6.—REPORT ON AN INVESTIGATION OF THE FISHERIES OF LAKE ONTARIO.

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[Plates XXI to L.]

PREFATORY NOTE.

The fisheries of Lake Ontario have recently received much attention, especially among citizens of that portion of northern New York bordering on the lake, and the past and present condition of the industry has been a fertile subject of local discussion and general interest. The scarcity of certain fish that formerly abounded in the lake and the possibility of a further decrease in those and other species have been the basis for an agitation which has become one of the most noteworthy movements of the kind in recent years. Fish and game clubs, anglers' associations, and economic and trade organizations have given the matter consideration; sporting and industrial publications have contained numerous and detailed accounts of the progress of the movement; the daily press has noticed the subject editorially and opened its columns to correspondence and news; conferences have been held between representatives of the two countries immediately interested in the preservation of the lake fisheries; the New York legislature has provided for a new code of fishery laws with a view to secure better protection to the fish, and the national Congress has made provision for the establishment of a fish-hatching station on or near Lake Ontario.

In 1891 the U. S. Commission of Fish and Fisheries undertook an investigation of the commercial fisheries of the Great Lakes, under the direction of Capt. J. W. Collins, the assistant in charge of the Division of Fisheries. The subjects embraced by the inquiry included, among others, the following points: (1) Complete statistics of the number of persons employed; the number and value of vessels, boats, and apparatus used; the quantity and value of each species of fish taken; the wholesale fish trade; the extent of fisheries in Canadian waters operated, owned, or controlled by American citizens, and such other phases of the industry as can be expressed in figures. (2) A history of the changes in the methods and relations of the fisheries that have occurred since the last investigation in 1885, when a detailed report* was issued covering the lake fisheries. (3) A determination of the effects of artificial propagation in preserving and increasing the supply of food-fishes in the Great Lakes.

The investigation of the fisheries of Lake Ontario was conducted by the writer during the months of August and September, 1891, the data obtained at that time serving as a basis for the accompanying remarks.

*A Review of the Fisheries of the Great Lakes in 1885, compiled by Hugh M. Smith and Merwin-Marie Snell, with introduction and description of fishing vessels and boats, by J. W. Collins. 8°, pp. 333, 44 plates and folding maps. Report of Commissioner of Fish and Fisheries, 1887.

The information presented in this paper includes a brief account of the physical characteristics of the lake as far as they may have influence on the fish and fisheries; statistics showing the extent of the commercial fisheries in each county on the lake, with a consideration of the present and past importance of the lake fisheries; an exhibition of the extent of the import trade in Canadian fish, with a discussion of the same; remarks on certain fishes of economic importance; and a suggestion of the steps necessary for the improvement of the fisheries.

PHYSICAL CHARACTERISTICS OF LAKE ONTARIO.

A thorough study of the physical conditions of Lake Ontario is necessary for and must antedate a comprehensive knowledge of the fish fauna. Temperature, depth of water, character of bottom, currents, winds, and sediment all have important bearings on the movements, habits, and abundance of fishes. Unfortunately, such an investigation has never been undertaken, and it is only possible to present a few facts having a general application.

Ontario is much the smallest of the Great Lakes. Its maximum length is 185 miles, and its greatest width, opposite Irondequoit Bay, is 55 miles; the average breadth is about 40 miles. The area is about 6,500 square miles, of which some 2,700 square miles are within the jurisdiction of the State of New York, and the remaining portion is controlled by the government of Canada. The province of Ontario occupies the entire northern and western and a part of the southern shores, leaving only the eastern portion of the southern side abutting on New York. The shores, following the major indentations, are 565 miles in length, of which New York occupies about 265 miles.

The surface of the lake is 232 feet above the level of the sea, although the mean level is subject to considerable variation within limits which are necessarily somewhat narrow. In 1891 the surface of the lake was lower than for many years, and toward the end of the season was said to be fully 3 feet below the mean level. This was due in a measure to the small quantity of water brought down by the tributary streams, and also to the reduction in the supply coming from the upper lakes. Persons familiar with Niagara Falls were heard to comment on the diminution in the amount of water passing through the river basin at certain periods during the summer.

Lake Ontario has a much greater average depth than the adjoining member of the chain, Lake Erie; this feature is of considerable importance in connection with the movements and distribution of fish. The eastern end of the lake is much the shallowest portion, the western extremity is somewhat deeper than the eastern, while the deepest water is found near the middle of the lake in the region of its greatest width. That part of the lake which is below or to the north of the chain of small islands, extending from Stony Point on the east to South Bay Point on the west, and which contains the most important fishing-grounds for whitefish, trout, and pike perch, varies in depth from 30 to 180 feet, and has an average depth of about 100 feet. A number of small shoals occur which serve as spawning-grounds for whitefish and trout. One of the most important of these is Charity Shoal, situated 6 miles west of Grenadier Island, which is the ground most resorted to by the trap-net fishermen of Jefferson County. In the middle and western portions of the lake the water, toward the middle, has a depth varying from 200 to over 700 feet, the average being about 400 feet. The deepest soundings made by the engineer corps of the U. S. Army were 13 miles from the American shore in a direction NNW. from Sodus Point; here the water was 738

feet deep. Other soundings of 600 feet and over are numerous in that portion of the lake south of the international boundary, opposite that part of the State of New York between Rochester and Oswego, at distances varying from 7 to 15 miles from the shore. No water of this depth occurs in the Canadian portion of the lake. The deep water approaches nearest to the shore opposite the eastern county line of Monroe County; here, at a distance of a little less than 7 miles from the shore, the depth of water is 636 feet.

A favorable feature of the lake, so far as fish are concerned, is the varying character of the bottom. Some of the most important of the lake fishes are bottom feeders, and the quantity and variety of small animal and vegetable organisms which comprise the food of these species largely depend on the nature of the bottom. That portion of the lake north of a line drawn west from Stony Point is characterized by a rocky and sandy bottom; the remaining part is mostly muddy, with small areas of sand and clay. It would be extremely interesting to know to what extent the distribution and movements of such bottom feeders as the whitefish, herring, and sturgeon are influenced by the nature of the bottom.

PRESENT AND PAST CONDITION OF LAKE ONTARIO FISHERIES.

The following tables, which relate to the year 1890, present the salient features of the fisheries of the lake and show the extent of the industry in each county.

The first table gives the number of persons engaged in the fisheries in different capacities. The use of vessels has never been a prominent feature of the fisheries of this lake, and in 1890 only 11 men were employed on vessels. The wholesale trade in fish, which has a very intimate connection with the fisheries proper and is included in the statistics so far as the personnel and capital are concerned, gave employment to 22 persons. The shore fisheries, prosecuted from boats and from the shore, had the services of 356 men. Jefferson County, at the extreme eastern end of the lake, had 172 persons engaged in the fisheries, a greater number than in any other two counties combined. Oswego County ranked second in the number of fishermen, with 62, followed by Niagara, with 54. Cayuga and Orleans Counties had 15 and 17 respectively.

The number and value of vessels and boats, the quantity and value of apparatus, and the amount of cash capital and shore property employed in the fisheries of Lake Ontario are shown in the next table. The total investment in the industry was $123,533, of which sum Jefferson County is to be credited with $95,208, a circumstance illustrating the great relative importance of the fisheries in that county. The three vessels employed were valued at $9,585, and the 373 boats were worth $21,577. The most important forms of apparatus were the trap nets and pound nets, of which 288 were operated, valued at $24,577. Gill nets with a combined length of 1,103,945 feet, worth $18,110, were employed, and constituted the next prominent apparatus.

The quantity and value of each important species taken in 1890 are shown in the third table. The aggregate catch was 3,446,448 pounds, for which the fishermen received $124,786. The species of which the greatest quantity was caught were the cisco and the other minor varieties of whitefish classed in the tables under the general name of herring, but both pike perch and sturgeon yielded larger returns than the herring. The output in Jefferson County was much in excess of that of all the other

counties combined, and amounted to 2,416,458 pounds, valued at $90,142. The quantities given in the tables represent, in all cases, the weight of the fish as taken from the water.

One of the most interesting subjects involved in a discussion of the lake fisheries is the relative effectiveness of the different forms of apparatus employed in the capture of fish. This is clearly brought out in the last table of the series, the quantity and value of the species taken in each of the principal devices being shown. Gill nets take the largest quantities of fish and yield the greatest money returns, the specially prominent species thus caught being herring and sturgeon. Trap nets and pound nets closely follow gill nets, the pike perch being the most valuable species. Among the minor kinds of apparatus, fyke nets rank first in the amount of catch, after which come lines, seines, and miscellaneous forms.

Table showing by counties and nature of employment the number of persons (citizens of New York) engaged in the fisheries of Lake Ontario in 1890.

Counties.	In vessel fishery.	In shore fishery.	On shore.	Total.
Jefferson	4	152	16	172
Oswego	5	53	4	62
Cayuga	2	11	2	15
Wayne	.....	41	.....	41
Monroe	.....	28	.....	28
Orleans	.....	17	.....	17
Niagara	.....	54	.....	54
Total	11	356	22	389

Table showing by counties the number and value of vessels, boats, and apparatus, and the value of shore property and cash capital employed by New York fishermen in the fisheries of Lake Ontario in 1890.

Designation.	Jefferson.		Oswego.		Cayuga.		Wayne.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels	1	$5,880	1	$3,300	1	$405	.....	.....
Boats	202	15,700	48	1,390	13	595	54	$2,245
Gill nets, feet	696,425	10,911	57,180	792	18,315	296	66,591	935
Pound and trap nets	286	24,455	.....	.....	.....	.....	2	122
Fyke nets	458	6,850	140	2,100	26	315	39	365
Seines	3	60	4	240	.....	.....	2	60
Set lines, feet	17,182	35	37,200	75	.....	.....	1,210	4
Miscellaneous apparatus	.....	45	.....	4	.....	.....	.....	.....
Shore property	.....	18,882	.....	3,980	.....	260	.....	1,525
Cash capital	.....	12,390	.....	500	.....	.....	.....	.....
Total	.....	95,208	.....	12,381	.....	1,871	.....	5,256

Designation.	Monroe.		Orleans.		Niagara.		Total for the State.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels	.....	.....	.....	.....	.....	.....	3	$9,585
Boats	20	$472	11	$305	25	$870	373	21,577
Gill nets, feet	42,240	434	76,395	1,775	146,799	2,967	1,103,945	18,110
Pound and trap nets	.....	.....	.....	.....	.....	.....	288	24,577
Fyke nets	21	192	.....	.....	.....	.....	684	9,822
Seines	4	48	.....	.....	14	248	27	656
Set lines, feet	.....	.....	59,200	296	24,840	80	139,632	490
Miscellaneous apparatus	.....	.....	.....	.....	.....	.....	.....	49
Shore property	.....	606	.....	71	.....	453	.....	25,777
Cash capital	.....	.....	.....	.....	.....	.....	.....	12,890
Total	.....	1,752	.....	2,447	.....	4,618	.....	123,533

Table showing by counties and species the quantities and values of fish taken by New York fishermen in Lake Ontario in 1890.

Species.	Jefferson.		Oswego.		Cayuga.		Wayne.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	11,855	$1,058	6,201	$340	2,676	$148	3,993	$231
Bullheads and catfish	315,711	8,360	108,650	2,173	15,100	302	16,030	757
Eels	247,490	8,396	3,600	188	910	44	2,890	173
Herring	369,334	14,199	24,525	981	1,600	48	26,210	776
Perch	241,520	2,383	70,600	1,765	3,960	109	33,985	715
Pike (*Esox*)	39,950	1,595	61,795	3,361	10,370	463	15,060	753
Pike perch	296,832	26,955	24,673	1,245	3,454	172	1,900	76
Sturgeon	374,235	14,949	22,532	1,083	.....	.....	2,330	70
Suckers	168,820	1,900	51,115	935	4,865	72	5,410	113
Trout	40,400	2,048	500	30	.....	.....	.....	.....
Whitefish	143,771	6,517	3,550	213	.....	.....	720	72
Other fish	166,540	1,782	67,880	1,697	4,498	72	9,480	124
Total	2,416,458	90,142	445,621	14,011	47,433	1,430	118,008	3,860

Species.	Monroe.		Orleans.		Niagara.		Total for the State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	2,800	$224	3,000	$210	2,567	$153	33,092	$2,364
Bullheads and catfish	11,564	653	1,500	30	3,400	169	471,955	12,444
Eels	2,300	112	.....	.....	.....	.....	257,190	8,913
Herring	10,960	438	6,000	120	160,349	4,374	598,978	20,936
Perch	4,115	245	1,150	35	3,617	116	358,947	5,368
Pike (*Esox*)	2,000	100	.....	.....	315	12	129,490	6,284
Pike perch	.....	.....	.....	.....	4,143	281	331,002	28,729
Sturgeon	.....	.....	90,675	3,830	51,980	2,359	541,752	22,291
Suckers	7,420	312	910	27	40,630	1,219	279,170	4,578
Trout	.....	.....	.....	.....	110	11	41,010	2,089
Whitefish	.....	.....	.....	.....	730	73	148,771	6,875
Other fish	2,753	129	440	13	3,500	98	255,091	3,915
Total	43,912	2,213	103,675	4,265	271,341	8,865	3,446,448	124,786

Table showing by apparatus and species the quantities and values of fish taken by New York fishermen in Lake Ontario in 1890.

Species.	Gill nets.		Pound nets and trap nets.		Fyke nets.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	23,284	$1,547	6,488	$623	.....	.....
Bullheads and catfish	8,530	330	49,010	1,222	400,273	$10,484
Eels	.....	.....	196,204	6,550	56,336	2,177
Herring	586,629	20,516	5,724	161	.....	.....
Perch	30,210	648	150,975	1,427	170,645	3,111
Pike (*Esox*)	41,740	2,032	520	26	73,770	3,340
Pike perch	26,970	1,330	297,132	26,967	.....	.....
Sturgeon	428,919	17,607	26,075	992	.....	.....
Suckers	13,580	351	93,800	938	76,320	1,056
Trout	10,637	566	30,181	1,513	.....	.....
Whitefish	78,249	3,717	68,392	3,007	.....	.....
Other fish	8,968	177	120,350	1,278	122,183	2,393
Total	1,257,716	48,821	1,044,851	44,704	899,527	22,561

Species.	Seines.		Lines.		Minor apparatus.		Total apparatus.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	1,967	$118	1,353	$76	.....	.....	33,092	$2,364
Bullheads and catfish	6,735	240	2,847	77	4,560	$91	471,955	12,444
Eels	.....	.....	4,650	186	.....	.....	257,190	8,913
Herring	6,625	259	.....	.....	.....	.....	598,978	20,936
Perch	6,117	162	1,000	20	.....	.....	358,947	5,368
Pike (*Esox*)	1,685	81	9,275	730	2,500	75	129,490	6,284
Pike perch	4,718	312	2,182	120	.....	.....	331,002	28,729
Sturgeon	2,480	78	84,068	3,608	210	6	541,752	22,291
Suckers	44,580	1,290	1,250	25	49,640	918	279,170	4,578
Trout	.....	.....	192	10	.....	.....	41,010	2,089
Whitefish	2,130	151	.....	.....	.....	.....	148,771	6,875
Other fish	3,590	67	.....	.....	.....	.....	255,091	3,915
Total	80,627	2,758	106,817	4,852	56,910	1,090	3,446,448	124,786

The fisheries on the Canadian shores of Lake Ontario which are controlled by dealers on the southern shores of that lake gave employment to 92 fishermen in 1891; the value of the boats, apparatus, etc., used was $8,860; and the products were as given in the chapter on imports.

In Jefferson County the fishermen selling to local dealers received the following prices for their fish in 1890 and 1891. The figures do not differ materially from those obtained in other regions, and may be taken as a general average for the entire lake. The average prices paid by dealers are somewhat less than those received by the American fishermen, for the reason that the Canadian fish bring rather lower prices than those taken in home waters, the output being controlled by the dealers.

Average wholesale prices per pound received by the fishermen of Jefferson County, New York.

Species.	1890.	1891.
	Cents.	*Cents.*
Wall-eyed pike (or pike perch)	10	8
Black bass	10	5½
Whitefish*	6¼	6
Trout*	6¼	6
Sturgeon†	6	5
Muskellunge	5	5
Pike (or pickerel)	4	4
Bullheads and catfish†	4	4
Eels	3½	4
Ciscoes	3	3
Perch	1	1
Suckers	1	1
Sheepshead	1	1
White bass	1	1

* The prices given were for dressed fish, which represent about three-fourths the original weight.
† The prices given were for dressed fish, which represent about two-thirds the round weight.

One of the most valuable uses of statistics is the opportunity they afford for noting comparisons between different years, and recourse to this advantage is nowhere more important and necessary than in the fisheries, especially in cases in which it becomes desirable to gauge accurately the effects of fish-culture.

Comparing the present and past extent of the fisheries of Lake Ontario, it is seen, in the first place, that since 1880 the decrease in the number of persons employed in the fisheries has been 223, and since 1885, which was probably the most prosperous year during the decade, the decrease has been 211.

The amount of capital devoted to fishing appears to have increased considerably since 1880, although there has been a decline in this respect since 1885. The principal factor in the increase is the shore property and working capital, which in 1880 amounted to only $5,000, and in 1890 to $38,667; the latter sum represents chiefly the wholesale handling of fish by firms on the lake shore, a business which is so intimately connected with actual fishing that it has been included in the foregoing tables. The investment in steam and sail vessels and boats is also much larger than in 1880, the increase being $19,062 and being due to the employment of more boats, required by the prosecution of fisheries of a more varying character than was demanded in 1880, when the most important species were abundant; there has also been an improvement in the type of steamers used in the fisheries. The apparatus employed in 1890 was worth $7,756 more than in 1880, an increase due entirely to the use of greater quantities of

trap nets and fyke nets, while the quantity and value of gill nets have been reduced. Compared with 1885, the diminution in the amount of investment has been $12,216, made up chiefly of pound nets, shore property, and cash capital.

The most interesting comparison, however, is that which shows the past and present catch of the different species, a subject which is of the utmost importance at this time, in that the figures must serve as a basis for determining the result of artificial propagation, which it is hoped will soon be undertaken on a large scale.

It will probably occasion some surprise to state that the aggregate yield of the fisheries of Lake Ontario in 1890 was but little less than in 1880, the decrease in quantity of fish amounting to only 5.32 per cent, and in the value of catch only 2.19 per cent; when it is considered, however, that a more unfavorable general showing has been prevented only by the capture of larger quantities of the cheaper grades of fish, and that the output of the two most valuable species in 1880 has been reduced 88.38 per cent, the matter assumes a different phase. In the following table the catch of whitefish, trout, sturgeon, herring, and other species in 1880 and 1890 is shown, together with the increase or decrease and the percentage of increase or decrease. The aggregate value of the output each year, the reduction in the value, and the percentage of decline are also given.

Comparative table showing the output of the fisheries of Lake Ontario in 1880 and 1890.

Species.	1880.	1890.	Increase or decrease.	
			Quantity.	Percentage.
	Pounds.	*Pounds.*	*Pounds.*	
Whitefish	1,064,000	148,771	— 915,229	— 86.02
Trout	569,700	41,010	— 528,690	— 92.80
Sturgeon	545,283	541,752	— 3,531	— .65
Herring	611,217	598,978	— 12,239	— 2.00
All others	849,800	2,115,937	+1,266,137	+147.11
Total	3,640,000	3,446,448	— 193,552	— 5.32
Total value	$159,700	$124,786	— $34,913	— 2.19

THE CANADIAN IMPORT TRADE.

A discussion of the fisheries of Lake Ontario would be incomplete without some allusion to the extent of the international trade depending on the prosecution of the industry on the Canadian side of the lake. The province of Ontario occupies the entire northern and a portion of the southern shores of the lake, and the fisheries therein are more or less dependent for their successful maintenance on the markets of the United States; on the other hand, consumers of fish in many parts of New York are, to a considerable extent, dependent for their supply on the Canadian fisheries.

During the first three quarters of the year 1890 fresh fish were admitted into United States ports free of duty, but on October 1 of that year the new tariff went into effect, which provides that only those fish caught in apparatus belonging to citizens of the United States are entitled to free entry. Persons importing fish free of duty are now required to make the following oath:

I, ——— ———, residing at ——— ———, a citizen of the United States, do solemnly swear that all of the fish imported by me in the [name of vessel] from [name of foreign port] on the ——— day of ———, 18—, viz, ——— pounds, are fresh fish (not salmon), and that they were caught in fresh water by nets and other devices which are owned by citizens of the United States.

Contrary to what might have been expected, the imports of free fish in 1891 were in no respect diminished by the tariff law, but, as shown by the following tables, based on figures compiled from official custom-house records, the receipts in 1891 were considerably in excess of 1890, except in one district, in which the imports in 1890 were from fisheries in which Americans were not interested. The explanation is that the American dealers purchased or furnished the apparatus of the Canadian fishermen from whom they obtained fish, and the increased importation represents an increased output and a more extended demand, the conditions of trade in the two years being essentially similar.

Table showing by customs districts the quantity of fresh fish, free of duty, imported into the United States from the Canadian shore of Lake Ontario in 1890 and 1891.

Quarters.	Cape Vincent.	Oswego.	Genesee.	Total.
1890.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
First	70,000	.....	.....	70,000
Second	341,211	81,853	103,900	526,964
Third	239,928	30,582	60,550	331,060
Fourth	82,790	33,851	1,800	118,441
Total	733,929	146,286	166,250	1,046,465
1891.				
First	118,000	.....	(*)	118,000
Second	286,062	109,209	(*)	395,271
Third	305,589	34,176	(*)	339,765
Fourth	286,350	25,315	(*)	311,665
Total	996,001	168,700	(*)	1,164,701

* No free fish imported in 1891.

A comparison of the receipts for the two years shows that in the two districts in which the imports represent fish from Canadian fisheries operated or controlled by American capital, the increase of 1891 over 1890 was 284,486 pounds, and the net increase for all districts was 118,236 pounds. The imports of free fish into the Genesee district, which in 1890 amounted to 166,250 pounds, were entirely cut off in 1891 by the tariff, although a few thousand pounds of dutiable fish were imported.

Trout and whitefish are the most important fish brought in from Canada, although all the other commercial species of the lake are imported in greater or less quantities, among which yellow perch, pike (*Esox lucius*), sturgeon, lake herring, bullheads, and wall-eyed pike may be especially mentioned.

It is only in the Cape Vincent district that figures are available showing the quantities of whitefish, trout, and other species imported. The following tabular presentation will therefore prove of interest and will serve as a basis for determining the approximate proportions for the entire lake:

Table showing the quantities of whitefish, trout, and other species imported free of duty into the Cape Vincent district during each quarter of the years 1890 and 1891.

Quarters.	Whitefish.		Trout.		All other species.		Total.	
	1890.	1891.	1890.	1891.	1890.	1891.	1890.	1891.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
First	2,100	10,390	275	.....	67,625	107,610	70,000	118,000
Second	66,747	47,163	14,144	25,027	260,320	213,872	341,211	286,062
Third	115,216	141,544	18,712	17,086	106,000	146,959	239,928	305,589
Fourth	13,695	70,964	3,240	12,343	65,855	203,043	82,790	286,350
Total	197,758	270,061	36,371	54,456	499,800	671,484	733,929	996,001

It is seen that in 1890 whitefish constituted about 27 per cent of the fish imported from Canada, trout 4 per cent, and other species 69 per cent. In 1891 the proportions were 27 per cent, 5 per cent, and 68 per cent, respectively. Applying these figures to the entire lake it appears that the Canadian fisheries of Lake Ontario furnished to United States markets in 1890 about 282,545 pounds of whitefish, 41,859 pounds of trout, and 722,061 pounds of miscellaneous fish; while in 1891 there were 314,469 pounds of whitefish, 58,235 pounds of trout, and 791,997 pounds of all other fish.

The fish brought into the Cape Vincent and Oswego districts are chiefly obtained at the Duck Islands and in the Bay of Quinte, near the eastern end of the lake; they are collected from the various fishing stations by vessels sent out by the dealers. The receipts in the Genesee district in 1890 were chiefly from Port Hope, and were landed by regular passenger and freight steamers.

The greater prolificness of the Canadian waters at the present time in whitefish and trout, which is hereinafter alluded to in the chapter on the whitefish, is well illustrated by the foregoing table. The difference in the output of the two sides becomes even more marked in view of the fact that the imports represent only a portion of the yield of the Canadian fisheries.

NOTES ON IMPORTANT COMMERCIAL FISHES OF LAKE ONTARIO.

The principal commercial fishes of Lake Ontario are reviewed somewhat in detail in this chapter. The information is not intended to include a life history of the species considered. Even if the circumstances incident to the collection of the data had permitted thorough study, such work would have been supererogatory in view of the elaborate biographies already extant. The species have been discussed primarily from an economic standpoint, although certain information concerning their habits and movements is introduced which has a bearing on the practical side of the question and is thought to add something to the present knowledge of the fish life of the lake.

THE STURGEON.

The sturgeon (*Acipenser rubicundus*), the largest and one of the most important and valuable of the lake fishes, has decreased in abundance since 1880. In that year 545,283 pounds were taken; in 1885 the catch was 386,974 pounds; in 1890, as a result of increased demand, 490,000 pounds were obtained. At one time there was little value placed on the sturgeon, which was regarded as almost unfit for food, and, as on the other lakes, the fish was unnecessarily persecuted and often wantonly destroyed. Now it brings the fishermen the same price per pound as whitefish and trout.

Under the name of "rock sturgeon" the fishermen of the St. Lawrence River and Lake Ontario recognize the small fish caught almost entirely during the summer months, when the larger sturgeon are spawning and are only occasionally taken. It has very prominent scales and a long snout as its principal differential features, and is regarded by many fishermen as a distinct species. It weighs from 10 to 25 pounds.

While it is known that the sturgeon is a bottom feeder, and that the shape of the mouth and the general anatomy must determine the character of its food, much yet remains to be learned concerning the food and the food habits of the fish.

