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RESULTS OF THE SHIRAS EXPEDITIONS TO WHITEFISH POINT, MICHIGAN: FISHES.

T. L. HANKINSON.

The fish of the Whitefish Point region, Chippewa County, Michigan, and the organisms ecologically related to them were studied in the field between July 29, 1913, and August 31, 1913, by the writer who was sent there for this purpose by the Museum of Zoology of the University of Michigan. The investigations form a part of the biological survey of the region which is being made by the Museum and the Michigan Geological and Biological Survey with the support of Hon. George Shiras 3d.

As it is believed that the animal life of any area cannot be understood without a knowledge of the environmental conditions and the interrelations of the faunas and the habitat conditions, an attempt was made to consider the fish of the Whitefish Point region from this ecological standpoint.

No studies have heretofore been made of the fish of this part of Michigan, and very few notes relating to them can be found in literature. Lists of plantings at Whitefish Point, statistics, and notes chiefly of commercial interest on the fish there, are given in the publications of the United States Bureau of Fisheries, especially in those entitled, "Distribution of Fish and Eggs," and also in the Reports of the Michigan Fish Commissioners. These show that the Lake Superior fishery at Whitefish Point is an old and important one. Milner (1872) says that this is one of the principal fisheries on Lake Superior. G. Brown Goode (1887) discusses the importance of the Whitefish Point Fishery and informs us that it first attained magnitude in 1870. Smith and Snell (1887) state that in 1866 fishermen from Sackett's Harbor, New York, caught fish, chiefly whitefish, there, which they salted and sent to Cleveland and Detroit. C. H. Moore (1893) says, "Located at Whitefish Point, are the most productive whitefish grounds anywhere to be found in Lake Superior," and again (1895) he states that the most important fishery upon Lake Superior is Whitefish Point, and "from this point, large and complete outfits of pound and gill nets are fished, and the catch is mainly whitefish and trout, about one-half of each variety."

GENERAL DESCRIPTION OF THE WHITEFISH POINT REGION.

The Whitefish Point Region is considered by this survey to include that part of Chippewa County which lies north of the Shelldrake River and east of a line drawn from this to the Chippewa-Luce County line at Lake Superior (Plate XI). It lies between 46° 40′ and 46° 46′ north latitude and between 84° 7′ and 85° 15′ west longitude.

In the short time spent in the field at Whitefish Point all of its bodies of water could not be visited so special attention was given to the fish near Vermilion, this place being headquarters for the work. This limited region, fortunately, was very diversified and appeared to have, within a radius of two miles, fish habitats typical of the whole area (Fig. 3).

Topography.

Country of two distinct kinds exists in the Whitefish Point Region: (1) forested upland with sandy soil, recently burnt over almost everywhere, (2) lowland with tree-covered sand ridges running in general parallel with the Lake Superior shore and separating large areas of low and level open marsh and wooded swamp land containing a number of small lakes. The upland and lowland areas are sharply demarcated by a steep slope or bluff. This is about seventy-five feet high near Vermilion where it runs in a general east and west direction and is located nearly a mile back from Lake Superior. Some distance east of Vermilion it is much farther from the lake than this; and west of this place, it approaches within a few hundred feet of the lake. The bluff represents the shore line of the old Lake Nipissing. The lowland about Vermilion was thus once covered by the water of Lake Nipissing, so it is newer than that of the more remotely submerged upland. Along Lake Superior lies a broad, sandy beach with scant vegetation and much drift strewn upon it and with a pebble zone several feet wide close to the water's edge (Plates XII, XIII and XIV). The shoal is here broad with a firm sandy bottom, without evident plants, and with a submerged pebble zone in the shallowest part. The small lakes of the belt of marsh land (called marsh lakes in this paper) are surrounded by sedge marshes and wooded swamps; they lie with their long axes generally parallel with the shore of Lake Superior and the sand ridges. They are all shallow, probably nowhere over seven feet and in most places less than three feet (Plate XVII and Fig. 3). The Shelldrake River cuts through the upland some two miles south of Vermilion, expanding into a lake, called Shelldrake Lake (Plate XI, XXV and Fig. 3). Conditions about this lake, except a few marked vegetal differences, are quite similar to those about the marsh lakes.

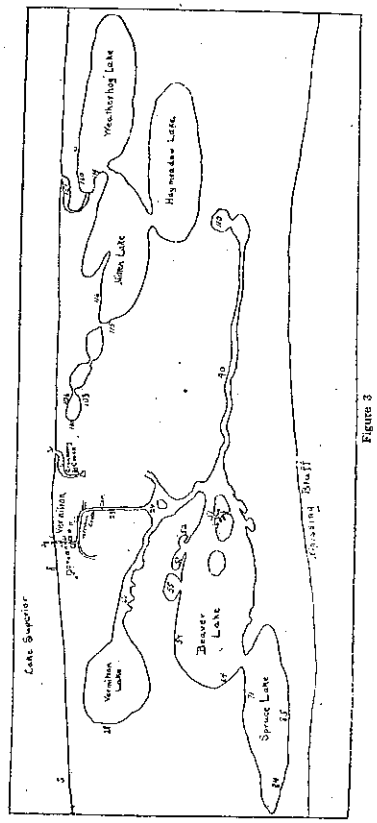


Figure 3

Vegetation.

The Whitefish Point region has a rich and varied vegetation. This has been little interfered with on the lowland, but much of the upland has been burned over, and the forests have been cut off, so that the plant life retains little of its primitive character. One small area of several acres near Vermilion still has a thick, untouched growth of large pines (*Pinus strobus* and *Pinus resinosa*) and is an isolated relic of the great pine forest that once covered this region as well as much of the rest of northern Michigan. In other places, the upland has only small trees, prominent among which are spruces (*Picea* sp.), jack pines (*Pinus Banksiana*), birches (*Betula* sp.), alders (*Alnus* sp.), aspens (*Populus tremuloides* and *Populus grandidentata*), red oaks (*Quercus rubra*), maples (*Acer* sp.), all forming scattered growths or in a few places small forests or coppices. Tall pines exist here and there over the burned area, but their charred stubs are more numerous. Everywhere on this upland, there is an undergrowth, composed chiefly of oak ferns (*Phegopterus dryopterus*), blueberry (*Vaccinium* sp.), wintergreen (*Gaultheria* sp.), bearberry (*Arctostaphylos uva-ursi*), sarsaparilla (*Aralia* sp.), trailing arbutus (*Epigaea repens*), pearly everlasting (*Anaphalis*) and a number of other plants including many grasses and sedges. Reindeer moss (*Cladonia* sp.) and other lichens were abundant and very generally distributed.

The belt of lowland along Lake Superior, where marsh conditions are prevalent, has a vegetation very different from that of the upland just described, but the dry sand ridges have associations of plants very similar to those of the upland. Both the upland and the sand ridges support birches, aspens, alders, maples, red pines, and white pines as their most noticeable trees; and blueberries, huckleberries, wintergreens, and oak ferns form the chief undergrowth on the high ground as well as on the low ground. There are some plants, however, that while common on the sand ridges appear to be scarce or absent on the upland. These are: Balsam fir, (*Abies balsamea*), willows, (*Salix* sp.), service berry, (*Amalanchier canadensis*), wild cherry, (*Prunus* sp.), red osier dogwood, (*Cornus stolonifera*), raspberry, (*Rubus* sp.), low juniper, (*Juniperus communis depressa*), Labrador tea, (*Ledum* sp.), bunch berry (*Cornus canadensis*), dogbane (*Apocynum* sp.), pigeon berry, (*Phytolacca decandra*), beach pea (*Lathyrus maritimus*), skull cap (*Scutellaria* sp.), rattle snake plantain (*Epipactis* sp.), St. John's wort (*Hypericum* sp.), spotted touch-me-not (*Impatiens biflora*), squaw berry (*Vaccinium* sp.), and sand cherry (*Prunus pumila*). A number of other common plants were not determined; and there are many species on these ridges represented by but a few individuals in each case. One

of these is the red cedar (*Juniperus virginiana*). Many mosses and lichens were present here; the latter including some long pendant forms that made festoons among dead tree branches.

The low ground between the sand ridges has a large variety of plants, which are chiefly hydrophytic. In the small lakes, extensive carpets of stonewort (Characeae) are found in some places; in others, water weeds (*Elodea canadensis*) grew in patches on the bottom. Pondweeds thrived in the deeper parts of the lakes. Of these there are the oblong-leaved forms (*Potamogeton lucens* and *P. natans*) and the narrow, linear-leaved, grass-like pondweeds (*Potamogeton rutilis* and *P. heterophyllus*), commonly producing grayish green tufts up from the bottom. In places there are also many water milfoils (*Myriophyllum* sp.) and bladderworts (*Utricularia intermedia* and *U. vulgaris americana*). Yellow water lilies (*Nymphaea americana*) form patches of varying extent. Distinct zonal arrangements of pondweeds and water lilies are not present in these lakes, the plants occurring in irregular patches; indeed, water plants are not a conspicuous feature of these bodies of water, for, in most places, rooted plants are absent and the bottom is composed of loose muck or hard sand, neither of which appears favorable for rooted aquatic plants. Considerable algae were found in a number of places, but like the seed plants, were not generally distributed. They mostly form gelatinous masses (*Nostoc* sp., *Anabaena* sp., and *Rivularia* sp.) or green, floating scums, with filaments of several species intermixed, but with those of *Spirogyra fluviatilis* and *Zygnema* sp. predominating. Green tufts of *Vaucheria* filaments grew on the bottom at some stations.

Extensive sedge growths border the marsh lakes almost everywhere. In places the plants are in clumps so it is impossible to find a line separating lake and marsh (Plate XIX). Some plants taken from a typical shore growth proved to be *Carex lanuginosa*, *Dulichium arundinaceum*, and *Eleocharis* sp. Much moss, including *Sphagnum*, grows about the bases of the sedges in the wet marshes, as well as pitcher plants (*Sarracenia purpurea*) and cranberry (*Vaccinium Oxycoccus*). The latter is propagated in the Whitefish Point region and forms a very profitable industry there. A low shrub (*Myrica Gale*) thrives in large numbers in zones and patches about the edges of the lakes as well as in other parts of the marsh region. This plant is shown in Plates XVIII, XX and XXI. No attempt was made to identify all the marsh plants, and only a few other conspicuous ones will be mentioned. These are: cat-tails (*Typha latifolia*), blue flags (*Iris versicolor*), arrow head (*Sagittaria* sp.), bulrush (*Scirpus validus*), Cassandra (*Chamaedaphne* sp.), smart weed (*Polygonum Muhlenbergii*), bur-reed (*Sparganium eurycarpum*), marsh bluebell (*Campanula aparinoides*), marsh five-

finger (*Potentilla palustris*), rosemary (*Andromeda* sp.), cotton grass (*Eriophorum virginicum*), and high huckleberry- (*Gaylussacia* sp.). Willows formed patches and borders. Tamaracks (*Larix laricina*) with spruces formed thick swamps and also grew singly over the marsh. Many of these tamaracks were dead (Plate XVIII).

Where the marsh lakes touch tamarack or spruce-cedar swamps, their shores are wooded (Plate XXIIA). The oldest, thickest swamps and those with largest trees are near the Nipissing bluff. These are quite extensive near Vermilion and contain besides spruces many white cedars, with birches, maples, mountain ashes, and many tamaracks forming marginal growths. These swamps have wet, soggy floors or small pools or streams with hummocks, exposed roots, fallen trees or limbs. *Sphagnum* sp. and other mosses thrive here with many pitcher plants, ferns orchids and other forms. About the edges of these swamps, thick undergrowth is commonly present with such plants as high huckleberry, cotton grass, willows, sweet gale and rosemary conspicuous.

Invertebrates.

As with the plants, only those invertebrates most closely related to the fish life in an ecological way were given particular attention; these, of course, are those which are aquatic or have aquatic stages. Insects were observed in largest numbers. Some very noticeable ones are biting flies, about the size and general appearance of house flies, which are exceedingly numerous, much more so near Lake Superior. In appearance and behavior, they are like stable flies (*Stomoxys calcitrans*); and it is possible that they are this insect, since a specimen of the species was found in a small collection of insects made along the lake shore. Mosquitoes are very numerous, and they were most in evidence about the lowland marshes, toward evening. A few specimens collected proved to be *Culex sylvestris*, *Culex subcantans*, and *Anopheles quadrimaculatus*. A number of kinds of dragon-flies and damsel-flies, swarms of gnats, small, annoying tabanids, and many moths, and butterflies, were the most conspicuous of the aerial insects. On the water surface were gyrinids, water striders, and other insects with some spiders. On floating water lilies were seen leaf-eating beetles (*Donacea* sp.) and frequently large, slender, naked caterpillars (*Bellura* sp.), that eat the channels in these leaves and mine their petioles (Welch, 1914). Tiger beetles are common on Lake Superior beach. Some caught there are *Cicindella hirticollis*. Beneath the surface in the marsh lakes and in the beach ponds were found many insect larvae and some adults. A list of those collected is here given:

May-flies: *Heptagenia*.

Dragon-flies: *Aeschna* sp., *Gomphus* sp., *Tetragoneura* sp., *Somatochlora* sp., *Leucorhinia intacta* Hag., *Sympetrum* sp., *Ladonia exusta* Say, *Libellula pulchella* Drury, *Plathemis lydia* Drury, and *Enallagma* sp.

Aquatic Hemiptera: *Notonecta undulata* Say, *Corixa* sp., *Arctocorisa nitida* Lieb., *Arctocorisa interrupta* Say, *Lethocerus* sp., *Gerris remiges* Say, *Gerris rufoscutellatus* Latr., *Gerris marginatus* Say.

Alder flies: *Sialis* sp.

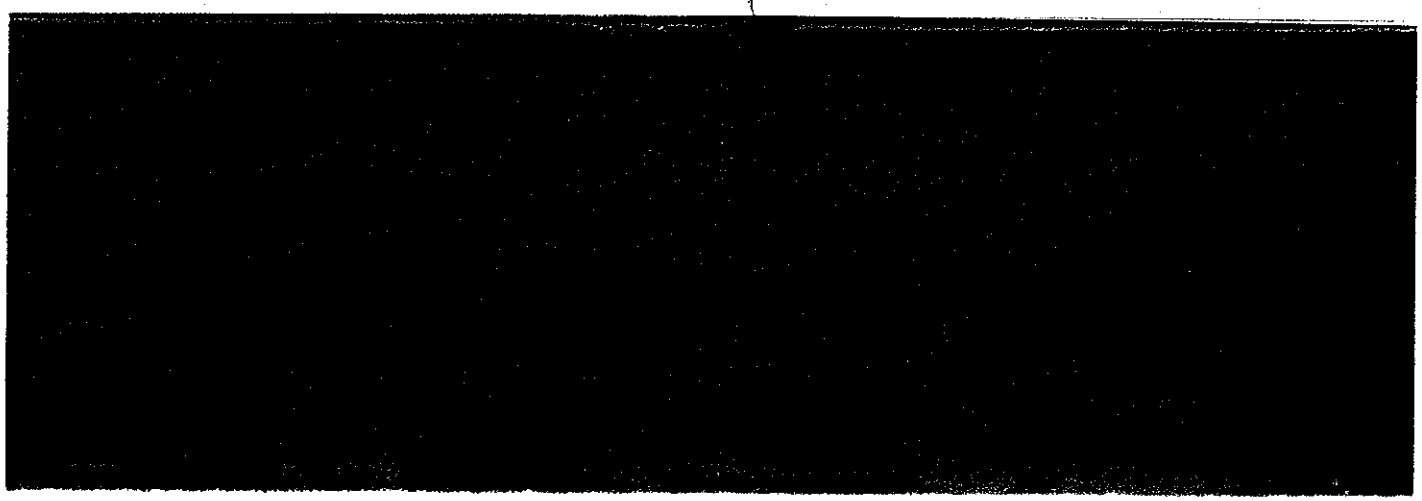
Aquatic Diptera: *Chironomus* sp., *Ceratopodon* sp.

Aquatic Coleoptera: *Dytiscus* sp., *Gyrinus ventralis* Kirby, *Gyrinus canadensis* Regimbart, *Dineutes nigrior* Rob.

Crustaceans were not found in noticeable numbers anywhere, yet entomostracans formed a prominent part of the food of small whitefish, herrings, suckers, sticklebacks, and perch that gathered in large numbers during calms on the Lake Superior shoal. The compact masses of entomostracans in the fish stomachs and intestines are of an orange color and frequently are evident through the body wall of an undissected fish. Analyses of the material revealed three genera and three species in the stomachs of the little fish examined; these are: *Bosmina longirostris*, *Diaptomus ashlandi*, and *Cyclops viridis brevispinosus*. Droppings of the fish were numerous on the shore at the water's edge, where they formed minute windrows, like orange-colored strings, thrown up by the gentle waves. The distribution of these small crustaceans was not studied, but they appeared very scarce in shallow water; none could be seen in water dipped up in a pail or bottle. The marginal shoal may not be the main feeding ground for the fish, which may be there for other reasons such as higher water temperature, or excess of oxygen. Entomostracans were also found in the stomachs of fish taken in bodies of water other than Lake Superior.

