UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

FISH AND WILDLIFE SERVICE
Ira N. Gabrielson, Director

Fishery Bulletin 40

THE WHITEFISH FISHERY OF LAKES HURON AND MICHIGAN WITH SPECIAL REFERENCE TO THE DEEP-TRAP-NET FISHERY

By John Van Oosten, Ralph Hile, and Frank W. Jobes

From FISHERY BULLETIN OF THE FISH AND WILDLIFE SERVICE
Volume 50

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON: 1946

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. - - - - Price 35 cents

ABSTRACT

This study of the whitefish fishery of Lakes Huron and Michigan includes: (1) a review of the available statistics of production, 1879-1942; (2) a detailed analysis of the annual fluctuations in the production and abundance of whitefish and in the intensity of the whitefish fishery in the State of Michigan waters of the lakes, 1929-1942, with special reference to the effects of fishing with deep trap nets; (3) an account of the bathymetric distribution and vertical movements of whitefish and certain other species; and (4) a report of field observations made in 1931 and 1932, as related particularly to the destruction of undersized whitefish by pound nets and deep trap nets. The main body of the manuscript and appendices A, B, and C, completed in March 1942, contain statistics through the year 1939. Since that time, records for the years 1940–1942 have become available. Because these additional data did not alter any of the conclusions of the manuscript but actually strengthened them, it was not deemed justifiable to expend the considerable amount of time and money that would be required to revise the study. The 1940-1942 records are therefore presented in appendix D.

From a relatively high production in the earlier years of the period, 1879 to 1942, the yield of whitefish declined to a lower level about which the catch fluctuated until the late 1920's and early 1930's when a general increase in production occurred. This recent increase was higher and the subsequent decline more severe in the Michigan waters of Lake Huron than in other areas.

THE WHITEFISH FISHERY OF LAKES HURON AND MICHIGAN WITH SPECIAL REFERENCE TO THE DEEP-TRAP-NET FISHERY[1]

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[1]Approved for publication September 5, 1944. Fishery Bulletin 40.

GENERAL INTRODUCTION

The great economic value of the whitefish (*Coregonus clupeaformis*) and the widespread demand for it by the general public combine to make conservation of this species a matter of primary importance. Accordingly, conservation officials were gravely disturbed by the numerous reports and complaints of commercial fishermen in 1928, 1929, and 1930 concerning the operation of a new type of gear—the deep trap net—in the waters of Lake Huron off Alpena, Mich. These nets, the complainants contended, took whitefish literally by the tons, threatening the immediate extinction of the commercial stock. They held further that the deep trap net not only took legal-sized whitefish in unreasonable quantities but that it was also highly destructive to immature fish.

Gill-net fishermen stated that they were forced to suspend operations in areas in which deep trap nets were fished because of the thousands of rotting, undersized whitefish that drifted into their nets. These fish, they believed, had been destroyed in the deep-trap-net fishery. They charged specifically that young whitefish were killed by confinement in deep trap nets, by gilling in the trap-net meshes, by the rapid change of pressure when the nets were lifted, and by excessive and rough handling in the sorting of the catch. They charged further that deep-trap-net fishermen habitually dumped the dead, undersized whitefish overboard, and thus ruined the best whitefish grounds by polluting the bottom and driving away the fish.

Operators of both gill nets and pound nets objected to allegedly unfair tactics of deep-trap-net fishermen. Gill-netters stated that deep-trap-netters had usurped the traditional gill-net grounds and even had deliberately set deep trap nets across strings of gill nets. Pound-netters asserted that deep trap nets were set offshore in such positions as to block the passage of whitefish to the inshore pound-net grounds.

Both groups of fishermen complained that the high production by deep trap nets had glutted the market and depressed prices, making operations with other gears unprofitable.

The extent to which the many accusations leveled against deep trap nets and their operators were just could not be determined without extensive field observations. Preliminary inquiries, nevertheless, revealed that the deep trap net constituted an undeniably serious threat to the whitefish fishery. It was in recognition of this menace that the Michigan Department of Conservation and the United States Bureau of Fisheries (now the Fish and Wildlife Service) agreed to carry out cooperatively a program of field observation, in order first, to determine the effects of the deep trap net on the whitefish fishery, and second, to obtain information on which to base recommendations for sound regulation of the gear.

By 1931, the first year of the cooperative field investigations, the deep-trap-net fishery had expanded so rapidly that in a number of localities the net had become the dominant gear for the catching of whitefish. These nets were then being fished extensively in the State of Michigan waters of Lake Huron as far south as the "Middle Grounds" off the mouth of Saginaw Bay and had spread also into Lake Michigan where they were used in Green Bay and in northern Lake Michigan, out of Manistique and especially out of ports of the north channel area (region north of the Beaver Islands). In 1931 deep trap nets were fished also in the waters of Door County, Wisconsin. (For a condensed report of the brief survey of these waters in 1931 consult appendix C.)

The Michigan Department of Conservation's Patrol Boat No. 1 was placed at the service of the United States Bureau of Fisheries investigators from July 22 to 27, 1931, when a general survey of the deep-trap-net grounds of northern Lake Michigan and of Lake Huron was made. For the conduct of the later routine field observations, the Department of Conservation assigned one field assistant and paid the operating expenses of one automobile from August 1 to October 21, 1931, and during the month of May 1932. Beginning June 1, 1932, and extending into October, when the field work was discontinued, the Michigan Department of Conservation furnished three field assistants and paid the operating expenses of two automobiles. This increase of the staff made it possible to conduct the investigation simultaneously on both northern Lake Michigan and Lake Huron. The fishermen were practically all willing to cooperate by allowing

the investigators to go aboard their boats, by giving specific information requested, and by discussing frankly problems concerning the fishing industry on the Great Lakes.

The research staff of the U.S. Fisheries Vessel *Fulmar* obtained data in 1932 on some of the deep trap nets and pound nets fishing in Green Bay and around Gull Island in northern Lake Michigan.

The general procedure in the field investigation was to observe the lifting of the deep trap nets, to make counts of all fish in the net, and to take notes both from observation and interviews with the fishermen.

Certain data were, of necessity, obtained from the fishermen. They were: distance and direction from port or from some charted landmark; depth of water in which the net was set; size of mesh (as manufactured) in the lifting pot; depth of lead; and the dimensions of the net.

Other data were recorded as observed. These included: size of mesh (as found in use) in the lifting pot; preservative with which the twine was treated; numbers of legal- and illegal-sized fish, and of dead, bloated, and gilled fish of each species. Gilled whitefish were measured and weighed whenever possible. When it was impossible to measure or weigh the gilled fish, an estimate was made of the numbers that were of legal or illegal size. Lengths, weights, and scales were procured from samples of the catches of whitefish when possible. Few data could be obtained on the sex and maturity of the legal-sized whitefish because practically all were sold in the round.

The procedure for the study of pound nets was the same as that for the deep trap nets. As these two types of gear are of such similar construction, it has been possible in certain phases of the study to combine the data collected from both.

The data collected during the course of the 1931–1932 field investigations form the basis of parts III and IV of the present report.

Statistical investigations also have been made an integral part of the present study of the whitefish fishery of Lakes Huron and Michigan. In order to provide a better background for the understanding of conditions in the recent critical years, a compilation was made of all available statistics of production in the United States waters of the two lakes and of production in the Ontario waters of Lake Huron, beginning in 1879. These data are presented in part I.

Detailed statistical analyses have been made of local fluctuations in the production and abundance of whitefish and in the intensity of the whitefish fishery in the State of Michigan waters of Lakes Huron and Michigan over the period, 1929-1939 (part II). These analyses, which were based on commercial fishing reports supplied by the Michigan Department of Conservation, have contributed greatly to the understanding of the effects of extensive deep-trap-net operations on the general conditions of the fishery.

The deep trap net, with the effect of which on the course of the whitefish fishery this report is primarily concerned, was developed by the late John H. Howard at Cape Vincent, N.Y., and was first used by him in Lake Ontario in 1924. By experimentation Mr. Howard discovered that "the bigger the trap the bigger was the catch of fish taken."[2] Accordingly, he built larger trap nets, using his Lake Erie type of trap nets as a pattern, and increased their depth from about 12 feet to as much as 30 feet. This type of net soon was adopted by other fishermen in the vicinity of Cape Vincent, but apparently did not spread to other ports on Lake Ontario.

The deep trap net was introduced into Lake Huron July 12, 1928, when John H. Howard and his brother, D. C. Howard, set five nets in Thunder Bay off Alpena, Mich Deep-trap-net operations were confined to the Alpena region in 1928 and 1929. In 1930, however, an expansion of the fishery got under way, that ultimately carried the deep trap net to all parts of the United States waters of Lake Huron and to most of the important whitefish grounds of Lakes Michigan and Superior.

In all three of these lakes the deep-trap-net fishery was confined to, or underwent its principal development in, the State of Michigan. Since deep trap nets were never permitted in the Province of Ontario or introduced into the Minnesota and Wisconsin

[2] We are indebted to the late John H. Howard and to J. P. Snyder, former Superintendent of the Federal Fish Hatchery, Cape Vincent, N. Y., for information on the deep trap net in Lake Ontario.

waters of Lake Superior, operations with the gear in Lakes Huron and Superior were limited to Michigan waters. Deep trap nets were fished in Lake Superior as far west as Ontonagon but were most abundant in Whitefish Bay at the eastern end of the lake. The use of deep trap nets became illegal in the Michigan waters of Lake Superior, July 1, 1936. The most extensive deep-trap-net fisheries of Lake Michigan were developed in the State of Michigan waters of Green Bay and of the northeastern section of the lake. Relatively limited operations were carried on also in Michigan waters off Grand Haven (chiefly in 1934), in the Wisconsin waters off Door County (1931-1935), and in Indiana (June 1935-July 1, 1936). The use of deep trap nets became illegal in the Michigan and Wisconsin waters of Lake Michigan after the 1935 season and in Indiana, effective July 1, 1936. This type of gear was never used in Illinois. The deep trap net may now be legally operated in the Great Lakes only in Lake Huron (Michigan waters) and Lake Ontario (New York waters).

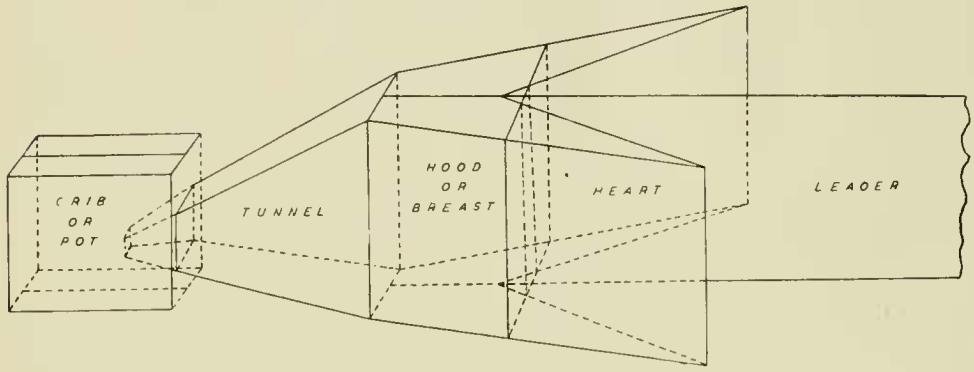


FIGURE 1.—The deep trap net.

The deep trap net (fig. 1) consists of the leader, hearts, hood or breast, tunnel, and lifting pot or crib.

The lifting pot or crib of the deep trap net is covered with webbing, whereas that of the pound net is open at the top. Deep trap nets are held in position by means of anchors and buoys while pound nets are generally held in position by stakes driven in the lake bottom. Aside from these two differences, deep trap nets and pound nets are of similar construction. In fact, during the earlier years of the deep-trap-net fishery the gear frequently was termed a "submarine pound net."

In the nets observed,[3] the anchors were 2-point hook anchors weighing about 35 pounds each except the "king" anchor which weighed about 60 pounds. The smaller anchors (usually numbering 12 to 16) were attached to lines that varied from 400 to 600 feet in length; the "king" line attached to the back of the crib was about 1,800 feet long. The leader was from 40 to 80 rods long, from 20 to 47½ feet deep, and had meshes of 7 to 9 inches. (All mesh sizes in this description are extension measure as manufactured.)

The hearts had the same depth as the leader. The size of mesh in the hearts was reported to have ranged from 5 to 7 inches. The hearts were about 45 feet long with a spread of approximately 100 feet between the tips. In some nets the outside walls of the hearts were extended forward about 24 feet as single thicknesses of netting known as wings. The hood or breast, which connects the hearts and the tunnel, varied from 24 to 27 feet in length.

The tunnel, the length of which varied from about 45 to 75 feet, tapered from a depth equal to that of the hearts to form a 3-foot square opening inside the pot. Meshes in the part of the tunnel outside the pot varied from 5 to 7 inches, but meshes as small as 2 inches were reported for the tunnel inside the pot. Variations reported in the length

[3] The dimensions given in this description were obtained from the fishermen and based on those nets observed in the field and possibly may not cover the full range of variation in the size of deep trap nets. It was, for example, reported to us that one fisherman operated a net that was 75 feet deep.

and depth of the lifting pot were: depth—18 to 47½ feet; length—30 to 40 feet. The lifting pot usually tapered from front to rear so that the width in a single net varied from about 24 to 20 feet. Mesh sizes in the pots ranged from 3½ to 5 inches as manufactured[4] except that the front side of the net (the side through which the tunnel enters) contained meshes measuring not more than 3½ inches. In some nets this small mesh was extended along the sides and bottom of the net, but for a distance of not more than one third the length of the pot.

The lifting methods employed varied considerably, the most general method being that in which the net was brought to the surface by means of a lifting line attached to the "king" anchor line 75 to 150 feet from the back of the pot. When the net was brought to the surface, the boat was pulled under the anchor line and worked forward until it was under the pot of the net. The fish were shoaled on the front or tunnel side of the net and removed through laced openings. After the fish were removed, the boat was worked back to the point where the lifting line was attached, the lines were allowed to slip into the water, and the net was permitted to settle to the bottom. The average time required to lift a deep trap net was approximately one hour. Numerous mechanical devices have been developed to reduce the amount of labor involved and several types of power lifting machines are now in use. Some fishermen released the tension on the back anchor line and handled the net alongside the boat in a way similar to that employed for lifting pound nets.

[4] The present minimum size of mesh permitted in the pots of deep trap nets operated in the Michigan waters of Lake Huron is 4½ inches as found in use; provision is made for a section of netting the meshes of which may not be more than 3½ inches on which the fish may be shoaled.

PART I

PRODUCTION OF WHITEFISH IN LAKES HURON AND MICHIGAN, 1879-1939

LAKE HURON

Because of defects in the data on the catch of whitefish in the United States (State of Michigan) waters of Lake Huron in certain of the earlier years, the graphical representation (fig. 2) of the production history of the lake (table 1) begins with the year

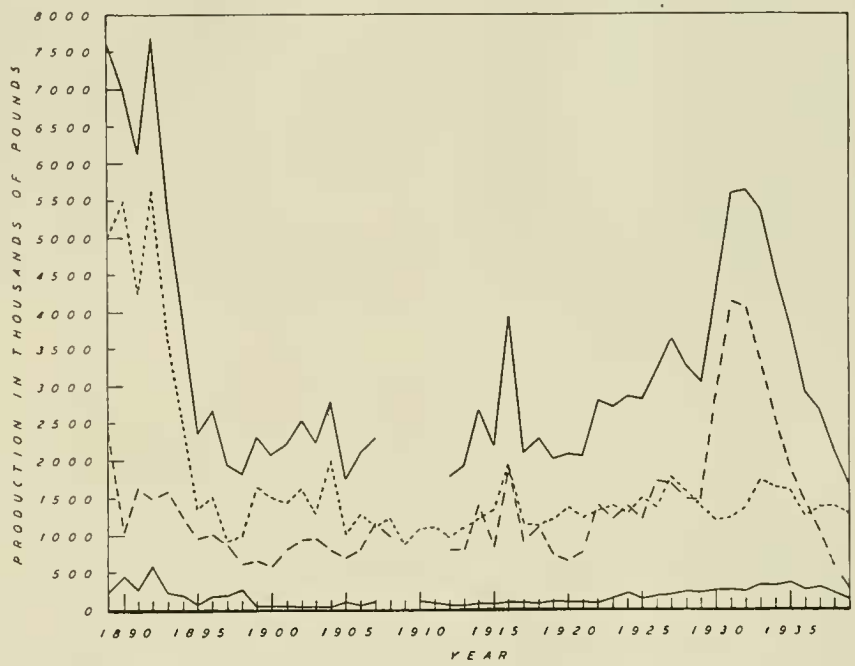


FIGURE 2.—Commercial production of whitefish in Lake Huron, 1889–1939. Lower solid line, Ontario waters of Huron proper; short dashes, North Channel and Georgian Bay; long dashes, State of Michigan waters; upper solid line, entire lake.

1889.[5] It is true that data are available for Ontario waters of Lake Huron for years prior to 1889. However, it is with the course of production in the State of Michigan waters that the present study is most concerned.

Despite the known inclusion of the catch of Menominee whitefish or pilots[6] in the data for 1879, 1885, and 1890, the recorded production of whitefish in the State of Michigan waters of Lake Huron exceeded 2 million pounds in only 2 of the 4 earliest years for which records are available (1879 and 1889) and was less than 1½ million pounds in 1885 and 1890 (only slightly above a million in the latter year).

The production of whitefish in the State of Michigan waters of Lake Huron was well over 2 million pounds in 1889, the first year for which acceptable data are available. In 1891, the second year for which presumably usable statistics are available, this yield was somewhat above 1½ million pounds. The next several years saw an irregular but distinct downward trend. The average production for the years, 1889

[5] See appendix A for a listing of the sources of the statistical data of table 1 and statements concerning their limitations in certain years. Also see appendix D for the 1940–1942 records.

[6] Although there can be no certainty concerning the production of Menominee whitefish in the early years of the fishery, it is not believed that catches of that species made up a great part of the reported production of whitefish in years earlier than 1891. Consequently, the catch for 1890 was graphed in figure 2 although the yield for that year was excluded from the computation of averages. The catch of Menominee whitefish in the State of Michigan waters of Lake Huron exceeded 100,000 pounds only 6 times in the 32 years for which data are available within the period, 1893–1939, and frequently was less than 50,000 pounds.

and 1891–1896 (1896 was the last of the earlier years in which the catch exceeded a million pounds), was 1,464,000 pounds. (In the discussion of this section, yields will be given to the nearest thousand pounds.) The period, 1897–1921, was one of rather consistently low output, the catch of whitefish exceeding a million pounds in only 4 isolated years of the 22 for which there are records. The average annual yield for this period was 885,000 pounds.

TABLE 1.—*Production of whitefish in pounds in Lakes Michigan and Huron, 1879–1939*

[See appendix A for list of sources of the data]

Year	Lake Michigan			Lake Huron			
	Wisconsin	Michigan	Entire lake[1]	Michigan	Ontario Huron proper	Ontario Georgian Bay	Entire lake
1879	----------	----------	[2]12,030,400	[3]2,700,778	726,600	864,800	[3]4,292,178
1880	----------	----------	----------	----------	762,800	1,540,400	----------
1881	----------	----------	----------	----------	907,000	2,178,523	----------
1882	----------	----------	----------	----------	836,500	1,838,485	----------
1883	----------	----------	----------	----------	620,000	1,668,392	----------
1884	----------	----------	----------	----------	701,750	1,640,946	----------
1885	[2]1,733,675	[2]6,672,225	[2]8,652,986	[3]1,425,380	757,100	1,421,160	[3]3,603,640
1886	----------	----------	----------	----------	557,000	1,823,849	----------
1887	----------	----------	----------	----------	325,600	2,664,406	----------
1888	----------	----------	----------	----------	236,550	4,946,788	----------
1889	481,955	5,004,641	5,523,971	2,391,503	210,219	5,003,259	7,604,981
1890	187,442	[4]4,281,921	4,056,841	[3]1,033,158	442,020	5,498,800	[3]6,973,978
1891	----------	2,404,571	----------	1,624,860	267,900	4,236,880	6,129,640
1892	334,080	2,522,402	2,856,482	1,486,183	578,050	5,630,106	7,694,339
1893	470,325	1,975,800	2,446,125	1,577,600	226,000	3,645,800	5,449,400
1894	417,100	1,295,805	1,712,905	1,218,250	187,600	2,509,436	3,915,286
1895	520,325	1,022,740	1,543,065	945,867	58,230	1,355,275	2,359,372
1896	553,000	1,447,300	2,000,300	1,005,735	168,520	1,498,180	2,672,435
1897	886,358	2,418,953	3,345,071	865,960	172,570	910,466	1,948,996
1898	----------	2,320,100	----------	592,750	249,340	968,590	1,810,680
1899	125,355	1,633,880	1,769,793	645,580	28,074	1,651,086	2,324,740
1900	----------	1,625,600	----------	555,420	26,154	1,503,101	2,084,675
1901	----------	2,079,550	----------	788,245	23,606	1,413,239	2,225,090
1902	----------	2,723,350	----------	913,530	17,018	1,621,540	2,552,088
1903	116,764	2,284,600	2,404,269	937,460	19,630	1,279,060	2,236,150
1904	----------	2,501,700	----------	787,360	16,500	2,002,870	2,806,730
1905	----------	2,570,100	----------	674,860	78,980	994,050	1,747,890
1906	----------	2,820,700	----------	791,720	45,300	1,273,850	2,110,870
1907	----------	3,273,800	----------	1,132,972	82,020	1,095,220	2,310,212
1908	116,900	3,106,095	3,287,995	973,905	[4]875,292	1,211,251	3,060,448
1909	133,253	----------	----------	----------	[4]354,405	861,721	----------
1910	77,561	----------	----------	----------	92,332	1,072,665	----------
1911	124,519	1,305,447	1,420,966	----------	70,352	1,104,336	----------
1912	180,283	1,157,510	1,337,793	781,739	38,738	955,821	1,776,298
1913	117,925	1,202,299	1,320,224	787,101	39,017	1,105,683	1,931,801
1914	40,665	1,331,364	1,372,029	1,393,139	69,608	1,211,499	2,674,246
1915	120,916	1,358,838	1,479,754	812,286	56,859	1,335,484	2,204,629
1916	108,221	1,521,107	1,629,328	1,919,369	77,160	1,944,109	3,940,638
1917	126,933	2,458,084	2,022,767	888,977	76,535	1,144,620	2,110,132
1918	254,079	2,092,334	2,346,413	1,101,948	65,668	1,123,608	2,291,224
1919	202,119	1,286,601	1,488,720	727,194	97,419	1,200,842	2,025,455
1920	131,433	805,558	936,991	646,696	83,094	1,354,506	2,084,296
1921	362,415	958,709	1,321,124	757,616	76,493	1,222,676	2,056,785
1922	163,201	1,151,250	1,335,251	1,401,347	68,111	1,323,390	2,792,848
1923	442,923	1,061,701	1,504,624	1,198,971	128,909	1,390,021	2,717,901
1924	247,104	1,149,683	1,396,787	1,381,694	193,122	1,282,569	2,857,385
1925	242,379	1,405,028	1,652,000	1,203,149	121,524	1,495,881	2,820,554
1926	325,420	1,537,554	1,875,068	1,722,757	155,351	1,365,055	3,243,163
1927	314,232	2,254,623	2,591,291	1,676,875	191,494	1,773,983	3,642,093
1928	554,067	2,956,146	3,525,667	1,468,801	224,262	1,568,267	3,261,330
1929	644,489	4,287,869	4,968,733	1,456,368	204,761	1,385,316	3,046,445
1930	559,028	4,812,825	5,382,548	2,879,440	246,551	1,186,319	4,312,310
1931	841,539	3,823,983	4,675,277	4,139,772	245,157	1,214,918	5,599,847
1932	491,606	3,332,284	3,836,340	4,050,334	219,227	1,362,809	5,632,370
1933	332,000	2,235,840	2,574,440	3,333,901	309,519	1,733,056	5,376,476
1934	246,000	1,932,178	2,182,778	2,568,233	308,939	1,635,832	4,513,004
1935	263,900	1,431,724	1,697,124	1,894,807	340,327	1,596,312	3,831,446
1936	142,600	876,411	1,025,511	1,442,169	235,304	1,244,030	2,921,503
1937	122,300	946,867	1,072,967	1,018,681	286,981	1,377,130	2,682,792
1938	141,800	1,117,079	1,258,879	557,969	205,230	1,381,841	2,145,040
1939	110,700	839,856	950,556	[4]255,183	115,061	1,275,255	1,645,499

[1] See appendix A for list of years in which the Lake Michigan total includes the catches in the waters of Illinois and Indiana.
[2] Includes blackfins, longjaws, and pilots (Menominee whitefish); the total for the lake in 1890 does not include the catch of these three species
[3] Includes pilots; the totals for the lake include only the pilots from the State of Michigan waters.
[4] Accuracy considered questionable; see p. 381.

The production of whitefish in the State of Michigan waters of Lake Huron rose to a higher level in 1922 and was consistently between 1 and 2 million pounds through the period, 1922–1929. The average catch for the 8 years was 1,439,000 pounds, practically the same as that for 1889 and 1891–1896.

In 1930, the whitefish fishery entered a period of chaotic change. The production of 2,879,000 pounds in this year was nearly double that of 1929 and was greater than that of any previous year. A further increase carried the yield of whitefish to an all-time high of 4,140,000 pounds in 1931. The 1932 output (4,050,000 pounds) was only a little below the record catch. In the years following 1932, whitefish production declined rapidly. This decline culminated in a 1939 yield of only 255,000 pounds, less than half the lowest production recorded for any previous year (555,000 in 1900). Detailed treatment of the violent fluctuations in the catch of whitefish in the State of Michigan waters of Lake Huron over the period, 1930–1939, is given on pp. 317–333. There evidence is presented that the high production in the earlier years of the period was made possible in large measure by the use of deep trap nets, and that this excessive yield in turn brought about a depletion of the stock that was responsible for the great severity of the subsequent decline.

The history of production of whitefish in the State of Michigan waters of Lake Huron may be summarized as follows. An early period of relatively high but decreasing yield (1889–1896) was followed by a long period (1897–1921) over which the catch was fairly stable at a rather low level. Production was stable in the years, 1922–1929, also, but the level of the take was considerably higher than that of the period, 1897–1921. The most recent period of the fishery (1930–1939) was one of violent fluctuations. Production rose suddenly to an all-time peak in 1931 of more than 4 million pounds only to decline to an all-time low in 1939 of ¼ million pounds. The normal annual take may be estimated as 1,114,000 pounds, the average catch per year for the period, 1889–1929.

The early yield of whitefish was high in the Ontario waters of Lake Huron proper;[7] the average was 759,000 pounds for the 7 years, 1879–1885. The annual catch varied erratically but averaged much lower (283,000 pounds) in the period, 1886–1898. The year 1899 was the first in a long period of low production. With the exception of 1908 and 1909, for which years the accuracy of the statistics is open to question (appendix A), the take of whitefish did not exceed 100,000 pounds at any time in the years, 1899–1922 (average, 57,000 pounds). These years of low output nearly coincided with a similar period in Michigan (1897–1921). The increase to a higher level of production in 1923 in Ontario resembles the increase that occurred in the State of Michigan waters of the lake a year earlier, in 1922. The significance of the increase in 1923 is made questionable by the fact that additional waters were included under Huron proper in 1922 and later years (see footnote 7). It should be pointed out, however, that this extension of Huron proper was not accompanied by an increase in the recorded catch in 1922. Furthermore, comparisons may be made among the years, 1922–1939. Within this period the yield increased irregularly through 1935 and thereafter dropped rapidly. The take exceeded 300,000 pounds in each of the years, 1933–1935. The relatively high yields of these years were still considerably less than those of the early period (1879–1886) even though the recent figures covered more territory. Although production declined in the Ontario waters of Lake Huron proper after 1935, it was still above 100,000 pounds in 1939.

The catch of whitefish in Georgian Bay[8] increased from an average of 1,622,000 pounds per year in 1879–1886 to an average of 4,267,000 pounds in 1887–1894. The decrease that began toward the close of the latter period brought the production of whitefish in 1895 approximately to the level about which the yield fluctuated during the 45 years, 1895–1939. The relative stability of the take in 1895–1939 is brought out by the fact that production exceeded 2 million pounds only once (1904) and fell below

[7] Production listed in table 1 under this heading for the years, 1879–1921, is for the shore of Lake Huron from Cape Hurd at the tip of the Saugaen Peninsula to the extreme southern end of the lake. Beginning in 1922, however, more northerly localities (islands of the open lake and the westerly shore of Manitoulin Island) were included in "Huron proper."

[8] Production listed in table 1 under this heading includes the catches from the entire North Channel and Manitoulin Island regions except in 1922 and later years. (See footnote 7.)

one million pounds only 5 times (1897, 1898, 1905, 1909, and 1912) during the 45 years. The average annual production of 1895–1939 was 1,333,000 pounds. This average may be accepted as an estimate of normal production in Georgian Bay. The relatively good yields of 1933–1935 suggest an increase comparable (but less pronounced) to that which took place in the same years in the Ontario waters of Lake Huron proper. Again it may be observed that the change in the territory covered by the statistics collected after 1921 showed no effect on the figures of yield.

It may be noted here that the periods of decline and of increase in the production of whitefish in the Michigan waters were followed a year or two later by similar periods in the Ontario waters of Lake Huron. This correspondence suggests that the annual fluctuations in ecological conditions on the two sides of the lake may be similar. The changes in take in the Georgian Bay waters, however, showed no similarity with those in Lake Huron proper.

The totals for the entire lake indicate that the earlier years of the fishery were the years of the heaviest yields. Especially noteworthy was the high production in the period, 1889–1894, when the average annual catch was 6,295,000 pounds.[9] Subsequent to 1894 the production of whitefish was relatively stable over a long period. The catch rose above 3 million pounds only once (1916) in the period, 1895–1925,[10] and dropped below 2 million pounds only 5 times (1897, 1898, 1905, 1912, and 1913). The average production in this period (with the catch for 1908 omitted) was 2,351,000 pounds, which yield may be accepted as the normal for the entire lake. Good catches in both Canadian and United States waters made possible yields that were consistently above 3 million pounds in the years, 1926–1929 (average, 3,298,000 pounds). It was in the period, 1930–1934, however, that the production of the modern fishery reached its greatest heights. The take was greater than 4 million pounds in all 5 years and exceeded 5 million pounds in 3 years. The average was 5,087,000 pounds. The most recent of the earlier years with comparable production was 1893. It is to be noted that Canadian waters were largely responsible for the high production of the early years (1893 and earlier), whereas in 1930–1934 United States waters accounted for the bulk of the catch. In fact, the Canadian production exceeded that of the United States in every year except 1914, 1922, 1926, and the years, 1930–1934. By reason of a continuous decrease in production the average yield for 1935–1939 was only 2,645,000 pounds. The catch of 1,645,000 pounds in 1939 was the lowest for which there is a record. The small yield in that year can be attributed in large measure to the collapse of the fishery in United States waters.

LAKE MICHIGAN

The first acceptable records of the production of whitefish in Lake Michigan (table 1), as in the United States waters of Lake Huron, begin with the year 1889. (The 1890 record for the State of Michigan includes species other than whitefish.)[11] Attention will be given first to the production in the State of Michigan waters, the area with which the present report is most concerned. It is true also that the data are more complete for the State of Michigan waters than for other regions of the lake and that the production in these waters dominates the catch in the entire lake.

The production of whitefish in the State of Michigan waters of Lake Michigan was between 2 and 3 million pounds in 10 of the 19 years, 1889 and 1891-1908. (See fig. 3.) The catch was less than 2 million pounds in 6 years (less than 1½ million pounds in the 3 years, 1894-1896) and was more than 3 million pounds in only 3 years (1889, 1907, and 1908). The 1889 yield of 5,005,000 pounds was the highest for which there is a dependable record. The average for the period was 2,370,000 pounds. Production tended to decrease in the earlier span of years but to increase in the later part of the period.

[9] It is unlikely that the inclusion of the catch of pilots in the production figures of whitefish in State of Michigan waters in 1890 affected this average materially.

[10] No data for 1909–1911; the production of 3,060,000 pounds in 1908 may be discounted because of the questionable accuracy of the data for the Ontario waters of Huron proper in that year (p. 381).

[11] See appendix A for a discussion of the defects in the statistics for 1879 and 1885 and for the State of Michigan waters in 1890 and appendix D for the 1940–1942 records.

FIGURE 3.—Commercial production of whitefish in Lake Michigan, 1890–1939. Short dashes, State of Wisconsin waters; long dashes, State of Michigan waters; solid line, entire lake.

The general level of the yield was lower over the period, 1911-1926, than in 1889 and 1891-1908; the 1911-1926 average was only 1,361,000 pounds. The catch was between 1 and 1½ million pounds in 10 of the 16 years. Four years (1916, 1917, 1918, and 1926) had productions of more than 1½ million pounds (more than 2 million pounds in 1917 and 1918) and two years (1920 and 1921) had yields of less than a million pounds.

An increase in production that got under way as early as 1924 and proceeded slowly in the years, 1924-1926, became sufficiently rapid in 1927 to raise the catch above 2 million pounds. The catch continued to increase rapidly until a maximum of 4,813,000 pounds was reached in 1930. The subsequent decline did not carry the take of whitefish below 2 million pounds until 1934. The average yield for the 7 years, 1927-1933, was 3,386,000 pounds. This average was greater than the largest yield reported for any single year earlier than 1929 with the exception of 1889 and possibly of some other years prior to 1891—years for which accurate statistics are lacking.

The average production of whitefish in the most recent period, 1934-1939, was 1,191,000 pounds. The yield exceeded 1½ million pounds in only one year (1934), and in two years (1936 and 1939) it was not far above the lowest catch recorded for any previous year (806,000 pounds in 1920).

The history of the production of whitefish in the State of Michigan waters of Lake Michigan may be summarized as follows. The catch fluctuated about a level of somewhat more than 2⅓ million pounds during the earliest period (1889 and 1891-1908) for which reliable statistics are available; the annual yields tended to be below average and to decrease in the earlier years and to be above average and to increase in the later years of this period. The level of production was relatively low in the years, 1911-1926, with the catch exceeding 1½ million pounds in only 4 of the 16 years. The grand average of 1,909,000 pounds covering both periods (1889-1926) may perhaps be accepted as the normal yield in these Michigan waters. The years, 1927-1939, constituted a period of wide fluctuations in production that resembled the variations that took place in the State of Michigan waters of Lake Huron at about the

same time (1930–1939). Further considerations of these more recent fluctuations will be found in the next section.

The take of whitefish was relatively high in the Wisconsin waters of Lake Michigan[12] in most of the earlier years for which records are available. The catch averaged 481,000 pounds for the years, 1889-1897, and was less than 300,000 pounds in only 1 of 8 years (1890). The yield of 886,000 pounds in 1897 was the highest for which there is a record. (The statistics for 1885 include species other than whitefish.)

Statistics of the production of whitefish in the Wisconsin waters of Lake Michigan are available for only 2 of the 10 years, 1898-1907. The catches of both 1899 and 1903 were a little above 100,000 pounds and at approximately the level of production for 1908-1917. The average annual take for 12 years within the 20-year period. 1898–1917 was 116,000 pounds. In these 12 years the production exceeded 150,000 pounds only once (1912) and was less than 100,000 pounds twice (1910 and 1914).

An increase occurred in 1918 in the general level of production. The average catch of the 8 years, 1918-1925, was 256,000 pounds. Production within the period was variable and ranged from 131,000 pounds in 1920 to 443,000 pounds in 1923.

The year 1926 was the first in an 8-year period during which the output of whitefish in the Wisconsin waters of Lake Michigan did not fall below 300,000 pounds. The average 1926-1933 yield was 508,000 pounds, the maximum of 842,000 pounds in 1931 constituting the highest production since 1897. The increased catch in Wisconsin waters of Lake Michigan in 1926-1933 corresponds to the high production in the State of Michigan waters of Lakes Michigan and Huron in approximately the same general period.

The peak Wisconsin yield of 1931 was followed by a rapid if irregular decrease. The average annual production of the most recent 6-year period, 1934-1939, was 171,000 pounds. The catch of 111,000 pounds in 1939 was the lowest since 1916. Production was below the 1939 level in only 3 years (1910, 1914, and 1916) of the 42 years for which there are records in the period, 1889–1939. Probably the best estimate of the normal take of whitefish for these Wisconsin waters is the grand average for all years (1889–1939), namely, 295,000 pounds.

Despite defects (inclusion of the catches of blackfins, longjaws, and Menominee whitefish) in the whitefish statistics for the whole of Lake Michigan in 1879 and 1885 (in 1890 a separation of the catches of whitefish and of blackfins, longjaws, and pilots was possible for the entire lake but not for Michigan waters; Wisconsin data were taken from State sources) the data provide evidence, nevertheless, that the level of production of whitefish in the earlier years was considerably higher than in later years. The only information on the extent to which the whitefish statistics for Lake Michigan may have been distorted by the inclusion of the catches of blackfins, longjaws, and Menominee whitefish is provided by the data for 1890. In that year, according to the Report of the United States Commissioner of Fisheries, the catch of these three species made up 1,398,238 pounds of the reported whitefish take of 5,455,079 pounds in the entire lake. (Data were not given on the production of the species named, in the waters of the individual States.) The catch of whitefish alone (4,056,841 pounds), therefore, made up 74.4 percent of the combined output of whitefish, blackfins, longjaws, and Menominee whitefish.

If it is assumed that whitefish made up the same percentage of the reported catch in Lake Michigan in 1879 and 1885 as in 1890, the following estimates of production in these years are obtained: 1879, 8,951,000 pounds; 1885, 6,438,000 pounds. To be sure, the use of the percentage derived from statistical data for 1890 for the estimation of the catch of whitefish in earlier years is open to severe criticism. Undoubtedly, the relative abundance of whitefish and of blackfins, longjaws, and Menominee whitefish in the catch varied from year to year. Nevertheless, the preceding estimates, inexact as they may be, together with records for 1889 and 1890 provide strong evidence in support of the belief that production of whitefish in the

[12] For a discussion of Wisconsin's whitefish production in Green Bay and Lake Michigan proper separately, see appendix C.

earlier years of the fishery was greater than in 1891 and subsequent years. The normal annual output of these earlier years most probably exceeded 5 million pounds.

The description of the fluctuations in the production of whitefish in the entire lake before 1911 is made difficult by the lack of complete information in a number of years.[13] Records of the total yield are available for only 11 years of the period, 1889-1910. These catches exhibited considerable variation. The production was less than 2 million pounds in 3 years (1894, 1895, and 1899), ranged between 2 and 3 million pounds in 4 years (1892, 1893, 1896, and 1903), fell between 3 and 4 million pounds in 2 years (1897 and 1908), and exceeded 4 million pounds in 1889 and 1890, the earliest years of the period. The average for the 11 years was 2,813,000 pounds.

The level of whitefish production for the entire lake was considerably lower in the years, 1911-1926. The catch was greater than 2 million pounds in only 2 years (1917 and 1918) of the 16, and in 10 years production was below 1½ million pounds. The 16-year average was 1,566,000 pounds.

Improved catches in both Wisconsin and Michigan waters were responsible for an uninterrupted period of 8 years, 1927–1934, in which the total catch of whitefish in Lake Michigan did not fall below 2 million pounds. The production was more than 3 million pounds in 5 of these years (1928-1932), was above 4 million pounds in 3 years (1929-1931), and exceeded 5 million pounds in 1930. The average for the 8-year period was 3,717,000 pounds. The production in each of the 3 years, 1929-1931, was greater than that recorded for any year of the period, 1890-1928, although a higher yield was recorded for 1889 and there is evidence that the catch of whitefish in certain years prior to 1889 may have been even greater.

The average annual production of whitefish in Lake Michigan in the most recent 5-year period, 1935-1939, was 1,201,000 pounds. The catches in 1936, 1937, and 1939 were all below the smallest yield recorded for any year prior to 1936 except 1920; the 1939 record provides the second report of a total whitefish catch in Lake Michigan of less than a million pounds.

The grand average of 2,074,000 pounds for the years, 1889-1926, may perhaps be accepted as the normal yield of whitefish for the entire lake.

RECENT LARGE INCREASE IN THE PRODUCTION OF WHITEFISH IN GREAT LAKES WATERS

The preceding pages were devoted exclusively to a description of fluctuations in the production of whitefish in the various waters of Lakes Huron and Michigan. A discussion of these fluctuations in terms of variations in the abundance of whitefish has been avoided deliberately because of the many disturbing factors that render such interpretations exceedingly unreliable.

A fundamental difficulty in the use of the statistical data of the type given in table 1 for estimations of fluctuations in the abundance of fish lies in the lack of adequate information on the intensity of the fishery. It is known that in general the fishing intensity of the early fishery was far less than that of the modern fishery—that with the passage of the years the number of men and boats engaged in commercial operations increased greatly. It is known too that certain technical developments such as the invention of power lifters, improvements in the efficiency of nets, and the construction of faster and more cheaply operated craft, permitted an expansion of fishing activity out of proportion to the mere increase in men and boats. Because of the known increase in fishing intensity a given annual catch in the earlier years of the fishery may be held to indicate a greater abundance of fish than an equally large production a number of years later.

Changes in fishery regulations also may affect production significantly. Increases or decreases in the minimum legal mesh size, the imposition of a closed season, the establishment or abandonment of a fishery for spawn, the closure of grounds or the restriction of operations in certain areas, changes in the size limit of fish—all these

[13] Totals were omitted for all years in which records were lacking for either the State of Michigan or the State of Wisconsin waters. Certain of the totals listed for Lake Michigan in table 1 do not include the production in Illinois and Indiana waters, but the omission of these catches most probably had little effect on the values of the totals. (See appendix A.)

and other changes in fishery regulations can have a profound if undeterminable effect on total yields.

Production may vary according to general economic conditions. In periods of depression low prices may render operations unprofitable and thus bring about a curtailment of fishing activities. On the other hand, an economic depression has been observed in at least one industrial district to have the reverse effect of stimulating fishing intensity. Here numbers of unemployed turned to small-scale fishing as an emergency source of income—meager, to be sure, but preferable to none at all.

Other factors, such as weather conditions, might be listed which cause fluctuations in production that are independent of the level of abundance of the stock. However, those mentioned are sufficient to bring out the difficulties inherent in the use of catch statistics for the estimation of changes in the abundance of fish, particularly over long periods of time.

Despite the limitations just outlined, there is good reason to believe that under normal conditions (without disruption in the methods or regulations of the fishery), over limited areas, and for short periods of years, large increases or decreases of production may serve as reliable indicators of increases or decreases in the abundance of fish on the grounds. The changes in annual yields do not measure the changes in abundance, but merely indicate their occurrence. This view concerning the general relationship between the production and abundance of fish has grown from the careful examination of records that have been maintained, beginning in 1929, of the annual fluctuations in the catch and abundance of fish on the grounds and in the intensity of the fishery for all commercially important species in 21 fishing areas of the State of Michigan waters of the Great Lakes.

Ordinarily fluctuations in production exceed those in abundance; that is, the increases in the catch tend to be relatively greater than the increases in abundance when the latter rises above the average, and conversely, the decreases in the yields tend to be greater than the decreases in abundance when the latter falls below the average. As a result the curves of production often are "exaggerations" of the curves of abundance. This general relationship between abundance and catch has its origin in the circumstance that fishing intensity tends to be above average when abundance is above average and below when abundance is below. Of course, exceptions occur in the relationships outlined above but these exceptions do not affect the general validity of the statements.[14]

Among the increases in production that safely may be held to reflect (but not measure) a greater abundance of fish on the grounds are those that occurred in the catch of whitefish in Great Lakes waters near the beginning of the 1930's. Although the actual years of high yields varied somewhat in the different waters, an increase occurred in every important center of production. The increase in the catch was relatively greater in the State of Michigan waters of Lake Huron than in other areas.