Milner, whose studies of the Great Lake fishes were the most complete ever made, writes as follows on this question:

> Their [the sturgeons'] food consists almost entirely of the shellfish of the lakes, principally gastropods, the thinner-shelled kinds of the genera *Physa*, *Planorbis*, and *Valvata* being found broken in the stomachs, while *Limnæa* and *Melantho* remain whole. A few eggs of fishes have been found at different times, but examination of stomachs during the spawning season of the most numerous fishes did not prove them to be very extensive spawn-eaters.*

A few observations can be recorded which are thought to add to the published information on this subject. In June, 1891, a sturgeon weighing 150 pounds was taken at Oswego, New York, which was found to be filled to its utmost capacity with wheat. The fish had evidently been feeding under the grain elevators on the Oswego River. Individual specimens are also occasionally caught in Lake Ontario with corn in their stomachs. A favorite food at times is the crayfish, which occurs abundantly in the lake and is commonly known as the "crab" among fishermen; sturgeon have been eviscerated at Oswego and elsewhere with large quantities of this crustacean in their alimentary tracts. The fishermen often use these "crabs" as bait on their set lines and secure fish when all other kinds of bait fail to attract them. The fondness of the male fish for sturgeon spawn has been repeatedly attested.

Prof. John A. Ryder, in his able paper on "The Sturgeons and Sturgeon Industries of the East Coast of the United States," etc.,† shows that the food of the young sturgeons consists chiefly of minute animal forms of great variety; as the fish become more mature, larger organisms, principally worms and crustaceans, are taken, and the full-grown fish often resort to mollusks of considerable size. Summing up his observations, the writer says:

> The story of the life of a sturgeon is therefore seen to be bound up with the lives of vast myriads of organisms in no way related to it in the system, but only as sources of nutriment. It is quite certain from what has preceded that if the minute life upon which the young sturgeons subsist were exterminated, the sturgeon would also become extinct. It follows from this that whatever affects the relative abundance of the minute life of the rivers and estuaries where sturgeons are found must also affect the survival and abundance of the latter. The importance of a study of all the organisms upon which the sturgeon is directly or indirectly dependent must therefore be obvious to everyone. The legitimacy of the inquiries into the life histories of all organisms, even those in no way directly related to the economy of the State, should therefore need no apology from those engaged in the study of the problems of economic fish-culture.

The food value of the sturgeon is yearly becoming more fully appreciated on the lakes as the supply becomes scarcer, and it is only a question of time under existing conditions when the demand for the fish will far exceed the yield of the fishery. The necessity not only of perpetuating but of increasing the abundance of this species in Lake Ontario needs no demonstration. Mention has already been made of the relatively high price commanded by the fish in comparison with other commercial species; but the economic importance of the sturgeon is not only in its flesh, for such valuable secondary products as caviare, glue, isinglass, oil, and fertilizer are made from it, and the skin is capable of being converted into a valuable leather.

The question which presents itself is, How shall the supply of sturgeon in Lake Ontario be preserved? It is suggested (1) that legal restrictions should be placed on

* Report U. S. Fish Commission, part II, 1872-73 † Bulletin U. S. Fish Commission, VIII, 1888.

the capture of immature fish and that the adult individuals should be protected during the spawning season; and (2) that artificial propagation should be resorted to. As to the expediency of enacting more fishery laws for Lake Ontario there may be considerable difference of opinion; but in regard to the desirability of carrying out the second suggestion there can be no doubt, for the feasibility of hatching the lake sturgeon artificially has been fully demonstrated by both the United States and the Michigan fish commissions.

THE ALEWIFE.

This is one of the most interesting species in Lake Ontario, and its occurrence is the cause of the most diversified comment and speculation on the part of fishermen and others. The fish is recognized by fishermen of Lake Ontario under numerous names, which alone are sufficient to exhibit the various ideas which are entertained regarding the presence and identity of the species. The name alewife is naturally the most common and generally distributed one, but in many localities this is unknown. The most numerous designations were heard at Cape Vincent and in the eastern end of the lake, where the names shad, little shad, alewife, mĕnhāden, and mănhădeñ were indiscriminately used by different fishermen. Both "shad" and "menhaden," in addition to "alewife," were quite frequently heard in other portions of the lake and in the St. Lawrence River. Among some Canadian fishermen of French extraction at Ogdensburg, New York, the name gaspereau was used—a designation applied to the alewife throughout the maritime provinces of Canada—but shad and alewife were the common names in the river. In Monroe County the name sawbelly was in use, and in Niagara County the name moon-eye was heard.

The alewife (*Clupea pseudoharengus*) is a coastal species not indigenous to this lake, and the circumstances of its introduction can probably never be established beyond question. Three principal views are now entertained regarding the origin of the fish in Lake Ontario: (1) That it gained a circuitous entrance into the lake from salt water by means of certain lakes, canals, and rivers in the State of New York; (2) that the fish ascended the St. Lawrence River from the gulf of the same name; and (3) that alewife fry were accidentally introduced with young shad obtained in the Hudson River.

In support of the first view the existence of a continuous water way, other than the St. Lawrence River, between the ocean and Lake Ontario is to be recognized and the possibility of a fish making this transit acknowledged. The writer has no personal acquaintance with the conditions of union of the bodies of water in question, but the maps available indicate numerous routes to the lake by way of the Susquehanna and Hudson rivers and their tributaries; lakes Seneca, Cayuga, Canandaigua, Onondaga, and Oneida, and the Seneca, Oneida, and Oswego rivers, together with the numerous canals which traverse this part of the State.

The existence of alewives in lakes Seneca and Cayuga has been known since 1868, some years before the planting of shad in this region began, and there is little doubt that the fish naturally wandered into these lakes from the ocean, artificial water courses probably being important factors in this extension of the species' range. Both of these lakes have easy communication with Lake Ontario by way of the Seneca River and the Oswego River or Oswego Canal.

The most thorough and scientific inquiry into the presence of the alewife in Lake Ontario has been made by Dr. T. H. Bean, whose studies were published under the title "On the occurrence of the Branch Alewife in certain lakes of New York."* It is unfortunate that this valuable essay could not have received a more general distribution, especially among the fishing interests of the lakes in question, and thus contributed to a proper appreciation of the actual conditions and to a dissipation of some of the erroneous and even absurd views that have become current. Dr. Bean appears to have proved that the fish were first observed in Lake Ontario in 1873, and holds that prior to the introduction of shad fry by the late Mr. Seth Green, of the New York fish commission, they were unknown in those waters. He concludes that the fish owe their existence in Lake Ontario to their accidental introduction with shad, and thinks that the evidence is against their migration up the St. Lawrence River from the Gulf of St. Lawrence, the presence of the fish in the lower river at Montreal being unusual and altogether subsequent to their appearance in large numbers in Lake Ontario and the upper river. He says:

> We are in possession of information which seems to establish conclusively that the alewife does not occur in the lower water of the St. Lawrence River, nor was there any evidence of its presence at Montreal until the past nine years.

Mr. Seth Green, jr., who was associated with his father in fish-cultural work for 20 years, in a conversation with the writer on November 10, 1891, emphatically denied that his father put alewife fry in Lake Ontario and stated that he always disclaimed any responsibility for the presence of this fish in the lake. It seems but proper and just that this statement should be recorded.

It is probably within bounds to say that the alewife is the most abundant fish occurring in Lake Ontario. Schools of great size are often observed at or near the surface; gill nets, pound nets, trap nets, and other forms of apparatus have been known to take large quantities; and thousands of young are caught in small seines to serve as bait in angling for bass, pike, etc. But it is by noting the enormous mortality that the most accurate idea is gained as to the wonderful prolificness of the alewife, the firm hold it has taken in this lake, and the extent to which it has populated the waters.

The alewives of Lake Ontario are remarkable for their small size. On the Atlantic coast the average length of this species is about 11 or 12 inches, but in Lake Ontario no individuals of such large size are seen and the average length is very much less. Among several thousand specimens examined by the writer none were found to be over 7 inches long, and the average was less than 6 inches. This stunting of growth, which is said to be gradually becoming more marked, has no doubt been produced by the unnatural conditions to which the fish are subjected. The extent to which this dwarfing has gone may be readily judged when it is stated that fish only 4 or 5 inches long have been caught with ripe spawn.

The few notes that can be offered concerning the habits and migrations of the alewife in Lake Ontario do not add much, if anything, to the present knowledge of the species. One interesting habit witnessed, which no doubt accounts for the origin of one of the popular names, was the schooling of the fish at the surface in considerable numbers and their "flipping" after the manner of menhaden.

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* The Fisheries and Fishery Industries of the United States. Section I, Natural History of Aquatic Animals. Washington, 1884.

Regarding the spawning habits, it can be said that in spring the fish are observed to resort to the shallow portions of the lake and also to ascend creeks for the purpose of depositing their eggs. The favorite grounds appear to be around the shores and islands in the eastern end of the lake, the same region which is frequented by the whitefish. A rather important fact that bears upon the question of migration of alewives to and from the Gulf of St. Lawrence is that almost every winter greater or less numbers of the fish are seen through the ice and on the ice banks which form in the lake. The fishermen, as a rule, regard the alewives as permanent inhabitants of these waters and think that the fish retire into the deepest portions of the lake during the cold weather. Fish only 1 or 2 inches long have been seen in March at Oswego and elsewhere. On the other hand, inquiries among fishermen and others at Ogdensburg elicited information tending to show that at that point at least there is a well-marked migration up the river toward Lake Ontario in June and down the stream in the fall. The fish are caught in considerable numbers in nets along the Canadian shore, and in many places are peddled through the country and sold for food. The greatest quantities are taken below the rapids, where the fish always appear to be more numerous than elsewhere in the river.

Mr. Charles H. Strowger, of Nine-Mile Point, Monroe County, New York, communicates some interesting observations on the spawning condition of alewives examined by him at that place in the spring of 1892. He says:

> The ice did not leave the shore at Nine-Mile Point until the first week in April. A few full-grown alewives were cast ashore together with a number of small ones ranging from 1½ to 2¼ inches in length. This was on April 9. The fish were fat and apparently healthy, and about half of the full-grown ones had spawn matured; no males noticed. April 17—Picked up fifteen grown alewives on the beach varying from 5¼ to 6¼ inches in length from the nose to the insertion of the tail fin. Several small ones were also present. They were fat, with no signs of disease visible. The spawn in the females was ripe except in one instance, and in most of them the spawn was running. Two were males, but in neither of them was the milt mature. April 18—Took from a gill net with 1¼-inch mesh sixteen live alewives, largest 8¼ inches long, more only 6 inches long. Of these, nine had spawn running, five were immature, and two were males with milt not ripe. These fish were all in fine condition, with flesh plump and firm. April 28—Have caught only yellow perch since the 18th until this morning, when I took up a single alewife. Its spawn was running. Since the yellow perch has appeared here (to spawn) the alewife has left the shore.
>
> Owing to the new fish laws of this State, it will be difficult to make a very thorough study of our shore fish, as the law now prohibits netting within a mile of the shore. What few fish I have examined give me the impression that alewives spawn rather earlier than perch.

Viewed from the economic standpoint, the alewife is no doubt a more important fish than is generally believed among the fishing interests and should not be regarded as altogether a pest. Used as bait in the trawl-line fishery for sturgeon and trout it is a valuable fish and takes the place of other fish that are of more importance as food species, notably young ciscoes and suckers. The young also constitute a prominent bait in the sport fishing which is so extensive on this lake.

When washed up on the shores, or when caught and treated like menhaden, they form a valuable fertilizer, and many tons are utilized annually by the farmers living adjacent to the lake; although it should be said that in most localities the washing ashore of dead alewives is not favorably regarded, and unless measures are taken to bury or haul off the fish they become public nuisances. At one time a small factory was operated in the eastern end of the lake for the purpose of utilizing the abundant

alewives in the manufacture of oil and guano; this was soon closed, however, owing partly to opposition to the use of the pound nets and partly to the growing deficiency of oil in the fish.

Perhaps the most valuable purpose which alewives subserve in this region is that of supplying food for other fish. In their defenseless condition they fall a ready prey to bass, pike, pike perch, muskellunge, perch, trout, ciscoes, and other species, and in this way become really important factors in the growth and multiplication of other fish. Black bass eat alewives in large quantities, and when the former first arrive in the inshore waters in the spring they are almost invariably found filled with alewives. In certain places, but more especially at Oswego, both bass and pike perch have increased greatly since the alewives became abundant. Wall-eyed pike are reported to be particularly fond of alewives, and "pickerel" (*Esox*) also feed on them to a considerable extent. At Oswego, New York, on August 19, a whole alewife, over half the length of its captor, was found in the stomach of a small pickerel.

The value of the lake alewife as food for man should not be overlooked. Although of small size and bony, it is not without its champions among the lake fishermen, and it is occasionally eaten. It has no commercial value, however, at present, and will probably never be in demand as a fresh article of food; but the writer believes that it can be made to take a prominent place among the economic lake species if put on the market in a smoked condition. The alewife is similar in size to the sea herring so extensively used on the New England coast in preparing the most popular brands of smoked herring, and there does not seem to be any objection to its utilization in this way.

The method of preparing the small sea herring on the coast of Maine is entirely applicable to the lake alewife and is, briefly, as follows: The fish, as taken from the water, are closely strung through their mouths and gills on smooth sticks about a yard in length, after which they are immersed in a solution of common salt for the purpose of hardening and preserving them and of removing the scales; they are then suspended in the smokehouse, where they are left until cured and well colored, and are afterwards arranged crosswise in boxes to the number of 50 to 75, when they are ready for sale. The boxes are made of soft wood and are quite inexpensive. The usual dimensions are 15 inches long, 7½ inches wide, and 4 inches deep. Such a box holds about 5 pounds of smoked fish. The best prepared "cross" herring usually have a ready market at from 15 to 20 cents a box, and the lake alewife would no doubt prove a satisfactory substitute and yield as good returns.

One of the most interesting phases in the history of the alewives in Lake Ontario is the enormous mortality to which they are subject. This fact more than any other has brought the fish into prominence and during the past few years has called forth voluminous newspaper correspondence and comment. The mortality occurs chiefly during warm weather, especially during June and July. When the wind is favorable the fish will be washed up along the entire southern shore of the lake, at times being piled up to the depth of a foot or more in certain places. Large areas of the lake bottom have also been found to be thickly covered with dead fish.

The decomposition of the fish washed ashore has proved a nuisance in almost every community on the lake. People have in certain instances been obliged to leave their homes, owing to the unbearable odor arising from the putrefying fish. Tons of dead fish have been annually hauled away to be used on land as fertilizer or buried

to prevent noxious odors. In some sections the town authorities have been obliged to come to the aid of the inhabitants and have the fish disposed of at public expense. This was the case in Wilson, New York, where, in 1891, about $300 was expended in ridding the shores of the town of decaying fish. In a small slip, about 30 feet wide, at Sacketts Harbor, New York, in June, 1891, three wagon loads of dead alewives were hauled off the shore in one day. This was after a strong blow from the north. At the same place, on August 15, 1891, several thousand were seen on a small point that enters into the formation of the harbor. They were all dry, and not putrefying; and were of small size and exceedingly thin.

The contamination of the water adjacent to large bodies of dead fish on the bottom must exert a harmful influence on the presence and abundance of desirable food-fish. The absence of whitefish and trout from the American shores is by many fishermen attributed entirely to this cause.

In attempting to account for the death of the alewives it should be stated at the outset that no scientific investigation of the subject has ever been made, although it would seem to be a most inviting field for research. The question is of no little economic importance from several points of view, and it seems somewhat remarkable that during the two decades in which the fish have been dying in such enormous numbers no systematic study of the conditions of their life and death has been undertaken.

Among the causes which have been suggested as leading to the death of the alewives, the following may be mentioned:

(1) *Fungous disease.*—Fishermen living at various places on the lake have at times noticed moldy spots on many dead fish that have been washed ashore. Some alewives still alive have also been seen suffering with this condition. The fungus has been observed to be usually on an ulcerated or abraded area.

A correspondent of the Rochester Post-Express, writing on this subject in the issue of that paper for October 28, 1891, says that as soon as the ice moves out of the lake in spring the fish approach the shores and the mouths of rivers, and that at this time they are healthy and fat. He continues as follows:

> But as soon as the water grows warm the fish are attacked by a white fungoid parasite, which soon covers large spots on the fish, looking like short, fine, white hair or fur. Sometimes it will envelop the whole fish, but more frequently only a spot on a fish will appear, from the size of a speck to that of a quarter of a dollar or larger. The consequence of this attack is seen in the establishment of curious ulcers, which soon destroy the fish. This white pilose parasite (whether animal or vegetable) is carried by these fish into the bays and impregnates the water so that it is almost impossible to confine minnows for bait in such localities. Not being in possession of a good microscope I have not attempted to investigate the nature of the parasite I mention, but it is certain that it is the slayer of millions of alewives.

This gentleman speaks from personal observation and his remarks are entitled to consideration. The villous parasite which he mentions is quite common on fish kept in captivity and has recently appeared among the trout at the Caledonia hatchery of the New York fish commission. It is probable that the fungous growth attacks fish whose general vitality is lowered by other causes, and it is not definitely known that it ever appears on perfectly healthy fish or on an unabraded surface.

(2) *Deficient food.*—Hon. Marshall McDonald, U. S. Commissioner of Fish and Fisheries, whose great familiarity with the clupeoids is well known, thinks that insufficient food may play an important part in the mortality observed among the alewives in Lake Ontario. The fish multiply rapidly, a single female laying as many as 60,000

eggs each season, and it is thought that the minute organisms which form the principal part of the food of such fish may not grow sufficiently rapidly or abundantly to supply the countless millions of alewives (in addition to other fishes with similar food habits) which are restricted to this body of water year after year.

Lack of food must no doubt be the principal if not the only cause of the excessive leanness which is universally recognized and commented on by fishermen, many of whom state that a fat alewive is now rarely seen, although during the earlier years the fish were quite oily.

Prof. Charles S. Dolley, of the University of Pennsylvania, in an article in the Rochester Post-Express of August 8, 1891, says:

> The probable reason for the death of such large numbers of fish is that they have the habit of abstaining from food during the breeding season, and thousands undoubtedly succumb to the fatigues of a long swim from the sea against the current of the St. Lawrence, and in their subsequent search for suitable spawning-grounds.

This view is contrary to the observations of Mr. Strowger (page 189) and is strongly antagonized by an anonymous writer in the issue of the same paper for October 28, 1891, who says:

> That the professor was entirely without information on the subject may readily be seen from the fact that it is not in the spawning season that the mortality occurs. I doubt if any person ever saw eggs in a dead alewife in the latter part of May or June and beginning of July, in which this mortality occurs. They do not die at the spawning season, and they do not perish from fatigue in ascending the St. Lawrence River. The alewife, or sawbelly, is always present in Lake Ontario, and * * * as a whole does not migrate, although it is not at all improbable that millions of them descend the St. Lawrence to the sea in the autumn.*

(3) *Storms.*—Every heavy storm during the warmer months is accompanied by the washing ashore of greater or less quantities of alewives, and the fishermen in some localities have come to regard disturbances of the elements as the most potent factors in causing the death of the fish. It is held that the fish are partial to shoals in the lake and shallow places near the shore, and that when overtaken there by storms they are easily destroyed by the violence of the wind and water. This theory is hardly tenable for several reasons, chief among which is that no such mortality is observed in other fish that are also known to resort to shoals for feeding and spawning.

(4) *Temperature of water.*—The apparent prevalence of the epidemic only during the warmer months has induced many fishermen to look upon the elevation of the water temperature as the cause of the death of the fish. The highest temperature would naturally be found on the shoals, which, as has been stated, are favorite resorts of the alewives.

Mr. S. Wilmot, superintendent of fish-culture for the Dominion of Canada, is quoted as favoring this theory: "He attributes the heavy mortality to the higher temperature of the lake water in summer time as compared with the ocean, and particularly to the fact that these fish seek the shallow and consequently warmer water to spawn, and in this way are killed off by thousands."† This idea is favorably entertained at Wilson, New York, and other places towards the western end of the lake.

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* See Forest and Stream, September 10, 1891, for further discussion of this question.

† Ogdensburg Journal.

THE SHAD.

In a learned paper on the shad (*Clupea sapidissima*) in the Annual Report of the Commissioner of Fish and Fisheries for 1872–73, Prof. Baird considers the question of the naturalization of shad in inland waters, and says:

The problem as to the possibility of naturalizing the shad in the Great Lakes, so that they may subsist there the greater part of the year and find a supply of food, is more difficult of solution, and one that can only be decided by experiment. We have, however, the interesting fact that the deep waters of the Great Lakes abound in certain species of minute crustaceans, precisely similar to those occurring on the Atlantic coast, and which, while consumed to a great extent by the whitefish, may be presumed to be in sufficient surplus to feed an indefinite number of shad. The experiment of stocking the lakes with shad has been already made by Seth Green, who planted 15,000 in the Genesee River near Rochester, in 1871. A number of these were subsequently taken in nets, and it is thought probable that the spring of 1874 will witness the movement of mature fish up the Genesee River.

Concerning the same deposit of shad fry to which Prof. Baird refers, the New York fish commissioners say:

This was purely an experiment to test the question whether these fish, which, according to their natural habits, seek the salt water every winter, would live and thrive either in the fresh water of the river or by passing from it into a fresh-water lake. It was not considered probable that any of them would be able to descend the St. Lawrence to the sea and reascend, escaping all the implements of destruction in their route, so as to reappear in this river. But experiments which had been made with the salmon on the northern shore of Lake Ontario had given credence to the impression that it is possible for migratory fish to live in streams which connect with any large body of water, whether fresh or salt. This impression has been in a measure confirmed by the result; for, in the month of June, 1872, young shad were caught near the mouth of the Genesee, 5 or 6 inches in length. Two months later shad weighing a quarter of a pound and 7 inches in length were taken in Lake Ontario, within 5 miles of the mouth of the Genesee. As many as 100 of these were caught at a time in a small net, so that the conclusion may be regarded as established that shad will live and thrive under such circumstances, although whether they will attain the size and the age that they reach in the rivers running to the ocean, or whether they will breed, are questions yet to be settled. In order to make the experiment more thorough and to give it a better chance of success other rivers were stocked in the same way. Sixty thousand additional young shad were turned loose in the Genesee on the 21st day of June, 1872. On the 25th 30,000 were placed in Lake Onondaga. (Report of New York fish commission, 1872.)

The initial plants of shad fry in 1870 and 1871 were followed in the two succeeding years by larger deposits, and, after an interval of three years, by still more numerous plants in 1877 and 1878. The total number of shad fry deposited each year in the streams entering Lake Ontario and in the smaller lakes connected therewith is shown in the following table. The plants were all made by Mr. Seth Green, under direction of the New York fish commission.

Years.	Genesee and Black rivers.	Lakes Onondaga, Canandaigua, and Cayuga.	Total.
1870	5,000	.....	5,000
1871	15,000	.....	15,000
1872	60,000	30,000	90,000
1873	70,000	108,000	178,000
1877	80,000	.....	80,000
1878	290,000	.....	290,000
Total	520,000	138,000	658,000

As noted by Prof. Baird, the appearance of adult shad promptly followed the introduction of young fish into the Genesee River, and from that time on for a number of years the indications pointed to the probably successful acclimatization of the species. Since about 1885, however, the fish have appeared to be growing scarcer, and their final disappearance seems to be only a question of a few years.

Prior to this experimental introduction shad were unknown in Lake Ontario, and the theory that their presence was due to their migration up the St. Lawrence River is considered untenable by those who have given the subject sufficient study.

The shad appear to have distributed themselves over the entire lake. At almost every fishing community on the American shores of the lake the fishermen remember to have taken at irregular intervals between 1875 and 1885 the fish, which was at first a stranger to them and which they now seldom, if ever, see. Reports from the northern shore of the lake indicate that the shad were probably fully as numerous there as on the southern side. The greatest numbers seem to have been taken in the eastern end of the lake, in the vicinity of Cape Vincent, in Chaumont Bay, and around the islands, where the principal trap fisheries have been prosecuted. Prior to 1888 several hundred adult shad were caught each year in this region, but of late the American fishermen have seen none whatever, and the few fish secured of which any record could be obtained have all been caught in Canadian waters. About August 6, 1891, Mr. W. Ainsworth, of Cape Vincent, received a shad from Canada, this being the only one seen during the year. In 1890 he handled a fine specimen, also from Canada, weighing 5 or 6 pounds and about ready to spawn.

A suggestion as to the cause of the disappearance of shad in the waters of the lake is that the fish went to salt water down the St. Lawrence River and failed to return. They have been repeatedly seen in the river, and one of the most interesting observations of their habits was made at Thousand Island Park. In August, 1881, Mr. H. L. Matheson, of Oswego, New York, was fishing at that place for black bass. As an experiment he baited his hook with a grasshopper and cast his line from the shore of the island into the current, made somewhat muddy by a strong westerly wind. The bait was promptly taken, and to his great surprise a 3-pound shad was landed. More grasshoppers were secured, and fifteen shad, weighing from 2½ to 3 pounds, were taken in a few hours. On succeeding days six, three, and two fish, respectively, were caught. Several other parties took one or two fish each in the same way.

While it is possible that some of the fish left the lake by way of the St. Lawrence River, the most plausible reason for their disappearance seems to be that of the necessarily small proportion of the original plants which reached maturity nearly all were caught before natural reproduction supervened. It is also probable that the great multiplication of alewives unfavorably affected the increase of shad by diminishing the food supply.

The fact that shad were taken in Lake Ontario in 1891, thirteen years after the last fry were deposited, may be taken as a sufficient indication that the waters of the lake are adapted to this species, although it does not necessarily prove that the continued introduction of young shad would eventually result in the production of sufficient numbers of fish suitable for food to serve as the objects of a special fishery or to offset, in point of value, the original outlay. At the same time it must be apparent that the plants of shad in the tributaries of Lake Ontario were wholly inadequate to stock such a large body of water; and it is unfortunate that the experiments should have

been discontinued at the very time when most important results were beginning to be manifested. To illustrate the apparent inadequacy of the measures taken to produce an abundant supply of shad in the lake, it need only be remarked that the average number of fry annually deposited was equivalent to only 17 fish to the square mile of lake surface, and that the entire plants during a period of six years represented less than $\frac{1}{100}$ of the quantity of fry that has been devoted to a single coast basin in a single season. It is estimated that probably 10,000 or 12,000 more or less mature shad have been taken in Lake Ontario. This is assuredly a satisfactory experiment, and strongly argues for the resumption of shad-culture in the lake.