Crayfish were occasionally caught in the marsh lakes and were quite common in their outlet streams. *Cambarus virilis* was the only species found here, but of the two specimens taken in Shelldrake River, one was *Cambarus virilis* and the other *C. propinquus*. Amphipods could be picked from masses of aquatic plants drawn in by a net. Those taken were all *Hyalella knickerbockeri* (Bate) and *Eucrangonyx gracilis* (Smith). The former appear the most common and more generally distributed. Amphipods also were in Lake Superior for they were taken from the stomachs of Menominee whitefish. A few isopods, *Mancasellus tanax* (Smith), were found on plant debris from the marsh lakes.

Mollusks were found in numbers by the writer only in certain places. In a small, marsh-bordered bay of Beaver Lake (Station 55), many small bivalves could be taken by drawing the net through the thick



muck on the bottom. These were *Sphaerium rhomboideum* Say. They were taken in other parts of the marsh lakes, but nowhere were they found in such numbers as they were at Station 55. *Sphaerium simile* Say, was found in a collection from the marsh lakes. Three univalve mollusks, *Physa heterostropha* Say, *Planorbis antrosus striatus* Baker, and *Physa gyrina* Say, were incidentally collected with fish. *Physa gyrina* was found only in the Shelldrake River, and the others in marsh lakes and beach ponds west of Vermilion.

The margins of the shallow marsh lakes are favorable places for leeches. These creatures are ravenous, and much difficulty is experienced in keeping them from one's body while wading. The following leeches were taken by the writer in the region: *Placobdella rugosa* (Verrill), *Haemopsis marmoratus* (Say). *Macrobdella decora* (Say) Verrill, *Glossiphonia complanata* (Linn.) Johnston, *Erobdella punctata* (Leidy), and *Dina fervida* (Verrill).

Sponges, bright green in color, often formed extensive growths on submerged brush, roots, logs, and other objects. The following were collected:

Spongilla lacustris (Linn.), *Spongilla fragilis* Leidy, and *Mycnia fluviatilis astrosperma* Potts.

These three forms appeared to be closely associated.

Near the surface of one of the beach ponds, the water was a bright green due to an abundance of ciliated protozoans (*Stentor igneus* Ehr.). Another conspicuous protozoan in one of the marsh lakes produced large, jelly-like colonies It appeared to be *Ophrydium* sp., which the writer has found abundant in Walnut Lake, Oakland County, Michigan (Hankinson, 1908).

Vertebrates Other Than Fish.

The amphibians and reptiles of the Whitefish Point region have been studied and a paper published on them (Thompson and Thompson, 1913). A number of species were taken in the course of the field work on fish, which were, *Rana pipiens* Shr., *Rana septentrionalis* Baird, *Rana clamitans* Latreille, *Bufo americanus* LeConte, *Thamnophis sirtalis* (Linn.), and *Chrysemys belli* Gray. Tadpoles were found in some numbers in quiet sunny shoals of Shelldrake River and Shelldrake Lake and in shallow, quiet tributaries of Vermilion Creek.

Many birds were present in the region during the time of the field work, but like other terrestrial animals, they were given little attention. A detailed report on the birds and mammals of the region has been published by N. A. Wood (Annual Report of the Michigan Academy of Science, Vol. XVI, pages 55-73). Since these forms have been treated by Mr. Wood, only notes on the beaver, *Castor canadensis michiganensis* (Bailey) will be given in this paper, for this species is related to the fish life of the marsh lakes in an especially important ecological way.

The work of beavers was very manifest almost everywhere about the marsh pools. These were in the form of lodges (Ruthven, 1914), submerged piles of sticks gathered for food, felled trees, dams (Plate XVB), and networks of channels through the marshes. The dam on Mason's Creek was a new one, and above it a large pond had been recently formed; this had many dead trees standing in the water, as well as dying ones with wilting leaves. Forest conditions are rapidly changing to pond conditions here; and thus a new dwelling place for fish will in all probability be formed. The marsh lakes appear to be very good habitats for beavers. Both the marsh and lake region are readily accessible one from the other by the animals, and by means of channels they can easily get to wooded areas where there is an abundance of food in the way of young trees.

Climatic Features.

The climate of the Whitefish Point region is probably that of northern Michigan generally with a little more than the usual rainfall due to its proximity to Lake Superior. According to data given by Leverett (1911), the mean annual temperature of the Northern Peninsula is near 40° F, with a few days when it exceeds 90° F, and a few when it is below 20° F. In August, the average temperature is near 60° F. The rainfall is near 34 inches each year; at Whitefish Point it varied from less than 25 inches to near 30 inches from 1906 to 1910, inclusive. There is considerable snow, and winter conditions last usually from early November to late April. The small lakes are frozen over during this time. The warm season is, therefore, short, with spring, summer, and autumn conditions from May to October. There is an abundance of sunshine, and the periods of daylight are from 3 A. M. to 9 P. M., a length of time favorable for plant growth.

In August, 1913, when most of the fish work was done, the weather was, for the most part, pleasant with days mostly warm and sunny and nights cool and clear. There was a rainy day or two and a few showers of short duration. The season was called by residents a wet one. From July 15, 1913, to August 28, 1913, the range of temperature readings at the Life Saving Station on Lake Superior beach were from 38° F. to 89° F. With the permission of the U. S. Life Saving Service, these readings are published here:

	Midnight.	6 A. M.	Noon.	6 P. M.	Wind.
July 16	47	46	55	54	W-N. E.
16	52	63	72	63	S-SE.
17	60	58	60	52	SE.-N-W.
18	52	56	55	56	N. W. S-W.
19	57	55	61	58	W. S. W.
20	52	53	54	56	N-N. W.
21	50	54	63	70	N. E. S.
22	64	62	76	67	E. S. W. E.
23	60	61	56	55	S-N-W.
24	48	52	54	52	W.
25	50	54	65	65	N. S. W. N. E.
26	61	62	73	71	S-S. E.
27	68	70	75	70	S. N. E. W.
28	54	56	58	60	N-W.
29	49	52	64	60	S-N-W.
30	55	60	80	72	W-S. E.
31	77	76	68	61	S-N-W.
Aug. 1	60	62	62	60	W.
2	55	53	60	60	S-W-N.
3	63	53	59	58	N-W.
4	52	52	62	60	N-W-E.
5	60	58	62	60	S-N. E. S.
6	61	57	62	60	N-N. W.
7	59	60	75	70	N. E.-SE.
8	64	64	75	64	S. SE. W-E.
9	62	64	67	66	S-N. S. W.
10	59	58	56	52	W-N. NW.
11	54	54	67	63	SE. SE.
12	60	58	71	70	SE. NE. N.
13	58	62	76	73	S. E. N. E. E.
14	66	66	82	80	S. E.
15	68	68	89	82	SE.-S.
16	77	67	74	72	S. N. NW-N.
17	67	64	66	62	W-S-W.
18	62	64	68	66	NW. E. N.
19	65	62	73	70	E-SE.
20	56	60	77	76	SE.
21	64	63	66	62	S. E. SW. E.
22	62	54	69	57	W. SW. NW.
23	52	53	59	58	N. NE. N. W. NE.
24	55	49	48	46	N. W-N-NW.
25	38	49	71	66	
26	59	60	63	66	
27	55	56	55	60	
28	58	60	68	60	

The wind as shown in the above table varied much as to direction in the late summer of 1913. It also varied in intensity, but only a few times was it strong enough to produce a very rough sea on the lake. Water temperatures were taken with each fish collection. A list is here given with accompanying air temperatures taken at the same times. The latter are given in parentheses.

Lake Superior Shoal; water under two feet deep: 65 (60), 65 (70), 66 (67), 55 (68), 66, 64.

Beach Ponds: 65 (79), 80 (82), 70 (63), 69.

Marsh Lakes: 71 (69), 73 (68), 73 (77), 76 (72), 73, 72 (72), 70 (70), 62 (60), 69 (60), 68 (58), 75 (62), 64 (60), 70 (68), 75 (70), 74 (68), 75 (64), 67, 69 (69) 65 (64).

Outlet Streams of the Marsh Lakes: 68 (62), 69, 74 (68), 65.

Shelldrake Lake 68 (59), 65 (68).

Shelldrake River: 63 (70).

Methods and Acknowledgments.

In the study of the fish of the Whitefish Point region, extensive collections were made and each was studied in detail before another was taken up. An attempt was made to get a complete collection of the fish inhabiting the region, but not to such an extent as to interfere with the study of the habits of the species in their respective habitats. A convenient laboratory was fitted up, and the fish were studied in an aquarium. In this way it was possible to become well enough acquainted with the different species so that they could easily be recognized under favorable circumstances in the water afield.

For watching fish binocular field glasses and a water-glass were found very helpful. In Lake Superior a large, fifty-foot minnow seine and smaller "common sense" seines were hauled on the marginal shoal. Fish from the deeper shoal were obtained from fishermen, who very willingly permitted the writer to examine their "catches," and to retain desirable specimens. In the marsh lakes and beach ponds a six-foot, "common sense" seine was used almost everywhere. This can readily be handled by one person while wading or from a row boat. In the marsh, in narrow beaver channels, and for scooping under banks of streams, under gale growths, and about sedge clumps, a large minnow dip net (1 1-2 x 3 ft.), was successfully used. A minnow trap on the plan of a fyke-net was kept set much of the time, and some interesting specimens were taken with it.

Many photographs of the fish and their environments were taken to supplement the field notes, negatives and prints of which are filed in the Museum of Zoology, Ann Arbor, Michigan. The field work was nearly all done by the writer unassisted, but at times help and suggestions were given by the following named residents of Vermilion: John Clarke, Will Clarke, Fred Wetherbog, and Captain J. A. Carpenter of the Life-Saving Station. Special mention should be made of the services given by Mr. John Clarke, whose lamented death in May, 1914, removed a good friend, advisor, and efficient assistant to the members of the several field parties. Mr. Robert Carlson, lightkeeper at Whitefish Point, furnished information concerning the fisheries at that place. Mrs. Hankinson prepared and identified plants and contributed in other ways to the progress of the work. Mr. Seymour Bower, Superintendent of the Michigan Fish Commission, made the investigations possible by procuring a permit to collect specimens of fish. The work was done under the direction of A. G. Ruthven, Director of the Museum of Zoology and Chief Naturalist of the Michigan Geological and Biological Survey. Mr. N. A. Wood of the Museum of Zoology at Ann Arbor gave the writer some useful suggestions and directions and col-

lected some fish for him in the region The following specialists named material collected:

E. N. Transeau, Charleston, Illinois, Algae and some seed plants,
Philip Dowell, Port Richmond, New York, Club-mosses,
C. K. Dodge, Port Huron, Michigan, Seed Plants,
G. N. Calkins, New York, New York, Protozoans,
N. A. Harvey, Ypsilanti, Michigan, Sponges,
J. P. Moore, Philadelphia, Pa., Leeches,
Bryant Walker, Detroit, Michigan, Molluska,
J. G. Needham, Ithaca, New York, Dragon-flies,
J. R. De la Torre Bueno, White Plains, New York, Hemiptera,
C. Betten, Lake Forest, Illinois, Caddice-flies,
Chas. A. Hart, Urbana, Illinois, Water beetles,
V. E. Shelford, Urbana, Illinois, Tiger beetles,
O. A. Johannsen, Ithaca, New York, Aquatic Diptera,
Chancey Juday, Madison, Wisconsin; Entomostracans,
Miss Ada Weckel, Oak Park, Illinois, Amphipods,
Miss Harriet Richardson, Washington, D. C., Isopods,
A. E. Ortmann, Pittsburg, Pennsylvania, Crayfish,
A. G. Ruthven, Ann Arbor, Michigan, Amphibians and Reptiles.

FISH HABITATS.

Fish are the most abundantly represented of all the vertebrates of the Whitefish Point region, but they do not inhabit all of the bodies of water or all parts of any one of them. Descriptions of the more important places where fish are found will be given for the purpose of enabling one to understand better the conditions under which the different species live in the region. Data on the relations of the fish to the environmental factors in their habitats will be included, although little information of this kind was revealed in the necessarily brief time that could be spent in the field. The portions of the bodies of water examined are called stations and are designated by numbers; those near Vermilion are indicated on the sketch map (Fig. 3). They may be classified as follows:

Lake Superior Shoal
- Deeper Shoal
- Marginal Shoal

Beach Ponds
- Lower Beach Ponds
- Upper Beach Ponds
  - Open Pond
  - Marsh
  - Beaver Dam Pool

Marsh Lakes
- Deeper water Areas
- Shallow water Areas
- Marsh bordered Shoal
- Wooded Shore
- Outlet streams

Shelldrake Lake
Shelldrake River

Lake Superior Shoal.

Deeper Shoal. Station 2. At the end of Clark's pier, at Vermilion, the water is about six feet deep. The zone having this or a little greater depth out to about ten feet is called the deeper shoal, and the part of it examined, about the end of the pier, is Station 2. Plate XIIB shows the region in the background. The following conditions maintained at Station 2 during August, 1913: depth, 6-10 feet; water clear, cold, and commonly disturbed, even to the bottom; bottom of clear, yellow sand; and visible plants absent. The species of fish, found in the order of their apparent abundance, were: lake herring, common sucker, brook trout, long-nosed sucker, Menominee whitefish, common whitefish, rainbow trout, and tullibee.

The fish caught were all fair-sized examples of their species, since they were caught by fishermen for the table. Direct observations are easily made of all parts of this station from the pier end. At times, many fish were seen which could not be positively identified, but it is evident that the station is visited by these larger fish periodically, and they do not permanently inhabit the place. Small fish also frequent this region, but according to the writer's observations, only on their way to or from shallower or deeper water. Immense numbers of little fish were seen about sunset after an unusually warm and quiet day moving in a steady, direct, purposive way from the shallower water near shore close to the water surface and going out to some depth beyond. None were seen lingering at this station.

Marginal Shoal. The zone of shallow water close to the shore, out as far as collections could be obtained by wading, is called the marginal shoal. The conditions here are as follows: depth three feet or less; water usually clear, only clouded by sand or debris close to shore when breakers are present; water cold; bottom of hard, clear, yellowish sand or with pebbles, the latter forming a discontinuous, marginal zone; no visible plants except some *Ulothrix zonata* on submerged parts of piles and other objects; aquatic animals other than fish inconspicuous. Gnats and caddice-flies (*Mystacides sepulchralis*) were seen at times over the water surface; a kingfisher, at one time, was

seen to dash in where small fish were schooling near the shore. In four places, there are unusual conditions, near the mouths of the three streams draining the marsh and where there is a broad sand flat free of pebbles and debris, a short distance west of Vermilion (Station 5). Here a person can wade out several hundred feet before reaching water waist deep. The mouths of streams appeared to have no special attraction for shoal fish except that of Vermilion Creek, which is probably due to kitchen wastes thrown in it a short distance up stream from its mouth The shoal here is called Station 1. Many small fish were observed at times about the entering water. The following species were collected at this station: *nine-spined stickleback, lake herring, common sucker, common perch, common sculpin, common whitefish, brook trout, spot-tail minnow, long-nosed dace, and brook stickleback.

The little herring were in large, compact schools, and the whitefish were associated with them. The common suckers and the nine-spined sticklebacks were both numerous, and each species schooled by itself with a few individuals of one often in large schools of the other. The perch associated little with other species but were solitary or in little companies. The sculpins lived on the bottom among the pebbles, and there were probably many more of them at Station 1 than the collections revealed since it was difficult to catch them with a seine. Small burbots were apparently for the same reason poorly represented in collections. The brook sticklebacks and spot-tailed minnows and long-nosed dace were all very scarce.

Over the large submerged sand flat, Station 5, thousands of young herring and nine-spined sticklebacks schooled. A few young whitefish, suckers, and perch were also here; the first closely associated with young herring and the other two were chiefly by themselves.

Pebble-covered shoals appeared to be avoided by all the shoal fish except the bottom forms—sculpins and burbots. Often immense schools of sticklebacks were seen just off the pebble zone and not moving over it.

The main food of these little shoal fish appears to be entomostracans, chironomid larvae, and adults of various insects that fall into the water, and filamentous algae (*Ulothrix zonata*).

Beach Ponds.

Upon the Lake Superior shore, there are a number of small bodies of water, some only temporary, and formed in depressions (Plate XIII) by the waves during storms and some larger and formed by the damming of the small streams. The latter are the only ones of interest here

*In the lists of fish given in this habitat discussion, the species are named, as far as possible, in the order of apparent abundance, the best represented one first.

for they alone contained fish. The beach ponds belonging to creek systems are of two kinds: (1) those of the lower beach, which are close to Lake Superior and freely connected with it and (2) those of the older, upper, or fossil beach several hundred feet back from the lake and with scarcely any water connection with the lake except during spring floods.

