based on grand averages of back-calculated lengths from scale samples collected in 1970 and 1971. Lengths were converted to weight using a length-weight relationship for this stock, and exponential growth rates were calculated from these weights. These values are given in Table 11.

Vulnerability to commercial nets at each age and length was estimated from the length distribution of age groups given in Table 12. This table is based on commercial, net-run samples collected in mid-summer. The length distribution of age-group II whitefish in the population may be biased by net selectivity, but sufficient samples from other gear are not available for comparison. It seems doubtful that this type of bias would significantly change the pattern of the yield regressions generated here, and would have no effect at the higher size limits.

Yield regressions for six minimum size limits are given in Fig. 4 for a range of instantaneous fishing rates. The values of yield per recruit are very similar over the range of fishing rates for size limits between 17.0 and 20.0 inches. In fact, at fishing rates above 0.8 the 18.0-20.0" limits theoretically will yield a greater return than will the present 17.0" size limit. Even the 21.0" and 22.0" size limits do not depress yield-per-recruit values more than 17%. Accordingly, other factors such as spawner escapement can be weighed more heavily in determining a quota and size limit for the Oscoda fishery.

In view of the historical record of production (appendix) the present fishery at Oscoda, which lands around 40,000 lb. of whitefish per year, can be termed depressed. Average landings in MH 3 and MH 4 in the years 1891-1908 amounted to 314,000 lb. Landings in 1929, the year before the introduction of the deep trap net in MH 3, totaled 640,000 lb. At the height of the fishery in 1931 and 1932 an average of 2.5 million lb. of whitefish were landed (Van Oosten et al, 1946). The stock collapsed thereafter and has not recovered since, but the 1931-32 yield figures provide some idea of the standing crop at that time. Landings from the Oscoda stock today are small because recruitment is weak. The present fishermen are well equipped, efficient and could produce more whitefish if they were available. Therefore, management measures should be directed at encouraging a greater recruitment.

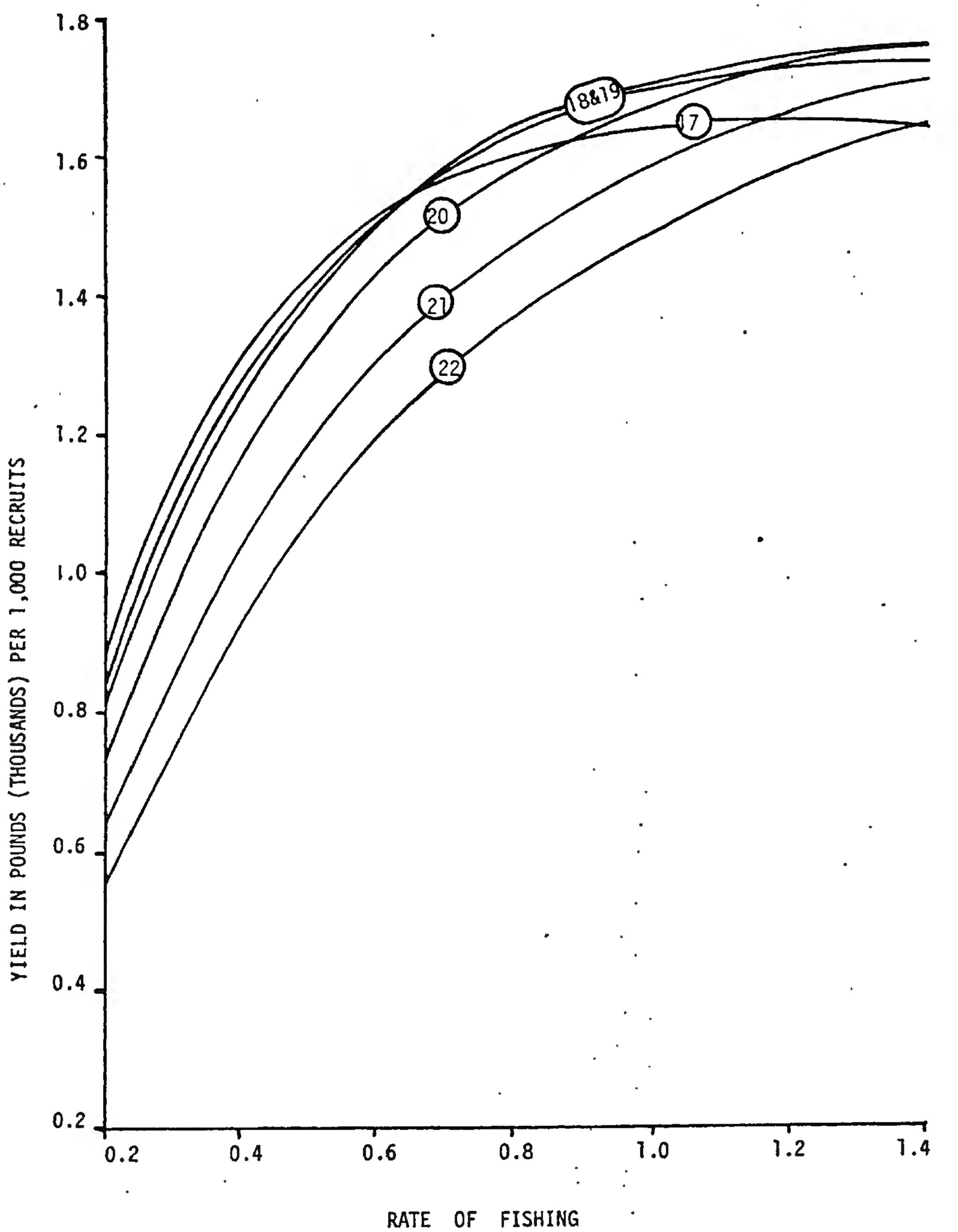

FIG. 4-YIELD PER 1,000 RECRUITS FOR OSCODA WHITEFISH VS. RATES OF FISHING FOR 6 SIZE LIMITS AND AN INSTANTANEOUS NATURAL MORTALITY RATE OF 0.4. MINIMUM SIZE LIMITS ENCIRCLED.