The extent to which the recent increase in production was relatively greater in the State of Michigan waters of Lake Huron than in other areas may be brought out by comparisons of the take in the 2 or 3 recent years of greatest yield with the average catch over a period of earlier years. The average production in the peak years, 1931 and 1932, was 3.67 times the average for the years 1889 and 1891-1929. This value is considerably higher than the ratios for other areas as the following tabulation shows:

Area	Years of early period	Years of recent period	Ratio of recent to early production
Huron (State of Michigan)	1889, 1891–1929	1931–1932	3.67
Huron (Province of Ontario-Huron proper)	1893–1932	1933–1935	2.86
Huron (Province of Ontario-Georgian Bay, North Channel)	1895–1932	1933–1935	1.26
Michigan (State of Michigan)	1889, 1891–1926	1929–1930	2.38
Michigan (State of Wisconsin)	1889–1927	1929–1931	2.58
Superior (State of Michigan)	1911–1930	1931–1933	1.97
Erie (entire lake)	1921–1927	1929–1931	1.68

[14] See part II for a discussion of the relationships among the fluctuations in the production and abundance of whitefish and in the intensity of the whitefish fishery in Lakes Huron and Michigan.

Although the selections of the periods for the preceding comparisons, based on the examination of the statistical data, were to a certain extent arbitrary, reasonable changes in the years included in these periods would not affect the validity of the general conclusion that the increase in the production of whitefish was greater in the State of Michigan waters of Lake Huron than in other Great Lakes areas.

Despite the known risks involved in the estimation of changes in abundance from changes in production, the ratios of the preceding paragraph would suggest the possibility that the recent increase in the abundance of whitefish may have been somewhat higher in the Michigan waters of Lake Huron than in other Great Lakes areas. Information from other sources, however, proves that such an assumption would be utterly invalid. The higher production in the Michigan waters of Lake Huron (as compared to other waters) was made possible by the introduction of a new and marvelously efficient gear, the deep trap net. The use of this net made possible a tremendous increase in fishing intensity. No doubt an increase in catch would have taken place without the use of deep trap nets; however, it was deep-trap-net operations that accounted for the relatively greater heights of production attained in the Michigan waters of Lake Huron.

The description of the annual fluctuations in the yields and abundance of whitefish and in the intensity of the whitefish fishery in the Michigan waters of Lakes Huron and Michigan, 1929–1939, presented in part II, is concerned largely with the effects of deep-trap-net operations on the fishery. It is shown that the widespread use of deep trap nets in Lake Huron (the gear was fished much less extensively in Lake Michigan) led to a multiplication of fishing intensity that raised production far beyond a reasonable level and was responsible for the subsequent collapse of the fishery.

PART II

FLUCTUATIONS IN THE PRODUCTION AND ABUNDANCE OF WHITEFISH AND IN THE INTENSITY OF THE WHITEFISH FISHERY IN THE STATE OF MICHIGAN WATERS OF LAKES HURON AND MICHIGAN, 1929-1939

INTRODUCTION

In the proper administration of commercial fisheries it is of primary importance to have at hand statistical data that afford a reliable indication of changes in the abundance of the commercially available stocks of the leading species. These data must include a record not only of the quantity of fish taken, but also of the extent of the fishing operations that led to the reported catch. Obviously, a decrease in production cannot be held with certainty to represent a depletion of the stock unless it can be demonstrated that this lowered yield has not resulted from a reduction of fishing intensity. On the other hand, an increase in catch with its suggested danger of possible overfishing may not be the result of an expansion of fishing activities but may originate in an increase in the abundance of fish on the grounds. Nor can it be said that a sustained production over a period of years demonstrates a corresponding stability of abundance, for abundance may decline or increase greatly while compensating fluctuations of fishing intensity hold the total catch at a nearly constant level. The true condition of the fisheries, therefore, cannot be measured accurately by statistics of catch alone, but should be expressed in terms of production in relation to fishing intensity, that is, catch per unit of fishing effort.

It was with a view toward obtaining complete and reliable information on the fisheries of the Great Lakes waters under the jurisdiction of the State of Michigan that the senior author devised and recommended to the Michigan Department of Conservation the monthly report system now in effect. Under this system all licensed commercial fishermen must submit each month a complete record of their daily fishing activities. The required data on each day's fishing include: fishing locality; kind and amount of gear fished; the length of time (number of nights out) stationary gear fished before it was lifted; and the catch in pounds of each species taken. From these data it is possible to determine both the yield and the intensity of the fishery.

The law requiring the submission of monthly reports became effective in September 1927. The early returns were incomplete and the individual reports were often faulty. By the beginning of 1929, however, the fishermen had obtained sufficient experience in making out their reports so that almost all returns contained the complete data necessary for statistical analysis. These records for the 11-year period, 1929–1939, comprise the basic materials on which part II of this paper is founded.

METHODS OF ANALYSIS

Methods proposed for the analysis of Great Lakes fishery statistics were described by Hile and Duden (1933).[15] In general, the procedure outlined in this publication has proved satisfactory, although subsequent experience has shown certain simplifications of the original methods to be valid. (See discussion under "Units of Fishing Effort" in this section.) As an addition to the original procedure, methods have been devised for a more precise statement of changes in abundance and fishing intensity.

STATISTICAL DISTRICTS

Statistical tabulations and analyses have been made separately for six areas in Lake Huron and eight in Lake Michigan. (The boundaries of the different districts are indicated in the accompanying chart, fig. 4.) It was attempted to make these dis-

[15] Hile, Ralph and William R. Duden. Methods for the Investigation of the Statistics of the Commercial Fisheries of the Great Lakes. Trans. Am. Fish. Soc., vol. 63, 1933, pp. 292–305.

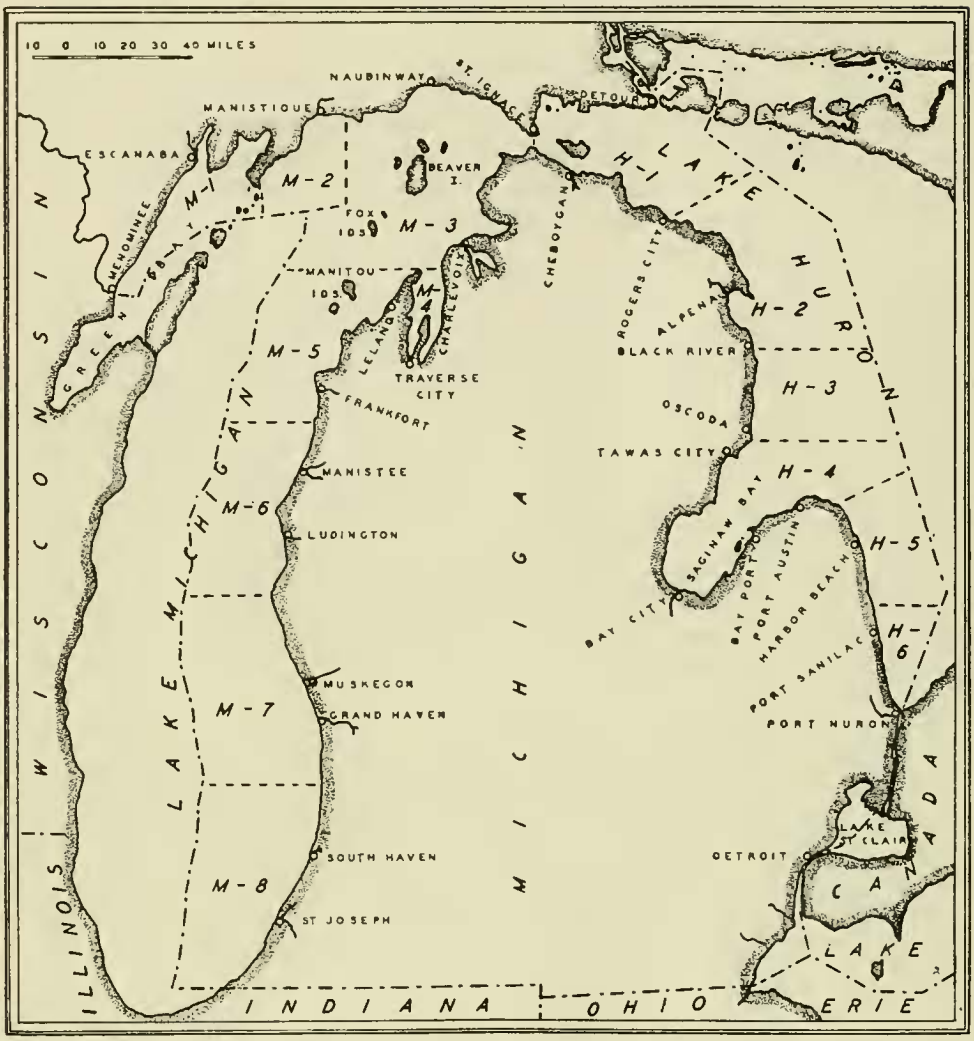


FIGURE 4.—Map showing the statistical districts of the State of Michigan waters of Lakes Huron and Michigan.

tricts natural divisions from the standpoint of both fishing grounds and fishing operations.[16] For some purposes the data for the separate districts have been combined to provide more general information for different regions of the lakes and for the entire lakes. For convenience, the districts will be designated in later discussions by the initial letter of the lake and the number of the district. For example, the third district of Lake Huron will be termed H-3, the fifth district of Lake Michigan, M-5,***.

PRODUCTION

The production was tabulated according to gear for each month. The only important gears used for the taking of whitefish are the large-mesh gill net (4½ inches or larger, stretched measure), the deep trap net, and the pound net. The discussion in this paper will be concerned chiefly with annual totals of the catch of the different gears and of all of them combined. Data on monthly yields will be confined to the discussion

[16] Hile and Duden (*loc. cit.*) stated that Lake Michigan had been divided into 11 statistical districts. Experience revealed, however, that certain of the original tentative divisions were not practical. Changes of boundaries and combinations of areas have reduced the number of statistical districts in Lake Michigan to eight. The six statistical districts of Lake Huron all proved satisfactory as originally defined.

of the effects of the deep trap net on the seasonal trend of production in Lake Huron (p. 332).

UNITS OF FISHING EFFORT

The units of fishing effort employed in this paper are:

Gill nets.—The lift of 10,000 linear feet of net (10,000 foot-lifts).[17]

Impounding nets (deep trap nets and pound nets).—The lift of one net (1 net-lift).

Fishing effort may be expressed as total effort and as effective effort (with respect to a given species). In large-mesh gill nets, for example, the total effort for a given area over a certain interval of time is the total number of units of 1,000 feet (see footnote 17) of net lifted. The effective effort with respect to whitefish is the number of units of gill net lifted that actually took this species. Corresponding definitions of total and effective effort apply to the pound net. A distinction between total and effective effort is necessary because both large-mesh gill nets and pound nets are fished for other species on grounds where whitefish do not occur. In the deep trap net, which was designed and operated primarily for the capture of whitefish, the total fishing effort and the effective effort with respect to this species may be considered identical. All tabulations of catch per lift in this paper are based on effective fishing effort.

In addition to the above "units of effort," the methods proposed by Hile and Duden defined "units of intensity" which included a consideration of fishing time (nights out). The intensity unit for gill nets was defined as the fishing effort of 1,000 feet of gill net over a period of one day, and for impounding nets as the fishing effort of one net over a period of one day. The basis for these definitions of intensity units was the assumption that the amount of fishing done by stationary gear varies directly with the time out. This assumption holds, for example, that a net which is out three nights may be expected to take three times as many fish as the same net in one night.

Subsequent detailed analyses of hundreds of fishermen's reports made by Hile and described briefly by him in 1935[18] and by Van Oosten (1935)[19] have proved this preliminary assumption to be erroneous. Although the catches of both gill nets and impounding nets, on the average, become larger with increase in fishing time, the improvement in the catch is far less than might be expected on theoretical grounds. A summary of the data on the actual relationship between fishing time and the average size of the lift in the gears most important in the whitefish fishery appears in table 2. In this table all catches are expressed as percentages of the catch of nets one night out. Although the data for the three gears disagree somewhat as to the relationship between the actual size of the catch and the number of nights out, these small discrepancies lose significance in the face of the large deviations that all the actual catches show with respect to the theoretical catches. For example, the largest increase in nets 2 nights out over nets 1 night out (pound nets) was only 16 percent of the expected increment of 100. Similarly, the largest increase in the catch of nets 5 nights out over 1 night out (54 in pound nets) was only 13.5 percent of the expected increment of 400. It is obvious, therefore, that only small increases in the catch can be expected as the time between lifts is increased. Consequently, the use of the catch per net per night as a measure of abundance is not valid. The strictly valid unit for the measure of abundance is neither the catch per lift nor the catch per night, but is rather the catch per lift, corrected for fishing time (from empirical data of the type contained in table 2).

The necessity for considering fishing time in the computation of annual fluctuations in abundance depends, of course, on the existence of annual variations in the average number of nights out. Annual variations in fishing time occur in all areas and for all stationary gears, but for a single area and a single type of gear these variations have a limited and characteristic range. The limited range of variation in the average number of nights out, together with the fact that a change in fishing time affects the

[17] The unit of effort was defined originally as the lift of 1,000 feet of gill nets. In the present study, however, the catch of gill nets has been recorded in terms of the yield per 10,000 foot-lifts (tables 11 and 17) in order to obtain values more nearly comparable with the catch per unit of effort of pound nets and deep trap nets.

[18] The Fisherman, vol. 4, no. 12, pp. 1 and 2, 1935.

[19] Van Oosten, John. Logically Justified Deductions Concerning the Great Lakes Fisheries Exploded by Scientific Research. Trans. Am. Fish. Soc., vol. 65, 1935, pp. 71–75.

TABLE 2.—*Relationship between fishing time and the average size of the lift*

[In order that the data for the different gears may be comparable, the catch per lift at one night out is set at 100 and all other catches expressed as percentages of this value. In parentheses, the number of fishermen's reports upon which determination was based]

Item		Number of nights out				
		1	2	3	4	5
Theoretical catch		100	200	300	400	500
Actual catch	Large-mesh gill nets	100	111 (304)	120 (430)	133 (403)	150 (278)
	Deep trap nets	100	115 (157)	116 (228)	128 (272)	[1]126 (197)
	Pound nets	100	116 (353)	138 (458)	141 (306)	154 (177)

[1]Less than preceding catch.

size of the catch only slightly, suggested the possibility that abundance curves calculated from the average catch per lift without reference to time might differ only slightly from curves calculated from the average catch per lift, corrected for time. To test this possibility a series of abundance curves for the period, 1929–1934, was computed by each of the two methods, covering all types of stationary gear and a variety of species and fishing areas. For each gear particular care was taken to select the statistical district with the widest annual variation in the average fishing time. Despite this selection, in each example the two curves resembled each other so closely that the same conclusions concerning the annual changes in abundance would have been drawn from either of them. As the neglect of the time element does not affect the results materially, all computations of abundance have been based on the catch per lift, without reference to time.

ESTIMATION OF ABUNDANCE AND FISHING INTENSITY

The method employed for the estimation of the abundance of species of fish in the State of Michigan waters of the Great Lakes in different calendar years was outlined by Hile (1937).[20] The definition of fishing intensity was given by Hile and Jobes (1941).[21] The steps in the determination of the general abundance of a species within a fishing area (statistical district) in a particular calendar year are:

(1) The "expected catch" of each important gear is determined as the product of known fishing intensity (number of impounding nets or thousands of feet of gill nets, that took the species, lifted within the district during the entire 12 months) and the average catch of that species per unit of fishing effort over a period of years.

(2) The expected catches as determined individually for the important gears are added to obtain the "total expected catch."

(3) The "general abundance" is the actual catch of the important gears expressed as a percentage of the total expected catch of the same gears.

As the average catch per unit of effort is constant in all of the computations of expected catch for a single type of gear, annual fluctuations in the expected catch by each gear and hence for all gears combined depend only on the amount of gear lifted. Consequently, the total expected catch of any single year, expressed as a percentage of the average total expected catch over a period of years, provides a measure of the relative intensity of the fishery in that particular year.

The above procedures make it possible to combine the data for all gears important for the capture of a particular species in such a way as to obtain estimates of the "general" abundance and of the total fishing intensity.

Originally all estimates of abundance and fishing intensity were made with reference to average conditions over the 6-year period, 1929–1934. Later, the percentages were adjusted to describe deviations about the mean for the 11 years, 1929–1939.

[20] Hile, Ralph. The Increase in the Abundance of the Yellow Pike-Perch, *Stizostedion vitreum* (Mitchill), in Lakes Huron and Michigan, in Relation to the Artificial Propagation of the Species. Trans. Am. Fish. Soc., vol. 66, (1936) 1937, pp. 143–159.

[21] Hile, Ralph and Frank W. Jobes. Age, Growth, and Production of the Yellow Perch, *Perca flavescens* (Mitchill), of Saginaw Bay. Trans. Am. Fish. Soc., vol. 70, (1940) 1941, pp. 102–122.

GENERAL REMARKS

It does not come within the province of this paper to undertake a detailed criticism of the statistical methods employed here, to discuss at length possible sources of systematic errors, to attempt to estimate the degree of reliability of certain necessary approximations, or to explain the basis for the selection of methods followed over possible alternative procedures. It can be said only that the methods employed for the analysis of the statistics of the commercial fisheries of the Great Lakes have been developed gradually from a careful study of extensive data covering all the commercially more important species over a period of years and in a large number of different localities. These methods have been adapted specifically to conditions in the Great Lakes. An outstanding feature of the Great Lakes fisheries is that most species are taken in quantity by several types of gear and that most types of gear take several species (usually simultaneously). These circumstances add greatly to the complexity of the problem of analysis.

No claims are advanced for the indexes of abundance and fishing intensity as "precision measures" of the changes that occurred in the fishery. On the other hand, we believe them to be sufficiently sensitive to bring out all changes of significant magnitude. This belief is supported by the consistency with which conclusions based entirely on our statistical data have been corroborated by reliable evidence gained independently from other sources (interviews with fishermen; observations of field workers).

Although, as stated previously, a general criticism of our methods of analysis will not be undertaken, it does appear desirable to call attention to certain difficulties of interpretation peculiar to the statistics of the whitefish fishery.

It is indeed unfortunate that the statistical data on the commercial fishery for whitefish are less satisfactory than those for any other important commercial species. The invention and rapid expansion in the use of that tremendously efficient gear, the deep trap net, brought about, particularly in Lake Huron, an almost immediate threat of depletion or commercial extinction to the whitefish stocks of the areas in which the net was fished. In this critical situation the need for dependable statistical measures of abundance was most pressing. However, the very circumstances that made the need for adequate statistical data so urgent also made the interpretation of these data difficult. The chief obstacles to appraising the statistical data on the whitefish over the period, 1929–1939, are: lack of information concerning normal conditions, inaccurate data on the deep-trap-net fishery, and the difficulty of bridging the transition to a fishery dominated by this gear.

As stated earlier (p. 314), in the statistical study of the important commercial species in the State of Michigan waters of the Great Lakes, the average conditions of production, abundance, and fishing intensity during the 6-year period, 1929–1934, were employed tentatively as the point of reference for the study of fluctuations. The fisheries for most species appeared to be approximately normal (with reference to modern conditions) during this period; consequently the 6-year averages may be expected to provide a fairly reliable basis for estimating changes in the condition of the fisheries, not only in that period but in subsequent years as well.

The whitefish fishery, however, was not normal in the years, 1929–1934, nor can the average conditions in the longer period, 1929–1939, be held to provide a satisfactory point of reference. It is recognized generally that whitefish were abnormally abundant at the beginning of these periods. The peak of abundance probably was reached in Lake Michigan in 1929 and in Lake Huron a year or so later. The high abundance in turn stimulated fishing intensity. As a result, production, abundance, and fishing intensity were all doubtless far above normal in the earlier years of the period for which detailed statistics are available. It should then be kept in mind throughout the discussion of the following sections that all fluctuations are described with reference to averages the relationship of which to the normal is not known.

The interpretation of the Lake Huron data is made even more difficult by the disturbing effects of the use of the deep trap net. This gear, which became the dominant one for the capture of whitefish as early as 1931, raised production to excessive heights and disrupted completely the ordinary course of return to normal conditions.

The fact that in all districts but H-2 the deep trap net was not fished throughout the entire "period of reference" (1929–1934) introduced certain difficulties into the estimation of abundance. For example, the deep trap net was operated in H-1 during only 5 years (1930–1934) of this 6-year period. The average catch of whitefish per lift of deep trap nets in the years, 1930–1934, was 111.08 pounds. However, the data for large-mesh gill nets and pound nets indicated that the 1930–1934 abundance averaged only 99.12 percent of the 1929–1934 mean. Consequently, the average catch per lift of deep trap nets would have been higher had the gear been fished in 1929 also. It was necessary, therefore, to base the computations of the expected catch (p. 314) of deep trap nets on the "corrected" catch per lift, $111.08/0.9912=112.07$ pounds.

Although this method of "correcting" the average catch per lift of deep trap nets (in some districts the data for pound nets had to be treated similarly) is sound logically, the actual reliability of the results is open to question in some districts in which the rise of the deep-trap-net fishery was accompanied by the practical extinction of the gill-net and pound-net fisheries (for whitefish). The correction was based, for example, on the data for only 3 years in H-3 and H-5 and for 2 years in H-6. The difficulties involved in following annual changes in abundance in areas in which the deep trap net replaced other types of gears completely or nearly completely will be mentioned again on page 328.

The deep trap net was important also in Green Bay and northern Lake Michigan, but the disturbance of the fishery was not as severe as in Lake Huron.

Although the greatest need for dependable statistical data existed with respect to those districts in which the deep trap net became almost the only gear that produced whitefish, it was for precisely these areas that the original data were least trustworthy. This lack of dependability had its origin in the extensive inaccuracies and misstatements of fact known to have occurred in the reports of numerous deep-trap-net fishermen. This observation is not intended as an indictment of any fisherman or group of fishermen. Nevertheless, the fact that these inaccuracies existed cannot well be ignored. To discuss changes in abundance computed from deep-trap-net data without giving some idea as to their degree of dependability would be misleading. Misstatements were found in the reports of deep-trap-net fishermen as to the type of gear fished, the numbers of nets lifted, and the size of the catch.

Numerous deep-trap-net reports were indicated erroneously to be reports of pound-net operations. Most of the errors of this type were made by operators in the Saginaw Bay region in 1931 and in both the Saginaw Bay and Harbor Beach regions in 1932. In other years and in other districts the designation of deep trap nets as pound nets was much less frequent. Without naming sources of information or explaining the procedure followed, it may be stated that we are certain that we have detected and corrected practically all, if not all, of the misstatements as to the type of gear. Consequently, this originally serious source of error does not affect materially the data of this paper.

It has not been possible to correct the inaccuracies of data as to the number of nets lifted and the size of the catch, nor is there any basis for a good estimate of the extent of these inaccuracies. Where there was opportunity of comparing actual and reported data the discrepancies were sometimes appalling. Some fishermen not only reported incorrectly the number of nets lifted but gave dates of lifting that did not coincide with the dates on which they actually left port. The reported catches were often understatements. The extreme in this type of misrepresentation is offered by the report of an operator who is known to have taken more fish in a single day than he reported for the entire month. It must be considered highly probable that the actual total production of whitefish in deep trap nets was far above that recorded in this study.

In calling attention to the defects in the deep-trap-net data it is not intended to imply that all operators of deep trap nets submitted erroneous and carelessly prepared reports. There is good evidence that many of them prepared scrupulously accurate accounts of operation and of catch. Although the number of inaccurate reports may be sufficient to invalidate the deep-trap-net data as descriptive of details, these data still serve satisfactorily to indicate the trends of the fisheries in the different districts. This view finds support in the fact that for the whitefish as well as for other species there

was good agreement between conclusions as to the course of the fishery based on statistical data and on the testimony of the fishermen themselves.

WHITEFISH FISHERY OF LAKE HURON, 1929-1939

In part I attention was called to the general increase in the abundance and production of whitefish that occurred in the waters of the Great Lakes in the late 1920's and early 1930's. Emphasis was placed on the fact that the increase in yield in Michigan waters of Lake Huron was relatively much higher than in other waters. The average Michigan catch in Lake Huron in the two peak years, 1931 and 1932, was 3.67 times the average annual production over a period of earlier years, and the years 1930, 1933, 1934, and 1935 had yields well above normal, whereas in other waters the average annual productions during the recent maximum were only 1.26 to 2.86 times the earlier averages (p. 309). The excessive catch in Lake Huron was attributed to the widespread use of the deep trap net in that lake. The detailed data that will be presented for the six statistical districts in the State of Michigan waters of Lake Huron fully support this earlier position. In fact, the origin and expansion of the deep-trap-net fishery dominate the recent history of Michigan's whitefish fishery of Lake Huron so completely that a summary of the 1929–1939 statistics constitutes in reality little more than a study of the effects of this new gear.

The deep trap net was introduced into Lake Huron off Alpena, Mich., in district H–2 in July 1928, and continued to be fished in the same area in 1929. The rapid expansion of the deep-trap-net fishery got under way in 1930. In this year the net was fished extensively not only in the neighborhood of Alpena but also in H-1 (especially in Hammond Bay) and in H–3 (mostly from Au Sable-Oscoda); a few deep trap nets were used also in 1930 on the "Middle Grounds" off Saginaw Bay (H-4). No new statistical districts were added to the deep-trap-net grounds until 1932, in the latter part of which season the net was introduced into the waters of southern Lake Huron off Harbor Beach (H-5). The expansion into H-6 in 1933 completed the coverage of the Michigan waters of the lake. This sequence makes the history of the deep-trap-net fishery, in a sense, discontinuous as the major "scene of action" shifted from year to year.

FLUCTUATIONS IN THE PRODUCTION OF WHITEFISH IN LAKE HURON

The production of whitefish in Lake Huron[22] increased phenomenally in 1930 and 1931 (table 3). The catch of 2,879,000 pounds in 1930 was nearly twice the 1929 yield of 1,456,000 pounds, and the 1931 production of 4,140,000 pounds represented an additional increase of 1,260,000 pounds above the 1930 level. The decline from the 1931 yield was relatively insignificant in 1932 (decrease of 89,000 pounds). The reduction in the catch was large, however, in the succeeding years, averaging 719,000 pounds per year for the 3 years, 1933–1935, 446,000 pounds for the 3 years, 1936–1938, and 303,000 pounds in 1939. Despite these large decreases the catch did not return to an approximately normal level until 1936. The subsequent declines carried the production far below normal. The 1938 yield of 558,000 pounds was only a little above the lowest catch recorded for any previous year (555,000 pounds in 1900), and the 1939 production of only 255,000 pounds was less than half the previous all-time low. The 11-year period (1929–1939) saw, therefore, a remarkable cycle in the yield of whitefish in Lake Huron. From a nearly normal level in 1929 the catch increased suddenly to the unprecedented height of more than 4 million pounds in 1931 and 1932 only to decline rapidly to an unprecedented low yield in 1939.

Much of the increase to the 1931–1932 peak and of the high production in 1933–1935 can be traced to the new gear, the deep trap net. The catch by this gear jumped from 87,000 pounds in 1929 to 871,000 pounds in 1930 (a ten-fold increase), 2,080,000 pounds in 1931, and 2,764,000 pounds (the peak production for the gear) in 1932. The catch of deep trap nets did not fall below 2 million pounds in the 4 years, 1931-1934.

[22] In this and the following section the terms, "Lake Huron" and "the entire lake," refer to the State of Michigan waters only.

TABLE 3.—*Production of whitefish in pounds according to gear in the State of Michigan waters of Lake Huron, 1929–1939*

[Percentages of annual yield in parentheses]

Year	Production in gear				Total annual production	Increase or decrease
	Large-mesh gill net	Deep trap net	Pound net	Other		
1929	489,961 (33.6)	87,121 (6.0)	823,696 (56.6)	55,590 (3.8)	1,456,368	—12,433
1930	613,752 (21.3)	871,321 (30.3)	1,302,586 (45.2)	91,781 (3.2)	2,879,440	1,423,072
1931	619,515 (15.0)	2,079,596 (50.2)	910,940 (22.0)	[1]529,721 (12.8)	4,139,772	1,260,332
1932	385,566 (9.5)	2,764,317 (68.2)	569,698 (14.1)	[1]330,753 (8.2)	4,050,334	—89,438
1933	269,271 (8.1)	2,704,576 (81.1)	305,229 (9.2)	54,825 (1.6)	3,333,901	—716,433
1934	189,701 (7.4)	2,061,483 (80.3)	258,207 (10.0)	58,842 (2.3)	2,568,233	—765,668
1935	132,789 (7.0)	1,487,342 (78.5)	172,280 (9.1)	102,396 (5.4)	1,894,807	—673,426
1936	88,951 (6.2)	1,166,707 (80.9)	127,100 (8.8)	59,411 (4.1)	1,442,169	—452,638
1937	49,937 (4.9)	834,164 (81.9)	107,221 (10.5)	27,359 (2.7)	1,018,681	—423,488
1938	55,677 (10.0)	423,073 (75.8)	58,813 (10.5)	20,406 (3.7)	557,969	—460,712
1939	41,072 (16.1)	178,517 (70.0)	28,911 (11.3)	6,683 (2.6)	255,183	—302,786
Average	266,927 (12.4)	1,332,565 (62.1)	424,062 (19.8)	121,615 (5.7)	2,145,169	

[1] A considerable portion of this catch, entered in the original records under the heading, "Gear unknown," was taken by deep trap nets.

It cannot be concluded that all of the production of deep trap nets represented additional demands on the whitefish stock of Lake Huron or that an increase in yield would not have taken place after 1929 without the operation of this gear. Substantial increases occurred in the production of whitefish by both gill nets and pound nets in 1930, and the 1931 catch in these gears was above the 1929 level. Unquestionably the output of gill nets and pound nets would have been even higher in 1930 and 1931 and the subsequent decline in production in those two gears would have been less rapid had not considerable numbers of fishermen abandoned the use of gill nets and pound nets in favor of the much more efficient deep trap net. On the other hand, the fact that deep trap nets produced more whitefish in every year of the 5-year period, 1931–1935, than did all gears combined in 1929, and did so, as will be shown later (p. 330) in the face of a rapid decline in abundance after 1931, suggests that this gear possesses capabilities for the capture of whitefish far greater than can be attributed to either gill nets or pound nets. (Superiority of deep trap nets over pound nets is due largely to the greater range of fishing depths of the former. See pp. 331 and 332.) Although the deep trap net cannot be held to be solely responsible for the increase in production that took place after 1929, the conclusion is justified, nevertheless, that the increase would have been much smaller had this gear not been fished.

The superiority of the deep trap net for the capture of whitefish is indicated strongly by the speed with which it replaced other gears. In 1929 deep trap nets accounted for only 6.0 percent of the total yield of whitefish in Lake Huron. Two years later in 1931 they took more than half the total and by 1933 were responsible for more than 80 percent of the catch. Deep-trap-net production as a percentage of the total yield fluctuated about the 80-percent level for 5 years (1933–1937) and declined only with the virtual collapse of the fishery in 1938 and 1939.

The deep trap net became at some time the dominant gear for the capture of

whitefish in every statistical district of Lake Huron (table 4 and appendix B). With the increase in the use of deep trap nets the operations with pound nets and gill nets declined in most districts to the point of insignificance. Only in H–1 did the deep trap net fail to become established as the overwhelmingly dominant gear. The percentage of the total production of whitefish taken by deep trap nets was not greater than 38 percent in that district before 1935, and exceeded 50 percent in only 3 years (1936, 1937, and 1939). In other districts the deep trap net accounted for more than 50 percent of the total catch of whitefish in the first or second year of operation (possible exception in H–4 where considerable quantities of whitefish taken by deep trap nets in 1931 are included in the catches for which the records of gear were not available) and maintained a dominant position with great consistency throughout the later years. This statement is true especially for southern Lake Huron (H–5 and H–6 combined) where the deep trap net was responsible for more than 90 percent of the total yield in every year after 1932 and for more than 95 percent in every year after 1935.

TABLE 4.—*Production of whitefish in pounds in deep trap nets in Lake Huron, 1929–1939*

[In parentheses, the deep-trap-net production expressed as a percentage of the total whitefish production]

District or area	Production of whitefish in deep trap nets in year											Total
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	
H-1		286,453 (37.9)	375,122 (38.0)	170,313 (27.3)	64,251 (17.6)	104,699 (27.7)	163,465 (43.8)	346,821 (64.1)	236,196 (73.2)	73,184 (40.6)	73,406 (52.0)	1,893,910 (37.2)
H-2	87,121 (31.7)	358,872 (60.4)	376,887 (78.7)	94,527 (80.5)	28,540 (50.3)	44,153 (47.4)	94,584 (80.0)	46,602 (83.8)	14,009 (67.3)	34,315 (83.0)	41,980 (99.3)	1,221,590 (64.5)
Northern Lake Huron (H-1 and H-2)	87,121 (13.4)	645,325 (47.8)	752,009 (51.3)	264,840 (35.7)	92,791 (22.0)	148,852 (31.6)	258,049 (52.5)	393,423 (65.9)	250,205 (63.4)	107,499 (48.5)	115,386 (62.9)	3,115,500 (44.6)
H-3		157,248 (63.5)	395,230 (84.0)	85,236 (62.0)	9,912 (70.1)	12,558 (87.2)	7,964 (89.4)	7,567 (94.5)	1,934 (69.1)	8,910 (97.2)	277 (49.7)	686,836 (67.9)
H-4		68,748 (6.6)	[1]932,357 (47.9)	[1]1,934,325 (78.5)	620,125 (81.4)	116,849 (59.9)	138,446 (65.1)	75,438 (58.6)	121,796 (78.5)	38,224 (68.4)	18,785 (72.4)	4,065,093 (53.8)
Central Lake Huron (H-3 and H-4)		225,996 (17.5)	1,327,587 (54.9)	2,019,561 (77.7)	630,037 (81.2)	129,407 (61.8)	146,410 (66.1)	83,005 (60.7)	123,730 (78.4)	47,134 (72.5)	19,062 (71.9)	4,751,929 (55.4)
H-5				479,916 (93.5)	1,658,753 (98.9)	783,606 (99.9)	272,746 (99.8)	119,103 (100.0)	66,688 (99.8)	41,832 (99.8)	12,247 (100.0)	3,434,891 (92.4)
H-6					322,995 (70.3)	999,618 (90.6)	810,137 (89.1)	571,176 (96.9)	393,541 (98.5)	226,608 (98.7)	31,822 (96.1)	3,355,897 (77.7)
Southern Lake Huron (H-5 and H-6)				479,916 (67.7)	1,981,748 (92.8)	1,783,224 (94.5)	1,082,883 (91.6)	690,279 (97.4)	460,229 (98.7)	268,440 (98.9)	44,069 (97.2)	6,790,788 (84.5)
Lake Huron (all 6 districts)	87,121 (6.0)	871,321 (30.3)	2,079,596 (50.2)	2,764,317 (68.2)	2,704,576 (81.1)	2,061,483 (80.3)	1,487,342 (78.5)	1,166,707 (80.9)	834,164 (81.9)	423,073 (75.8)	178,517 (70.0)	14,658,217 (62.1)

[1] Pounds and the corresponding percentage are too low; the total production in H–4 in 1931 and 1932 included considerable quantities of whitefish for which records of the gear of capture were lacking, but a large part of which came from deep trap nets. Other totals and percentages in the computation of which these figures were involved were affected relatively less severely.

A peculiar feature of the production of whitefish in Lake Huron, 1930-1935, lay in the circumstance that a high level of yield was maintained by a successive rather than a simultaneous exploitation of the stocks in the various portions of the lake (table 5 and appendix B). In each area the catch of whitefish followed a typical cycle after the introduction of the deep trap net. Production was raised to tremendous heights for about 2 years, only to fall away sharply. Since the use of the deep trap net spread gradually throughout the lake, first one area and then another bore the burden of heavy fishing.

Although the deep trap net was fished in H–2 in 1929 (in 1928 also), it did not produce large quantities of fish until 1930. In this same year the net was employed extensively in H–1 and H–3 also and was introduced into H–4. In 1931 high yields were obtained in each of these first four districts. Thus it was possible for the production of whitefish in Lake Huron to increase phenomenally in 1930 and attain an

TABLE 5.—*Total annual production of whitefish in pounds in the different districts and areas of the State of Michigan waters of Lake Huron, 1929–1939*

[Each total is expressed also as the percentage (in parentheses) of the production of the entire lake]

District or area	Total whitefish production in year											Average
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	
H-1	375,577 (25.8)	[1][2]755,362 (26.2)	[2]987,466 (23.8)	623,670 (15.4)	364,683 (11.0)	378,105 (14.7)	372,874 (19.7)	541,392 (37.5)	373,755 (36.7)	180,127 (32.3)	141,051 (55.3)	463,187 (21.6)
H-2	[1]274,640 (18.9)	[2]594,526 (20.7)	[2]478,969 (11.6)	117,432 (2.9)	56,745 (1.7)	93,116 (3.6)	118,287 (6.2)	55,606 (3.9)	20,813 (2.0)	41,363 (7.4)	42,285 (16.5)	172,162 (8.0)
Northern Lake Huron (H-1 and H-2)	650,217 (44.7)	1,349,888 (46.9)	1,466,435 (35.4)	741,102 (18.3)	422,428 (12.7)	471,221 (18.3)	491,161 (25.9)	596,998 (41.4)	394,568 (38.7)	221,490 (39.7)	183,336 (71.8)	635,349 (29.6)
H-3	98,818 (6.8)	[1][2]247,572 (8.6)	[2]470,423 (11.4)	137,463 (3.4)	14,130 (0.4)	14,399 (0.6)	8,907 (0.5)	8,006 (0.6)	2,798 (0.3)	9,163 (1.7)	557 (0.2)	92,021 (4.3)
H-4	571,605 (39.2)	[1]1,043,395 (36.2)	[2]1,948,085 (47.0)	[2]2,462,958 (60.8)	761,562 (22.8)	194,945 (7.6)	212,513 (11.2)	128,717 (8.9)	155,091 (15.2)	55,885 (10.0)	25,945 (10.2)	687,337 (32.0)
Central Lake Huron (H-3 and H-4)	670,423 (46.0)	1,290,967 (44.8)	2,418,508 (58.4)	2,600,421 (64.2)	775,692 (23.2)	209,344 (8.2)	221,420 (11.7)	136,723 (9.5)	157,889 (15.5)	65,048 (11.7)	26,502 (10.4)	779,358 (36.3)
H-5	62,987 (4.3)	91,493 (3.2)	74,038 (1.8)	[1]513,403 (12.7)	[2]1,676,432 (50.3)	784,215 (30.5)	273,421 (14.4)	119,140 (8.3)	66,825 (6.6)	41,915 (7.5)	12,247 (4.8)	337,830 (15.8)
H-6	72,741 (5.0)	147,092 (5.1)	180,791 (4.4)	195,402 (4.8)	[1]459,349 (13.8)	[2]1,103,453 (43.0)	[2]908,805 (48.0)	589,308 (40.8)	399,399 (39.2)	229,516 (41.1)	33,098 (13.0)	392,632 (18.3)
Southern Lake Huron (H-5 and H-6)	135,728 (9.3)	238,585 (8.3)	254,829 (6.2)	708,811 (17.5)	2,135,781 (64.1)	1,887,668 (73.5)	1,182,226 (62.4)	708,448 (49.1)	466,224 (45.8)	271,431 (48.6)	45,345 (17.8)	730,462 (34.1)
Lake Huron (all 6 districts)	1,456,368	2,879,440	4,139,772	4,050,334	3,333,901	2,568,233	1,894,807	1,442,169	1,018,681	557,969	255,183	2,145,169
Percentage of average	68	134	193	189	155	120	88	67	48	26	12	

[1] Year of introduction nf deep trap net.
[2] Years of heaviest production of whitefish in deep trap nets.

all-time high in 1931 without the benefit of a really significant contribution from the southern region of the lake (H–5 and H–6) where the increase from 1929 to 1931 amounted to only 119,000 pounds.

In 1932 the first three districts, H–1, H–2, and H–3, after 2 peak years, suffered a severe decline in production. The combined decrease amounted to more than a million pounds. This reduction was compensated to a large extent by further increases in H–4, the center of the deep-trap-net fishery in 1932, and by the phenomenal rise in output in H–5, into which district deep trap nets were introduced for the first time. As a result, the total catch for the lake fell only slightly from the 1931 maximum.

After 2 years of extremely high production the catch of whitefish in H–4 decreased 1,701,000 pounds in 1933. The yield in the first four districts combined dropped from 3,342,000 pounds in 1932 to 1,198,000 pounds in 1933, a decrease of 2,144,000 pounds. It was hardly to be expected that this large decline in the first four districts could be compensated fully by a rise in production in southern Lake Huron, a region that produced only 136,000 pounds of whitefish in 1929. The increase in catch in southern Lake Huron was nevertheless enormous—1,163,000 pounds in H–5, 264,000 pounds in H–6, and 1,427,000 pounds in the two districts combined. In H–5 the 1933 production was 26.6 times the yield in 1929; for H–5 and H–6 combined the 1933 catch was 15.7 times that of 1929. The production in the entire lake, however, decreased in 1933 by 716,000 pounds.

The output of whitefish increased markedly in H–6 in 1934 (increase of 644,000 pounds), but the larger decrease of 892,000 pounds in H–5 led to a drop of 248,000 pounds in southern Lake Huron. Increases ranging from an insignificant recovery in H–3 to a sharp rise in H–2 occurred in the first three districts. In H–4, however, the catch dropped 567,000 pounds (from 762,000 pounds in 1933 to 195,000 pounds in 1934). The decrease for all six districts was 766,000 pounds.

The increases in the catch of whitefish in H–2 and H–4 in 1935 exceeded the decreases in H–1 and H–3; consequently, the totals increased slightly in both northern and central Lake Huron. However, the large decreases in H–5 and H–6 (705,000 pounds for the two districts) caused the yield of the entire lake to decline 673,000 pounds.

With the onset of the decline in production in H–6 in 1935 the cycle of exploitation of the stocks of Lake Huron whitefish by means of the deep trap net was approaching its final stages. As the fishery failed in other areas deep-trap-net fishermen had moved on to new grounds. H–6, however, had provided the last unexploited fishing area available. The lack of new grounds may account for the fact that large numbers of deep-trap-net fishermen remained longer in H–6 than they had in any other district. H–6, despite a continued decline in the catch, maintained first rank among the districts in the production of whitefish during the 5-year period, 1934–1938, relinquishing this position only with the almost complete collapse of the fishery in 1939.

It is true that in some districts the general decline during the later years of the fishery was interrupted by temporary increases as fishermen returned to glean a scant harvest from their former grounds. The most noteworthy recovery occurred in H–1, where in 1936 the production of whitefish rose above a half million pounds. However, the deep-trap-net operations in H–1 in 1936 were not centered in the southeastern part of the district (especially in Hammond Bay) as in earlier years but were carried on chiefly in the northwestern end (Cheboygan-St. Ignace) in an area that formerly had been exploited only moderately. These temporary increases in certain districts were insufficient by far to halt the general downward trend of the catch in the lake as a whole.

An outstanding feature of the statistical data discussed in the preceding pages was the shift from year to year in the center of production of whitefish. The output fluctuated over a wide range in all districts. Especially striking, however, were the increases in southern Lake Huron which accounted for only 9.3 percent of the 1929 production but yielded more than 60 percent of the total for the lake in 1933, 1934, and 1935 (73.5 percent in 1934).