Lower Beach Ponds. Two of these were found in the region near Vermilion, one at the mouth of Cranberry Creek (Station 31, Plate XVA) and one a mile or so farther east on Wetherhog Creek (Station 121). Fish might readily enter these ponds from Lake Superior, but there is no evidence that they often do this. No fish were found on the lake shoals anywhere near the mouths of these two streams, and the fauna of these ponds is very different from that of Lake Superior. Each of these ponds is long and narrow, extending several hundred feet making a small angle with the lake margin. The water is stained brown but free from sediment and has a variable temperature, usually about that of the air. They are shallow, under two feet in depth and the bottom is of hard, yellow sand with conspicuous "ripple marks." No vegetation except some diatom scum and filamentous green algae was evident in the water and the shore was practically barren of vegetation. There were no noticeable water invertebrates, except a few insects. Some aquatic beetles (*Coptotomus interrogatus*) were caught. The following fish, given as near as possible in the order of their abundance, were found in these pools: common sucker, red-bellied dace, *Leuciscus neogaeus*, Cayuga minnow, silvery minnow, common perch, horned dace, brook stickleback, Iowa darter, and brook trout.

All of the fish taken in these pools are small examples of their species, and none were represented in any numbers except the suckers, which were only in a depression about two feet deep around a partly submerged stump at Station 31. Here were a great many little suckers with very small examples of the other species listed, except the trout. Only one trout was found and this was beneath a water-logged piece of wreckage. Very few fish were moving out in the open water of the pond, but all stayed about objects which afforded some concealment.

Upper Beach Ponds. The ponds of the upper beach are about two miles west of Vermilion and are much larger than those just considered and possess a larger biota. They are fed by Mason's Creek, and a little, shallow, narrow outlet winds over the beach to Lake Superior. The series of several ponds are not distinct from each other but are expansions of one system. Two of these are much larger than the others and are about five hundred by seventy-five feet. Much vegetation is in and about these bodies of water, and this approaches in character that of the marsh lakes farther back from Lake Superior. At the

upper end of the series plants are especially numerous and form a small marsh (Station 172, Plate XVIB). A short distance above this a beaver dam is across the creek near where it emerges from the woods (Plate XVB). The dam is a new one and has caused the creek to flood a large wooded area recently. Below the dam is a pool (Station 171, Plate XVB).

Much invertebrate life was in evidence about these pools and marshes. The following aquatic forms were taken in the net with fish collections: dragon-fly larvae (*Aeschna, Somatochlora, Gomphus*), water striders (*Gerris remiges*), and leeches (*Macrobdella decora, Haemopsis marmoratus*, and *Placobdella rugosa*). Attached to many submerged objects were sponges (*Spongilla fragilis*). A protozoon (*Stentor igneus*) swarmed near the water surface, giving a considerable area of it a bright green color.

The noticeable vertebrates were frogs, tadpoles and a number of birds. In general four types of fish habitats are present: (1) the deeper, open water areas; with water about three feet deep and a hard sand bottom, over which there is little debris or humus; water plants are absent, except a few small patches of stoneworts or bladderworts, (2) the marsh region, with a thick growth of partly submerged sedges, rushes, flags, sweet gale, and a number of others and also much green algae on the surface and much stonewort beneath it, (3) marginal areas of very shallow water, two or three inches deep, and unusually warm, and well exposed to sunlight owing to a scarcity of seed plants, and (4) the pool beneath the beaver dam (Station 171, Plate XVB), which is about twenty by thirty feet with a depth of about three feet down to the sand bottom, over which there is a foot or more of dead leaves, sticks, and other litter, and growths of stonewort; the water was cold (65° F.) and stagnant, since the pool is supplied by percolations through the beaver dam.

In the open deep areas (No. 1, above), the following fish were taken: black-head minnow, Cayuga minnow, horned dace, *Leuciscus neogaeus*, black-nosed dace, and brook stickleback.

None of these were abundant or generally distributed in this type of region. The Cayuga minnows were chiefly in a few large schools in the deepest water; and those observed were large examples of their species, while all the other fish taken were much undersized.

In the marsh area (No. 2, above), chiefly in the more open places, the following fish were caught: red-bellied dace, silvery minnow, black-head minnow, horned dace, *Leuciscus neogaeus*, Cayuga minnow, black-nosed dace, mud minnow, and brook stickleback.

Most of these fish were small, under an inch in length, and each species, except Cayuga minnows, *L. neogaeus*, and mud minnows, was

abundantly represented. This marsh is the only place in the Whitefish Point region where horned dace were found in any numbers. The marsh appears to be an important feeding ground for the smaller fish.

The marginal shoals (No. 3, above) were visited by many small fish, but a representative collection of them was not made; one species, the barred killifish, seemed to be confined to these places and was tolerably common.

The pool below the beaver dam (No. 4, above) was frequented by brook sticklebacks, red-bellied dace, *Leuciscus neogaeus*, black-nosed dace, and mud minnows.

The sticklebacks were numerous, and appeared to thrive better than in any habitat examined in the Whitefish Point region. Some of them were large, being nearly three inches long. A few opened had been eating insects and algae. The other fish were all small and present only in small numbers.

Marsh Lakes and Streams.

The small lakes among the sand ridges on the strip of lowland along Lake Superior with their outlet streams, channels, pools, beaver runs, and other bodies of water connected with them, contain many small fish and some large ones. They are, moreover, everything considered, the most productive places for studying and collecting aquatic organisms in the Whitefish Point region. The lakes given particular attention are close to Vermilion and are shown on the sketch map. The names used for these were for the most part invented by the writer.

According to Leverett (1911), regions below the Nipissing shore line, including the lowland about Vermilion, are very young geologically, perhaps not older than three thousand years. When the waters of the Great Lakes descended to their present level, sand ridges, produced probably by both waves and ice, were formed with the intervening depressions. Marsh plants began to grow and thrive here till they captured the shallower parts of the flooded low ground. In places, the beavers made dams to retain and elevate the water, which on rising drowned out portions of the marsh or otherwise changed its features. These animals thus helped to preserve the small lakes, and in this and other ways they have been a dynamic factor in determining the character of the fish habitats. Man has also affected the region in a similar way by damming the water to facilitate cranberry culture. No inlets were found leading to these lakes, except short streamlets from springs near the base of the Nipissing bluff. They appear to be fed chiefly by seepage from the higher ground. The bottom of these lakes is at foundation a hard, yellow sand, but over this in many places, there is

a thick stratum of loose, buoyant muck, barren of visible growing vegetation. Where this deposit is absent, the clean yellow sand supports few plants; but where a little humus is present, there is often a growth of submerged aquatic plants, principally stoneworts, pondweeds, bladderworts, water weeds, and water lilies. The marshy shores have, as a rule, either sedge growths (Plate XXIIB) or partly submerged patches of sweet gale (XXIA). Cat-tails, bulrushes, smartweeds, and some other plants characterize the open marsh region. In a number of places, the wooded swamps extend to the lake margin (Plate XXIIA). The water of these marsh lakes is without evident turbidity, but is slightly brown stained. In temperature it was found commonly to be about that of the air, and the readings made were not far from 70° F.

Although fish are numerous in these lakes they are not found in all of them or in all parts of any one of them. They have a marked tendency to dwell near the shore, although bottom and water conditions in midlake are very similar to those about the margin, except for those produced by the shore features. Muck bottoms are evidently much preferred to the sandy ones. On account of these restrictions in distribution, very definite fish habitats could be found. A consideration of the important types of these will now be made. It is very difficult and apparently impossible to work out these habitats in a successional way, on account of complications in their history, brought about by dams, channels, and other structures built by beavers and man and by the removal of beaver dams by man, when their presence interfered with cranberry culture and other interests, but in general the habitats have developed as follows. When the water receded from the Nipissing to the Lake Superior level and the sand ridges were formed, the intervening depressions were capable of containing water in sufficient amounts in some cases to form small lakes. Wind and water borne sand and accumulating humus tended to make these lakes shallower. Beavers, however, converted parts of their shoals into deep water areas by digging channels. Similar work may have been done by water currents. Marshes followed the shoals by the encroachment of plants on them, but in places there is a reversion to lake conditions by the formation of channels and pools in marshes by beavers and sometimes this occurs temporarily when the marshes are flooded by man to protect or harvest cranberries. These operations appear to be the chief source of the muck deposits over the sand bottom in these lakes. A considerable amount of this light black soil could be transferred by beavers from the marshes while making their channels or while using them as runways, and when the lakes are lowered by opening the sluices in dams for flooding cranberry marshes, currents might be set

up in these channels that would wash much of this material into the lake. A rapid accumulation of muck over a plant association would obliterate it, and the looseness of the soil would prevent plants again taking root. Thus regions like Stations 52 and 55 could be produced. In more open parts of the lakes, this light muck may be carried and very generally distributed by wind-made water currents. Beaver Lake and Spruce Lake have muck practically over their entire bottoms. It is possible that currents sweep this away completely in some cases, thus returning the shoals to a primitive type, that is, with sandy bottoms and no plants, but a continued accumulation of organic debris in these lakes must in time bring about a firm substratum, peaty in nature, that will support plants readily. The marsh, then, can rapidly encroach on the lake, and the last stage as a fish environment would thus be reached. Beaver channels and pools will finally give way to the marsh if man destroys these animals, as he is rapidly doing at present. Spruce swamps encroach on the open marsh and, in places, they have reached the edges of the lake producing conditions for fish life which are different from those of other parts of the lake (Plate XXIIA).

The probable developmental relation of these fish habitats to each other is shown in the diagram below.

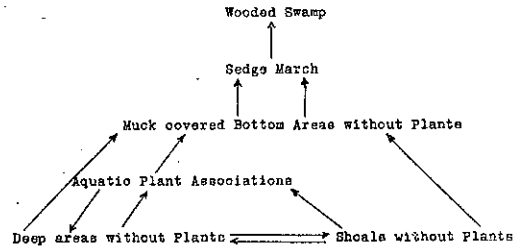


Diagram showing probable developmental relation of fish habitats near Vermilion, Michigan.

A classification of the fish habitats in the marsh lakes may be made as follows:

Deep Water Areas; five to seven feet. Natural depressions, deep channels, beaver excavations, etc.
With few or no visible plants
With stonewort association
With pondweed association
With water-lily association

Shallow Water Areas; about three feet and under
- Without higher plants (barren shoal)
- With stonewort association
- With water-weed (*Elodea*) association
- With pondweed association
- With dense growth of submerged aquatic plants, a number of kinds forming a complex association
- With thick deposit of muck over a sandy bed; no higher plants
- With sweet gale (*Myrica*) association
- With water-lily (*Nymphaea*) association

Marsh Area; sedge, gale association
- With shallow water about plant bases
- With beaver channels and pools

Wooded Shore.
Outlet Streams.

Examples of the above-listed types of fish habitats in the marsh lakes, so far as they were examined, are here described in detail.

Deep Water Areas without Vegetation. This type of fish habitat is poorly represented in the small lakes, for most of the water is less than four feet deep. Where it is considerably more than this, from about five to seven feet, it is called deep water. The channel of Vermilion Lake (Station 25, Plate XXIIIB) is in many places of this depth with the bottom of hard sand. No collections were made in the channel, but from the boat only a few large perch were seen. Apparently there were no minnows or other small fish. It is likely that these are poor feeding places and used by fish chiefly as highways. Fish lingering here would be much exposed to the attacks of pikes, which undoubtedly frequent regions of this type; some huge ones were seen in this channel and other deep parts of the marsh lakes. A large sculpin was caught in a place of this character by N. A. Wood.

Deep Water Areas with much Vegetation. Some deeper parts of the channel of Vermilion Lake (Plate XXIIIA) had many water lilies forming patches. Scarcely any fish, except a few very small ones, about an inch in length, and a few large perch were seen about these. At the east end of this channel, Station 24, there is a region where the water is five or six feet deep and where much fine-leaved pondweed grows. The area is roughly circular and about a hundred feet in diameter with gale and sedge-formed shores and an island of gale near its center. A nearly submerged pile of beaver-cut wood lies against this. The bottom is of hard, yellow sand. This depression was undoubtedly dug out by beavers. Large perch frequented this place; and they were easily caught with a hook baited with leeches. On one occasion a huge pike,

two or more feet long, was seen to move away from here on the approac of the boat. Some small fish were seen here, but they were uncommo

Shoal Areas without evident Plants. These have a hard, sand bottom with very few or no rooted aquatic plants. A strip of regio of this type examined lay along the dam at the west end of Vermilio Lake (Station 28). Fish were uncommon here as at other places of th type and with many hauls of the seine only a few examples of *Leuciscu neogaeus*, brook sticklebacks, and Iowa darters were caught. There i an extensive shoal of this type at the north end of Little Lake but almos no fish were found over it. At Station 111, of Hay Meadow Lak barren shoal is also prevalent with the usual scarcity of fish.

Shoals with Stonewort Association. Shallow water a few inch deep with thick bottom mats of stonewort plants is found in a number o bays near the east end of Vermilion Lake. One of these (Station 53 was given particular attention. This extends some three hundre feet into the marsh and is from about twenty to eighty feet wide. Onl very small fish, an inch or so long, including many little brook stickl backs, were found over this growth. Others caught were red-bellie dace, *Leuciscus neogaeus*, black-head minnow, and Iowa darter. Cray fish dwelt in the stonewort masses. In the westward prolongation o Spruce Lake (Station 84) stoneworts covered a very thick muck deposi almost everywhere. Large mats of these plants often became detache and came to the surface and floated as shown in (Plate XXIB.) Only few very small fish were found here as elsewhere where stonewor covered the bottom.

Shoals with Water Weed Association. Water weeds (*Elodea can densis*) grow in dense patches on a hard sandy bottom in Hay Meado Lake (Station 111), where the depth is about two feet. Many Iow darters were found among these plants, but no other fish were foun with them.

Shoals with many Aquatic Plants forming a dense, complex Associa tion. In a few, shallow, sheltered places, submerged plants are num erous, filling the water. One of these is at the west end of a small lak (Station 101) where pondweeds, stoneworts, bladderworts, green alga with partly submerged rushes, sedges, sweet gale, and other plants forr a complex association that nearly fills the water leaving little swimmin space for water animals (Plate XXIIIB). The entire lake is char acterized by an abundance of vegetation (Plate XXIIIA). At Statio 101 mud minnows are common, and this is a typical habitat of th species. A great many small *Leuciscus neogaeus* were caught along th margin in different parts of the lake. These were about an inch i length. A few small Iowa darters were also caught in this lake. A small pike was noted. The following aquatic invertebrates wer

common about the water plants: Sponges (*Spongilla* sp.), leeches (*Placobdella rugosa* and *Haemopsis marmoratus*), snails (*Physa heterostropha*), and insects (*Libellula pulchella*, *Somatachlora* sp., *Leucorhinia intacta*, *Aeschna* sp., *Arctocorisa nitida*, and *Dytiscus* sp.).

Muck Bottom Shoals without Plants. The shoals, with deposits of loose muck forming layers from a few inches to five or more feet thick over hard, sandy substrata were along much of the shore region of these small lakes, but the layer is thickest in wind sheltered places such as small bays. A good example of one of these is Station 55, which is a bay running into the marsh on the northeast shore of Beaver Lake. Here the muck is two or three feet thick with two feet or less of water over it. The sand foundation is not down so far but that wading and hence collecting can be easily done; and the muck is scarcely more resistant than the water to a person going through it. The bay is irregular in form and some seventy-five by a hundred feet in diameter. It opens into the lake by a mouth about fifty feet wide. The sedges of the marsh about it are nearly three feet high and form marginal clumps (Plate XIX). The water is slightly brown stained but free from sediment and was found usually to have a temperature of 70° F. This station has the largest and most constant fish population for its size of any station studied in the Whitefish Point region, and it is evident from general observations about the marsh lakes that the conditions in this bay are those most attractive to the fish of these small lakes. The following species were found here: red-bellied dace, Cayuga minnow, black-head minnow, silvery minnow, *Leuciscus neogaeus*, Iowa darter, brook stickleback, common perch, horned dace, white sucker, mud minnow, and common pike.

The first five species listed associate closely with each other, forming dense, compact schools that tend to gather in peripheral depressions, getting as near the marsh as possible but apparently not entering it. They were probably finding food especially abundant near it. Dissections showed that diatoms, alga filaments, and insects were being eaten. Sticklebacks were abundant and very generally distributed in this bay; they were not in company with other fish or noticeably with each other. They rest, apparently motionless, off the bottom, and when the muck is disturbed they quickly gather about the cloud so made, evidently looking for food.

Only one mud minnow was caught and this in the minnow trap placed on the bottom near the middle and deepest part of the bay. This species may be abundant in this bay, but because of the habit of hiding in the mud (Gill, 1904), few could be captured with nets. The Iowa darters could be seen "creeping" over the surface of the muck

bottom, leaving little trails behind them. A few pikes were noted i and about this bay.

A few dragon fly larvae (*Somatochlora* sp.) and many small Sphaer ums (*Sphaerium rhomboideum*) and a few snails (*Physa heterostroph* and *Planorbis antrosus striatus*) were the aquatic invertebrates found a this station in making fish collections. Some tadpoles and a turtl were noted. A solitary sandpiper was flushed, and a kingfisher re mained about the station, and now and then its splash could be hear as it struck the water, or it could be seen to dash from a dead tamarac to the place where fish were schooling. Recently used channels an other evidences made it appear that beavers were frequenting this ba at the time the field work was being done. These animals certainl constitute a dynamic feature in the aquatic life of this bay.