THE ATLANTIC SALMON.

The Atlantic or salt-water salmon (*Salmo salar*) was at one time an exceedingly abundant fish in Lake Ontario and its tributary streams; to-day it occurs only as a straggler, a curiosity to the young and a relic of other days to the aged inhabitants of the region. The practical disappearance of salmon from the lake is another of those almost phenomenal changes which have occurred in the fisheries of Lake Ontario, but the comparison of the past and present abundance of salmon is much more striking than in the case of the trout and whitefish. The history of the salmon in this body of water is a forcible illustration of what may be expected to take place in all inland waters when the destruction of fish by man is not mitigated or counterbalanced by resort to artificial propagation of adequate scope, supplemented in the case of certain species by protection and encouragement during the important period of reproduction.

The narration of the previous abundance of the salmon in Lake Ontario and its tributary streams reads like a romance, and the possibility of reëstablishing a good run of salmon in Lake Ontario and of restocking its waters with this valuable food-fish opens up one of the most important, interesting, and inviting fields connected with the present fishery agitation in this region, making a thorough inquiry into the past and present conditions very desirable. The accounts of the early abundance of salmon indicate that the fish at certain times ascended nearly every stream on both the American and Canadian shores, chief among which were the Salmon River, Little Salmon River, Black River, Big Sandy Creek, and Oswego River on the southern side, and Wilmot Creek in Canada, the first named being the most famous. The cause which led to the ascent of the streams was the same which now operates in the coast rivers in which salmon occur, namely, the reproductive instinct. The fish approached the shores in June and, if the water was sufficiently high, went up the streams to their head waters, deposited their spawn, and returned again to the lake. There are also numerous authentic records of another fluvial migration for the same purpose later in the year, usually in September, a circumstance which led some of the fishermen to believe in the existence of two kinds of salmon in the lake,* which were distinguished as spring spawners and fall spawners.

There was an advent of salmon in the Oswego River which was called the "June run." This was usually two or three weeks earlier than the appearance of fish in the Salmon River. The inland lakes in which the Oswego rises kept that river well filled most of the time, but the Salmon River was ordinarily low when the salmon first came on the shore.

* See paper by Dr. Edwards (hereafter quoted) and testimony of B. E. Ingersoll and John S. Wilson.

The question as to whether, after spawning, the salmon returned to the sea, after the manner of the fish in the coastal streams, or simply retired to the deeper portions of the lake, naturally comes up for consideration. The weight of the testimony and evidence seems to indicate that the salmon had, possibly during a long period of years, become acclimated in the waters of the lake and ceased to require salt water, although it is not improbable that certain individuals annually made their way down the St. Lawrence River to the large tributary of the sea at the mouth of that stream. In a discussion of the salmon of Lake Ontario, participated in by Prof. Baird, Mr. Seth Green, and others, an abstract of which is given elsewhere, this subject is further considered.

The usual range in the weight of the salmon caught during the period of their abundance was from 7 to 40 pounds, individuals of the latter size being uncommon; the average weight was probably about 10 pounds. Mr. B. E. Ingersoll, now of Oswego, New York, informs me that his father killed a fish in Salmon River that weighed 42 pounds.

From a mass of notes and correspondence from fishermen and others concerning the former occurrence of salmon in Lake Ontario, a few extracts are here presented which are thought to add to the published knowledge of the history of salmon in that region.

Mr. B. E. Ingersoll has furnished some interesting statements concerning the former occurrence of salmon in the Salmon and Oswego rivers. Writing of the former stream he states that fifty or sixty years ago the river was well supplied with salmon. He was born and lived within 100 rods of the river until 16 years of age. His grandfather was the second man to settle in the town of Richland, and his father was brought to the region at the age of 2 years. The abundance of salmon seems to have been a very important factor in the settlement of the region; the salmon were all the settlers had to depend on for ready money, and constituted a valuable and easily accessible food. About fifty years ago his father and a Mr. Arthur Matheson, while fishing from a boat with jacklight and spear, caught 601 salmon in a single night.

Mr. Ingersoll has heard his father relate the circumstances of a visit to the Oswego River to spear salmon. He had his log cabin on the shore of the river on the present site of the Doolittle House. At that time there was only one store in Oswego, which was situated on what is now the corner of West First and Cayuga streets. The elder Ingersoll entered into a contract with the proprietor of the store by which the latter was to take all the salmon caught during the two weeks' sojourn on the river at the uniform rate of 2 cents a pound. For about a week only from 25 to 50 fish were speared each night, and the storekeeper during that time continually importuned Ingersoll to catch more fish. Another school of fish then struck on and from 300 to 400 were taken each night. This was more than the dealer could handle, and he paid $50 for the privilege of suspending the contract.

It was nothing uncommon for teams fording the rivers and creeks at night to kill salmon with their hoofs. An old settler living in the town of Hannibal told Mr. Ingersoll that one night while driving across Three-Mile Creek the salmon ran against his horses' feet in such numbers that the horses took fright and plunged through the water, killing one large salmon outright and injuring two others so that they were captured. The farmers living near the smaller creeks easily supplied their families with salmon caught by means of pitchforks.

The salting of salmon for trade and winter consumption was largely engaged in by farmers and others. On the Salmon River the fish were salted in the fall and many were peddled through the country during the winter. One barrel of salt salmon was then equivalent in value to two barrels of salt. Salmon were so plentiful that men hiring out to work stipulated that salmon should be given them to eat not more than three days in a week, and in binding out apprentices the same agreement was made.

On the Salmon River the people who owned the land controlled the riparian privileges connected therewith. The owners often combined, and as much as 2 miles of shore were operated by some companies.

During the spawning season, fishing was permitted only on every other night, and about half the run was thus allowed to pass up unmolested. Fishing at that time was principally with spears, 90 per cent of the fish being caught in that way. A few weirs were sometimes built, usually between an island and the mainland. When a school was seen adjacent to the weir, two or three boats were launched and the fish frightened or driven into the weir, which was often completely filled. There seems to have been considerable opposition to the use of weirs; rival fishermen often tore out the weirs of their neighbors, and the existence of a weir intact was only secured by vigilance day and night; and even among those who operated weirs they were not very popular, as a great many small fish were sacrificed for which there was no use. After the fish began to grow scarce, the use of weirs was entirely discontinued.

Mr. John S. Wilson, of Wilson, New York, at the mouth of Twelve-Mile Creek, reports that about twelve years ago two salmon weighing 1½ pounds each were caught there, and none has since been seen; at one time they were plentiful in that vicinity. They came to the shores in spring, ascended the creeks, spawned, and then went back to the deep water of the lake where they remained until the following spring and where they were sometimes taken in gill nets, although the principal means of capture was the spear, used when the fish were in the streams. In the fall there was another run in the creeks made up of fish that had not entered in the spring.

Mr. W. E. Nelson, of Port Ontario, New York, writes that 40 or 50 years ago salmon were very numerous in the lake and in Salmon River. They were netted and speared in great numbers in the river. The fish were of good size, often weighing as much as 40 pounds. Since that time they have gradually decreased, and the last of which he has heard were caught in the lake at Port Ontario about three years ago. They were small fish weighing only 2 or 3 pounds. He further states that, although there are dams in the Salmon River, near Pulaski, with proper fishways this river (which was in former days the most famous salmon stream flowing into Lake Ontario) would be accessible for a distance of over 12 miles from its mouth.

Mr. Charles Learned, of Sandy Creek, Oswego County, who has been a fisherman for thirty years, writes as follows regarding the salmon in that vicinity:

I have not seen a salmon in this part of the lake in about ten years. Twelve or fourteen years ago the salmon were quite plenty. I caught eleven in one day in a seine. Thirty years ago they were taken in trap nets. I never caught one that weighed more than 20 pounds. About fifteen or twenty years ago some young salmon were put in Salmon River, and the fish were quite numerous for three or four years. I think that Salmon River is suitable for salmon to run up to spawn. The conditions are as favorable as they were fifty years ago, and on some smaller streams more favorable, for the sawmills have shut down and the dams are gone. On Salmon River it is 4 miles to Pulaski, where there are two dams; on Little Sandy it is 5 miles to the first dam; but the country is being cleared up so that there is not so much water as formerly in the streams in the latter part of the season.

Writing of the former occurrence of salmon in Chaumont Bay, Mr. Earl S. Douglass says that it has been at least ten years since he saw any salmon in that vicinity. The fish never inhabited that section of the lake to such an extent as they did the portion adjacent to Oswego and Port Ontario. Regarding the availabilty of the rivers, he thinks that the conditions are not as favorable for the ascent of fish as they were during the period of their abundance, and that some of the streams in that vicinity which the fish formerly frequented are now mostly dry, at least during a portion of the year. The few fish which he remembers to have been caught in Chaumont Bay were taken in a pound net and weighed about 10 pounds.

Mr. E. B. Horton, of Henderson Harbor, Jefferson County, New York, says that he has not caught a salmon in that vicinity for twelve or thirteen years, and knows of only one being taken in that time. This was taken in Stony Creek, with a whitefish gill net having a mesh of 2¼ inches, and weighed 6¼ pounds. The only stream in that immediate vicinity is the Black River, which he does not think would be adapted for salmon, as the water is contaminated by refuse from paper mills situated not far from its mouth, and the acid used is said to kill pike, bass, and other fish, and would prove equally injurious to salmon.

At a conference of fish commissioners held in New York City October 19, 1872, the subject of salmon in Lake Ontario was one of the principal questions discussed.* Many important points having a bearing on the present agitation were brought out, and it is thought advisable to introduce the following abstract of the proceedings:

Prof. Baird, in speaking of the migrations of the salmon, stated that it had not been determined whether the Ontario salmon went to the ocean and returned to the lake again each year. Dr. Edmunds, whose observations are given in full elsewhere, said that some of the fishermen made a distinction between the salmon of the lake and what they called the Bay Chaleur salmon, but he did not know in what respect they differed from each other. Mr. Seth Green remarked that a good many salmon still ran up to the head of Lake Ontario and up Wilmot Creek, which is only 10 or 12 miles in length. He did not regard these as landlocked salmon, though they may never go down the St. Lawrence, and thought the fish might find suitable food in the lake. Mr. Thaddeus Norris was an old salmon-fisher, and had given considerable attention to the habits and instincts of the salmon. He thought the salmon that Mr. Wilmot, of Canada, procured were fresh-water fish, and that the salmon of Lake Ontario had lost their sea-going instinct; Lake Ontario was their wintering-place; they live there all the year when not going up the rivers to spawn. Mr. Norris thought that the salmon of Lake Ontario were fresh-water salmon, for the reason that they had minnows in them, the habit of salt-water salmon being to abstain from food when ascending the rivers to spawn. Mr. Seth Green gave his experience as a fisherman and fish-dealer for many years on Lake Ontario. In the course of his operations he had dressed tons of salmon, but had failed to find food in their stomachs. The fish were taken in trap nets in the lake, set along the shores, and he thought the trap nets had practically exterminated the salmon in Lake Ontario during a period of five years.

Prof. Baird, speaking concerning the introduction of salt-water salmon into the lakes, said he had full confidence that the experiment with the Penobscot salmon would be successful. It was well known that the principal food of the salmon in the

*See Report U. S. Fish Commission, 1872-73, p. 763.

North Atlantic consists of small shrimps, about half an inch long, mostly belonging to the genus *Mysis*. Investigations recently made in the deep waters of lakes Superior and Michigan had disclosed the existence of the same shrimp at a depth below 25 fathoms, where it constitutes, to a great extent, the food of the whitefish. The professor called attention to the fact that the gastric juice of fish acts after their death and this accounts for finding so little in stomachs of fishes which feed on small, soft organisms, unless examined immediately after being caught. After a few hours, only a microscopic examination would demonstrate on what a fish feeds. The occurrence of this small shrimp in the larger lakes is the guaranty that salmon will thrive there, and when the fish descend the rivers to the lakes they are practically in the ocean.

In an important article on obstructions to the ascent of fish in rivers, printed in the Report of the U. S. Commissioner of Fish and Fisheries for 1872–73, Dr. M. C. Edmunds, of Vermont, recounts his observations in the St. Lawrence Basin, undertaken at the request of the late Prof. Baird, in 1872. This inquiry, although made twenty years ago, may appropriately be alluded to in this connection, since it covered Lake Ontario and related to the causes which had operated to render the salmon a rare species in the lake fisheries even at that time. The investigation included an examination of all the streams on the southern shore of the lake formerly frequented by salmon. That portion of the paper pertaining to Lake Ontario is here quoted in full:

The salmon formerly were very plenty along the southeast shore of the St. Lawrence, inhabiting the lower reaches of the Chateaugay, St. Regis, Racquet, and Grass rivers, emptying into the St. Lawrence within the Canadian Dominion, as also the Oswegatchie in the State of New York. Of these streams I took but little notice, but passed on to the inspection of the rivers immediately debouching into Lake Ontario proper. Of these, first in order I inspected the Black River and Chaumont, both of which I found to have been formerly inhabited by the salmon. Neither of these rivers at the present time offers any inducements for the introduction of the salmon by reason of high and impassable dams. Both of these streams at their outlets into the lake are susceptible of being made quite profitable fields for salmon-breeding could the trap weirs and pound nets be permanently excluded; but these are so plenty and the fishermen so lawless that it would be useless to begin any experiments here.

My attention was directed to the Big Sandy Creek and Salmon River, in Oswego County. The former of these ceased long ago to be a salmon stream and received but slight notice at my hands, while the latter claimed my *special* attention, being the first river which I have yet found in all my travels in which the salmon are now found. I inspected the river several miles from its mouth upward and found it all the way admirably adapted to the growth of salmon. There are several dams situated on the river, but so low and in such favorable localities as to give easy passage to the salmon. I found, on inquiry, the fact that several salmon were caught below and above the dams last fall, and that several were caught below the dams early the past summer. I think this, above all streams heretofore seen, to be the best calculated to commence the breeding of salmon artificially. It is quite evident that they ascend the river above the dams, and when above have a wide range and are free from the attacks of all predatory fish. An establishment might be built upon some favored locality above the dams where the process of artificial propagation could be begun and successfully prosecuted. I noticed several streams where such an institution might be begun, and where as favorable results could be effected as those attending the experiments of Wilmot at Newcastle, Ontario. There are no trap weirs or pound nets, as I am informed, in the mouth of the river to prevent the salmon from entering the same with safety. The people in this locality are all kindly disposed to aid and assist this project and are quite anxious that experiments should be commenced here.

After leaving this river I took up next in order of inspection the Oswego. This river has its source in the interior lakes of central New York. It was also once a very noted salmon stream, and salmon ascended into the Cayuga and Seneca lakes; but the canal, which extends from Oswego to Syracuse, follows nearly the whole course of this river, debouching into it, thus making it unfit for a

salmon stream. I visited several other small streams between this point and the Genesee, at Rochester, and found them equally well-noted salmon streams, as also the Genesee as far as the falls, together with all streams between that point and the Niagara.

None of these streams visited are now inhabited by the salmon, but the testimony of all with whom I had any conversation on the subject confirmed the fact that they once had been salmon streams of greater or less celebrity. Their testimony all went to show that the last salmon that had ever inhabited these streams had been caught, and that neither sawdust nor other foreign matter had aught to do in their extermination. It is a fact too apparent to need further confirmation that the trap and pound nets have entirely exterminated this fish from the south shore of Lake Ontario. They have been set in the mouths of nearly all the rivers emptying into the lake, and consequently the fish have become an easy prey to the fishermen.

In conclusion I would say that I found the St. Lawrence to have once been inhabited very largely by the salmon, and it is the opinion of the inhabitants living along its banks that it might again be stocked.

An account of the occurrence of salmon in Lake Ontario during the past three years will be a very meager record. In 1891 the writer saw one weighing 7½ pounds that was caught in a gill net in the Bay of Quinte about August 17. This was the only specimen taken that year of which any definite knowledge could be obtained, although there was a rumor that several others were killed near the mouth of Salmon River. In 1890 a salmon weighing 12 pounds was taken on a fly rod below the first dam in the Oswego River. About three years ago several small specimens, weighing 2 or 3 pounds, were secured along the shore near Oswego. There have probably been a few fish caught in some of the numerous streams on the Canadian side, but concerning these no information is available.

Coming now to a consideration of the cause or causes of the disappearance of salmon from the waters in question, attention is first directed to the opinions of Dr. M. C. Edmunds and Mr. Seth Green which have already been quoted. Both gentlemen attributed the decrease of salmon to the setting of nets near or in the mouths of rivers, by means of which the fish were caught when on their way to the spawning-grounds.

The erection of dams in the salmon streams has been regarded as a potent factor in the disappearance of the salmon and is the point on which the greatest stress was laid by the United States Commissioner of Fish and Fisheries in a report* submitted to the Senate on January 26, 1891, on the advisability of establishing a hatchery on Lake Ontario. To quote Commissioner McDonald:

> The cause of the disappearance, practically, of salmon from the streams of the St. Lawrence Basin has been chiefly and primarily the erection of obstructions in all of the rivers, which have prevented the salmon from reaching their spawning-grounds, and so natural reproduction has been absolutely inhibited.

In the first annual report of the New York fish commission, dated March 9, 1869, a statement appears showing the condition of the chief salmon streams of that State emptying into Lake Ontario. An examination of this leads to the conclusion that the dams must have had great influence on the decrease in salmon and that Commissioner McDonald's point was well made. The report mentions the Salmon and Oswego rivers and Little Sandy, Big Sandy, and Little Salmon creeks. The number of obstructions in Little Salmon Creek was not known, but in the other streams there were no less than sixty-two dams.

* Report of the United States Commissioner of Fish and Fisheries on advisability of establishing a fish-hatchery near the St. Lawrence River. (Senate Mis. Doc. 55, Fifty-first Congress, 2d session.)

It may be stated that the catching of salmon *per se* was not the cause of their decrease, which was due to the prevention of their ascent of the streams in sufficient numbers to secure the perpetuation of the species.

The practical questions to which the preceding discussion leads are:

1. Can the return of salmon to Lake Ontario be accomplished?

2. Are the conditions sufficiently favorable to warrant the attempt?

3. How is the reëstablishment of the salmon fishery to be brought about, and what steps would be necessary to secure the best and most immediate results?

4. Will it be possible to obtain a sufficient abundance of salmon to permit the prosecution of commercial fishing, and will the value of the fishery to the State be a profitable return for the original outlay?

The first question can be promptly answered in the words of the United States Fish Commissioner in his report to the Senate, to which reference has already been made: "It is not only possible, it is entirely practical, to restore and maintain these fisheries by adequate recourse to means and agencies entirely within our control."

The present conditions in most if not all the streams are certainly not such as to invite efforts to secure a return of salmon to them. Refuse and insurmountable dams are still present. A very important consideration, also, is the change in the topography of certain regions due to the clearing up of swamps and the cutting away of forests, by which the water supply of some streams has been materially affected.

Mr. B. E. Ingersoll thinks the fishery for salmon can not be reëstablished in the Oswego River, as it is so filthy with sewage and refuse from manufactories that the salmon will not go up it. It is thought, however, that they might ascend the Salmon River, as that is less filthy than the Oswego River, and beyond Pulaski, where the manufactories are located, the water is of good quality, although it is open to the further objection that the river gets very low, especially in dry weather, and rises and falls very rapidly after rains, because the swamps that formerly acted as reservoirs for the surface water are being gradually cleared up.

The initial steps in an attempt to obtain a return of salmon would include an examination of the streams in order to determine the character of the water, the number and nature of obstructions, and the extent of the contamination of the water by refuse from manufactories, sewers, etc. This should be followed by the removal of unnecessary obstructions and the building of fishways in such dams as were required for the prosecution of important business enterprises. Provision should be made for other disposal of mill and city refuse. Protection of salmon for a term of years should be secured. Coöperation between Canada and this country should exist from the outset, as Canada has streams as well adapted to salmon as any in New York and would no doubt profit by work done on the southern shore of the lake. Uniform regulation of the lake fisheries by the two nations would be necessary, but this can not now be secured, owing to the exclusive jurisdiction of New York over the American portion of the lake. The Canadian members at the international fishery conferences held in November and December, 1891, in New York, Rochester, and Hamilton (Ontario), expressed the hope that the Imperial Government would cede to the provinces the control of the inland waters; but even if this privilege were granted, no agreement between New York and Ontario affecting the lake fisheries would be binding on either party, and protective laws would be subject to repeal at any time, and the work of restocking the lake with salmon (and other fish) would be in constant jeopardy. The

assumption by the United States of the control of the fisheries of international waters, as is already the case with navigation, would permit the conclusion of a treaty with Great Britain by which alone could adequate protection be assured.

Having arranged the foregoing preliminaries, the important work of artificially propagating salmon could be undertaken with every prospect of success. The Maine hatching stations of the U. S. Fish Commission could furnish an abundance of salmon ova for the first few years, after which the supply could be drawn from Lake Ontario, in the opinion of United States Fish Commissioner McDonald. He also thinks that generous plants of yearling fish in the head waters of the rivers formerly frequented by the salmon will accomplish more than the simple deposit of fry in these waters or in the lake. The employment of the young of the land-locked variety of salmon would be an important feature of the work of rejuvenating this fishery, for it is probable that the instinct to migrate to salt water would in this fish be lost and the constant presence of salmon in the lake basin would be secured. To sum up this subject in the words of Commissioner McDonald:

> The regeneration of the fisheries must be accomplished through fish-cultural work, systematically and persistently pursued. Their maintenance must be assured by the concurrent regulation of the lake fisheries by the United States and Canada and by the enforcement on the part of the State of New York of such regulations and requirements as will permit the salmon to ascend to their spawning-grounds. In the absence of such regulations and requirements it will not be reasonable to expect that the results of fish-cultural work will be permanent or compensating, however extensive such work may be.
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> A fish-cultural station planned to meet all the requirements must be very extensive and complete in all its appointments. * * * The hatchery must be commodious, providing * * * for the incubation of 1,000,000 salmon ova. It must also provide trough accommodations for holding 1,000,000 salmon fry for some weeks after they begin feeding. * * * An extensive system of ponds for rearing the salmon must be constructed, for none would be released in open waters until they were of sufficient size to have comparative immunity from capture by other fish. * * * The station should be * * * placed * * * convenient to transportation routes, and should control a gravity water supply which should be without stint or measure.

THE LAKE TROUT OR SALMON TROUT.

Next to the whitefish, the lake trout (*Salvelinus namaycush*) is probably the most highly esteemed species occurring in Lake Ontario, a popularity arising from its commercial importance, food value, game qualities, size, and beauty. Regarding the size of the Lake Ontario trout, it may be said that examples weighing 24 pounds are sometimes taken, but the average weight is much less than that. The fish caught in seines, on lines, etc., do not average more than 2 pounds, but in the large-meshed gill nets, set especially for trout, the average is probably 8 pounds.

Trout are now very scarce on the American shores of Lake Ontario, and the decrease in the catch since 1880 has been one of the most remarkable changes in the fisheries of that body of water. In 1880 over half a million pounds were taken; in 1890, although the yield was double that in 1885, only one-fourteenth of the catch in 1880 was obtained. The figures for the three years mentioned are as follows:

	Pounds.
1880	569,700
1885	20,510
1890	41,010

In many localities on the American shore, near which the lake trout were formerly very abundant and were taken in large numbers, they are now rarely seen. Off Oswego, for instance, the catch is now insignificant, but at one time thousands of trout were caught in summer in about 300 feet of water on set lines baited with ciscoes. There is an authentic record of two fishermen in one boat, operating about 800 hooks, taking 2,300 pounds of trout in one night. Now only a few fish visit the shores to spawn; this is usually in October.

Although differing widely from each other in habits, the trout and whitefish of Lake Ontario seem to be somewhat related in abundance and movements. The principal spawning-ground for the whitefish is also the locality most frequented by trout, and the largest quantities of each are taken in the same localities and at the same season. The trout, however, have decreased proportionally somewhat more than whitefish, the percentages being 93 and 86, respectively. As was shown in the consideration of the imports of fish from Canada, the provincial fishermen of Lake Ontario are now annually shipping into the United States larger quantities of lake trout than are caught by our fishermen.

Concerning the cause of the decreased abundance of trout in Lake Ontario, nothing definite can be asserted. The most plausible explanation seems to be that the largest quantities of fish are caught during or before the spawning season and on spawning-grounds, and that no adequate steps have been taken to replenish this unfortunate destruction of eggs and breeding fish. The U. S. Fish Commission has deposited no trout fry in Lake Ontario; and of the 35,444,800 young trout hatched by the New York fish commission between 1882 and 1891 not one has been planted in this lake, as I am informed by Mr. Edward P. Doyle, secretary of the New York fish commission.

The trout is a carnivorous and piscivorous fish, and in considering the question of increasing its abundance by resort to artificial means the food supply for young and adults becomes important. Fortunately it is thought that the alewives which now inhabit the lake in such countless myriads are admirably suited for trout food, a view which is sanctioned by the known habits of the trout and the opinion and experience of fishermen. The effect of the abundance of suitable food has been observed in the increased fatness of the fish caught. A dealer who handles large quantities of fish writes that he has noticed for several years that the trout caught in Lake Ontario are much fatter than those taken on the upper lakes, and it is now almost impossible to find a Lake Ontario trout that has not rolls of fat on its sides.

In regard to the feasibility of increasing by artificial means the abundance of lake trout, Mr. Ingersoll writes:

> I think the conditions are now very favorable for restocking this lake with salmon trout. The alewives are food for the young fry on the shores and shoals, and as soon as they get large enough to enter the deep water in the warm weather there are thousands of long-jaws for them to feed on.

THE COMMON WHITEFISH.

The present scarcity of the highly esteemed whitefish (*Coregonus clupeiformis*) in the American waters of Lake Ontario is one of the most noteworthy features of the fish life of the lake. The yield of this species is now only one-tenth what it was ten years ago, and in many localities in which the fish was formerly caught in considerable numbers it is now rarely, if ever, taken. The full extent of the decrease will be seen when it is stated that 1,064,000 pounds were obtained in 1880, while in 1890 the total yield was only 148,771 pounds.