TABLE 10. - ESTIMATED PERCENTAGES OF THE INSTANTANEOUS RATES OF GROWTH AND MORTALITY OF A YEAR FOR RECRUITED OSCODA WHITEFISH, WITHIN VARIOUS PERIODS.

	Growth	Fishing mortality	Natural mortality
June 1 - Aug. 15	50	50	20
Aug. 16 - Oct. 31	50	50	20
Nov. 1 - May 31	0	0	60

TABLE 11. - AVERAGE BACK-CALCULATED LENGTHS (INCHES), WEIGHTS (POUNDS) AND EXPONENTIAL GROWTH RATES FOR 389 OSCODA WHITEFISH CAUGHT IN 1970-71.

	Age						
	II	III	IV	V	VI	VII	VIII
Length	14.0	18.8	21.7	23.5	25.3	26.5	27.1
Weight	1.00	2.40	3.85	4.87	5.75	6.43	6.74
Exp. growth rate	0.876	0.472	0.234	0.166	0.113	0.049	----

TABLE 12. - LENGTH-FREQUENCY DISTRIBUTION WITHIN SIX AGE GROUPS OF OSCODA WHITEFISH TAKEN IN COMMERCIAL NET-RUN SAMPLES COLLECTED IN MID-SUMMER, 1970-72.

Inch group	II	III	IV	V	VI	VII
12						
13						
14	3					
15	18					
16	42					
17	74					
18	13	24				
19	4	79				
20		108	3			
21		39	22			
22		5	64			
23		1	38	26		
24			5	26	3	
25			2	14	7	2
26				5	15	9
27				2	4	4
28						2
Totals:	154	256	134	73	29	17

The relationship between yield and the standing crop of repeat-female spawners in November is shown in Fig. 5 for the range of size limits employed in the model at the 0.8 fishing rate. The data indicate that at the present 17.0" size limit the yield for a given recruitment is much greater than the spawner escapement. In fact the disparity is great enough to suggest that the weak recruitment problem may be a function of the present rate of fishing and size limit. A size limit of 22.0" would not be unreasonable for the Oscoda fishery from a biological standpoint. A 22.0" size limit could increase spawning escapement by as much as 250%.

A change in size limit from 17.0 to 22.0 inches seems large, but the net effect is only to shift the modal age group in the catch from age III to age IV and V. Such a change, however, should be made over a period of years to allow the fish protected by the new size limit to reach the new legal size. A size limit of 20" is suggested for 1974 and a 22.0" size limit is suggested for 1977. A 40,000-lb. quota is recommended through 1979. If recruitment is going to increase because of the increased size limits, it should begin to be evident in the catch by 1980, and a larger quota, perhaps double the 1977 quota, could be recommended at that time.