Another bay (Station 52) with similar conditions to that of Statio 55 is a short distance east of Station 55 and connected with the ba called Station 53 (Plate XXA). It is oval in surface form and son fifty by eighty feet in diameter. A deposit of muck some six or seve feet thick exists here. In all probability the bay was dug out b beavers. Hundreds of fish were seen here on every visit. They wer similar in relative numbers and manner of association to those Station 55. The following were collected: red-bellied minnow Cayuga minnow, black-head minnow, silvery minnow, *Leuciscu neogaeus*, Iowa darter, brook stickleback, and common sucker.

Shrub-bordered Shoal. In a number of places small shrubs (*Myri Gale*) form fringes about the edges of these lakes. Fish find seclusi near and among the submerged bases of these plants. Station (Plate XXB) and Station 71 (Plate XXIIA) are the examples of th type studied. Pikes were frequently seen here, apparently in ambus Red-bellied dace, Cayuga minnows, black-head minnows, and bro sticklebacks were also often found and schools of large common sucke stayed about the gale fringe of Station 59. Many of the suckers we a foot or a little more in length, and dozens of them were seen at eve visit to the place, although none were noted elsewhere in the mar lakes except for a few at Station 55. This may have been due to t unusually deep water, about three feet, along this shore.

Sponges were abundant on submerged gale branches. Those c lected were *Spongilla lacustris*. Amphipods (*Hyalella knickerbocker* dragon-fly larvae (*Tetragoneura* sp.) and dipterous larvae (*Chironom* sp. and *Ceratopogon* sp.) were also noted.

Water Lily Association in Shallow Water. A place of this kind Station 116 (Plate XXIVA). A large school of small perch, about inch and a half long, and also many little minnows, an inch or less length, were found in this habitat.

Marsh Areas. The water in the sedge marsh close to the lake is frequented by mud minnows and a good many small examples of other species common in the lakes. The latter was composed of black-head minnows, brook sticklebacks, Iowa darters, *Leuciscus neogaeus*, and silvery minnows. These were mostly about an inch in length and were caught chiefly in the marsh near Station 55 and at Station 115. When the marshes are artificially flooded, the small fish of the lakes are said to go over them in large numbers. The marshes are undoubtedly used as breeding grounds for pike in the spring, and people living at Vermilion tell of their coming into these places at that time.

Some water insects and other invertebrates were taken in the marsh. Mosquitoes were very numerous. A few specimens belonging to the species, *Anopheles quadrimaculatus*, were caught. About the bases of the sedge plants some dragon fly larvae (*Plathemis lydia* and *Somatachlora*) were taken, also a few snails (*Planorbis antrosus striatus* and *Physa heterostropha*).

Beaver Channels and Pools in the Marsh. These are narrow passages through the marsh dug by beavers. Some of them are quite deep and extensive as at Station 51. These lead to houses, a number of which are on the island in the east part of Beaver Lake. The passages are from about two to seven feet in width and three or four feet deep, and have a great deal of the soft muck on their bottoms. Five radiating from the house and one connecting the channel system with the lake are present at this station. Many small fish frequented them, but no collections of them were made. To what extent beavers are a factor in forming little bays like Station 52 and 55, is an interesting problem. It can readily be seen how a group of radial channels like those of Station 51 could start one of these bays by being widened till the marsh between them is obliterated.

Wooded Lake Border. Stations 85 and 110 are of this type. Trees here produce much shade, which is the chief characteristic of this type of habitat. Much submerged brush is present, which furnishes hiding places for small fish. On the shore with trees are many shrubs, logs, fallen limbs, and much herbage, including sedge growths. The lake margin is cut up by little bays or channels that are numerous on the swamp floor. The following species were caught along wooded shores: black-head minnow, red-bellied dace, *Leuciscus neogaeus*, Cayuga minnow, brook stickleback, and common pike.

Pikes find many retreats in the shore indentations. Black-head minnows were numerous at Station 85, and hundreds of them crowded up into the little bays and channels. Brook sticklebacks also frequented these places in some numbers. Attached to the submerged

brush were many sponges (*Myenia fluviatilis astrosperma*) as well as dragon-fly larvae, leeches, snails and other invertebrates.

The marsh lakes have three small outlet streams in the Vermilion region, called by the writer, Vermilion Creek, Cranberry Creek, and Wetherhog Creek (Fig. 3).

Vermilion Creek flows from a pool at the junction of three channels (Station 24, Fig. 3), the largest of which extends southward to Beaver Lake. It is, for the most part, an artificially dredged ditch with a board dam, which has a controllable spillway so the water may be made to rise in the several ditches of the cranberry marshes to flood them. According to many observations the creek above the dam has a fish fauna like that of the marsh lakes. Below the dam, the stream is irregular in width and depth, perhaps six or seven feet on the average and shallow except for a few "holes" where the water is still and nearly two feet deep with mud bottom and growths of pondweeds, filamentous algae, and other aquatic plants. These are favorite places for brook sticklebacks. Where the creek cuts under the bank small brook trout find hiding places from which they are easily captured with a dip net. Fish were seldom seen out in the open stream, but stayed in deep places. Their absence here may have been due to blue herons which feed along this creek (Plate XXIVB). The following fish were taken in this part of the stream (Station 22): brook stickleback, brook trout, silvery minnow, common sucker, and *Leuciscus neogaeus*.

A number of other animals were taken in the few net collections made at Station 22. Among these were: two kinds of leeches (*Bropdella punctata* and *Hnemopsis marmoratus*), crayfish (*Cambarus virilis*), dragon-fly larvae (*Somatochlora* sp., *Gomphus* sp., and *Aeschna* sp.), water bugs (*Lithocerus* sp.), water beetles, and snails (*Physa heterostropha*). Tadpoles were abundant in shallow tributaries of this creek and a number of frogs were seen about it.

At Vermilion the creek is covered with a tramway made of heavy timbers and driven piles. It extends out into Lake Superior about a hundred and fifty feet as a strong pier (Plate XIIB, background). The separated overhead cross timbers of this structure put the creek in heavy shade like a woodland stream. No leafy plants develop from its sandy bottom or shore. It is a few feet wide, rather swift, and but a few inches deep, except in a few restricted areas where it is two feet or so deep. The following fish were caught under this tramway (Station 21): brook trout, common sucker, long-nosed sucker, red-bellied dace, common perch, burbot, and common sculpin.

The trout here are small, but one nearly a foot long was seen. They were all found beneath submerged objects in the deeper parts of the creek. Schools of little suckers wandered into the creek short dis-

tances from the Lake Superior shoal. Twelve large examples of long-nosed dace, a little over three inches in length, were caught in a depression of the creek bottom, where the water is about two feet deep, just above the stream mouth. This very small and restricted region is the only place in the whole area studied, where any but very small long-nosed dace were taken. These large ones from Station 21 were eating black-fly larvae, which made up all of the material in the intestines of four of the dace opened. The other species from this station, listed above, were scarce. The burbot was caught in the small fyke net set across the creek just above its mouth so as to catch entering fish. It is possible that burbots visit the creek at night for food.

Cranberry Creek is a short stream which cuts through the sand ridge along the Lake Superior beach a short distance east of Vermilion (Plate XIVB). On the beach it spreads out into a long, shallow pond (Station 31, Plate XVA). The part of the creek through the sand ridge (Station 30) was the only part examined. Here it runs some two hundred feet below a small road bridge, winding about making pools and narrows; the former are as deep as three feet and as wide as fifteen feet, while at the narrows the creek is constricted to two or three feet and is but a few inches deep. The water is clear but slightly stained brown; it is swift, and moderate in temperature (68° F. at times when the principal collections were made). The bottom is of clean dune sand except in pools where much organic debris has collected. The banks are high, with scant vegetation, and are well-lighted. The following species of fish were taken in Cranberry Creek: brook trout, black-nosed dace, *Leuciscus neogaeus*, horned dace, common sucker, and brook stickleback.

The small, deep pools with overhanging banks harbored a number of small brook trout, but this was the only species well represented; only a few of each of the others listed being found.

Wetherhog Creek is a short stream running from below a dam at the end of Wetherhog Lake and expanding in a beach pond. The creek is wide and very shallow and concealed by bushes for much of its course. Fish were scarce in it, and few little perch and some Iowa darters were the only ones taken in many hauls.

Shelldrake Lake.

The lake that lies in the course of the Shelldrake River some two miles southeast of Vermilion (map Fig. 3 and Plate XXVA) is in general similar to the larger of the marsh lakes just described. It is perhaps a little over a half mile in length by a quarter of a mile in width. An extensive shoal is present and apparently a large deep water

area, but this could not be examined. The bottom of the shoal is of hard sand with a thin layer of humus over it in many places and much vegetation occurs in this shallow water, although irregularly distributed. Partly submerged bulrushes, yellow water lilies, scouring rushes (*Equisetum*) form large and conspicuous patches; and along the marshy shore at the west end are rank growths of *Sagittaria*, cat-tails, and sweet gale, as well as sedges, grasses, and other plants. Under the water are pond-weeds, bladderworts, tape grass, and water milfoil. Sponges produce conspicuous tufts and incrustation on submerged brush and other objects; some collected were *Myenia fluviatilis* and *Spongilla fragilis*. Leeches were common, and two forms were taken, *Haemopsis marmoratus* and *Placobdella rugosa*. Some isopods (*Mancasellus tenax*) were found. Larvae of May-flies (*Heptagenia*), some water bugs (*Corixa*), and a few whirl-i-gig beetles (*Gyrinus canadensis*), were the aquatic insects taken.

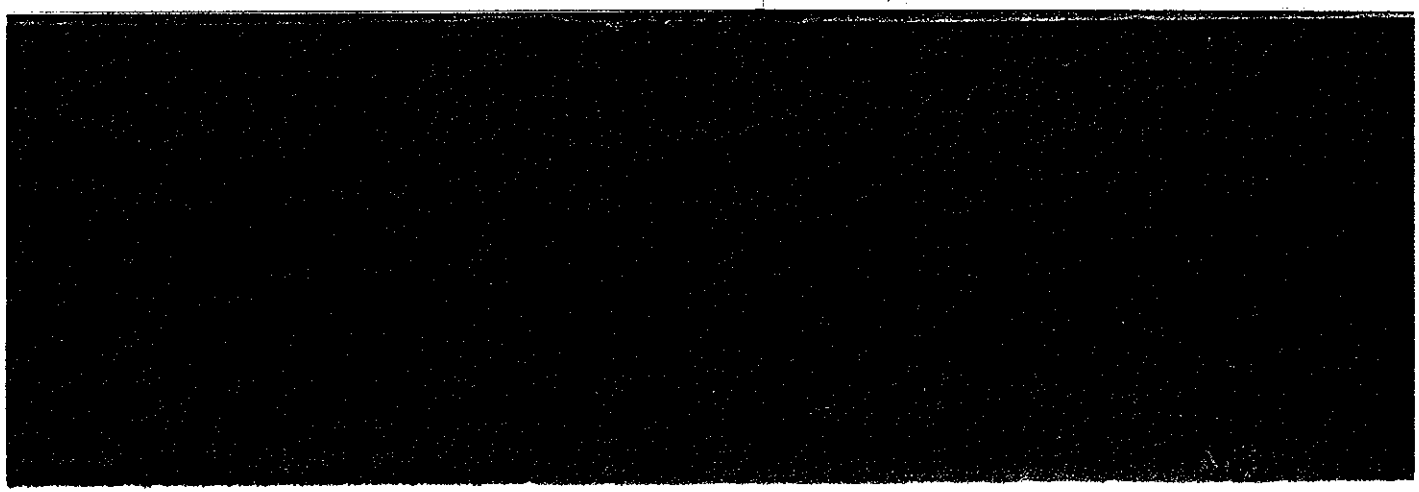
The more detailed observations on the fish were made at Station 142 (Plate XXVB). Small perch were very abundant here but they stayed about the water lily zone. Good-sized Cayuga minnows were in large schools on the shoal but chiefly on parts where the water lilies were absent and thus not associated closely with the perch. A few small pikes were found in the sweet gale zone along the shore here. One good-sized one (about nineteen inches long) was captured beneath the gale. The species of fish taken at this station were as follows: common perch, Cayuga minnow, spot-tailed minnow, common sucker, common pike, black-sided darter, Johnny darter, and common sculpin.

In the large marsh area at the west end of the lake and cut through by Shelldrake River, one or two specimens of each of the following were caught: mud minnow, common pike, Johnny darter, and common sculpin. A small crayfish, *Cambarus propinquus*, was taken here with the fish.

Shelldrake River.

A portion of Shelldrake River, about a half mile in length, lying about two miles southeast of Vermilion and about a quarter of a mile above Shelldrake Lake, was examined by wading the entire length of this portion and dipping with the hand seine in all places likely to have fish.

This part of the stream winds through a swamp with alders, spruces, birches, pines, and other trees, which produce a very dense growth (Plate XXVIA). It averages here perhaps thirty feet in width, but in places narrows to a few feet and widens to as much as fifty feet. The water is clear, and very free of sediment but stained. The bottom is of hard, firm sand and is bare almost everywhere except that it is



covered with humus in depressions or about plant growths. The depth is mostly less than two feet, but very irregular, with many shoals and pools, some five or more feet deep. Wading could be done, however, almost everywhere. The water was cold (63° F. on the day when the examinations of this part of the stream were made), and almost everywhere with a good current, but there are no rapids. Water plants were abundant in the swifter parts of the stream, forming oblong patches; the principal ones of these were tape grass, stoneworts, or slender-leaved pondweeds, and *Vaucheria*, the latter forming bottom mats or tufts.

Sponges (*Myenia fluviatilis*) were found, and crayfish (*Cambarus propinquus* and *C. virilis*) were caught. Water insects were usually in evidence. On the surface, were many water-striders and whirl-i-gig beetles (*Gyrinus ventralis* and *G. canadensis*). Beneath the surface, black-fly larvae were abundant on the leaves of tape grass, and some dragon-fly and May-fly larvae and caddice-worms were caught. Small bugs (*Arctocorisa nitida*) were taken in quantities in the seine. A few snails (*Physa gyrina*) were collected.

Small tadpoles were seen on quiet marginal shoals. Frogs and small toads (*Bufo americanus*) were frequently seen along the shore of the stream. Kingfishers were absent, which may have been due to the scarcity of small fish. Some beaver work was noted, but these mammals probably influenced the meager fish fauna of the river to a very slight degree. All conditions appeared to be favorable for a large fish fauna, but nevertheless fish were surprisingly few both as species and individuals. This part of the river looked like a fine trout stream but no trout were found in it by the writer or anyone else, according to good testimony. Brook trout are in the south fork of Shelldrake River, according to information received; and they have been planted there but apparently not elsewhere in the river. The following species of fish were caught in Shelldrake River: common sculpin, long-nosed dace, common pike, common sucker, Cayuga minnow, common perch, and long-eared sunfish (?).

The first three species are apparently the only ones at all generally distributed in the part of the stream examined, and sculpins are much more common than the others. A number of long-nosed dace were caught, but they were all very small. These, with the sculpins, were taken in the masses of stoneworts, tape grass and pondweeds that grow in the swift parts of the stream. The presence of so many sculpins may be an important factor in keeping trout from the stream for they are well-known destroyers of trout eggs. One sculpin opened had been eating a large burrowing May-fly larva and some other insects. Small pike were frequently seen along the quiet margins. A sculpin two

inches long was taken from a pike ten inches long. Another, smaller pike had eaten some small fish that were too badly digested for identification, and still another had fed upon insects. The suckers were scarce. All seen were little fish in a small school. The sunfish (two taken in a small bay with a muddy bottom) were the only members of the sunfish family found by the writer in the Whitefish Point region. A little perch, the only one caught in the river, was caught in the net with these sunfish. Conditions in Shelldrake River, thus, appear to be favorable for but one kind of fish, the common sculpin. The other species were not thriving there and were represented by few or small individuals.

LIST OF SPECIES.

The list below contains the data on thirty species of fish represented in the collections made in the Whitefish Point region by the writer. Following this is a hypothetical list giving names of species whose presence was not ascertained by the writer's data, but from published notes on their distribution and from statements made by people living in the region, the fish listed probably in some cases, possibly in others, belong to the fauna of northern Chippewa County. When there was opportunity to do so, color descriptions were made of fish fresh from the water or from aquarium specimens. Ridgway's Color Standard and Nomenclature (1912) was used in this work. Dimensions of fish are stated in inches and tenths of inches. The lengths given are total ones, from the tip of the snout to the tip of the caudal fin.

1. *Coregonus clupeaformis* (Mitchill). Labrador Whitefish.—Whitefish are abundant in Lake Superior, but they are chiefly in a zone where the depth is between sixty and a hundred feet (Paul Reighard 1910). This zone is close to the shore at the east end of the region, at Whitefish Point, but westward it departs farther and farther from the shore and is about eight miles out at Vermilion. The proximity of the area to the shore at Whitefish Point makes it very available to fishermen; hence the importance of the fishery there. Moore (1895) states that the best whitefish grounds on Lake Superior are at Whitefish Point. Goode (1884) calls attention to the importance of the fishing grounds here and to the many whitefish caught and the large size of some of them; he states that in seventy-four barrels of whitefish taken at one time, none were under six pounds and records one specimen that weighed twenty-three pounds. Mr. Robert Carlson informs the writer that about thirty tons of whitefish are taken at the Point every year, and the largest one that he knows of taken there weighed twenty-six pounds.