The localities now chiefly resorted to by the whitefish are Charity Shoal, the Bay of Quinte, and around the Duck Islands; these are all in the eastern end of the lake. Charity Shoal has been for many years a famous breeding-ground for both whitefish and trout. The Bay of Quinte and the Duck Islands are in Canada, and are the centers of the most important whitefish fisheries now carried on in the lake. In the Bay of Quinte the fish run in very close to the shores, and the fishermen set their nets within a few rods of their dooryards.

The average weight of the whitefish now caught in Lake Ontario is about 2½ pounds. The maximum weight in recent years has been about 14 pounds. The largest specimen recently brought into Oswego from Canada weighed 12¼ pounds. At Sodus Point, where there was formerly a large run of whitefish, the gill-net fishermen now take only a few fish at a lift; these weigh from 5 to 14 pounds.

Observations on the spawning time of whitefish on the American shore go to show that this usually begins about November 10; it is, of course, subject to variation due to storms, temperature, etc.

The present scarcity of whitefish on the southern shores of the lake is not without precedent, although the length of the period of scarcity is probably greater than ever before known. There seems to have been a well-marked decennial diminution of whitefish on our shores through a long period of years, with a corresponding increase on the northern side of the lake. It is recorded,* for instance, that in 1870 whitefish were much more plentiful on the American shores; ten years before, the reverse was true; in 1880 the fish were less abundant on the southern side. In 1890, however, about which time, following the rule of the three previous decades, the whitefish should have reached the acme of their abundance on the shores of New York, they failed to appear; and, indeed, since 1880 the general tendency has been toward a decline on our shores, and the disparity between the two sides has been yearly more pronounced; while the experience of fishermen and personal observation indicate that the supply of whitefish in Canadian waters is annually increasing, and in 1891, in certain localities, was larger than for 20 years.

It is interesting to note that, in the experience of both anglers and fishermen, pike, bass, perch, pike perch, and similar predaceous species have increased on our shores in direct ratio with the decrease of the whitefish. Whether this is anything more than a coincidence is not known. The fish named, it may be observed, have had greater protection during the past decade than ever before. Fishing for them with nets has been practically stopped in waters adjacent to the shores. Incidentally whitefish and other species that do not readily take the hook have also had protection from

* The Fisheries and Fishery Industries of the United States, section 1, p. 510.

man, but the question has arisen whether the unrestricted increase of piscivorous fishes has not influenced the abundance and movements of the weaker species. Thus, the protection of game fishes may be the cause of the present scarcity of whitefish on our shores. The writer does not advance this opinion as being entertained by him, but as the view of a certain class of people interested in the lake fisheries; the theory is to be accepted or discarded in the light of facts to be disclosed by additional inquiry.

By some fishermen it is claimed that the decrease in the whitefish is more apparent than real. They argue (1) that if the laws permitted greater freedom with nets fish would be found to occur on our shores in much larger quantities than is now supposed; and (2) that the serious decline in the catch of late years is due to the fact that fewer men are engaged and more restrictions are placed upon the capture of whitefish than formerly.

The extent to which the alewife is responsible for the general scarcity of the whitefish can only be surmised. It has been suggested that the great multiplication of the alewives has led to a partial exhaustion of the food supply of the various species of fish whose habits are non-predatory, chief among which is the whitefish. This question needs careful investigation before conclusions should be drawn, and can only be satisfactorily settled by an examination of the contents of full series of stomachs of whitefish and alewives. It may be stated that the available information bearing on this subject rather militates against the idea that the alewives consume the same kinds of food upon which the whitefish subsist, the former taking their food while freely swimming and the latter being essentially bottom-feeders.

Less attention has been given to the artificial culture of whitefish and fewer fry have been deposited in Lake Ontario than in any other of the Great Lakes. The reasons for this are (1) the New York fish commission has not had the facilities for doing this work on a sufficiently large scale, and the whitefish, being an essentially commercial species, has not profited by the otherwise liberal appropriations of the legislature which have been chiefly directed toward an increase of game fish; and (2) the Government hatcheries have been located at points too distant to warrant the introduction of large quantities of fry. It would seem that the time has arrived when the economic importance from a fishery standpoint of this magnificent body of water should be recognized, and steps taken to utilize the fine natural advantages which it offers for increasing the food supply of the region and adding to the wealth of the inhabitants.

The extent to which the fish commissions of the United States, Dominion of Canada, and State of New York have engaged in artificially stocking Lake Ontario with whitefish is shown in the following summary:

Whitefish fry planted in Lake Ontario.

Planted by—	No. of fry liberated.	Period.
United States	45,207,000	1882 to 1891
Dominion of Canada	34,350,000	1877 to 1890
State of New York	6,888,000	1877 to 1890
Total	86,445,000	

From the table it will be seen that for fifteen years the average number of young whitefish liberated annually in the waters of the lake has been 5,763,000, or about 890 fry to the square mile of lake surface. It must be apparent to fish-culturists and economists that if artificial stocking is to have any perceptible effect in increasing whitefish in Lake Ontario more generous plants will have to be made, and this can only come about by establishing hatching stations on or conveniently near the lake. The recent action of Congress in providing for the location of a hatchery in this region is a step of great importance to the fisheries of the lake, and similar legislation is looked for on the part of the State of New York, whose interests in this matter are very great. With the establishment of a station of design similar to the hatchery of the Michigan commission at Detroit or that of the Government at Put-in-Bay, Ohio, each of which has a capacity for hatching 150,000,000 to 200,000,000 whitefish eggs annually, it is thought that only a few years will have elapsed before the abundance of whitefish in Lake Ontario will be satisfactorily and materially increased.

THE LESSER WHITEFISHES.

Lake Ontario is included within the range of a number of other species of *Coregoni* which have been appropriately designated the "lesser whitefishes." It is probable that four of these occur in the lake. These are the lake herring or cisco (*C. artedi*); the moon-eye, or Hoy's whitefish (*C. hoyi*); the menominee or round whitefish (*C. quadrilateralis*), and the mongrel whitefish, or tullibee (*C. tullibee*). The cisco is such a common and well-known fish that no special study was necessary; two of the others were not observed, and, in the limited time available for the investigation, it was not possible satisfactorily to identify all the fish by the numerous names applied by the fishermen in the various parts of the lake.

The lake herring is usually known as the cisco throughout Lake Ontario. The name herring is also in use, and the designation "greenback" was heard in Wayne County, to which it appears to be restricted.

The cisco is a very abundant fish in the waters of Lake Ontario, where it ranks as one of the most important economic species, although it is less numerous than formerly. The principal fisheries at present are in Jefferson County, gill nets being the apparatus chiefly used. The fish come to the shores in the fall and winter to spawn, and it is at that time that the most fishing is done.

Since the bloater whitefish has assumed commercial importance the abundance of ciscoes appears to have been considerably reduced at many fishing centers on the American shore; and in some communities in which they formerly constituted the principal part of the catch they are now taken in only one-tenth the quantity that bloaters are. This, for example, is the case at Wilson, New York.

The average weight of the cisco of Lake Ontario is three-quarters of a pound. Examples weighing 3 to 3½ pounds are not rare. The largest individuals taken weigh about 4½ pounds, but fish of such size are only occasionally obtained.

The cisco belongs to that group of whitefishes chiefly characterized by a projecting lower jaw, a feature which produces a larger mouth, which in turn indicates a greater range of food than is possessed by the common whitefish. In addition, therefore, to feeding on minute organisms, such as form the pabulum of the whitefish, the cisco takes small fish. In the summer of 1891 an Oswego fisherman speared a 3-pound

cisco in whose mouth was a large alewife which had just been seized. The young alewives are said to have been repeatedly found in the stomachs of the lake herring.

Hoy's whitefish, or the lake moon-eye, is one of the smallest *Coregoni* occurring in the Great Lakes, and it is considered to be the handsomest member of the genus. According to Jordan, the average length is only 1 foot and the weight only half a pound, but specimens considerably larger occur in Lake Ontario, some of those seen being 18 inches long and weighing nearly 2 pounds. This species resembles the cisco (*C. artedi*) and differs from the regular whitefish in having the lower jaw projecting instead of included, and is further distinguished from the common whitefish by having less elevation of the back. The upper part of the body is of bluish color, and the sides and under parts have a very brilliant silvery reflection. The moon-eye is essentially a deep-water fish, and in Lake Ontario it is never observed in shallow water.

The menominee or round whitefish differs from the other species in having a remarkably small and narrow mouth, situated on the under side of the snout. Its back is not elevated as in the common whitefish. It frequents the deeper waters of the lake.

The mongrel whitefish or tullibee reaches a length of 18 inches, and is a stout and deep fish, with a projecting lower jaw. It is a species inhabiting deep water, and is very prolific.

In the absence of specimens, it would be futile to attempt to assign to the various less common species the names given by the fishermen. The most that can be done is to record the vernacular designations, together with such information as could be obtained regarding the fish represented, and to defer the settlement of the question until further data shall be secured. It is hoped that the presentation of the illustrations of the rarer whitefish may aid in bringing about a clearer and wider knowledge of the fish life of the lake.

Under the names "bloater" and "round whitefish" the fishermen of the eastern end of the lake recognize a species (probably *Coregonus hoyi*) which is smaller than the common whitefish, usually attaining a length of only 15 inches and weighing less than a pound. A few years ago the fish was almost unknown to the fishermen making their headquarters at Cape Vincent, the principal fishing center on the lake, but of late considerable quantities have been taken, and the fish appears to be increasing in numbers with great rapidity. It has soft, oily flesh, and during recent years has commanded only half the price of regular whitefish.

This may be the same fish which further west on the shores of the lake is known by various other names. At Oswego, for instance, the names heard were "bloater," "bloater whitefish," "silver whitefish," "Ontario whitefish," "siscowet" or "ciscoette," and "long jaws"; it seems very probable, however, that more species than one are included in this list. In 1885* it was remarked of the fish called "siscowet" or "silver whitefish" at Oswego, that it was quite plentiful, weighed from 1½ to 2 pounds, and sold almost as readily as the common whitefish. This fish in 1890 and 1891 was said to be less abundant than formerly in the vicinity of Oswego. The fish is found in much deeper water than the common species, being taken in gill nets at a depth of 600 feet. It is said to be very prolific.

To what extent the decrease in the regular whitefish may be influenced by the abundance of these fish in different parts of the lake is yet to be determined.

* Review of the Fisheries of the Great Lakes, p. 316.

THE PIKE PERCHES.

The decrease in the abundance of whitefish and trout during recent years has brought the pike perches into greater commercial prominence than they ever before attained. This is particularly true of the wall-eyed or yellow pike (*Stizostedion vitreum*), which is taken in much greater numbers than the other species. In many localities, more especially in the eastern end of the lake where the most important fisheries are prosecuted, the wall-eyed pike (also called pickerel) has become the most highly-prized fish taken, and yields the fishermen from 2 to 5 cents per pound more than whitefish and trout. The average price at Cape Vincent during the past two years has been 8 or 10 cents per pound, although at times in 1890 the price advanced to 14 cents. Many fishermen who formerly caught whitefish and trout now almost confine their operations to the taking of "pickerel," which in the important trap fisheries in Jefferson County constitutes about one-third of the total quantity of fish taken and yields three-fifths of the total income of the trap-net fishermen. From the foregoing facts it will be seen that the fishermen and fish-dealers have reason to desire that the supply of wall-eyed pike shall be maintained and increased, and they are almost unanimous in looking to artificial propagation as the means to accomplish this end. It is expected that when the United States hatching station is established on Lake Ontario, wall-eyed pike will be one of the chief species propagated.

At Oswego, where the species is called the yellow pike, and at other places along the western shore of the lake, this fish is now scarce and has been so for some years, and will always yield the fishermen 10 or more cents a pound.

It has been observed that in spring the wall-eyed pike is found close to shore; by summer it has left the shore and frequents the shoals in the lake; in fall it seeks the deeper water and remains there throughout the winter. In 1890 the fish was tardy in retiring from the shoals and was taken in considerable numbers on Charity Shoal as late as October 20. Soon after coming from the deep water the fish spawns, frequenting for this purpose the shores and the mouths of rivers and creeks. The spawning season usually occupies the month of April, and, fortunately, the reproductive process is about completed by the time the fishing season opens.

In 1880 it was recorded that since the introduction of the alewife the wall-eyed pike had apparently increased in size. Observations in the summer of 1891 showed that the alewife constituted the chief food of the fish and was no doubt the cause of its great fatness. The average weight of fish now taken is 4 pounds and the maximum is 14 pounds.

The variety of wall-eyed pike known as the blue pike (*S. vitreum*, var. *salmoneum*) is not abundant in Lake Ontario, and in most localities is rare. In 1891, in the vicinity of Oswego, there was a most remarkable run during the summer months, which contrasted strongly with the previous scarcity of the species. For about six weeks from July 1, the Oswego River and the adjacent lake waters were frequented by enormous quantities of blue pike which attracted large parties of sportsmen and others; at times more than 500 people were fishing from boats, wharves, and piers. It is estimated that not less than 150,000 fish were taken during this time. The fish were mostly of small size, weighing from 2 ounces to 2 pounds, although many individuals weighing 4 pounds were secured; the average weight was probably less than half a pound.

The sauger (*S. canadense*) has always been more or less uncommon in Lake Ontario, and now appears to be less numerous than ever before. The few specimens taken of late have been mostly from Chaumont Bay. The sauger occurring in the lake and the St. Lawrence River differs considerably from the fish found in the other lakes, and is regarded as a distinct variety, chiefly characterized by a rougher head more extensively and closely covered with scales, and an increased number of spines on the opercles. At Oswego the name "mad piké" was heard applied to the sauger.

THE STRAWBERRY BASS OR CALICO BASS.

From the various standpoints of angler, commercial fisherman, and fish-culturist, the strawberry bass (*Pomoxis sparoides*) is one of the most valuable and least appreciated fishes of Lake Ontario. In Lake Erie, under the name grass bass, the fish is an important food species, but in Lake Ontario it is not of economic value at the present time. It occurs chiefly in the bays, ponds, and bayous with grassy shores connected with or adjacent to the lake, and seems to be especially abundant in Irondequoit Bay, Monroe County. As long ago as 1874, the late Prof. Kirtland accorded high praise to the strawberry bass, and his testimony, being in great measure applicable to the present time, deserves careful consideration. He says:

> The grass bass has not hitherto been deemed worthy of consideration by fish-culturists; yet, from a long and intimate acquaintance with its merits, I hesitate not to pronounce it the fish for the million. It is a native of our western rivers and lakes, where it usually resorts to deep and sluggish waters; yet in several instances, where it has found its way into cold and rapid streams and even small-sized brooks, by means of the constructing of canals or by the hand of man, it has adapted itself to the change, and in two or three years stocked to overflowing these new locations. As a pan fish, for the table, it is surpassed by few other fresh-water species. For endurance and rapidity of increase it is unequaled. The grass bass is perfectly adapted to stocking ponds. It will thrive without care in very small ponds of sufficient depth. It will in no wise interfere with the cultivation of any number of species, large or small, in the same waters. It will live harmoniously with all others, and while its structure and disposition restrain it from attacking any other but very small fry, its formidable armature of spinous rays in the dorsal and abdominal fins will guard it against attacks of even the voracious pike. (American Sportsman, February 28, 1874.)

The strawberry bass of Lake Ontario is a fine fish, weighing from a half pound to 2 pounds. As a fish for anglers, it has few superiors in the lake region, being a vigorous and prompt biter and a scarcely inferior substitute for the black bass. In 1890 two anglers in Irondequoit Bay took 120 of these fish during part of one day, a circumstance which illustrates the abundance of the species and the readiness with which it takes the hook. Without any apparent encouragement the fish has greatly increased in several localities of late years, and the facility with which it can be propagated and acclimated in ponds and bays along the shores of Lake Ontario strongly recommends it for additional attention by fish-culturists.

BAIT FISHES.

With a view to protect the game fish, laws have been enacted in New York restricting the means of capture to hook and line in the St. Lawrence River and within a certain distance of the shore in Lake Ontario. The use of small-meshed seines to supply bait minnows for angling is permitted, and enormous quantities of minnows are thus annually consumed. In the river and at the numerous fishing resorts on the lake more than 100 men and boys give more or less exclusive attention to seining minnows during the angling season, and generally secure handsome returns, the ruling prices for minnows being from ½ cent to 2 cents each.

The yearly drain on the minnows is not without its results, especially in the St. Lawrence River, where the supply is said to have been much diminished in 1891, and minnow fishermen in the vicinity of Alexandria Bay were often obliged to go in their boats a distance of 20 miles to Lake Ontario to find sufficient quantities of small fish, although at one time all the bait consumed in the river was caught locally.

Careful estimates, based on information furnished by bait-dealers and others, show the number of minnows caught for bait in 1891 in Lake Ontario and its tributaries and in the St. Lawrence River to have been not less than 9,000,000, including those which died before being used and were thus sacrificed. The mortality is very large.

Besides the minnows, so called, used for bait, considerable destruction of immature fish occurs. Young fish of almost every species are naturally taken in the seines, and are classed as "minnows" or "bait" by the dealers. Unfortunately, small whitefish are not exempt, and in the vicinity of Fox Island, where whitefish formerly spawned in great numbers and where the young now appear to congregate at times, considerable quantities are sometimes taken for bait; these are from 1½ to 3 inches long. Small trout, bass, pike, and herring are also used whenever they happen to be taken.

This matter is not without its practical bearing on the question of food and food supply of the piscivorous fishes and the following list of bait minnows is offered as a fragmentary contribution to the subject. The species mentioned were obtained from bait fishermen in various localities on the southern shore of Lake Ontario. The list could of course be greatly extended by a special investigation; as it stands, it simply represents the personal observations incidentally made by the writer. The local names applied to the fish, so far as heard, are given in quotation marks.

1. **Catostomus teres** (Mitchill). *Common sucker; "Mullet."*

This is a well-known fish in Lake Ontario, and is often used for food. It attains a length of 18 inches. When of small size it is frequently employed as a bait. Six specimens, about 1¾ inches in length, were obtained from minnow fishermen.

2. **Campostoma anomalum** (Rafinesque). *Stone-roller; Stone-lugger.*

Four specimens of this interesting species were preserved, the largest of which was 2⅜ inches, the smallest 1¾ inches. These differ much in color from more mature examples. The upper parts are of a dark-brownish color, with faint mottlings; the under parts are white. A blackish lateral band about width of eye extends the entire length of body and appears as a bar on the snout; above the dark band is a narrower light one.

3. Pimephales notatus (Rafinesque). *Blunt-nosed minnow; "Sucker."*

One of the most important and abundant baits. It is easily distinguished by its sucker-like head and the black spot at the base of tail. Frequently seen around wharves feeding on decayed fish. Takes the hook readily; at Cape Vincent dozens were caught on a pinhook baited with a piece of angleworm. The six specimens preserved were about 3 inches long.

4. Notropis hudsonius (De Witt Clinton). *Spawn-eater; "Chub."*

Reaches a length of 10 inches, and is abundant in Lake Ontario. It is a common bait for bass and pike. Three specimens were preserved, the largest 3¼ inches long.

5. Notropis whipplei (Girard). *Silver-fin; "Shiner."*

The name "shiner" was heard applied to this minnow by fishermen. It is less common than the preceding species. A single specimen was preserved. This was a male, 3¼ inches long, with the head, nape, and back anterior to dorsal fin thickly beset with short, broad-based spines.

6. Notropis megalops (Rafinesque). *Common shiner; Red-fin; Dace.*

The most abundant member of the genus *Notropis* and one of the minnows most commonly used for bait. Eighteen specimens were collected, the largest of which was 4½ inches long. The species attains a length of about 8 inches. A number of the examples obtained were affected with the larvæ of a parasitic worm (Trematod), manifested in the form of small round black spots thickly scattered over the body and fins. These parasites were found also on *Catostomus teres* and *Semotilus atromaculatus*. In Irondequoit Bay minnows kept in captivity were very frequently attacked in this way.

7. Notropis heterodon (Cope).

A single specimen, 2½ inches long, has been identified by Dr. Charles H. Gilbert as belonging to this species.

8. Hybopsis kentuckiensis (Rafinesque). *Silver-fin; Horny-head; "Chub."*

A very common and important bait minnow for bass and pike. It reaches a length of 10 inches, but none of the seven specimens preserved was over 3½ inches long.

9. Semotilus atromaculatus (Mitchill). *Horned dace.*

A common bait fish, usually found in the clear streams entering the lake. The five specimens obtained were only about 2 inches long, although the fish attains a length of 10 or 12 inches. The fall fish or roach (*Semotilus bullaris*) was not seen, but it is an abundant inhabitant of the lake region, where it reaches a much larger size than the preceding.

10. Clupea pseudoharengus (Wilson). *Alewife; "Shad."*

This brilliant silvery fish is often used for bait when immature. One example, 2¼ inches long, was received from a bait fisherman at Grenadier Island August 12, 1891.

11. Umbra pygmæa (Dekay). *Mud minnow; "Dogfish."*

Occurs in shallow places with weedy and muddy bottom. One specimen, 3½ inches long, was obtained from a bait-fisherman in Irondequoit Bay.

12. Etheostoma nigrum (Rafinesque.) *Johnny darter.*

Not uncommon in small brooks debouching into Lake Ontario, and often taken in minnow seines. One specimen preserved.

HOW THE FISHERIES OF LAKE ONTARIO MAY BE IMPROVED.

The State of New York at the present time is expending considerable money in carrying out the provisions of restrictive fishery laws applicable to Lake Ontario. The State has valuable interests dependent on the preservation of its fishes, more especially the game species; and it is chiefly with a view to protect these interests that a fishery code has been enacted particularly favorable to angling and inimical to commercial fishing. As a result, there is much discontent among those citizens who live chiefly by fishing, and a more liberal policy is much desired by them. The scarcity of fish, however, seems to the legislature a sufficient cause for restrictive laws, and under the present conditions it is not probable that material changes will be made in the statutes. This being the case, it seems that the only hope which may be entertained by the professional fisherman for obtaining greater freedom in his pursuit depends on an increase, either naturally or artificially secured, in the abundance of fish in the lake.

The entire history of the fisheries of Lake Ontario tends to prove that even under the radically restrictive laws which have been in force for a sufficient length of time to test their effects, some of the most valuable fishes have not been competent to replenish the lake to such an extent as to warrant the abrogation of a legal check on their capture, and the intervention of man seems to be urgently demanded. The agitation by the fishermen of this phase of the subject seems more rational and more likely to accomplish the desired results than direct efforts to obtain a less rigorous fishery code. It has always been the policy of the U. S. Fish Commission, whenever the occasion arose, to advocate the maximum expense for and attention to the increase of fish by recourse to positive methods, in order that there may be necessity for resort to the minimum amount of prohibitive legislation.

A study of fish-culture, as practiced in the waters of Lake Ontario, leads to the conclusion that none of the Great Lakes has received less attention. While in other lakes the natural decline in the abundance of food-fishes incident to the prosecution of important commercial fisheries has been mitigated and in many instances completely reversed by the rational resort to artificial propagation, in Lake Ontario fish-culture has been a secondary consideration in the attempts to increase the supply of fish, and restrictive and prohibitory measures have been the remedies most persistently advocated and resorted to. This policy has not led to any increase in the fishes sought to be protected, but, on the contrary, has, in the case of the two most important species, resulted in the most alarming and phenomenal decrease which has probably ever occurred in a body of water of similar size and with like natural advantages. The decrease of 915,229 pounds in the catch of whitefish in the waters of Lake Ontario tributary to New York, between 1880 and 1890, was met by the planting by the State of New York of 6,888,000 whitefish fry in the same lake during the same period. Since 1880 the quantity of lake trout taken in the lake by citizens of New York has been reduced 528,690 pounds, during which time the State has not deposited a single young trout in the waters of the lake, but has planted 35,444,800 fry in inland waters having no commercial fisheries. These subjects are referred to at greater length in the special chapters relating to the individual species, and need be only incidentally mentioned in this place.

There can be no doubt whatever that the waters of Lake Ontario are capable of sustaining fisheries of as great relative magnitude as those of any other of the Great Lakes. It is equally true that the creation of an abundance of fish necessary to maintain these fisheries is entirely within the province of fish-cultural work. In the words of U. S. Fish Commissioner McDonald, "it is not only possible, it is entirely practicable, to restore and maintain these fisheries by adequate resort to means and agencies entirely within our control." The "means and agencies" consist of well-known and approved fish-cultural methods which, in other lakes and waters under similar conditions, have been successful.

At comparatively small expense, one or more hatching stations could be established on the shores of Lake Ontario, the results of whose operations after a few years would be an increased supply of food-fish whose value to the State would be a profitable and perpetual return for the original outlay. At such hatcheries whitefish, lake trout, pike perch, salmon, and sturgeon should be artificially propagated.

In connection with the fish-cultural work the question of temporarily prohibiting fishing for whitefish and trout during the spawning period, and of limiting the size of these and other species marketed, would come up for consideration; but sufficiently large plants of fry would probably, after a short time, obviate the necessity for any restrictive fishery measures.

NOTES ON THE ACCOMPANYING PLATES.

Illustrations of all of the principal economic and game fishes occurring in Lake Ontario are presented with this report. It is thought that this feature of the article will contribute to a clearer knowledge of the lake fishes on the part of fishermen and others. The species figured are as follows:

Plate XXI. *Acipenser rubicundus* Le Sueur. Lake sturgeon.

Plate XXII. *Amia calva* Linnæus. Dogfish; Mudfish.

This fish has no commercial value, and is only interesting because of its anatomical relations, its destruction of other fish, and its extremely tenacious hold on life. It reaches a length of 2½ feet and a weight of 15 pounds. It may be taken with a hook or trolling spoon. The young are considered excellent bait for pike.

Plate XXIII. *Ameiurus vulgaris* (Thompson). Bullhead.