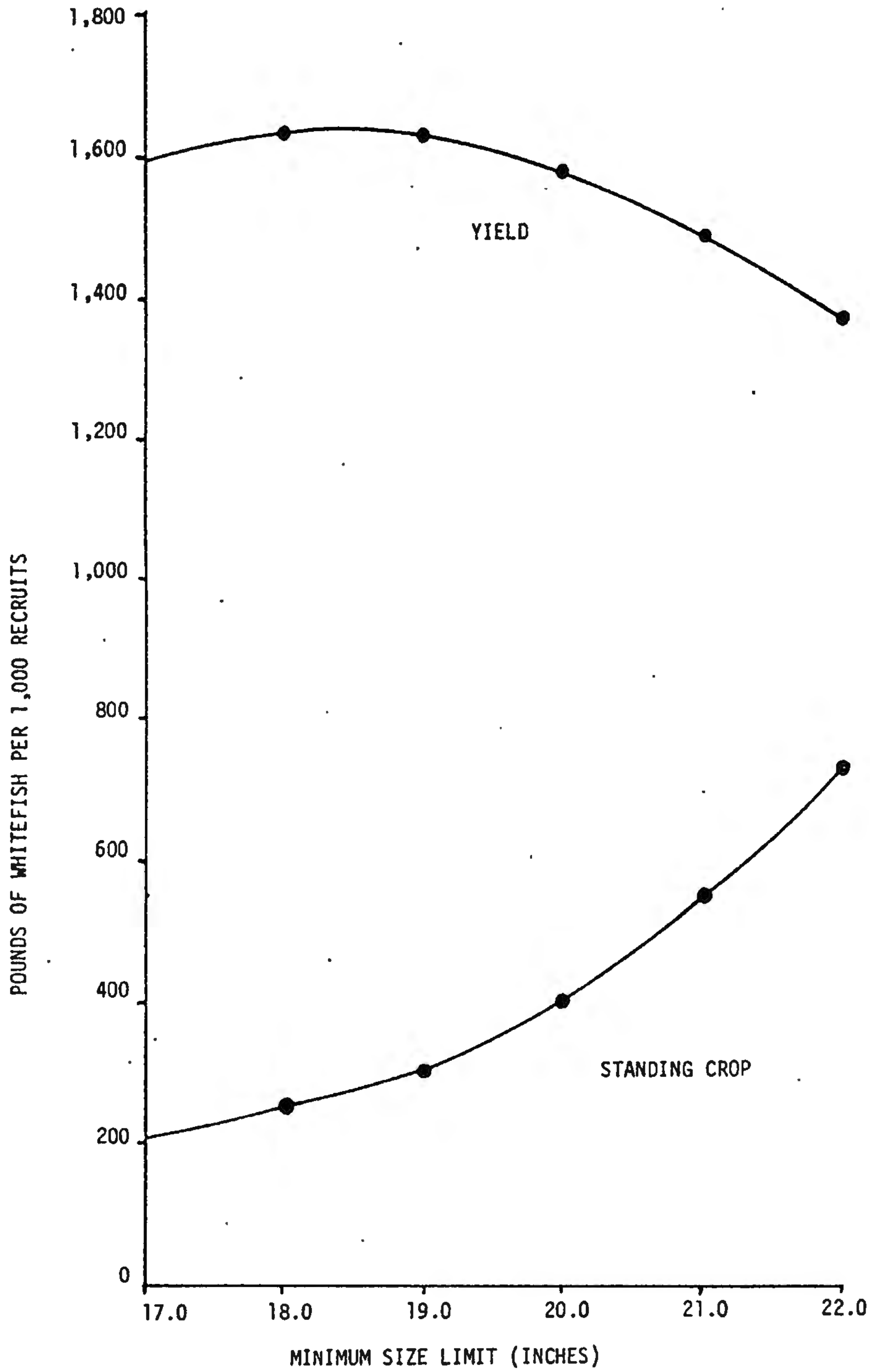

FIG.5-RELATIONSHIP BETWEEN SIZE LIMIT, YIELD AND STANDING CROP OF REPEAT FEMALE SPAWNERS IN NOVEMBER PER 1,000 RECRUITS FOR OSCODA WHITEFISH. (P=0.8; Q=0.4).

ROUND WHITEFISH

The round whitefish (menominee) has always been a minor commercial species in Lake Huron and, since 1950, landings have never been greater than 20,000 lb. per year, except in 1969 (Appendix B). Demand at the wholesale level is very light for this species because it has a short shelf life. Successful marketing normally involves retail sales by the producer but this is discouraged by the distance between major metropolitan areas and the fishing grounds. Menominees have traditionally been taken in small-mesh gill nets which are no longer legal gear in Lake Huron. Gill nets are very effective gear for this species because it is primarily a bottom feeder. In spring and fall menominees inhabit relatively shallow water (shore to 50'), but as summer progresses they seek cooler temperatures and concentrate in the area where the thermocline contacts the bottom. At this time they are most vulnerable to fishing because this strip of bottom is often quite narrow.

Gill-net fishing for menominees cannot be recommended at this time. The depth distribution of round whitefish overlaps that of other protected species and gill nets do not fish selectively. In spring and fall the following protected species would be vulnerable to gill nets set for menominee: yellow perch, brown trout, steelhead, salmon and lake trout. The depths preferred by menominees in mid-summer are also inhabitated by salmonines.

However, menominees are relatively abundant in Lake Huron and a selective fishery could be developed if the marketing problem were solved. Trap nets of shallow construction might be an effective gear. In the unlikely event that some operator is interested in developing a trap-net for this species, a quota of 10,000 lb. in any of the four northerly, statistical districts would be reasonable. The areal distribution of round whitefish parallels that of lake whitefish to some extent. They are most abundant where shoreline development and the slope in the littoral zone favor biological productivity. Three such areas are (1) St. Martin Bay and the South Channel, (2) outer Thunder Bay, and (3) outer Saginaw Bay. Outer sections of Thunder and Saginaw bays would include the outlying water masses that these bays influence and would cover the littoral zone between South Point and Au Sable Point which is prime menominee habitat.

A considerable body of data is available at this station concerning menominee growth, abundance and year-class strength. From these data yield-per-recruit models could be developed which would establish fishing rates and size limits. In view of time limitations and the lack of commercial interest, these data were not analyzed. If, in the future, a menominee fishery becomes feasible a detailed look into the dynamics of the species would be warranted and forthcoming.

CHANNEL CATFISH

The channel catfish fishery in Saginaw Bay utilizes three major types of gear: trap nets, seines, and set lines. The set line is used exclusively for this species. Annual landings of channel catfish have averaged 250,000 lb. since 1940, and landings in any one year have not exceeded the mean yield by more than 50% (Appendix B). There have not been any catch trends since 1940 that are suggestive of significant changes in fishing effort or population abundance.

Several changes in management of the fishery will be recommended here in spite of the history of relatively stable landings. Evidence of wide fluctuations in year-class strength, estimates of relatively fast growth and low natural mortality and the present harvest of fish before maturity together form a basis for these recommendations. A Ricker (1958) yield-per-recruit type of analysis indicated that the age of recruitment could be raised one year without decreasing yield. We recommend an increase in the present size limit from 15.0" to 17.0" with an interim quota of 150,000 lb. An increase in biomass is expected with the higher size limit, and a larger quota of perhaps 300,000 lb. could be realized after the stock reaches a new equilibrium. The discussion which follows details the growth, age structure and mortality characteristics of the stock as well as the yield-per-recruit analysis referred to above. In addition, a description of the fishery by gear and operator is included in Table 1 along with recommendations on allocation of the quota by gear.

Channel catfish from Saginaw Bay were captured in experimental trap nets in 1971 for age and growth analysis. The calculated lengths and weights for these fish are presented in Table 13. Comparative data for Lake Erie and Lake St. Clair are also included in the table. These data show that Saginaw Bay channel catfish have the fastest rate of growth. Accuracy of the growth estimates was confirmed by comparing these values with length-at-capture data for the same year classes. These comparisons (Table 14) indicated relatively good agreement between calculated and observed lengths. Therefore, the calculated growth data were used in the yield-per-recruit analysis.

Estimates of the age composition of catfish catches in experimental trap nets, commercial trap nets and set lines in 1971 are given in Table 15. Estimates for commercial trap nets include both net-run and landed samples. The data in Table 15 show that channel catfish are caught in commercial trap nets at age IV well before reaching legal size. Year-class strength is also highly variable with the 1966 year class dominating the commercial samples. Wide fluctuations in year-class strength are also evident from trawl catches of yearling channel catfish in the years 1970-72. The yearling catch in 1972 was 10 times greater than in 1970 or 1971.