It is known that Labrador whitefish migrate shoreward, apparently to feed on insects, in the summer (Nash 1908 and Patton 1912), and

apparently the catching of a few adults, each nearly a foot long, in about eight feet of water at Vermilion in August 1913, is evidence of such a movement. One of these fish had in its stomach insects of several kinds, some of which were winged. In summer insects undoubtedly fall in the water in large numbers along the shore.

The specimens collected from the deeper part of the shoal (Station 2) agree well with the description of *Coregonus clupeaformis*, given by Jordan and Evermann (1911), but there is a possibility that some or all of them were Lake Erie Whitefish, *Coregonus albus*, many of which have been planted in Lake Superior. Mr. H. H. Marks says that fish packers can distinguish the two forms, and Mr. Carlson reports two types in the region, those with dark backs and those with backs more yellowish in color. From all this information it appears likely that *C. albus* is a valid species and is found in the Whitefish Point region.

Eighteen little whitefish, 3 to 3.5 inches in length, were found in a lot of small herring of similar size to them on the shoal of Lake Superior, at Stations 1 and 5 (Plate XXVIIIB). These were undoubtedly either *albus* or *clupeaformis* (Hankinson 1914) and perhaps both were represented in the schools. A typical one of these is described as follows: length, 3.5 inches; head in body, 4; depth in body, 5; eye in head, 3.5; snout in head, 3.5; interorbital space in head, 3.5; ventral line of caudal peduncle, 2.3; least depth of caudal peduncle in head, 3; dorsal rays, 12; anal rays, 12; branchiostegals, 8; gill-rakers, 10 plus 16; scales in lateral line, 75.

The writer has been unable to find a record in the literature of whitefish beyond the fry stage as small as these taken at Vermilion. Kendall (1903), writing of *Coregonus clupeaformis*, says, "It is not known to the writer that the young of this species has been observed, except the fry at fish hatcheries, or where they are to be found after leaving their birthplace in the thoroughfares and streams, or at what age they leave these places. It is probable that when quite young, they go to deep water, where, having thus escaped their enemies in the streams, they become the prey of rapacious fishes of the lakes." G. B. Goode (1884) says, "Relative to the movements of the whitefish in Lake Superior, Mr. George Barnston is of the opinion that the young and immature whitefish confine their range entirely to shallow water near shore. He states that pound nets in twenty to forty feet of water catch great numbers seven to eight inches long. From the fact that none have been found in lake trout stomachs, he infers the young whitefish are not in deep water where the trout dwell."

Eight of the little whitefish were opened and their food examined. The principal data are given below:

Size of fish, inches.	Entomostracans.	Chironomid larvae.	Winged insects.	Miscellaneous insects.	Algae.
*2.4	*Bosmina, Cyclops*	Several	One		
2	Copepods			Chironomid pupae	*Ulothrix zonata*
2.5	Copepods and Cladocera				*Ulothrix zonata*
1.9	Copepods				
3.5	Copepods and Cladocera	Few		Insect legs	*Ulothrix zonata*
3	Copepods	Few		Few	*Ulothrix zonata*
2.4		One		One	
*3	*Bosmina, Diaptomus and Cyclops*		Several	Insect pupae	*Ulothrix zonata*

*Stomach contents examined and identified by Chaney Juday.

The young whitefish, as shown above, were eating entomostracans freely, and this appears to be the chief food of those found near Vermilion. Chironomids were also taken by them in important numbers. In general the food of the young whitefish appears to be like that of the adult (S. J. Smith, 1873a, Forbes 1883a, Hankinson 1908, and Patton 1912). No evidence was obtained that whitefish spawn in the Vermilion region; a sandy bottom like the one there is unfavorable for this activity according to most writers. Leathers (1911), however, tells of their spawning on the broad sand flats in Huron County, Michigan. Mr. Robert Carlson informs the writer that whitefish spawn near Whitefish Point.

2. *Coregonus quadrilateralis* (Richardson). Menominee Whitefish.—This species was found common on the deeper part of the shoal near Vermilion (Station 2). Those taken were of edible size, a little over a foot long. Two typical specimens opened had been eating principally amphipods; one had these only in its stomach, and the other had miscellaneous insect remains in addition to them.

3. *Leucichthys harengus* (Richardson). Saginaw Bay Herring.—The many herrings found in the deeper part of the Lake Superior shoal are probably of this species for they agree with the description given of *L. harengus* by Jordan and Evermann (1911), who state that "The ordinary herring of Lake Superior are placed provisionally under *Leucichthys harengus*, of which they constitute a tangible variety or subspecies, distinguished by the larger size, the more cylindrical form, and, in general, by the still smaller adipose fin. But these characters are average only, and are subject to much variation, hence we refrain from regarding the Lake Superior herring a distinct species."

Large schools of little herring, two to three inches long, were frequently seen close to the shore, at Stations 1 and 5, but preferring the latter where there is a broad sandy area. Here they formed compact schools, which had remarkable coordination and rapidity of movements, making it difficult to get them with a seine. Associated with them

were a few young whitefish and other species. These young herrings were, in all probability, the same species as the adults taken from the deeper shoal, but since there are at least four other *Leucichthys* in Lake Superior (*L. supernas, L. cyanopterus, L. zenithicus,* and *L. tullibee*), whose young are apparently unknown in this body of water, it is possible that they also have young representatives on the shoal.

The coloration of one of the large herrings from Station 2, just as it was taken from the water, was as follows: upper parts, yellowish olive, except for a porcelain green streak just back of the dorsal fin; lower parts white, with light pinkish lilac reflections on the sides; dorsal and caudal fins olive; lower fins white. The very small herrings caught close to shore were similar in color to the large ones, but they were paler and more silvery on the sides.

Many lake herrings are caught at the Whitefish Point fishery. Mr. Carlson reports sixty tons taken there in 1914. They constituted the chief food fish for residents of Vermilion during the time the writer was in the region, and they are of much importance to these people. Many of them were discarded as unfit for food on account of parasitic worms in them. These were of two types: nematodes in coiled masses in the coelome and cestodes embedded in the flesh of the back.

Four small ones were examined as to their food, which was found to consist entirely of entomostracans, chiefly *Cyclops viridis brevispinosus.*

Forbes (1888) and Juday (1907) give notes on the food of Lake Herrings. G. B. Goode (1884) considers them great destroyers of whitefish eggs.

4. *Leucichthys tullibee* (Richardson)? Tullibee.—A tullibee was taken by a fisherman at Station 2, in a gill net (Plate XXVIII). In depth of body, size of eye, and number of branchiostegals, it is more like *L. manitoulinis* than *L. tullibee,* but it is most like the latter in length of head, maxillary, and anal fin and in the number of gill-rakers and scales before the dorsal fin. It, therefore, seems best to assign it to the species *tullibee,* but not with positiveness, because these characters are apparently variable (see table page 33, Jordan and Evermann 1911), because either species may be found in Lake Superior, and because the writer is able to examine but one specimen of tullibee and is unable at present to compare this with type specimens.

The following descriptive notes were made on this fish: Length, 10.6 inches; length to base of caudal fin, 8.5 inches; depth in length (to base of caudal) 3.3; adipose fin in eye, 1.3; eye in head 4.4; caudal peduncle, 2.5 in head; head in length, 4.3; dorsal fin with 12 developed rays; anal with 12 rays; scales in lateral line, 74; branchiostegals, 8; gill rakers, 16 + 32; color (fresh from water of the lake) upper parts bluish gray; lower parts white with brassy reflections on the sides.

5. *Salmo irideus* Gibbons. Rainbow Trout.—One specimen was taken at Station 2. It was about a foot in length, and in color was bluish slate above and white below, sides silvery with pinkish reflections, many small black spots scattered over the back and sides as well as the dorsal and caudal fins, which had a ground color like that of the back; lower fins white.

Four small fish, each about three inches in length, distended the stomach of this trout. They were badly digested, but there can be little doubt but that they are little herring.

The species is not native to Lake Superior, but it has been introduced in waters connected with it. Fishermen say that they are frequently taken in Lake Superior in the Whitefish Point region. Townsend (1902) records the capture of three at Whitefish Point, and of a large one, weighing seven pounds, taken there on July 9, 1900.

6. *Salvelinus fontinalis* (Mitchill). Eastern Brook Trout.—Common in a number of places in the Whitefish Point region, in Lake Superior, in the lower part of Vermilion Creek, in lower Cranberry Creek; and one was found in the beach pond into which Wetherbog Creek flows. None were seen in the marsh lakes or in Sheldrake River or Lake. In Lake Superior, the fish are of edible size, usually about a foot long. Here many were seen and some were caught in about six feet of water about Clarke's pier (Station 2). The following notes were made on a typical specimen from here just after it was taken from the water: length, 10.5 inches; color very pale compared with stream fish; a light bluish-green above, with faint marblings of a slightly darker shade of this color; sides silvery gray with lilac reflections and with a few indistinct spots, some white and some red; dorsal and caudal fins yellowish-green with dark mottlings; the other fins and the lower parts of the fish white.

All of the fish caught elsewhere than in Lake Superior were small; the dozen or so examples taken were 3 to 8.5 inches in length. The largest one of these was of a light yellowish-green above and white below; the sides had broad, slaty, transverse bands or "parr marks," which are found on small brook trout, and had conspicuous bright red spots.

In the small streams the brook trout were never seen unless disturbed, and then they would dart from beneath banks or other hiding places and back to near the same place; never swimming any distance in the creek before finding a retreat. A small trout found under a water-logged piece of timber in the beach pond at Station 122, re-

mained under this even when it was dragged on the bottom or rolled over; and it moved out far enough to be caught in the seine only after many attempts were made to dislodge it.

The food of brook trout in the region is, in all probability, chiefly insects, as it is in the other places where the food of the species has been examined (Needham and Macgillivray 1903 and Juday 1907). One fish from a stream had remains of insects in its alimentary canal, including winged forms, and one from Lake Superior had eaten a fly and a small fish.

The brook trout is a well-known game fish in eastern North America and a species that attracts many fishermen to northern Michigan, thus benefitting the state (Dickerson 1904 and Newcombe 1904); but no evidence could be found that the Whitefish Point region is ever visited by trout fishermen. In fact, the species appears to be of little value to the few people living there. None large enough for food are in the streams, and the ones in Lake Superior are only to be caught in small numbers and then with difficulty.

7. *Catostomus catostomus* (Forster). Long-nosed Sucker.—These suckers were frequently taken with common suckers from Station 2, but they were not as common as the latter. Three typical specimens (10.5-16 inches long) were preserved. In color they were as follows: dark greenish-olive finely spotted with light greenish-yellow due to each scale having a center of that color; sides yellow with metallic reflections; below white with a pinkish tinge, dorsal and caudal find similar to the back in color; lower fins of a light reddish brown.

The only other place where this species was found was in the beach pond at Station 31, where three little ones were caught.

8. *Catostomus commersonii* (Lacépède). Common Sucker.—Abundant in the shallow water of Lake Superior, both close to the shore, where schools of many little ones were frequently found, and farther out in eight or more feet of water, where many individuals about 1½ feet long were taken. Schools of the little suckers entered Vermilion Creek to feed near its mouth and also the beach ponds freely connectes with the lake (Stations 31 and 121). None were found in Mason's Creek or the connecting ponds on the Lake Superior beach. They were only locally abundant in the marsh lakes, since they were only found along the north shore of Beaver Lake, chiefly at Station 59 (Plate XXB). Some were present in Shelldrake River and in Shelldrake Lake, but they appeared uncommon here.

All of the little fish from close to the Lake Superior shore, chiefly in one or two feet of water, as well as those from the beach ponds were very uniform in size and appearance, commonly about 2.5 inches long. One of the larger fish (16.5 inches long) from the deeper shoal (Station 2) was in color like the others taken there. It was of a dark greenish olive above with numerous lighter spots of the same color due to each scale having a center of a lighter shade. The lower parts were white and the sides had brassy, metallic reflections.

The suckers in Beaver Lake are quite large. Many of them were about a foot in length, and they moved in large schools in two or three feet of water along the gale zone on the north side (Station 59). The three specimens caught there measured seven to eight inches in length There was much food in their intestines composed of chironomid larvae filamentous algae, diatoms, and undeterminable material. Eight specimens of the little common suckers from Lake Superior shoal had been eating chironomid larvae, entomostracans, *Ulothrix* filaments diatoms, and winged insects, with chironomids the principal food in each. Tracy (1910) says that these suckers eat young fish and fish eggs. Kendall and Goldborough (1908) found them feeding on black-fly larvae.

Common suckers are probably an important source of food for lake trout in Lake Superior (Nash 1913). In Beaver Lake, large pikes were especially common at Station 59 where these suckers predominated Residents of Vermilion used them little if at all for the table although many were taken with nets. The fish were given to chickens.

9. *Chrosomus erythrogaster* Rafinesque. Red-bellied Dace.—Red-bellied dace were found to be the most abundant of all the species of fish in the marsh lakes south and west of Vermilion, but in those east of Vermilion (Hay-Meadow, Mitten, and Wetherhog Lakes) the species is at least scarce for no examples could be found in the several large collections made in them and their outlet streams. Likewise, none were taken from Lake Superior, Shelldrake River, or Shelldrake Lake. A number were found in the few collections made at the north end of Little Lake. These dace preferred the shore regions of the small lakes in which they were found, especially the small deep bays and beaver channels, and the neighborhood of submerged patches of sweet gale.

The several hundred specimens captured ranged in length from .7 to 3 inches. The coloration of a few typical large ones was as follows olive green above; white below, with two indistinct dark stripes along each side of the back above the two prominent lateral ones separated by an area of yellowish green. These linear markings furnish a character by which the species is readily identified in the water. In some of the largest dace, the white lower parts were more or less red, a feature found in breeding males.

The red-bellied dace were most often found in schools, commonly associated with other species, but usually predominating when present Station 55 (a marsh bay of Beaver Lake) was an ideal place for them

The immense schools of minnows here contained more red-bellied dace than other species, but the following were also abundant in the schools: *Leuciscus neogaeus*, Cayuga minnow, black-head minnow, and silvery minnow.

The intestines of a number of the dace examined were filled with humus and many diatoms, alga filaments, and some pine pollen. Data on the food of the species is given by Forbes (1883), Needham (1908) and Ellis (1914).

10. *Hybognathus nuchalis* Agassiz. Silvery Minnow.—This species was found to be abundant at Station 55, in schools with red-bellied dace and other species (see supra). A few were found in other parts of the marsh lakes, except those east of Vermilion, where there were none. They are also found in the beach ponds west of Vermilion. Nowhere were they of full size, except at Station 55 where conditions appeared unusually favorable for the species. One which was opened had been eating some insects including chironomid larvae and mud rich in diatoms.

The hundred or so captured measured from 1 to 3.3 inches in length. One of the larger ones was colored as follows: light-yellowish olive above, below white with yellowish reflections, a distinct black lateral band, sides not silvery as they usually are in this species.

11. *Pimephales promelas* Rafinesque. Blackhead Minnow.—The species is similar in distribution to the red-bellied dace and the silvery minnow in that it is abundant in the west group of marsh lakes near Vermilion and relatively scarce and of small size in the east group. Like the others, it also finds optimum conditions in marsh bays (Station 52, 53, and 55). It was common in the beach ponds at Mason's Creek, and some were found in Little Lake.

Over two hundred of these minnows were taken; they measured from .7 to 2.5 inches in length. One of the larger specimens was of a light-yellowish olive above, fading to the white of the lower parts, and had a black, lateral stripe.

Mud rich in diatoms was found in a few intestines examined. Forbes (1883) found the species eating mud and insects, and Fowler (1908) states that it eats green algae and mud.

12. *Semotilus atromaculatus* (Mitchill). Horned Dace.—Horned dace were uncommon in the Whitefish Point region. Small specimens .7 to 2.7 inches long were caught in Beaver Lake, in Cranberry Creek and in the beach ponds west of Vermilion. The last named place was the only one in which they were found to be at all common.

13. *Leuciscus neogaeus* (Cope). This abundant species of minnow also belongs to the red-bellied dace association, and is very similar to it in distribution, except that it is fairly common in the east marsh

lakes. All of the specimens in the east lakes were small, howeve Many occurred in the beach ponds of the Mason's Creek region, an some were found in a small shallow bay at the north end of Little Lak

A hundred or more specimens were taken, which were 1 to 3.4 inche long. In color a typical large one was light yellowish-olive above an yellowish-white below, with a whitish streak along each side of the body and below this a grayish line, and then a jet black stripe. The side in a few specimens were tinged with pink, which brightened anteriorly This species resembles the red-bellied dace but differs from it in havin a more robust form, a larger and more oblique mouth, and a single not double, black lateral stripe.

14. *Abramis chrysoleucas* (Mitchill). Golden Shiner.—Small golde shiners (1 to 1.3 inches long) were found in Mitten and in Wetherbe Lake, but none were taken elsewhere.