This is one of the common catfishes of Lake Ontario, where it reaches a length of 18 inches. Although called bullhead, it is to be distinguished from the more abundant bullhead or horned pout (*A. nebulosus*), which has the upper jaw longer than the lower, while in the species figured the upper jaw is usually shorter than the lower.

Plate XXIV. *Catostomus teres* (Mitchill). Common sucker; Brook sucker; Mullet.

In the statistical tables the fish enumerated as suckers consist chiefly of this species. It attains a length of 2 feet and has considerable commercial value in some places, but its edible qualities are inferior. The fish ascends streams in the breeding season and is there taken in seines and with spears.

Plate XXV. *Moxostoma anisurum* (Rafinesque). Carp mullet.

Distinguished from the redhorse, which also occurs in the lake, by the much larger fins and by the coloration of the lower fins. In the redhorse they are red or orange; in this species, white.

Plate XXVI. *Cyprinus carpio* Linnæus. Leather carp.

This fish has been introduced into Lake Ontario and has also accidentally found its way there by the breaking of dams. It appears to thrive well in the cold, clear waters of the lake, and some fine examples have been caught in recent years by net fishermen.

Plate XXVII. *Semotilus atromaculatus* (Mitchill). Horned dace; Chub.

The horned dace is found mostly in the smaller streams and bays tributary to the lake, where it reaches the length of a foot. It is often caught by the boys on hooks baited with angleworms. The species is distinguished by a large, black spot on the anterior part of the dorsal fin. The male fish, in the breeding season, develops peculiar dermal protuberances on the head, whence the name "horned dace."

Plate XXVIII. *Hiodon tergisus* Le Sueur. Moon-eye.

This is a handsome fish, with a brilliant silvery color on the sides and green above. It has recognized game qualities, and takes the fly or baited hook with avidity. Feeds on minnows, insects, and crustaceans. It weighs 1 or 2 pounds, but is not generally esteemed as a food-fish.

Plate XXIX. *Clupea pseudoharengus* Wilson. Alewife; Branch herring.

Plate XXX. *Clupea sapidissima* Wilson. Shad.

Plate XXXI. *Clupea chrysochloris* (Rafinesque). Skipjack.

Although not observed by the writer in Lake Ontario, its occurrence there can hardly be doubted. The fish is abundant in Lake Erie, to which it gained access by means of canals communicating with streams of the Mississippi Valley. The fish reaches the length of a foot or more. It is of little value as food.

Plate XXXII. *Dorosoma cepedianum* (Le Sueur). Mud shad; Gizzard shad.

Like the skipjack, this fish has entered the Great Lakes through canals, and has become very abundant in lakes Michigan and Erie. Its flesh is coarse and not of a delicate flavor. The fish is about a foot in length and is readily distinguished by the elongated ray in the dorsal fin.

Plate XXXIII. *Coregonus clupeiformis* (Mitchill). Common whitefish.

Plate XXXIV. *Coregonus artedi* Le Sueur. Cisco; Lake herring.

Plate XXXV. *Coregonus hoyi* (Gill). Hoy's whitefish; Lake Moon-eye; Long-jaw.

The specimen figured was from Seneca Lake, New York, and represents a much more slender race than is found in Lake Ontario. The resemblance between this species and the cisco is great. In a special paper on this fish, now in course of preparation, its relations, habits, commercial importance, etc., will be considered.

Plate XXXVI. *Coregonus quadrilateralis* Richardson. Round whitefish; Menominee whitefish.

Plate XXXVII. *Coregonus tullibee* Richardson. Tullibee; Mongrel whitefish.

Plate XXXVIII. *Salmo salar* Linnæus. Atlantic salmon.

Plate XXXIX. *Salvelinus namaycush* (Walbaum). Lake trout; Salmon trout.

Plate XL. *Esox lucius* Linnæus. Pike; Pickerel.

Plate XLI. *Esox nobilior* Thompson. Muskellunge.

This magnificent fish is comparatively rare in Lake Ontario, but is more or less abundant in the St. Lawrence River. Examples weighing 65 pounds have been taken in the lake, but the maximum in recent years has been much less. This fish may always be distinguished from the pike (*E. lucius*) by having the lower part of the cheek destitute of scales.

Plate XLII. *Pomoxis sparoides* (Lacépède). Strawberry bass; Calico bass.

Plate XLIII. *Ambloplites rupestris* (Rafinesque). Rock bass.

Abundant in Lake Ontario in suitable situations, and is taken for market in seines, hoop nets, etc. It has pronounced game qualities, and readily takes a hook baited with live minnow. The weight attained is 1½ pounds. Spawns in summer like the black bass.

Plate XLIV. *Micropterus salmoides* (Lacépède). Large-mouthed black bass; Oswego bass.

This popular species is very abundant in Lake Ontario and its tributaries. While found in the clear, rapid water of the St. Lawrence River and other similar streams, it appears to be most at home in quiet or sluggish waters overgrown with rushes and other aquatic plants. The large-mouthed black bass may be distinguished from the other species with which it is generally associated by its larger mouth, the extension of the maxillary bone beyond the orbit, the less numerous and larger scales on the cheeks, the fewer soft rays in the dorsal fin (12 instead of 13), and many other characters.

Plate XLV. *Micropterus dolomieu* Lacépède. Small-mouthed black bass.

The small-mouthed black bass has been generally regarded as more gamy than the other species, but Dr. J. A. Henshall, who has given this genus more study than anyone else, thinks there is little difference in this respect between fish of equal size and under similar conditions. He regards both as "inch for inch, and pound for pound, the gamest fish that swim." The distinguishing morphological characters of this species can easily be noted by comparing the plates.

Plate XLVI. *Perca flavescens* (Mitchill). Yellow perch.

Plate XLVII. *Stizostedion vitreum* (Mitchill). Wall-eyed pike; Dory; Pike perch.

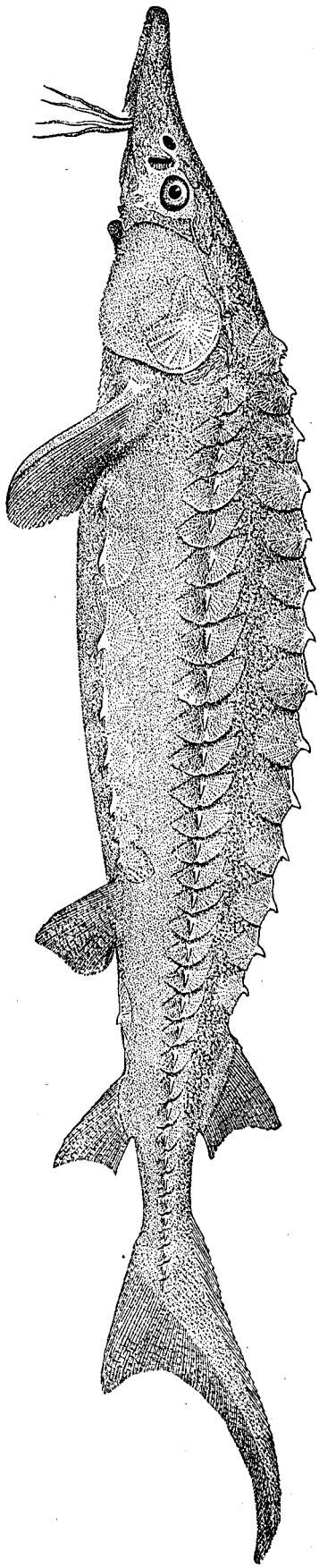
Plate XLVIII. *Stizostedion canadense* (C. H. Smith). Sauger; Sand pike.

Plate XLIX. *Aplodinotus grunniens* (Rafinesque). Sheepshead; Fresh-water drum.

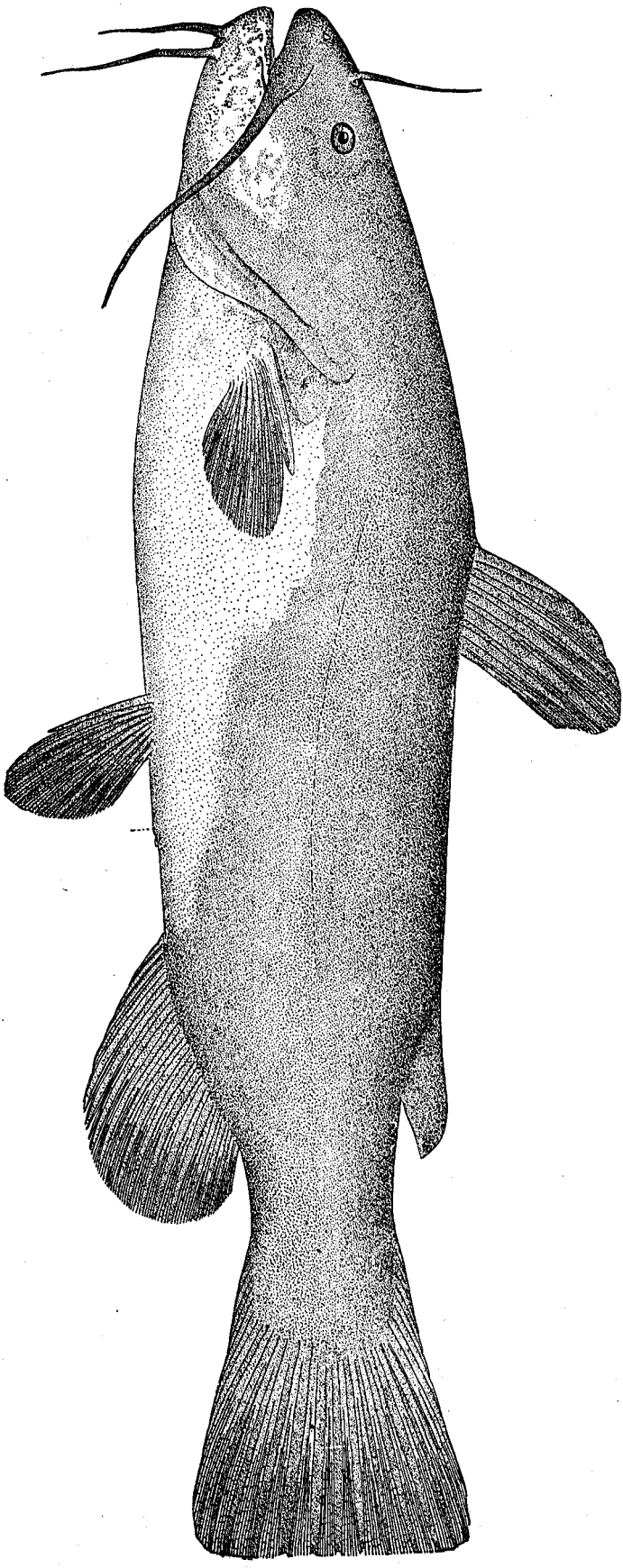
The sheepshead has some value as a market fish in Lake Ontario, although it is one of the cheapest fish sold. It sometimes reaches a length of 4 feet and a weight of 50 pounds. The smaller fish are considered most palatable.

Plate L. *Lota maculosa* (Le Sueur). Ling; Burbot; Lawyer; Fresh-water cusk.

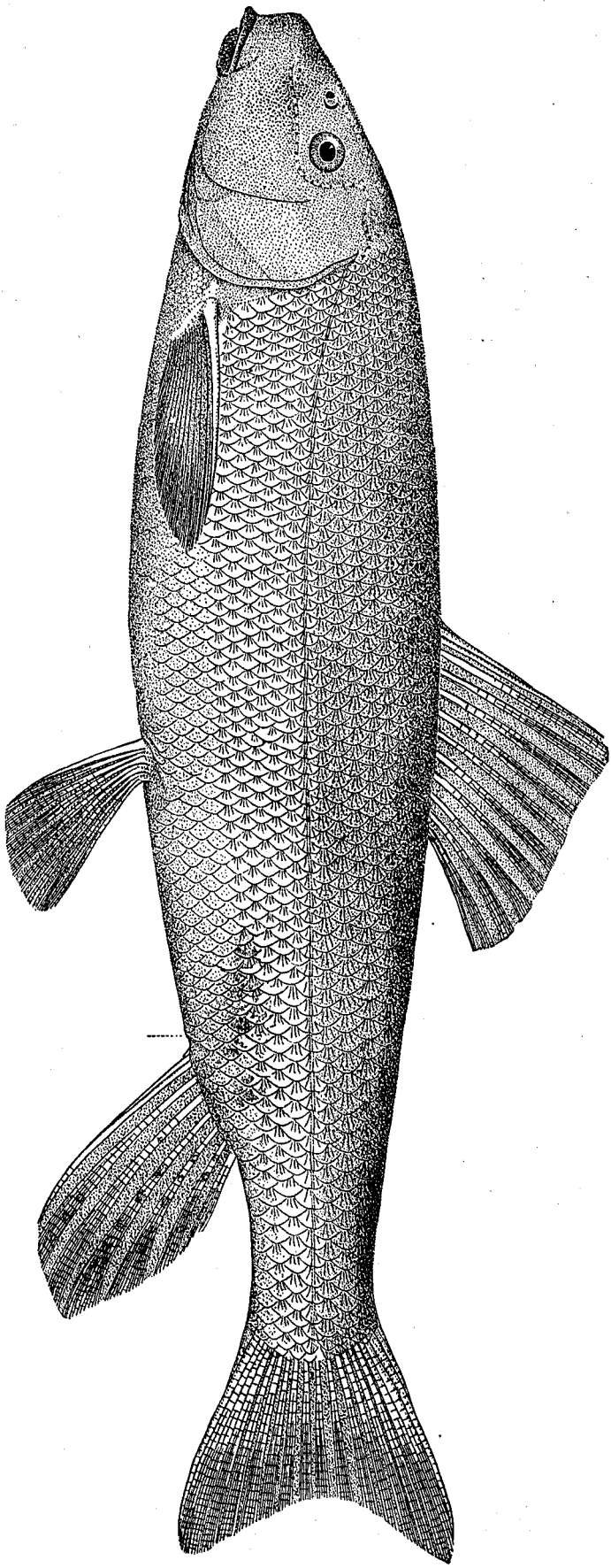
Mr. Charles H. Strowger, of Nine-Mile Point, Monroe County, N. Y., communicates the following note on this interesting member of the cod family: "I wish to suggest that the ling (*Lota*), which has generally been counted a worthless nuisance, can be utilized to good advantage and made of commercial value. Some years ago the whim took me to try the experiment of salting and drying a few ling to see what they would amount to. I split open a dozen, rubbed them with salt, and dried them in the sun. They dried quickly and became very hard and developed the smell of codfish. When cooked they smelled and tasted like salt codfish, and I have no doubt that by curing them in the same way that codfish are treated no one but an expert could distinguish them from salt codfish, except from the shape of the tail. As thousands of these fish are thrown away every day, it strikes me that attention called to the question of curing them properly would result in considerable addition to the earnings of our lake fishermen."



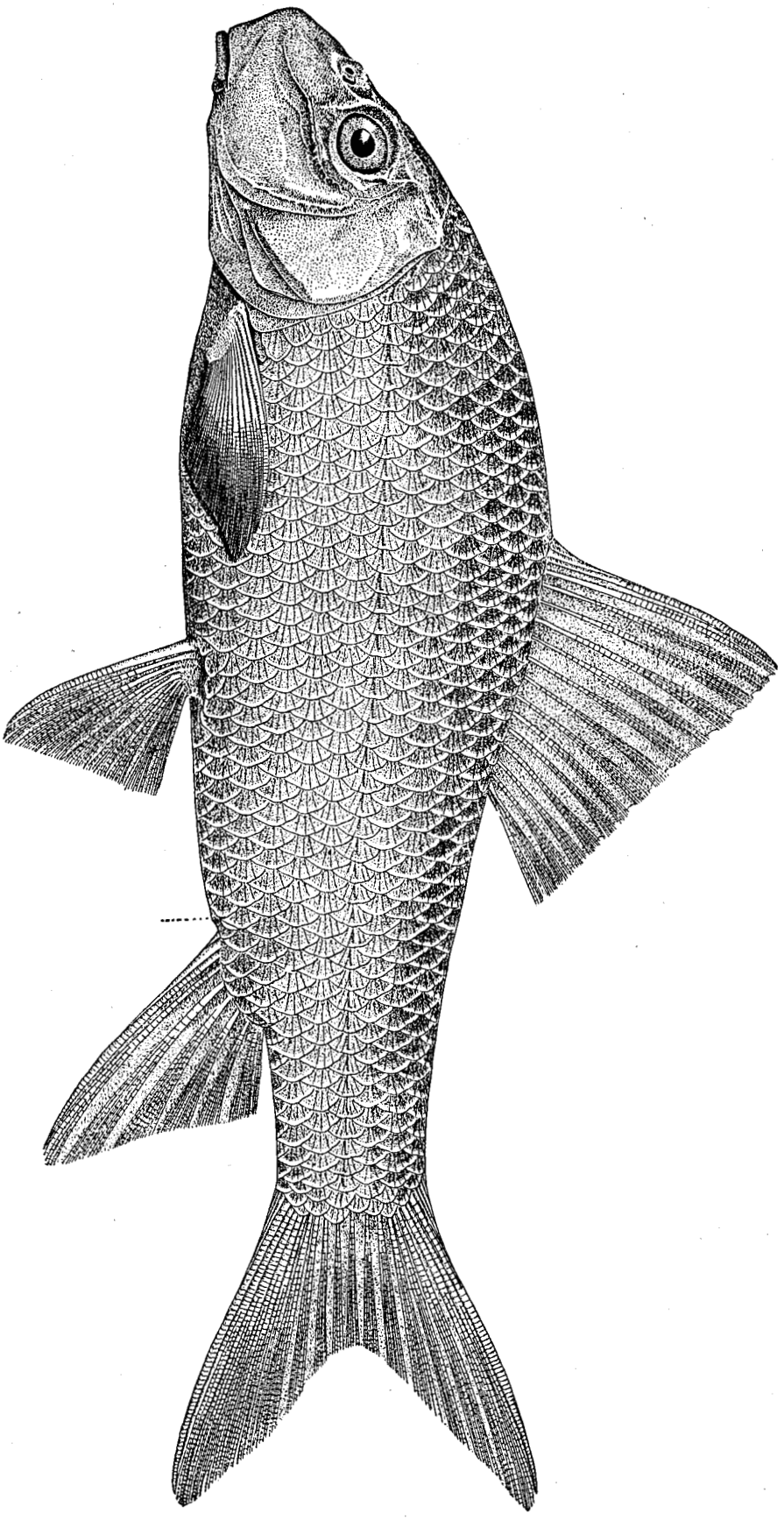
ACIPENSER RUBICUNDUS Le Sueur. *Lake Sturgeon.*



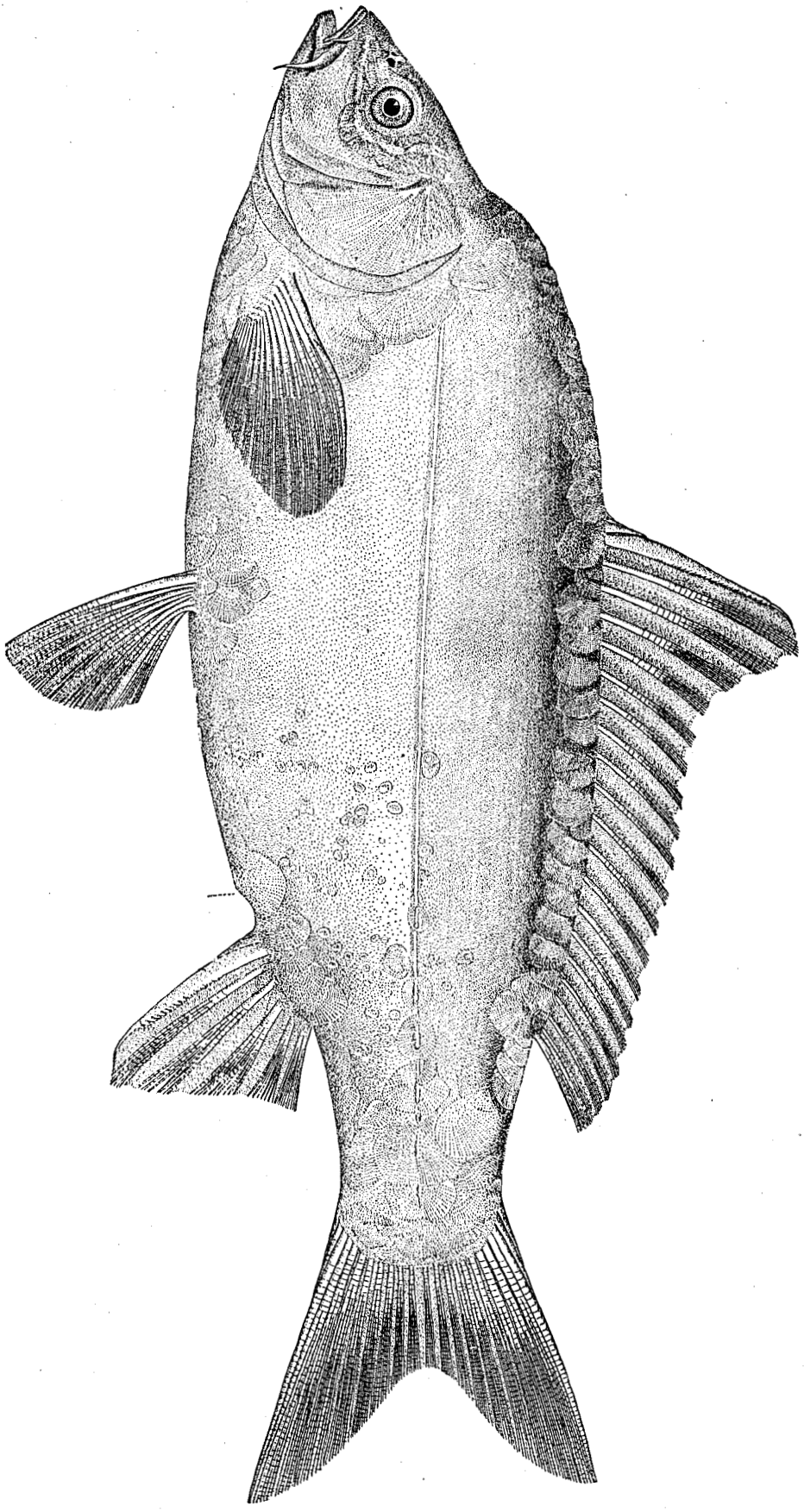
AMEIURUS VULGARIS (Thompson). *Bullhead.*



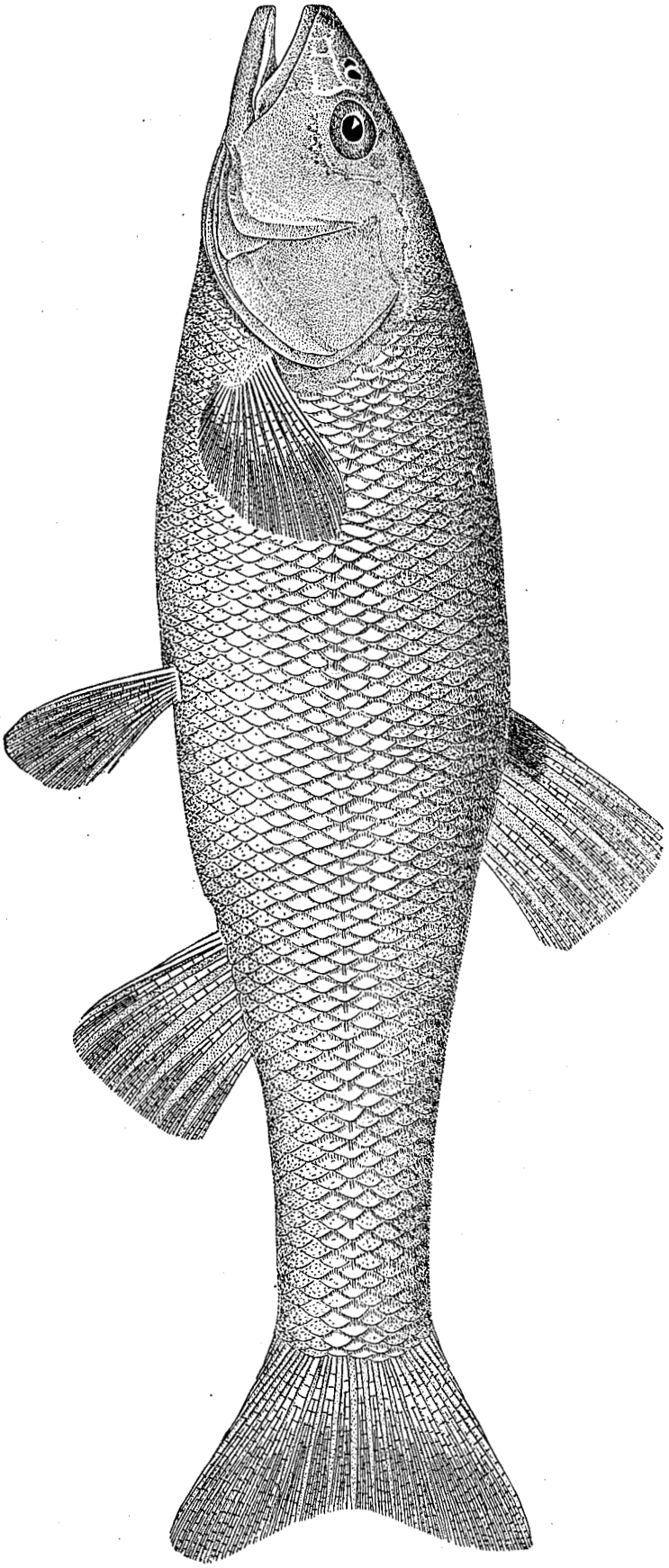
CATOSTOMUS TERES Mitchill. *Common Sucker; Brook Sucker; Mullet.*