TABLE 13. - BACK-CALCULATED LENGTHS (INCHES) AND WEIGHTS (POUNDS) FOR CHANNEL CATFISH IN SAGINAW BAY, LAKE ERIE AND LAKE ST. CLAIR.

	Saginaw Bay (1971)		Lake Erie (1972)		Lake St. Clair (1969-71)	
age	length	weight	length	weight	length	weight
I	2.7*	.01*	6.7	----	3.0	.03
II	6.2*	.07*	8.7	----	8.2	.17
III	10.0*	.31*	10.4	----	8.9	.21
IV	13.2	.75	12.0	----	10.7	.43
V	15.9	1.32	13.4	.75	13.8	.87
VI	19.3	2.14	14.7	.99	15.1	1.13
VII	22.1	2.92	15.4	1.14	17.1	1.75
VIII	22.4	3.10	16.4	1.38	19.1	2.79
IX	23.2	3.78	17.8	1.80	20.9	3.66
X	23.9	4.55	19.9	2.52	22.2	4.62
XI	24.8	4.76	21.6	3.27	23.8	5.75
Number of fish	253		495		507	

* Length at capture

TABLE 14. - BACK-CALCULATED LENGTHS (INCHES) AND LENGTHS AT CAPTURE IN THE FALL FOR THE 1966-1969 YEAR CLASSES OF SAGINAW BAY CHANNEL CATFISH COLLECTED IN EXPERIMENTAL GEAR IN 1970-72. NUMBER OF FISH IN PARENTHESES.

		(inches)	
Year class	Age	Calculated	Length at Capture
1966	IV	15.8(201)	15.8(51)
	V	17.9(4)	17.3(11)
1967	III	13.8(25)	15.7(3)
	IV	14.9(1)	15.2(16)
1968	II	10.3(118)	11.7(1)
	III	13.0(4)	12.9(6)
1969	I	7.5(179)	6.9(4)
	II	9.6(19)	10.0(15)

TABLE 15. - PERCENTAGE AGE COMPOSITION OF CHANNEL CATFISH CAUGHT IN SAGINAW BAY IN SURVEYS AND BY COMMERCIAL FISHERMEN IN 1971.

Age group	Experimental trap net	Commercial trap net (net run)	Commercial trap net (landed run)	Commercial set line (landed run)
II	53.4	15.4	----	----
III	26.9	29.0	----	----
IV	2.9	6.6	3.9	6.3
V	14.9	45.6	85.3	66.7
VI	0.2	1.0	2.9	10.4
VII	0.2	2.0	4.9	8.3
VIII	0.2	1.0	1.0	2.1
IX	0.2	----	1.0	----
X	----	----	----	4.2
XI	----	----	1.0	2.1
Number of fish	350	531	102	48

The survival rate for catfish in Saginaw Bay was calculated from a catch curve using both survey and net-run commercial trap-net data. Log frequencies were plotted against age, the slope of the computed regression line being equivalent to survival (Ricker, 1958). Survival was estimated to be 51% which is equivalent to an instantaneous mortality rate of 0.67. The instantaneous natural mortality rate for Saginaw Bay channel catfish is unknown but was assumed to be the 0.105 value estimated for the unexploited Lake St. Clair stock (Great Lakes Fishery Commission, Lake Erie Committee report for 1971). Accordingly, the approximate instantaneous rate of fishing for Saginaw Bay channel catfish, by subtraction, was 0.56.

These estimates of growth and mortality were used in a computer program for calculating yield per recruit described by Paulik and Bayliff (1967). Various rates of fishing, ages of entry into the fishery and combinations of time periods for the rates were tried. Although the assumptions inherent in this type of analysis cannot be rigidly met, the estimated potential yields support a recommendation to increase the age at recruitment into the fishery. In Table 16 we present calculated theoretical values of yield and production per 1,000 fish recruited to the fishery at age IV and weighing 0.75 lb. each. Computer trials using different time periods and several values for natural mortality exhibited a similar relationship that present yield can be maintained by increasing age at recruitment from IV to V and by lowering the rate of fishing by 50%. By so doing, production will exceed yield instead of the reverse under current conditions and there should be an increase in the biomass of older fish. Such a build-up would help smooth out fluctuations in recruitment and definitely improve the stock of fish available to the sport fishery on Saginaw Bay.

The present 15.0" size limit permits the exploitation of immature fish, especially in the trap-net fishery. Only an insignificant portion of 15.0" and 16.0" fish reach maturity. At 17.0" approximately 50% of the examined channel catfish attained maturity and at 18.0" all were found to be mature. Obviously a 17.0" size limit would favor greater recruitment.

Trap nets, seines and set lines account for nearly all of the commercial catfish harvest from Saginaw Bay. During a 3-year period, (1970-1972) trap nets caught 57%, seines 16% and set lines 27% of the total catch. Since these three types of commercial gear cannot be readily compared, a tabulation was made of the average catch per commercial operation by gear in the years 1970-72 (Table 17). The average annual catch by gear per operator was similar for seines and set lines in two of the three years but roughly two-fold greater for trap nets. Most of the fishermen fish several types of gear and some catch catfish with more than one type so that apportioning an annual quota by gear will be difficult. It is important to note that few fishermen have grossed enough from channel catfish in the past three years to sustain a viable fishery, except for several of the largest trap-net operations. Many of the channel catfish fishermen, especially set line operators, conduct a very small, part-time fishery. Under a franchise-quota system such operations would have to be combined into larger units to be manageable. Large trap-net fisheries would be capable of harvesting any established quota, if such fishermen sought out the species.

TABLE 16. - ESTIMATED YIELD AND PRODUCTION IN POUNDS PER 1,000 RECRUITS AT AGE IV FOR SAGINAW BAY CHANNEL CATFISH UNDER THREE RATES OF FISHING (p) AND FOUR AGES AT ENTRY INTO A FISHERY.