15. *Notropis cayuga* Meek. Cayuga Minnow.—Cayuga minnow were common and very generally distributed in the Whitefish Poin region. They were common in the upper beach ponds west of Ver milion, in the west group of marsh lakes, and in Shelldrake Lake. A few were caught in Shelldrake River, and many were taken in the eas marsh lakes, but these were small in size, not over 1.5 inches long while most of the individuals caught in the west group (Beaver Lak and others) were about 2.5 inches long. The largest numbers wer found at Station 55, where they belonged to the red-bellied dace asso ciation. There is a tendency in most regions, however, for Cayug minnows to school by themselves.

Two large examples caught at Station 55 had been eating entomos tracans, insects, and diatoms.

16. *Notropis hudsonius* (DeWitt Clinton). Spot-tailed Minnow.— The minnow appears uncommon in the region, except possibly in Shell drake Lake. Six were obtained from Lake Superior close to shore i two feet or less of water; they were small, an inch or less in length, ex cept one, which was a fine large specimen 3.5 inches long. This larg specimen answers more closely to the description of typical *N. hud sonius* than it does to *N. hudsonius selene*, which is considered to be th typical Lake Superior form. The other fish were too small for sub species determination. The only other place where spot-tailed minnow were found in the region was Shelldrake Lake, where many little ones less than an inch long were found in the collections made along it northwest shore (Station 142. Plate XXVB).

17. *Rhinichthys cataractae* (Cuvier and Valenciennes). Long-nose Dace.—This fish was found in one very restricted region,—a deep are under the pier in Vermilion Creek, and close to Lake Superior. Twelv large ones (3 inches long on the average) were caught here (Plat

XXVIIB). In but two other places were long-nosed dace taken,—in Shelldrake River and on the Lake Superior shoal at Station 1, and these were small (about 1.5 inches). It was quite common in the river, and was found among thick plant growths in swift water.

One of the large fish from Vermilion Creek was grayish olive-green above and on the sides, under parts pinkish white, an indistinct dark, lateral band, the fins and head with a pinkish tinge.

18. *Rhinichthys atronasus lunatus* (Cope). Black-nosed Dace.—This species is also much restricted in the region and not at all associated with the long-nosed dace. It is abundant in the beach ponds formed by Mason's Creek, but was found elsewhere only in Cranberry Creek, where it appeared scarce. The eighty or more caught were from 1.5 and 3 inches in length.

19. *Umbra limi* (Kirtland). Mud Minnow.—Mud minnows are common in the shallow water of the marshes about the marsh lakes, and they are also found in some numbers in these lakes, but little information could be obtained concerning their abundance and distribution on account of the difficulty of getting them from the dense vegetation and the deep mud of their habitats in which they are said to retreat on being approached (Gill, 1904). Station 101 (Plate XXIII B) is a typical habitat for this species in the Whitefish Point region. A single specimen was found in the stomach of a pike taken in Wetherhog Lake. The twenty-two specimens collected measured 1 to 3.3 inches in length.

20. *Esox lucius* Linnæus. Common Pike.—Fish of this species are common in the marsh lakes and in Shelldrake Lake and River. None were found elsewhere in the region, but in all probability it occurs in Lake Superior (Townsend 1902).

Individuals reach a large size in the marsh lakes, at least in the west group, just south and west of Vermilion, where some very large ones were seen. A specimen 30 inches long caught on a trolling hook in this habitat weighed 6½ pounds. In color it was black on the back, sides gray, with scattered spots of greenish-yellow, lower parts yellowish-white. A pike 19 inches long was taken in Shelldrake Lake by the writer.

These large pikes preferred the deeper water of the marsh lakes and the cover of vegetation, such as gale growths. A number were usually seen at Station 59, perhaps to prey on the suckers that schooled there. Small ones (four to ten inches) were common in shallow bays of these lakes and of Shelldrake River.

The stomachs of the small pike caught were for the most part empty. One had eaten a mud minnow and a leech; in another, from Shelldrake River, a sculpin was found.

The pike is a well-known predator. Notes on its food are given l Forbes '78, '88, and '88a, Kirsch '94, Marshall and Gilbert '05, a Reighard '13a. Besides fish they sometimes eat crayfish, other cru taceans, water insects, and leeches.

Residents of the Vermilion region seldom use the pike for food; i flesh is said to be "wormy." The large specimen caught in the mars lakes had flesh of the usual good quality for the species, and no par sites were evident in it. Pikes are said to be detrimental in the regio by catching wild ducklings and young muskrats.

The marshes about the small lakes must furnish excellent breedi places for pikes in the early spring, and according to information giv by residents many frequent these places at that time.

21. *Fundulus diaphanus menona* (Jordan and Copeland). Barre Killifish.—Seven (1-3 inches) were caught from two diverse and sepa ated regions; five from the Mason's Creek pools and two from t west end of Mitten Lake. The species is poorly represented in t region.

22. *Eucalia inconstans* (Kirtland). Brook Stickleback.—The broo stickleback is very common and generally distributed in the Whitefis Point region. It was found in all of the bodies of water examine except Shelldrake River and Lake. Only two, very small ones we taken in Lake Superior. They were numerous in the beach pon connected with Mason's Creek, and the pool beneath the beaver da here appeared to have optimum conditions. Many were also o served in Vermilion Creek, where they prefer deep, quiet poo with much algae and other vegetation. While they are numerous Beaver Lake and others of the west group, they are scarce in the ea group, the beaver dam at Station 110 apparently marking the limit their eastward extention in this system of small lakes. They are ve common in Little Lake, at least at its north end.

The sticklebacks were easily seen and distinguished in the water, a they were usually suspended, apparently motionless, off the botto When the bottom soil is disturbed they quickly gather about the clou evidently looking for food. They appear to be insectivorous in t region for insects with a little algae made up the stomach contents the few opened.

The two hundred or more specimens collected were from .7 to 2 inches in length.

23. *Pygosteus pungitus* (Linnæus). Nine-spined Stickleback. This species was not found elsewhere than in Lake Superior, where it exceedingly abundant, outnumbering by far all other kinds of fi found there. The enormous schools came shoreward in quiet, war weather, where they remained a short distance out from shore in abo

a foot of water. They were not closely associated with the other small fish, but a few small suckers and young herring were occasionally with them. For some reason, they avoided all but the sandy bottoms and in no instance were these schools seen over the pebble zone, although often close to its margin.

The sixteen specimens opened had been eating entomostracans. The material appeared to be the same in all of the fish, and it was of an orange color and showed through the thin body walls of most of the several hundred captured. The contents of twelve stomachs were sent to Mr. Chauncy Juday, who determined the material as fragments of *Cyclops viridis, brevispinosus, Diaptomus ashlandi,* and *Bosmina longirostris.* It will be seen that these hoards of little sticklebacks were eating the same objects as were the young whitefish and herrings. They are, thus, of some economic interest as competitors of these more useful fish.

24. *Lepomis megalotis* (Rafinesque) (?).—Two small sunfish were taken in a little bay having about a foot of water and a mud bottom in Shelldrake River. These were the only sunfish, in fact the only members of the Centrarchidae found by the writer in the Whitefish Point region.

They were each about 1.5 inches long. While they answer well to the descriptions of *L. megalotis* and resemble specimens of that species, the present state of our knowledge of *Lepomis,* makes it impossible to identify with certainty such small specimens as these, especially since they came from a region remote from any where sunfish have heretofore been thoroughly studied.

25. *Perca flavescens* (Mitchill). Yellow Perch.—Perch were common and the most generally distributed of all the fish in the Whitefish Point region, according to the writer's notes. Many small ones (1 to 1.5 inches long) were present on the shoal of Lake Superior, either solitary, in schools, by themselves or in schools of small suckers and herring. They did not appear to associate with the sticklebacks. They are uncommon in the beach ponds, and none were found in those not freely connected with Lake Superior. The marsh lakes contained many perch, both large and small, and here also they were found as solitary individuals and in schools, the latter being always made up of perch of about the same size. Companies of large perch appeared to wander freely about in some of the marsh lakes, not clinging to the neighborhood of the shores as most of the smaller lake fish did. They tended, however, to remain in the deeper water, from which they were readily caught with hooks baited with leeches.

In the northwest corner of Shelldrake Lake conditions seemed to be very favorable for young perch for large numbers of them were found about the water lily growth there.

Some of the large perch from Station 24 of the marsh lakes were colored as follows: light yellowish olive above with transverse bands of olivaceous black, sides yellowish-white, under parts white, pectoral and anal fins greenish yellow, ventral fins reddish orange.

One fish, 8 inches long, from Station 24, had eaten two leeches and a caddice larva. In the stomachs of four little perch from the Lake Superior shoal were entomostracans (*Cyclops viridis brevispinosus* and *Diaptomus ashlandi*), which were the same as those making up the bulk of the material in the stomachs of the young whitefish, herring and sticklebacks found in the same habitat. Notes on the food of this species are given by S. I. Smith (1873a), who found them eating small fish, spawn of fish, and dipterous larvae, and by Forbes (1880), who obtained from stomachs of adults, mollusks, crustaceans, insects, and small fish, and in the stomachs of the young entomostracans and *Chironomus.* Forbes (1890a) records perch eating large, red *Chironomus* larvae in certain Wisconsin lakes. Marshall and Gilbert (1905) state that perch eat insect larvae, snails, crayfish, some other crustaceans, minnows, fish spawn, plankton, and plants.

Perch are eaten by at least two species of fish found in the Whitefish Point region, the common pike and the burbot (Reighard 1913 and Forbes 1888).

G. B. Goode (1884) considers perch common along the south Lake Superior shore and states that Whitefish Bay has fishing grounds for perch, and that fishermen consider them detrimental to whitefish.

26. *Hadropterus aspro* (Cope and Jordan). Black-sided Darter.—One small example of the black-sided darter, an inch long, was found in the collection made in the shallow water at the northwest corner of Shelldrake Lake.

27. *Boleosoma nigrum* (Rafinesque). Johnny Darter.—Four specimens, 1 to 1.5 inches long, were found in the collection made at the northwest corner of Shelldrake Lake.

28. *Etheostoma iowae* Jordan and Meek. Iowa Darter.—This darter is common in the marsh lakes, but none were found elsewhere in the region, except one small example in the small beach pool at Station 121. In the marsh lakes they are present over both sandy and mucky bottoms. On the latter a network of their trails often formed a conspicuous bottom feature.

Some fifty specimens, 1 to 1.7 inches in length, were taken. A few of them were in high coloration as follows: above greenish-yellow with faint dark blotches, the dorsal fin black with a coral red band near it

outer edge, sides of the body with about ten feruginous spots interspersed with bluish dusky ones, below yellowish white.

29. *Coltus ictalops* (Rafinesque). Common Sculpin.—Sculpins are common on the Lake Superior shoal (Station 1), where they appear to frequent the pebble zone. Many were also found in Shelldrake River in the thick submerged masses of tape grass and stonewort, and a few were caught in Shelldrake Lake. They appeared to be scarce in the marsh lakes, as none were found in the many collections made from them by the writer. But in the summer of 1914, Mr. N. A. Wood caught two in the marsh lakes in three or four feet of water, one on a sandy bottom and the other over a mud bottom. Aquatic plants were absent in both places. No sculpins were found in the beach ponds or in the streams draining the marsh lakes except at their mouths. It should be stated, however, that this data on the distribution of sculpins in the Whitefish Point region probably has little significance owing to the difficulty of getting them with nets or of seeing them in the water.

Some thirty specimens were taken. These were 1 to 3.5 inches in length. One from Shelldrake River had a large, burrowing May-fly larva in its stomach as well as fragments of other insects. A sculpin was found in the stomach of a small pike taken in the Shelldrake River.

30. *Lota maculosa* (LeSueur). Burbot.—Two of these were taken, —one at Station 1 on the Lake Superior shoal and one in the mouth of Vermilion Creek. They were both small specimens, 2.5 to 7 inches in length. The largest one was colored as follows: above light greenish yellow mottled with darker, a violet reflection on the caudal fin, lower parts and lower fins white, the latter with a bluish and pinkish tinge.

The stomach of the larger specimen contained the remains of five or more small fish and chironomid larvae. The habits of the fish are similar to those of sculpins, hence few were noted. Residents of Vermilion say that they are common in Lake Superior. If so, their predaceous habits make them important enemies of fish in this body of water. Forbes (1888) found young perch, young whitefish, and a crayfish in the stomachs examined, and he considers young perch an important article of food for this species.

HYPOTHETICAL LIST OF SPECIES.

It is evident that only a month of collecting and observing would almost certainly not reveal all the species of fish found in the region studied. Lake Superior shoal forms could easily be overlooked and fish that visit this region at other times of the year would not be found. It was, therefore, considered advisable to attempt to make a list of species not found by the writer but probably present in the region, as a guide to future collectors.

On the preparation of this list the writer made many inquiries of members of the Life Saving crew at Vermilion and of others familiar with the aquatic life there, who were willing and capable of giving reliable information; and he has examined the literature pertaining to Lake Superior fish, and has corresponded with ichthyologists who might furnish facts concerning the aquatic biota of the region. Chiefly from these sources the data given in the following hypothetical list has been obtained.

1. *Acipenser rubicundus* Le Sueur. Lake Sturgeon.—Sturgeons are said to visit the shallow water of Lake Superior near Vermilion, and Mr. John Clarke informed the writer that they used to run up the Tahquamenon River which enters Whitefish Bay. Records of sturgeons in Lake Superior are given by Smith and Snell (1885), who say that they are captured there but seldom marketed. Cox (1897) states that they are often taken in Lake Superior. Townsend (1902) reports 711 pounds taken from Lake Superior in 1899 with pound and trap nets, and asserts that they are not as common in Lake Superior as in the other lakes.

2. *Amia calva* Linnaeus. Dogfish.—Mr. Robert Carlson reports that the dogfish or bowfin is caught at Whitefish Point.

3. *Leucichthys harengus arcturus* Jordan and Evermann.—This subspecies was recently described by Jordan and Evermann (1911). The type specimen is from Knife River, Duluth, Minnesota. It is possible that all *L. harengus* of Lake Superior belong to this subspecies.

4. *Leucichthys eriensis* (Jordan and Evermann).—Recorded from Port Arthur, Lake Superior, by Fowler (1911).

5. *Leucichthys supernas* Jordan and Evermann. Cisco of Lake Superior.—The species was described by Jordan and Evermann (1911). It is said to be a deep water form, living in water 300 feet or over in depth. Absence of information concerning the habits and characteristics of the young of this and other *Leucichthys* of Lake Superior, makes it impossible to determine whether or not this species is represented in the hosts of little herring that school in the shallow water of Lake Superior near Vermilion.

6. *Leucichthys prognathus* (H. M. Smith.) Cisco of Lake Ontario.—Nash (1908) reports this fish from the Great Lakes except Lake Erie, and it is recorded from Devil's Isle, Lake Superior, by the Bureau of Fisheries at Washington (Michael 1904).

7. *Leucichthys johannae* (Wagner).—Found in Lake Superior, according to Wagner (1910).

8. *Leucichthys nigripinnis* (Gill). Blackfin of Lake Michigan. The blackfin is said to be common in Whitefish Bay. Townsend (1902) states that 36,818 pounds have been taken in Whitefish Bay

since 1893, when it was first noticed there. Nash (1908) reports it as occasionally taken in Lake Superior.

9. *Leucichthys cyanoptera* Jordan and Evermann.—Found in deep water of Lake Superior (Jordan and Evermann 1911).

10. *Leucichthys zenithicus* (Jordan and Evermann).—This form according to Jordan and Evermann (1911) and H. M. Smith (1894), occurs in deep waters of Lake Superior.

11. *Leucichthys manitoulinus* Jordan and Evermann. Manitoulin Tullibee.—North channel of Lake Huron and perhaps in Lake Superior according to Jordan and Evermann (1911).

12. *Cristivomer namaycush* (Walbaum). Lake Trout.—No lake trout were found by the writer, but there is abundant evidence that they occur at least in the deep water near Vermilion. Mr. N. A. Wood got one weighing fifteen pounds about a mile out from Vermilion in the summer of 1914. John Clarke informed the writer that they frequent the shoal at times, and other reliable testimony as to their occurrence there was obtained. A number of plantings of the species have been made at Whitefish Point and Grand Marais.

The lake trout is a well-known predator. The one taken in 1914 by Mr. Wood had five sculpins, each about three inches long in its stomach. Nash (1913) states that they eat herrings, young whitefish, and other soft-finned fish. Mr. John Clarke says that they spawn in fall in five or six feet of water where the bottom is gravelly in Lake Superior. Nash (1908) states that the spawning season in Lake Superior commences early in October.

13. *Cristivomer namaycush siscowet* (Agassiz). Siscowet.—This subspecies is said to live in Lake Superior, in water from three hundred to nearly five hundred feet deep. Jordan and Evermann (1911) state that, "It is never seen in shallow water." It is doubtful if it should be included in this list.

14. *Salmo gairdneri* Richardson. Steelhead Trout.—These trout have been planted in streams tributary to Lake Superior and are said to frequent the open lake. Nash (1908) states that they have been introduced in Lake Superior with marked success.