These violent fluctuations in production and shifts in the center of operations suggest distinctly abnormal conditions in the fishery. The belief that conditions were abnormal in the years following 1929 finds support in the data on the catch of whitefish in the various districts in the earlier period of the fishery, 1891–1908 (table 6). Although a certain amount of shifting did occur in the relative importance of the several districts for the production of whitefish, these changes were insignificant in comparison with the tremendous fluctuations that took place during the recent years, 1930–1939 (table 5). In the earlier period, for example, H–1 and H–4 held first or second rank in every year except 1891 when the second highest yield was made in H–2 (H–1 in first position and H–4 in the third). Third and fourth rankings usually were held by H–2 and H–3 (characteristically in that order) while H–6 commonly ranked fifth and H–5 was normally sixth (only one exception). The limited extent of the fluctuations in the rankings of the districts with respect to the production of whitefish in 1891–1908 is brought out by the following tabulation (left half) which shows the number of years each position was held by each district. The right half of the tabulation brings out the sharp contrast in yield with that for the period of the deep-trap-net fishery, 1930–1939:

District	Rank (1891–1908)						District	Rank (1930–1939)					
	1	2	3	4	5	6		1	2	3	4	5	6
H-1	12	6	--	--	--	--	H-1	1	7	1	1	--	--
H-2	--	1	12	3	2	--	H-2	--	1	2	--	6	1
H-3	--	--	4	12	2	--	H-3	--	--	--	2	1	7
H-4	6	11	1	--	--	--	H-4	3	1	3	3	--	--
H-5	--	--	--	--	1	17	H-5	1	1	2	3	1	2
H-6	--	--	1	3	13	1	H-6	5	--	2	1	2	--

The range of rank was the greater in the more recent period in each district except H–3, a region in which the whitefish fishery was unimportant after 1932. The greatest increase in range occurred in H–5 which held every position from first to sixth although this area had ranked sixth 17 times (fifth in the remaining year) in the period, 1891–1908, and had not yielded more than 7,500 pounds in any one of the 18 years.

It should be noted further that with only one exception (the rank of 5) each of the rankings from 1 to 6 occurred in more districts in 1930–1939 than in 1891–1908. For example, first position was held in four districts (all but H–2 and H–3) in the more recent period as compared with only two (H–1 and H–4) in the earlier years, second rank was held by four districts in 1930–1939 as compared with three in 1891–1908,***.

The actual figures of catch of tables 5 and 6 support the observations based on the rankings, for the yields of the individual districts were in general far less variable in the early than in the recent period.

TABLE 6.—*Production of whitefish in pounds in Lake Huron according to statistical districts, 1891–1908*

Year	Statistical district						Total
	H-1	H-2	H-3	H-4	H-5	H-6	
1891	1,304,220	133,000	58,500	91,540	6,000	31,600	1,624,860
1892	1,150,933	94,000	29,200	160,450	3,500	48,100	1,486,183
1893	1,204,400	12,000	131,500	199,900	2,000	27,800	1,577,600
1894	939,250	91,600	61,500	116,550	1,000	8,350	1,218,250
1895	614,830	75,550	39,500	203,687	1,500	10,800	945,867
1896	440,600	118,616	167,300	264,119	500	14,600	1,005,735
1897	392,100	141,555	38,300	285,200	4,000	4,805	865,960
1898	239,800	59,500	38,500	249,050	1,500	4,400	592,750
1899	201,600	96,000	36,100	306,560	1,800	3,520	645,580
1900	152,400	104,000	99,500	191,520	4,500	3,500	555,420
1901	219,025	137,000	154,300	263,720	5,000	9,200	788,245
1902	307,000	137,500	122,000	331,930	600	14,500	913,530
1903	312,700	106,100	70,700	436,360	400	11,200	937,460
1904	328,000	54,000	85,000	303,860	1,000	15,500	787,360
1905	381,200	30,300	29,800	208,260	3,500	21,800	674,860
1906	492,300	38,500	25,600	198,220	5,000	32,100	791,720
1907	658,500	45,000	64,600	282,772	3,300	78,800	1,132,972
1908	578,915	48,963	41,666	270,832	7,500	26,029	973,905
Average	550,987	84,621	71,865	242,474	2,922	20,367	973,236
Percentage	56.6	8.7	7.4	24.9	0.3	2.1	

The records of yield for the years, 1891–1908, indicate also that the percentages of the total catch of whitefish in the different districts were approximately normal in 1929, the only recent year (with data for each district separately) in which the statistics were not seriously distorted by the deep-trap-net fishery. It is true, the percentage distribution of the catch of whitefish in Lake Huron in 1929 (table 5) differed somewhat from that for the average for 1891–1908. It will be noticed, for example, that in 1929 the greatest production (39.2 percent) was from H–4 with H–1 in second position (25.8 percent) whereas in 1891–1908 the greatest average yield came from H–1 (56.6 percent) with H–4 in second position (24.9 percent). Among the remaining districts the percentages were higher in 1929 in H–2 (in part because of the catch in deep trap nets), H–5, and H–6, and possibly lower in H–3,[23] but the rankings of the districts were the same.

The differences in the values of these percentages are not large enough, however, to warrant the conclusion that the relative capacities of the various districts for the production of whitefish in 1929 were changed greatly from those of 1891–1908. Although the high percentage of the total yield of whitefish in H–4 in 1929 is in disagreement

[23] The division of the statistics for the earlier years was based on the location of the home port and not necessarily on the grounds actually fished. It is known that, in more recent years at least, some fishermen from Au Sable-Oscoda (H-3) have operated with gill nets in H-4 on the "Middle Grounds" off Saginaw Bay. In 1929 and 1930 these fishermen accounted for about 14 percent of the total whitefish catch of H-4. If this same percentage held for the earlier years the average production in H-3 and H-4 should have been 32,392 pounds and 281,947 pounds, respectively, instead of 71,865 pounds and 242,474 pounds as recorded in table 6; the percentages should have been 3.3 and 29.0 instead of 7.4 and 24.9. There is no reason to believe that the data for other districts were affected significantly by the division of the catch according to port.

with average conditions in 1891–1908, evidence that the 1929 percentage for the district did not represent an abnormal condition may be seen in the fact that the catch in H–4 exceeded that in H–1 in 6 successive years (1898–1903) of the 18 in the early period. The percentage of the Lake Huron catch produced in H–4 in 1929 apparently was somewhat above the average for the modern as well as the early period, as in the 9 years, 1920–1928, the percentage of whitefish taken in Saginaw Bay (in H–4) did not exceed 31.3 percent and averaged only 23.5 percent. (This statement is based on statistics published for Saginaw Bay and Huron proper by the Michigan Department of Conservation.)

The evidence that the percentages of the 1929 yield of whitefish taken in the several districts were within the normal range of variation lends further support to the belief that the deep-trap-net fishery brought about abnormal conditions in 1930–1939.

CHANGES IN PRODUCTION IN LAKE HURON AS RELATED TO FLUCTUATIONS IN THE ABUNDANCE OF WHITEFISH AND IN THE INTENSITY OF THE FISHERY

Up to this point the discussion has been concerned only with the fluctuations in the catch of whitefish, because it was believed that this, the more obvious phase of the fishery, should be outlined clearly before the changes in production were analyzed in relation to concurrent fluctuations in the abundance of whitefish and the intensity of the whitefish fishery. The fundamental problem in the analysis of the statistical data relative to the whitefish fishery of Lake Huron is the determination of the probable effects of deep-trap-net operations on the abundance of marketable whitefish. As pointed out previously (p. 315) this problem is complicated greatly by the circumstance that whitefish are known to have been abnormally abundant during the years in which the deep-trap-net fishery was undergoing its most rapid expansion. The abundance of whitefish in Lake Huron was possibly above normal in 1929; certainly it was well above normal in 1930 and 1931 (table 10). A decline from this abnormally high abundance would have occurred even if deep trap nets had not been operated in the lake. It is only logical to believe also that the high abundance following 1929 would have stimulated fishing intensity even had deep trap nets not been fished. The general problem resolves itself, therefore, into the estimation of the degree to which the increased fishing intensity and the heightened production made possible by the use of deep trap nets affected the rate of the decline in abundance and its ultimate extent.

That the deep trap net accounted for the bulk of the extremely high yields of whitefish over the period, 1930–1935, was brought out in the preceding section. It will now be demonstrated that the high production resulted from an unreasonably great fishing intensity and that this overfishing in turn accelerated the decline in the abundance of whitefish. In the four southernmost districts in which the deep trap net was fished most extensively the whitefish fishery reached a state of collapse. Abundance and catch were reduced in the other two districts in which the deep-trap-net operations were less extensive but the decline was far less pronounced than in the four districts.

A comparison of the extent of the changes in production, abundance, and fishing intensity in the several districts may be found in table 7. In this one table the year 1929 rather than the 11-year period (1929–1939) has been taken as the point of reference. To be sure, there is no certainty that 1929 was a "normal" year. However, the catch in 1929 was at approximately the typical level for 1922–1929, and there is no evidence of any unusual conditions in the fishery in that year. Certainly, 1929 is the most nearly normal year for which detailed statistical data are available.

The data of table 7 do not provide a complete history of the deep-trap-net fishery. They do serve, however, to show the variation among the districts in the maxima of yields and fishing intensity that followed the introduction of the deep trap net, and the apparent relationship between these maxima and conditions in 1939. The increases in catch were by no means as great in H–1 and H–2 as in the remaining districts. In

these two northern districts the maximum productions were 263 and 317 percent, respectively, of the 1929 yield. In central Lake Huron the maxima were 476 percent in H–3 and 431 percent in H–4. It was in southern Lake Huron, however, that the greatest relative increases in production occurred. The maximum yield was more than 26 times the 1929 catch in H–5 and more than 15 times the 1929 production in H–6.

The differences in the relative maximum yields attained in the several districts are to be attributed primarily to differences in the relative increases in fishing intensity. The maximum intensity in H–1 and H–2 was a little more than twice that of 1929. It was roughly 5 times the 1929 level of intensity in H–3 and 4 times in H–4. In H–5 and H–6, however, the maximum fishing intensities were, respectively, 42 and 27 times the 1929 intensity.

The relative maximum abundance attained in the various districts exhibited remarkable agreement. In four of the six districts (H–1, H–4, H–5, and H–6) the maximum abundance was between 140 and 150 percent of the abundance in 1929, and in a fifth (H–2) the maximum was a little less than 140 percent (136 percent) of the 1929 level. In H–3 the greatest estimated abundance occurred in 1929 in which year the pound nets were particularly successful (table 11). The abundance in H–3 fell in 1930 but increased in 1931; peculiarly enough the abundance in 1931 was 143 percent of that in 1930 (*cf.* increases in other districts over 1929 abundance).

Production and abundance in 1939 were below the 1929 level in every district, and the fishing intensity was less than that of 1929 in all but the two southernmost districts. Of especial significance is the fact that the abundance in 1939 was relatively much higher in H–1 and H–2, the two districts in which production and intensity had reached the relatively lowest maxima. In the remainder of the lake the whitefish had almost disappeared. So great was the depletion that in H–5 and H–6

TABLE 7.—*Maximum and 1939 production and abundance of whitefish and maximum and 1939 fishing intensity for whitefish expressed as percentages of the 1929 values in each statistical district of Lake Huron*

District	Year of maximum production	Production		Year of maximum intensity	Intensity		Year of maximum abundance	Abundance	
		Maximum	1939		Maximum	1939		Maximum	1939
H-1	1931	263	38	1931	233	89	1930	140	41
H-2[1]	1930	317	23	1930	228	50	1930	136	43
H-3	1931	476	1	1931	528	5	1929	100	6
H-4	1932	431	5	1932	377	60	1931	149	7
H-5	1933	2,662	19	1933	4,211	433	1931	142	5
H-6	1934	1,517	46	1935	2,678	489	1932	148	10

[1] The deep-trap-net fishery of 1929 was excluded in the computations of these percentages of production and fishing intensity for H-2.

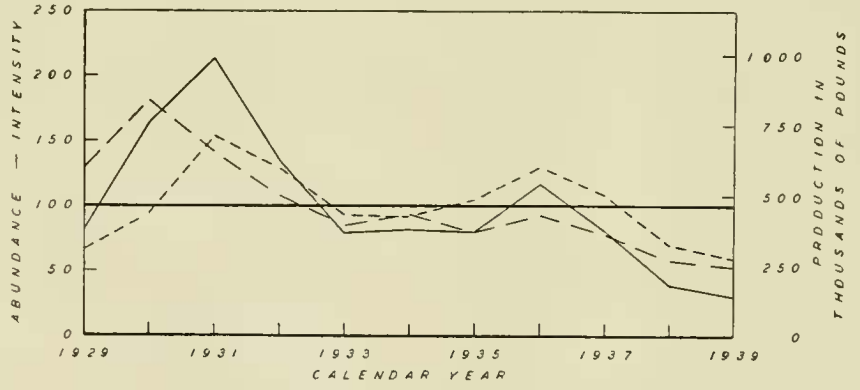


FIGURE 5.—First district, H-1.

Figures 5 to 10 show the annual fluctuations in the production (solid lines) and abundance (long dashes) of whitefish and in the intensity of the whitefish fishery (short dashes) over the period, 1929–1939, in each of the six statistical districts of Lake Huron (see fig. 4). In each figure the central horizontal line represents the average conditions for the 11 years, 1929–1939.

fishing intensities between 4 and 5 times those of 1929 yielded productions amounting to only 19 and 46 percent, respectively, of the 1929 catch. For practical purposes it can be said that there was no whitefish fishery in H–3 in 1939, and that the fishery in H–4 was insignificant.

The data of table 7 have brought out the fact that a disastrous depletion of the

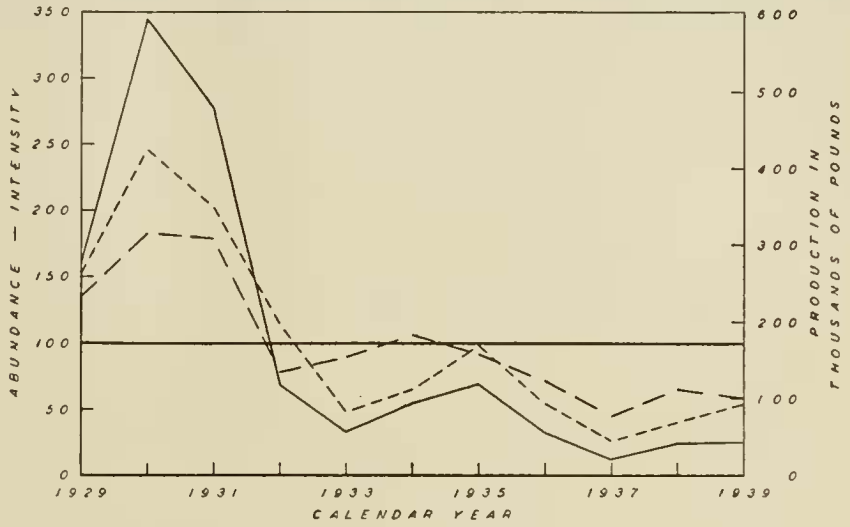


FIGURE 6.—Second district, H-2.

FIGURE 7.—Third district, H-3.

whitefish occurred in the four districts in which the use of the deep trap net led to an excessive multiplication of fishing intensity and catch. The decline in the abundance of whitefish was much less severe in the two districts in which the exploitation of the stock was more moderate. Further evidence on the harmful effects of deep-trap-net operations will be brought out by a more detailed consideration of the annual changes in production, fishing intensity, and abundance in the various districts with reference to the 1929–1939 averages.

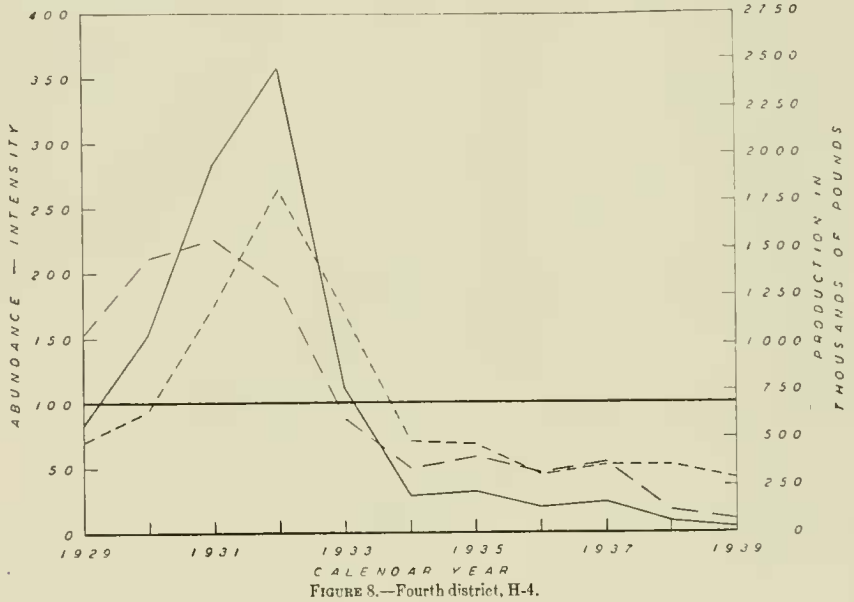


FIGURE 8.—Fourth district, H-4.

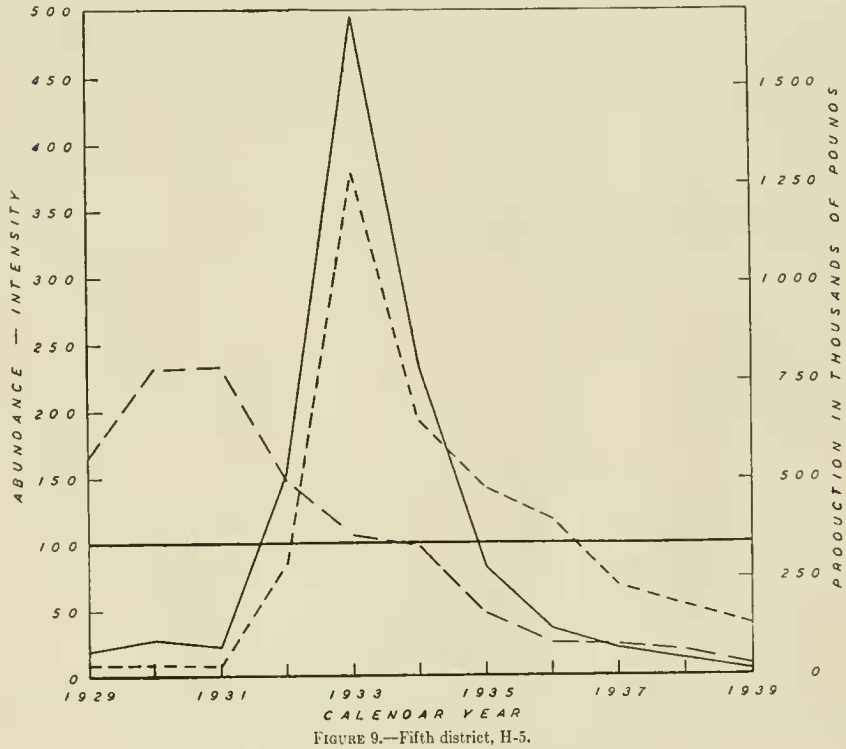


FIGURE 9.—Fifth district, H-5.

In the previous section attention was called to the existence of a typical deep-trap-net cycle of production (p. 319) in which the catch "was raised to tremendous heights for about 2 years, only to fall away sharply." It is equally valid to speak of "typical deep-trap-net cycles" of fishing intensity and in the abundance of whitefish. (For graphical representations of the annual fluctuations in the catch and abundance of whitefish and in the intensity of the whitefish fishery in the several districts, see figs. 5 to 10.) The tremendous increases in yields were accompanied by

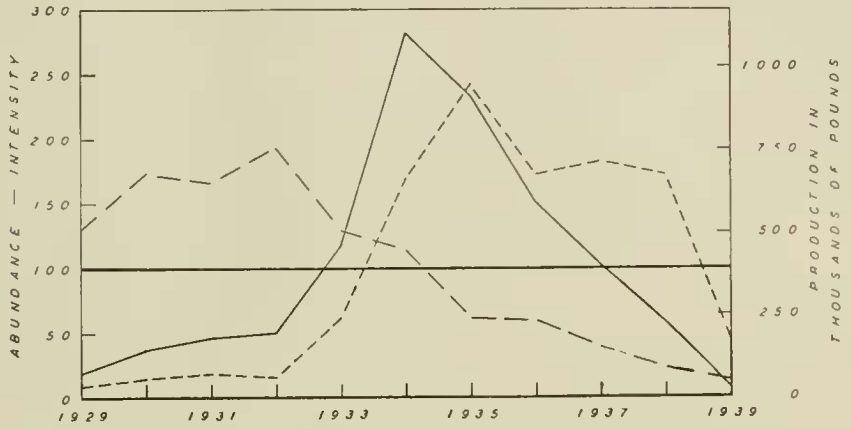


FIGURE 10.—Sixth district, H-6.

great increases in fishing intensity (table 8). To a large extent these increases in intensity represented deep-trap-net operations (table 9). In about 2 years, however, the fishing intensity declined in a district as the fishermen moved on to more productive grounds. An exception to this cycle of intensity is to be found in H–6 where an extremely intensive fishery was carried on for 5 years (1934–1938) despite a rapid decrease in the returns. Operators of deep trap nets remained longer in H–6 because the more northerly grounds had been exploited thoroughly in previous years (p. 321). H–1 and H–2 showed limited secondary increases in fishing intensity (about 1935–1937 in H–1 and 1934–1935 in H–2) as some fishermen returned from the depleted grounds in the south.

Without exception the abundance of whitefish fell sharply after a period (usually 2 years) of intensive deep-trap-net operations. This fact is brought out clearly by the data of table 10 in which the years of greatest production of deep trap nets have been designated. (The comparison of tables 4 and 9 will reveal that the years of greatest yields of deep trap nets and the years of greatest intensity of the deep-trap-net fishery were not always the same.) The nature of the changes in abundance that followed heavy removals of whitefish may be summarized for the districts as follows:

H–1. Abundance began to decline in 1931, the second year of heavy production by deep trap nets. This decline continued through 1933.

TABLE 8.—*Annual fluctuations in the intensity of the fishery for whitefish in each district of Lake Huron*

[Expressed as percentages of the average 1929–1939 intensity in the district]

District	Fishing intensity as percentage of average in year										
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
H-1	66	94	154	129	93	92	105	130	108	70	59
H-2	152	246	203	114	48	65	98	54	26	40	54
H-3	61	250	322	153	39	50	69	67	19	67	3
H-4	70	94	174	264	170	70	68	44	52	52	42
H-5	9	9	8	84	379	192	141	118	68	53	39
H-6	9	15	19	16	62	168	241	172	182	172	44

H–2. Abundance was high in 1930 and 1931, the years of high yields; in 1932 abundance declined to less than half that of 1931.

H–3. Abundance increased in 1931, the second year of heavy production, but was less than half as great in 1932 as in 1931.

H–4. Abundance decreased somewhat in 1932, the second year of high production; the abundance in 1933 was less than half that of 1932.

TABLE 9.—*Annual fluctuations in the intensity of the whitefish fishery for all six districts of Lake Huron combined (third row from bottom of table) and distribution of each year's fishing intensity among the districts*

[The average annual intensity for the entire lake, 1929–1939, is 100.0. In parentheses are the intensity values of the deep-trap-net fishery. The value of one unit is 1/1,100 of the total expected catch (p. 314) of all districts, 1929–1939]

District or area	Fishing intensity in year											Total	Percentage of intensity represented by deep trap nets
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939		
H-1	13.8	19.9 (7.5)	32.4 (13.0)	27.0 (8.1)	19.6 (4.5)	19.3 (4.2)	22.0 (7.3)	27.3 (16.0)	22.7 (13.5)	14.7 (7.4)	12.6 (6.2)	231.3 (87.7)	37.9
H-2	9.7 (2.8)	15.5 (9.5)	12.8 (10.1)	7.2 (5.7)	3.1 (1.5)	4.1 (2.2)	6.2 (4.7)	3.4 (3.1)	1.7 (1.3)	2.5 (2.4)	3.4 (3.4)	69.6 (46.7)	67.1
Northern Lake Huron (H-1 and H-2)	23.5 (2.8)	35.4 (17.0)	45.2 (23.1)	34.2 (13.8)	22.7 (6.0)	23.4 (6.4)	28.2 (12.0)	30.7 (19.1)	24.4 (14.8)	17.2 (9.8)	16.0 (9.6)	300.9 (134.4)	44.7
H-3	1.6	6.3 (4.6)	8.2 (7.0)	3.9 (3.5)	1.0 (0.7)	1.2 (1.0)	1.7 (1.6)	1.7 (1.6)	0.5 (0.4)	1.7 (1.6)	0.1 (0.1)	27.9 (22.1)	79.2
H-4	16.4	21.8 (4.5)	40.2 [1](16.6)	61.2 [1](47.4)	39.4 (30.8)	16.2 (11.2)	15.6 (10.7)	10.1 (7.2)	12.0 (9.2)	12.1 (10.7)	9.7 (8.6)	254.7 (156.9)	61.6
Central Lake Huron (H-3 and H-4)	18.0	28.1 (9.1)	48.4 (23.6)	65.1 (50.9)	40.4 (31.5)	17.4 (12.2)	17.3 (12.3)	11.8 (8.8)	12.5 (9.6)	13.8 (12.3)	9.8 (8.7)	282.6 (179.0)	63.3
H-5	1.8	1.9	1.5	16.6 (15.7)	75.3 (74.5)	38.2 (38.1)	27.9 (27.7)	23.4 (23.4)	13.6 (13.5)	10.6 (10.5)	7.7 (7.7)	218.5 (211.1)	96.6
H-6	2.5	4.0	5.1	4.4	16.9 (12.6)	45.4 (42.2)	65.3 (62.9)	46.5 (45.5)	49.2 (48.5)	46.6 (46.4)	12.1 (12.0)	298.0 (270.1)	90.6
Southern Lake Huron (H-5 and H-6)	4.3	5.9	6.6	21.0 (15.7)	92.2 (87.1)	83.6 (80.3)	93.2 (90.6)	69.9 (68.9)	62.8 (62.0)	57.2 (56.9)	19.8 (19.7)	516.5 (481.2)	93.2
Lake Huron (all 6 districts)	45.8 (2.8)	69.4 (26.1)	100.2 (46.7)	120.3 (80.4)	155.3 (124.6)	124.4 (98.9)	138.7 (114.9)	112.4 (96.8)	99.7 (86.4)	88.2 (79.0)	45.6 (38.0)	1,100.0 (794.6)	72.2
Percentage of intensity represented by deep trap nets	6.2	37.6	46.6	66.8	80.2	79.5	82.8	86.1	86.7	89.6	83.3	72.2	

[1] Value too low; the estimate of the total intensity for H-4 in 1931 and 1932 included consideration of large catches for which gear records were lacking, but a large part of which was taken by deep trap nets. Other totals and percentages in the computation of which these figures were involved were affected, but relatively less severely than those indicated by the footnote.

H–5. Abundance decreased considerably in 1933, the first of the two years of heaviest production, and declined slightly in 1934, the second of these years. In 1935 after the two years of heaviest production the abundance fell to less than half the 1934 level.[24]

H–6. Abundance declined somewhat in 1934, the first year of heaviest production, and fell sharply in 1935, the second year. (See footnote 24.) The decline was small in 1936 but a rapid rate of decrease was resumed in 1937.

Comment was omitted deliberately on the recorded decreases in abundance from 1931 to 1932 in H–5 and from 1932 to 1933 in H–6. Because of the difficulty of bridging the gap between a fishery dominated by gill nets and pound nets to one dominated by deep trap nets (p. 316) there is some question as to the accuracy of the comparison between the two years involved in each district. However, comparisons are valid within each of the periods, 1929–1931 and 1932–1939 in H–5, and 1929–1932 and 1933–1939 in H–6. Consequently the observations on the change in abundance that followed the extensive use of deep trap nets in these two districts also are valid. Furthermore,

[24] Part of the decline from 1933 to 1934 and 1934 to 1935 may be attributed to the fact that effective August 1, 1934, deep trap nets were restricted in Lake Huron to water with depths of 80 feet or less.

TABLE 10.—*Annual fluctuations in the abundance percentages for whitefish in the various districts and areas of Lake Huron, 1929–1939*

[Expressed as percentages of average 1929-1939 abundance. In the computation of percentages for areas of more than one district and for the entire lake, the abundance percentage for each district was weighted according to the percentage of the total 1929 production contributed by that district]

District or area	Abundance percentage in year										
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
H-1	129	[1][2]181	[2]141	108	85	94	80	93	78	58	53
H-2	[1]135	[2]183	[2]179	78	89	106	91	71	45	65	58
Northern Lake Huron (H-1 and H-2)	131	182	157	95	87	99	85	84	64	61	55
H-3	301	[1][2]183	[2]261	115	67	55	25	22	26	26	19
H-4	152	[1]211	[2]226	[2]189	88	49	58	46	54	17	10
Central Lake Huron (H-3 and H-4)	174	207	231	178	85	50	53	43	50	18	11
H-5	164	231	233	[1]147	[2]106	98	47	24	23	19	8
H-6	130	173	166	193	[1]129	[2]114	[2]61	59	39	23	13
Southern Lake Huron (H-5 and H-6)	146	200	197	172	117	107	54	43	32	21	11
Lake Huron (all 6 districts)	152	195	195	140	89	77	67	61	55	38	31

[1] Year of introduction of the deep trap net.
[2] Years of greatest production by deep trap nets.

TABLE 11.—*Annual fluctuation in the catch of whitefish per unit of fishing effort of gill nets, deep trap nets, and pound nets in the various districts of Lake Huron, 1929–1939*

District	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	Average
	Pounds of whitefish per 10,000-foot-lift of gill nets											
H-1	109 4	115 9	99 4	65 3	67 8	70 2	56 8	57 8	56 7	91 1	44 1	75 9
H-2	29 4	61 8	48 8	10 8	16 6	21 8	15 0	15 3	6 1	.....	2 0	22 8
H-3	62 5	60 6	48 7	24 7	16 7	11 5	8 4	6 1	9 0	3 8	4 6	33 3
H-4	72 1	81 5	69 3	63 7	13 7	40 5	4 1	.....	5 6	4 2	6 4	36 1
H-5	131 2	187 5	186 0	137 4	87 3	14 1	6 4	.....	8 7	3 4	.....	84 7
H-6	88 8	115 8	107 9	134 4	106 6	83 0	33 6	18 5	24 0	14 2	.....	72 7
	Pounds of whitefish per lift of one deep trap net											
H-1	.....	167 7	125 6	91 7	61 8	108 5	97 3	94 5	76 2	43 3	51 3	91 8
H-2	115 2	141 9	139 1	62 2	73 0	76 3	75 8	56 6	40 4	52 8	45 7	79 9
H-3	.....	282 4	476 1	206 1	115 3	99 1	41 5	39 2	41 7	45 9	.....	149 7
H-4	.....	127 3	470 4	340 7	168 3	87 5	108 2	87 1	110 8	30 0	18 2	154 9
H-5	.....	.....	.....	404 3	295 9	272 9	130 8	67 5	65 2	52 8	21 3	163 8
H-6	.....	.....	.....	.....	402 5	372 3	202 2	197 2	127 3	76 8	41 9	202 9
	Pounds of whitefish per lift of one pound net											
H-1	65 2	120 5	93 7	78 4	54 6	50 7	35 8	47 1	42 8	29 2	24 2	58 4
H-2	70 2	94 6	97 1	43 1	49 1	65 8	39 6	34 1	.....	5 2	.....	55 4
H-3	98 3	68 5	53 1	12 2	.....	.....	4 5	.....	.....	3 2	.....	47 3
H-4	33 1	57 5	40 0	35 1	13 8	9 8	11 3	8 1	5 0	4 5	2 5	20 1
H-5	46 1	60 2	78 5	100 3	26 2	12 3	101 2	3 1	.....	.....	.....	53 5
H-6	30 0	42 0	51 7	38 8	25 1	18 7	9 9	11.7	5 3	12 3	6 6	22 9

these same decreases are apparent in the records of the actual catch per lift of deep trap nets in these same districts (table 11).

The history of the annual fluctuations in the abundance of whitefish in the years subsequent to the decline that followed immediately upon the extensive use of the deep trap net varied widely among the districts.

In H–1, where the use of deep trap nets may be described as "moderate," the abundance percentage for whitefish dropped to 85 in 1933, fluctuated irregularly in 1933–1937, and declined to a level of less than 60 percent in 1938 and 1939. Abundance did not fall significantly below 80 before 1938. In H–2, the other district in which the maxima of production and fishing intensity were relatively low, the sudden decline to

78 percent in 1932 was followed by recoveries in 1933 and 1934 (89 and 106 percent, respectively) and relatively high abundance in 1935 (91 percent). The decreases in 1935–1937 that led to the minimum of 45 in 1937 were followed by a recovery in 1938 and a slight decline in 1939. In both H–1 and H–2 the secondary declines in abundance were preceded by secondary increases in fishing intensity—increases traceable to revivals of deep-trap-net operations.

The remaining districts experienced greater ultimate declines than did H–1 and H–2. Furthermore, these districts failed to show recoveries comparable to those that occurred in H–1 and H–2. In H–3 the decline in abundance continued through 1935; abundance remained rather stable at about 25 in the years, 1935–1938, and declined to 19 in 1939. The abundance in H–4 declined through 1934, was at approximately 50 percent in 1934–1937, and dropped to an extremely low level in 1938 and 1939. In both H–5 and H–6 the decline in abundance that followed the introduction of the deep trap net proceeded without interruption (albeit at an irregular rate) through 1939. In that year whitefish were extremely scarce in both districts.

The data that have been discussed in the preceding pages support the general conclusion that the deep trap net was in large measure responsible for a disastrous depletion of the whitefish in the four southernmost districts of Lake Huron. This depletion was the result of the unreasonable increases in fishing intensity and hence in production in these districts. In the northern portion of the lake where the net was used more moderately the decline in the abundance of whitefish was severe but it did not reach such extremes as were found in the central and southern regions of the lake.

Largely for the sake of completeness the annual fluctuations of production, abundance, and fishing intensity for all six districts combined have been presented graphically in figure 11 (data from tables 5, 9, and 10). To some extent the data for the entire

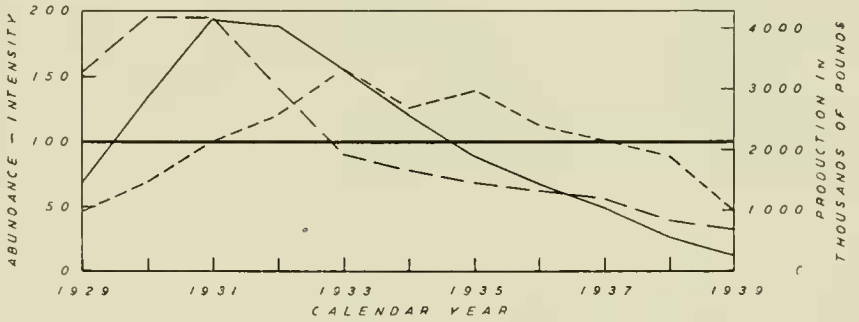


FIGURE 11.—Annual fluctuations in the production (solid line) and abundance (long dashes) of whitefish and in the intensity of the whitefish fishery (short dashes) in Lake Huron (all six districts combined), 1929–1939.

lake lack significance as the combination of the data for all districts obscures the extreme nature of the fluctuations that took place within the individual districts. The data serve chiefly to show that a relatively great abundance of whitefish contributed materially to the high production in 1930–1932 (especially in 1930 and 1931), and that the decline in catch subsequent to 1932 would have been much more rapid had not the intensity of the fishery been so great. Although the decline in abundance began in 1932 the intensity of the fishery increased rapidly until 1933. Beyond 1932 the abundance of whitefish was below the 11-year average and decreasing in every year. Fishing intensity, however, did not return to the 11-year average before 1937 or to the 1929 level before 1939.

The question now arises, "What characteristics made the deep trap net so deadly effective?" The tremendous production of deep trap nets was possible chiefly because: (1) they can be set in deeper water, and hence in areas with greater concentrations of whitefish, than can the pound nets; and (2) they are much more efficient in taking whitefish than are gill nets fished on the same grounds. Attention will be given first to the advantages of the deep trap net over the pound net.

In size and construction the pound net and deep trap net resemble each other so closely that the latter gear was known in some localities as the "submarine pound net" (p. 300). If the two gears are fished in the same depth of water neither has an important advantage over the other.[25] However, pound nets which are held in place by stakes driven into the bottom of the lake, and have cribs or pots extending from the bottom to above the surface, ordinarily cannot be fished successfully at depths greater than 80 feet. Most pound nets are operated in much shallower water. Deep trap nets, on the other hand, have covered cribs and are held in position by means of lines attached to anchors and by buoys. Consequently, they can be employed at all depths frequented by whitefish. The use of stakes also limits pound nets to areas with a soft bottom into which stakes can be driven. Deep trap nets do not suffer from this limitation.

A further advantage of the deep trap net lies in its greater mobility. Pound nets are fished in the same locality throughout the season (and usually year after year) but deep trap nets can be moved much more easily and consequently can be fished in the exact locations at which whitefish are found to be concentrated.

The vertical distribution of the whitefish will be treated in part III. It may be stated at this time, however, that usually whitefish are readily available to pound nets

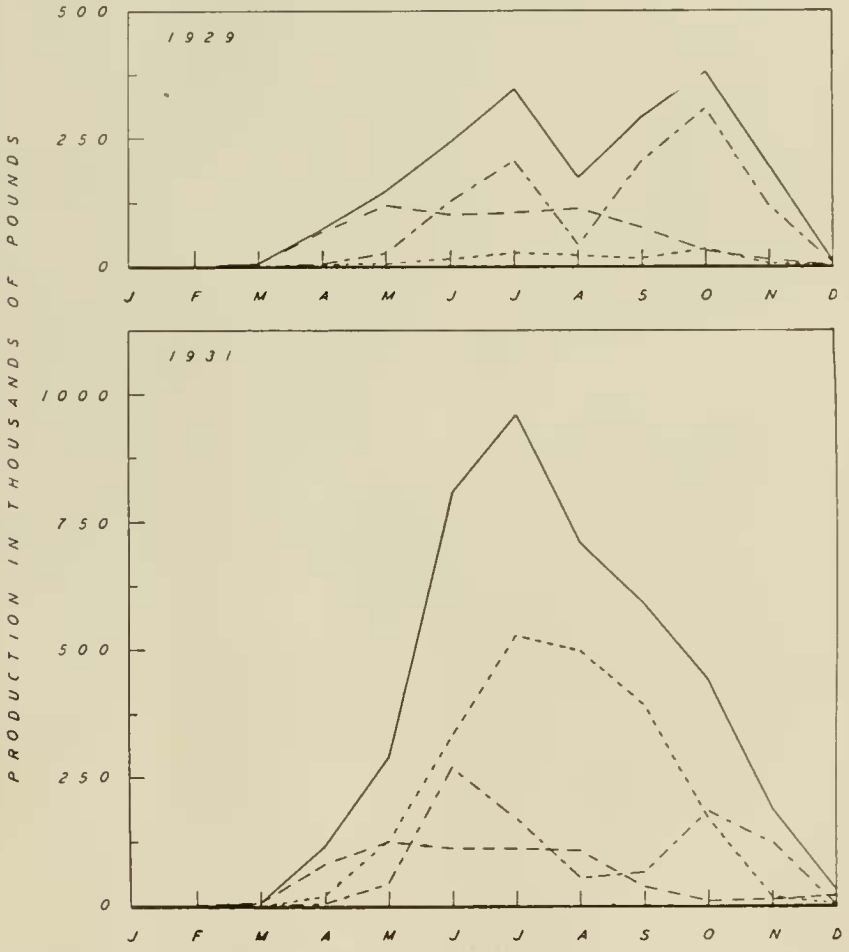


FIGURE 12.—Comparison of the monthly production of whitefish in the Michigan waters of Lake Huron in 1929 and 1931, to bring out the effects of the deep-trap-net fishery on the seasonal distribution of the catch. Gill nets, long dashes; deep trap nets, short dashes; pound nets, short and long dashes; total production, solid line.

[25] Field observations in northern Lake Michigan indicated that pound nets may take slightly more fish than deep trap nets fished at the same depth. This relationship is not surprising since the pound net is a "lighter" net (that is, the open top permits the free penetration of light) and would, therefore, be entered by fish more readily than the "darker" deep trap net. Also see table 51, appendix C.

TABLE 12.—*Monthly production of whitefish in Lake Huron, 1929 and 1931, in gill nets, deep trap nets, pound nets, and all gears combined*

[Percentages are in parentheses]

Gear	Production of whitefish in pounds in month												Total
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
1929													
Gill net	180 (0.0)	580 (0.1)	2,465 (0.5)	52,029 (10.6)	94,066 (19.2)	79,724 (16.3)	82,332 (16.8)	88,890 (18.2)	58,534 (12.0)	21,744 (4.4)	8,848 (1.8)	569 (0.1)	489,961 (100.0)
Deep trap net	.....	.....	.....	1,239 (1.4)	1,774 (2.0)	10,867 (12.5)	20,535 (23.6)	15,068 (17.3)	9,809 (11.3)	24,061 (27.6)	3,768 (4.3)	.....	87,121 (100.0)
Pound net	.....	.....	.....	1,278 (0.2)	19,582 (2.4)	101,424 (12.3)	165,066 (20.0)	33,145 (4.0)	163,763 (19.9)	244,055 (29.6)	91,878 (11.2)	2,505 (0.4)	823,696 (100.0)
All gears	180 (0.0)	580 (0.0)	2,468 (0.2)	57,764 (4.0)	117,463 (8.1)	193,906 (13.3)	276,917 (19.0)	137,161 (9.4)	233,074 (16.0)	302,087 (20.7)	130,694 (9.0)	4,074 (0.3)	1,456,368 (100.0)
1931													
Gill net	390 (0.1)	317 (0.1)	4,663 (0.7)	82,423 (13.3)	124,071 (20.0)	112,776 (18.2)	113,365 (18.3)	107,329 (17.3)	36,492 (5.9)	7,752 (1.2)	9,001 (1.5)	20,936 (3.4)	619,515 (100.0)
Deep trap net	.....	.....	.....	19,220 (0.9)	115,241 (5.6)	334,943 (16.1)	528,609 (25.4)	498,984 (24.0)	391,921 (18.8)	172,701 (8.3)	15,757 (0.8)	2,220 (0.1)	2,079,596 (100.0)
Pound net	.....	2 (0.0)	55 (0.0)	3,340 (0.4)	41,882 (4.6)	269,224 (29.5)	169,001 (18.5)	53,513 (5.9)	65,801 (7.2)	184,552 (20.3)	121,774 (13.4)	1,796 (0.2)	910,940 (100.0)
All gears	390 (0.0)	319 (0.0)	4,785 (0.1)	116,754 (2.8)	289,342 (7.0)	808,065 (19.5)	961,095 (23.2)	709,469 (17.2)	591,894 (14.3)	441,501 (10.7)	186,997 (4.5)	29,161 (0.7)	4,139,772 (100.0)

only during limited periods, one in late spring and early summer and another in mid-autumn. Many fishermen discontinue pound-net operations at other seasons. It is true also that even in periods of active operation the greatest concentrations of whitefish may be at depths beyond the reach of pound nets.

The offshore movement that leads to a concentration in relatively deep water in the summer and early autumn exposes the whitefish to the inroads of the deep trap net at the time it is most vulnerable. Formerly, the only toll on the whitefish in its summer concentration was that levied by gill nets, and in the modern fishery of Lake Huron this type of gear has not proved generally effective for the large-scale catching of whitefish. The gill net is so ineffective for the capture of whitefish under modern conditions that gill-net fisheries are supported by this species alone only in very limited areas or over extremely short periods of time (chiefly during the spawning season).[26] The large-mesh gill-net fishery is now conducted ordinarily for the capture of both trout and whitefish or of trout alone, but very seldom exclusively for the taking of whitefish.[27] The comparative ineffectiveness of gill nets made the time of summer concentration of the whitefish a "semi-closed" season during which the species was in large measure immune to capture. The introduction of the deep trap net made this same period the season of maximum production.

The effect of the deep-trap-net fishery on the monthly distribution of the whitefish catch and the high production this gear made possible in the summer months may be illustrated by the data of table 12 and figure 12. The gill-net season extended through the months, May-August, in both 1929 and 1931. (September was a fairly good month in 1929.) No distinct peaks occurred in either year. The pound-net catch, on the contrary, was divided into two distinct seasons, each with a sharp peak. The early-season maximum occurred in July in 1929 and in June in 1931. Both of the autumn maxima were in October. The 1931 data which show the more pronounced summer depression provide the better description of the monthly distribution of pound-net production because the 1929 early-summer peak was later and the September catch was relatively higher than usual. The data for both years, however, have a distinct late-summer minimum—August in 1929 and August-September in 1931.