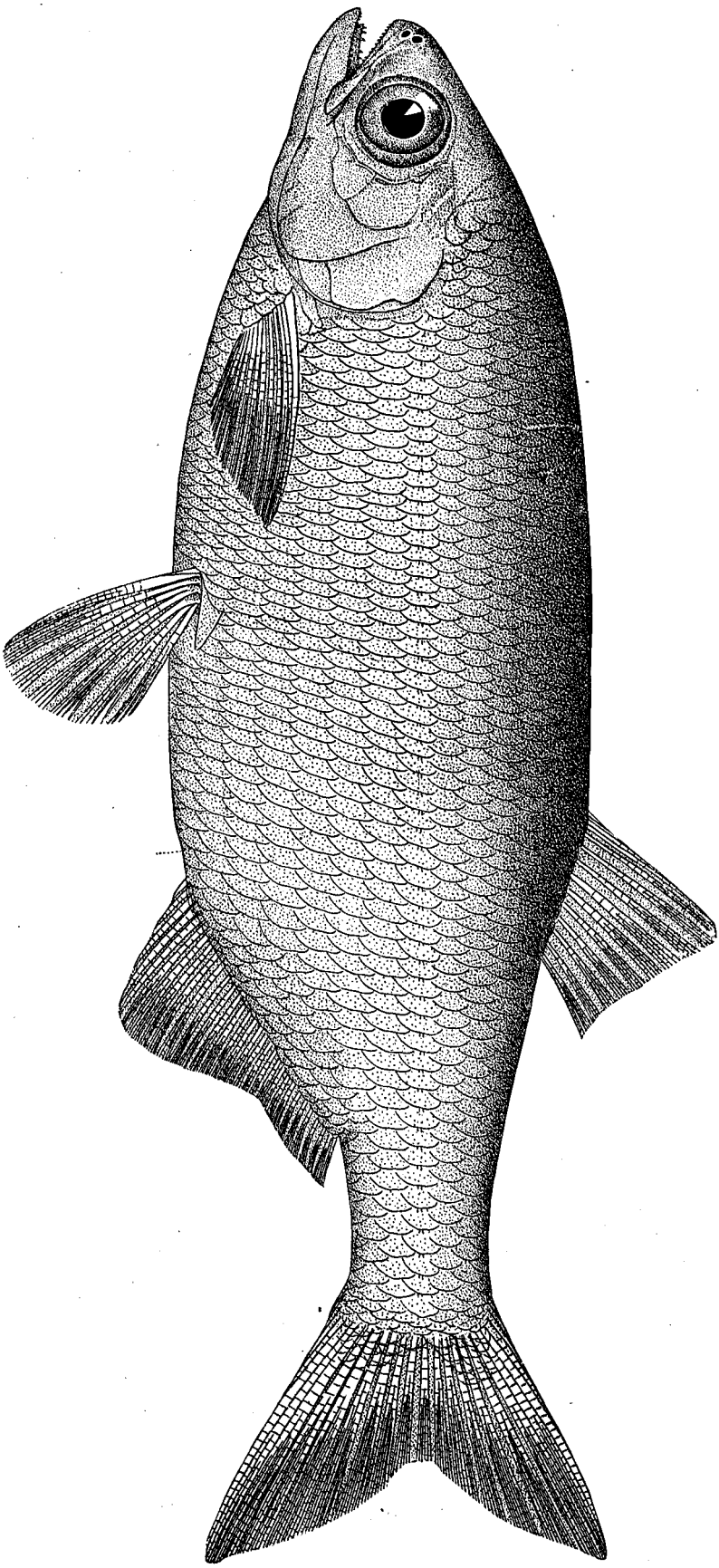
MOXOSTOMA ANISURUM (Rafinesque). *Carp Mullet.*



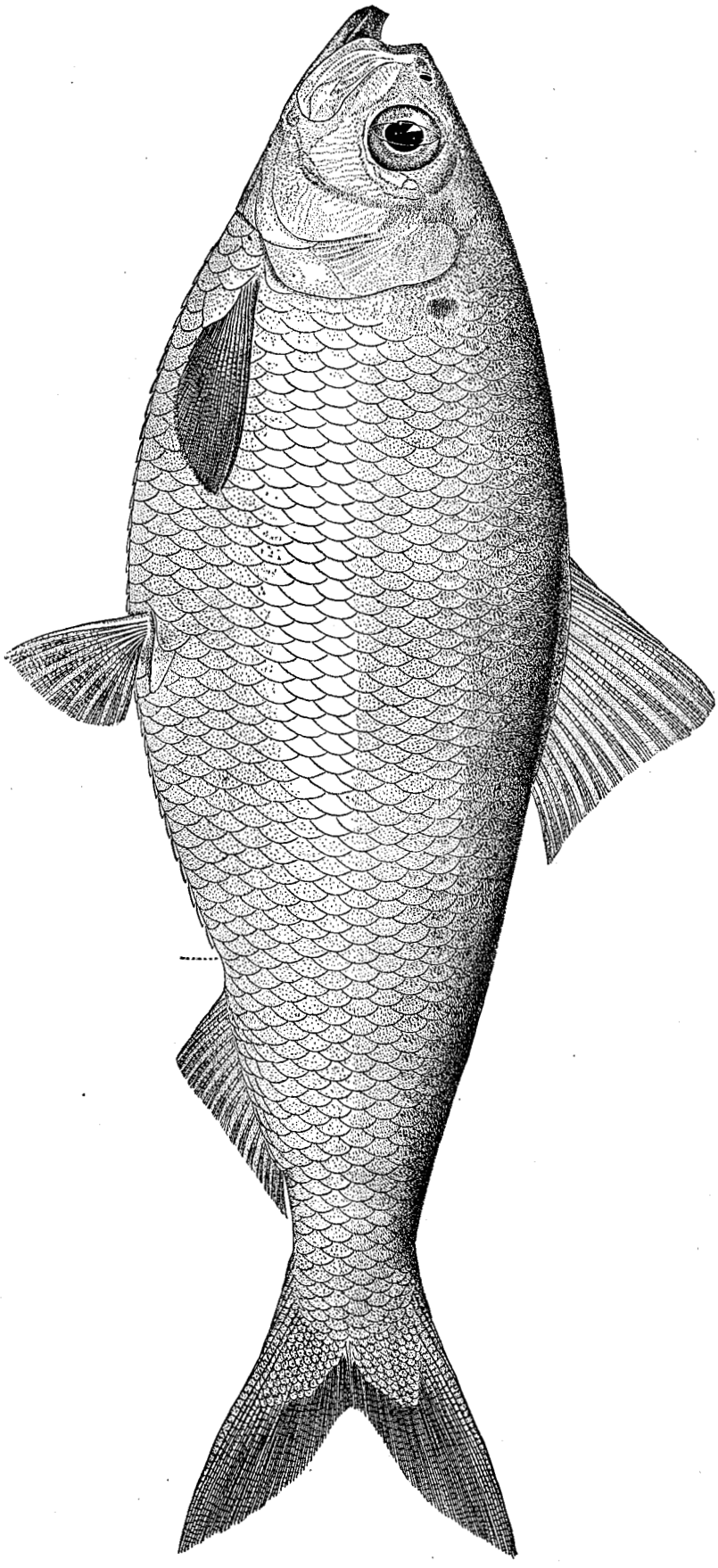
CYPRINUS CARPIO Linnæus. *Leather Carp.*



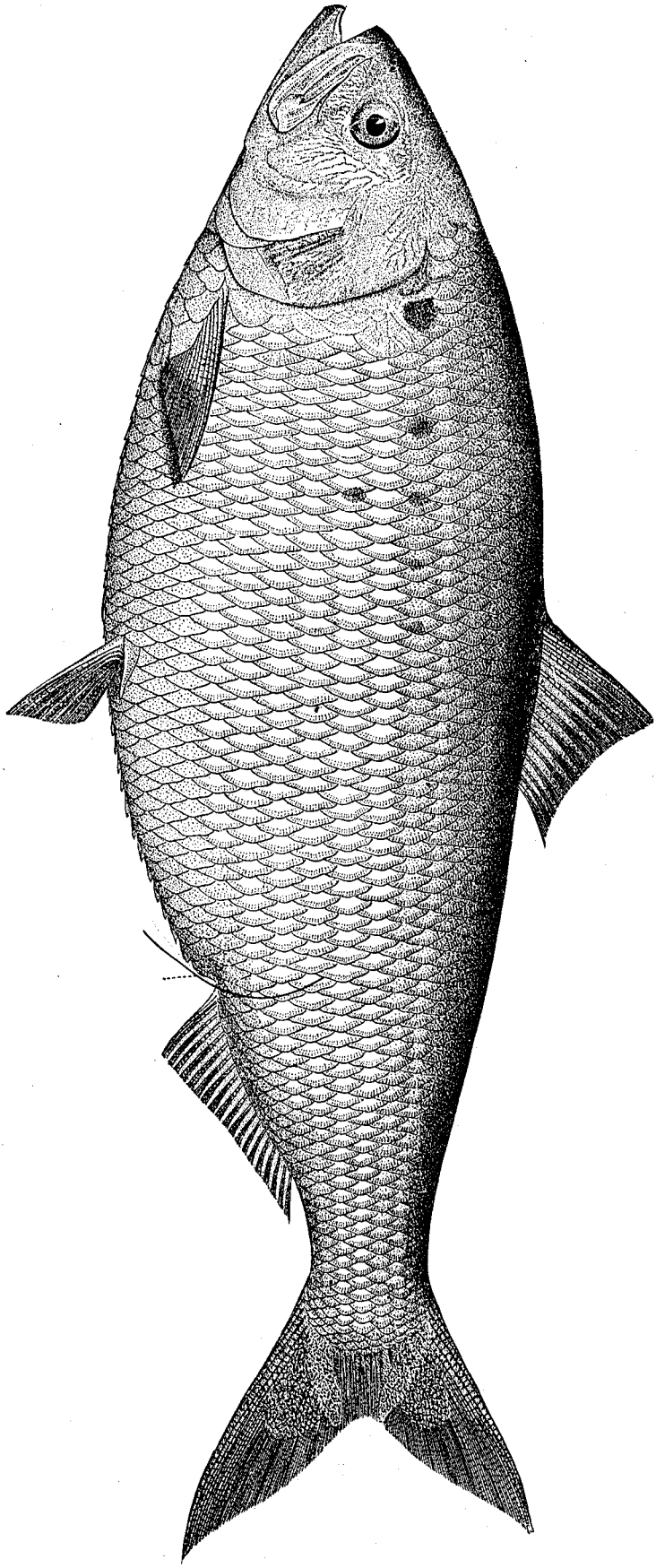
SEMOTILUS ATROMACULATUS (Mitchill). *Horned Dace; Chub.*



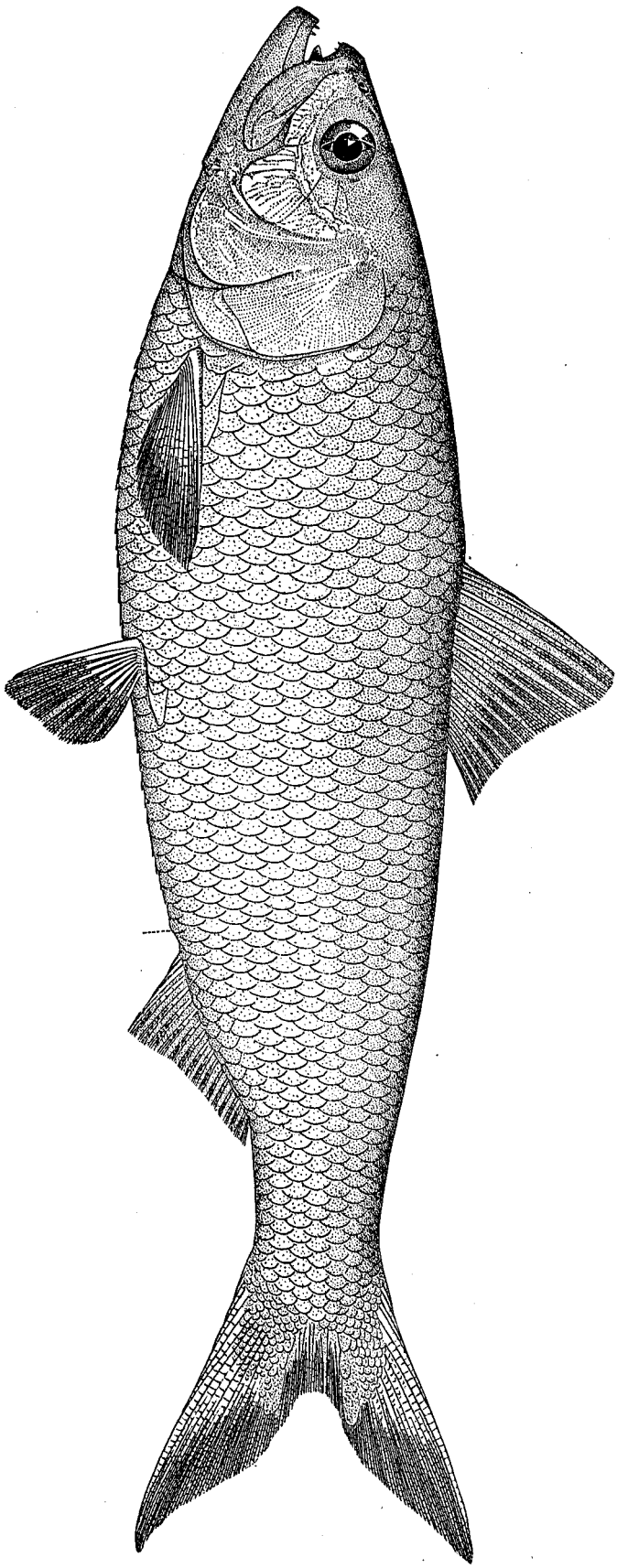
HIODON TERGISUS Le Sueur. *Moon-eye.*



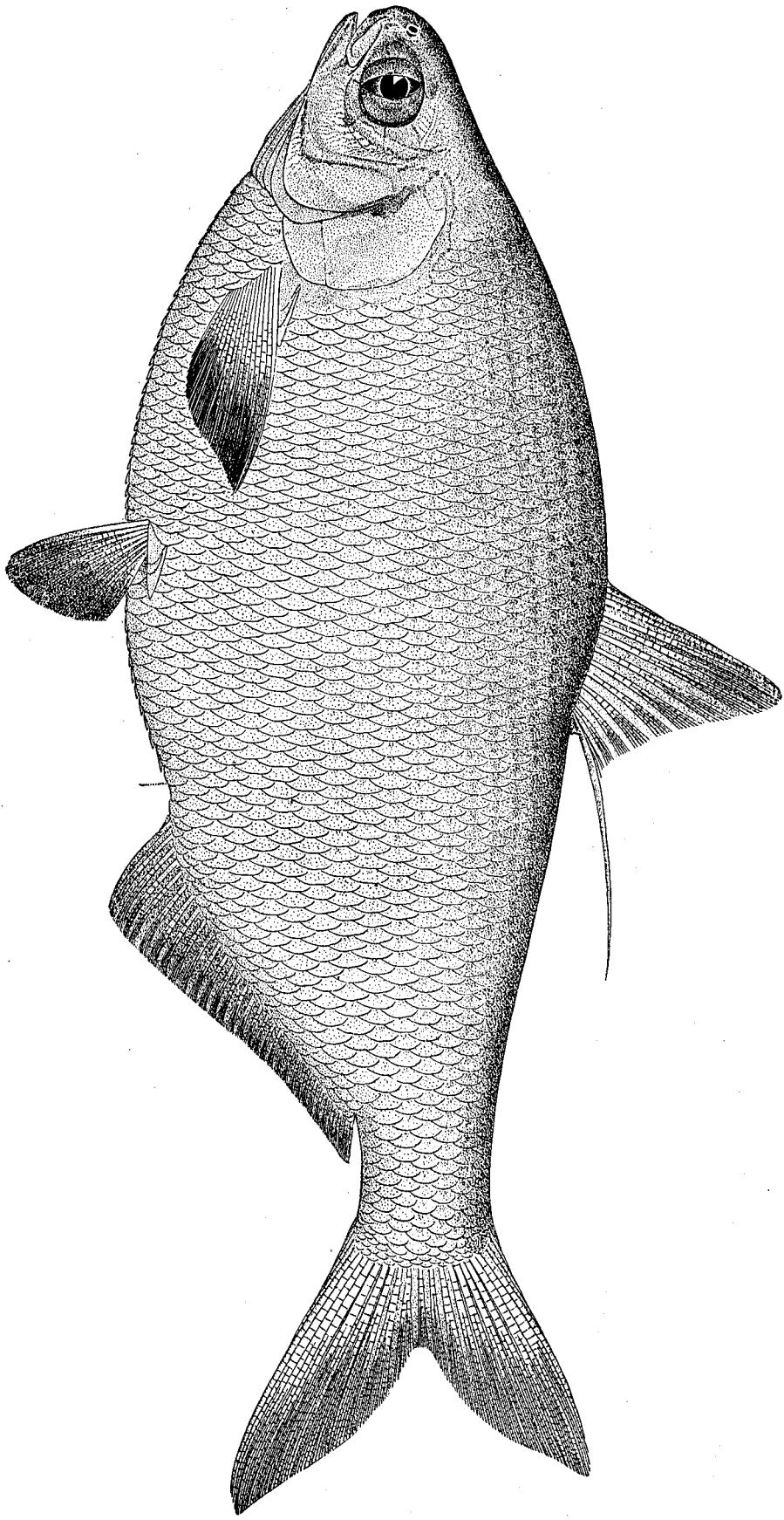
CLUPEA PSEUDOHARENGUS Wilson. *Alewife; Branch Herring.*



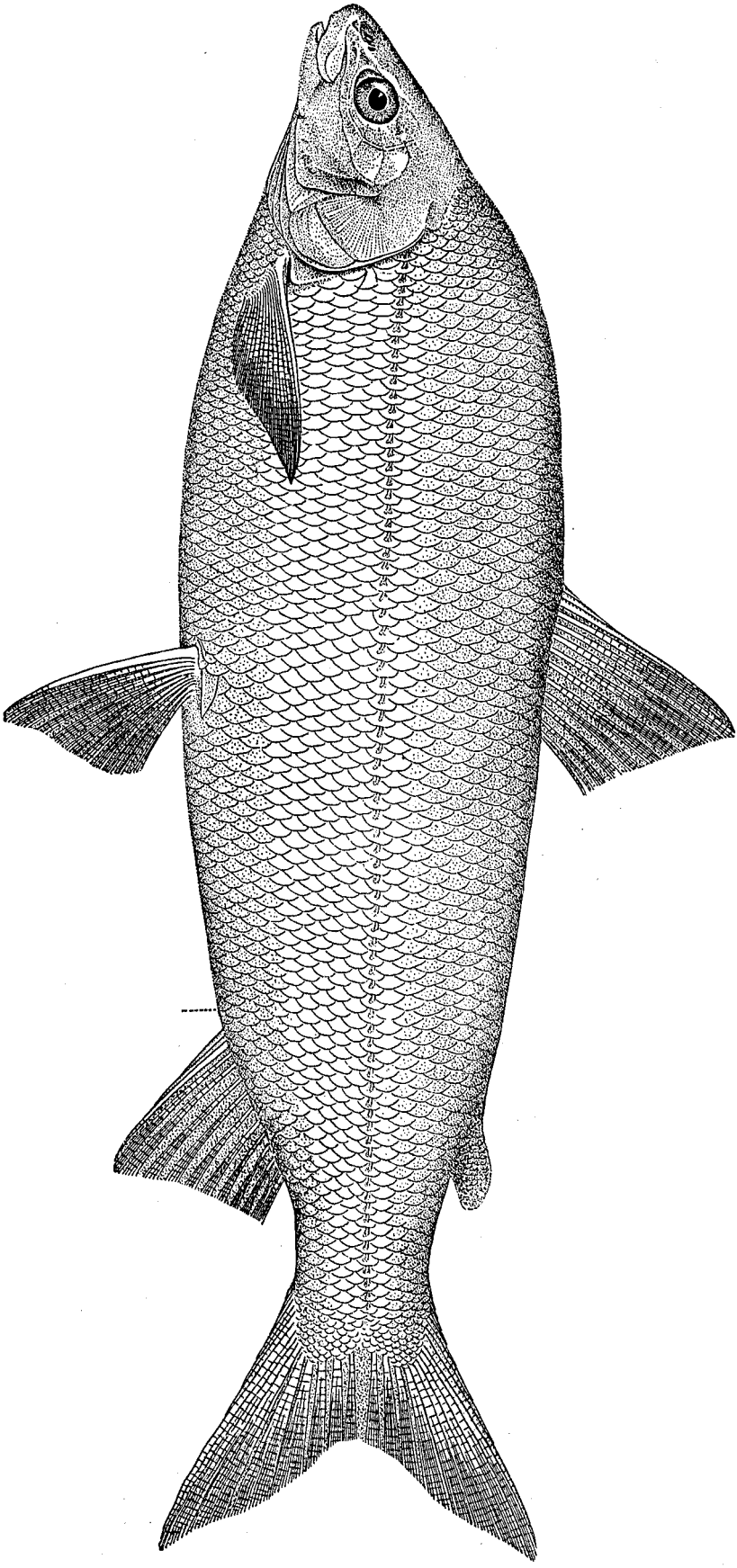
CLUPEA SAPIDISSIMA Wilson. *Shad.*



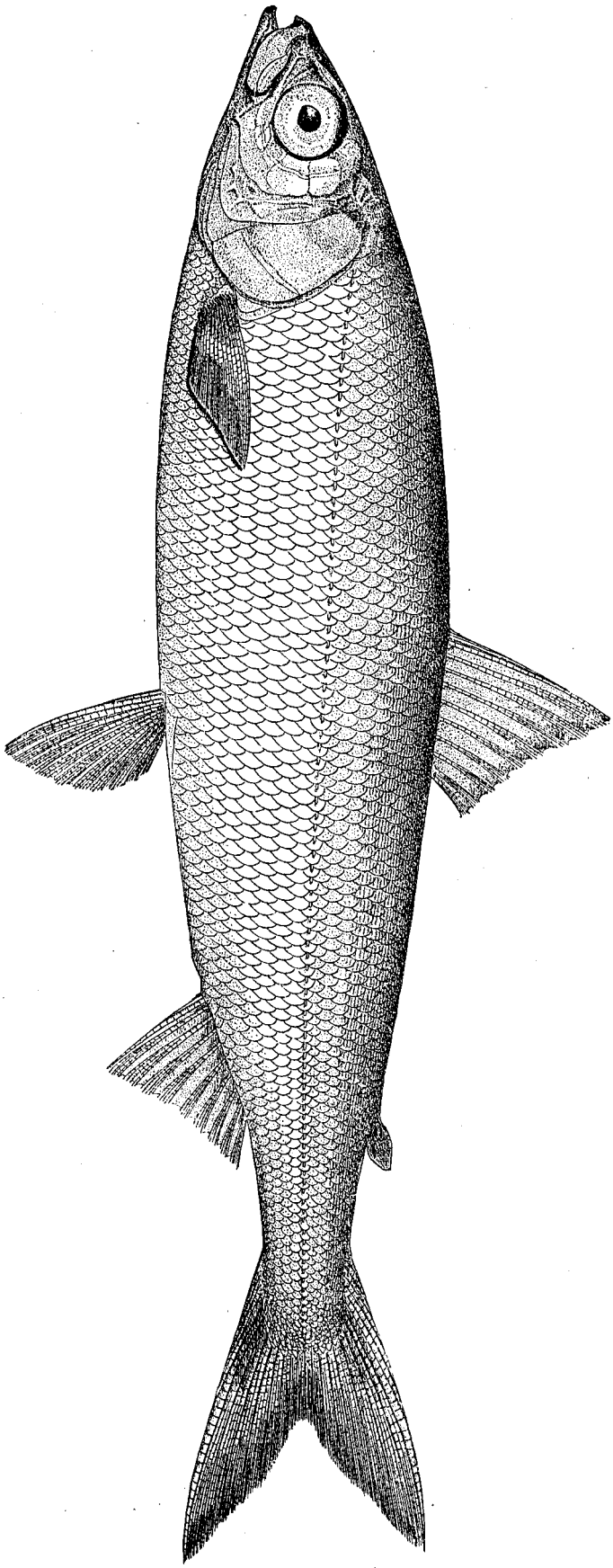
CLUPEA CHRYSOCHLORIS (Rafinesque). *Skipjack.*



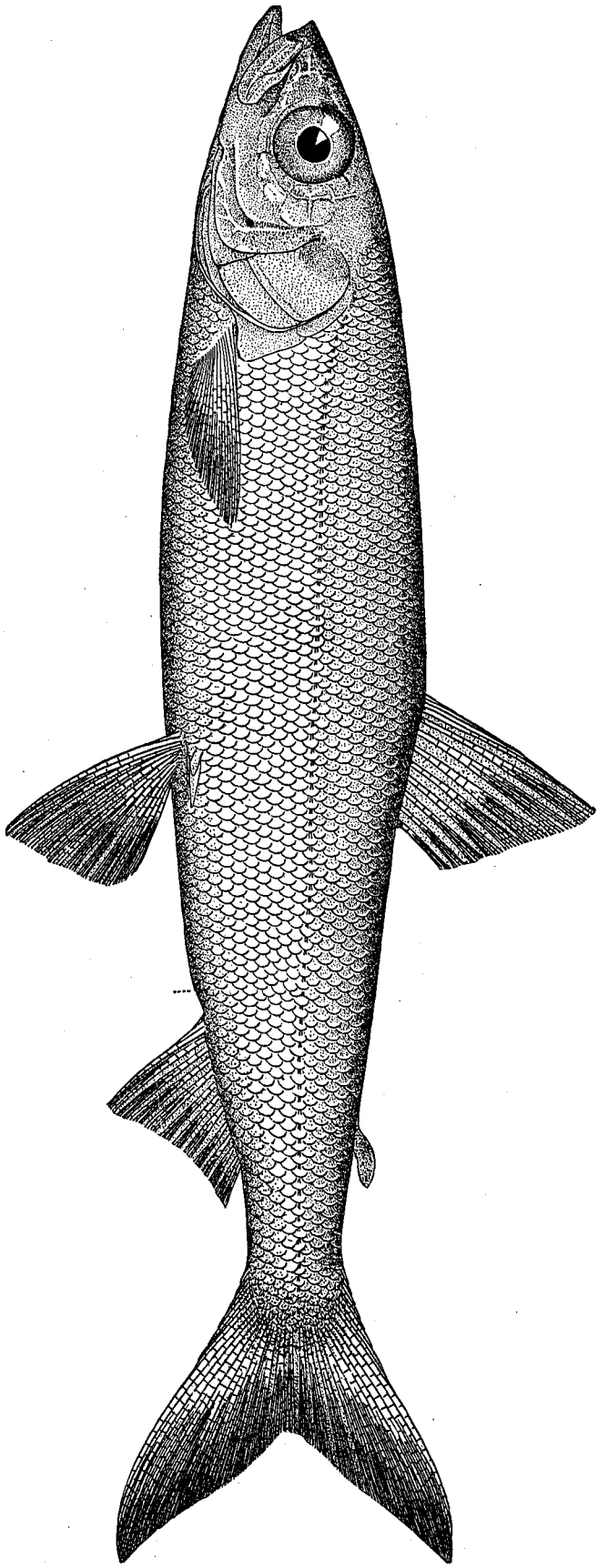
DOROSOMA CEPEDIANUM (Le Sueur). *Mud Shad; Gizzard Shad.*