	0.5p		p(0.56)		3p	
Age at Entry	Yield/1,000 Recruits	Production	Yield/1,000 Recruits	Production	Yield/1,000 Recruits	Production
IV	1,657	1,901	1,723*	1,300*	1,355	593
V	1,746	2,124	1,935	1,606	1,803	1,013
VI	1,819	2,534	2,259	2,553	2,517	1,717
VII	1,725	2,844	2,369	2,616	3,077	2,293

* Assumed to be present conditions of the fishery

TABLE 17. - THE POUNDS OF CHANNEL CATFISH CAUGHT IN SAGINAW BAY BY THREE KINDS OF GEAR, 1970-72, TOGETHER WITH NUMBER OF OPERATORS, MEAN CATCH, AND MAXIMUM CATCH BY ONE OPERATOR.

Item	1970	1971	1972
TRAP NET			
Number of operators	17	17	24
Total catch	151,130	203,303	113,520
Mean catch	8,890	11,959	4,732*
Maximum by one operator	76,199	88,633	32,454
SEINE			
Number of operators	7	9	9
Total catch	6,799	56,437	58,253
Mean catch	971	6,270	6,473
Maximum by one operator	3,383	21,300	22,335
SET LINE			
Number of operators	16	13	12
Total catch	63,142	76,915	71,290
Mean catch	3,946	5,917	5,947
Maximum by one operator	8,357	10,443	11,442

* Decline in catch caused largely by influx of former gill netters who operated small trap-net fisheries

When the channel catfish is added to the potential catch of other species such as yellow perch, it might be reasonable to assume that trap nets could meet a quota for the combined species most efficiently. However, catfish are important to carp fishermen too and some portion of the quota probably will have to be allotted to carp seiners and gill netters. Seines take channel catfish along with carp, and the large mesh gill netters will presumably use set lines for catfish. A multiple-species, trap-net fisheries would probably provide the best compromise for an efficient and manageable channel catfish harvest. A single-species fisheries in Saginaw Bay would be too inefficient for franchise-quota management even though they would be considerably easier to regulate.

If the recommended 17.0" minimum size can be implemented, a future annual harvest of 250,000 - 300,000 lb. per year seems reasonable. However, it is unlikely that the present level of fishing effort could harvest 250,000 lb. in the immediate years following adoption of a 17.0" size limit. We suggest that the 1974 quota be placed at 150,000 lb. By 1977, the population of older fish should have improved and the quota could be raised to 250,000 lb. In 1980, a 300,000 lb. quota might be feasible if recruitment and age structure improve as anticipated. Furthermore, we recommend one-half of the quota be allotted to the trap-net fishery and the other half split between the two carp fisheries.

YELLOW PERCH

Recommendations for a 155,000 lb. catch quota on yellow perch in Zone 22 for 1974 (Table 1) are based on projections of upcoming year-class strength and their sustainable yield in 1974. Commercial catch sampling in 1971-72 provides recent data on the age composition of the catch in spring and fall as shown in Table 18.

From these estimates of the age composition, it is reasonable to assume that the catch in 1974 would be composed mainly of age groups II-V (1969 through 1972 year classes).

Estimates of year class strength for the 1969-1972 year classes can best be made from trawl catches which sample young perch not yet vulnerable to the fishery. Stock assessment with trawls has been conducted in Saginaw Bay each fall since 1970 and the catch per tow in each year class is given in Table 19.

The most consistent and hence reliable estimates of year class strength are for ages I and II. Estimates based on young-of-the-year (age 0) abundance do not appear to be reliable as differences in their CPE's do not carry through to age-group I. This apparent discrepancy is evidenced by the data for the 1971 and 1970 year classes. Estimates based on 3-year-olds and older can be strongly biased by differences in fishing intensity because yellow perch begin to enter the fishery at age II.

A comparison of the above catch-per-tow figures at ages I and II for the 1968-1971 year classes indicates that the 1968, 1970 and 1971 broods were nearly identical but the 1969 group was three times as strong. At present we can assume that the 1972 brood is comparable to that of 1971. This assumption will not greatly affect the estimated yield for 1974 and can be adjusted as additional information becomes available in 1973. Thus, estimates of the relative strength of the 1968-1972 year classes are available, and an estimate of the actual yield of the 1968 year class, which has nearly run its course, can establish potential yields for the 1969-72 year classes.

The commercial harvest of the 1968 year class was estimated by projecting the proportion of this year class found in sub samples of the commercial catch in a given period onto the total catch for that same period. The results are presented in Table 20. This year class first became vulnerable to the fishery in 1970 and continued through the fall of 1972, after which relatively few will be caught.

The 1968 year class contributed an estimated total of 229,000 lb. to the commercial fishery over a 3-year period. Projected yields from the

TABLE 18. - ESTIMATED PERCENTAGE AGE COMPOSITION OF COMMERCIAL CATCH OF SAGINAW BAY YELLOW PERCH IN 1971-72.

Year/Season	Number of fish	Percentage in Each Age II	III	IV	V	VI	VII
1971 Spring	151	5	50	28	12	4	1
1971 Fall	109	90	7	1	--	2	--
1972 Spring	101	--	72	16	7	3	2
1972 Fall	125	20	72	8	--	--	--
Average		29	50	13	5	2	1

TABLE 19. - AVERAGE CATCH OF YELLOW PERCH PER 10-MINUTE TOW BY YEAR CLASS, 1970-1972.

Age	Year class 1972	1971	1970	1969	1968	1967	1966	1965
0	6.7	9.7	14.2	----	----	----	----	----
I	----	30.7	30.3	89.7	----	----	----	----
II	----	----	15.9	48.3	14.6	----	----	----
III	----	----	----	17.3	3.5	2.5	----	----
IV	----	----	----	----	1.6	1.1	3.4	----
V	----	----	----	----	----	0.2	0.7	----
VI	----	----	----	----	----	----	----	0.5

TABLE 20. - ESTIMATED HARVEST OF THE 1968 YEAR CLASS OF YELLOW PERCH IN SAGINAW BAY BY COMMERCIAL FISHERMEN.