The curve of total catch in 1929 has a minimum in August corresponding to the August depression in the pound-net data. A similar minimum would have existed in

[26] When gill nets were fished on the spawning grounds the catches were sometimes enormous—thousands of pounds in a single lift.
[27] This statement holds true even in Lake Michigan where the gill net is normally the dominant gear for the production of whitefish.

the curve of total production in 1931 if only gill nets and pound nets had been in operation. The deep-trap-net catch, however, changed the form of the curve completely. This gear not only deprived the whitefish of its former temporary respite during the period of habitation in deep waters, but actually exposed the fish to a far more severe exploitation in late summer than it had previously suffered at any season. From these facts it is obvious that effective regulation of the deep trap net must include the reduction of its catches on the deep-water grounds on which whitefish congregate during late summer.

The summer assemblings of whitefish that made possible the great effectiveness of the deep trap net seemingly were not as dense in northern Lake Huron as in the central and southern regions of the lake. In each of the four southerly districts the average catch per lift of deep trap nets exceeded 400 pounds in one year and was more than 200 pounds per lift in 2 or 3 years (table 11). In the northern districts the greatest average catch per lift of deep trap nets was 168 pounds in H–1 and 142 pounds per lift in H–2 (in 1930 in both districts). The relatively poor success of deep trap nets is the more remarkable in H–1 because that area under normal conditions had been an important and in many, if not the majority of years, the leading center of whitefish production in the lake. At any rate these small catches per lift account for the more moderate use of deep trap nets in H–1 and H–2.

A final point that deserves consideration is the possibility that mass migrations of whitefish may have played a role in the shift from year to year in the center of the deep-trap-net fishery. The failure of the grounds on which the deep trap nets first were fished and the resultant necessity for opening up new areas gave an early indication of the disastrous results to be expected from the unrestricted operation of this gear. Deep-trap-net fishermen denied most vigorously, however, that their activity had caused any depletion on the grounds. They contended that the fish had not been caught but that they merely had migrated to another area. They held further that in changing the center of the fishery they were only following the movements of the whitefish population. In support of their contention they stressed the argument that only mass migrations could make possible such high production in southern Lake Huron (H–5 and H–6), an area in which the catch of whitefish had always been small.

The assumption of a mass migration of whitefish proceeding in the same direction year after year runs counter to all known facts concerning the habits of the species. Nevertheless, the possibility cannot be denied that extraordinary conditions might bring about unusual reactions on the part of the fish. The strongest argument against the theory of mass migration lies in the fact that such an assumption is altogether unnecessary. The heavy yield in southern Lake Huron in 1932 and later years was not made possible, as fishermen contended, by the influx of whitefish from more northerly grounds. The records of the catch of gill nets per unit of effort (table 11) prove that dense concentrations of whitefish had been present on the offshore grounds of H–5 and H–6 for years before the deep trap net was introduced. In fact, the catch of whitefish per unit of effort of gill nets in H–5 exceeded that in every other district during the four years, 1929–1932. The catch per unit of effort of gill nets in H–6 was greater than that in any other district in 1933 and was second only to the catch per lift in H–5 in 1931 and 1932.

The large production of deep trap nets in H–5 and H–6 was made at the expense of the reserve stock rather than of a population of recent migrants. The generally low output of whitefish in southern Lake Huron prior to the introduction of the deep trap net can be attributed to a low fishing intensity. Gill nets, comparatively ineffective gear for the capture of whitefish, accounted for the bulk of the catch (appendix B). Apparently the relatively few pound nets were fished either at the wrong localities or depths to produce large quantities of whitefish. Actually, suitable localities for whitefish pound nets are scarce in southern Lake Huron.

WHITEFISH FISHERY OF LAKE MICHIGAN, 1929–1939

The most important difference between the histories of the whitefish fisheries of Lakes Michigan and Huron, 1929–1939, lies in the relatively limited development of the deep-

trap-net fishery in the former lake. With the exception of the deep-trap-net fishery out of Grand Haven, Mich., in 1934 (the deep trap net was the dominant gear for the production of whitefish in M–7 in that year), significant operations with this gear were confined to the extreme northern portion of the lake (M–1, M–2, and M–3). Deep trap nets were introduced into M–1 and M–3 in 1930 and into M–2 in 1931. Even in these northern districts the place of the deep trap net in the fishery resembled that which it occupied in northern Lake Huron rather than in central and southern Lake Huron. At no time did the deep trap net become the dominant gear for the capture of whitefish in the Green Bay area (M–1). In M–2 and M–3 deep trap nets led other gears in the production of whitefish in only two years (1932 and 1933 in both districts). The use of deep trap nets in the Michigan waters of Lake Michigan became illegal after 1935.[28]

The fact that the deep trap net did not disturb the whitefish fishery as seriously in Lake Michigan as in Lake Huron makes it possible to follow a more or less natural course of events subsequent to an abnormal increase in abundance. Comparisons with the data on the whitefish fishery of Lake Huron should prove particularly instructive.

FLUCTUATIONS IN THE PRODUCTION OF WHITEFISH IN LAKE MICHIGAN

The increase in the catch of whitefish that characterized the late 1920's and early 1930's in the various waters of the Great Lakes got under way early in Lake Michigan.[29] Production exceeded 2 million pounds in 1927 and was nearly 3 million pounds in 1928.

TABLE 13.—*Production of whitefish in pounds according to gear in the State of Michigan waters of Lake Michigan, 1929–1939*

[Percentages of annual yield in parentheses]

Year	Production in gear				Total annual production	Increase or decrease
	Large-mesh gill net	Deep trap net	Pound net	Other		
1929	2,244,093 (52.3)	----------	2,032,083 (47.4)	11,693 (0.3)	4,287,869	+1,331,723
1930	2,339,162 (48.6)	135,634 (2.8)	2,328,326 (48.4)	9,703 (0.2)	4,812,825	+524,956
1931	1,986,579 (51.9)	408,209 (10.7)	1,421,576 (37.2)	7,619 (0.2)	3,823,983	—988,842
1932	1,564,505 (46.9)	856,804 (25.7)	890,667 (26.7)	20,308 (0.6)	3,332,284	—491,699
1933	1,307,943 (58.4)	440,090 (19.7)	485,187 (21.7)	2,620 (0.1)	2,235,840	—1,096,444
1934	1,001,074 (51.8)	398,635 (20.6)	531,070 (27.5)	1,399 (0.1)	1,932,178	—303,662
1935	911,079 (63.6)	211,246 (14.8)	301,367 (21.0)	8,032 (0.6)	1,431,724	—500,454
1936	635,284 (72.5)	----------	240,508 (27.4)	619 (0.1)	876,411	—555,313
1937	709,515 (74.9)	----------	236,527 (25.0)	825 (0.1)	946,867	+70,456
1938	765,416 (68.5)	----------	351,447 (31.5)	216 (0.0)	1,117,079	+170,212
1939	482,801 (57.5)	----------	356,488 (42.4)	567 (0.1)	839,856	—277,223
Average	1,267,950 (54.4)	222,784 (9.6)	834,113 (35.8)	5,782 (0.2)	2,330,629	----------

[28] Limited operations have been carried on in the northern Michigan waters since 1935, with a modified deep trap net in which the crib or pot extends to the surface of the water and is open at the top. This arrangement has qualified the nets for legal definition as pound nets with which gear they have been grouped in the preparation of this report.

[29] In this section the terms, "Lake Michigan" and "the entire lake," refer to the State of Michigan waters only.

In 1929, the first year for which detailed statistics are available, the catch of whitefish (4,288,000 pounds) was greater than that of any previous year, except 1889, for which there are usable records (table 1). The increase over the take for 1928 was 1,332,000 pounds (table 13). A further rise of 525,000 pounds in 1930 brought the yield of whitefish in Lake Michigan to the peak of 4,813,000 pounds.

Whitefish production declined continually throughout the next 6 years. The decreases were large (average of 656,000 pounds per year). In two years (1931 and 1933) the drop in catch amounted to roughly a million pounds. In three years (1932, 1935, and 1936) the decreases were approximately a half million pounds. The smallest drop in production (304,000 pounds) in the 6-year period occurred in 1934.

The 1931–1936 decline in catch was followed by increases in 1937 (70,000 pounds) and 1938 (170,000 pounds). A new drop of 277,000 pounds in 1939 carried the yield to a level that was only a little above the lowest recorded for any previous year (806,000 in 1920).

Great as the decline in production was in Lake Michigan, the yield in 1939 amounted to 17.5 percent of the 1930 maximum as compared with a 1939 catch in Lake Huron that was only 6.2 percent of the 1931 peak in that lake.

The records of the production of whitefish in deep trap nets (tables 13 and 14) confirm the earlier statement that the gear failed by far to become as important in Lake Michigan as in Lake Huron. In Lake Michigan the deep trap net accounted for only 25.7 percent of the total catch in 1932, the year of its greatest success. This percentage was less than that of pound nets (26.7 percent) and was far below the percentage for gill nets (46.9 percent). In fact, the total quantity of whitefish taken by deep trap nets in Lake Michigan in their 6 years of operation (1930–1935) was less than the amount taken by the same gear in Lake Huron in each of the single years, 1932 and 1933. The gill net was the most important gear for the capture of whitefish throughout the 11-year period and accounted for more than 50 percent of the total yield in 9 years (average of 54.4 percent for 1929–1939). With equal consistency the pound net held second rank, and accounted for 35.8 percent of the 1929–1939 take.

TABLE 14.—*Production of whitefish in pounds in deep trap nets in Lake Michigan, 1930–1935 (use of deep trap nets illegal after July 1, 1935)*

[In parentheses, the deep-trap-net production expressed as a percentage of the total whitefish production]

District or area	Production in deep trap nets in year						Total
	1930	1931	1932	1933	1934	1935	
M-1	37,655 (3.5)	111,523 (9.3)	191,979 (21.1)	77,161 (32.4)	56,918 (21.6)	22,783	498,019
M-2		13,645 (16.7)	59,303 (61.0)	30,753 (72.7)	11,580 (43.1)	3,621	118,902
M-3	97,454 (4.0)	273,282 (19.8)	596,246 (40.0)	318,260 (35.7)	251,012 (32.9)	177,374	1,713,628
M-4		174 (0.2)	1,218 (1.5)	1,569 (3.1)	249 (0.5)	4,389	7,599
Northern Lake Michigan (M-1, M-2, M-3, and M-4)	135,109 (3.6)	398,624 (14.5)	848,746 (33.0)	427,743 (35.0)	319,759 (29.1)	208,167	2,338,148
Central Lake Michigan (M-5)			3,797 (0.7)	3,482 (0.7)			7,279
M-6	525 (0.2)	8,877 (3.5)	173 (0.2)	2,625 (6.0)	3,920 (10.5)		16,120
M-7		347 (0.3)	3,819 (8.0)	6,240 (4.0)	74,956 (39.3)	3,079	88,441
M-8		361 (0.3)	269 (0.4)				630
Southern Lake Michigan (M-6, M-7, and M-8)	525 (0.1)	9,585 (1.9)	4,261 (2.2)	8,865 (1.8)	78,876 (14.8)	3,079	105,191
Lake Michigan (all 8 districts)	135,634 (2.8)	408,209 (10.7)	856,804 (25.7)	440,090 (19.7)	398,635 (20.6)	211,246	2,450,618

The deep trap net became the dominant gear for the taking of whitefish in only three (M–2, M–3, and M–7) of the eight districts of Lake Michigan (table 14 and appendix B), and maintained that position in the first two districts only 2 years (1932 and 1933) and in M–7 only 1 year (1934). With the exception of the fishery in M–7 in 1934, deep trap nets were operated only sporadically in waters south of M–3.

Although the actual yield of whitefish in each district and the percentage distribution among the several districts of the total for the lake both varied rather widely in Lake Michigan during the period, 1929–1939 (table 15), there is no evidence of a shifting of the center of production comparable to that which took place in Lake Huron. For example, M–3 did not relinquish once its position as the most productive district of the lake; neither did northern Lake Michigan (M–1, M–2, M–3, and M–4) fail in any year to account for more than 50 percent of the catch of the entire lake.

TABLE 15.—*Total annual production of whitefish in pounds in the different districts and areas of the State of Michigan waters of Lake Michigan, 1929–1939*

[Each total is expressed also as the percentage (in parentheses) of the production of the entire lake]

District or area	Total whitefish production in year											Average
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	
M-1	1,139,628 (26.6)	1,075,748 (22.4)	1,194,969 (31.3)	910,106 (27.3)	238,169 (10.7)	263,005 (13.6)	174,637 (12.2)	90,203 (10.3)	104,888 (11.1)	354,235 (31.7)	237,509 (28.3)	525,736 (22.6)
M-2	90,019 (2.1)	100,625 (2.1)	81,618 (2.1)	97,248 (2.9)	42,277 (1.9)	26,858 (1.4)	46,264 (3.2)	46,465 (5.3)	31,49[illegible] (3.3)	24,221 (2.2)	15,402 (1.8)	54,772 (2.3)
M-3	2,202,064 (51.3)	2,460,656 (51.1)	1,380,450 (36.1)	1,489,472 (44.7)	890,899 (39.8)	761,831 (39.4)	749,666 (52.4)	445,967 (50.9)	450,619 (47.6)	497,776 (44.6)	425,495 (50.7)	1,068,627 (45.9)
M-4	72,629 (1.7)	84,119 (1.7)	84,253 (2.2)	78,771 (2.4)	51,010 (2.3)	48,369 (2.5)	47,978 (3.3)	56,234 (6.4)	43,866 (4.6)	29,249 (2.6)	31,767 (3.8)	57,113 (2.4)
Northern Lake Michigan (M-1, M-2, M-3, & M-4)	3,504,340 (81.7)	3,721,148 (77.3)	2,741,290 (71.7)	2,575,597 (77.3)	1,222,355 (54.7)	1,100,063 (56.9)	1,018,545 (71.1)	638,869 (72.9)	630,867 (66.6)	905,481 (81.1)	710,173 (84.6)	1,706,248 (73.2)
Central Lake Michigan (M-5)	284,620 (6.6)	280,701 (5.8)	580,536 (15.2)	558,573 (16.8)	529,697 (23.7)	298,497 (15.5)	208,807 (14.6)	198,801 (22.7)	267,385 (28.3)	189,658 (17.0)	97,268 (11.6)	317,686 (13.6)
M-6	103,397 (2.4)	222,148 (4.6)	252,015 (6.6)	85,080 (2.5)	43,181 (1.9)	37,450 (1.9)	24,861 (1.7)	14,063 (1.6)	11,100 (1.2)	6,787 (0.6)	4,653 (0.5)	73,158 (3.2)
M-7	139,690 (3.3)	447,760 (9.4)	107,206 (2.8)	47,934 (1.4)	157,699 (7.1)	190,582 (9.9)	30,506 (2.2)	5,212 (0.6)	8,017 (0.8)	1,137 (0.1)	1,537 (0.2)	103,389 (4.4)
M-8	255,822 (6.0)	141,068 (2.9)	142,936 (3.7)	65,100 (2.0)	282,908 (12.6)	305,586 (15,8)	149,005 (10.4)	19,466 (2.2)	29,498 (3.1)	14,016 (1.2)	26,225 (3.1)	130,148 (5.6)
outhern Lake Michigan (M-6, M-7, and M-8)	498,909 (11.6)	810,976 (16.9)	502,157 (13.1)	198,114 (5.9)	483,788 (21.6)	533,618 (27.6)	204,372 (14.3)	38,741 (4.4)	48,615 (5.1)	21,940 (1.9)	32,415 (3.8)	306,695 (13.2)
Lake Michigan (all 8 districts)	4,287,869	4,812,825	3,823,983	3,332,284	2,235,840	1,932,178	1,431,724	876,411	946,867	1,117,079	839,856	2,330,629
Percentage of average	184	206	164	143	96	83	61	38	41	48	36	----------

Nevertheless, the relative importance of the districts varied considerably. M–3 produced as little as 36.1 percent (1931) and as much as 52.4 percent (1935) of the total catch of whitefish in the lake. In M–1, the district that ranked second in average yield, the percentages ranged from 10.3 (1936) to 31.7 (1938). The district that ranked third in average production (M–5) yielded from 5.8 percent (1930) to 28.3 percent (1937) of the total for the lake.

The percentage contributions of the less important districts varied relatively more widely than did those for the more productive areas. The greatest relative variation occurred in M–7 which produced 9.9 percent of the 1934 total but only 0.1 percent of the 1938 catch. However, among the five districts that each accounted for less than 10 percent of the 1929–1939 average only one (M–8) produced more than 10 percent of

the total for the lake in any single year (percentages of 12.6, 15.8, and 10.4 in 1933, 1934, and 1935, respectively).

Comparison of later and earlier production of whitefish in the various districts of Lake Michigan (tables 15 and 16) reveals that M–3 contributed an even higher percentage of the total for the lake in 1891–1908 (59.5 percent) than in 1929–1939 (45.9 percent). M–2 and M–4 also accounted for higher percentages of the total in the earlier period (7.4 and 7.3 percent, respectively, as compared with 2.3 and 2.4 percent). However, the percentages for these two districts may be too high for the years, 1891–1908. As stated in footnote 23, the division of the catches for the early period was based on the home ports of the fishermen, not necessarily on the actual location of their fishing grounds. In recent years, at least, numbers of fishermen who operate from ports of M–2 and M–4 have done part of their fishing in other districts (chiefly in M–3). It is believed that the data for the remaining districts were not affected greatly by the separation of the catch of the earlier years according to the port from which the fishermen operated.

TABLE 16.—*Production of whitefish in pounds in Lake Michigan according to statistical districts, 1891–1908*

Year	Statistical district								Total
	M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	
1891	78,140	237,000	1,521,101	214,580	290,100	41,050	17,100	5,500	2,404,571
1892	148,600	325,650	1,477,412	168,725	329,300	41,100	11,000	20,615	2,522,402
1893	123,150	83,000	1,326,900	137,050	233,600	19,500	27,500	25,100	1,975,800
1894	89,050	41,100	801,750	146,500	147,300	8,730	31,450	29,925	1,295,805
1895	71,850	18,500	631,550	109,990	138,000	7,400	21,150	24,300	1,022,740
1896	88,600	148,000	863,400	86,600	210,750	10,000	13,350	26,600	1,447,300
1897	83,570	180,000	1,762,900	84,300	261,700	13,700	6,053	26,730	2,418,953
1898	85,050	302,100	1,504,900	84,200	303,000	16,700	6,350	17,600	2,320,100
1899	111,560	104,100	1,040,870	87,500	249,600	12,350	2,800	25,100	1,633,880
1900	83,350	140,500	961,800	104,000	292,000	16,100	3,100	24,750	1,625,600
1901	97,700	146,100	1,372,600	148,700	278,200	8,700	8,900	18,650	2,079,550
1902	140,150	177,500	1,739,800	200,500	429,000	10,000	3,400	23,000	2,723,350
1903	228,200	166,000	1,369,400	148,500	319,500	17,100	6,200	29,700	2,284,600
1904	283,000	158,000	1,337,000	282,500	338,000	33,000	19,100	51,100	2,501,700
1905	348,000	184,000	1,246,800	218,000	338,500	62,600	73,500	98,700	2,570,100
1906	291,800	89,500	1,387,700	322,300	322,500	77,300	170,300	159,300	2,820,700
1907	291,700	179,000	1,689,500	214,100	330,000	139,300	265,500	134,700	3,273,800
1908	222,500	289,400	1,793,155	148,424	337,116	83,700	89,800	142,000	3,106,095
Average	159,221	164,969	1,323,808	163,137	280,009	34,352	43,153	49,076	2,223,725
Percentage	7 2	7 4	59 5	7 3	12 9	1 6	1 9	2 2	

M–1, M–5, M–6, M–7, and M–8 yielded smaller percentages of the total catch of whitefish in 1891–1908 than in 1929–1939. Especially noteworthy are the comparative yields for M–1 which accounted for only 7.2 percent of the early total catch as against 22.6 percent of the recent production. The change was not large in M–5 (12.9 percent in the early period; 13.6 percent in the recent). The percentages were considerably lower in 1891–1908 than in 1929–1939 for all three districts (M–6, M–7, and M–8) of southern Lake Michigan (1.6, 1.9, and 2.2 percent as compared with 3.2, 4.4, and 5.6 percent).

Despite the changes just described in the percentage distribution of the catch of whitefish according to district, the most productive areas of the earlier years seem to be in general the best areas of recent years. This conclusion is supported by the following comparison of regions of the lake:

Area	Percentage of total whitefish production	
	1891–1908	*1929–1939*
Northern Lake Michigan (M-1, M-2, M-3, M-4)	81.4	73.2
Central Lake Michigan (M-5)	12.9	13.6
Southern Lake Michigan (M-6, M-7, M-8)	5.7	13.2

CHANGES IN PRODUCTION IN LAKE MICHIGAN AS RELATED TO FLUCTUATIONS IN THE ABUNDANCE OF WHITEFISH AND IN THE INTENSITY OF THE FISHERY

In Lake Michigan as in Lake Huron the abundance of whitefish was abnormally high near the beginning of the 1929–1939 period. The peak of abundance occurred a year or two earlier in the more productive areas of Lake Michigan than in Lake Huron. The abundance of whitefish was greater in 1929 than in any other of the 11 years in each of the four districts of northern Lake Michigan, a region that accounted for 73.2 percent of the 1929–1939 production. The maximum abundance occurred in 1929 in M–8 also. The large increase in catch in 1929 (table 1) suggests strongly that the abundance in this year was greater than that in 1928 and hence constituted the maximum for the modern fishery. (Certainty on this point is not possible as the intensity of the fishery in 1928 is unknown.) The maximum abundance of the 1929–1939 interval occurred later in the remaining districts (1930 in M–6 and M–7, 1931 in M–5). However, these districts were relatively far less important in the fishery of the entire lake than were those in which 1929 was the year of peak abundance. Lake Michigan resembles Lake Huron again in that a decline from the high level of abundance that existed early in the period was to be expected.

These resemblances between the data for Lake Michigan and Lake Huron are fortunate, as they make possible a comparison of the course of the decline in Lake Michigan, where the whitefish fishery was not disturbed violently by the use of deep trap nets, and in Lake Huron where the introduction and widespread use of that new and efficient gear brought about an utterly chaotic condition in the fishery. Accordingly, comparisons of data for Lakes Michigan and Huron are emphasized in the present section.

Several reasons may be advanced to account for the failure of the deep-trap-net fishery to develop as extensively in Lake Michigan as in Lake Huron: (1) no extensive or good whitefish grounds are found in Lake Michigan south of Frankfort; (2) pound-netters and gill-netters rather than trap-netters were dominant on Lake Michigan and opposed the use of deep trap nets (the Lake Huron deep-trap-netters who entered M–7 in 1934 were driven out by local fishermen; shortly thereafter the Lake

TABLE 17.—*Annual fluctuation in the catch of whitefish per unit of fishing effort of gill nets, deep trap nets, and pound nets in the various districts of Lake Michigan, 1929–1939*

District	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	Average
	Pounds of whitefish per 10,000-foot-lift of gill nets											
M-1	183 4	150 0	131 0	116 3	71 4	100 2	105 2	76 5	71.7	119.7	74 0	109 0
M-2	69 4	63 8	44 3	27.0	15.3	19.5	49.4	43 0	32 1	26 2	24 4	37.7
M-3	138 9	131 6	87 6	89.9	70 4	74 0	85.8	59 0	54 6	48 6	47.3	80 7
M-4	52.0	50 1	60.0	48 2	37 7	29 4	34 5	48 3	25 7	25 3	25.8	39 7
M-5	103 9	85 8	127 1	110 6	104 1	78 4	56.5	57 1	60 2	46.9	31 3	78 4
M-6	55 0	65.4	75 6	40 1	37.5	31.9	31 5	14 5	22 6	14 9	17 0	36 9
M-7	132.5	161.5	72 8	92.4	193 1	133 3	156.5	128.8	133 1	76 4	71 0	122 9
M-8	156 7	117.6	111.6	81 5	160.2	141.9	102 0	48 7	75 1	70 8	79.1	104 1
	Pounds of whitefish per lift of one deep trap net											
M-1	.....	131.7	100 2	118.0	54 6	74 6	91 1	.....	.....	.....	.....	95 0
M-2	.....	.....	184 4	257.5	120 6	68 1	43 1	.....	.....	.....	.....	134 8
M-3	.....	153.7	137 2	164 9	97 0	121 8	94 6	.....	.....	.....	.....	128 2
M-7	.....	.....	.....	.....	.....	118.2	.....	.....	.....	.....	.....	118 2
	Pounds of whitefish per lift of one pound net											
M-1	113 2	88.7	104 5	74 1	41.0	56 0	41.8	47.6	38.0	53.9	63 0	65 6
M-2	105 2	85 9	217 1	.....	.....	.....	.....	.....	.....	.....	.....	136.1
M-3	153 3	148 8	96 0	80 0	85.6	98 5	92 4	85 3	81 5	80 0	75 6	97 9
M-4	73 4	71 0	57 7	63 3	67 7	63 0	54 3	56 7	63.6	31 5	40 7	58 4
M-5	123 1	134 2	159 2	106 8	145 0	71 4	73 6	60 5	65 2	84 1	53 9	97.9
M-6	.....	261 7	126 9	55 2	26 6	41 2	34 2	84 7	.....	121 8	55 0	89.7
M-7	102 9	195 4	59 8	25 7	39 4	61 1	11 0	8 8	13.1	12 7	9 2	49 0
M-8	.....	243 1	146 0	.....	37 6	73.7	29 0	54 1	70.1	.....	13.4	83 4

Michigan fishermen were able to abolish the net from their waters by law); (3) the summer aggregation of whitefish occurs in shallower water in Lake Michigan than in Lake Huron and hence the Lake Michigan fish never moved beyond the reach of pound nets to the same degree as did those in Lake Huron; (4) the deep-water population of whitefish available to the deep trap nets was less dense in Lake Michigan than in Lake Huron, hence in contrast to the situation in Lake Huron the deep-trap-net lifts did not always average much larger than those of the pound nets. (See, for example, M–1 and M–2 for 1931, table 17.)

Although the deep trap net usually took more whitefish per lift than did the pound net in Lake Michigan, and from this point of view may be considered to have been very effective and successful, in no district of the lake did the catch per lift of deep trap nets approach the level that it attained in the four southerly districts of Lake Huron (tables 11 and 17). The average catch per lift of deep trap nets in Lake Michigan reached values of 257.5 pounds in M–2 in 1932 and 184.4 pounds in the same district in 1931. Operations were limited, however, in M–2. In M–1 and M–3, where deep-trap-net operations were more extensive, the greatest average catches per lift were 131.7 pounds (M–1 in 1930) and 164.9 pounds (M–3 in 1932). These values were far below the greatest averages in the districts of central and southern Lake Huron (402.5 to 476.1 pounds per lift), but compared favorably with the maxima in northern Lake Huron (167.7 pounds per lift in H–1 in 1930; 141.9 pounds per lift in H–2 in 1930). The deep trap net was relatively unsuccessful in southern Lake Michigan also, for the only significant operations with the gear (M–7 in 1934) yielded an average of 118.2 pounds of whitefish per lift.

To be sure, the deep trap net was introduced into northern Lake Michigan after the peak of abundance of the whitefish had passed. The examination of the abundance percentages of table 21 suggests that if this gear had been fished in 1929, the year of high abundance, the average catch per lift in that year most probably would have exceeded the highest yields listed in table 17 for deep trap nets in each of the northern districts. On the other hand, abundance percentages may not validly serve as an exact index to the average size of a lift since the fluctuations in the catch per lift of this gear did not always correspond with those in abundance subsequent to 1929. For example, the average catch per lift of deep trap nets in M–1 decreased in 1931 and increased in 1932 despite the fact that abundance remained practically unchanged in 1931 and fell in 1932. Again, the highest yield (257.5 pounds per lift) of the northern area occurred in a district (M–2) when abundance was normal (1932).

As the average deep-trap-net lifts were small in comparison with those of central and southern Lake Huron irrespective of how much abundance was above average, the conclusion appears valid that in northern Lake Michigan as in northern Lake Huron the deep trap net was far less successful than it was in central and southern Lake Huron.

The maximum and 1939 percentages of production, fishing intensity, and abundance in table 18 have been computed with respect to average conditions in 1929–1939. The corresponding estimates for Lake Huron (table 7) were made with reference to

TABLE 18.—*Maximum and 1939 production and abundance of whitefish and maximum and 1939 fishing intensity for whitefish*

[Expressed as percentages of the average 1929–1939 values in each statistical district of Lake Michigan]

District	Year of maximum production	Production		Year of maximum intensity	Intensity		Year of maximum abundance	Abundance	
		Maximum	1939		Maximum	1939		Maximum	1939
M-1	1931	227	45	1931	196	65	1929	170	81
M-2	1930	184	28	1932	180	41	1929	169	69
M-3	1930	230	40	1930	159	65	1929	166	67
M-4	1931	148	56	1931	127	88	1929	127	66
M-5	1931	183	31	1932	129	77	1931	162	41
M-6	1931	345	7	1931	242	16	1930	209	53
M-7	1930	433	1	1930	271	7	1930	222	33
M-8	1934	235	20	1934	215	34	1929	151	71

conditions in the single year, 1929. The figures for this year were taken as the most nearly "normal" data available (p. 323). The computation of the above percentages for Lake Michigan also with respect to 1929 conditions would not have been valid because production, abundance, and almost certainly fishing intensity, as well, were above normal in Lake Michigan in that year. On the other hand, the data for the period, 1929–1939, were not greatly, if at all, distorted by the deep-trap-net fishery in Lake Michigan. Furthermore, these 11 years included periods of high, moderate, and low production and apparently also periods of high, moderate, and low abundance and fishing intensity. Consequently, the 11-year averages have been taken as the most nearly normal bases available for the estimation of the maximum and 1939 percentages of production, fishing intensity, and abundance for the Lake Michigan whitefish. It is believed that this variation of procedure has made the data of tables 7 and 18 as nearly comparable as is possible.

In comparison with Lake Huron the maxima of yields in Lake Michigan were relatively small. The maximum exceeded 3 times the assumed normal in only two districts (433 percent in M–7 and 345 percent in M–6). Of the remaining six districts the maximum production was greater than twice the normal in three (M–1, M–3, and M–8), was between 1½ and 2 times the normal in two (M–2 and M–5), and was less than 1½ times the normal in one (M–4). In Lake Huron, on the contrary, the relatively lowest maximum yield was 263 percent of the 1929 catch (H–1) and the maxima in the remaining districts ranged from 317 in H–2 to as high as 2,662 in H–5. This comparison lends additional strong support to the belief that the use of the deep trap net brought about an excessive increase in yield in Lake Huron, especially in the four southern districts.

The maxima of fishing intensity were relatively lower in Lake Michigan than were the maxima of production. The peak fishing intensity was more than twice the normal only in southern Lake Michigan (M–6, M–7, and M–8). The five remaining percentages were all below 200, and two of them (M–4 and M–5) were less than 150. In Lake Huron the maximum percentage was more than twice the normal in every district; in the four southerly districts the maxima ranged from roughly 4 to 42 times the normal. Again the comparison of data for Lake Michigan and Lake Huron supports the earlier conclusion, namely, that the deep-trap-net operations led to an abnormally increased fishing intensity in Lake Huron with the increase greatest in the central and southern regions of the lake.

The maxima of abundance of whitefish were relatively higher in Lake Michigan than in Lake Huron. In two districts the percentages exceeded 200 (M–6 and M–7); of the remaining six districts the percentages were above 150 in five and below 150 in only one. The corresponding percentages for Lake Huron were all below 150. These low values of the maximum abundance of whitefish in Lake Huron suggest the possibility that abundance in 1929, the year taken as normal, may have been somewhat above normal as well as above the Lake Huron average for 1929–1939. An alternative explanation is offered by the possibility that, in some districts at least, a higher maximum abundance might have been attained if fishing intensity and production had been less.

The estimates of the 1939 conditions in Lakes Michigan and Huron in relation to the assumed "normals" for the lakes provide further striking comparisons. Production was at a low level in both lakes in 1939. In Lake Michigan, however, only two districts of eight had yields below 20 percent of normal, whereas in Lake Huron three of the six districts were below that level. Three of the Lake Michigan districts had percentages of 40 or above; in Lake Huron the only production greater than 40 percent of normal (46 in H–6) was made possible by reason of a fishing intensity that was more than 4 times the normal.

Fishing intensities in 1939 were generally relatively lower in Lake Michigan than in Lake Huron. In five of six districts of Lake Huron the intensity of the fishery for whitefish was 50 percent or more of the 1929 "normal"; in 2 districts (H–5 and H–6) the intensity in 1939 was more than 4 times the normal. The intensity of the whitefish fishery in Lake Michigan was above 50 percent of normal in only four of eight districts and was only 88 percent in M–4, the district with the most intensive fishery.

The comparison of the relative abundance of whitefish in Lakes Michigan and Huron in 1939 provides an explanation for the fact that the percentages for production were the higher in Lake Michigan in that year despite a relatively more intensive fishery in Lake Huron. The abundance of whitefish was below normal in 1939 in every district of Lake Michigan. However, the percentage was below 50 in only two of the eight districts (M–5 and M–7) and was below 60 in only three (M–5, M–6, and M–7). In Lake Huron, on the other hand, the abundance of whitefish was less than 50 percent of the 1929 "normal" in every district, and was so low as to suggest the virtual disappearance of the species from the four most southerly districts. Thus it seems that where the whitefish merely declined in abundance in Lake Michigan the species approached extermination in most of Lake Huron.

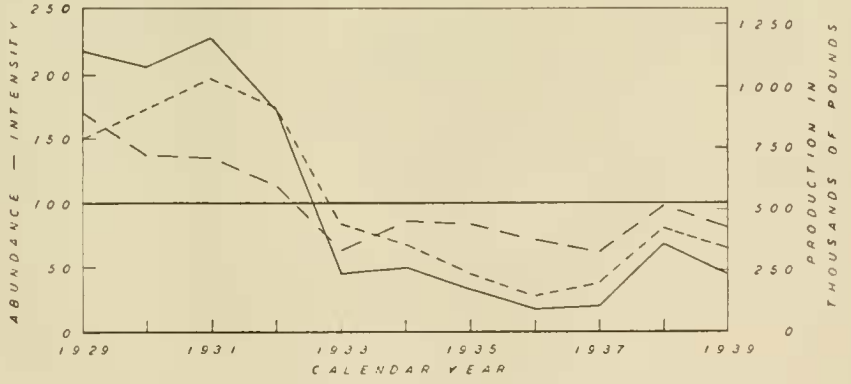
The possibility that abundance may have been above normal in 1929, the "normal" year of reference for Lake Huron, does not affect the validity of the preceding statement. If it is assumed, for example, that the abundance of whitefish in Lake Huron was 50 percent above normal in 1929, hence that the percentages for 1939 should be increased 50 percent, the following estimates are obtained of 1939 abundance as percentages of normal:

District	*Abundance*	*District*	*Abundance*
H–1	62	H–4	10
H–2	64	H–5	8
H–3	9	H–6	15

Even this increase leaves the percentages extremely low for the four southerly districts, although the percentages for H–1 and H–2 are raised to a point corresponding roughly with the general level in Lake Michigan.

The evidence that the use of deep trap nets in Lake Huron led to an excessively great, and ultimately ruinous, expansion of the whitefish fishery should not be taken to signify that overfishing did not take place in Lake Michigan also. The capacity for overfishing is not an exclusive characteristic of any one type of gear. Emphasis has been placed on overfishing by the deep trap net merely because its extraordinary efficiency made possible the extreme condition of overfishing observed in central and southern Lake Huron. Obviously the removal of an equal quantity of whitefish by any other gear would have proved equally disastrous.

Although the maxima of production were relatively lower in Lake Michigan than in Lake Huron, it must be considered probable that in some of the Lake Michigan districts the catch of whitefish was sufficiently great to affect adversely the abundance of the species in later years. In M–1, for example, the high fishing intensity (tables 19 and 20) that made possible the production of roughly a million pounds of whitefish in



Figures 13 to 20 show the annual fluctuations in the production (solid lines) and abundance (long dashes) of whitefish and in the intensity of the whitefish fishery (short dashes) over the period, 1929–1939, in each of the eight statistical districts of Lake Michigan (see fig. 4). In each figure the central horizontal line represents the average conditions for the 11 years, 1929–1939.

FIGURE 13.—First district, M-1.

the four consecutive years, 1929–1932 (table 15), may well have contributed to the sharp decline in abundance in 1933 (table 21). Similarly, in other districts the declines in abundance that followed years of increased fishing intensity and high yields might have been less severe had the fishery of the preceding years been less intensive. The actual detection of the possible effects of high production on the abundance of whitefish in later years is difficult, since in Lake Michigan as in Lake Huron a decline from the peak of abnormal abundance was to be anticipated whether or not extensive overfishing occurred. Furthermore, the data for Lake Michigan do not provide the sharp contrasts that made the presence and effects of overfishing in Lake Huron so easy to detect. (Compare especially the annual fluctuations in the production and fishing intensity in the various districts of the two lakes—figs. 5–10 for Lake Huron and 13–20 for Lake Michigan.)

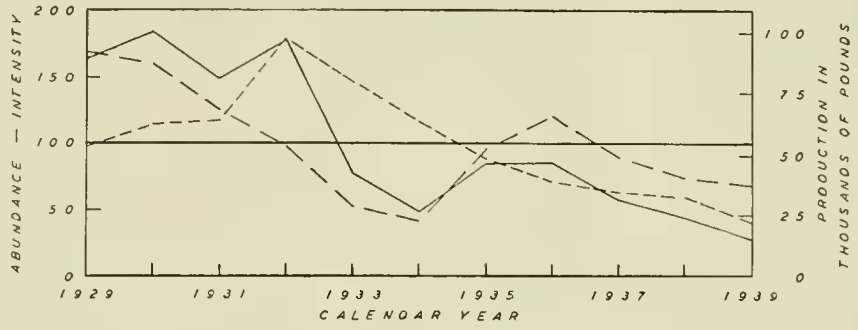


FIGURE 14.—Second district, M-2.

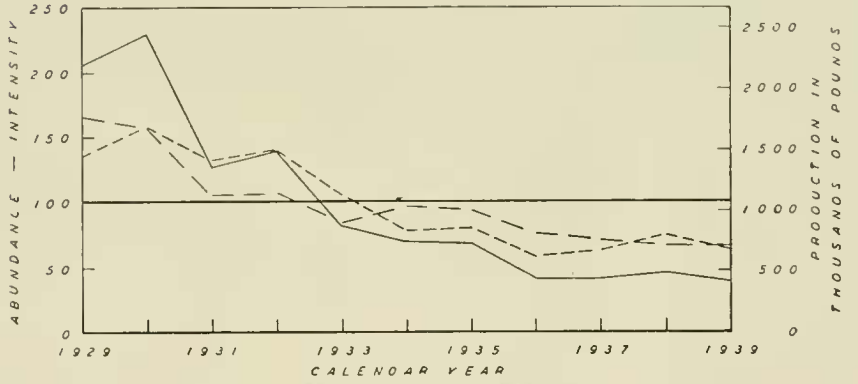


FIGURE 15.—Third district, M-3.

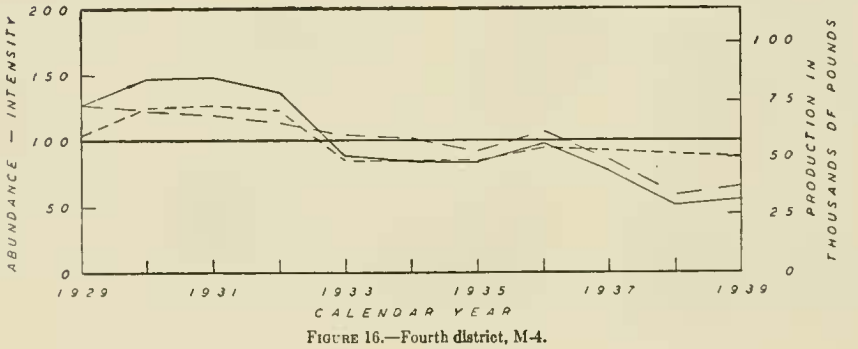


FIGURE 16.—Fourth district, M-4.

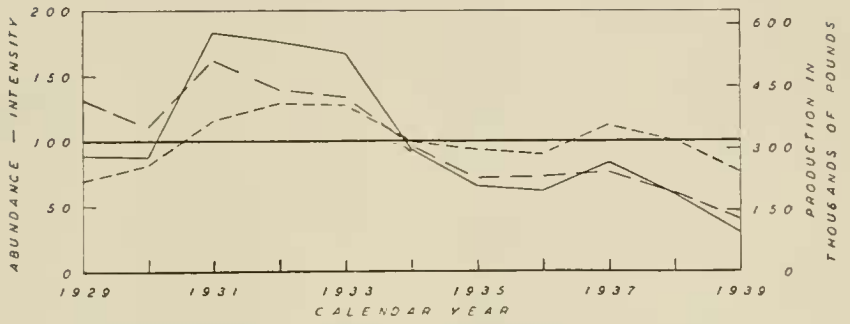


FIGURE 17.—Fifth district, M-5.

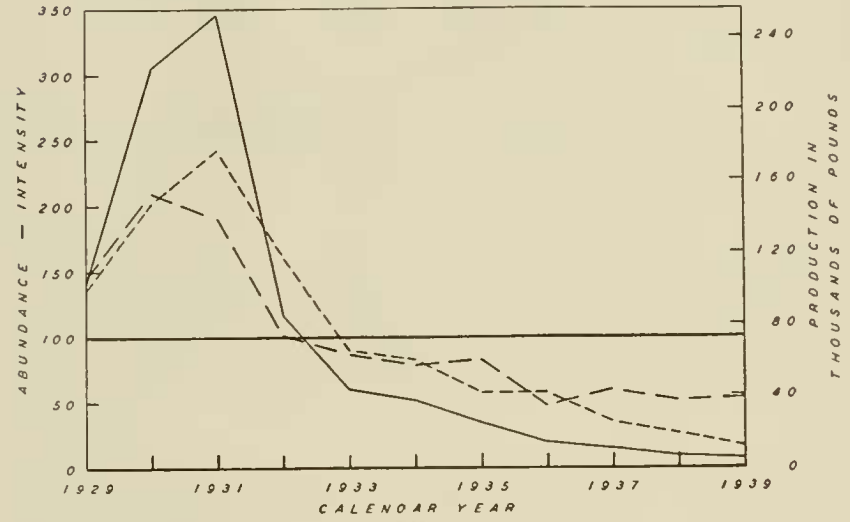


FIGURE 18.—Sixth district, M-6.

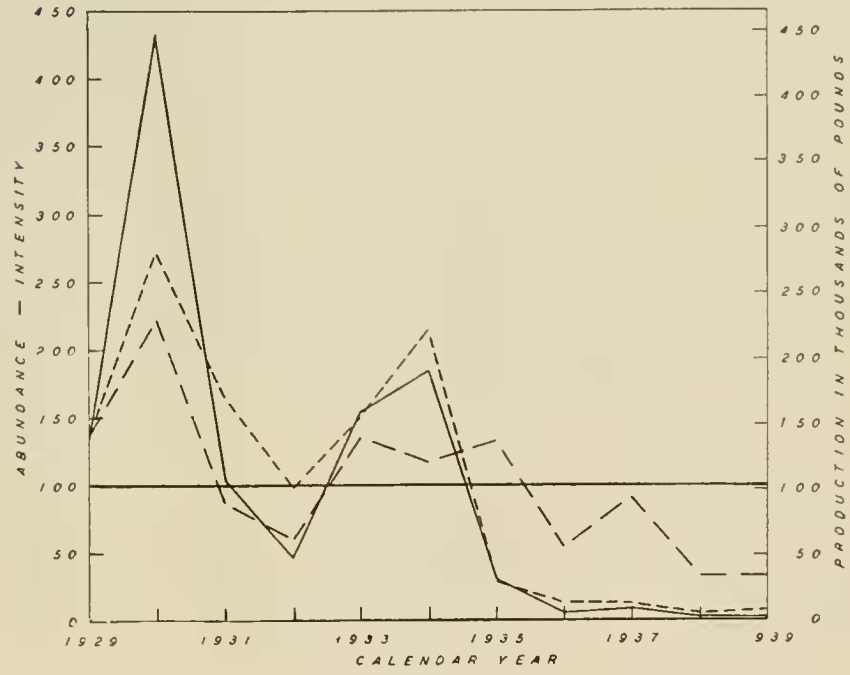


FIGURE 19.—Seventh district, M-7.