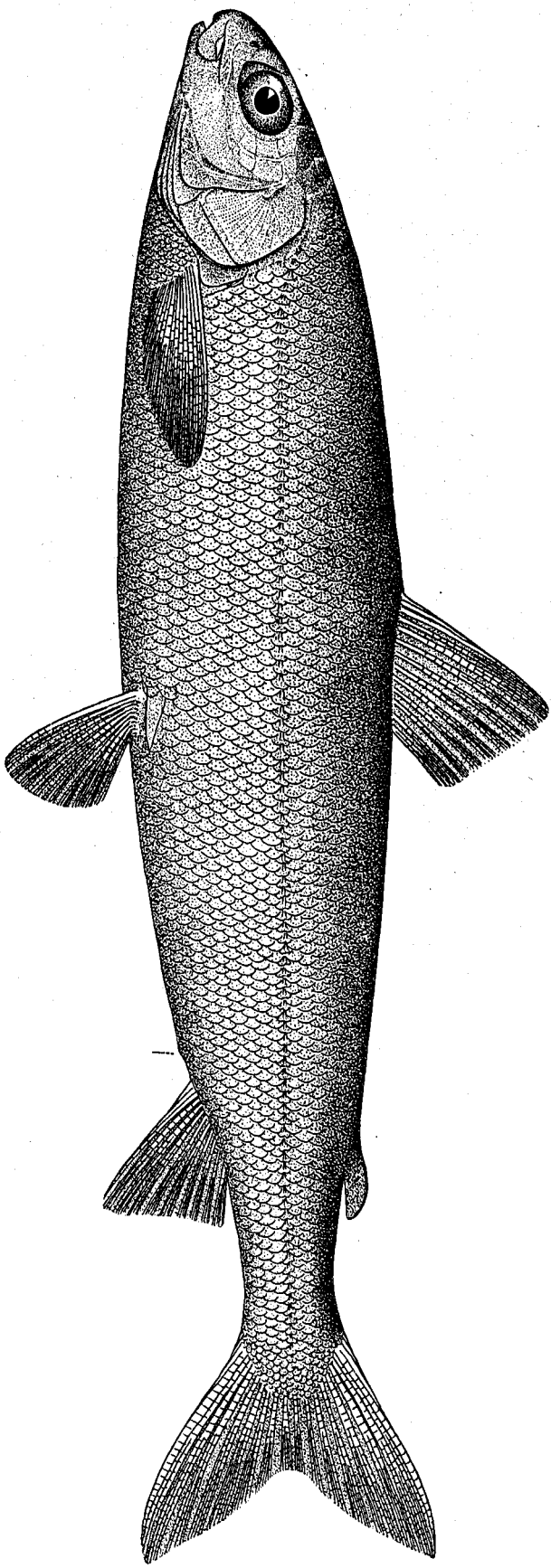
COREGONUS CLUPEIFORMIS (Mitchill). *Common Whitefish.*



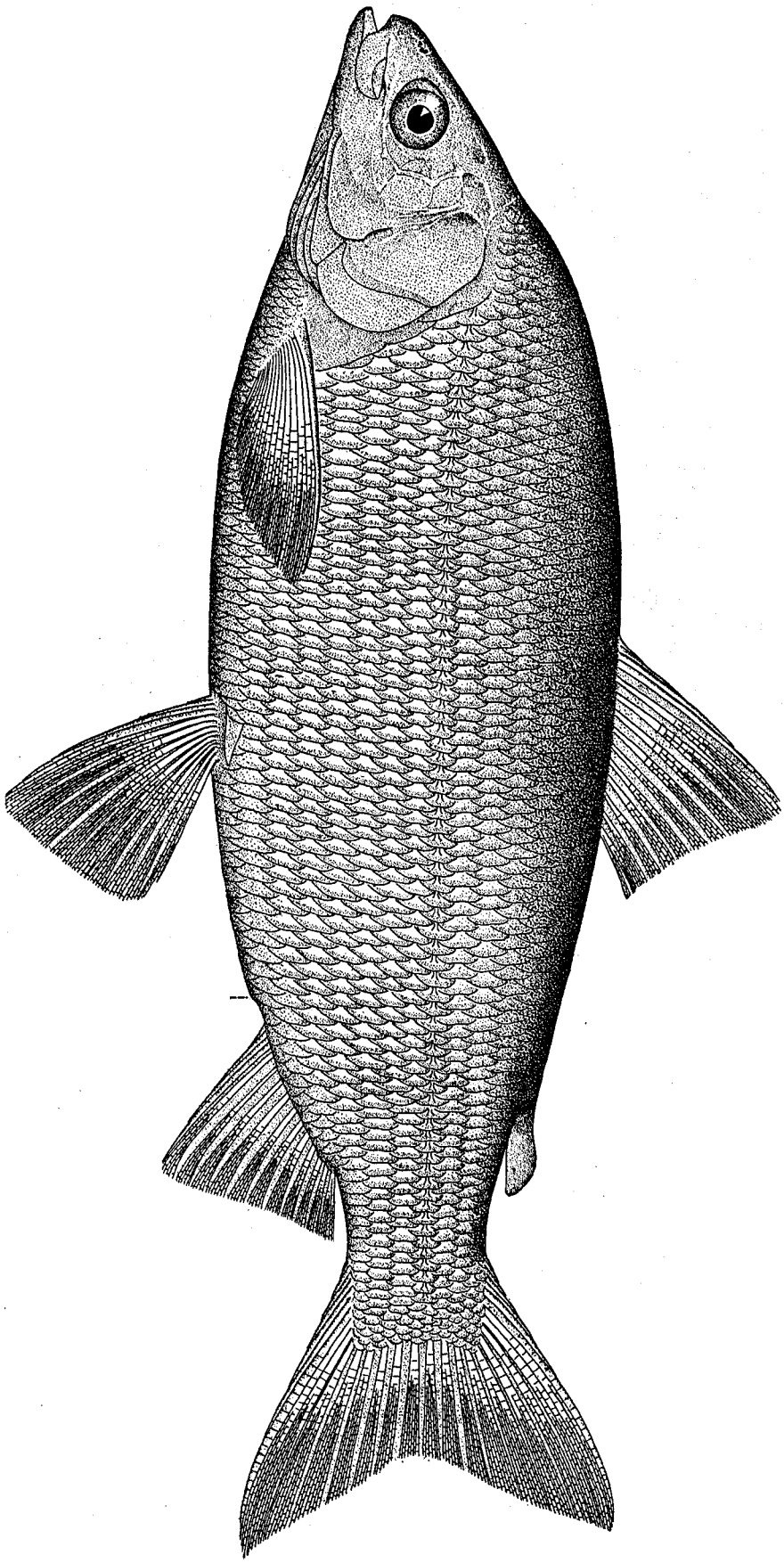
COREGONUS ARTEDI Le Sueur. *Cisco; Lake Herring.*



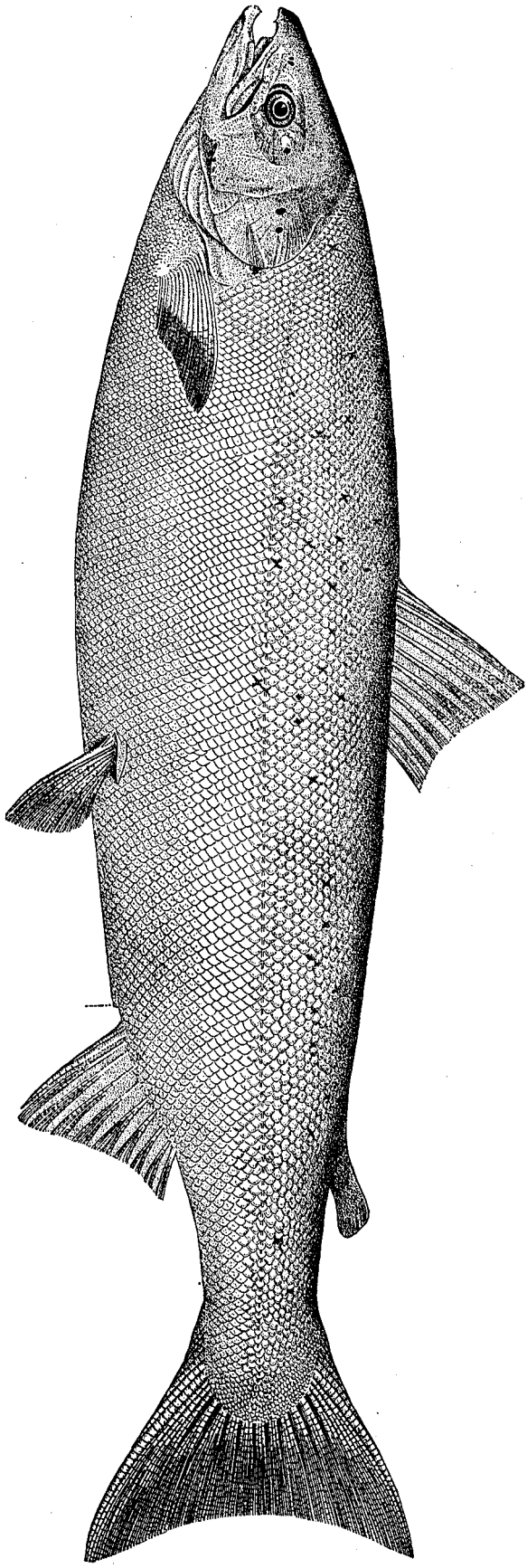
COREGONUS HOYI (Gill). *Hoy's Whitefish; Lake Moon-eye; Long-jaw.*



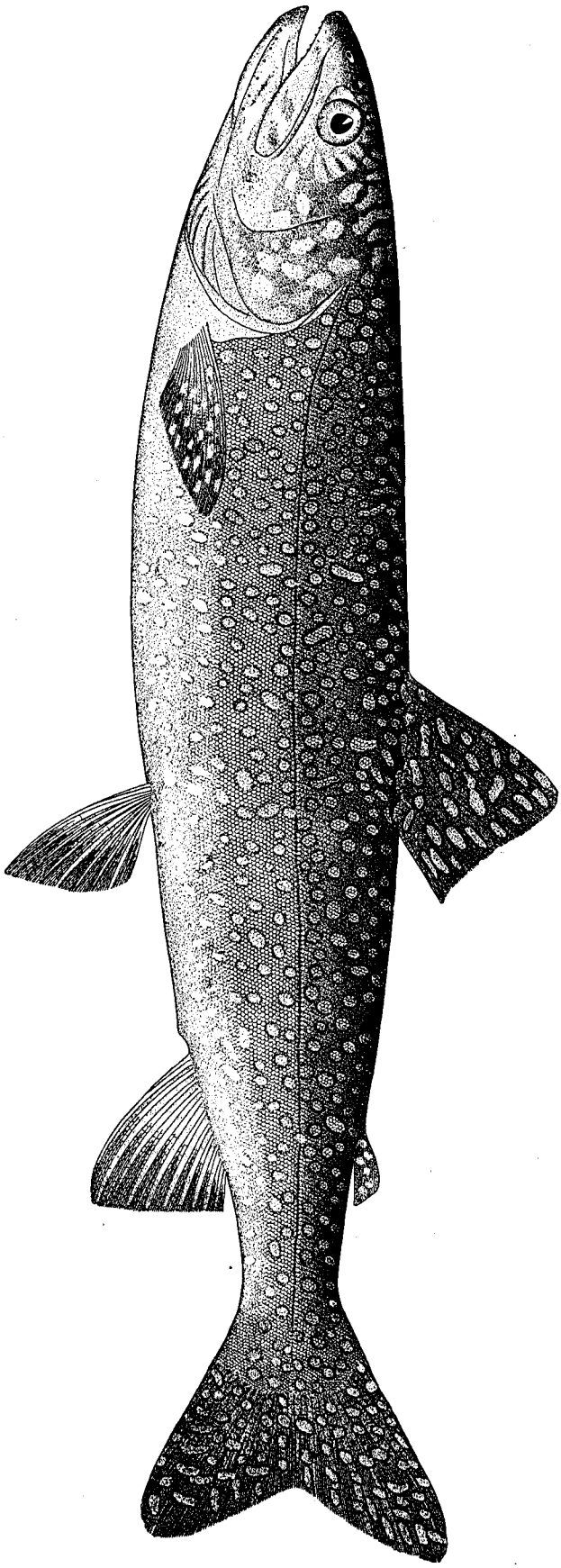
COREGONUS QUADRILATERALIS Richardson. *Round Whitefish; Menominee Whitefish.*



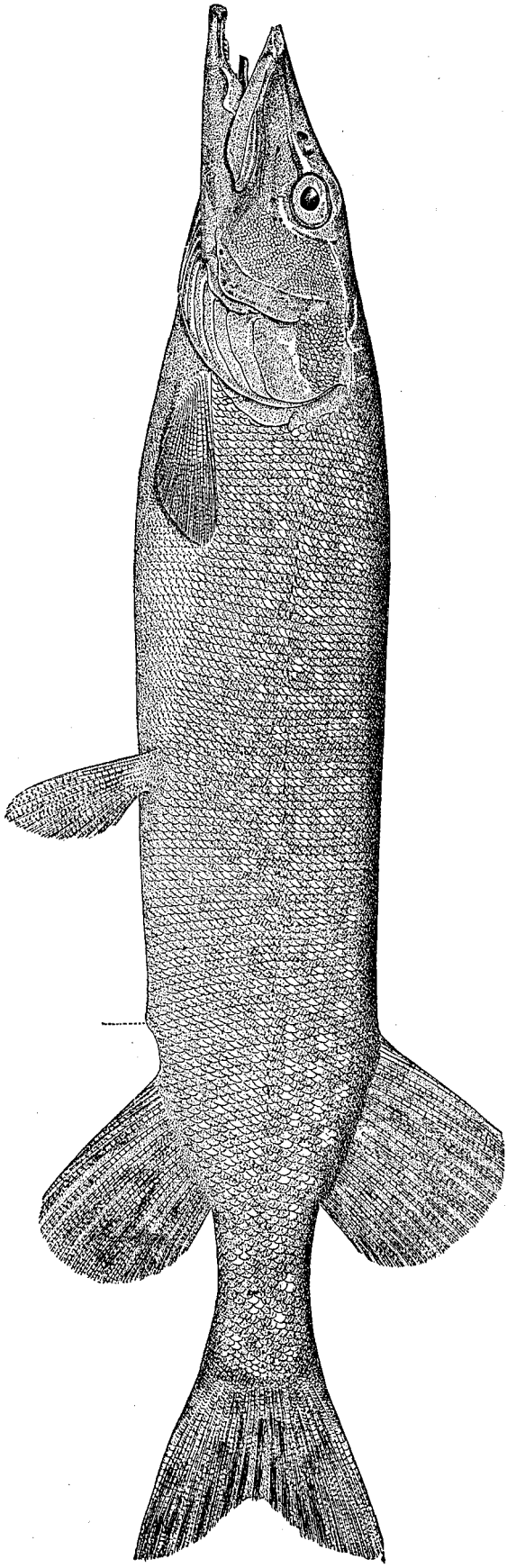
COREGONUS TULLIBEE Richardson. *Tullibee; Mongrel Whitefish.*



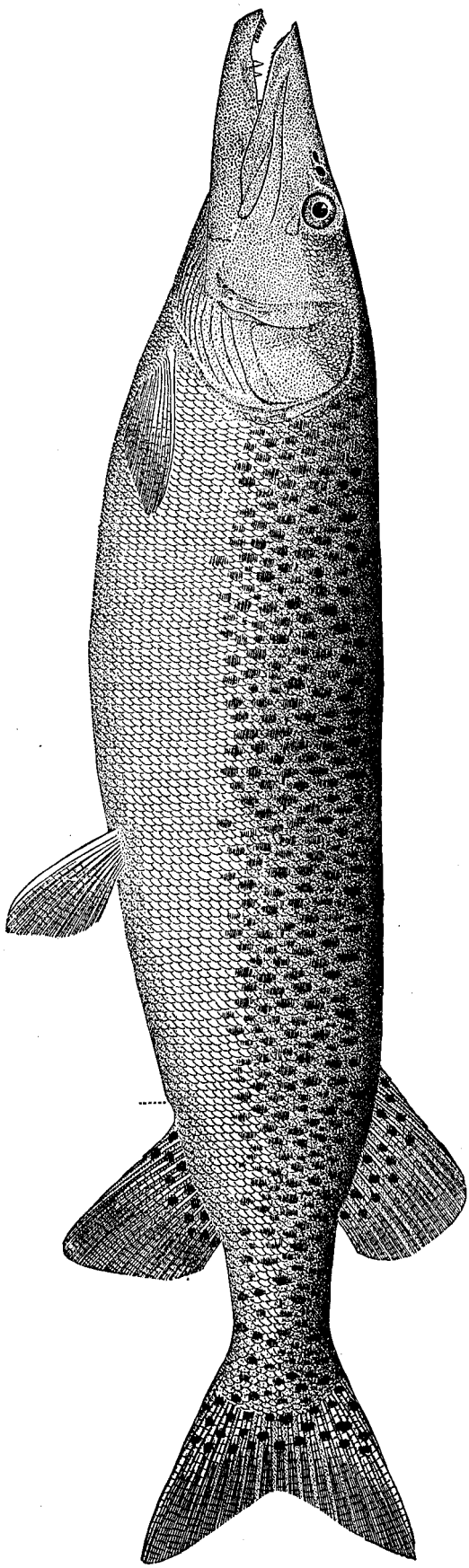
SALMO SALAR Linnæus. *Atlantic Salmon.*



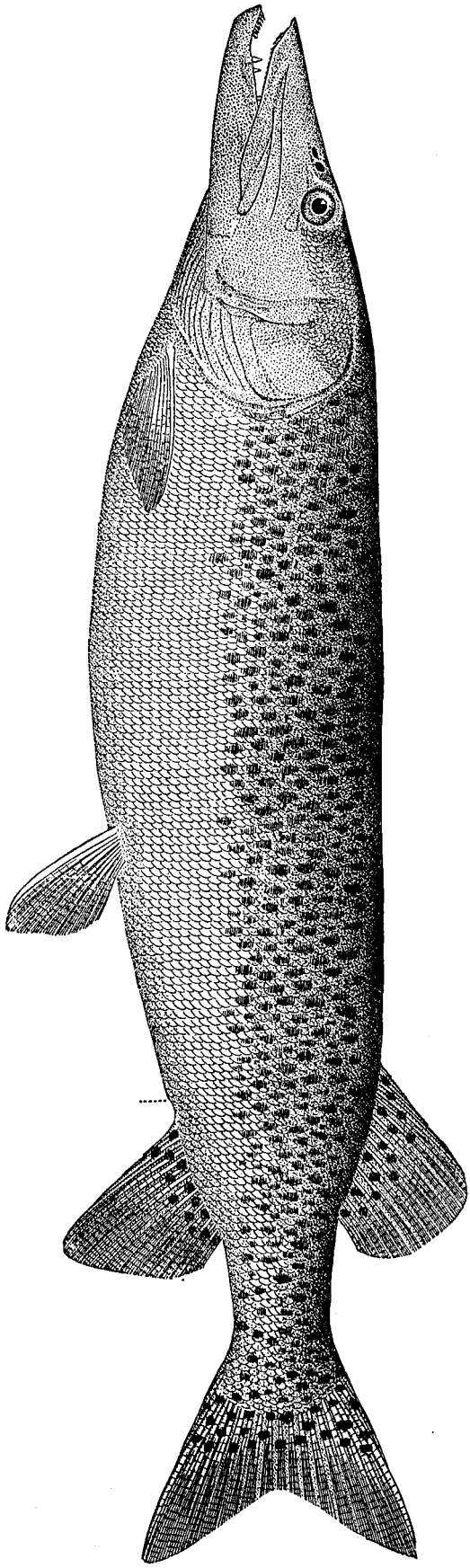
SALVELINUS NAMAYCUSH (Walbaum). *Lake Trout; Salmon Trout.*