Year/Season	Landings (lb.)	% 1968 Year Class	Landings 1968 Year Class (lb.)
1970 Fall	293,000	11	32,200
1971 Spring	266,000	50	133,000
1971 Fall	323,000	7	22,600
1972 Spring	189,000	16	30,200
1972 Fall	138,000	8	11,000
Totals:	1,209,000		229,000

1969-1972 year classes were estimated by applying the estimates of relative recruitment strength at ages I and II from the trawling data to the estimated harvest for the 1968 year class, as shown below:

Year class	Relative strength	Potential yield
1968	1.0	229,000
1969	3.3	755,700
1970	1.1	252,000
1971	1.1	252,000
1972	1.1	252,000

Fish from a particular year class are caught over a period of years as they grow into marketable size. To estimate the potential yield of the 1969-1972 year classes in 1974, the expected proportion of the total yield for a year class at each age must be estimated. The percentage contribution for each age group in the 1971-72 catch (Table 18) was applied to the potential yield for each year class noted above to arrive at an estimated yield in 1974 of almost 270,000 lb., as shown in Table 21.

A potential yield of 270,000 lb. in 1974 is, of course, a projection and is contingent upon conditions such as growth and mortality rates not changing over the next 2 years. More importantly, it implies a commercial fishing intensity in 1974 comparable to that which occurred in the years 1970-72. The estimates of year class strength generated here hinge on the estimated yield of the 1968 year class or, in another sense, on the exploitation rate when this year class was available. This year class made its greatest contribution in 1970 and 1971, when the commercial catch was thought to be excessive. Gill nets were eliminated from the fishery in 1972 to reduce the catch or exploitation rate. Accordingly, if a quota of 270,000 lb. is met in 1974, the rate of exploitation in 1974 will be similar to that in 1970-71. "Similar" is used here because more of the 1968 year class would have been caught if gill nets had been fished in 1972--perhaps 30-40,000 additional pounds. Therefore it would be more accurate to state that a catch of 310,000 lb. in 1974 would require an exploitation rate comparable with that of 1970-71!

That the recent rate of exploitation is unacceptably high is seen in both commercial catch and assessment netting data. The basic problem in the stock of yellow perch in Saginaw Bay, which resulted in the closure of the gill net fishery, is related to high mortality after the perch are recruited to the fishery. This excessive mortality began in 1964 with the expansion of the gill-net fishery, and was compounded by the fact that the fishery operated initially in the outer bay where recruitment was weak. Yellow perch stocks in the outer bay were depleted because recruitment was dependent upon emigration from inner bay stocks--apparently a slow process. Trawling in 1956 by biologists of the U.S. Bureau of Commercial Fisheries (Carr, 1962) and the DNR in 1970-72 conclusively showed that significant reproduction occurs only in the inner bay. The lag in recruitment in the outer bay is very evident in a study of gill-net landings along the west shore of the outer bay between Oscoda and Point Lookout for 1963-67 (Table 22).

TABLE 21. - ESTIMATED POTENTIAL HARVEST (BY YEAR CLASS) OF SAGINAW BAY YELLOW PERCH BY COMMERCIAL FISHERMEN IN 1974.

Year Class	Age in 1974	% Contribution in 1974	Total Yield (lb.)	1974 Yield (lb.)
1969	V	5	755,700	37,780
1970	IV	13	252,000	32,760
1971	III	50	252,000	126,000
1972	II	29	252,000	73,080
Total:				269,620

TABLE 22. - GILL-NET CATCH OF YELLOW PERCH ALONG THE WEST SHORE OF OUTER SAGINAW BAY (ZONE 21) IN 1963-67.

Year	Landings (lb.)	%
1963	73,000	90
1964	337,000	75
1965	380,000	70
1966	365,000	78
1967	27,000	6

These data show that the gill-net fishermen must have moved out of this area by choice in 1967, and the only reasonable explanation for this movement is that the perch were gone. In fact, a more detailed look at the pattern of fishing reveals that almost all of the 1964 perch were taken in the vicinity of Tawas Point; by 1965, landings from Tawas Point were insignificant. One can conclude, then, that the perch at Tawas Point were fished-up in but one year. Gill nets were efficient.

In the first attempt to alleviate the above problem, all waters less than 18.0' deep between Harrisville and Point AuGres were closed to commercial fishing during the period June 10-September 10, effective in 1966. This regulation was not a meaningful restraint on the fishery and is mentioned here only to put it in perspective. Gill nets were fished normally at depths greater than 18.0' in summer months and the 1966 catch nearly equaled that of 1965.

Catches of yellow perch continued to be high after 1966 (Appendix B). The removal of the minimum legal size that year enabled the trap-net fishery to exploit younger fish. Survival of recruited fish declined between 1966 and 1971. The commercial fishery became increasingly dependent upon young fish which were now vulnerable to commercial gear because their growth rate increased. The average age of yellow perch in the commercial catch was relatively stable at 4.6 years from 1960 to 1965, after which it declined gradually to 2.6 years by 1971. Growth reached a peak in 1970 but has declined slightly since that time. A decrease in average age in the catch at a time when growth is not increasing is an indication of over-harvest and a reduction in the rate of exploitation is required to balance yield with recruitment. Therefore, the projected yield of 310,000 lb. for 1974 would be excessive.