FIGURE 20.—Eighth district, M-8.

TABLE 19.—*Annual fluctuations in the intensity of the fishery for whitefish in each district of Lake Michigan*

[Expressed as percentages of the average 1929–1939 intensity in the district]

District	Fishing intensity as percentage of average in year										
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
M-1	149	173	196	174	84	68	45	28	38	80	65
M-2	98	115	118	180	147	117	89	71	64	60	41
M-3	136	159	133	141	107	79	81	59	64	76	65
M-4	104	125	127	123	85	85	85	95	93	90	88
M-5	70	82	116	129	128	100	94	90	113	101	77
M-6	135	201	242	160	89	82	57	57	35	26	16
M-7	136	271	165	98	150	214	28	14	12	5	7
M-8	152	99	114	74	183	215	139	36	36	18	34

TABLE 20.—*Annual fluctuations in the intensity of the whitefish fishery for all eight districts of Lake Michigan combined (third row from bottom) and distribution of each year's intensity among the districts*

[The average annual intensity for the entire lake, 1929–1939, is 100.0. In parentheses are the intensity values of the deep-trap-net fishery. The value of one unit is 1/1100 of the total expected catch (p. 314) of all districts, 1929–1939]

District or area	Fishing intensity in year											Total	Percentage of intensity represented by deep trap nets
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939		
M-1	32.1	37.5 (1.2)	42.3 (4.8)	37.7 (7.0)	18.1 (6.1)	14.7 (3.3)	9.7 (1.1)	6.1	8.2	17.3	14.0	237.7 (23.5)	9.9
M-2	2.6	3.0	3.1 (0.7)	4.6 (2.3)	3.8 (2.6)	3.1 (1.7)	2.3 (0.8)	1.8	1.7	1.6	1.1	28.7 (8.1)	28.2
M-3	63.6	74.7 (3.7)	62.6 (11.8)	66.1 (21.4)	50.4 (19.4)	37.4 (12.2)	37.9 (11.1)	27.7	30.0	35.4	30.8	516.6 (79.6)	15.4
M-4	2.7	3.3	3.4	3.3	2.3	2.2	2.3	2.5	2.5	2.4	2.3	29.2	
Northern Lake Michigan (M-1, M-2, M-3, & M-4)	101.0	118.5 (4.9)	111.4 (17.3)	111.7 (30.7)	74.6 (28.1)	57.4 (17.2)	52.2 (13.0)	38.1	42.4	56.7	48.2	812.2 (111.2)	13.7
Central Lake Michigan (M-5)	10.3	12.1	17.2	19.1	18.9	14.7	13.9	13.2	16.7	14.9	11.5	162.5	
M-6	3.4	5.1	6.1	4.0	2.3	2.1	1.5	1.4	0.9	0.6	0.4	27.8	
M-7	4.9	9.7	5.9	3.5	5.4	[1]7.7	1.0	0.5	0.4	0.2	0.2	39.4	7.4
M-8	8.0	5.2	6.1	3.9	9.6	11.3	7.4	1.9	1.9	1.0	1.8	58.1	
Southern Lake Michigan (M-6, M-7, & M-8)	16.3	20.0	18.1	11.4	17.3	21.1	9.9	3.8	3.2	1.8	2.4	125.3	2.3
Lake Michigan (all 8 districts)	127.6	150.6 (4.9)	146.7 (17.3)	142.2 (30.7)	110.8 (28.1)	93.2 [1](20.1)	76.0 (13.0)	55.1	62.3	73.4	62.1	1,100.0 (114.1)	10.4
Percentage of intensity represented by deep trap nets		3.3	11.8	21.6	25.4	21.6	17.1					10.4	

[1] Intensity represented by deep-trap-net operations in M-7 in 1934 was 2.9.

TABLE 21.—*Annual fluctuations in the abundance percentages for whitefish in the various districts and areas of Lake Michigan, 1929–1939*

[Expressed as percentages of average 1929-1939 abundance. In the computation of percentages for areas of more than one district and for the entire lake the abundance percentage for each district was weighted according to the percentage of the total 1929–1939 production contributed by that district]

District or area	Abundance percentage in year										
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
M-1	170	137	135	113	63	86	84	71	62	98	81
M-2	169	161	126	99	53	42	96	121	90	74	69
M-3	166	158	106	108	85	98	95	77	72	68	67
M-4	127	123	120	114	104	102	92	107	86	59	66
Northern Lake Michigan (M-1, M-2, M-3, and M-4)	166	150	116	109	78	93	92	78	70	77	71
Central Lake Michigan (M-5)	132	111	162	140	134	97	72	73	77	61	41
M-6	144	209	190	101	86	78	82	47	59	51	53
M-7	136	222	86	60	135	117	133	54	91	33	33
M-8	151	131	113	78	142	130	96	48	72	68	71
Southern Lake Michigan (M-6, M-7, and M-8)	144	180	123	78	126	113	105	50	75	52	54
Lake Michigan (all 8 districts)	158	149	123	109	92	96	91	73	72	72	65

A suggestion of overfishing is provided by the data for M–7. In this district the greatest maximum yield (433 percent of the 1929–1939 average) was associated with the lowest relative abundance (33 percent) in 1939 (table 18). Abundance in 1939 was low also in M–6 (53 percent), the district with the second highest maximum production percentage (345). The maximum fishing intensity also was relatively high in both M–6 and M–7 (242 and 271, respectively). On the other hand, the 1939 abundance was low (41 percent) in M–5, where there was no indication of overfishing in 1929–1939 (maximum production, 183 percent of normal; maximum intensity, 129 percent of normal).

Although, as stated previously, overfishing cannot be disregarded as a possible contributing factor in the decline in abundance of the Lake Michigan whitefish, there can be no doubt that overfishing was relatively unimportant in Lake Michigan as compared with Lake Huron. In the discussion of the data for Lake Huron emphasis was placed on the unreasonable expansion of fishing intensity and especially on the fact that this intensity remained abnormally high even in the face of decreasing abundance. The data for Lake Michigan, on the contrary, reveal a much more rational relationship between abundance and fishing intensity (and hence between abundance and yield).

Despite certain exceptions it can be said that in the Lake Michigan districts, as a whole, periods of relatively high abundance were also periods of relatively high fishing intensity and production (tables 15, 19, and 21; figs. 13 to 20). It is true that the changes in fishing intensity tended to lag somewhat behind the changes in abundance. Commonly the peak of fishing intensity occurred a year or two later than the peak of abundance, and the subsequent decline in fishing intensity was delayed correspondingly. Nevertheless, fishing intensity and yield were above average in a large majority of the years in which the abundance of whitefish was above average, and, conversely, fishing intensity and production were below average in the majority of the years in which the abundance of whitefish was below average. There was a tendency also for the percentages of fishing intensity and catch to be greater than the abundance percentages when abundance was above average and less than the abundance percentages when abundance was below average. The curves of fishing intensity tended to lie outside (with reference to the average) the curves of abundance, and the curves of production tended to fall outside both the curves of abundance and fishing intensity.

The tendency for the Lake Michigan fishermen to regulate their fishing activities according to the abundance of whitefish is brought out further by the fact that the coefficient of correlation between the percentages of fishing intensity and abundance

over the 11-year period (88 pairs of percentages) was 0.70. For Lake Huron, where intensive fishing frequently was carried on despite a low abundance of whitefish, the coefficient of correlation between the percentages of fishing intensity and abundance (66 pairs of percentages) was only 0.23.

The statement that fishing intensity and production were better adjusted to the abundance of whitefish in Lake Michigan than in Lake Huron applies to the data for the entire lakes (table 22) as well as to the data for the individual districts. (Compare also figs. 11 and 21.) In Lake Michigan the fishing intensity for whitefish was

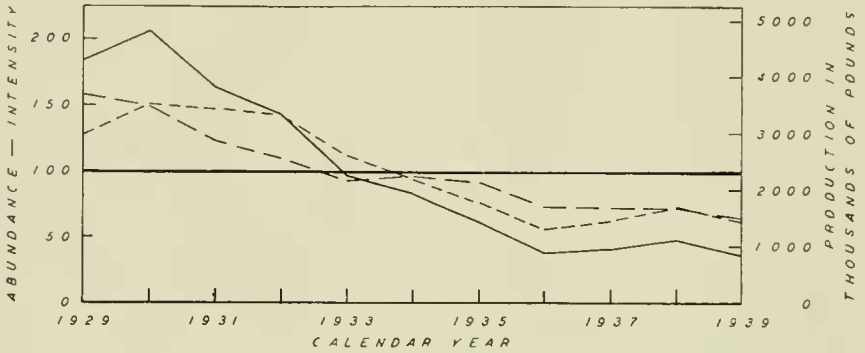


FIGURE 21.—Annual fluctuations in the production (solid line) and abundance (long dashes) of whitefish and in the intensity of the whitefish fishery (short dashes) in Lake Michigan (all eight districts combined), 1929–1939.

above average in every year in which the abundance was above average and was less than average in 6 of the 7 years in which abundance was below average. Furthermore, the intensity percentage exceeded the abundance percentage in 3 of the 4 years in which abundance was above 100 but was less than the abundance percentage in 5 of the 7 years in which abundance was below 100. Every year in which the abundance of whitefish was above average was a year of greater than average production; the catch of whitefish was below average, however, in every year in which the abundance of the species was below average. The production percentage exceeded the abundance percentage in every year in which abundance was above average, but the former was less than the latter in 6 of the 7 years with abundance below average.

TABLE 22.—*Production and abundance of whitefish and the intensity of the whitefish fishery in the State of Michigan waters of Lakes Michigan and Huron*

[Expressed as percentages of the 1929–1939 average]

Lake	Item	Year										
		1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
Michigan	Production	184	206	164	143	96	83	61	38	41	48	36
	Fishing intensity	128	151	147	142	111	93	76	55	62	73	62
	Abundance	158	149	123	109	92	96	91	73	72	72	65
Huron	Production	68	134	193	189	155	120	88	67	48	26	12
	Fishing intensity	46	69	100	120	155	125	139	112	100	88	46
	Abundance	152	195	195	140	89	77	67	61	55	38	31

Altogether different was the relationship of fishing intensity and production to the abundance of whitefish in Lake Huron. In that lake the fishing intensity was above average in 5 (exactly 100 percent in 1 year) of the 7 years in which abundance was below average; furthermore, the intensity percentage exceeded the abundance percentage in every one of these 7 years. The catch also was disproportionately high in periods of low abundance. The catch percentage exceeded the abundance percentage in

4 of the 7 years in which abundance was less than 100. The circumstance that fishing intensity was so much below the maximum in the years in which the abundance of the Lake Huron whitefish was above average should not be taken to indicate that the Lake Huron fishermen were less prompt than the Lake Michigan fishermen to take advantage of this abnormal abundance. In fact, the fishing intensity rose sharply in Lake Huron as the increase from 46 in 1929 to 100 in 1931 shows. The 1931 intensity was more than twice that of 2 years earlier. The fishing intensity in these early years of the 11-year period is represented by small percentages simply because the excessive use of deep trap nets led to a 1929–1939 average of fishing intensity that was far above a level that could reasonably be considered normal. It is doubtful whether without the use of deep trap nets the intensity would have reached the high level recorded for 1932, and much less have risen to still higher levels and maintained itself above the 1932 intensity until 1936. These considerations serve to bring out again the immensity of the overfishing that occurred in Lake Huron.

From the mass of evidence obtained from the statistical data of the whitefish fisheries of Lakes Huron and Michigan the following general conclusions may be drawn.

Lake Huron.—The deep-trap-net fishery, expansion of which was fostered by an abnormal abundance of whitefish that reached its peak in 1930–1931, was the primary cause of excessive overfishing in Lake Huron. This overfishing led to the collapse of the whitefish fishery in central and southern Lake Huron and contributed to the decline of the fishery in the northern part of the lake.

Lake Michigan.—A similar abnormal abundance of whitefish in Lake Michigan, with the peak probably in 1929, was accompanied by increases in fishing intensity and production. Although this intensive fishery may have affected adversely the later abundance of whitefish, there is no evidence of overfishing comparable to that which occurred in Lake Huron. The decline of the whitefish in Lake Michigan was pronounced but not disastrous. The difference in the course of the fishery in the two lakes can be attributed to the relatively limited use of deep trap nets in Lake Michigan.

PART III

BATHYMETRIC DISTRIBUTION OF WHITEFISH AND OF CERTAIN OTHER SPECIES IN THE SHALLOWER WATERS OF LAKES HURON AND MICHIGAN

The following sections are based on counts of whitefish and certain other species in 456 lifts of pound nets and deep trap nets in Lake Huron and 380 lifts in Lake Michigan in the years, 1931–1932. The original compilations of the data were much more detailed than those presented here. The tables showing the bathymetric distribution of the fish represent combinations of large-mesh (4 inches and larger, stretched measure) and small-mesh (less than 4 inches) nets of different dimensions, of different fishing grounds in the same general area, and of data for corresponding months in 1931 and 1932. However, these combinations were made only after a careful examination of the material demonstrated that the condensed data did not lead to conclusions that were at variance with those that would have been drawn from more detailed information.

In the main, the data have been compiled according to 10-foot depth intervals. However, for species other than the yellow pike, all lifts of nets from depths of 40 feet and less have been combined, as have also those from 41–60 feet. In deep water all lifts from more than 120 feet (more than 110 feet in Lake Michigan) have been combined. The greatest depth in which a deep trap net was set, so far as we know, was about 160 feet. This net was set in Lake Huron. Seldom were deep trap nets placed in water deeper than 140 feet. In Lake Michigan the whitefish grounds were located in much shallower water. Although a few pound nets set in more than 60 feet of water were visited and a few deep-trap-net lifts from depths of 60 feet or less were observed, for practical purposes the 60-foot contour may be considered as the line of separation of the two types of gear. The change from pound nets to deep trap nets at a depth of about 60 feet should not affect the value of the data, since we did not find any important differences in the catch of pound nets and deep trap nets that were fished in the same depth of water. All lifts observed from depths of more than 120 feet were made in Lake Huron.

As a convenience in reading the tables, asterisks have been employed to designate those depth intervals that contained the more significant peak concentrations of fish. As an additional convenience, whitefish and yellow pike frequently will be termed merely "legal" and "illegal" fish on the basis of a 2-pound and 1½-pound size limit, respectively, which limits were in effect in Michigan at the time of the investigation.

BATHYMETRIC DISTRIBUTION OF WHITEFISH IN LAKE HURON

NORTHERN LAKE HURON (CHEBOYGAN AND ROGERS CITY)

The number of lifts (20) of pound nets and deep trap nets observed in northern Lake Huron was insufficient to provide reliable data on the bathymetric distribution of the whitefish. The largest lifts of legal-sized whitefish were taken from depths of 71–80 feet in July and August and of 61–70 feet in September (table 23). The greatest numbers of illegal-sized fish occurred in lifts from 71–80 and 91–100 feet. (Only one lift from the latter depth was observed.)

ALPENA-OSSINEKE GROUNDS

Although a fairly large number (158) of pound-net and deep-trap-net lifts was examined on the Alpena and Ossineke grounds, the scarcity of data for the shallower water makes a detailed description of the depth distribution of whitefish in this area impossible (table 24). Nearly half of the lifts were from depths of 111–120 feet and the

bulk of the remainder were from depths of 81–110 feet. For no month were data available for all waters. Outstanding features of the Alpena-Ossineke data were the comparative scarcity of legal whitefish and the great abundance of undersized individuals.

TABLE 23.—*Number of legal and illegal whitefish per lift of pound nets and deep trap nets in northern Lake Huron (ports of Cheboygan and Rogers City), 1931–1932*

[Number of lifts in parentheses. Asterisks indicate concentrations]

Month	Number of legal whitefish per lift at depth (in feet)					Month	Number of illegal whitefish per lift at depth (in feet)				
	41–60	61–70	71–80	81–90	91–100		41–60	61–70	71–80	81–90	91–100
July		20 0 (2)	51 2 (4)			July		46 5 (2)	40 0 (4)		
August			19 0 (2)	3 0 (2)	12 0 (1)	August			88 0 (2)	17 5 (2)	69 0 (1)
September	9 0 (1)	26 2 (5)	12 3 (3)			September	6 0 (1)	5 8 (5)	5 7 (3)		
Average	9 0 (1)	24 4 (7)	31 1* (9)	3 0 (2)	12 0 (1)	Average	6 0 (1)	17 4 (7)	39 2* (9)	17 5 (2)	69 0 (1)

TABLE 24.—*Number of legal and illegal whitefish per lift of pound nets and deep trap nets in the Alpena-Ossineke area, 1931–1932*

[Number of lifts in parentheses. Asterisks indicate concentrations]

Month	Number of legal whitefish per lift at depth (in feet)							
	41–60	61–70	71–80	81–90	91–100	101–110	111–120	>120
May				20 0 (1)		20 0 (1)	34 0 (23)	54 0* (4)
June	9 8 (4)	9 0 (1)		39 0 (1)	23 0 (1)	23 7* (6)	14 7 (18)	15 0 (5)
July	7 0 (1)		24 0 (1)	43 2* (5)	37 3 (12)	12 6 (7)	36 0* (23)	
August	42 0 (2)	71 0 (1)	92 7* (7)	50 4 (9)	44 3 (3)	21 0 (5)	35 2* (10)	
September						96 8 (5)	198 5* (2)	
Average	19 6 (7)	40 0 (2)	84 2* (8)	45 6 (16)	37 8 (16)	35 0 (24)	34 5 (76)	32 3 (9)

Month	Number of illegal whitefish per lift at depth (in feet)							
	41–60	61–70	71–80	81–90	91–100	101–110	111–120	>120
May				219 0 (1)		243 0 (1)	255 8* (23)	239 2 (4)
June	106 0 (4)	109 0 (1)		311 0 (1)	163 0 (1)	190 0* (6)	64 2 (18)	62 8 (5)
July	262 0 (1)		95 0 (1)	195 8* (5)	117 8 (12)	52 3 (7)	69 0* (23)	
August	173 0* (2)	86 0 (1)	75 7 (7)	114 1* (9)	38 7 (3)	36 4 (5)	66 5* (10)	
September						33 4 (5)	92 5* (2)	
Average	147 4* (7)	97 5 (2)	78 1 (8)	158 5* (16)	105 8 (16)	87 4 (24)	124 7 (76)	141 2 (9)

Distribution of legal-sized whitefish.—In May the average numbers of legal whitefish taken in 111–120 feet and in "deep-water" (more than 120 feet) lifts were above those of the single lifts from 81–90 and 101–110 feet. In June, however, the average catches of the nets from the deeper water were exceeded by the catch of the 6 nets set in 101–110 feet. The 5 lifts in shallow water (41–70 feet) averaged only 9.0 and 9.8 fish for the two intervals involved. The largest average lifts in July occurred at depths of 81–90 feet (43.2) and 91–100 feet (37.3). However, the average number of fish in lifts from 111–120 feet was almost three times that of lifts from the 101–110 foot interval. The single lift in shallow water (41–60 feet) was again small (7.0 fish). The depth from which the largest lifts were made in August was shallower than that in July (71–80 feet). It is to be noted also that the average numbers of fish taken in the shallow water far exceeded the corresponding averages for June and July. In August, again, the catch of nets set at 111–120 feet was well above that of nets set at 101–110 feet. This agreement between the July and August data suggests that in late summer whitefish may be concentrated at more than one depth.[30] The September data cover only two intervals of depth. In this month the average number of legal whitefish per lift from 111–120 feet was twice that of nets from 101–110 feet, and in both intervals the numbers were relatively large, suggesting a return of the fish to deep water.

The data offer some evidence of an onshore movement of legal whitefish as the summer progresses. In May concentrations were greatest in the deepest water (beyond 110 feet). In June a general shift seemed to have occurred to waters between 80 and 111 feet deep, in July to waters of depths between 70 and 101 feet, and in August to depths between 60 and 91 feet.

In the averages for the entire season the number of legal fish per lift increased from shallow water to a maximum of 84.2 fish at depths of 71–80 feet. Beyond this depth interval there was a continuous decline in the average number of legal whitefish per lift.[31]

Distribution of illegal-sized whitefish.—The data on the bathymetric distribution of illegal whitefish bear considerable resemblance to those of legal fish. In both size groups the average number of fish per lift was greater at 111–120 feet than at 101–110 feet in every month but June. Furthermore, both groups appear to undertake an onshore movement as the summer progresses. A difference is found between the vertical distribution of legal and illegal whitefish in the greater abundance of the latter group in shallow water.

The averages for the entire season show heavy concentrations of young whitefish in the intervals: 41–60 feet, 81–90 feet, and more than 120 feet. These fish were least abundant in depths of 71–80 and 101–110 feet. These averages, however, are influenced by the shift in concentrations. The monthly figures indicate a heavy concentration in all depths beyond 80 feet in May, between 80 and 111 feet in June, between 80 and 101 feet in July, and in 81–90 feet in August. In September the number again increased in the 111–120 foot interval. A comparison of the seasons' averages reveals that the maximum concentration of illegal whitefish (81–90 feet) was in water 10 feet deeper than the maximum for legal fish (71–80 feet). However, legal fish did not share the inshore abundance of the smaller whitefish.

SAGINAW BAY AREA (OSCODA, EAST TAWAS, AND BAY PORT)

A total of 223 lifts of pound nets and deep trap nets was examined in the Saginaw Bay area. Despite this large total, the distribution of the lifts leaves certain depths of less than 91 feet poorly represented (table 25). With the exception of a few lifts on northerly and easterly courses out of Oscoda, the deep-trap-net lifts were made on the grounds of district H–4. (See fig. 4.) Most of the pound nets observed were in the neighborhood of East Tawas. The Saginaw Bay area differed from the Alpena-Ossineke grounds in the relatively high abundance of legal, as compared with illegal, fish.

[30] The evidence for more than one "concentration depth" is not strong (particularly for legal whitefish) in the Alpena-Ossineke data. The suggestion is brought out here because of the later conclusive evidence that there are two concentration zones in northeastern Lake Michigan (p. 353). No good evidence of a concentration at 111–120 feet was found in other Lake Huron waters.

[31] The September data obscure the presence of two concentrations of legal whitefish. If the September data are excluded the average numbers of legal whitefish per lift become 18.7 at 101–110 feet and 30.3 at 111–120 feet.

TABLE 25.—*Number of legal and illegal whitefish per lift of pound nets and deep trap nets in the Saginaw Bay area (ports of Au Sable-Oscoda, East Tawas, and Bay Port), 1931–1932*

[Number of lifts in parentheses. Asterisks indicate concentrations]

Month	Number of legal whitefish per lift at depth (in feet)								
	<41	41–60	61–70	71–80	81–90	91–100	101–110	111–120	>120
May						1 0 (1)	23 0 (7)	30 8 (6)	93 0* (5)
June	15 8 (5)	7 6 (9)				11 0 (1)	37 3* (14)	31 2 (22)	18 6 (11)
July	0 2 (6)	18 0 (1)			71 5 (2)	87 7 (11)	129 1* (7)	45 2 (15)	84 3* (6)
August		51 8 (5)	24 0 (3)	111 5 (4)	190 9 (12)	216 8* (12)	176 9 (15)	171 7 (15)	117 0 (10)
September				200 0* (2)	4 0 (1)	15 5 (2)	44 0 (2)	299 8* (4)	250 5 (2)
October								108 0 (2)	167 3* (3)
Average	7 3 (11)	23 0 (15)	24 0 (3)	141 0 (6)	162 5* (15)	133 7 (27)	96 2 (45)	86 6 (64)	90 5 (37)

Month	Number of illegal whitefish per lift at depth (in feet)								
	<41	41–60	61–70	71–80	81–90	91–100	101–110	111–120	>120
May						7 0 (1)	82 3* (7)	56 3 (6)	15 2 (5)
June	30 2 (5)	14 3 (9)				20 0 (1)	52 0* (14)	21 8 (22)	3 7 (11)
July	2 3 (6)	21 0 (1)			17 0 (2)	16 2 (11)	21 0* (7)	5 7 (15)	7 3* (6)
August		25 8 (5)	47 0 (3)	99 8 (4)	150 9* (12)	115 2 (12)	47 6 (15)	30 7 (15)	13 4 (10)
September				63 0* (2)	14 0 (1)	40 5 (2)	85 0* (2)	74 8 (4)	66 5 (2)
October								24 5 (2)	44 0 (3)
Average	15 9 (11)	18 6 (15)	47 0 (3)	87 5 (6)	123 9* (15)	61 8 (27)	51 9 (45)	26 7 (64)	15 1 (37)

Distribution of legal-sized whitefish.—Again there is evidence of an onshore movement of legal whitefish during the summer followed by a return to deeper water in early autumn, apparently beginning in August. (See also p. 350.) The depths of maximum concentration in the different months were: May—more than 120 feet; June and July—101–110 feet (the shift was more toward shallower water in July than in June); August—91–100 feet; September—111–120 feet; October—more than 120 feet (only two intervals represented). There were two peaks in the August data (41–60 feet and 91–100 feet) and in the September data (71–80 feet and 111–120 feet). However, the number of lifts was so small at some depths that it cannot be concluded that the whitefish were concentrated at two depth intervals. The average number of legal whitefish per lift through the entire season increased continuously from shallow water (less than 41 feet) to the maximum at 81–90 feet, declined in the next three intervals, and increased slightly at depths greater than 120 feet.

Distribution of illegal-sized whitefish.—The data on the bathymetric distribution of young whitefish indicate an onshore movement followed by an offshore movement similar to that of legal fish. The depths of maximum concentration were: May, June, and July—101–110 feet (in each succeeding month, however, the shift was toward the shallower water); August—81–90 feet; September—101–110 feet; October—more than 120 feet. In the averages for the entire season the maxima for legal and illegal fish

were in the same interval (81–90 feet). The strongest indication of two concentration zones of illegal fish is found in the scanty September data. Young whitefish were much scarcer in the shallower water of the Saginaw Bay area than at corresponding depths on the Alpena-Ossineke grounds.

HARBOR BEACH GROUNDS

The observations of 55 lifts of deep trap nets off Harbor Beach (no pound nets were observed here) were all made in the latter part of the 1932 season (table 26), when on the basis of the preceding data the whitefish would be expected to be concentrated in the deeper water. Actually here is where the deep trap nets were found in operation. Fifty of the lifts were made from depths greater than 90 feet. Consequently, no detailed description of the vertical distribution of whitefish at all depths in this area is possible. The maximum concentration of both legal and illegal whitefish occurred in the 101–110 foot interval in all three months. In the season's average the number of legal fish per lift was greater at 91–100 feet than in waters deeper than 110 feet, but the reverse relationship was found in the data for illegal whitefish. The single shallow-water lift (41–60 feet) contained no whitefish. The legal whitefish were more abundant than the illegal fish at all depths.

TABLE 26.—*Number of legal and illegal whitefish per lift of deep trap nets off Harbor Beach, 1932*

[Number of lifts in parentheses. Asterisks indicate concentrations]

Month	Number of legal whitefish per lift at depth (in feet)							
	41–60	61–70	71–80	81–90	91–100	101–110	111–120	>120
August					251 0 (1)	420 5* (2)	408 3 (4)	135 8 (5)
September	0 0 (1)		101 0 (1)	42 0 (3)	270 5 (8)	291 7* (12)	134 2 (6)	163 0 (3)
October					62 5 (2)	117 3* (3)	34 5 (2)	46 0 (2)
Average	0 0 (1)		101 0 (1)	42 0 (3)	231 5 (11)	276 1* (17)	208 9 (12)	126 0 (10)

Month	Number of illegal whitefish per lift at depth (in feet)							
	41–60	61–70	71–80	81–90	91–100	101–110	111–120	>120
August					150 0 (1)	298 0* (2)	266 8 (4)	79 0 (5)
September	0 0 (1)		65 0 (1)	33 3 (3)	73 2 (8)	167 2* (12)	67 7 (6)	75 3 (3)
October					32 0 (2)	67 7* (3)	32 0 (2)	55 5 (2)
Average	0 0 (1)		65 0 (1)	33 3 (3)	72 7 (11)	165 0* (17)	128 1 (12)	73 2 (10)

BATHYMETRIC DISTRIBUTION OF WHITEFISH IN LAKE MICHIGAN

GREEN BAY AREA (MARINETTE, ESCANABA, AND FAIRPORT)

The 30 lifts of pound nets and deep trap nets observed in the Green Bay area do not offer adequate information on the bathymetric distribution of the whitefish at any one time or on the seasonal movements of whitefish. The data of table 27, however, indicate rather clearly that legal whitefish in this region were in deeper water in September (61–80 feet) than in May (60 feet and less). Illegal whitefish were relatively numerous in May at depths less than 61 feet, and were present in large numbers also in the two lifts from the 81–90 foot interval. Few illegal whitefish were taken at any depth in September.

TABLE 27.—*Number of legal and illegal whitefish per lift of pound nets and deep trap nets in the Green Bay area (ports of Marinette, Escanaba, and Fairport), 1931–1932*

[Number of lifts in parentheses. Asterisks indicate concentrations]

Month	Number of legal whitefish per lift at depth (in feet)						
	<41	41–60	61–70	71–80	81–90	91–100	101–110
May	61 4 (5)	51 2 (5)	16 0 (1)		23 5 (2)		
September	4 0 (1)	9 8 (4)	33 8 (5)	68 7* (3)		4 5 (2)	8 5 (2)
Average	51 8 (6)	32 8 (9)	30 8 (6)	68 7 (3)	23 5 (2)	4 5 (2)	8 5 (2)

Month	Number of illegal whitefish per lift at depth (in feet)						
	<41	41–60	61–70	71–80	81–90	91–100	101–110
May	56 0 (5)	65 8 (5)	11 0 (1)		183 0 (2)		
September	2 0 (1)	3 5 (4)	7 2 (5)	9 7* (3)		1 5 (2)	2 0 (2)
Average	47 0 (6)	38 1 (9)	7 8 (6)	9 7 (3)	183 0 (2)	1 5 (2)	2 0 (2)

NORTHEASTERN LAKE MICHIGAN
(MANISTIQUE, EPOUFETTE, AND NAUBINWAY)

The data on the bathymetric distribution of the whitefish are more complete for northeastern Lake Michigan than for any other region. Not only was the number of lifts of pound nets and deep trap nets observed large (350) but these lifts were well distributed as to depth of water. Only the deep water (depths greater than 110 feet) was poorly represented, largely because few nets were set there owing to the comparative scarcity of whitefish.

Distribution of legal-sized whitefish.—Peak concentrations of legal whitefish in June occurred at 61–70 feet and 81–90 feet (table 28 and fig. 22). The average number of fish per lift in "deep water" (more than 110 feet) exceeded slightly the average in 101–110 feet but the deeper water was represented by only two lifts. There were again two peaks in July, but in this month they occurred in water 20 feet deeper (81–90 and 101–110 feet). This offshore movement was reflected also in the reduced catches of nets in all waters shallower than 71 feet. The depths of greatest concentration of legal whitefish were the same in August as in July although the small decrease in the average number of fish from nets set in 71–80 feet together with the increase in the catch per net from all deeper waters may be taken as an indication of possible further offshore movement. In September the average number of legal whitefish per lift was below the August average at all depths less than 91 feet. The single peak occurred in the 101–110 foot interval. (Nothing is known concerning the abundance of whitefish at depths greater than 110 feet in September.) The improved catches in the shallower water (less than 71 feet) in October offer evidence of a return onshore movement. In this same month the condition of two concentration zones reappeared although it was by no means pronounced.

The seasons' averages show a consistent increase in the number of legal fish per lift from shallow water (less than 41 feet) to the 81–90 foot interval, followed by a sharp decline at 91–100 feet and a rise to a second peak at 101–110 feet. The average of 7 lifts from the deepest water was about half that of lifts from the 101–110 foot interval.

Distribution of illegal-sized whitefish.—The data on the depth distribution of illegal whitefish resembled in general those for legal fish. Both groups were characterized by

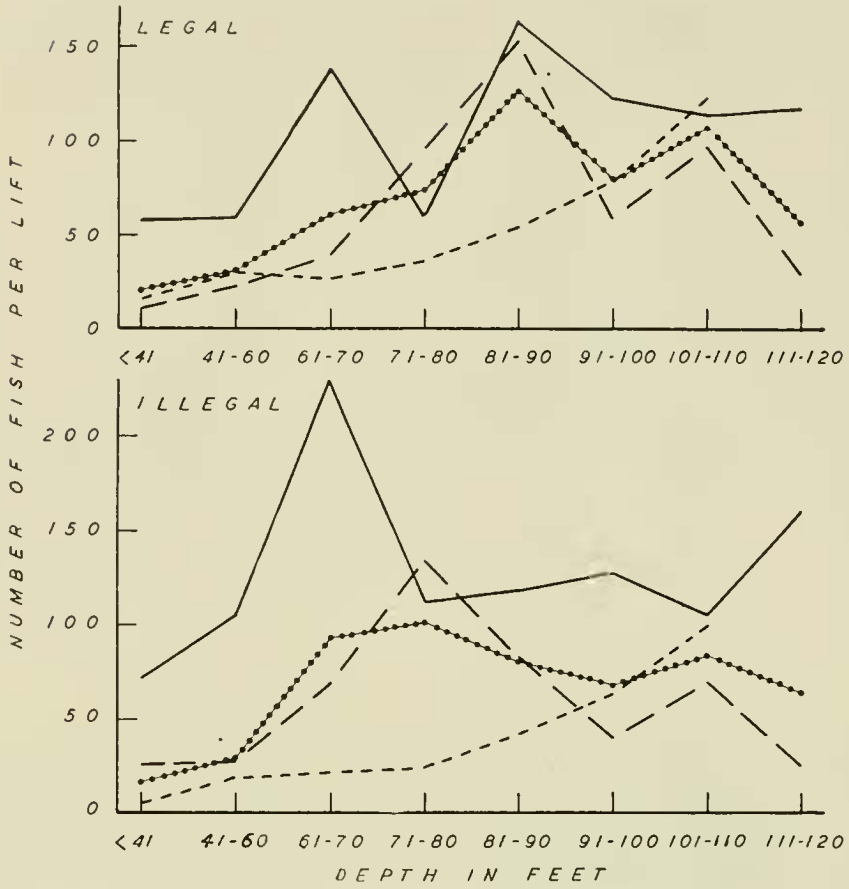


FIGURE 22.—Bathymetric distribution of legal- and illegal-sized whitefish in northeastern Lake Michigan as determined from the average numbers of fish per lift of pound nets and deep trap nets. June, solid line; July-August, long dashes; September-October, short dashes; entire season, dotted line.

two concentration zones in every month but September, and both showed an offshore movement of the fish during the summer. The two groups of data differed at times, however, as to the actual depths of the concentrations. A further difference lay in the lack of evidence of an onshore movement of illegal fish in October.

The June averages of the number of undersized whitefish per lift had peaks at 61–70 and 91–100 feet. With the illegal, as with the legal, fish the average for the deepest water (more than 110 feet) exceeded that for the 101–110 foot interval. The inshore concentration coincided with that of the legal fish, but the offshore concentration occurred 10 feet deeper. In July the movement toward deeper water increased the depth of each of the concentration zones of illegal whitefish by only 10 feet as compared with 20 feet for the legal fish. The depth intervals of the concentration zones remained unchanged in August although the decrease in the average number of fish per lift in all depths less than 91 feet points toward further offshore movement. The decrease in the number of illegal fish per lift at these depths continued in September. At the same time the number per lift increased in the 91–100 foot and 101–110 foot intervals. The September data had only one peak (at 101–110 feet) but there were again two concentration zones in October. The October averages for shallow-water lifts (depths less than 71 feet), contrary to the data for legal fish, showed no tendency to increase over those for September.

The seasons' averages indicated an increase in the number of illegal whitefish per lift from shallow water (less than 41 feet) to a peak at 71–80 feet, followed by a decline to 91–100 feet, a rise to a second peak at 101–110 feet, and yet another decrease in the

TABLE 28.—*Number of legal and illegal whitefish per lift of pound nets and deep trap nets in northeastern Lake Michigan (ports of Manistique, Epoufette, and Naubinway), 1931–1932*

[Number of lifts in parentheses. Asterisks indicate concentrations]

Month	Number of legal whitefish per lift at depth (in feet)							
	<41	41–60	61–70	71–80	81–90	91–100	101–110	>110
June	57 5 (8)	59 3 (3)	138 8* (4)	59 5 (8)	164 3* (23)	122 5 (11)	113 7 (7)	117 5 (2)
July	10 0 (7)	17 6 (5)	39 2 (5)	104 3 (11)	140 9* (17)	58 4 (5)	92 9* (13)	7 7 (3)
August	----	44 0 (1)	----	90 2 (16)	162 3* (22)	59 4 (15)	100 0* (15)	63 5 (2)
September	7 6 (20)	28 1 (9)	18 0 (3)	36 2 (13)	55 0 (14)	88 4 (17)	121 6* (8)	----
October	23 1 (23)	31 5 (11)	35 7 (3)	----	52 6* (13)	49 5 (6)	122 7* (7)	----
Average	20 9 (58)	31 4 (29)	60 8 (15)	73 7 (48)	125 8* (89)	80 2 (54)	106 7* (50)	55 0 (7)
	Number of illegal whitefish per lift at depth (in feet)							
June	71 4 (8)	104 7 (3)	230 0* (4)	112 2 (8)	117 7 (23)	126 7* (11)	105 0 (7)	160 0 (2)
July	25 7 (7)	28 2 (5)	69 6 (5)	182 7* (11)	87 1 (17)	39 4 (5)	65 2* (13)	10 7 (3)
August	----	24 0 (1)	----	101 4* (16)	80 5 (22)	40 2 (15)	73 1* (15)	45 0 (2)
September	4 0 (20)	21 7 (9)	20 7 (3)	23 6 (13)	35 1 (14)	70 3 (17)	111 0* (8)	----
October	5 5 (23)	15 9 (11)	22 7 (3)	----	48 5* (13)	43 2 (6)	85 9* (7)	----
Average	16 5 (58)	29 3 (29)	93 2 (15)	100 8* (48)	79 6 (89)	67 6 (54)	83 4* (50)	63 1 (7)

deepest water (more than 110 feet). The zones of concentrations of illegal fish (seasons' average) are separated by 30 feet (difference between average depths of the intervals) as compared with 20 feet in the legal fish. This same difference is to be found in the data for the three months—June, July, and August—but is lacking in October (relatively incomplete data, however).

In general, undersized whitefish tended to live in shallower water than did legal-sized individuals. This tendency is apparent not only from the lesser depth of the inshore concentration zone (71–80 feet for illegal fish and 81–90 feet for legal fish) but also from the large numbers of small whitefish per lift in the still shallower interval, 61–70 feet. Legal-sized fish were slightly the more numerous, however, at depths shallower than 61 feet.

The vertical movements of the whitefish in northeastern Lake Michigan are the reverse of those indicated by the Lake Huron data for the Alpena-Ossineke and Saginaw Bay areas (pp. 350 and 351). In each of these regions of Lake Huron the data indicated an onshore movement of both legal and undersized fish during the summer. Whitefish of both size groups made an offshore movement in northeastern Lake Michigan.

Possible significance of two concentration zones.—The occurrence of two concentration zones of both legal and illegal whitefish in northeastern Lake Michigan[32] raises the interesting question of the possible existence of distinct inshore and offshore populations or races. Certainly, the consistency of the occurrence and the seasonal move-

[32] There was some indication of a similar distribution of whitefish on the Alpena-Ossineke grounds (p. 350). The data for the Saginaw Bay area (p. 351) offered only a suggestion of two concentration zones.

ments of these two concentration zones are such as to label their existence as a real phenomenon, and not a chance result to be ascribed to inadequate data. However, the mere presence of two distinct groupings of whitefish throughout all or most of the season does not make absolutely necessary the assumption of two permanently separated stocks. It is possible that conditions within the lake at certain seasons may produce an "ecological division" of an otherwise homogeneous population.

Records of a number of vertical series of temperature readings made in northeastern Lake Michigan[33] failed to give a clue to the cause of two zones of concentration of whitefish. Both the inshore and offshore concentrations of legal fish were below the thermocline[34] in June, July, and August and hence were in a region with extremely small temperature gradients. Preferences for water of different temperature, therefore, do not provide a logical explanation for the presence of two concentrations. The illegal whitefish of the inshore concentration were in the region of the thermocline in July and August, hence in substantially warmer water than were the fish of the offshore concentration. However, both groups were below the thermocline in June, and an inshore concentration at the thermocline was lacking in September.

Important arguments in support of the assumption of the existence of inshore and deep-water populations of whitefish are:

(1) The separation into two groups involved both large (legal) and small (illegal) fish. Consequently, the two groups are not entirely the result of different reactions of fish of different size to the same or similar environmental factors. This statement holds even though the concentration zones of the legal and illegal fish were not always identical in the same month.

(2) The fish of both concentration areas have similar seasonal vertical movements. The similarity of vertical movements kept the two zones of concentration distinct in all months but September. The presence of only one peak in the September data may represent the temporary approximation of the two concentrations or may be the result of lack of information on the distribution of whitefish beyond the 110-foot contour.

(3) There is evidence that some whitefish seldom, if ever, spawn in shallow water. The introduction of the deep trap net on gill-net grounds or in areas beyond the reach of pound nets was marked by the capture of considerable numbers of whitefish of exceptionally large size. These large fish could not be taken on these same grounds by the gill nets commonly employed since their great size prevented their becoming gilled. Pound nets, which are selective only with respect to small fish, are fully capable of taking large individuals of any size. Consequently, their failure to capture many fish as large as those found in the early catches of the deep trap nets may be taken as evidence that these giant individuals were seldom, if ever, present on the inshore pound-net grounds, at least during the period of fishing operation.

It must be remembered, nevertheless, that there is no proof that the smaller mature fish of the offshore group of whitefish do not spawn in shallow water. The separation of the whitefish into two depth groups may represent only a summer and early-autumn condition. Possibly most of the small fish of both groups spawn in shallow water and most of the large fish of both groups spawn in deeper water. However, it also seems logical to hold that the giant fish taken in deep trap nets were members of a deep-water population (that lived beyond the reach of pound nets) that had survived to a size at which they could not be taken in gill nets, and hence had become exempt from capture in the commercial fishery.

Even if the inshore and offshore groups of whitefish are held to be semi-independent or independent, it must be recognized that both groups exhibit similar fluctuations in the fishery. The records of the catch per lift and of production in M–3 (table 17 and appendix B) demonstrate a close correlation between the annual fluctuations in the

[33] Temperature data were not available from the north channel (region north of the Beaver Island archipelago), the center of the deep-trap-net fishery. However, the relatively limited local variation in temperature conditions at stations southeast, south, and northwest of Beaver Island and southeast of Manistique suggests that the data from these localities may be indicative of conditions in the area in which the deep-trap-net fishery was centered.

[34] The average positions of the thermocline were: last half of June, 24–33 feet; July, 67–77 feet; August, 69–80 feet; first 10 days of September, 72–86 feet. The thermocline had not yet formed in the first half of June; no readings were made in the area after September 10.

abundance of whitefish on the pound-net (shallow-water) and gill-net (deep-water) grounds of the district and also between the production of whitefish by these two gears. A similar close resemblance between the statistical data for pound nets and gill nets is to be found in other districts.

It must be remembered also that any assumption of the existence of shallow-water and deep-water stocks of whitefish in northeastern Lake Michigan does not make a similar assumption valid for any other region. In districts H–3 and H–4 of Lake Huron, for example, the simultaneous collapse of the deep-trap-net and pound-net fisheries must be interpreted as strong evidence that both gears drew a large part of their production from the same stock. It is not known, even in northeastern Lake Michigan, to what extent there may be an interchange of individuals between the inshore and offshore groups of whitefish.