15. *Hiodon tergisus* Le Sueur. Toothed Herring.—Probably occurs in Lake Superior. Nash (1908) states that it ranges to Lake Superior.

16. *Alosa sapidissima* (Wilson). The Shad.—Mr. Robert Carlson reports taking one at Whitefish Point. Nash (1908) says "it was formerly abundant in the lower Ottawa but has abandoned that river and its occurrence within our boundaries is now only accidental.

17. *Pimephales notatus* (Rafinesque). Blunt-nosed Minnow.—Recorded from Sault Ste. Marie by Meek and Clarke (1902). Found in the Lake Superior Region at Bear Lake, Houghton County, Michigan, in 1905, by the writer.

18. *Notropis heterodon* (Cope). Black-chinned Minnow.—Recorded from Sault Ste. Marie by Meek and Clark (1902).

19. *Notropis atherinoides* Rafinesque. Shiner.—Recorded from the Lake Superior region by Agassiz (1850) and by Meek and Clark (1902).

20. *Notropis cornutus frontalis* (Agassiz).—Recorded from Lake Superior by Agassiz (1850) and from the Lizard Islands in Lake Superior and from Sault Ste. Marie by Meek and Clark (1902).

21. *Couesius plumbeus* (Agassiz).—Lake Chub.—In Lake Superior, according to Nash (1908). Recorded from the region by Agassiz (1850). Found in a small lake in Houghton County, Mich., in 1905, by the writer. Cope (1866) records it from Keweenaw Point. Jordan and Evermann (1896) give its range as including Lake Superior.

22. *Ictalurus punctatus* (Rafinesque). Channel Cat.—It is possible that this species is recorded from Lake Superior under the term "catfish" by Townsend (1902). A letter from the U. S. Bureau of Fisheries interprets this name as including this and the following two species.

23. *Ameiurus nebulosus* (LeSueur). Common Bullhead.—Recorded for Lake Superior by Agassiz (1850) and probably included under the term "catfish" by Townsend (1902), who states that 6,200 pounds of catfish and bullheads were taken in Lake Superior in 1899, by fyke, trap, and pound nets.

24. *Ameiurus lacustris* (Walbaum). Catfish of the Lakes.—Nash (1908) states that this species is distributed throughout the Great Lakes. Jordan and Evermann (1896) give it as abundant in the Great Lakes, and Townsend (1902) probably includes this species among the "catfish" from Lake Superior.

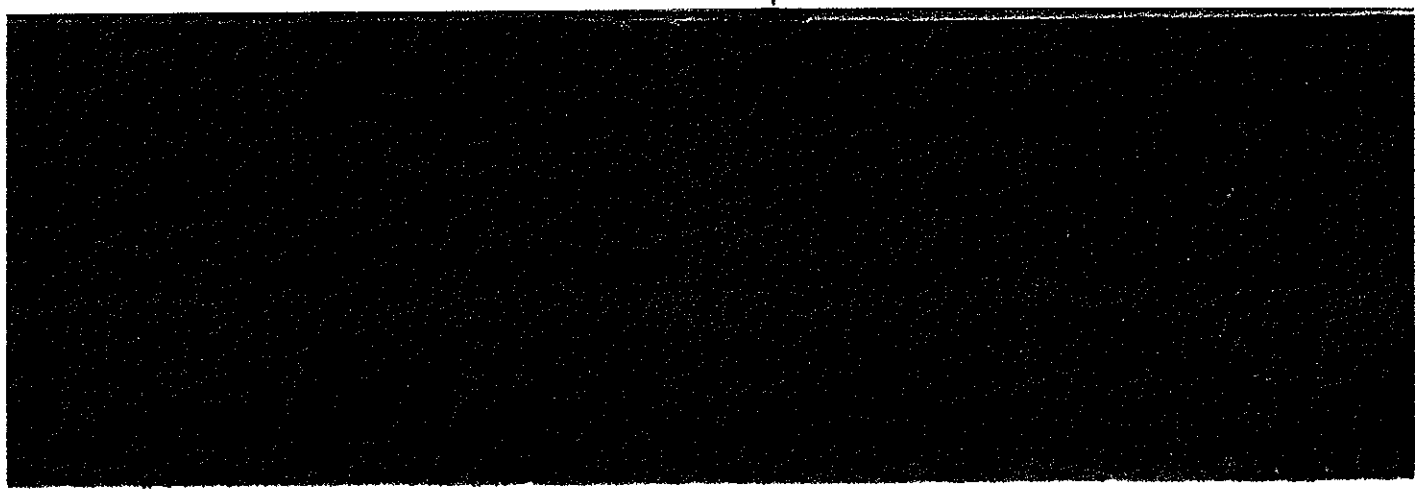
25. *Esox masquinongy* (Mitchill). Muskallunge.—Recorded from southwest Lake Superior by Goode (1884). Found in Portage Lake in Houghton County, Michigan, by the writer in 1905.

26. *Percopsis guttatus* Agassiz. Trout Perch.—Agassiz (1850) and Meek and Clark (1902) record the species from Sault Ste. Marie, Michigan. Nash (1908) states that it is frequently taken in the clear, cold water of Lake Superior.

27. *Amblopliytes rupestris* (Rafinesque). Rock Bass.—Townsend (1902) reports that 734 pounds of rock bass were caught in Lake Superior in 1899, with fyke nets, pound nets, and trap nets. Meek and Clark (1902) record it from Sault Ste. Marie.

28. *Micropterus salmoides* Lacépède. Large-mouthed Black Bass.—Found in Lake Superior, according to Michael (1904).

29. *Stizostedion vitreum* (Mitchill). Wall-eyed Pike.—Townsend



(1902) states that wall-eyed pike occur in Lake Superior and that they are caught chiefly in Chippewa County, Michigan. Goode (1884) says they are abundant in west Lake Superior, and gives a record of three hundred pounds taken at Whitefish Point, although they are not considered plentiful there. Apparently they are periodic in their occurrence in this region of the lake.

30. *Percina caprodes* (Rafinesque). Log Perch.—Found in Lake Superior according to Jordan and Evermann (1896), and recorded from Sault Ste. Marie by Meek and Clark (1902).

31. *Etheostoma caeruleum* Storer. Rainbow Darter.—Recorded from Lake Superior by Abbott (1860).

32. *Roccus chrysops* (Rafinesque). White Bass.—Nash (1908) reports the species from the Great Lakes of Ontario. Goode (1884) states that it is found about the Apostle Islands but not elsewhere in Lake Superior.

33. *Aplodinotus grunniens* Rafinesque. Fresh-water Drum.—Common and distributed throughout the entire Great Lake region, according to Nash (1908).

34. *Uranidea franklini* (Agassiz). This species is recorded from Lake Superior region by Meek and Clark (1902), Girard (1851), Ruthven (1909), and Nash (1908).

SUMMARY AND CONCLUSIONS.

The field work of 1913 established the occurrence of thirty species of fish in the Whitefish Point region. That at least thirty-four others belong to the fauna is very evident from testimony of residents and published data. Each of the species of fish found in the region by the writer may be considered common there with the exception of the following: tullibee, rainbow trout, horned dace, golden shiner, Menona top minnow, long-eared sunfish (?), black-sided darter, and Johnny darter.

Of the thirty species of fish taken, eighteen are common and generally distributed in the region of the Great Lakes and in the Central States generally. Only eight are boreal in distribution. These are Saginaw Bay herring, tullibee, Labrador whitefish, Menominee whitefish, long-nosed sucker, *Leuciscus neogaeus*, Menona top minnow, and nine-spined stickleback. The rainbow trout exists in the region through artificial introduction.

Within the Whitefish Point area, the different species are restricted in distribution, forming five rather distinct faunas, which are (1) that of the Lake Superior shoal, (2) of the beach ponds, (3) of the west group of marsh lakes, (4) of the east group of marsh lakes, and (5) of Shelldrake River and Lake. No one species was found in all of these

habitats and but few are at all generally distributed. The species of widest habitat range are common perch, brook stickleback, common sculpin and Cayuga minnow. Some very limited in distribution are sunfish (Lepomis), Menona top minnow, golden shiner, long-nosed dace, black-sided darter, and Johnny darter.

Of the fifteen species of fish taken from the Lake Superior shoal, seven were not found in the inland bodies of water. These were lake herring, tullibee, Labrador whitefish, Menominee whitefish, rainbow trout, nine-spined stickleback, and burbot. One burbot, however, was found in Vermilion Creek right at its mouth, where Lake Superior shoal conditions were present.

Of the twenty-three species taken in the inland bodies of water, fifteen were not found in Lake Superior. These were, red-bellied dace, silvery minnow, black-head minnow, Cayuga minnow, horned dace, golden shiner, black-nosed dace, *Leuciscus neogaeus*, mud minnow, Menona top minnow, common pike, Iowa darter, black-sided darter, Johnny darter, and the sunfish.

The species common to Lake Superior and the inland habitats are: brook trout, spot-tailed minnow, long-nosed dace, long-nosed sucker, common sucker, brook stickleback, common perch, and common sculpin.

Twenty species of fish were found in the marsh lakes and their outlet streams, of these five were abundant in the west group of lakes but scarce or absent in the east group. These were, red-bellied dace, silvery minnow, black-head minnow, common sucker, and brook stickleback.

Shelldrake River and Shelldrake Lake have a fauna very different from that of the marsh lakes and Lake Superior, for of the eleven species caught there, three (blacksided darter, Johnny darter, and the sunfish) appeared peculiar to the habitat and two (long-nosed dace and spot-tailed minnow) were scarce elsewhere but common in the Shelldrake region.

It was not possible in the time available to examine in detail the relations existing between the fish and their environment and thus to determine the ecological factors governing the distribution, but the general environmental features influencing the fish life of the region are climate, bottom soil, plants, and aquatic animals.

Climate. The long winters and cold nights even in summer subject the fish, especially those of the shallow lakes and ponds, to much low temperature. This undoubtedly affects their numbers, size, and activity. Fish are said to leave the shallow water near the shore of Lake Superior on the approach of storms. None could be found there during bad weather, and they only became numerous during rather

prolonged periods of quiet. Residents say, however, that herrings are thrown ashore at times by the waves. Water movements in all probability disturb the sand down to a depth of twenty-six feet as they do in Lake Michigan (Shelford 1913, page 74).

Bottom material. No definite relations of bottom soil to fish could be made out, yet certain types of bottom were preferred to others by certain fish. In Lake Superior the submerged pebble zone was avoided by the schools of free swimming young herring, perch, and suckers, as well as by sticklebacks and some others, while sculpins and burbots evidently preferred the stony area. In the marsh lakes, there was noted a marked preference for the muck bottoms on the part of all species. The loose, black soil undoubtedly harbored much food and furnished hiding places for the small fish, although none were seen retreating into it.

Plants. The larger aquatic plants are used by the fish for protection and seclusion. Growths of stonewort, water weeds, tape grass, and pondweeds were found utilized in this way. Partly submerged sweet gale, sedges, and many other plants of similar habits also furnished concealment for fish; pike lie in ambush about their submerged bases. Filamentous algae was eaten by common suckers, young whitefish, brook sticklebacks, and sculpins, according to the writer's observations, and diatoms were found in many digestive canals, especially those of common suckers, Cayuga minnows, silvery minnows, and black-head minnows. The food value of these little plants is questionable.

Invertebrates. The invertebrates are an important part of the fish environment when they serve as food or become parasites. The principal forms eaten by fish in the region are entomostracans, chironomid larvae, black-fly larvae, May-fly larvae, caddice-worms, amphipods, and leeches. Entomostracans constituted the chief food of young herring, young whitefish, and nine-spined sticklebacks on the Lake Superior shoal. All were feeding on the same forms, which belonged chiefly to the Crustacean genera, *Diaptomus, Bosmina*, and *Cyclops*. Small suckers, and perch, on this shoal, were also eating these forms to a considerable extent. Chironomid larvae are extensively taken by the fish of the Whitefish Point region; they seemed especially important to bottom feeders, suckers, sculpins and burbots. Black-fly larvae appeared to be the sole food for the colony of long-nosed dace living near the mouth of Vermilion Creek. Sculpins were also eating them in Shelldrake River. Amphipods made up most of the stomach contents of the few whitefish caught in the deeper part of the shoal. Leeches were eaten by large perch in the marsh lakes.

Vertebrates. The vertebrates are especially marked factors in the fish environment when they prey upon fish. Brook trout, rainbow

trout, common pike, and sculpins were found eating other fish. Of these the most important destroyers seem to be the common pikes, for they are numerous and often of a large size. Sculpins appear to eat other fish extensively in the region, including members of their own species. Some fish-eating birds are common. These are loons, blue-herons, night herons, bitterns, kingfishers, mergansers, and grebes. Kingfishers frequently attack schools of small fish. Minks are considered common in the region. If they are, many fish are probably eaten by them. Fish probably to some extent destroy other vertebrates for large pikes are said to catch young muskrats and young ducks in the marsh lakes.

Fish affect each other through competition for food. A conspicuous instance of this in the Whitefish Point region is in the case of the hosts of nine-spine sticklebacks eating the same food as the much-less numerous little whitefish and herring and other species of the shallow water.

Most of the species of fish in the Whitefish Point region influence man in unimportant ways. Whitefish, herring, and brook trout, furnish food for residents and the first two are of much commercial value at Whitefish Point, where many tons of them are taken each year and are the cause of a very important fishery there. Man and the beaver have varied the character of the fish habitats through dams, channels, and other structures that they have built about the marsh lakes.

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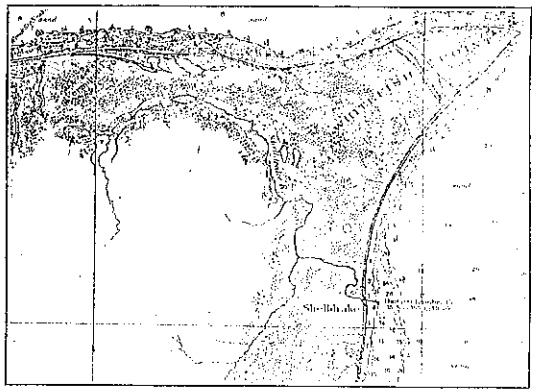
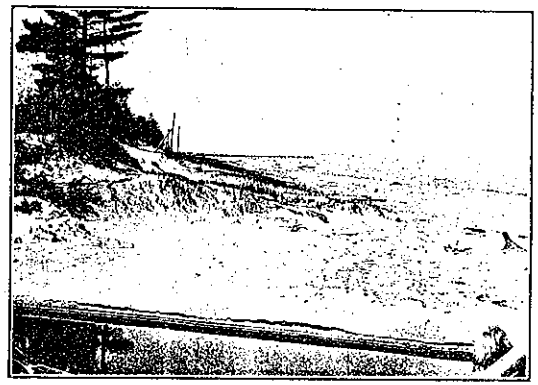
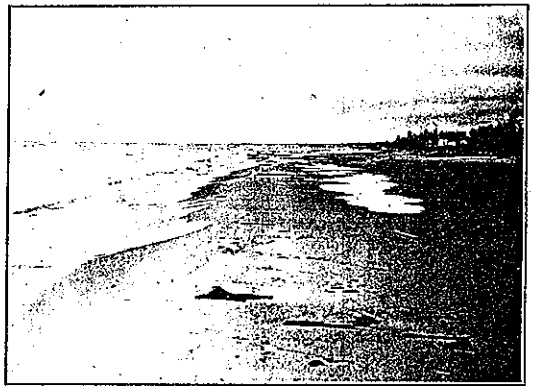


MAP OF THE WHITEFISH POINT REGION, CHIPPEWA COUNTY, MICHIGAN.

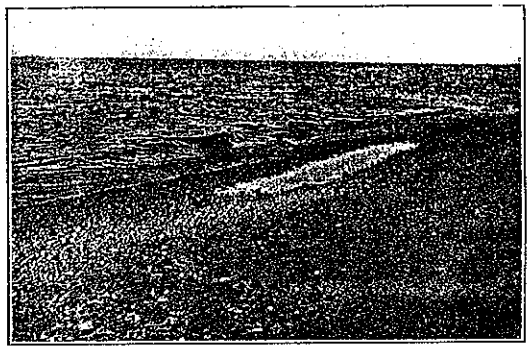
A. LAKE SUPERIOR BEACH AT VERMILION. UPPER AND LOWER BEACH SHOWN; THE LATTER WITH *AMMOPHILA ARENARIA* ZONE, SHOWN CHIEFLY IN THE FOREGROUND.



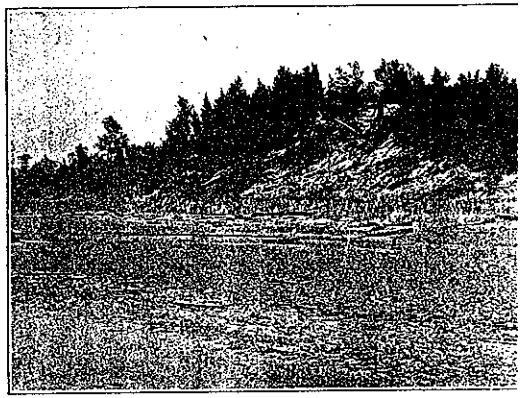
B. LAKE SUPERIOR BEACH WITH SAND RIDGE CROSSED BY CRANBERRY CREEK, JUST EAST OF VERMILION.