The question, then, is by what amount should this projected yield be reduced to balance recruitment and growth? The approach to this point has been analytical but hereafter becomes subjective. It seems obvious that a reduction of 5-10 percent would be inconsequential and a substantial reduction approaching 50% must be in order. Be reminded, however, that the strength of the 1972 year class was arbitrarily set at the level of its predecessor. Although the trawl catch of young-of-the-year perch has admittedly been a weak index to year-class strength, the fingerling catch in 1972 did not suggest a strong year class. Therefore a conservative quota for 1974 would be prudent at this time. Even with a ban on gill nets some control on yield beyond size limits and season is needed. Estimates of the percentage of females in the 1969 year class after the 1972 fishing season closed indicated that the mortality rate on females of this year class in 1972 was close to or exceeded 90%. These calculations are involved and will not be detailed here but the estimated percentage of females in the 1969 year class at the end of 1972 was only 11% ± 4% (95% confidence limits). In keeping with these arguments, we recommend a quota of 155,000 lb. for 1974--one-half of the potential yield of 310,000 lb.

Having selected a quota for 1974, the method and conditions involved in catching the quota should be discussed. Trap nets are the recommended gear. No change in the present season would be necessary but only the inner bay (Zone 22) should be fished, since recruitment was shown to be weak in the outer bay. Lastly, the old size limit of 8.5" should be restored. Perch are a valuable recreational resource and this size limit would give the angler the first chance at the fish. No size limit also greatly complicates assessment work making it more expensive to achieve reliability. This size limit also would offer some protection to females through their third year of life and consequently into their first spawning. The percentage length distribution for 2-year-old females at the end of their third growing season in 1972 was as follows:

Inch Group	% Frequency
5	4
6	9
7	72
8	13
9	2

The above figures provide a liberal estimate of the protective value of a size limit. This size distribution was influenced by late summer and fall fishing so that the above length-frequency is based on the survivors. Measured commercial catches of yellow perch show that fishermen will keep perch down to a size of 7.5" and less depending upon supply and demand. The 8.5" size limit offers substantial protection to a year class through its first spawning.

Projections of yield beyond 1974 would be premature at this time. At present, stability in growth and especially recruitment is lacking and long range estimates could not be meaningful under these conditions. The problem of achieving sustained yields to date relates as to excessive mortality on newly recruited yellow perch. Evidence that this excessive mortality affected recruitment is difficult to quantify. However, the current index of recruitment and the projected level for 1974 is hardly encouraging. There has been a dominant year class supporting the commercial catch in each of the past 11 years, 1962-1972, and a similar situation is projected for 1973; ie. the 1969 year class is expected to continue to be strong through 1973. The recommended catch quota in 1974 is small compared to recent landings largely because a dominant year class is not expected to be available in 1974. By 1974, the 1969 year class should be phasing out and no replacement has yet been detected. The 1969 year class may be only one-half as strong as the spectacular 1965 year class, which contributed approximately 1.5 million lb. to the commercial fishery and made possible the recent large harvests. Projections for quotas in 1977 and 1980 will only be forecast at the 1974 level until evidence to the contrary is forthcoming.

Some resistance to the implications of the analysis presented here can be anticipated. Criticism regarding the effectiveness of perch management in Saginaw Bay in the recent past has been heard, especially from commercial fishermen and within the Department. A simplistic look at the respectable 1972 trap-net catch and the successful catches by the gill-net fishery prior to 1972 can understandingly be interpreted as signs of a strong stock. However, consider that the recent fishery enjoys great productive advantages because of a two-year decrease in the age at recruitment, improved growth and no size limit. One wonders, if the stock is strong, why recent landings were not much greater than reported. Two years of natural mortality were eliminated as a potential drain on recruitment. Also, because of slow growth in the early 1960's plus an 8.5" size limit, many yellow perch (especially males) never reached a marketable size. Catch trends by themselves, whether sport or commercial, can be nearly meaningless as measures of stock strength. Regulation based on a deeper probe into the dynamics of a stock, as attempted here, is the correct approach to resource management.

CARP

Commercial landings of carp from Saginaw Bay have averaged 1.2 million lb. since 1940 and have been quite stable (Appendix B). Hile and Buettner (1959) reported increased carp landings for the period 1942-1956 and attributed it to an increase in abundance.

The Saginaw Bay carp fishery is composed of trap net, seine and gill net fishermen. In 1970-72, trap nets accounted for 12%, seines 19% and gill nets 69% of the total catch. Only one or two of the gill-net operations landed enough carp in recent years to alone support a fishery. All of the other operations, including the seiners, fish part-time or depend upon other gear and landings of other species such as channel catfish. As was pointed out above for channel catfish, the carp and catfish fisheries are very closely linked. We feel that under franchise-quota management many fishermen now harvesting carp would cease fishing. They would not be able to catch enough carp or have markets available to support their operations. Therefore, a decrease in landings to 500,000 lb. annually is anticipated even though no quota is established.

SUCKERS

White suckers, and to a lesser extent, longnose suckers were once prominent in the commercial fisheries catch of Lake Huron. Van Oosten (1938) gave catch figures for 1935 of 1.59 million lb. of white suckers and 170,000 lb. of longnose suckers with a dockside value of $70,000. Fishermen received 4¢ per lb. for suckers then and the price has not changed appreciably. Saginaw Bay is now the only area in the lake from which suckers are caught commercially, and the 1972 landings amounted to only 91,000 lb. (Appendix B). The current level of harvest reflects market demand rather than abundance. Suckers are caught incidentally in nets set for yellow perch and channel catfish. Incidental catches of suckers outside of Saginaw Bay usually are discarded.

In the virtual absence of exploitation suckers appear to be abundant. In the littoral area of the lake they are often the most common fish of a size vulnerable to small-mesh nets. In the main basin, suckers appear to be more abundant in the north than in the south, and lake-wide they favor gradually sloping bays into which larger rivers discharge, such as St. Martin and Hammond bays.

Suckers are unimportant forage species as relatively few are ever found in piscivore stomachs. Exploitation would be desirable because suckers are prominent converters of invertebrate food sources but this energy is little-utilized by man. In the absence of any significant demand for suckers a quota is unnecessary.