SUMMARY AND COMPARISON OF THE BATHYMETRIC DISTRIBUTION OF WHITEFISH IN LAKES HURON AND MICHIGAN, WITH SPECIAL REFERENCE TO THE REGULATION OF THE FISHERY

The present study of the bathymetric distribution of the whitefish was part of a program conducted to obtain reliable data upon which to base a sound regulation of the deep-trap-net fishery. One question was: "What regulation as to the depth of water in which deep trap nets should be fished will serve best the dual purpose of protecting

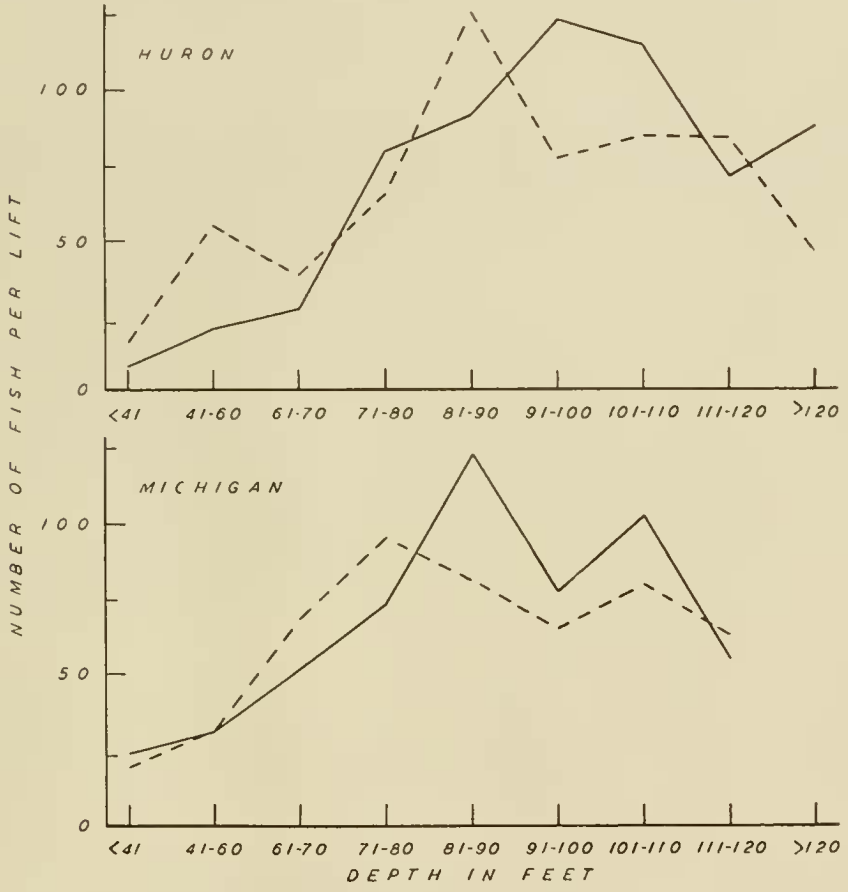


FIGURE 23.—Bathymetric distribution of legal-sized (solid lines) and illegal-sized (broken lines) whitefish in Lakes Huron and Michigan as determined from the combination of the data for all localities, years, and months in each lake.

young fish from capture and excessive handling, and of reducing production[35] to a level which does not threaten the extermination of the commercial stock?"

Ordinarily fishery legislation must be framed in conformity with average conditions during the entire season over a large part of a lake or an entire lake. Consequently, the most suitable data on the bathymetric distribution of whitefish in Lakes Huron and Michigan, as they pertain to fishery regulation, are those obtained by combining the available material for all grounds and all times in the fishing season in each of the two lakes. The data of table 29 (see also fig. 23) represent such combinations.

TABLE 29.—*Number of legal and illegal whitefish per lift of pound nets and deep trap nets in Lakes Huron and Michigan, 1931–1932*

[Number of lifts in parentheses. Asterisks indicate concentrations]

Lake	Size group	Number of whitefish per lift at depth (in feet)								
		<41	41–60	61–70	71–80	81–90	91–100	101–110	111–120	>120
Huron	Legal	7.3 (11)	20.5 (24)	26.9 (12)	79.2 (24)	91.6 (36)	123.1* (55)	114.7 (86)	70.2 (152)	87.5 (56)
	Illegal	15.9 (11)	54.9 (24)	38.2 (12)	65.3 (24)	125.8* (36)	76.9 (55)	84.2* (86)	83.7 (152)	45.7 (56)
Michigan	Legal	23.8 (64)	31.7 (38)	52.2 (21)	73.4 (51)	123.6* (91)	77.5 (56)	103.0* (52)	55.0 (7)	----------
	Illegal	19.4 (64)	31.5 (38)	68.8 (21)	95.4* (51)	81.8 (91)	65.2 (56)	80.2* (52)	63.1 (7)	----------

It should be pointed out, however, that recommendations based on the averages of table 29 which cover general conditions likewise cover very well the local conditions on the different grounds in the lake despite the variations in the bathymetric distribution of the legal and illegal whitefish in different localities.

In Lake Huron the average number of legal whitefish per lift increased continuously with increase in the depth of the water up to a maximum at 91–100 feet, decreased in the next two intervals, and increased slightly at more than 120 feet. The increase in the deepest water can be traced to the small number of lifts from this depth off Alpena, a region in which legal-sized whitefish were scarce. The limits of the general region of greatest abundance of legal fish may be set at approximately 81–110 feet. The number of undersized whitefish increased also from shallow to deeper water, but the maximum occurred at 81–90 feet, or 10 feet shallower than the depth of maximum abundance of legal fish. A second but lower peak in the number of illegal whitefish per lift was found at 101–110 feet. If legal fish are to be protected from excessive exploitation and illegal fish from frequent handling, the obvious depth limit beyond which impounding nets should not be fished in Lake Huron is 80 feet. Although this restriction curtails the production of deep trap nets severely, it cannot be considered extreme or oppressive, since a closely similar gear, the pound net, long supported a productive and prosperous fishery in even shallower water. (Few pound nets are fished in depths of more than 65 or 70 feet.)

The restriction of impounding nets in Lake Huron to depths of 80 feet or less does not mean the complete closure of the deeper waters to the commercial fishery for whitefish. These deeper areas are still open to the gill net, which was formerly the only gear fished in them. However, past experience has demonstrated that in these areas gill nets ordinarily did not catch whitefish in quantities dangerous to the stability of the stock. Furthermore, the selective action of the gill nets commonly employed precludes the capture of excessive numbers of small fish and also spares the large individuals that constitute the spawning reserve.

The Lake Michigan data differ from those of Lake Huron chiefly in the presence

[35] The present policy of fishery regulation in the State of Michigan waters of the Great Lakes does not include control of production through the limitation of the amount of gear fished or the setting of arbitrary limits on the season's catch.

of two distinct concentration zones for both legal and undersized fish and in showing a somewhat shallower habitat for the whitefish. The inshore concentrations, in both of which the numbers of fish per lift exceeded those of the offshore concentrations, were 10 feet shallower than the maxima for the corresponding size groups in Lake Huron. Consequently, the most suitable limit for the depth of water in which impounding nets should be operated in Lake Michigan is 70 feet, 10 feet shallower than in Lake Huron.

BATHYMETRIC DISTRIBUTION OF OTHER SPECIES

Other species were much less numerous in the catches of pound nets and deep trap nets than were whitefish. The data on the bathymetric distribution of these "miscellaneous" species, therefore, will not be given in the same detail as those on the distribution of whitefish.

LAKE TROUT

Nearly all of the lake trout (*Cristivomer namaycush*) were of legal size (minimum legal weight, 1½ pounds). As undersized lake trout were so few and because there was no evidence of important differences in the vertical distribution of legal and undersized fish, tables 30, 31, and 32 have been prepared from the records of all trout taken, regardless of size.

Lake Huron.—In the Alpena-Ossineke area (table 30) lake trout were numerous in May (31.0 to 39.8 fish per lift) at depths greater than 100 feet, but only one trout was taken in the lift from 81–90 feet. In June lake trout were fairly numerous in the shallower water (41–70 feet) while the average catch per lift declined (in comparison with the averages for May) in depths greater than 100 feet. The records for four lifts from depths between 40 and 71 feet in July and August suggest that most lake trout had abandoned the shallower water in these two months. Possibly this offshore movement accounts for the increase over the catch for the month of June in the average number of trout per lift from 81–120 feet. The average lifts in August were consistently below those of July from depths of 71–120 feet, and the September catches were smaller than those of August from the 101–120 foot interval. These decreases possibly may represent a movement of the lake trout to depths greater than those in which deep trap nets were operated.

TABLE 30.—*Number of lake trout per lift of pound nets and deep trap nets in the Alpena-Ossineke area, 1931–1932*

[Number of lifts in parentheses]

Month	Number of lake trout per lift at depth (in feet)							
	41–60	61–70	71–80	81–90	91–100	101–110	111–120	>120
May	----------	----------	----------	1.0 (1)	----------	31.0 (1)	37.4 (23)	39.8 (4)
June	21.3 (4)	40.0 (1)	----------	12.0 (1)	8.0 (1)	16.9 (6)	11.8 (18)	18.8 (5)
July	0.0 (1)	----------	56.0 (1)	40.2 (5)	35.5 (12)	26.2 (7)	50.0 (23)	----------
August	5.0 (2)	1.0 (1)	7.9 (7)	19.7 (9)	25.5 (3)	22.4 (5)	26.7 (10)	----------
September	----------	----------	----------	----------	----------	6.6 (5)	15.5 (2)	----------
Average	13.6 (7)	20.5 (2)	13.9 (8)	24.5 (16)	31.9 (16)	19.2 (24)	33.2 (76)	28.1 (9)

The seasons' averages indicate an irregular trend toward an increase in the abundance of lake trout with increase in the depth of the water. The decline in numbers in depths of 101–110 feet may be real since similar decreases occurred in the catch for July

and August. The decline in depths greater than 120 feet may be the result of the lack of data for months later than June.

It should be emphasized that, in contrast to the whitefish data, those presented for the lake trout on the Alpena-Ossineke grounds and in other areas should not be taken as descriptive of the general distribution of trout in Lake Huron and northern Lake Michigan. The chief summer fishery for trout is conducted by gill nets at depths considerably greater than those from which the pound nets and deep trap nets were lifted. The data given here describe only the distribution of the presumably sparse inshore population of trout.

Lake trout were considerably less abundant in the Saginaw Bay area (table 31) than off Alpena and Ossineke. In four of the six months (all but July and September) the largest lifts were made from the deepest water (more than 120 feet). Trout were scarce in shallow water (less than 61 feet) in June and were not taken at all in July and August. The data fail to indicate whether the improved catches beyond 90 feet in July and August were the result of an offshore movement of an inshore group of trout or of an onshore movement of an offshore group. The averages for September and possibly October are suggestive of a migration toward deeper water.

TABLE 31.—*Number of lake trout per lift of pound nets and deep trap nets in the Saginaw Bay area (ports of Au Sable-Oscoda, East Tawas, and Bay Port), 1931–1932*

[Number of lifts in parentheses]

Month	Number of lake trout per lift at depth (in feet)								
	<41	41–60	61–70	71–80	81–90	91–100	101–110	111–120	>120
May						1.0 (1)	2.7 (7)	3.5 (6)	3.8 (5)
June	0.0 (5)	2.2 (9)				0.0 (1)	2.4 (14)	1.8 (22)	5.0 (11)
July	0.0 (6)	0.0 (1)			5.5 (2)	7.0 (11)	10.4 (7)	5.9 (15)	5.0 (6)
August		0.0 (5)	0.3 (3)	1.7 (4)	2.5 (12)	7.6 (12)	14.6 (15)	7.7 (15)	18.4 (10)
September				0.5 (2)	1.0 (1)	3.0 (2)	3.0 (2)	23.2 (4)	2.5 (2)
October								4.5 (2)	17.3 (3)
Average	0.0 (11)	1.3 (15)	0.3 (3)	1.3 (6)	2.8 (15)	6.5 (27)	7.8 (45)	5.7 (64)	9.3 (37)

The seasons' averages show a general tendency for the number of lake trout per lift to increase with increase in the depth of water.

Tabular data are not given on the bathymetric distribution of lake trout in northern Lake Huron (Cheboygan and Rogers City area) and on the Harbor Beach grounds. (For the number of lifts at the various depths of water at these localities see tables 23 and 26.) The average number of trout per lift in northern Lake Huron varied widely (from 1.5 to 76.5 fish) with the best catch in 81–90 feet in August. Lake trout were fairly scarce on the Harbor Beach grounds. The best catches were: 20.3 fish per lift from 111–120 feet in August; 19.8 fish from depths greater than 120 feet in August; and 15.5 fish from 111–120 feet in September. Catches of lake trout were uniformly small in water shallower than 101 feet. In October only three trout were taken in a total of nine lifts, all from depths greater than 90 feet; apparently the lake trout had migrated from the Harbor Beach deep-trap-net grounds in that month.

Lake Michigan.—The rather extensive data from northeastern Lake Michigan (table 32) suggest that in certain months the lake trout as well as the whitefish may occur in two concentration zones. (See p. 353, table 28, and fig. 22.) In June and

July inshore concentrations occurred at 61–70 feet and offshore peaks at more than 110 feet. The offshore concentration in August was still in deep water but the inshore maximum was at 81–90 feet or 20 feet deeper than in June and July. (The August data were inadequate, however, for depths of less than 71 feet.) The data for September and October yield no evidence of two concentration zones of lake trout in these two months. Data were lacking, however, for depths beyond 110 feet.

TABLE 32.—*Number of lake trout per lift of pound nets and deep trap nets in northeastern Lake Michigan (ports of Manistique, Epoufette, and Naubinway), 1931–1932*

[Number of lifts in parentheses. Asterisks indicate concentrations]

Month	Number of lake trout per lift at depth (in feet)							
	<41	41–60	61–70	71–80	81–90	91–100	101–110	>110
June	3.5 (8)	6.3 (3)	14.5* (4)	10.5 (8)	1.7 (23)	3.1 (11)	2.6 (7)	5.0* (2)
July	0.0 (7)	3.6 (5)	17.4* (5)	10.0 (11)	6.3 (17)	3.4 (5)	4.1 (13)	17.0* (3)
August	----------	0.0 (1)	----------	4.2 (16)	5.2* (22)	2.9 (15)	2.1 (15)	22.5* (2)
September	0.5 (20)	0.0 (9)	0.0 (3)	3.1 (13)	3.6* (14)	1.6 (17)	1.6 (8)	----------
October	0.3 (23)	0.2 (11)	1.3 (3)	----------	1.6 (13)	2.2 (6)	5.6* (7)	----------
Average	0.8 (58)	1.3 (29)	9.9* (15)	6.3 (48)	3.7 (89)	2.5 (54)	3.1 (50)	15.1* (7)

There was no general agreement as to the actual location of the concentration zones of lake trout and whitefish. It is true that lake trout, large (legal) whitefish, and small (illegal) whitefish (table 28) were all concentrated at 61–70 feet in June and that both trout and legal whitefish exhibited peaks at 81–90 feet in August. On the other hand, the inshore concentration of lake trout was shallower in July than the concentration of either the legal or illegal whitefish, and the offshore concentrations of lake trout in June, July, and August were without exception deeper than the concentrations of whitefish. In October, however, a peak was evident at 101–110 feet in both lake trout and the whitefish (large and small).

Possibly it is not strictly proper to term as "concentrations" the increased abundance of lake trout at depths in excess of 110 feet, for these increases in the number per lift may be merely part of a general trend for trout to become more plentiful with increase in depth of water and not, as the term concentration implies, be indicative of a peak abundance bordered on either side by a lesser abundance.

The data of table 32 as a whole point toward an offshore movement of lake trout in northeastern Lake Michigan from June to October. (A few trout appear, however, to have returned to shallow water in October.) The seasons' averages show an increase in the catch per lift from shallow water (less than 41 feet) to a peak at 61–70 feet, followed in turn by a decline through the depth interval, 71–100 feet, and a secondary rise beyond 100 feet.

In the Green Bay region of Lake Michigan the best catches of lake trout were made in 41–60 feet in May (19.8 fish per lift). The September catches varied but little with depth of water, averaging 6.8 fish for 13 lifts in 41–80 feet and 5.0 for 4 lifts in 91–110 feet.

YELLOW PIKE

Yellow pike (*Stizostedion vitreum*) occurred in large numbers in the lifts of pound nets and deep trap nets only in the Saginaw Bay region (table 33). Because of the concentration of yellow pike in the shallower water of the area it was considered desir-

able in the preparation of the table to employ a greater number of intervals at depths less than 61 feet than was necessary in the tabulation of the data for the whitefish and the lake trout.

No data are available on the abundance of yellow pike in shallow water in May, but in June legal-sized fish (1½ pounds or larger) were plentiful in the lifts from 31–60 feet. In both May and June legal-sized yellow pike were totally lacking in all lifts from depths greater than 90 feet. The catch per lift in shallow water (less than 61 feet) declined in July and August. At the same time legal yellow pike penetrated to the greatest depths from which deep trap nets were lifted. The abundance at depths of more than 80 feet was generally higher in August than in July. Legal yellow pike were still present in the deeper water in September and October. The distribution in September was irregular. An average of 17.0 fish per lift was obtained at 111–120 feet, while yellow pike either were scarce or lacking in the lifts from other depths.

Undersized yellow pike as well as legal fish were abundant in 31–60 feet in June (with the greatest abundance in 31–40 feet) and absent from depths beyond 90 feet in both May and June. Illegal yellow pike had penetrated to a depth of 101–110 feet in July and 111–120 feet in August and September. None were taken in any month from water deeper than 120 feet.

Not only did illegal yellow pike fail to range as deep in summer as did fish of legal size, but apparently a smaller percentage of them left the shallow water. In

TABLE 33.—*Number of yellow pike per lift of pound nets and deep trap nets in the Saginaw Bay area (ports of Au Sable-Oscoda, East Tawas, and Bay Port), 1931–1932*

[Number of lifts in parentheses]

Month	Number of legal yellow pike per lift at depth (in feet)										
	<31	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110	111–120	>120
May								0.0 (1)	0.0 (7)	0.0 (6)	0.0 (5)
June		82.6 (5)	43.7 (6)	27.0 (3)				0.0 (1)	0.0 (14)	0.0 (22)	0.0 (11)
July	0.3 (3)	2.0 (3)		24.0 (1)			0.5 (2)	0.5 (11)	1.9 (7)	1.9 (15)	0.7 (6)
August			1.0 (1)	9.2 (4)	2.5 (3)	4.5 (4)	9.7 (12)	5.8 (12)	6.4 (15)	1.7 (15)	0.4 (10)
September						2.5 (2)	0.0 (1)	0.0 (2)	0.0 (2)	17.0 (4)	1.0 (2)
October										1.5 (2)	0.0 (3)
Average	0.3 (3)	52.4 (8)	37.6 (7)	17.7 (8)	2.5 (3)	3.8 (6)	7.8 (15)	2.8 (27)	2.0 (45)	1.9 (64)	0.3 (37)
	Number of illegal yellow pike per lift at depth (in feet)										
May								0.0 (1)	0.0 (7)	0.0 (6)	0.0 (5)
June		412.8 (5)	163.0 (6)	63.7 (3)				0.0 (1)	0.0 (14)	0.0 (22)	0.0 (11)
July	56.0 (3)	87.7 (3)		159.0 (1)			0.0 (2)	0.4 (11)	0.1 (7)	0.0 (15)	0.0 (6)
August			81.0 (1)	218.0 (4)	119.5 (3)	5.0 (4)	10.0 (12)	4.7 (12)	9.5 (15)	1.9 (15)	0.0 (10)
September						5.0 (2)	0.0 (1)	0.5 (2)	0.5 (2)	9.3 (4)	0.0 (2)
October										0.0 (2)	0.0 (3)
Average	56.0 (3)	290.9 (8)	151.3 (7)	152.8 (8)	119.5 (3)	5.0 (6)	8.0 (15)	2.3 (27)	3.2 (45)	1.0 (64)	0.0 (37)

the shallow-water lifts (less than 71 feet) the average numbers of illegal yellow pike per lift were consistently several times as great as the numbers of legal fish. Especially noteworthy were the large catches of undersized fish at these depths in July and August, months in which legal fish were scarce in shallow water. At the greater depths, however, the numbers of legal and illegal yellow pike per lift differed only slightly and in a random manner.

A total of seven yellow pike (all of legal size) was taken in northern Lake Huron (Cheboygan and Rogers City area). One of these fish was caught in 71–80 feet in July and the remaining six in 41–70 feet in September.

Yellow pike were scarce at all depths on the Alpena-Ossineke grounds, but were more numerous at depths less than 70 feet than at greater depths. No yellow pike were taken in water deeper than 90 feet before July. A few individuals (both legal and illegal) penetrated to depths of at least 111–120 feet in July and August. (No nets were lifted beyond 120 feet in these months and in September—see table 24.) In September a total of three legal fish but no illegal fish was taken from depths of 101–120 feet.

The single lift from shallow water (41–60 feet) off Harbor Beach contained eight legal and three illegal yellow pike. The maximum depths at which legal fish were taken were 111–120 feet in August and more than 120 feet in September and October. No illegal yellow pike were captured in August, but in September and October fish of this group penetrated to depths in excess of 120 feet.

Not one yellow pike was taken in the lifts of pound nets and deep trap nets in northeastern Lake Michigan. In May a total of five fish (all legal) was captured in the 10 lifts in the Green Bay area from depths of less than 61 feet and 28 yellow pike (10 legal and 18 illegal) were taken in the two lifts from 81–90 feet. No yellow pike were caught in the Green Bay area in September.

BURBOT

Because of the small total number captured and the sporadic occurrence of burbot (*Lota maculosa*) in the catches, a combination of the data for all localities appears to provide the most valid description of the inshore bathymetric distribution of the species in Lake Huron (table 34). This table cannot serve as the basis for a detailed discussion; attention will be called, however, to certain general trends. Burbot were scarce or lacking at all depths from which nets were lifted in both May and June. In June they occurred in both shallow water (less than 71 feet) and deep water (more than 100

TABLE 34.—*Number of burbot per lift of pound nets and deep trap nets in Lake Huron, 1931–1932 (data for all localities combined)*

[Number of lifts in parentheses]

Month	Number of burbot per lift at depth (in feet)								
	<41	41–60	61–70	71–80	81–90	91–100	101–110	111–120	>120
May					0 0 (1)	0 0 (1)	0 2 (8)	0 5 (29)	0 2 (9)
June	0 2 (5)	0 2 (13)	1 0 (1)		0 0 (1)	0 0 (2)	0 3 (20)	0 6 (40)	0 8 (16)
July	0 0 (6)	0 0 (2)	0 0 (2)	0 6 (5)	2 3 (7)	3 1 (23)	0 6 (14)	0 8 (38)	0 3 (6)
August		0 0 (7)	0 0 (4)	2 0 (13)	1 9 (23)	2 0 (17)	1 5 (22)	0 9 (29)	1 2 (15)
September		0 0 (2)	0 8 (5)	2 6 (6)	1 2 (4)	1 3 (10)	2 2 (19)	3 2 (12)	2 8 (5)
October						0 0 (2)	2 5 (3)	3 8 (4)	2 8 (5)
Average	0 1 (11)	0 1 (24)	0 4 (12)	1 9 (24)	1 8 (36)	2 1 (55)	1 1 (86)	1 0 (152)	1 1 (56)

feet). Burbot were absent from shallow water in July and August, and appeared to be concentrated at intermediate depths (81–100 feet in July and 71–110 feet in August). In September and October they apparently were concentrated in depths beyond 100 feet. The changes in the average number of fish per net at the various depths for the months, July-October, suggest a general tendency for the burbot to move toward deeper water. The regular increase from July to September in the catch from 71–80 feet provides an exception to this general trend. The seasons' averages show a scarcity of burbot at depths of less than 71 feet and the greatest abundance at intermediate depths (71–100 feet), with the abundance in deep water (more than 100 feet) about half that at intermediate depths.

TABLE 35.—*Number of burbot per lift of pound nets and deep trap nets in northeastern Lake Michigan (ports of Manistique, Epoufette, and Naubinway), 1931–1932*

[Number of lifts in parentheses]

Month	Number of burbot per lift at depth (in feet)							
	<41	41–60	61–70	71–80	81–90	91–100	101–110	>110
June	0 1 (8)	0 3 (3)	4 0 (4)	3 1 (8)	2 2 (23)	2 4 (11)	1 7 (7)	3 0 (2)
July	0 0 (7)	3 2 (5)	3 0 (5)	1 6 (11)	1 9 (17)	0 8 (5)	5 4 (13)	1 3 (3)
August	----------	0 0 (1)	----------	3 6 (16)	2 0 (22)	1 3 (15)	1 6 (15)	10 0 (2)
September	0 1 (20)	1 0 (9)	4 7 (3)	2 2 (13)	3 7 (14)	2 0 (17)	2 8 (8)	----------
October	1 8 (23)	4 6 (11)	10 7 (3)	----------	8 6 (13)	2 3 (6)	5 4 (7)	----------
Average	0 8 (58)	2 6 (29)	5 1 (15)	2 7 (48)	3 3 (89)	1 8 (54)	2 1 (50)	4 3 (7)

The data on the bathymetric distribution of the burbot in northeastern Lake Michigan (table 35) provide little evidence of any extensive vertical movements. Characteristic of the averages for each month appeared to be an inshore concentration at 41–60 or 61–70 feet (except in August when only one lift was observed from a depth of less than 70 feet), a reduced abundance at intermediate depths up to 101 feet (111 feet in June), and a second concentration at 101–110 feet or more than 110 feet. The average catches in October were greater than those in other months from every depth but 91–100 feet. (The average catch from 101–110 feet was the same in July and October.) The seasons' averages show an increase in the number of burbot from 0.8 in shallow water (less than 41 feet) to a maximum of 5.1 fish per lift at 61–70 feet. The average catch per net varied between 1.8 and 3.3 fish in depths of 71–110 feet and rose to 4.3 in water more than 110 feet.

WHITE SUCKER AND LONG-NOSED OR STURGEON SUCKER

Separate counts of white suckers (*Catostomus commersonnii*) and long-nosed or sturgeon suckers (*C. catostomus*) were obtained for only a limited number of lifts in the Alpena-Ossineke and Saginaw Bay areas of Lake Huron. The available data indicate that white suckers were most numerous in depths of less than 81 feet; only one individual was captured in deeper water (in 101–110 feet). Long-nosed suckers also were most plentiful inside the 81-foot contour, but were taken in fair numbers at greater depths. No long-nosed suckers were captured in depths beyond 110 feet.

PART IV

OBSERVATIONS ON THE FISHING ACTION OF POUND NETS AND DEEP TRAP NETS

EFFECT OF THE SIZE OF THE MESH ON THE CATCH OF LEGAL- AND ILLEGAL-SIZED WHITEFISH AND LAKE TROUT

The question of the proper legal minimum size of mesh is a highly controversial one that involves nearly all commercial fishing gears. Certainly the most desirable size of mesh is that which releases the greatest number of illegal-sized and immature fish without serious loss of legal-sized fish. However, a great diversity of opinion exists as to what this "desirable" size of mesh may be. Although there are a few exceptions, commercial fishermen usually oppose most vigorously any attempt to increase the legal minimum mesh size, and in practice generally fish the smallest mesh permitted by law.

The lack of proper legal regulations and enforcement in the early years of the deep-trap-net fishery led to a wide range of mesh size in this gear. Many of the early deep trap nets had meshes that were ridiculously small (as small as 2¼ inches, stretched measure as fished) for a gear designed to take a species with a 2-pound legal-size limit. Continued experience, however, led many deep-trap-net fishermen to increase the size of mesh in their nets. This increase in mesh size not only reduced the labor of sorting out the illegal fish and returning them to the lake, but also improved the catch of legal fish as will now be shown.

The data in tables 36 and 37 on mesh selectivity in pound nets and deep trap nets are based on comparison of the numbers of legal- and illegal-sized whitefish (2-pound size limit) taken in nets with meshes less than 4 inches (stretched measure as fished) and in nets with meshes of 4 inches and more. For convenience in the discussion, the two groups of nets will be termed "small-mesh" and "large-mesh" nets.[36]

Table 36 lists the total numbers of legal and illegal fish, the average numbers per lift, and the percentages of fish of both size groups in all lifts of large-mesh and small-mesh pound nets and deep trap nets observed in the course of the investigation. On the average, small-mesh nets took more fish per lift, both legal and illegal, than did large-mesh nets. The percentage of legal fish in the lift was higher (58.7 as compared with 51.3) in large-mesh nets.

TABLE 36.—*Comparison of total numbers, averages per lift, and percentages of legal and illegal whitefish taken in small-mesh and large-mesh pound nets and deep trap nets*

[The 1931–1932 data have been combined for all ports, all depths, and all months. Numbers of lifts in parentheses]

Item	Whitefish taken in mesh			
	Less than 4 inches		4 inches and more	
	Legal	Illegal	Legal	Illegal
Total number of whitefish taken	48,939	46,441	18,231	12,820
	(598)		(238)	
Average number of whitefish per lift	81 8	77 7	76 6	53 9
Corrected for equal commercial yields	81 8	77 7	81 8	57 6
Percentage legal and illegal	51.3	48 7	58 7	41 3

The unequal numbers of fish in the lifts of large-mesh and small-mesh nets make a comparison of their selective action difficult. A better comparison is made possible by the determination of the numbers of illegal fish that must be handled in nets of

[36] In the original compilations the nets were grouped according to mesh size by half-inch intervals. This grouping proved unsatisfactory, however, since nets that fell within some intervals of mesh size were fished chiefly on grounds with an abundance of undersized whitefish whereas the nets of other mesh sizes were fished predominantly on grounds where young whitefish were extremely scarce. In order to reduce irregularities from this source, only two size groups of mesh were employed in the preparation of data on the release of illegal-sized whitefish.

each mesh size when the commercial yields are equal. This determination (third row in body of table) shows that large-mesh nets that take an average of 81.8 legal fish may be expected to contain an average of 57.6 illegal individuals as compared with 77.7 undersized whitefish in small-mesh nets with equal commercial lifts.

From the averages of 77.7 and 57.6 illegal whitefish per lift it may be estimated that large-mesh nets released $100 \times \frac{77.7 - 57.6}{77.7}$ or 25.9 percent of the undersized individuals. For every 100 illegal whitefish taken in small-mesh nets, 74.1 should be taken by large-mesh nets with the same commercial catch.

The data of table 36 and the computations based upon them are open to the very serious objection that the actual numbers and the percentages of legal and illegal fish taken in nets of any size of mesh vary according to the nature of the stock at the place and time the nets are fished. Truly discriminating data on selectivity must be founded on the lifts of nets that are identical except for the size of mesh and that are fished under strictly comparable conditions, that is, on the same grounds, at the same depth, in the same year, and at the same time within the season.

Table 37 contains comparisons of the catch of large-mesh and small-mesh pound nets and deep trap nets, based on lifts made in the same year (1932), in the same month, on the same grounds, and at the same depth. The data are confined to comparisons in which nets of both sizes of mesh are represented by at least 5 lifts. The necessary restrictions reduced the number of possible comparisons. However, the averages of the 10 independent sets of observations are reasonably reliable.

TABLE 37.—*Comparison of the numbers of legal and illegal whitefish per lift in small-mesh and large-mesh pound nets and deep trap nets fished in the same year (1932) and month, on the same grounds, and at comparable depths*

[Number of lifts in parentheses]

Fishing grounds	Month	Depth (feet)	Number of whitefish per lift in nets of mesh size				Percentage legal in nets of mesh size	
			Less than 4 inches		4 inches and more			
			Legal	Illegal	Legal	Illegal	Less than 4 inches	4 inches and more
Northeastern Lake Michigan	October	<61	16.8 (6)	4.8	22.3 (22)	2.9	77.8	88.5
	August	71-80	62.8 (11)	80.1	150.4 (5)	148.2	43.9	50.4
	June	81-90	176.0 (15)	150.1	142.5 (8)	57.1	54.0	71.4
	July	81-90	158.6 (10)	97.5	130.7 (6)	78.8	61.9	62.4
	August	81-90	121.9 (14)	64.8	233.0 (8)	108.1	65.3	68.3
	August	91-100	39.4 (8)	25.1	82.3 (7)	57.4	61.1	58.9
	September	91-100	81.5 (6)	79.3	76.8 (8)	44.0	50.7	63.6
Alpena-Ossineke	May	>110	41.2 (20)	288.1	24.9 (7)	154.0	12.5	13.9
	June	>110	14.2 (18)	73.2	6.0 (5)	30.6	19.0	16.4
	July	>110	26.5 (14)	54.3	49.5 (8)	97.9	32.8	33.6
Average			74.2	91.7	91.8	77.9	44.7	54.1
Corrected for equal commercial yields			91.8	113.4	91.8	77.9		

The averages of the 10 comparisons show that the large-mesh pound nets and deep trap nets took more legal whitefish and fewer illegal fish than the small-mesh nets fished under comparable conditions. In round numbers, small-mesh nets took an average of 92 undersized individuals in producing 74 fish of marketable size, whereas large-mesh nets took only 78 illegal whitefish for a commercial production of 92 fish. The correction for equal commercial production shows that small-mesh pound nets and deep trap nets with a commercial catch equal to that of large-mesh nets (92 fish)

may be expected to capture 113 illegal whitefish to only 78 in large-mesh nets. The release of undersized fish by large-mesh nets is, therefore, $100 \times \frac{113.4 - 77.9}{113.4}$ or 31.3 percent. This percentage of release is more reliable than the release of 25.9 percent computed from the average catches of the two groups of nets without consideration of the effects of locality, depth, and time.

That the undersized whitefish, as well as the lake trout commonly taken with them, do escape from the pots of impounding nets with the larger meshes is further suggested by the progressive increase in the average sizes of these fish with each increase in the size of mesh (table 38).

The controversy concerning the proper size of mesh in the pots of impounding nets does not, however, revolve so much around the release of undersized fish as around the escape of legal-sized fish, both whitefish and lake trout. It is not believed that any legal-sized whitefish can go through meshes smaller than 4½ inches as found in use (the minimum size required by Michigan's law), but it is most probable that some legal-sized lake trout escape as is suggested by the larger average size of these fish in the bigger-meshed nets (table 38).

TABLE 38.—*Average size of whitefish and lake trout taken from Lakes Huron and Michigan in 1931 and 1932 in impounding nets with different sizes of mesh in the pot*

[Sizes of mesh represent stretched measurements as found in use. Numbers of fish employed are shown in parentheses]

Size of mesh (inches) in impounding nets	Undersized whitefish (less than 2 pounds)		Lake trout		
			Undersized (less than 1½ pounds)	Legal-sized	
	Average total length (inches)	Average weight (lbs. and oz.)	Average weight (lbs. and oz.)	Average total length (inches)	Average weight (lbs. and oz.)
<3			1-4 6 (3)	18 4 (10)	2-7 2 (45)
3-3 7/16	14 1 (54)	0-13 1 (54)		21 6 (49)	2-11 4 (90)
3 1/2-3 15/16	17 6 (123)	1-9 6 (123)	1-5 2 (18)	22 1 (189)	2-11 2 (395)
4-4 7/16	17 8 (36)	1-10 2 (36)	1-5 4 (4)	23 5 (20)	2-14 9 (203)
4 1/2-4 15/16					3-8 6 (7)

Additional information on this question of escapement is provided by the length and weight frequencies of the whitefish and lake trout gilled in the different sizes of mesh (tables 39, 40, 41, and 42). Table 39 shows that all of the whitefish gilled in meshes smaller than 3 inches were undersized. Presumably, then, no legal-sized whitefish can escape through these meshes. It was not until a mesh of 3½ to 3 15/16 inches (about 4 to 4 7/16 inches as manufactured) was used that legal-sized whitefish were gilled in any numbers, although 91 percent of the gilled fish were still below the 2-pound legal limit. Even the largest meshes for which data are adequate (4 to 4 7/16 inches) did not permit many of the smaller fish to escape as 79 percent of the gilled individuals in these meshes were undersized, and the average weight of all fish was noticeably less than 2 pounds (1 pound, 11 ounces).

It is of interest to note from the frequencies that the bulk of the gilled whitefish varied from 1 to 2 pounds in weight in meshes of 3 to 3 15/16 inches and from 1 to 2¼ pounds in the larger meshes—a range of only 1 or 1¼ pounds. The corresponding range in length of these fish (table 40) was 3½ inches (15 – 18½; 15½ – 19; 16 – 19½ inches).

The progressive increase in the average weight of the undersized gilled whitefish, as well as in the average length (table 40), with each increase in the size of mesh

indicates that some of the smallest individuals escaped. The average weight of the legal-sized, gilled whitefish, however, did not increase progressively with an increase in mesh size (the average length showed a slight increase), thus suggesting that virtually no whitefish of 2 pounds or larger passed through any of the meshes for which there were adequate data.

TABLE 39.—*Weight frequencies and average weights of whitefish gilled in the pots of impounding nets of Lakes Huron and Michigan, 1931–1932*

[The weight intervals apply to fish with weights up to but not including the upper limit. Undersized fish were separated on the basis of a 2-pound limit]

Weight interval (pounds)	Sizes of stretched mesh (inches) as found in use					Total number
	<3	3-3 7/16	3 1/2-3 15/16	4-4 7/16	4 1/2-4 15/16	
1/4 to 1/2	2	1	1			4
1/2 to 3/4	7	7	4			18
3/4 to 1	2	5	9	6		22
1 to 1 1/4	3	24	75	29		131
1 1/4 to 1 1/2	1	23	118	45		187
1 1/2 to 1 3/4		27	114	50		191
1 3/4 to 2	2	16	63	35		116
2 to 2 1/4		2	20	24		46
2 1/4 to 2 1/2		1	14	10	1	26
2 1/2 to 2 3/4		1	3	4		8
2 3/4 to 3				4		4
3 to 3 1/4			1	2		3
5 to 5 1/4				1		1
Total	17	107	422	210	1	757
Number of undersized fish	17	103	384	165	0	669
Number of legal-sized fish	0	4	38	45	1	88
Percentage of undersized fish	100.0	96 3	91.0	78.6	0 0	88 4
Average weight of all fish	0–14 4	1–6.1	1–8 0	1–11.0	2–4 0	1–8 4
Average weight of undersized fish	0–14 4	1–5 5	1–6 9	1–7 7		1–6 6
Average weight of legal-sized fish		2–5 1	2–3 8	.2–5 6	2–4 0	2–4.8

TABLE 40.—*Length frequencies and average lengths of whitefish gilled in the pots of impounding nets of Lakes Huron and Michigan, 1931–1932*

[The total-length intervals apply to fish with lengths up to but not including the upper limit. The average lengths of legal-sized and undersized fish were based only on those individuals for which records of weight also were available (number of specimens in parentheses). Undersized fish were separated on the basis of a 2-pound limit, not on length]

Total length interval (inches)	Sizes of stretched mesh (inches) as found in use					Total number
	<3	3-3 7/16	3 1/2-3 15/16	4-4 7/16	4 1/2-4 15/16	
11 1/2 to 12	1		1			2
12 to 12 1/2		1				1
12 1/2 to 13	2					2
13 to 13 1/2	5	1	4			10
13 1/2 to 14		6	1	1		8
14 to 14 1/2	1	2	2	2		7
14 1/2 to 15	1	5	3	5		14
15 to 15 1/2	1	12	13	6		32
15 1/2 to 16		12	45	9		66
16 to 16 1/2	2	14	58	19		93
16 1/2 to 17	2	10	65	25		102
17 to 17 1/2	1	12	86	32		131
17 1/2 to 18		14	53	20		87
18 to 18 1/2	2	15	40	27		84
18 1/2 to 19		6	22	27		55
19 to 19 1/2		5	15	18	1	39
19 1/2 to 20			7	5		12
20 to 20 1/2			6	9		15
20 1/2 to 21			1	3		4
21 to 21 1/2			1	2		3
24 to 24 1/2				1		1
Total	18	115	423	211	1	768
Average total length (inches) of all fish	14 7	16.5	17.0	17.6	19.2	17 0
Average total length (inches) of undersized fish	14 5 (17)	16 5 (103)	16 7 (356)	17 0 (160)		16 7 (636)
Average total length (inches) of legal-sized fish		18 9 (4)	19 1 (36)	19 4 (43)	19 2 (1)	19 2 (84)

TABLE 41.—*Weight frequencies and average weights of lake trout gilled in the pots of impounding nets of Lakes Huron and Michigan, 1931–1932*

[The weight intervals apply to fish with weights up to but not including the upper limit. Undersized fish were separated on the basis of a 1½-pound limit]

Weight interval (pounds)	Sizes of stretched mesh (inches) as found in use				Total number
	<3	3–3 7/16	3 1/2–3 15/16	4–4 7/16	
1 to 1 1/4	3	2	6		11
1 1/4 to 1 1/2	1	5	12		18
1 1/2 to 1 3/4		9	39	2	50
1 3/4 to 2		6	36	5	47
2 to 2 1/4		3	34	5	42
2 1/4 to 2 1/2		1	21	8	30
2 1/2 to 2 3/4		2	4	1	7
2 3/4 to 3		1	4	1	6
3 to 3 1/4				2	2
3 1/4 to 3 1/2			1		1
3 3/4 to 4			1	1	2
Total	4	29	158	25	216
Number of undersized fish	4	7	18	0	29
Number of legal-sized fish	0	22	140	25	187
Percentage of undersized fish	100 0	24 1	11 4	0 0	13 4
Average weight of all fish	1–2 8	1–11 8	1–14 4	2–4 6	1–14 6
Average weight of undersized fish	1–2 8	1–4 9	1–5 0		1–4 7
Average weight of legal-sized fish		1–14 0	1–15 6	2–4 6	2–0 8

TABLE 42.—*Length frequencies and average lengths of lake trout gilled in the pots of impounding nets of Lakes Huron and Michigan, 1931–1932*

[The total-length intervals apply to fish with lengths up to but not including the upper limit. The average lengths of legal-sized and undersized fish were based only on those individuals for which records of weight also were available (number of specimens in parentheses). Undersized fish were separated on the basis of a 1½-pound limit, not on length]

Total length interval (inches)	Sizes of stretched mesh (inches) as found in use				Total number
	<3	3–3 7/16	3 1/2–3 15/16	4–4 7/16	
15 1/2 to 16			1		1
16 to 16 1/2	2	1			3
16 1/2 to 17		1	4		5
17 to 17 1/2	3	1	13		17
17 1/2 to 18		2	21		23
18 to 18 1/2		6	27		33
18 1/2 to 19		3	30		33
19 to 19 1/2		7	28	3	38
19 1/2 to 20		1	22	1	24
20 to 20 1/2		4	13	8	25
20 1/2 to 21			13	5	18
21 to 21 1/2		2	19	3	24
21 1/2 to 22		1	6	2	9
22 to 22 1/2			2	2	4
22 1/2 to 23			5		5
23 to 23 1/2				1	1
23 1/2 to 24			1		1
24 to 24 1/2				1	1
Total	5	29	205	26	265
Average total length (inches) of all fish	16 8	18 8	19.1	20 7	19 2
Average total length (inches) of undersized fish	16 9 (4)	17 3 (7)	17 2 (18)		17 2 (29)
Average total length (inches) of legal-sized fish		19 3 (22)	19 4 (136)	20 6 (24)	19 5 (182)

The situation with respect to the lake trout was somewhat different. The few trout gilled in meshes smaller than 3 inches were all undersized (less than 1½ pounds) (table 41). The legal-sized trout started to gill noticeably in meshes of 3 to 3 7/16 inches. Only 24 percent of the gilled fish in these meshes were undersized, and the average weight (1 pound, 11.8 ounces) of all gilled fish was well over the legal size limit. The percentage of undersized gilled trout decreased to 11.4 in the 3½- to 3 15/16-inch meshes, and no illegal-sized fish were gilled in larger meshes. An exam-

ination of the frequencies and averages indicates that probably few legal-sized trout escaped through the meshes of 3½ to 3 15/16 inches (about 4 to 4 7/16 inches as manufactured) since the modal weight of the fish in these meshes (between 1½ and 1¾ pounds) was the same as in the 3- to 3 7/16-inch meshes and the average weight of legal-sized fish increased only 1.6 ounces in nets of the latter sizes of mesh. Individuals of these sizes did escape through meshes larger than 3 15/16 inches. It is doubtful, however, whether many fish of 1¾ pounds or larger were able to pass through meshes of exactly 4 inches (about 4½ inches as manufactured).