A. LAKE SUPERIOR BEACH, LOOKING EAST TOWARD VERMILION, DURING A STORM. SHOWING FORMATION OF TEMPORARY POOLS BY WAVES.

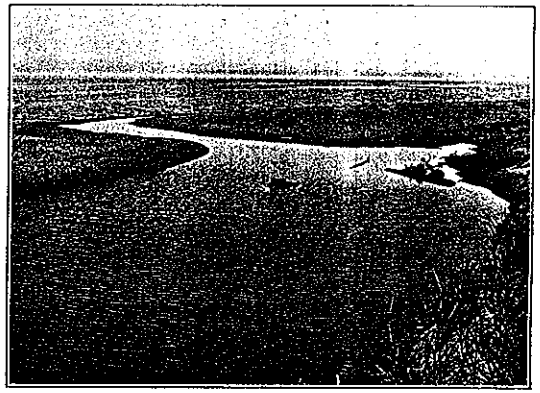


B. SMALL PORTION OF LAKE SUPERIOR BEACH SHOWING PEBBLE ZONE AND SMALL TEMPORARY POND.

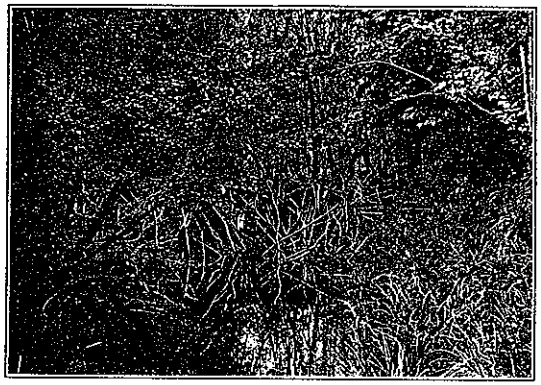


A. LAKE SUPERIOR BEACH WITH DUNES OF THE FIRST SAND RIDGE.

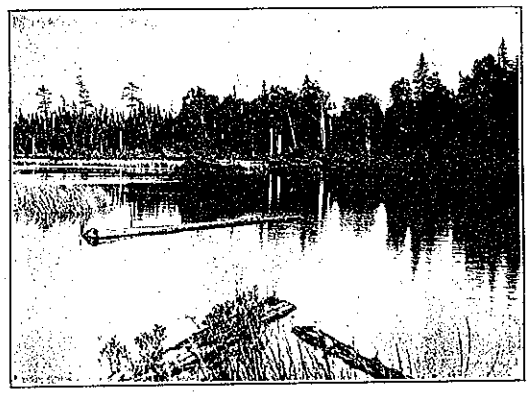
B. CRANBERRY CREEK (STATION 30). LOOKING NORTH AND DOWN STRE. SHOWING A PART OF THE BEACH POOL FORMED BY IT (STATION 31)



A. POND ON LAKE SUPERIOR BEACH (STATION 31) FORMED BY CRANBERRY CREEK.

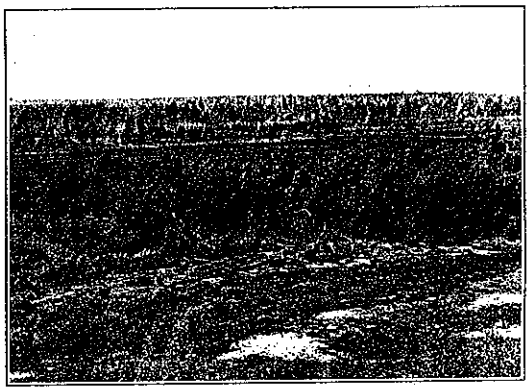


B. BEAVER DAM AND POND ON MASON'S CREEK (STATION 171).

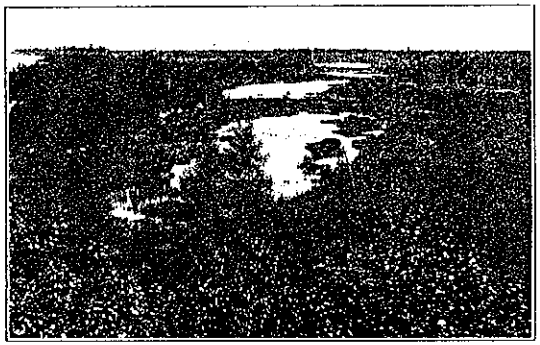


A. BEACH POND IN THE COURSE OF MASON'S CREEK.

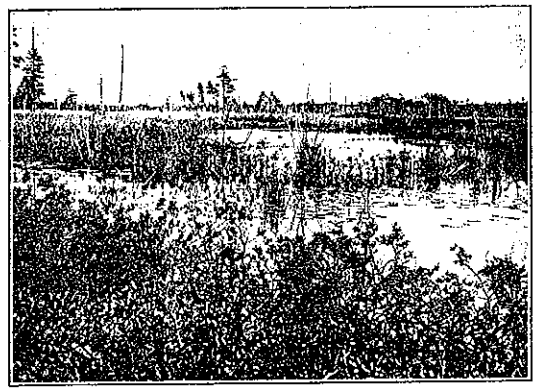
B. MARSH BORDERING MASON'S CREEK (STATION 172) ON LAKE SUPERIOR BEACH.



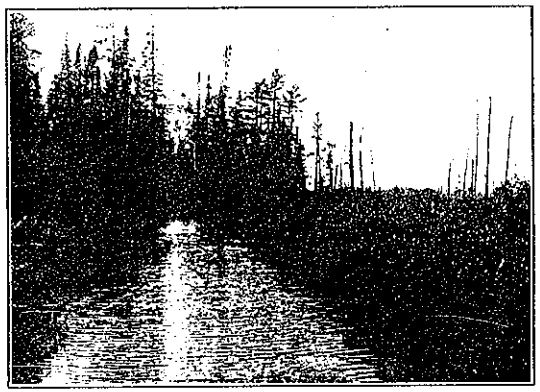
A. LOOKING SOUTHWEST FROM HIGH SAND DUNE NEAR STATION 101, SHOWING MARSH AND SAND RIDGES WITH UPLAND IN DISTANT BACKGROUND.



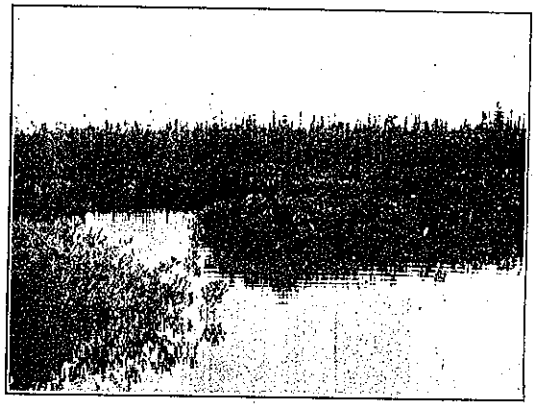
B. MARSH LAKES, LOOKING SOUTHEAST FROM THE HIGH DUNE NEAR STATION 101.



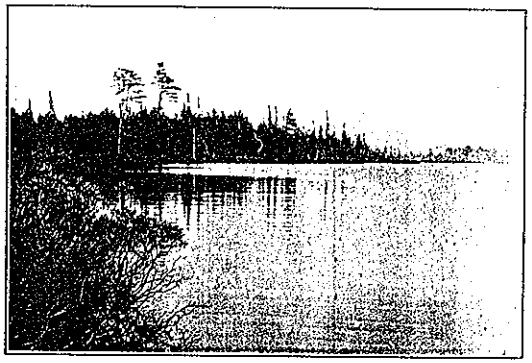
A. CHANNEL EAST FROM BEAVER LAKE (STATION 90).



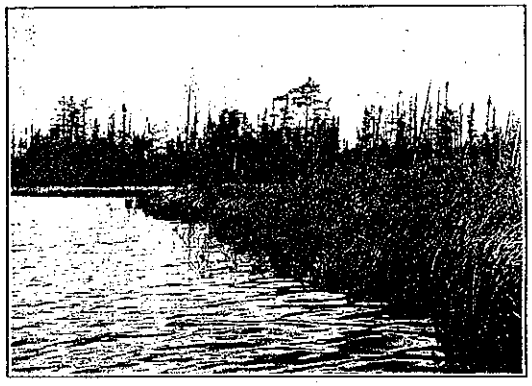
B. CHANNEL OF VERMILION LAKE (STATION 25).



A. MARSH BAY OF BEAVER LAKE (STATION 52), LOOKING NORTHEAST.

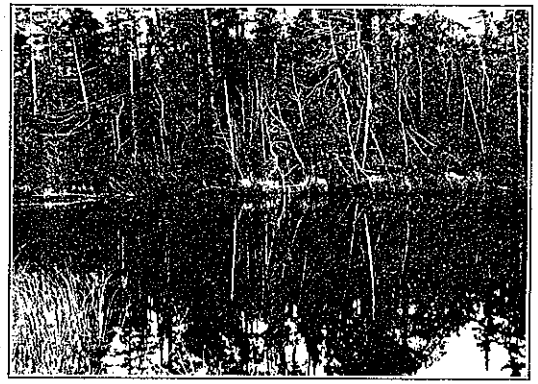


B. NORTHWEST SHORE OF BEAVER LAKE (STATION 59), LOOKING NORTHEAST.

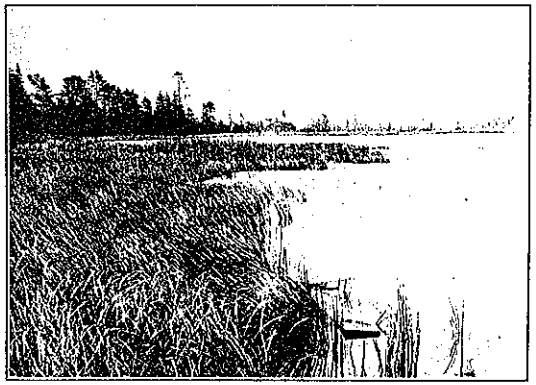


A. SPRUCE LAKE, LOOKING NORTHWEST (STATION 71).

B. STATION 84, SPRUCE LAKE, LOOKING EAST. FLOATING MATS OF STONEWORT ON THE SURFACE.

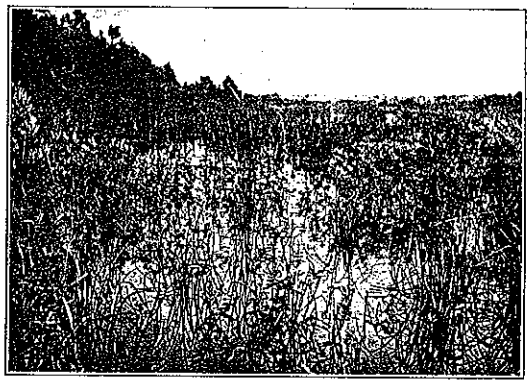


A. STATION 85, SPRUCE LAKE, LOOKING SOUTH ACROSS THE EAST END OF THE LAKE.

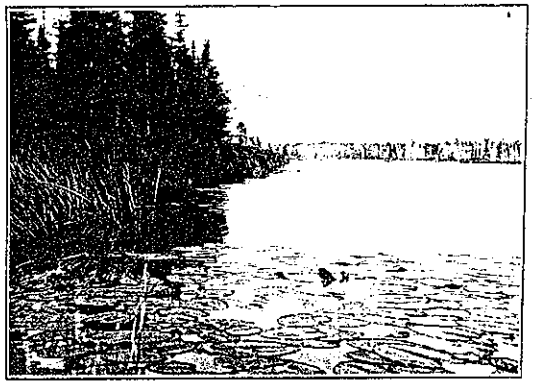


B. MARSHY NORTH SHORE OF VERMILION LAKE.

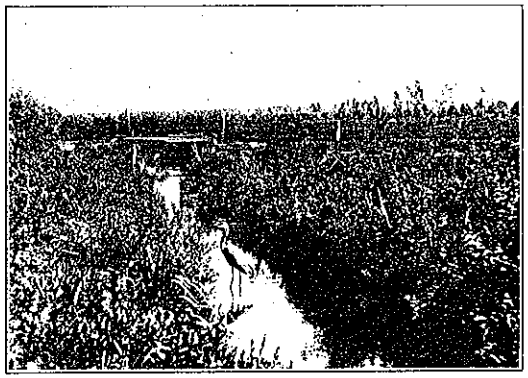
A. SMALL LAKE AND WOODED SAND RIDGE ABOUT A HALF MILE EAST OF VERMILION (STATION 100), LOOKING NORTHEAST.



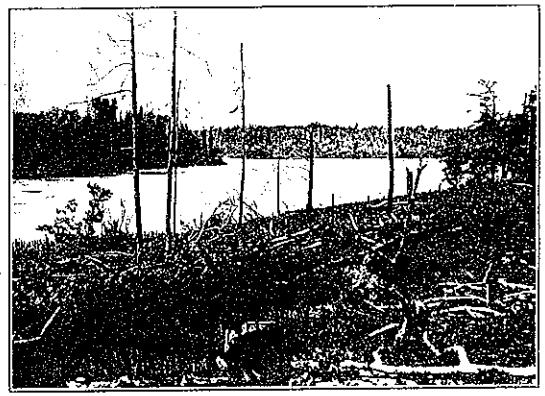
B. WEST END OF THE SMALL LAKE SHOWN IN A. STATION 101, LOOKING EAST.



A. MITTEN LAKE, STATION 116, LOOKING EAST.



B. VERMILION CREEK AT VERMILION. GREAT BLUE HERON FEEDING.

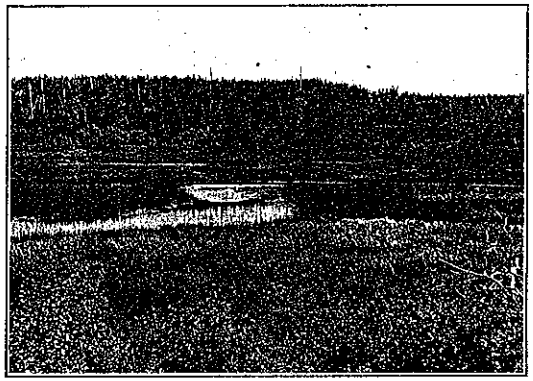


A. SHELLDRAKE LAKE, LOOKING SOUTHWEST.

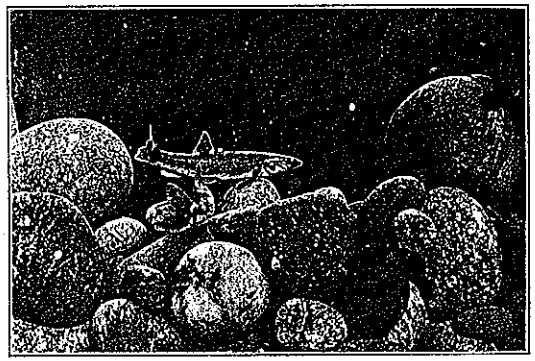
B. NORTHWEST SHORE OF SHELLDRAKE LAKE, LOOKING NORTHEAST (STATION 142).

A. SHELLDRAKE RIVER AND PORTION OF WOODED SWAMP, LOOKING DOWN STREAM FROM A HIGH, NORTH STREAM BANK.

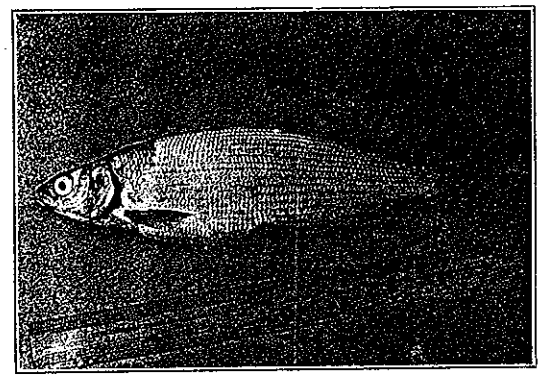
B. PORTION OF SHELLDRAKE RIVER JUST SOUTH OF VERMILION.



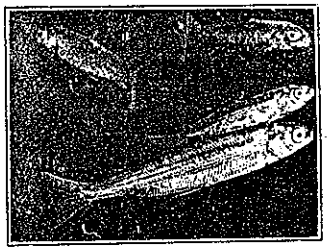
A. SHELLDRAKE RIVER JUST SOUTH OF SHELLDRAKE LAKE, LOOKING SOUTH.



B. LONG-NOSED DACE, *RHINICHTHYS CATARACTAE*.



A. TULLIBEE, *LEUCICHTHYS TULLIBEE* (?) CAUGHT AT STATION 2, LAKE SUPERIOR.



B. YOUNG WHITEFISH, *COREGONUS CLUPEAFORMIS* (POSSIBLY *ALBUS*) LENGTH OF LARGEST ABOUT THREE INCHES. CAUGHT AT STATION 1, ON LAKE SUPERIOR SHOAL.

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