CISCOES

In Lake Huron's main basin ciscoes (chubs) are scarce compared to the other upper Great Lakes. Assessment fishing by the Bureau of Sport Fisheries and Wildlife and our Department yields so few chubs that little can be said regarding their biology. Department nets caught a total of 68 chubs in gill nets and 12 in trawls in 1972. Trawling in 1969 and 1970 by the Bureau of Sport Fisheries and Wildlife produced only 74 and 64 chubs, respectively (Great Lakes Fish. Comm., 1971). All specimens taken in 1969 and 1970 were identified as bloaters. Those caught in gill nets in 1972 averaged 0.5 lb. in weight and 10.4" in length. The majority of the catch was from the 1969 year class, although all year classes from 1966 to 1970 were represented.

Only a minimal sampling effort has been directed at chubs in recent years. The scarcity of chubs taken incidentally in netting directed at other species on the edge of the littoral zone confirms the results obtained from deep-water sampling. Chubs were very abundant in inshore waters when the fishery was expanding in the late 1950's (Appendix B). After peak landings were reached in 1960-61, effort shifted towards the offshore grounds. White line recordings from the offshore banks in recent years indicate that fish as large as chubs, are very scarce. Therefore, even though deep water sampling effort has been light in recent years, there is evidence of severe depletion of Lake Huron's chub stocks. For this reason a catch quota on chubs in the next decade would be unwise and cannot be recommended here.

RAINBOW SMELT

Smelt may be the dominant species in Lake Huron as measured by their availability to bottom trawls. This conclusion is supported by data from Ontario, the Bureau of Sport Fisheries and Wildlife and the Department of Natural Resources. Little comparative data is available to determine the trend of smelt abundance in Lake Huron. It is reasonable to assume that smelt increased in abundance with the declines of native coregonine species witnessed in the 1940's and 1950's. Stock assessment to date has been limited to relative abundance studies, and information concerning the dynamics of the stock is not available.

Michigan's sampling design for stock assessment will not likely produce the type of information for smelt that is generated for alewives in southern Lake Michigan by the Bureau of Sport Fisheries and Wildlife. That type of assessment involves a major commitment in vessel operations and data processing to one species and would nearly preclude work on other species now receiving greatest attention. Therefore, without a change in agency commitment, smelt biology in Lake Huron will remain unexplored except for the relative abundance indices.

At present, smelt are taken only on a very casual basis and in limited amounts during the spring run by operators who cannot be considered commercial fishermen in the traditional sense (Appendix B). Smelt are caught in quantity in northern Lake Michigan by pound netters and trawlers but interest in such an enterprise in Lake Huron is lacking. Furthermore, much of northern Lake Huron is unsuited to shallow water trawling and the development of a spring trawl fishery is unlikely. Smelt provide a forage base for salmonids in Lake Huron, and this value outweighs their value in a commercial fishery. A catch quota on smelt is not recommended at this time.

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APPENDIX C. COMMERCIAL HARVEST OF EIGHT SPECIES IN THE MICHIGAN WATERS OF LAKE HURON, 1930-1972[1]

(thousands of pounds)

Year	Lake Whitefish	Round Whitefish	Channel Catfish	Yellow Perch	Carp	Suckers	Ciscoes (chubs)	Rainbow smelt
1930	2,879	57	82	719	868	2,237	513	--
1931	4,140	31	31	731	875	2,132	485	--
1932	4,050	31	31	690	1,011	2,403	543	--
1933	3,334	55	43	427	972	1,890	598	--
1934	2,568	48	36	523	1,023	2,123	447	--
1935	1,895	45	55	983	1,079	1,766	387	2
1936	1,442	45	98	1,175	770	1,814	335	--
1937	1,019	72	115	548	978	1,726	190	--
1938	558	54	135	500	631	1,788	192	*
1939	255	64	118	565	739	1,382	174	--
1940	188	44	245	528	644	1,343	148	--
1941	114	46	386	416	669	1,312	126	20
1942	95	61	397	575	753	1,196	80	1
1943	149	99	395	975	1,243	1,414	128	*
1944	185	49	325	604	1,151	1,236	221	*
1945	181	42	384	407	2,370	1,554	190	3
1946	545	76	254	341	1,669	1,646	40	3
1947	3,023	49	271	291	1,327	1,282	126	2
1948	2,972	26	193	694	1,459	1,305	159	*
1949	530	22	167	518	952	1,022	148	12
1950	114	35	162	405	1,181	977	83	116
1951	143	18	227	363	1,677	1,197	114	218
1952	168	13	303	494	1,637	1,199	63	227
1953	153	11	333	458	1,361	1,144	106	211
1954	91	8	256	507	1,432	1,185	248	161
1955	66	5	355	585	1,373	1,024	317	159
1956	30	5	338	415	1,218	611	301	296
1957	41	6	271	353	1,309	482	507	91
1958	72	5	286	377	2,212	451	1,343	101
1959	103	2	330	356	1,304	464	2,151	70
1960	338	3	277	509	1,333	454	2,936	78
1961	438	9	239	598	1,437	551	3,197	32
1962	305	14	177	372	1,638	707	2,300	29
1963	113	6	172	507	1,647	509	1,975	13
1964	165	3	153	836	1,003	438	1,256	32
1965	175	9	146	966	1,425	389	1,347	28
1966	172	12	166	1,318	832	313	807	30
1967	262	2	129	1,134	972	243	356	52
1968	281	12	101	885	1,016	162	104	28
1969	306	24	122	800	1,298	136	509	64

(Continued)

APPENDIX C, Continued.

(thousands of pounds)

Year	Lake Whitefish	Round Whitefish	Channel Catfish	Yellow Perch	Carp	Suckers	Ciscoes (chubs)	Rainbow smelt
1970	173	--	226	536	1,224	138	12	--
1971	203	1	365	597	1,388	134	--	*
1972	298	2	254	327	888	91	4	--

[1] See footnote, Appendix A, for data sources.

* Less than 1,000 lb.