It may be observed from the frequencies of weights that the bulk of the gilled trout shifted to a higher weight-interval with each increase in the mesh between 3 and 4 7/16 inches, but the fish were always concentrated within a relatively small range of weight (¾ to 1 pound). The majority of the gilled trout weighed between 1¼ and 2 pounds in the 3- to 3 7/16-inch mesh, between 1½ and 2½ pounds in the 3½- to 3 15/16-inch mesh, and between 1¾ and 2½ pounds in the 4- to 4 7/16-inch mesh. The ranges in length of the bulk of the trout (table 42) varied from about 1 to 2½ inches in these various meshes (18 – 19½; 17½ – 20; 20 – 21 inches).

The average weight of the undersized gilled trout, as well as the average length (table 42), increased with an increase in the size of mesh from less than 3 inches to 3 to 3 7/16 inches (indicating release of some small fish). The size of fish did not change, however (slight increase in weight; slight decrease in length), with a further increase of ½ inch in mesh size suggesting that, though additional undersized fish were released by the larger meshes, the size of mesh was not yet sufficiently large to permit the larger undersized trout to escape. An increase of another ½ inch in the size of the mesh apparently did permit this escapement for no undersized trout were gilled in meshes of 4 to 4 7/16 inches. Even though these meshes or larger ones are used, it may not be assumed that no undersized fish would remain in the net. They do not all attempt to escape.

The average weight and length of the legal-sized gilled trout increased slightly with an increase in mesh size from 3 to 3 7/16 to 3½ to 3 15/16 inches (indicating release of only a few fish), but increased to a greater degree with a further ½-inch increase of mesh size, suggesting that some of the smaller fish of legal size had escaped. Nearly all of the trout gilled in meshes of 4 to 4 7/16 inches weighed 1¾ pounds or more.

In general, the data on the gilled fish and on the average sizes of fish retained in the impounding nets indicate that Michigan's minimum size of mesh (4½ inches as found in use) prescribed for the pots of impounding nets employed in catching whitefish and lake trout should not be reduced. This mesh is in fact too small to liberate a large proportion of the undersized whitefish found in the nets, although on the other hand it is too large to hold the smaller individuals of the legal-sized trout. A 4-inch mesh as found in use would probably prove more effective for the capture of trout at the present size limit of 1½ pounds. A better solution than a reduction in mesh to prevent the escape of legal-sized trout would be a substantial increase in the legal size limit since most lake trout (especially the females) under 3 pounds are sexually immature. It is not practicable to prescribe different meshes for whitefish and trout as both species are usually taken together on the same grounds. Further, a 4½-inch mesh is also prescribed for gill nets employed for both species.

DESTRUCTION OF WHITEFISH THROUGH GILLING IN THE MESHES OF POUND NETS AND DEEP TRAP NETS

The gilling of undersized fish in the meshes of impounding nets constitutes a certain source of destruction since death follows soon after the individual is enmeshed. It is, therefore, of importance to know what percentage of the illegal-sized whitefish become gilled in commercial pound nets and deep trap nets, and how this percentage varies with the size of the mesh. The death of legal individuals through gilling is of lesser importance, although the market value of such fish may be impaired and large numbers of gilled fish of any size add considerably to the fishermen's labor in clearing their nets.

The data of table 43 on the numbers and percentages of gilled whitefish in pound nets and deep trap nets are based on a combination of all nets of similar sizes of mesh irrespective of fishing grounds, depth of water, and the month and year in which the nets were fished.[37] None of these variables was found to affect the percentage of gilled fish.

TABLE 43.—*Numbers and percentages of legal and illegal whitefish gilled in large-mesh and small-mesh pound nets and deep trap nets, 1931–1932 data combined for all localities and all depths of water*

[The table is based only on the lifts in which gilled fish were counted and separated according to size]

Item	Whitefish taken in nets of mesh size			
	Less than 4 inches		4 inches and more	
	Legal	Illegal	Legal	Illegal
Total number of whitefish taken	48,441	44,759	18,024	12,613
Number of whitefish gilled	154	1,077	161	340
Percentage of gilled whitefish	0 3	2 4	0 9	2 7

A larger percentage of both the legal and the illegal whitefish became gilled in large-mesh nets than in small-mesh nets. The percentage of the legal fish gilled in large-mesh nets although small was three times that gilled in small-mesh nets, but the percentage of the illegal fish gilled in large meshes was only slightly above that in small meshes. It may be considered probable that the greater ability of large meshes to gill the larger illegal fish is compensated by the numbers of smaller illegal fish that can pass through the meshes.

The percentages of gilled illegal whitefish in pound nets and deep trap nets (2.4 percent in small meshes and 2.7 percent in large meshes) do not point to gilling as a very important source of destruction of undersized fish in a single lift. Should the same fish be taken repeatedly the risk of death by gilling would be increased.

BLOATING OF LIVE WHITEFISH IN POUND NETS AND DEEP TRAP NETS

Another possible source of destruction of illegal-sized whitefish is the bloating (the result of changing pressure) that frequently occurs when nets are lifted. It cannot be stated exactly how serious the effects of bloating may be. It is possible that many fish that are not visibly bloated when a net reaches the surface may have been injured seriously by the change of pressure, particularly if the net was lifted rapidly. On the other hand, visibly bloated fish often appear to make a complete recovery, and swim away vigorously upon return to the water.

Table 44 shows the relationship between the depth of water from which nets were lifted and the extent of bloating of whitefish of legal and illegal size. The percentage

TABLE 44.—*Relationship between the depth of water and the bloating of live whitefish in pound nets and deep trap nets, 1931–1932 data combined for all localities*

Depth of water (feet)	Total number of fish[1]	Number of bloated fish	Percentage bloated fish	Percentage bloated legal fish[2]	Percentage bloated illegal fish[2]
<61	7,206	0	0 00	0 00	0 00
61 to 80	14,811	66	0 45	0 46	0 44
81 to 100	45,109	223	0 49	0 31	0 72
101 to 110	24,493	265	1 08	0 65	1 66
>110	31,029	527	1 70	1 33	2 08
Total or average	122,648	1,081	0 88	0 63	1 17

[1] Includes only lifts in which bloated fish were counted.
[2] Only 63 percent of the bloated fish were separated as to size.

[37] Fish were considered to be gilled only when it was obvious that they had become enmeshed while the net was actually fishing. Freshly gilled live fish were considered to have become enmeshed during the lifting process, and were not counted; usually they were not injured.

of bloated fish (legal and illegal fish combined) in the lift rose consistently as the depth of water increased. No fish were bloated in nets (mostly pound nets) set at depths of 60 feet and less. At depths of 61–80 and 81–100 feet slightly less than one-half of one percent were bloated. The percentage of bloated whitefish increased to 1.08 in 101–110 feet, and rose still further to 1.70 percent in deep water (more than 110 feet).

The data on the percentages of the legal and of the illegal whitefish that were bloated reveal that both sizes of fish share the general trend toward increased bloating with increase in the depth of the water. The greater percentage of bloated legal fish at 61–80 feet in comparison with the percentage at 81–100 feet constitutes the only exception. At all depths beyond 80 feet relatively more of the illegal whitefish than of the legal whitefish were bloated. This difference was probably due to the thinner body wall of the younger fish. The averages for fish taken at all depths show that 0.63 percent of all legal fish and 1.17 percent of all illegal fish were bloated.

The bloating of live whitefish was probably an unimportant source of destruction of undersized individuals. Only 1.17 percent of all illegal fish were bloated and the maximum percentage of bloated fish at any one depth was 2.08 (deep water). However, the repeated capture of undersized fish would increase the risk of injury or death through bloating.

DEAD WHITEFISH IN POUND NETS AND DEEP TRAP NETS

Commercial fishermen opposed to the use of deep trap nets contended that confinement in this type of gear was fatal to whitefish and that dead illegal fish were very numerous in the lifts. The data of table 45, which show the number and percentage of dead fish (exclusive of dead gilled fish) at three different depths and the percentages of the legal and of the illegal fish found dead at these same depths, do not, in general, support this contention.

TABLE 45.—*Relationship between the depth of the water and the numbers and percentages of dead whitefish in deep trap nets in Lakes Huron and Michigan, 1931–1932 data combined for all localities in each lake*

Lake	Depth of water (feet)	Total number of fish[1]	Number of dead fish	Percentage dead fish	Percentage dead legal fish[2]	Percentage dead illegal fish[2]
Huron	<81	4,734	107	2 26	0 44	3 96
	81 to 110	35,736	209	0 58	0 32	0 90
	>110	30,313	195	0 64	0 45	0 84
	All depths	70,783	511	0 72	0.38	1 10
Michigan	<81	11,613	24	0 21	0 05	0 35
	81 to 110	36,215	69	0 19	0 08	0 35
	>110	827	2	0 24	0 26	0 22
	All depths	48,655	95	0 20	0 08	0 35

[1] Includes only lifts in which dead fish were counted.
[2] Only 72 percent of the dead fish were separated as to size.

Almost 4 percent of the undersized whitefish were dead in the Lake Huron deep trap nets lifted from depths of 80 feet or less. However, at that time (1931–1932) relatively few deep trap nets were fished in such shallow water. Less than 1 percent of the illegal whitefish were dead in nets lifted from greater depths. The average percentage of the undersized fish found dead in the lifts of all deep trap nets observed in Lake Huron was slightly above 1 percent. The percentage of the dead among the legal whitefish in Lake Huron deep trap nets was small (average, 0.38 percent) and showed little variation with the depth of the water.

The percentages of both the legal and the illegal whitefish found dead in deep trap nets were much smaller in Lake Michigan than in Lake Huron. The shallow-water lifts (80 feet and less) in particular had relatively few dead fish as compared with nets from the same depth in Lake Huron. The percentages of dead whitefish in Lake

Michigan do not appear to vary according to the depth of the water. (The data for deep-water lifts are too scanty to be reliable.)

Although it cannot be said that deep-trap-net lifts contained large numbers of dead whitefish, there is good evidence that pound-net lifts contained even fewer. Not one dead whitefish was found in all the pound-net lifts observed in Lake Michigan. In Lake Huron pound nets only 0.61 percent of the whitefish were dead (0.94 percent of the legal fish and 0.45 percent of the illegal fish). The percentage of dead legal fish was rather high, but the percentage of dead undersized fish was far below that for deep trap nets in shallow water (80 feet and less).

ESTIMATES OF THE PROBABLE DESTRUCTION OF ILLEGAL-SIZED WHITEFISH IN CERTAIN LOCALITIES AND YEARS

It may be stated that the percentage of undersized whitefish handled by the fishermen and destroyed in the lifting of pound nets and deep trap nets was small, although that percentage was somewhat larger for deep trap nets than for pound nets. If we define as "known destruction" the quantities of whitefish dead at the time the nets were lifted (including dead gilled fish), the data of the preceding sections make possible the following estimates of the percentages of the undersized whitefish destroyed in Lakes Huron and Michigan in pound nets and deep trap nets of different sizes of mesh:

Lake	Mesh size	Pound nets	Deep trap nets
Huron	Less than 4 inches	2.85	3.50
	4 inches and more	3.15	3.80
Michigan	Less than 4 inches	2.40	2.75
	4 inches and more	2.70	3.95

These estimates, percentages of "known destruction," range from 2.40 to 3.80. To the "known" destruction of undersized whitefish must be added the undetermined loss that resulted from the death of bloated live fish (this loss could not have been much greater than 1 percent—see table 44) and of fish killed or injured fatally during the sorting of the catch.

Despite the fact that the percentage of the undersized whitefish that was destroyed in a single lift was relatively small, the total destruction during the entire season may have been considerable, especially in those localities where the fishery was intensive and young whitefish were abundant. It is of some interest, therefore, to have estimates of the total number of undersized whitefish captured by pound nets and deep trap nets and of the total "known" destruction in certain fishing areas (table 46).

The estimates of the total number of young whitefish captured were based on the known number of nets lifted (as determined from fishermen's reports) and the average

TABLE 46.—*Estimated numbers of illegal-sized whitefish captured by pound nets and deep trap nets in certain areas of Lakes Huron and Michigan in certain calendar years, and the estimated known destruction (fish dead at time of lifting) of undersized whitefish*

Statistical districts	Year	Undersized fish taken			Known destruction		
		Pound nets	Deep trap nets	Both	Pound nets	Deep trap nets	Both
H-2	1931	127,000	321,000	448,000	3,600	11,400	15,000
	1932	64,000	180,000	244,000	1,900	6,400	8,300
H-3, H-4	1931	198,000	124,000	322,000	5,600	4,400	10,000
	1932	113,000	269,000	382,000	3,200	9,600	12,800
H-5	1932	----------	130,000	130,000	----------	4,600	4,600
	1933	----------	616,000	616,000	----------	21,700	21,700
M-2, M-3	1931	136,000	169,000	305,000	3,600	4,800	8,400
	1932	120,000	315,000	435,000	3,200	8,900	12,100

number of undersized whitefish per lift (as determined from our observations in the field). Estimates were made separately for large-mesh (4 inches and greater) and small-mesh (less than 4 inches) nets and combined to obtain the totals listed in the table. It was necessarily assumed that the relative numbers of large-mesh and small-mesh nets in the general fishery were the same as those observed by our investigators in the field. Estimates were made of the capture and destruction of illegal-sized whitefish by deep trap nets in H–5 in both 1932 and 1933, although field observations[38] were made only in 1932. The computations for 1933 (based on the assumption that the abundance of young whitefish and the relative numbers of large-mesh and small-mesh nets were the same in that year as in 1932) were carried out merely to provide a rough idea of the large numbers of whitefish that probably were handled during the years of intensive fishing in southern Lake Huron.

The estimated numbers of young whitefish handled by pound-net and deep-trap-net fishermen in the various districts and years were large (130,000 to 616,000). The estimated destruction, however, appeared to be relatively small (4,600 to 21,700). The combination of the data for all districts and years indicates a loss of 2.8 percent of all undersized whitefish taken in pound nets and of 3.4 percent of those captured by deep trap nets. These figures should not be taken as indicative of the percentage loss of the total population of undersized fish (of the sizes handled) as many fish may have been captured more than once and others, doubtless, were not captured at all.

Estimates were made also of the loss of small whitefish in the entire lakes (Michigan waters) in 1932, the year of our most extensive field observations. The 1932 pound-net yield in districts H–2 to H–5, inclusive, amounted to 43.5 percent of the catch of whitefish in pound nets in the entire lake. The "known" destruction of whitefish by pound nets in these districts in 1932 amounted to 5,100 individuals (table 46). If the average conditions of the pound-net fishery (abundance of young fish on the grounds and relative numbers of large-mesh and small-mesh nets) in H–1 and H–6 are assumed to have been similar to those of the fishery in H–2 to H–5, the "known" destruction of undersized whitefish in the pound nets of all Michigan waters of Lake Huron in 1932 can be calculated as 5,100/0.435 or 11,700 fish. Similarly, the deep trap nets of districts H–2 to H–5 accounted for 93.8 percent of the total deep-trap-net catch and for the estimated destruction of 20,600 young whitefish. The estimated "known" destruction for all six districts was, therefore, 20,600/0.938 or 22,000 fish. The combined "known" destruction of pound nets and deep trap nets in Lake Huron in 1932 was 33,700 whitefish.

The same calculations for the Michigan waters of Lake Michigan showed that in 1932 districts M–2 and M–3 yielded 52.1 percent of the total catch of whitefish in pound nets and 76.5 percent of the deep-trap-net production. These percentages applied to the figures on "known" destruction in table 46 yielded the following estimates of the loss of undersized whitefish in all eight districts: pound nets—6,100; deep trap nets—11,600; pound nets and deep trap nets—17,700.

The estimates of the "known" destruction of undersized whitefish by deep trap nets in all Michigan waters of Lakes Huron and Michigan in 1932 (22,000 and 11,600 individuals, respectively) can not be termed large. If that gear was extremely harmful to the stocks of small fish the loss must have occurred through the death of fish that were killed or injured fatally in the sorting of the catch.

The opinions of the fishermen concerning the ability of the whitefish to withstand handling were found to vary widely. Some (particularly those who were opposed to the use of deep trap nets) contended that whitefish are extremely delicate—that they are unable to survive removal from the water for even short periods of time and will die as the result of the least amount of handling. Others (especially deep-trap-net fishermen) held that the whitefish is exceptionally hardy—that with only reasonable care very few or none at all are injured during the sorting of the catch.

Data are not available to show which of the above diametrically opposite viewpoints is the more nearly correct. However, the fact that 101 or 22.1 percent of 457

[38] The pound-net fishery for whitefish was negligible in H-5 in 1932 and 1933 (appendix B). Our investigators observed no pound-net lifts in this district.

young whitefish tagged in Lake Michigan were later recovered (Smith and Van Oosten, 1940)[39] suggests that they successfully withstand careful handling.

Our field investigators reported that almost all deep-trap-net fishermen were extremely careful in the sorting of the catch. To be sure, they may have been more than ordinarily painstaking when the investigators were aboard their craft. Nevertheless, most of them appeared to be following a well established routine that involved a minimum of handling of illegal-sized whitefish and a minimum length of time out of the water. Only one fisherman was observed whose method of sorting was considered likely to result in the death of a high percentage of the undersized whitefish.

The fact that the illegal whitefish taken by the deep trap nets in Lakes Huron and Michigan were so near the legal size increased greatly the potential harm resulting from the destruction of undersized individuals. It was estimated that practically all of the illegal-sized whitefish observed would have attained the legal weight of 2 pounds within another year, as their average weight at capture was 1 pound, 9.7 ounces (17.6 inches, total length). However, the illegal-sized whitefish from the pound nets of Lake Huron (no data from Lake Michigan pound nets) were relatively small (13.1 ounces and 14.1 inches, total length).

SHRINKAGE OF THE TWINE IN POUND NETS AND DEEP TRAP NETS

The fact that pound-net and deep-trap-net twine is treated regularly (usually in the spring of each year) with tar or copper oleate as a preservative gives rise to a troublesome question as to whether the minimum legal size of the mesh shall be designated "as found in use" or "as manufactured." It is well known that the application of a net preservative to cotton twine is almost always accompanied by some shrinkage. However, the exact extent of this shrinkage is not predictable for individual nets. The amount of shrinkage of the twine varies with the method of applying the treatment, the number of times the webbing is treated, the nature of the webbing as received from the manufacturer, and possibly with the type of preservative employed. If the minimum legal mesh size is defined "as found in use," honest fishermen conceivably might find themselves confronted with the problem of large amounts of expensive gear rendered useless by unexpected high shrinkage. On the other hand, if the minimum mesh size is defined "as manufactured," unscrupulous fishermen may so control the type of twine purchased and the method of preservation as to shrink the mesh to a size far below the intended legal minimum. Regardless of how the legal minimum mesh size is designated, it is of importance to have data available on the average amount and the range of the shrinkage of pound-net and deep-trap-net twine following the application of a preservative.

The results of 648 measurements of pound-net and deep-trap-net meshes as found in use are recorded in table 47.[40] The data have been grouped according to the size of the mesh (extension measure) as manufactured and to the type of preservative applied. The former grouping (as to size of mesh when manufactured) is based entirely on the fishermen's statements. The meshes were measured by inserting a thin steel rule in one end of the collapsed mesh, pulling the twine taut, and reading the length between and inside the knots (not from the centers of the knots). Measurements were made both parallel with the selvage (first measurement of each series in table 47) and at right angles to it (second measurement).

Although most of the fishermen who were interviewed believed that tar shrinks webbing more than does copper oleate, their belief is not entirely supported by the data of table 47. It is true that tarred nets of 4¼-inch and 4½-inch original mesh size suffered greater shrinkage than nets of the same mesh size treated with copper oleate. On the other hand, nets with a factory measurement of 3½ inches shrank considerably more under copper-oleate treatment than did nets of the same mesh size treated with tar; a slightly greater shrinkage from copper oleate was found also for 4-inch-mesh nets. If all sizes of mesh are considered together, there appears to be little difference between the

[39] Smith, Oliver H. and John Van Oosten. Tagging Experiments with Lake Trout, Whitefish, and Other Species of Fish from Lake Michigan. Trans. Am. Fish. Soc., vol. 69, (1939) 1940, pp. 63-84.

[40] The data of table 47 do not represent 648 different nets as some nets were visited more than once. Several nets of mesh size larger than 4½ inches as manufactured were measured, but there were not enough of any single mesh size to yield reliable averages.

TABLE 47.—*Shrinkage of pound-net and deep-trap-net twine following the application of tar or copper oleate as preservatives*

[The average amounts of shrinkage are given in parentheses below the average measurements of the meshes as found in use. All averages are to the nearest sixteenth of an inch]

Type of treatment	Size of mesh as manufactured							
	3 1/2 inches		4 inches		4 1/4 inches		4 1/2 inches	
	Number of measurements	Mesh size as fished	Number of measurements	Mesh size as fished	Number of measurements	Mesh size as fished	Number of measurements	Mesh size as fished
Tar	38	3 1/8x3 1/8 (6/16x6/16)	144	3 9/16x3 5/8 (7/16x6/16)	59	3 13/16x3 15/16 (7/16x5/16)	206	3 7/8x3 15/16 (10/16x9/16)
Copper oleate	47	2 15/16x3 (9/16x5/16)	80	3 9/16x3 9/16 (7/16x7/16)	34	3 15/16x4 (5/16x4/16)	40	4 1/16x4 1/8 (7/16x6/16)
Total or average	85	3x3 1/16 (8/16x7/16)	224	3 9/16x3 5/8 (7/16x6/16)	93	3 7/8x4 (6/16x5/16)	246	4x4 (9/16x8/16)

shrinkage produced by tar and by copper oleate. With both treatments measurements made parallel with the selvage showed on the average 1/16 inch greater shrinkage than did those made at right angles to the selvage.

The data for individual nets showed a variation from "no shrinkage" to a maximum shrinkage of 1 inch. It is this wide range of variation in shrinkage that makes the designation of the legal minimum mesh in terms of "size as manufactured" so eminently undesirable. The average shrinkage of meshes measured in this study was 7/16 inch or slightly less than ½ inch. If it were known that the shrinkage of all nets closely approximated this average, the designation of a legal minimum mesh size (as manufactured) ½ inch larger than that intended for nets as found in use might prove reasonably satisfactory. However, the wide range of shrinkage makes such a procedure impractical. If the legal minimum mesh is to be defined "as manufactured," allowance should be made not for the average observed shrinkage but for the maximum possible shrinkage. A further objection to the designation of the legal minimum mesh size "as manufactured" lies in the fact that illegal nets can be fished with impunity if they have been treated before examination by a conservation officer. In other words, there is no exact means of determining the original mesh size of a treated net.

The conclusion is obvious that the most satisfactory method of designating minimum legal mesh sizes of pound nets and deep trap nets is on the basis of mesh size "as found in use." The wide experience of most commercial fishermen with different kinds of webbing and preservatives is certainly sufficient to preclude excessive losses as the result of undue shrinkage of their twine.

SUMMARY

1. The present investigation of the whitefish fishery of Lakes Huron and Michigan was undertaken because of the threat to the whitefish stocks offered by the introduction and rapid expansion in the use of a new and tremendously efficient gear, the deep trap net. This net, which was developed in Lake Ontario, was introduced into Lake Huron off Alpena, Mich., in 1928. Beginning in 1930, the use of the deep trap net expanded rapidly throughout the State of Michigan waters of Lake Huron and northern Lake Michigan. Operations with this gear were relatively limited in other waters (Wisconsin waters of Lake Michigan; Indiana waters of Lake Michigan; Michigan waters of Lake Superior and southern Lake Michigan). The greatest development of the deep-trap-net fishery occurred in the Michigan waters of central and southern Lake Huron.

2. The investigation was carried out along the following general lines:

a. A review of the available statistics on the production of whitefish in Lakes Huron and Michigan over the period, 1879–1939.

b. A detailed analysis of the fluctuations in the production and abundance of whitefish and in the intensity of the whitefish fishery in the different areas of the Michigan waters of Lakes Huron and Michigan in the years, 1929–1939, with special reference to the effects of the operations with deep trap nets. The methods of analysis are described.

c. A study of the bathymetric distribution of whitefish of legal and illegal size in order to obtain data on which to base recommendations for possible restrictions on the depth of water in which deep trap nets may be fished.

d. Observations in the field on the fishing action of pound nets and deep trap nets —particularly on the extent of the destruction of undersized whitefish. The field work was carried out in 1931 and 1932.

3. Although the fluctuations in the yield of whitefish in the various areas of Lakes Huron and Michigan over the period, 1879–1939, were by no means the same, certain general trends may be described. Production was high in all areas in the early years of the period. Later declines brought the catch to a much lower, and in some waters remarkably stable, level about which the production fluctuated for several decades. A pronounced general increase in the yield of whitefish occurred in the late 1920's and/or early 1930's. This increase was relatively greater and the subsequent decline was relatively more severe in the State of Michigan waters of Lake Huron than in other regions of the Great Lakes. Graphical representations of the history of whitefish production in different areas of Lakes Huron and Michigan are given in figures 2 and 3.

4. The increase in the abundance of whitefish that occurred in the late 1920's and early 1930's complicated greatly the problem of detecting the effects of deep-trap-net operations on the whitefish fishery of the State of Michigan waters of Lakes Huron and Michigan. This increase would have brought about a rise in both fishing intensity and catch even had deep trap nets not been introduced. Furthermore, a decline from this abnormally high level of yield and abundance was logically to be expected; the mere occurrence of a decline could not be interpreted as the result of the use of deep trap nets.

5. Despite this difficulty, the following observations demonstrated conclusively the disastrously harmful effects of extensive deep-trap-net operations on the stocks of whitefish:

a. The regions in which the deep-trap-net fishery underwent its greatest expansion (the four southernmost statistical districts of Lake Huron—see fig. 4) suffered an unreasonable multiplication of fishing intensity. In these districts of central and southern Lake Huron (H–3 to H–6) the maximum yield of whitefish was 4.3 to 26.6 times the 1929 catch; the maximum fishing intensity was 3.8 to 42.1 times the 1929 intensity. In the two northerly districts (H–1 and H–2) —areas in which the use of deep trap nets was much less extensive—the respective maximum productions were only 2.6 and 3.2 times the 1929 catch; the maximum fishing intensity was 2.3 times that of 1929 in each district.

b. In all districts of Lake Huron the introduction of the deep trap net brought about a tremendous increase in the catch of whitefish. After about two years of high production the catch fell sharply. This decrease in yield was accompanied by a rapid decline in the abundance of whitefish. However, these declines were relatively greater in central and southern Lake Huron. The 1939 production of whitefish, expressed as a percentage of the 1929 catch, was 38 in H–1 and 23 in H–2. These percentages were only 1 and 5 in H–3 and H–4. In H–5 and H–6 the 1939 yields were only 19 and 46 percent, respectively, of the 1929 production despite fishing intensities that were 4.3 and 4.9 times those of 1929. The 1939 abundance of whitefish, expressed as a percentage of the 1929 abundance, was 41 in H–1 and 43 in H–2. In central and southern Lake Huron these percentages were: H–3, 6; H–4, 7; H–5, 5; H–6, 10. These figures demonstrate that whereas the whitefish fishery merely declined in those districts (H–1 and H–2) in which the use of the deep trap net was relatively moderate, it collapsed in the districts (H–3 to H–6) in which deep-trap-net operations underwent their greatest expansion. The excessive use of deep trap nets, therefore, may be stated positively to be the cause of the present critical condition of the whitefish fishery in Lake Huron. The severity of the depletion is illustrated by the fact that the 1939 production of only

255,000 pounds was less than half the previously reported all-time low (555,000 pounds in 1900).

c. The statistics of the whitefish fishery of northern Lake Michigan (districts M–1, M–2, and M–3) for the years, 1929–1939, lend support to the conclusions based on the data for Lake Huron. In these Lake Michigan districts as in H–1 and H–2 the development of the deep-trap-net fishery may be termed relatively moderate. Although the whitefish fishery of northern Lake Michigan underwent a decline—a decline to which the use of deep trap nets may have contributed substantially—the severity of the decreases did not approach that of the decreases of central and southern Lake Huron; rather the changes resembled those that took place in northern Lake Huron. The deep trap net was of no significance in the State of Michigan waters south of district M–3, except in M–7 where it was the dominant gear for the production of whitefish in the single year, 1934.

6. The harmful effects of the deep-trap-net fishery can be traced to its great efficiency for the capture of whitefish in comparison with pound nets and large-mesh gill nets. Pound nets, which are held in position by stakes driven into the bottom of the lake, occupy the same position throughout the season, can be set only on soft bottom, and seldom are fished in water deeper than 60 feet. Deep trap nets, which are held in position by anchors and buoys, can be set on almost any kind of bottom and can be moved readily to any depth of water in which whitefish occur abundantly. These characteristics of the gear made possible the heavy exploitation of the whitefish at the time of their summer concentration in relatively deep water—far beyond the reach of pound nets. Gill nets have long been fished in these depths of the summer concentration of whitefish but in the modern fishery this gear has proved to be relatively unsuccessful for the capture of whitefish, except under certain special conditions (as during the spawning run or in limited local areas).

7. Records of the catch per lift of deep trap nets revealed that the gear was much less successful in northern Lake Huron (districts H–1 and H–2) and Lake Michigan (districts M–1, M–2, M–3, and M–7) than in central and southern Lake Huron (H–3 to H–6) This situation doubtless accounted in part (see p. 339) for the relatively less extensive development of the deep-trap-net fishery in Lake Michigan and northern Lake Huron.

8. Counts of legal- and illegal-sized whitefish in lifts of pound nets and deep trap nets from different depths of water were employed in a study of the bathymetric distribution and vertical movements of the species during the summer and early autumn.

9. The combined data for the months, May to October, inclusive, indicated that legal-sized whitefish were most abundant in Lake Huron at depths of 81 to 110 feet with the peak concentration in 91 to 100 feet. Illegal-sized fish were most abundant in 71 to 110 feet with a maximum concentration at 81 to 90 feet, 10 feet shallower than the depth of greatest abundance of legal fish. The records for the grounds off Alpena and in the Saginaw Bay area suggest that both legal- and illegal-sized whitefish may move onshore during the summer and return to deeper water in the autumn.

10. The whitefish lives in shallower water in northern Lake Michigan than in Lake Huron. The averages for the entire season (May to October, inclusive) showed legal-sized whitefish to be most abundant in 71 to 110 feet (peak concentration at 81–90 feet) and illegal-sized fish in 61 to 110 feet (peak at 71–80 feet). The depths of the peak concentrations were 10 feet shallower in northern Lake Michigan than in Lake Huron for fish of corresponding size.

11. The records for the individual months indicated that both legal- and illegal-sized whitefish in northeastern Lake Michigan moved toward deeper water from June to September. The October data provided some indication of a return migration in the autumn. These movements are the reverse of those indicated by the data for the Lake Huron whitefish.

12. The vertical distribution of whitefish in northeastern Lake Michigan was characterized by the presence of two concentration zones of both legal- and illegal-sized fish. Although the actual depths at which the zones occurred varied from month to month with the offshore and onshore movements of the fish, the two concentrations remained

distinct nevertheless in every month but September in the 5-month period, June to October. The inshore and offshore concentrations of legal-sized whitefish were separated by a difference in depth of 20 feet in each of the four months in which both were present. The offshore concentration of illegal-sized whitefish was 30 feet deeper than the inshore concentration in June, July, and August, but was only 20 feet deeper in October.

13. The persistent occurrence of two concentration zones of whitefish in northeastern Lake Michigan throughout most of the summer and early autumn raises the question of the possible existence of distinct inshore and offshore populations or races. Arguments were outlined briefly for and against this interpretation of the two concentrations; available data do not, however, permit a definite decision.

14. On the basis of the observations on the bathymetric distribution of whitefish, it was suggested that young fish would be protected from excessive handling and possible destruction and legal-sized fish from ruinous exploitation if the operations of deep trap nets were limited in Lake Huron to depths of 80 feet and less and in Lake Michigan to depths of 70 feet and less. The proposed restriction has been effective in Lake Huron since August 1, 1934; the use of deep trap nets was made illegal in Lake Michigan after 1935.

15. A limited amount of information was presented on the bathymetric distribution and seasonal movements of the lake trout, yellow pike, burbot, white sucker, and long-nosed or sturgeon sucker.

16. Comparisons of the average numbers of fish per lift of large-mesh (meshes of 4 inches or more, extension measure, in the pot) and small-mesh (less than 4 inches) pound nets and deep trap nets operated under comparable conditions (on the same grounds, in the same calendar year and month, and in the same depth of water) revealed that in general the large-mesh nets took the greater numbers of legal-sized whitefish and the lesser numbers of illegal-sized individuals. Large-mesh nets took 31.3 percent fewer undersized whitefish than did small-mesh nets that captured an equal number of legal-sized fish. Further evidence for the escape of undersized whitefish from the nets with larger mesh sizes was provided by the regular increase, with increase in the size of mesh, in the average length and weight of illegal-sized whitefish captured in pound nets and deep trap nets or gilled in the meshes of the lifting pot. On the basis of the selectivity data a minimum mesh size of 4½ inches or greater (extension measure as found in use) in the pots was recommended for pound nets and deep trap nets employed for the capture of whitefish and lake trout. (This size of mesh is prescribed by the present State of Michigan law.) Although the data indicated that meshes of 4½ inches or more will permit the escape of the smaller legal-sized lake trout, a smaller mesh cannot be recommended because lake trout and whitefish ordinarily are taken together. Furthermore, data on the size of lake trout at first maturity indicate the need for an increase in the size limit (now 1½ pounds) rather than a decrease in the minimum legal mesh size of pound nets and deep trap nets.

17. Observations of the lifting of pound nets and deep trap nets did not indicate the destruction of illegal-sized whitefish to be excessive even in those areas in which it was estimated that hundreds of thousands of young fish were captured in a single season. The "known" destruction of undersized fish (individuals dead from gilling or other causes at the time of lifting) ranged from 2.40 to 3.80 percent according to the lake, type of net, and size of mesh. These percentages tended to be higher for deep trap nets than for pound nets. To the "known" destruction must be added the undetermined losses from the later death of live bloated fish (only a little more than 1 percent of the live illegal-sized whitefish were bloated) and of fish killed or injured fatally during the sorting of the catch. Field observations indicated, however, that most (but not all) fishermen attempted to avoid rough handling of small whitefish and returned them to the water as soon as possible.

18. Extensive measurements were obtained of meshes in the pots of pound nets and deep trap nets in order to determine the amount of shrinkage produced by different types of preservatives applied to the twine. No significant difference could be found between the shrinkage brought about by treatment with tar and copper oleate. The mesh size

of treated nets averaged a little less than a half inch smaller than the mesh size as manufactured. The amount of shrinkage varied widely, however, in the individual nets. Because of this variation the minimum legal size of mesh should be specified "as found in use" rather than "as manufactured." Once a net has been treated, it is impossible to determine exactly the original size of the mesh.

APPENDIX A

SOURCES OF THE DATA ON PRODUCTION, 1879-1939

The following paragraphs contain the details concerning the sources of the production data of table 1. Where more than one source was available for any single year, preference usually was given to that with the most continuous record over a period of years.

(1) Sessional Papers of the Parliament, Dominion of Canada: all data for the Canadian waters of Lake Huron, 1879–1905.

(2) Annual Reports of the Game and Fisheries Department of the Province of Ontario: all data for the Canadian waters of Lake Huron, 1906–1939.

(3) Reports of the United States Commissioner of Fisheries and his administrative successors: all data for United States waters, 1879 (repeatedly listed erroneously in the reports as for 1880) and 1885; United States waters, except the Wisconsin waters of Lake Michigan, 1890 (including the total for the Lake); Wisconsin waters of Lake Michigan, 1926–1939; total for Lake Michigan, 1925; Indiana and Illinois waters of Lake Michigan, 1879, 1885, 1890, 1897, 1903, 1917, 1922, and 1925–1939 (actually, no whitefish catch was reported from these States in 1938 and 1939). The Indiana and Illinois catches of whitefish in Lake Michigan for the above years, although not recorded in table 1, have been included in the Lake Michigan totals. All other Lake Michigan totals for individual years, except 1889 and 1908, are exclusive of the Indiana and Illinois catches.

(4) Reports of the State of Michigan Department of Conservation and its administrative predecessors: State of Michigan waters of Lake Michigan, 1911; State of Michigan waters of Lakes Huron and Michigan, 1912–1928.

(5) United States Bureau of the Census—Fisheries of the Great Lakes, Census Bulletin no. 173: all United States waters (including catches in Illinois and Indiana), 1889. Fisheries of the United States, Special Report: Wisconsin waters of Lake Michigan, 1908; Indiana and Illinois waters of Lake Michigan, 1908 (not listed in table 1 but included in the total for the lake).

(6) Compilations made from original State records:

Wisconsin.—Wisconsin waters of Lake Michigan, 1890, 1892–1897, 1899, 1903, and 1909–1925.

Michigan.—Michigan waters of Lakes Huron and Michigan, 1891–1908.

Michigan.—Compilations from the daily reports of commercial fishermen—State of Michigan waters of Lakes Huron and Michigan, 1929–1939. (These data are treated in detail in part II.)

Although certain data are available for earlier years, the statistical records for the whitefish fisheries of the United States waters of Lakes Huron and Michigan may be assumed for practical purposes to begin with 1889 and 1891. The 1879, 1885, and 1890 catches included longjaws, blackfins, and Menominee whitefish in Lake Michigan, and Menominee whitefish in Lake Huron. The only clue as to the extent of the errors brought about by these inclusions is provided by the fact that in 1890 longjaws, blackfins, and Menominee whitefish made up about 26 percent of the reported catch of whitefish in Lake Michigan (1,398,238 pounds in a total of 5,455,079 pounds). The 1890 total for the Wisconsin waters of Lake Michigan is based on State records and is not known to include any species other than whitefish. However, Wisconsin contributes a relatively small part of the total whitefish catch in Lake Michigan.

As has been mentioned previously, the Lake Michigan totals for several individual years do not include the catch of whitefish in Indiana and Illinois waters. However,

the error involved is small, as the following catches for the years in which the production in these two States is known will show:

Year	Pounds	Year	Pounds	Year	Pounds
1885	[1]247,086	1922	20,800	1933	6,600
1889	37,375	1926	12,094	1934	4,600
1890	[2]94,736	1927	22,436	1935	1,500
1897	[2]39,760	1928	15,454	1936	6,500
1899	10,558	1929	36,375	1937	3,800
1903	2,905	1930	10,695	1938	No catch
1908	65,000	1931	9,755	1939	do.
1917	37,750	1932	12,450		

[1] Includes longjaws, blackfins, and Menominee whitefish.
[2] Includes longjaws, blackfins, and Menominee whitefish—the total listed for the lake does not, however, include these species.
[3] Fiscal year.

The tabulation of the statistics of the production of whitefish in the Canadian waters of Lake Huron has been started with 1879, the first year for which statistics are available for United States waters. Available statistics on the production of whitefish in the Canadian waters of Lake Huron for the earlier years, 1867–1878, have been omitted from table 1 because of the lack of comparative data for United States waters. These earlier Canadian records also are open to the criticism that in a number of years the production reported for Huron proper included the catch in the St. Clair River and in Lake St. Clair to the point of inflow of the Thames River. The catches listed under "Huron proper" for the years, 1879–1921, were taken between the tip of the Saugeen Peninsula at Cape Hurd, Ontario, and the extreme southern end of Lake Huron. Beginning in 1922 the islands of the open lake and the westerly shore of Manitoulin Island to the north of the Saugeen Peninsula were included in "Huron proper."

As stated in footnote 8, the catches listed under the heading, "Georgian Bay," represent a combination of the take in the Bay and in the North Channel and Manitoulin Island regions to the north and west except in 1922 and later years as explained above. This combination was made partly in an attempt to reduce the size and complexity of table 1 and partly because of variation in the extent of the waters included in the two areas. For example, reports for certain of the earlier years listed the catches along the east shore of Georgian Bay as far south as Penetanguishene as part of the production in the Manitoulin Island and North Channel area.

Reference should be made here to the Canadian records compiled for the International Board of Inquiry for the Great Lakes Fisheries and published after this manuscript was completed.[41] The districts employed by Ford are not always the same as those used in this report and her statistics for these areas are therefore not always comparable with ours. However, both records of the total Canadian catch of Lake Huron should be the same. Minor discrepancies occur for some years because, in contrast to our records, Ford's figures were rounded to the nearest hundredweight. In other years the discrepancies are larger, though still insignificant. The reason for these differences is not known. A check with the published records of the Game and Fisheries Department of Ontario reveals that our figures agree with theirs. At any rate our conclusions would remain the same whether we utilized Ford's data or our own.

The accuracy of the catches recorded for the Ontario waters of Huron proper in 1908 and 1909 has been considered so questionable that the values were not plotted in figure 2 and were omitted in the computation of averages for periods that included these 2 years. The contrast between the catches for 1908 and 1909 and the production in the years immediately preceding and immediately following is in itself sufficiently great to give just grounds for suspicion. This suspicion is heightened by the observation that the large 1908 and 1909 catches are to be traced to reports of excessive quantities of whitefish as barrels of salt whitefish. In 1908 3,515 barrels (703,000 pounds) and in 1909 550 barrels (110,000 pounds) of salt whitefish were reported. In other years of the period, 1900–1917, the number of barrels of salt whitefish reported for Huron proper did not exceed 82, and averaged only 12 barrels.

Barrels of salt fish have been converted to fresh fish at the rate of 200 pounds per barrel. Catches given as numbers of fish have been converted to pounds at the rate of 2 pounds per fish.

[41] International Board of Inquiry for the Great Lakes Fisheries. Report and Supplement. Washington, 1943.
Ford, Marjory A. Annual Landings of Fish on the Canadian Side of the Great Lakes from 1867 to 1939 as Officially Recorded. Ottawa, 1943

APPENDIX B

DETAILED STATISTICS ON WHITEFISH PRODUCTION IN STATE OF MICHIGAN WATERS OF LAKES HURON AND MICHIGAN, 1929–1939

TABLE 48.—*Production of whitefish in pounds according to gear in the several districts of the State of Michigan waters of Lakes Huron and Michigan, 1929–1939*

[The districts of Lake Huron are numbered H-1, H-2, *** and of Lake Michigan, M-1, M-2, ***. In districts M-4, M-5, M-6, and M-8 the catch of deep trap nets is included under "Other."]