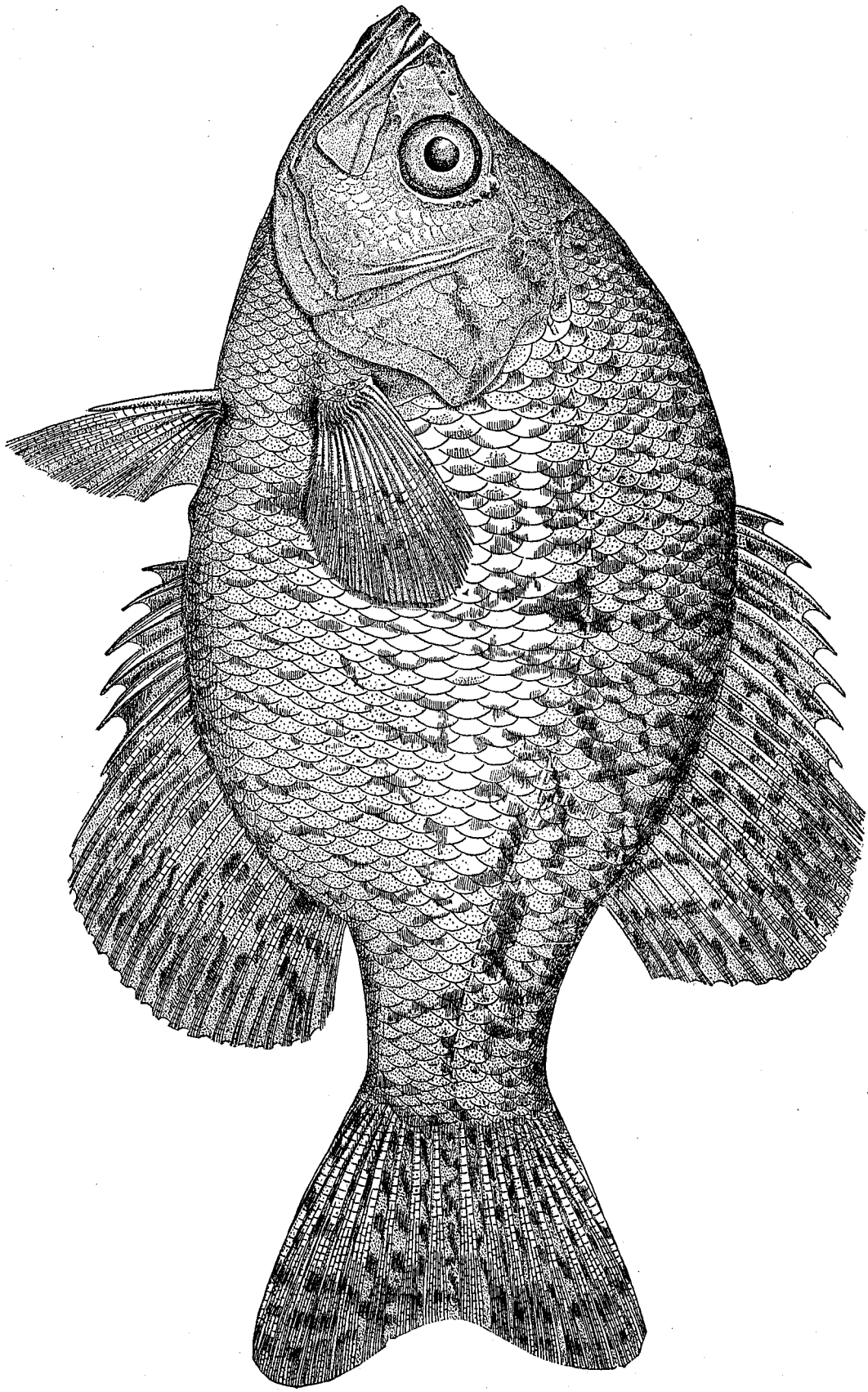
ESOX LUCIUS Linnæus. *Pike; Pickerel.*



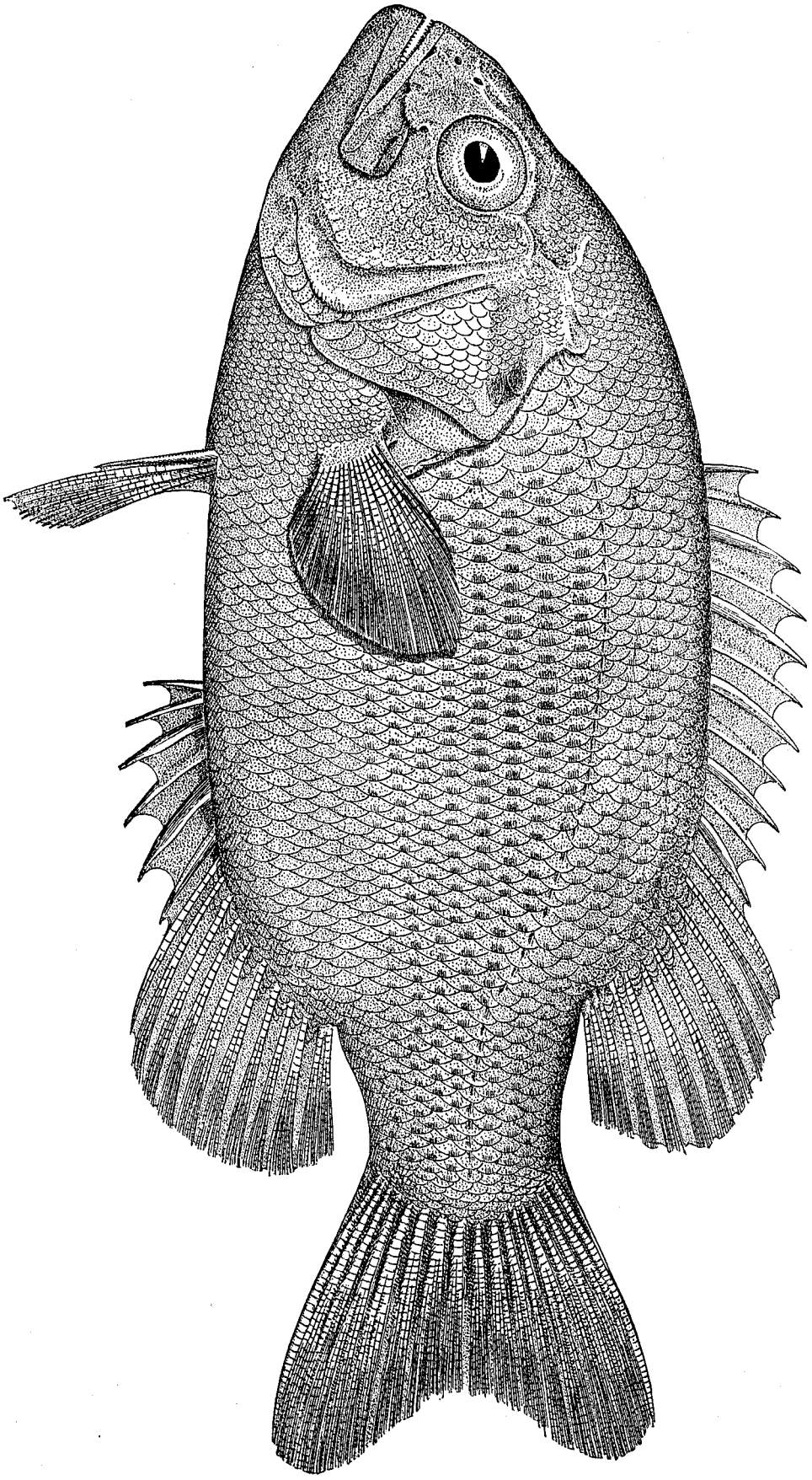
ESOX NOBILIOR Thompson. *Muskellunge.*



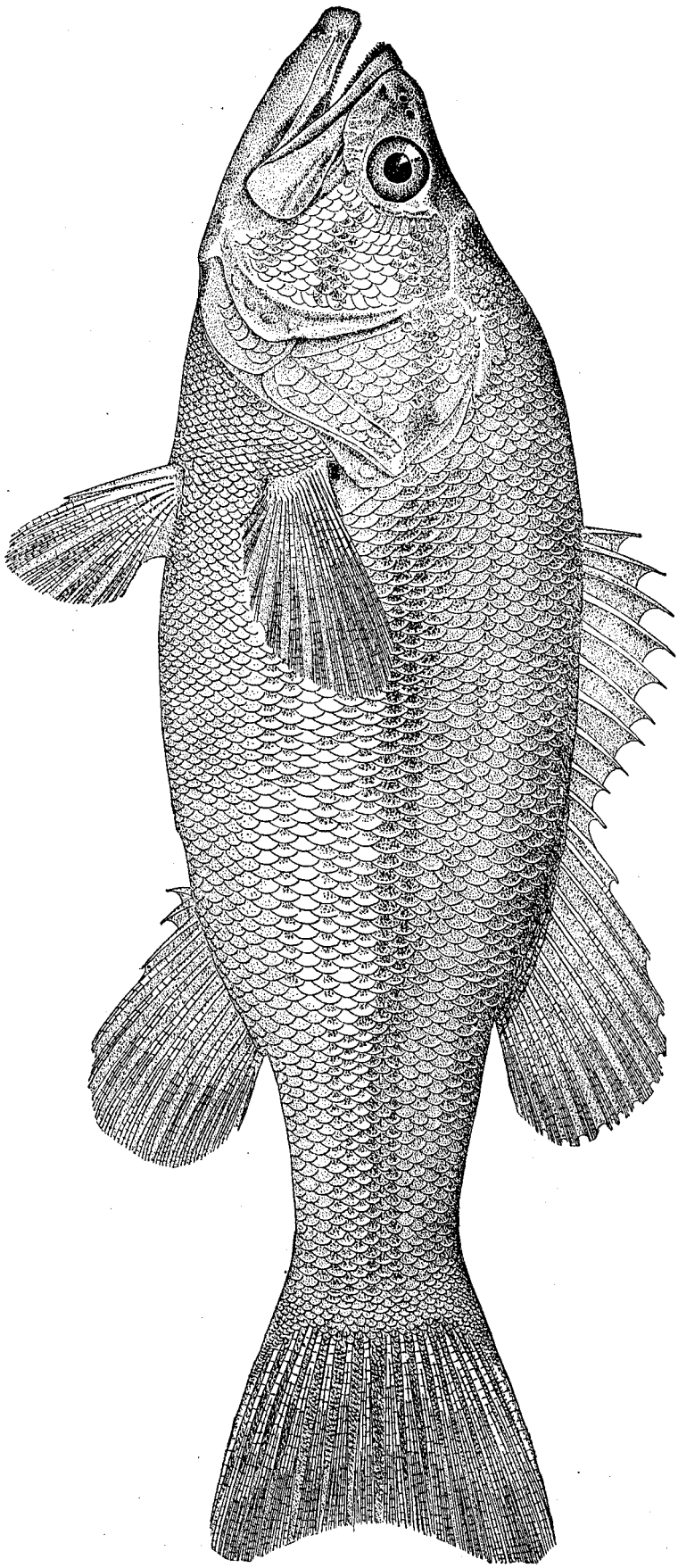
ESOX NOBILIOR Thompson. *Muskellunge.*



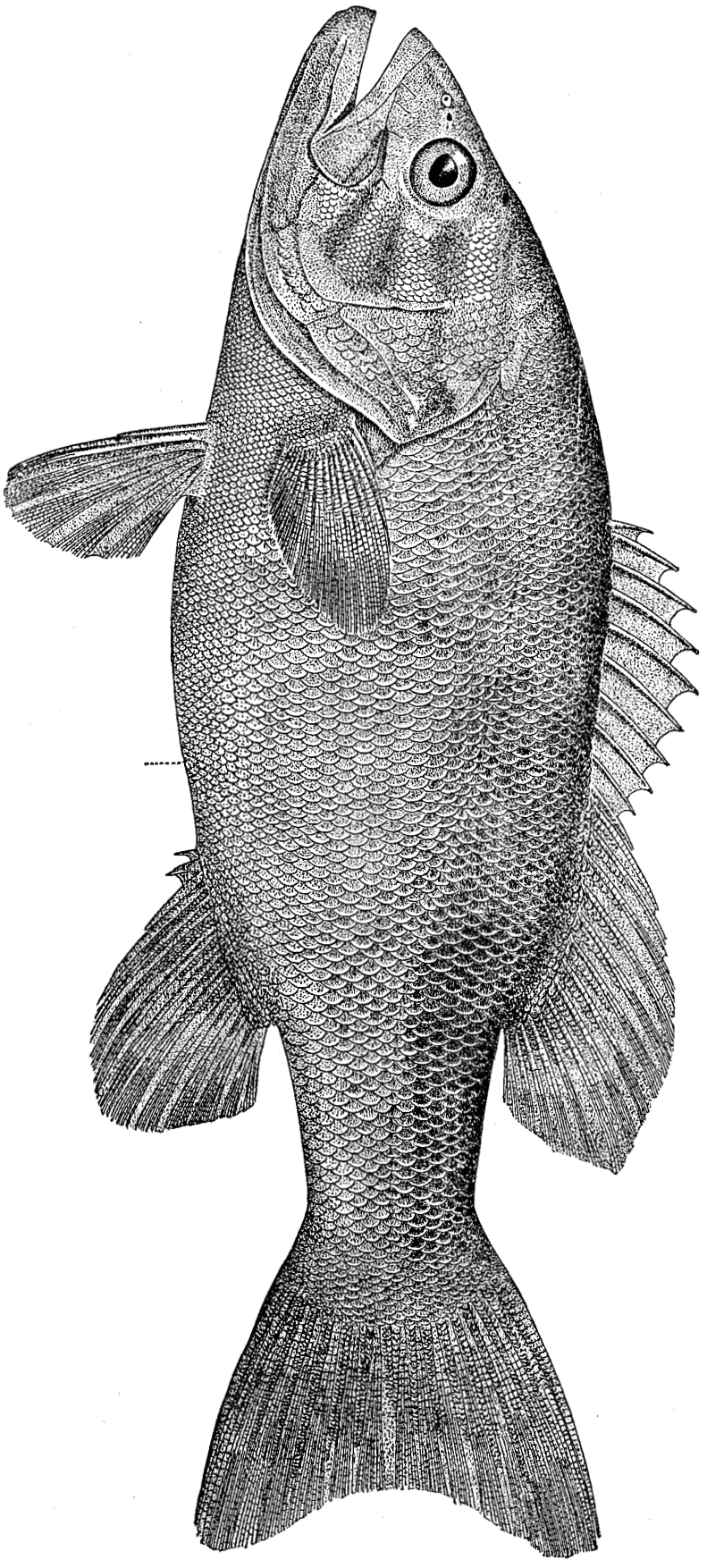
POMOXIS SPAROIDES (Lacépède). *Strawberry Bass; Calico Bass.*



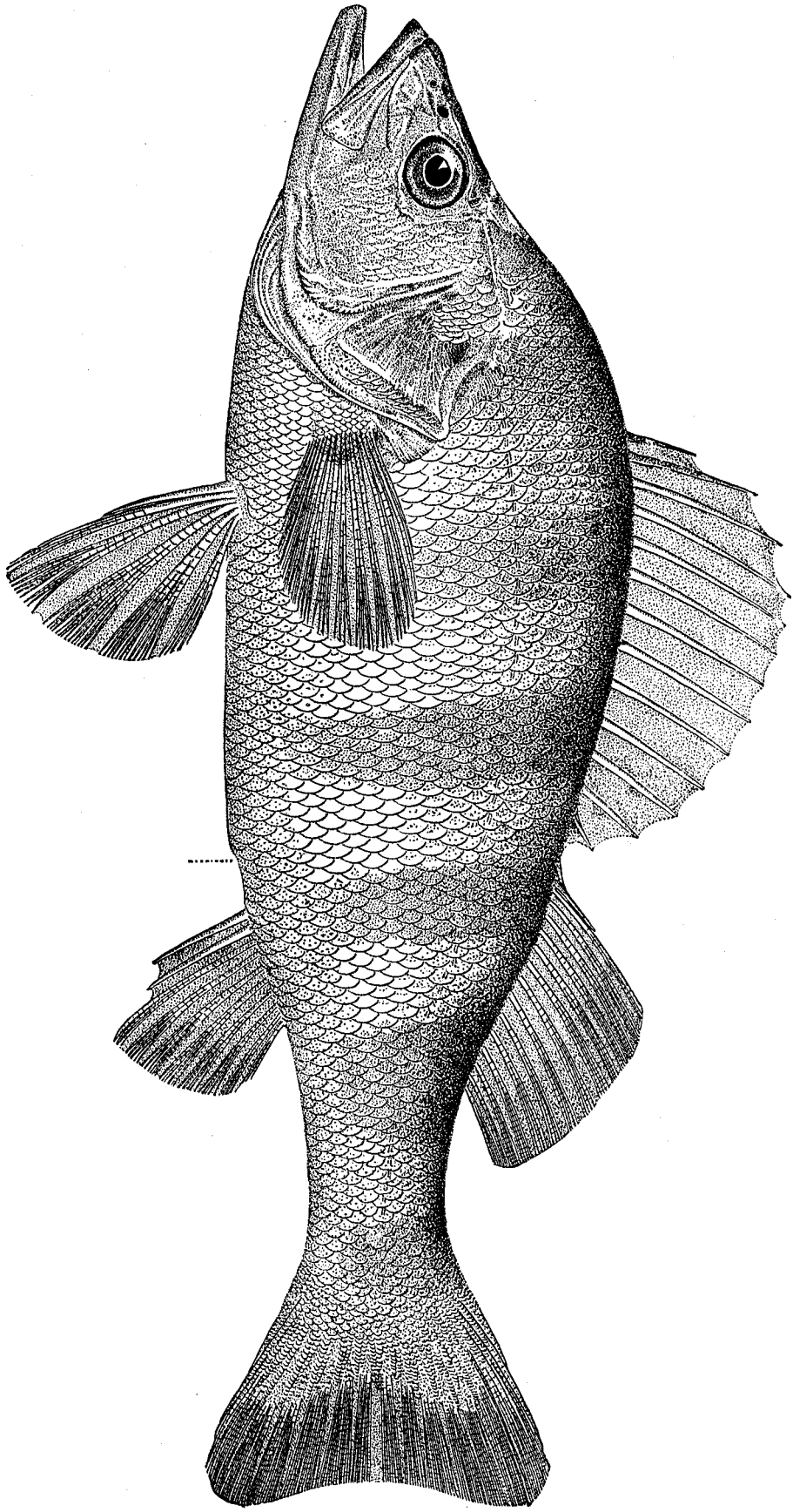
AMBLOPLITES RUPESTRIS (Rafinesque). *Rock Bass.*



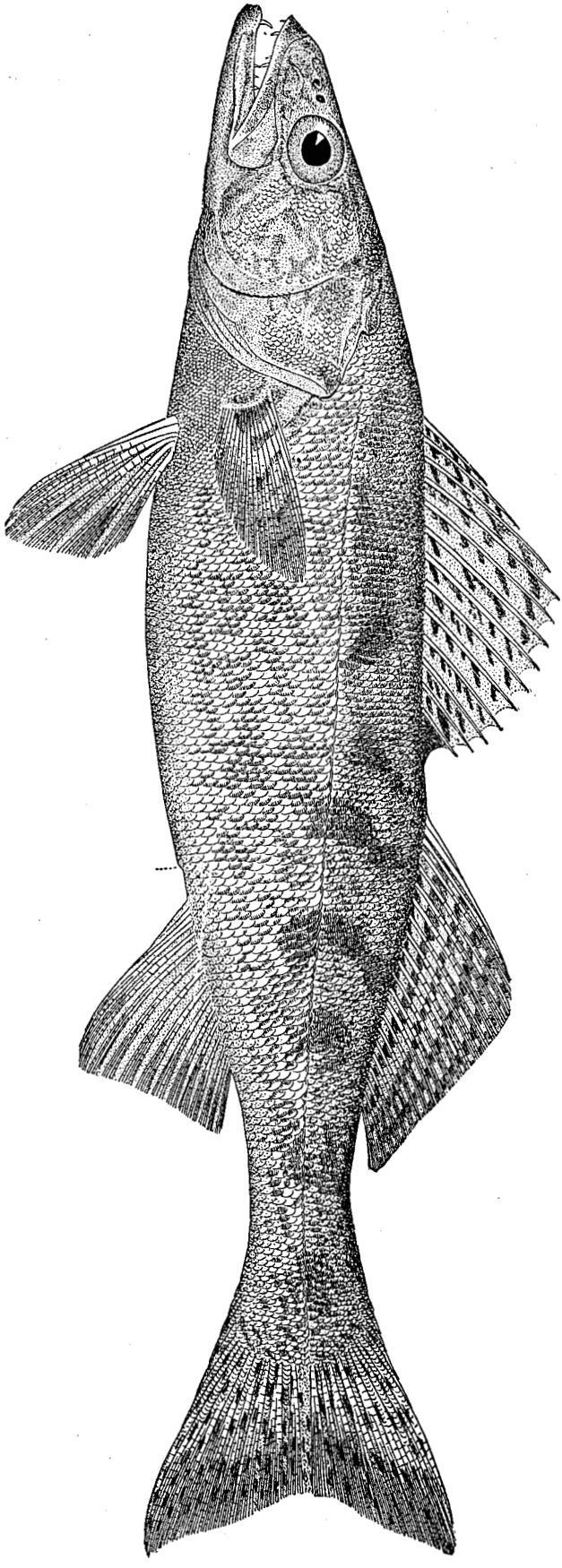
MICROPTERUS SALMOIDES (Lacépède). *Large-mouthed Black Bass; Oswego Bass.*



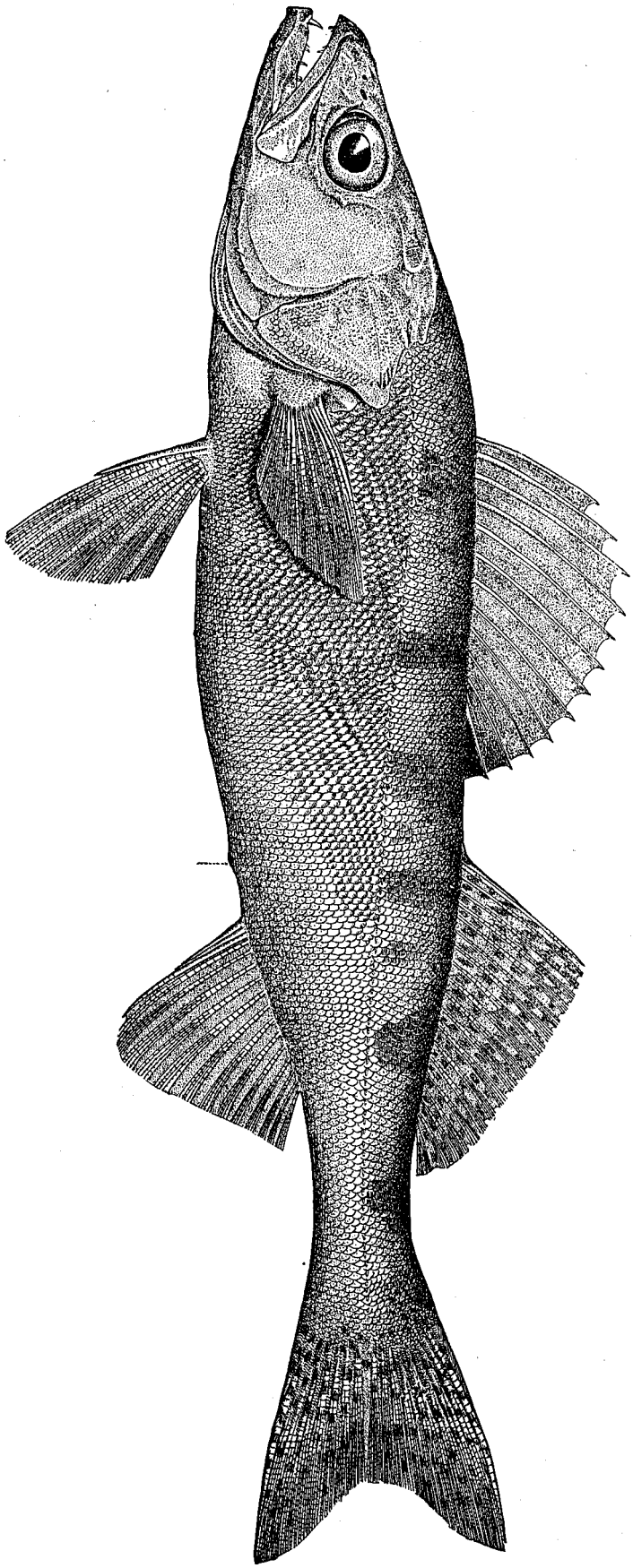
MICROPTERUS DOLOMIEU Lacépède. *Small-mouthed Black Bass.*



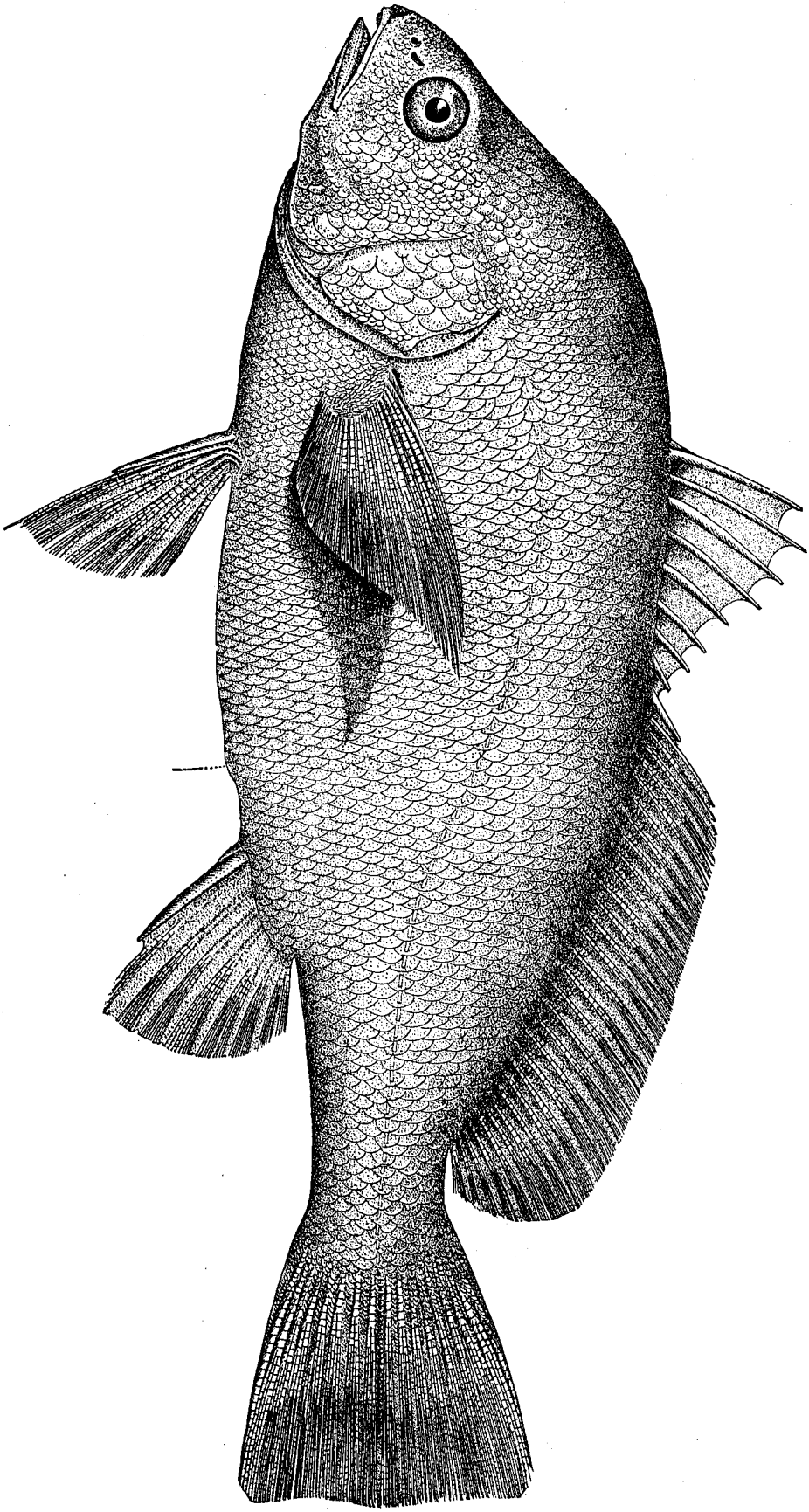
PERCA FLAVESCENS (Mitchill). *Yellow Perch.*



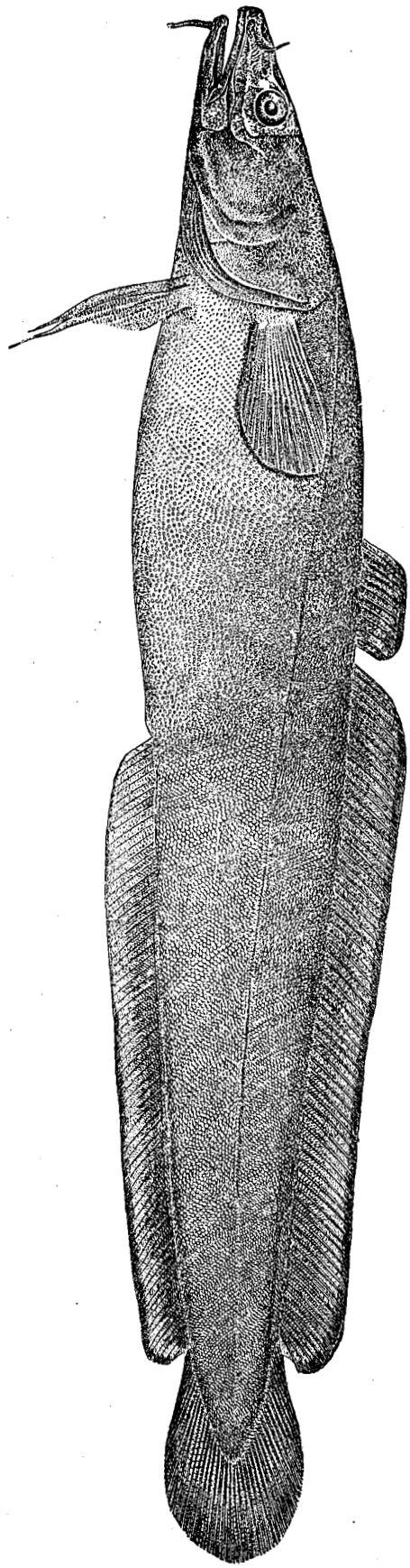
STIZOSTEDION VITREUM (Mitchill). *Wall-eyed Pike; Dory; Pike Perch.*



STIZOSTEDION CANADENSE (C. H. Smith). *Sauger; Sand Pike.*



APLODINOTUS GRUNNIENS (Rafinesque). *Sheepshead; Fresh-water Drum.*



LOTA MACULOSA (Le Sueur). *Ling; Burbot; Lawyer; Fresh-water Cusk.*