DISTRICT H-1

Year	Gear				Total annual production	Percentage of average annual production
	Large-mesh gill net	Deep trap net	Pound net	Other		
1929	232,063		142,182	1,332	375,577	81
1930	174,851	386,453	291,765	2,293	755,362	163
1931	246,897	375,122	337,805	27,642	987,466	213
1932	135,059	170,313	306,938	11,360	623,670	135
1933	121,664	64,251	161,133	18,635	365,683	79
1934	105,582	104,699	166,877	947	378,105	82
1935	106,498	163,465	98,512	4,399	372,874	80
1936	82,464	346,821	100,282	11,825	541,392	117
1937	43,626	236,196	93,428	505	373,755	81
1938	54,834	73,184	51,035	1,074	180,127	39
1939	40,368	73,406	25,876	1,401	141,051	30
Average 1929–1939	122,173	172,174	161,439	7,401	463,187	100

DISTRICT H-2

1929	12,708	87,121	173,904	907	274,640	160
1930	48,151	358,872	187,443	60	594,526	345
1931	18,252	376,887	83,679	151	478,969	278
1932	3,785	94,527	18,823	297	117,432	68
1933	5,641	28,540	22,386	178	56,745	33
1934	7,331	44,153	39,041	2,591	93,116	54
1935	3,653	94,584	19,025	1,025	118,287	69
1936	1,197	46,602	3,346	4,461	55,606	32
1937	1,923	14,009		4,881	20,813	12
1938	25	34,315	229	6,794	41,363	24
1939	8	41,980		297	42,285	25
Average 1929–1939	9,334	111,054	49,807	1,967	172,162	100

DISTRICT H-3

1929	43,426		54,536	856	98,818	107
1930	63,216	157,248	21,998	5,110	247,572	269
1931	44,336	395,230	7,121	23,736	470,423	511
1932	7,644	85,236	475	44,108	137,463	149
1933	4,218	9,912			14,130	15
1934	1,791	12,558		50	14,399	16
1935	928	7,964	9	6	8,907	10
1936	439	7,567			8,006	9
1937	799	1,934		65	2,798	3
1938	187	8,910	42	24	9,163	10
1939	230	277		50	557	1
Average 1929–1939	15,201	62,440	7,653	6,728	92,022	100

DISTRICT H-4

1929	85,186		437,848	48,571	571,605	83
1930	137,402	68,748	757,720	79,525	1,043,395	152
1931	96,986	932,357	446,010	472,732	1,948,085	283
1932	46,400	1,934,325	224,285	257,948	2,462,958	358
1933	2,969	620,125	105,255	33,213	761,562	111
1934	4,687	116,849	44,192	29,217	194,945	28
1935	183	138,446	51,002	22,882	212,513	31
1936		75,438	21,829	31,450	128,717	19
1937	260	121,796	12,716	20,319	155,091	23
1938	158	38,224	5,708	11,795	55,885	8
1939	176	18,785	2,319	4,665	25,945	4
Average 1929–1939	34,037	369,554	191,717	92,029	687,337	100

TABLE 48.—*Production of whitefish in pounds according to gear in the several districts of the State of Michigan waters of Lakes Huron and Michigan, 1929–1939—Continued*

[The districts of Lake Huron are numbered H-1, H-2, *** and of Lake Michigan, M-1, M-2, ***. In districts M-4, M-5, M-6, and M-8 the catch of deep trap nets is included under "Other."]

DISTRICT H-5

Year	Gear				Total annual production	Percentage of average annual production
	Large-mesh gill net	Deep trap net	Pound net	Other		
1929	61,052		1,935		62,987	19
1930	84,803		4,879	1,811	91,493	27
1931	66,647		6,125	1,266	74,038	22
1932	29,080	479,916	4,413		513,409	152
1933	15,114	1,658,753	2,565		1,676,432	496
1934	253	783,606	345	11	784,215	232
1935	270	272,746	405		273,421	81
1936		119,103	37		119,140	35
1937	137	66,688			66,825	20
1938	83	41,832			41,915	12
1939		12,247			12,247	4
Average 1929–1939	23,404	312,263	1,882	281	337,830	100

DISTRICT H-6

1929	55,526		13,291	3,924	72,741	19
1930	105,329		38,781	2,982	147,092	37
1931	146,397		30,200	4,194	180,791	46
1932	163,598		14,764	17,040	195,402	50
1933	119,665	322,995	13,890	2,799	459,349	117
1934	70,057	999,618	7,752	26,026	1,103,453	281
1935	21,257	810,137	3,327	74,084	908,805	232
1936	4,851	571,176	1,606	11,675	589,308	150
1937	3,192	393,541	1,077	1,589	399,399	102
1938	390	226,608	1,799	719	229,516	58
1939	290	31,822	716	270	33,098	8
Average 1929–1939	62,777	305,082	11,564	13,209	392,632	100

DISTRICT M-1

1929	596,743		535,227	7,658	1,139,628	217
1930	582,761	37,655	445,969	9,363	1,075,748	205
1931	500,828	111,523	575,457	7,161	1,194,969	227
1932	353,998	191,979	344,086	20,043	910,106	173
1933	72,722	77,161	85,755	2,531	238,169	45
1934	74,682	56,918	130,407	998	263,005	50
1935	97,241	22,783	50,246	4,367	174,637	33
1936	51,937		37,899	367	90,203	17
1937	54,767		50,039	83	104,889	20
1938	233,314		120,829	92	354,235	68
1939	100,381		136,660	468	237,509	45
Average 1929–1939	247,216	45,274	228,416	4,830	525,736	100

DISTRICT M-2

1929	62,339		27,678	2	90,019	164
1930	84,555		16,070		100,625	184
1931	55,593	13,645	12,374	6	81,618	149
1932	36,610	59,303	1,330	5	97,248	178
1933	11,288	30,753	236		42,277	77
1934	15,278	11,580			26,858	49
1935	42,643	3,621			46,264	85
1936	46,465				46,465	85
1937	31,489			4	31,493	57
1938	24,221				24,221	44
1939	15,402				15,402	28
Average 1929–1939	38,717	10,809	5,244	2	54,772	100

DISTRICT M-3

1929	805,344		1,396,439	281	2,202,064	206
1930	920,784	97,454	1,442,083	335	2,460,656	230
1931	484,121	273,282	622,686	361	1,380,450	129
1932	430,866	596,246	462,360		1,489,472	140
1933	277,322	318,260	295,309	8	890,899	83
1934	251,308	251,012	259,511		761,831	71
1935	368,955	177,374	202,793	544	749,666	70
1936	289,502		156,446	19	445,967	42
1937	297,274		153,176	169	450,619	42
1938	294,479		203,261	36	497,776	47
1939	228,482		196,998	15	425,495	40
Average 1929–1939	422,585	155,784	490,097	161	1,068,627	100

TABLE 48.—*Production of whitefish in pounds according to gear in the several districts of the State of Michigan waters of Lakes Huron and Michigan, 1929–1939—Continued*

[The districts of Lake Huron are numbered H-1, H-2, *** and of Lake Michigan, M-1, M-2, ***. In districts M-4, M-5, M-6, and M-8 the catch of deep trap nets is included under "Other."]

DISTRICT M-4

Year	Gear				Total annual production	Percentage of average annual production
	Large-mesh gill net	Deep trap net	Pound net	Other		
1929	30,433		42,158	38	72,629	127
1930	41,335		42,784		84,119	147
1931	43,753		40,235	265	84,253	148
1932	44,552		32,857	1,362	78,771	138
1933	22,683		26,758	1,569	51,010	89
1934	6,435		41,386	548	48,369	85
1935	7,663		35,864	4,451	47,978	84
1936	26,807		29,377	50	56,234	98
1937	16,671		27,179	16	43,866	77
1938	17,707		11,525	17	29,249	51
1939	18,735		13,022	10	31,767	56
Average 1929–1939	25,161		31,195	757	57,113	100

DISTRICT M-5

1929	271,324		13,296		284,620	89
1930	259,351		21,345	5	280,701	88
1931	548,048		32,488		580,536	183
1932	532,784		21,992	3,797	558,573	176
1933	493,070		33,070	3,557	529,697	167
1934	272,782		25,675	40	298,497	94
1935	198,864		9,790	153	208,807	66
1936	189,741		9,013	47	198,801	62
1937	263,057		4,236	92	267,385	84
1938	176,421		13,203	34	189,658	60
1939	90,359		6,899	10	97,268	31
Average 1929–1939	299,618		17,364	703	317,685	100

DISTRICT M-6

1929	102,934		463		103,397	141
1930	140,707		80,916	525	222,148	304
1931	195,233		47,905	8,877	252,015	345
1932	77,457		7,450	173	85,080	116
1933	37,498		3,058	2,625	43,181	59
1934	29,405		4,125	3,920	37,450	51
1935	24,415		444	2	24,861	34
1936	9,998		4,065		14,063	19
1937	10,887		210	3	11,100	15
1938	4,717		2,070		6,787	9
1939	2,600		2,037	16	4,653	7
Average 1929–1939	57,805		13,886	1,467	73,158	100

DISTRICT M-7

1929	123,905		15,647	138	139,690	135
1930	202,878		244,882		447,760	433
1931	41,836	347	65,023		107,206	104
1932	24,096	3,819	19,970	49	47,934	46
1933	118,728	6,240	32,725	6	157,699	153
1934	66,400	74,956	49,178	48	190,582	184
1935	26,090	3,079	638	699	30,506	30
1936	4,243		893	76	5,212	5
1937	7,306		705	6	8,017	8
1938	550		559	28	1,137	1
1939	1,022		471	44	1,537	1
Average 1929–1939	56,096	8,040	39,154	99	103,389	100

DISTRICT M-8

1929	251,071		1,175	3,576	255,822	197
1930	106,791		34,277		141,068	108
1931	117,167		25,408	361	142,936	110
1932	64,142		622	336	65,100	50
1933	274,632		8,276		282,908	217
1934	284,784		20,788	14	305,586	235
1935	145,208		1,592	2,205	149,005	114
1936	16,591		2,815	60	19,466	15
1937	28,064		982	452	29,498	23
1938	14,007			9	14,016	11
1939	25,820		401	4	26,225	20
Average 1929–1939	120,752		8,758	638	130,148	100

APPENDIX C

INVESTIGATION OF POUND NETS AND DEEP TRAP NETS IN THE WISCONSIN WATERS OF LAKE MICHIGAN, 1931[42]

The brief investigation of the pound-net and deep-trap-net fisheries of the Door peninsula was conducted for the specific purpose of determining the validity of the strenuous complaints of commercial fishermen against the use of the deep trap net. The objections against the deep trap net as a dangerously efficient gear, as a source of destruction to young fish, and as a usurper of pound-net grounds were in general the same as those put forward by Michigan fishermen, and, consequently, need not be outlined in detail here. (See p. 298.) The procedure of the investigation involved observations of the lifting of pound nets and deep trap nets, interviews with operators of both types of nets (including a public hearing attended by more than 250 fishermen at Fish Creek, July 10, 1931), and the compilation of statistics on (1) the production of whitefish in the Wisconsin waters of Green Bay and Lake Michigan, beginning in 1889, and (2) the production of whitefish and the catch per lift in pound nets and deep trap nets of the Door peninsula, 1930–1931.

PRODUCTION OF WHITEFISH IN THE GREEN BAY AND LAKE MICHIGAN WATERS OF WISCONSIN, 1889-1939

The data on whitefish production in the State of Wisconsin waters of Green Bay and Lake Michigan (table 49) were compiled from original records in the files of the Wisconsin Conservation Department.[43]

TABLE 49.—*Production of whitefish in pounds in Green Bay and Lake Michigan, 1889–1939*

[Compiled from State records at Madison, Wis.]

Year	Green Bay	Lake Michigan	Green Bay and Lake Michigan	Year	Green Bay	Lake Michigan	Green Bay and Lake Michigan
1889	248,810	78,450	327,260	1920	42,411	89,022	131,433
1890	181,692	5,750	187,442	1921	171,896	190,519	362,415
1892	54,540	279,540	334,080	1922	80,658	82,543	163,201
1893	450,000	20,325	470,325	1923	74,484	363,439	437,923
1894	392,100	25,000	417,100	1924	182,989	64,115	247,104
1895	500,000	20,325	520,325	1925	147,556	94,823	242,379
1896	525,000	28,000	553,000	1926	249,976	90,470	340,455
1897	568,367	317,991	886,358	1927	191,779	122,453	314,232
1899	37,685	37,670	125,355	1928	430,386	123,681	554,067
1903	5,949	110,815	116,764	1929	287,648	44,965	332,613
1909	83,114	50,139	133,253	1930	500,996	34,832	535,828
1910	49,340	28,221	77,561	1931	462,117	235,663	697,780
1911	36,424	88,095	124,519	1932	183,002	93,522	276,524
1912	102,080	78,203	180,283	1933	86,051	37,402	123,453
1913	41,750	76,175	117,925	1934	82,105	17,591	99,696
1914	21,435	19,230	40,665	1935			263,900
1915	60,835	60,081	120,916	1936	49,046	93,555	142,601
1916	12,049	96,172	108,221	1937	45,587	91,270	136,857
1917	20,853	106,080	126,933	1938	60,962	80,663	141,625
1918	21,012	233,067	254,079	1939	27,200	86,620	113,820
1919	83,184	118,935	202,119				

Green Bay.—Whitefish production was large in the early and middle nineties, but there was a sharp drop in the catch at about the turn of the century. Production remained rather consistently at a low level over the years, 1909–1923; only two years (1912 and 1921) of this period had yields in excess of 100,000 pounds. Beginning in 1924 the production of whitefish in Green Bay followed an irregular but definite upward trend that culminated in a yield of a half million pounds in 1930. This catch (1930) was the greatest since 1897 and was the third largest in the known history of the fishery.

[42] This section is condensed from the unpublished "Report to the Conservation Commission of the State of Wisconsin on the Investigation of Deep Trap Nets, Conducted Jointly by the State Fisheries Department and the United States Bureau of Fisheries during the Period, July 6 to 11, 1931, in the Waters of Door County, Wisconsin." The investigation was made by Dr. John Van Oosten of the United States Bureau of Fisheries (now the Fish and Wildlife Service) and Messrs. B. O. Webster and Ira G. Smith of the Wisconsin Conservation Department.

[43] There are certain discrepancies between the data of table 49 of this appendix and those of table 1 of part 1. These arise from the fact that the former table has been based entirely on State of Wisconsin records (in order to have data for Green Bay and Lake Michigan separately) whereas the records of whitefish production in Wisconsin waters in the latter table were obtained from several sources. (See appendix A.)

Production was still high in 1931; however, the years, 1932–1939, comprised a period of rapid decline. The 1939 catch of 27,200 pounds was the lowest since 1918.

Lake Michigan.—The Lake Michigan data are much more variable than those for Green Bay, and it is correspondingly difficult to speak of definite periods of high or low production. Frequently exceptionally good or poor years are isolated (as, for example, 1892 and 1931). The period of most consistently low production was 1909–1916 (all years below 100,000 pounds) and the most extended era of heavy yield was 1917–1923 (all but two years above 100,000 pounds). The best of the more recent years was 1931 with a catch of 236,000 pounds. The 1931 catch was exceeded by that of only one year (1923) since 1897 and was the fourth highest in the history of the fishery. Production was consistently below 100,000 pounds in the years, 1932–1939 (no data for 1935).

Green Bay and Lake Michigan.—The data for all of the State of Wisconsin waters of Lake Michigan show a fairly consistent high level of yield for the years, 1889–1897. Available data indicate a relatively low production in the period, 1899–1917; only once (1912) did the catch exceed 150,000 pounds in the 11 years for which there are records, and it fell below 100,000 pounds in 2 of them (1910 and 1914). An upturn occurred in 1918. Over the period, 1918–1925, production fell below 200,000 pounds only twice (1920 and 1922) and exceeded 400,000 pounds in 1923. A still higher level was maintained during the six years, 1926–1931. All of the annual yields were above 300,000 pounds and 3 years had catches in excess of 500,000 pounds. The 1931 take of 698,000 pounds was the largest since 1897 and the second largest in history. Production was at a relatively low level in the years, 1932–1939. The catch exceeded 200,000 pounds in only two of these years (1932 and 1935). The 1934 catch was the lowest since 1914 and the third lowest on record.

A striking feature of the State of Wisconsin data is the lack of agreement between the statistics for Green Bay and Lake Michigan. Some years were good or poor in both areas, as for example, 1897, 1931, and 1934. It is true also that the data for the two areas occasionally agreed rather well in general trend over a period of several years as in 1909–1917 and 1931–1934. On the other hand, there were numerous years that had a very high catch in one area and exceptionally poor production in the other. Outstanding examples of such disagreements occurred over the period, 1890–1896, and in the years 1918, 1923, 1926, 1929, and 1930.

POUND-NET AND DEEP-TRAP-NET FISHERY, 1930-1931

Table 50 contains data on the pound-net and deep-trap-net fisheries for whitefish in Door County waters, 1930–1931. (Practically all of Wisconsin's whitefish are produced in these waters.) The comparison of the average catch per lift of the two gears in corresponding months confirms the contention of fishermen that the deep trap net is the more effective gear. The catch per lift of deep trap nets was 2.7 times that of pound nets in May 1931, 2.2 times in June, and 2.3 times for May and June com-

TABLE 50.—*Production of whitefish and catch per lift in pound nets and deep trap nets of Door County, Wis., 1930–1931*

Date or period	Pound net			Deep trap net		
	Number of lifts	Production (pounds)	Catch per lift (pounds)	Number of lifts	Production (pounds)	Catch per lift (pounds)
1930						
May	265	23,427	88 4			
June	595	85,546	143 7			
May and June	860	108,973	126.7			
1931						
April				17	803	47 2
May	253	21,524	85 1	130	29,652	228 1
June	391	66,364	169 7	184	69,359	376 4
July				43	11,509	267 6
April to July				374	111,323	297.3
May and June	644	87,888	136.4	314	99,011	315 3

bined. The data do not, however, support the complaint that the deep-trap-net fishery was extremely harmful to the pound-net fishery in 1931. It is true that the total production in pound nets was less in 1931 than in 1930, but the decline was the result of reduced fishing intensity. The average catch of whitefish per lift of pound nets was approximately 10 pounds greater in 1931 than in 1930.

Although the average lifts of whitefish in deep trap nets in 1931 were 2.3 times those of pound nets, this advantage depended only on the greater depth of water in which deep trap nets were fished. The effect of the depth of water on the size of the lift is brought out by the comparison of the lifts of whitefish in shallow pound nets, deep pound nets (more than 50 feet of water), and deep trap nets (table 51). There was little difference between the size of the lifts of deep pound nets and deep trap nets, but both took more than 8 times as many fish per lift as shallow pound nets (less than 50 feet of water). It is obvious, therefore, that any indictment of the deep trap net in Door County waters as a dangerously effective gear must apply also to deep pound nets.[44]

TABLE 51.—*Comparison of the catch of whitefish of shallow pound nets, of deep pound nets, and of deep trap nets fished in Door County, Wisconsin waters, June 1931*

Gear	Number of lifts	Total production (pounds)	Catch per lift (pounds)
Shallow pound net	58	2,566	44.2
Deep pound net	60	21,861	364 3
Deep trap net	184	69,359	376.4

Further conclusions based on observations of pound nets and deep trap nets in Door County waters are summarized as follows:

(1) The sorting of fish was more difficult in deep trap nets than in pound nets. However, less sorting was necessary with deep trap nets than with pound nets which ordinarily had 2-inch mesh (stretched measure). Very few illegal whitefish (legal size limit, 13 inches, total length, at the time of the investigation) were seen in deep trap nets, the mesh of which ranged from 3½ to 4½ inches. On several occasions small fish were seen to escape through the meshes as deep trap nets were lifted.

(2) Very few gilled fish were observed in deep trap nets, and most of the fish gilled were of legal size. A 3½-inch-mesh net allows the escape of whitefish of 13 to 13½ inches, total length, and smaller; 4½-inch meshes release whitefish about 16 inches long, and smaller.

(3) The observations did not support the contention that illegal whitefish brought to the surface in deep trap nets die. Small whitefish and herring were seen to pass through the bottom of the trap nets when they reached the surface, apparently uninjured and certainly not bloated.

REGULATIONS RECOMMENDED FOR THE DEEP TRAP NET IN WISCONSIN WATERS

The investigating committee submitted the following recommendations for the regulation of the deep trap net in Wisconsin waters (almost entirely direct quotation from report):

1. The size of the mesh in the lifting pot must be not less than 4½ inches but the side of the pot where fish are bagged may be of smaller mesh.
2. The length of the lead shall be not more than 50 rods.
3. A buoy must be attached to every anchor and each buoy must have a flag attached to it, extending not less than 30 inches above the surface of the water.
4. The shortest distance between strings of trap nets or between trap nets and pound nets shall be not less than one-half mile. A trap net as here defined refers to any part of the net constructed of webbing and includes the pot, tunnel, heart, and lead (not the anchors, ropes, buoys, and flags).

[44] Both gears can operate on the concentrations of whitefish at depths of 50 or 60 feet. Attempts of deep-trap-net fishermen to locate whitefish in deeper water (*ca.* 100 feet) were unsuccessful.

5. A trap net shall not be set in water more than 60 feet deep. A trap net under this ruling is the same as that defined under regulation no. 4.

6. No more than two trap nets shall be placed in one string and an open space free from netting of not less than 50 feet shall be left between the nets.

7. In the event of a dispute between a trap-netter and a pound-netter concerning the distance between nets, priority consideration shall be given the pound-netter if it is established that he has fished for several years the grounds where his nets had been set. Such consideration shall be given even though the trap-netter was the first to set his nets on the disputed grounds at the beginning of the season.

8. A trap net or a string of trap nets must be set approximately at a right angle to the shore line or shoal or reef.

9. Regulations 2, 4, 5, 6, and 8 have been recommended for trap nets on the assumption that they will be observed by pound-netters also. Enforcement is to be contingent on the adherence of pound-netters to these regulations.

APPENDIX D

THE WHITEFISH FISHERY OF LAKES HURON AND MICHIGAN, 1940-1942

Because of unavoidable delays in publication, statistics of the whitefish fishery have become available for three additional years (1940, 1941, and 1942) since the preparation of the main body of this paper and appendices A, B, and C. The data for these years are presented in this appendix. Discussion is brief and is concerned chiefly with the demonstration that the new information substantiates the conclusions drawn previously. Emphasis is placed on the detailed statistics for the State of Michigan waters although production data are given for other areas.

TABLE 52.—*Production of whitefish in pounds in the State of Michigan waters of Lake Huron, 1940–1942*

District or area	Year	Production in gear				Total	Percentage of total catch of lake	Percentage of 1929–1939 average
		Large-mesh gill net	Deep trap net	Pound net	Other			
H-1	1940	43,661	52,996	25,637	415	122,709	65.2	26
	1941	24,282	41,987	28,298	367	94,934	83.5	21
	1942	22,657	29,450	23,527	104	75,738	79.7	16
H-2	1940	149	11,421	11	790	12,371	6.6	7
	1941	----------	3,384	----------	466	3,850	3.4	2
	1942	818	343	----------	5,914	7,075	7.4	4
Northern Lake Huron (H-1 and H-2)	1940	43,810	64,417	25,648	1,205	135,080	71.8	21
	1941	24,282	45,371	28,298	833	98,784	86.9	16
	1942	23,475	29,793	23,527	6,018	82,813	87.1	13
H-3	1940	28	1,282	4	435	1,749	0.9	2
	1941	10	----------	10	459	479	0.4	1
	1942	668	----------	48	----------	716	0.7	1
H-4	1940	80	25,454	3,847	2,172	31,553	16.8	5
	1941	217	8,604	977	1,719	11,517	10.1	2
	1942	907	5,068	60	1,263	7,298	7.7	1
Central Lake Huron (H-3 and H-4)	1940	108	26,736	3,851	2,607	33,302	17.7	4
	1941	227	8,604	987	2,178	11,996	10.5	2
	1942	1,575	5,068	108	1,263	8,014	8.4	1
H-5	1940	----------	8,702	----------	----------	8,702	4.6	3
	1941	----------	633	----------	----------	633	0.6	[1] 0
	1942	----------	----------	----------	----------	----------	0.0	0
H-6	1940	----------	10,795	82	153	11,030	5.9	3
	1941	256	1,996	37	25	2,314	2.0	1
	1942	135	3,238	188	706	4,267	4.5	1
Southern Lake Huron (H-5 and H-6)	1940	----------	19,497	82	153	19,732	10.5	3
	1941	256	2,629	37	25	2,947	2.6	[1] 0
	1942	135	3,238	188	706	4,267	4.5	1
Lake Huron (all 6 districts)	1940	43,918	110,650	29,581	3,965	188,114	----------	9
	1941	24,765	56,604	29,322	3,036	113,727	----------	5
	1942	25,185	38,099	23,823	7,987	95,094	----------	4

[1] Less than 0.5.

WHITEFISH FISHERY OF LAKE HURON, 1940-1942

The downward trend in the production of whitefish in the State of Michigan waters of Lake Huron which got under way in 1933, and in 1939 had carried the annual yield to less than half the previously recorded minimum (555,000 pounds in 1900), continued through 1940–1942 (table 52 of this appendix—for further data on production see also table 1 of part I, tables 3, 4, 5, and 6 of part II, and appendix B). The production of 95,000 pounds in 1942 amounted to only 4 percent of the 1929–1939 average for Lake Huron,[45] and was only 2 percent of the 1931 maximum yield. Aside from unimportant increases in H–2, H–3, and H–6 in 1942 the trend was downward in all districts during the 3-year period.

With the exception of H–1, where the production percentages ranged from 16 to 26, the 1940–1942 yields of all districts amounted to only 7 percent (H–2 in 1940) or less of the 1929–1939 mean. The 1942 production was nil in H–5, a district that yielded 1,676,000 pounds of whitefish in 1933.

H–1 accounted for 65.2 to 83.5 percent of the total whitefish yield of the lake in 1940–1942. The only other district that yielded as much as 10 percent of the total in a single year was H–4 (1940 and 1941). The dominance of H–1 in this limited fishery was even more pronounced than in the early years, 1891–1908.

The progressive decline in production in the years, 1940–1942, can be attributed to a continued general decrease in fishing intensity (tables 53 and 54—see tables 8 and

TABLE 53.—*Annual fluctuations in the intensity of the fishery for whitefish in each district of Lake Huron, 1940–1942*

[Expressed as percentages of the average 1929–1939 intensity in the district]

District	Intensity as percentage of mean for district			District	Intensity as percentage of mean for district		
	1940	1941	1942		1940	1941	1942
H-1	54	18	23	H-4	35	13	9
H-2	28	7	4	H-5	18	1	(2)
H-3	(1)	(1)	3	H-6	14	3	2

[1] Inadequate data.
[2] No production.

TABLE 54.—*Annual fluctuations in the intensity of the whitefish fishery for all six districts of Lake Huron combined (third row from bottom of right half of table) and distribution of each year's intensity among the districts*

[The average annual intensity for the entire lake, 1929–1939, is 100.0. In parentheses are the intensity values of the deep-trap-net fishery. The value of one unit is 1/1,100 of the total expected catch of all districts, 1929–1939]

District or area	Intensity as percentage of mean for entire lake			District or area	Intensity as percentage of mean for entire lake		
	1940	1941	1942		1940	1941	1942
H-1	11 3 (5 1)	8 1 (3 2)	4 8 (1 5)	H-5	3 6 (3 6)	0 1 (0 1)	(2)
H-2	1 7 (1 7)	0 5 (0 5)	0 2 (0 2)	H-6	3 9 (3 8)	0 8 (0 7)	0 6 (0 5)
Northern Lake Huron (H-1 and H-2)	13 0 (6 8)	8 6 (3 7)	5 0 (1 7)	Southern Lake Huron (H-5 and H-6)	7 5 (7 4)	0 9 (0 8)	0 6 (0 5)
H-3	(1)	(1)	0 1 (0 0)				
H-4	8 2 (7 2)	3 1 (2 6)	2 0 (1 8)	Lake Huron (all 6 districts)	28 7 (21 4)	12 6 (7 1)	7 7 (4 0)
Central Lake Huron (H-3 and H-4)	8 2 (7 2)	3 1 (2 6)	2 1 (1 8)	Percentage of intensity represented by deep trap nets	74 6	56.3	51 9

[1] Inadequate data.
[2] No production.

[45] In this appendix as in part II references to "Lake Huron," "Lake Michigan," "the entire lake," or "the lake" should be understood to mean the State of Michigan waters only, unless otherwise specified

TABLE 55.—*Annual fluctuations in the abundance of whitefish in the various districts and areas of Lake Huron, 1940–1942*

[Expressed as percentages of average 1929–1939 abundance. In the computation of percentages for areas of more than one district and for the entire lake, the abundance percentage for each district was weighted according to the percentage of the total 1929 production contributed by that district]

District or area	Abundance percentage in year			District or area	Abundance percentage in year		
	1940	1941	1942		1940	1941	1942
H-1	52	56	75	H-5	12	21	(2)
H-2	32	36	24	H-6	14	13	28
Northern Lake Huron (H-1 and H-2)	44	48	53	Southern Lake Huron (H-5 and H-6)	13	17	28
H-3	(1)	(1)	41				
H-4	17	15	15				
Central Lake Huron (H-3 and H-4)	17	15	19	Lake Huron (all 6 districts)	29	31	35

[1] Inadequate data.
[2] No production.

9 of part II) brought about by a level of abundance (tables 55 and 56—see tables 10 and 11 of part II) that made profitable operations impossible.

Although the abundance percentages (table 55) and records of catch per unit effort (table 56) can not be considered very reliable for the districts in which the production reached extremely low figures, the data of table 55 nevertheless give some indication that with respect to the entire lake the abundance, which began to decline in 1932, reached its lowest level in 1940 (29 percent of the 1929–1939 average) and improved slightly in 1941 (31 percent) and 1942 (35 percent).[46] These small increases in the abundance percentages can not be taken as the basis for optimism concerning a possible early recovery of the whitefish fishery. On the contrary, it is to be considered most probable that the abundance and production of whitefish will continue to be low for years to come. The fishing intensity which was relatively low in all districts in 1940–1942 (table 53) and which had declined to 7.7 percent of average in 1942 for all districts combined (table 54) can not be expected to increase materially until abundance has risen to a level that permits profitable fishing. If a significant recovery occurs at all in the whitefish fishery of Lake Huron it may be expected to be slow. It is conceivable, of course,

TABLE 56.—*Annual fluctuation in the catch of whitefish per unit of fishing effort of gill nets, deep trap nets, and pound nets in the various districts of Lake Huron, 1940–1942*

Gear and unit of effort	District	Catch of whitefish (pounds) per unit of effort		
		1940	1941	1942
Gill net (unit lift of 10,000 feet)	H-1	39.7	39.5	50.3
	H-2	10.1		37.9
	H-3			10.0
	H-4	2.9	3.2	11.8
	H-5			
	H-6		13.2	7.0
Deep trap net (unit lift of one net)	H-1	45.1	57.8	84.9
	H-2	24.9	28.0	6.2
	H-3			
	H-4	29.5	27.8	23.8
	H-5	32.0	57.5	
	H-6	44.8	42.5	98.1
Pound net (unit lift of one net)	H-1	32.2	30.0	40.9
	H-2	1.6		
	H-3			
	H-4	4.5	3.1	1.4
	H-5			
	H-6	1.2	1.8	11.1

[46] Tables 53, 54, 55, and 56 contain no figures for H-3 in 1940 and 1941 and for H-5 in 1942. In H-3 the small catches of whitefish in 1940 and 1941 were mostly reported by fishermen using a gear (shallow trap net) not considered in our estimations of abundance or by operators whose reports did not contain information on the amount of gear lifted. No whitefish were produced in H-5 in 1942.

that unusual conditions in the lake which permitted an abnormally high survival of young in one or more years may restore the stock at a much higher rate than the present depleted condition of the population would give reason to expect.

Not only did the Michigan production of Lake Huron continue its decline after 1939, but the Canadian yield showed a similar trend (table 57), although not to the same disastrous degree. In Lake Huron proper (see p. 304 for its boundaries) the Canadian catch fell to 92,000 pounds in 1940 and increased only 1,000 pounds in 1941. These records are the lowest two for these waters since 1922 and comprise 42 percent of the average catch (219,513 pounds) for the period, 1923–1939. In Georgian Bay (includes the North Channel—see p. 304) the take decreased progressively from 1,275,000 pounds in 1939 to 833,000 pounds in 1941, the lowest production recorded for this area at least since 1922. This figure represents 58 percent of the average yield (1,427,564 pounds) for the years, 1923–1939. In the Michigan waters the 1941 catch equaled only 6 percent of the average production (2,052,331 pounds) during the period, 1922–1937, a value considerably less than the comparable Canadian percentages of 42 and 58. The 1939–1941 records of total catch for all waters (United States and Canadian) represent the lowest three ever recorded for the lake.

TABLE 57.—*Production of whitefish in pounds in Lakes Michigan and Huron, 1939–1942*

Year	Lake Michigan			Lake Huron			
	Wisconsin	Michigan	Entire lake	Michigan	Ontario		Entire lake
					Huron proper	Georgian Bay	
1939	110,700	839,856	950,556	255,183	115,061	1,275,255	1,645,499
1940	196,600	754,115	954,815	188,114	92,403	1,006,082	1,286,599
1941	400,538	896,474	1,286,354	113,727	93,058	833,111	1,039,896
1942	279,363	1,061,056	1,340,419	95,094			

WHITEFISH FISHERY OF LAKE MICHIGAN, 1940-1942

The production of whitefish in the State of Michigan waters of Lake Michigan, which had declined irregularly from the modern peak of 4,813,000 pounds in 1930, reached an all-time recorded low of 754,000 pounds in 1940 (table 58—for further data on production see also table 1 of part I, tables 13, 14, 15, and 16 of part II, and appendix B). Although this yield amounted to only 32 percent of the 1929–1939 average, it was relatively much higher than the 1940 catch in Lake Huron (9 percent of the 1929–1939 mean—table 52). The take of whitefish in Lake Michigan improved substantially in 1941 (896,000 pounds; 38 percent) and 1942 (1,061,000 pounds; 46 percent). The 1940–1942 trend of production was consistently upward in northern and northeastern Lake Michigan (M–2, M–3, and M–4) and in the Grand Haven-Muskegon district (M–7), but was consistently downward in Green Bay (M–1) or irregular in the remaining districts (M–5, M–6, and M–8).

In all three years M–3 contributed considerably more than half of the total production (63.8, 58.4, and 67.5 percent in 1940, 1941, and 1942, respectively). The Green Bay district (M–1) ranked second each year but contributed a constantly decreasing percentage of the total (16.3, 12.9, and 8.7 percent). Third position was held by M–5 in 1940 and 1941 (11.5 and 10.0 percent) and by M–4 in 1942 (6.7 percent). The percentage of the total yield produced in the districts that ranked lower than third ranged from 7.5 percent in M–4 in 1941 to 0.1 percent in M–7 in 1940. It may be noted that the percentages of total production in the various districts in 1940–1942 resembled the corresponding figures for 1891–1908 much more closely than they did those for 1929–1939.

The abundance percentages, records of catch per unit of effort, and figures on fishing intensity (tables 59, 60, 61, and 62—see tables 17, 19, 20, and 21 of the main body of this paper) show that but for a low level of fishing intensity, production would have been much higher in 1940–1942, particularly in the last two years of the period. The abundance of whitefish which had dropped to an extremely low level in 1940 (23

TABLE 58.—*Production of whitefish in pounds in the State of Michigan waters of Lake Michigan, 1940–1942*

District or area	Year	Production in gear			Total	Percentage of total catch of lake	Percentage of 1929–1939 average
		Large-mesh gill net	Pound net	Other			
M-1	1940	50,170	71,015	1,618	122,803	16 3	23
	1941	73,707	41,982	63	115,752	12 9	22
	1942	66,654	25,884	8	92,546	8 7	18
M-2	1940	8,310	1,463		9,773	1 3	18
	1941	25,883			25,883	2 9	47
	1942	60,494			60,494	5 7	110
M-3	1940	225,939	254,771	66	480,776	63 8	45
	1941	280,571	241,884	629	523,084	58 4	49
	1942	384,704	331,228	54	715,986	67 5	67
M-4	1940	28,726	11,572	37	40,335	5 3	71
	1941	28,435	39,024	28	67,487	7 5	118
	1942	26,277	44,108	261	70,646	6 7	124
Northern Lake Michigan (M-1, M-2, M-3, and M-4)	1940	313,145	338,821	1,721	653,687	86 7	38
	1941	408,596	322,890	720	732,206	81 7	43
	1942	538,129	401,220	323	939,672	88 6	55
Central Lake Michigan (M-5)	1940	85,118	1,970	6	87,094	11 5	27
	1941	89,132	280	10	89,422	10 0	28
	1942	57,802			57,802	5 4	18
M-6	1940	925	108	130	1,163	0 2	2
	1941	6,348			6,348	0 7	9
	1942	1,823		62	1,885	0 2	3
M-7	1940	706	131	14	851	0 1	1
	1941	24,965	2,672	26	27,663	3 1	27
	1942	22,315	6,804		29,119	2 7	28
M-8	1940	11,312		8	11,320	1 5	9
	1941	36,460	4,375		40,835	4 5	31
	1942	31,559	1,014	5	32,578	3 1	25
Southern Lake Michigan (M-6, M-7, and M-8)	1940	12,943	239	152	13,334	1 8	4
	1941	67,773	7,047	26	74,846	8 3	24
	1942	55,697	7,818	67	63,582	6 0	21
Lake Michigan (all 8 districts)	1940	411,206	341,030	1,879	754,115		32
	1941	565,501	330,217	756	896,474		38
	1942	651,628	409,038	390	1,061,056		46

to 73 percent of the 1929–1939 average in the individual districts and 63 percent for the 8 districts combined—table 61) improved in every district in 1941. This general improvement was reflected in a rise in the abundance percentage from 63 to 91 for the lake as a whole. Further increases in 1942 in M–2, M–3, and M–8 more than compensated for declines in the remaining districts and carried the abundance percentage for all districts combined to the still higher level of 95. The abundance of whitefish was above the 1929–1939 average in three districts (M–4, M–6, and M–7) in 1941 and in five districts (M–2, M–3, M–4, M–7, and M–8) in 1942. Conspicuous among the percentages are the high value of 257 in M–6 in 1941 and the low figures of 45 and 34 in M–5 in 1941 and 1942. M–5 was the only district with abundance below 85 in 1941 or below 76 in 1942.

TABLE 59.—*Annual fluctuations in the intensity of the fishery for whitefish in each district of Lake Michigan, 1940–1942*

[Expressed as percentages of the average 1929–1939 intensity in the district]

District	Intensity as percentage of mean for district			District	Intensity as percentage of mean for district		
	1940	1941	1942		1940	1941	1942
M-1	38	30	27	M-5	71	64	55
M-2	47	48	91	M-6	4	5	4
M-3	67	61	64	M-7	5	23	27
M-4	108	96	126	M-8	18	44	27

TABLE 60.—*Annual fluctuations in the intensity of the whitefish fishery for all eight districts of Lake Michigan combined (bottom of right half of table) and distribution of each year's intensity among the districts*

[The average annual intensity for the entire lake, 1929–1939, is 100.0. The value of one unit is 1/1,100 of the total expected catch of all districts, 1929–1939]

District or area	Intensity as percentage of mean for entire lake			District or area	Intensity as percentage of mean for entire lake		
	1940	1941	1942		1940	1941	1942
M-1	8 3	6 5	5 8	M-6	0 1	0 1	0 1
M-2	1 2	1 3	2 4	M-7	0 2	0 8	1 0
M-3	31 4	28 8	29 9	M-8	1 0	2.3	1 4
M-4	2 9	2 5	3 3	Southern Lake Michigan (M-6, M-7, and M-8)	1 3	3 2	2 5
Northern Lake Michigan (M-1, M-2, M-3, and M-4)	43 8	39 1	41 4				
Central Lake Michigan (M-5)	10 5	9 5	8 1	Lake Michigan (all 8 districts)	55 6	51 8	52 0

TABLE 61.—*Annual fluctuations in the abundance of whitefish in the various districts and areas of Lake Michigan, 1940–1942*

[Expressed as percentages of average 1929–1939 abundance. In the computation of percentages for areas of more than one district and for the entire lake, the abundance percentage for each district was weighted according to the percentage of the total 1929–1939 production contributed by that district]

District or area	Abundance percentage in year			District or area	Abundance percentage in year		
	1940	1941	1942		1940	1941	1942
M-1	70	85	76	M-6	45	257	80
M-2	38	99	121	M-7	23	161	147
M-3	73	87	115	M-8	57	85	108
M-4	68	128	101	Southern Lake Michigan (M-6, M-7, and M-8)	43	152	114
Northern Lake Michigan (M-1, M-2, M-3, and M-4)	71	88	103				
Central Lake Michigan (M-5)	40	45	34	Lake Michigan (all 8 districts)	63	91	95

TABLE 62.—*Annual fluctuation in the catch of whitefish per unit of fishing effort of gill nets and pound nets in the various districts of Lake Michigan, 1940–1942*

Gear and unit of effort	District	Catch of whitefish (pounds) per unit of effort		
		1940	1941	1942
Gill net (unit lift of 10,000 feet)	M-1	83 0	124 6	92 0
	M-2	16 7	35 2	43 1
	M-3	45 0	59 9	80 8
	M-4	27 4	33 6	30 6
	M-5	31 2	35 5	27 0
	M-6	19 5	98 1	30 7
	M-7	31 4	221.7	161 1
	M-8	59 4	91 5	113.5
Pound net (unit lift of one net)	M-1	44 4	39 0	39 5
	M-2	14 6		
	M-3	98 9	106 2	135 0
	M-4	40 0	123 9	74 3
	M-5	41 0	56 0	
	M-6	18 0		
	M-7	6 0	27 3	68 7
	M-8		64.3	84 5

Despite the markedly improved abundance of whitefish in the State of Michigan waters of Lake Michigan in 1941 and 1942, fishing intensity was relatively low. For the eight districts combined (table 60) the intensity, which was lower in 1940 (55.6 percent) than in any year except 1936 (55.1 percent) of the period, 1929–1939, decreased even further in 1941 (51.8 percent) and remained at about the same level (52.0 percent) in 1942. Among the individual districts (table 59) fishing intensity tended to be rela-

tively high in M–2, M–3, M–4, and M–5 and low in southern Lake Michigan (M–6, M–7, and M–8) and Green Bay (M–1).

The significance of the most recent figures for the whitefish fishery of the State of Michigan waters of Lake Michigan may be summarized in the one statement that the abundance of whitefish appears to be returning to an approximately normal level while production is held in check by a low fishing intensity.

Whether this statement is equally true for the whitefish of the Lake Michigan waters of other States is not known. Virtually no whitefish production is recorded for Illinois and Indiana in 1940–1942. The Wisconsin statistics (table 57) suggest some improvement in that State. In contrast to the Michigan catch, that of Wisconsin increased in both 1940 and 1941, reaching a relatively high level in 1941, although again in contrast to Michigan's yield, it decreased to approximately the normal level in 1942. With respect to the entire lake (all States) the trend of production is upward, after 2 years of extremely low yields.

BEARING OF THE 1940-1942 STATISTICS OF THE WHITEFISH FISHERIES OF LAKES HURON AND MICHIGAN ON THE VALIDITY OF EARLIER CONCLUSIONS

The 1940–1942 statistics of the whitefish fishery of the State of Michigan waters of Lakes Huron and Michigan do not give the slightest reason for modifying the summary paragraphs at the end of part II of the main body of this paper. In Lake Huron the "collapse of the whitefish fishery" proved to be even more devastating than had been anticipated. The belief that in Lake Michigan the decline of the whitefish was "not disastrous" has been substantiated by the return of the whitefish to nearly normal abundance (91 and 95 percent) in 1941 and 1942.

The contrast between conditions in the whitefish fisheries of Lake Huron and Lake Michigan in 1940–1942 is brought out sharply by the data of table 63 (see also table 22 of part II). In Lake Huron, production and fishing intensity, already at an extremely low level in 1940, continued to decline in 1941 and 1942. Any improvement that did occur in the status of the whitefish was relatively small. The abundance of whitefish was relatively much higher in 1940 in Lake Michigan (63 percent of average) than in Lake Huron (29 percent). Furthermore, the abundance in Lake Michigan rose sharply in 1941 and increased again in 1942. The production of whitefish also increased significantly in 1941 and 1942. Only fishing intensity declined (in 1941) or remained unchanged (in 1942). The supplementary data of this appendix, therefore, support the conclusion that overfishing traceable to deep-trap-net operations brought about the ruin of the whitefish fishery in Lake Huron. Although overfishing admittedly may have occurred in Lake Michigan and may have contributed to the decline that culminated in 1940, this overfishing was much less severe than in Lake Huron and did not carry the level of abundance of whitefish so low as to make rapid recuperation of the stock impossible. In fact, only low fishing intensity prevented nearly normal production of whitefish in Lake Michigan in 1941 and 1942.

TABLE 63.—*Production and abundance of whitefish and the intensity of the whitefish fishery in the State of Michigan waters of Lakes Michigan and Huron*

[Expressed as percentages of the 1929–1939 average]

Lake	Item	Year		
		1940	1941	1942
Michigan	Production	32	38	46
	Fishing intensity	56	52	52
	Abundance	63	91	95
Huron	Production	9	5	4
	Fishing intensity	29	13	8
	Abundance	29	31	35

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