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DISTRIBUTION OF SEA LAMPREY AMMOCOETES IN MICHIGAN TRIBUTARIES OF LAKE SUPERIOR, 1955-1957

By

Thomas M. Stauffer and Martin J. Hansen

Introduction

Larvicides appear to hold considerable promise for the eventual control of the parasitic sea lamprey (Petromyzon marinus) in the Great Lakes.[1] A portion of Michigan's role in the cooperative endeavor to control this pest has been to determine the distribution of ammocoetes[2] in tributaries of the Great Lakes, in order to facilitate the later application of selective toxicants. Work on Lake Superior streams has been emphasized because of the widely held view that a significant proportion of this lake's dwindling lake trout population can still be saved by the prompt use of larvicides to control ammocoete populations.

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[1] Programs and Progress, 1957. Mimeographed report of Great Lakes Fisheries Investigations, Bureau of Commercial Fisheries, Fish and Wildlife Service, U. S. Dept. of Interior.

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[2] The terms ammocoete and larva refer to the sea lamprey unless stated otherwise.

This report is based primarily on surveys conducted in 1955, 1956, and 1957, when 298 stations in 58 Lake Superior tributaries were studied (one additional stream system was surveyed in 1953 and one in 1954). Of the 60 streams studied, 19 supported runs of adult sea lampreys[3] and 41 were without known spawning runs. Twelve streams with known sea lamprey runs[4] and many

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[3] The presence of spawning runs of sea lampreys in various tributaries of Lake Superior mentioned in this paper is based on unpublished records of the operation of electrical weirs, supplied by the U. S. Fish and Wildlife Service.

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[4] The 12 streams with known spawning runs of sea lampreys, which were not included in this study were: Waiska River, Pendills and Halfaday creeks, Chippewa County; Beaver Lake Creek, Laughing Whitefish River, Alger County; Carp River, Harlow Creek, Big Garlic and Pine rivers, Marquette County; Ravine River, Baraga County; Gratiot River, Keweenaw County; and Elm River, Houghton County.

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streams where there was little probability of sea lamprey use were not included in the survey. The majority of the large streams draining into Lake Superior and a large number of the relatively smaller tributaries were thus included. The seven streams which support the largest runs of sea lampreys (Betsy, Two Hearted, Sucker, Rock, Chocolay, Huron, and Silver rivers) were sampled extensively to define closely the areas in which ammocoetes occurred. The field study was less complete on 53 streams whose degree of use by sea lampreys was considered low or in doubt, as determined from catch records of electrical weirs, from surveys by Loeb and Hall (1952), and recent field observations by

the U. S. Fish and Wildlife Service. The primary purpose of the survey of these 53 streams was to determine whether sea lampreys were present; therefore, areas judged most likely to contain ammocoetes were selected for study.

Three men spent 30 to 60 minutes collecting ammocoetes and fish at each station, using a direct-current shocker of the type described by Pratt (1952). Direct current was found to be superior to alternating current for collecting ammocoetes. In practice, the positive electrodes were passed slowly over ammocoete habitat, which is generally composed of a soft substrate with various proportions of silt and is located in slack water along the stream edge, especially on the inside of stream meanders, or behind obstructions. Ammocoetes which emerged from their burrows were captured with a fine-mesh scap net. To retain the pattern of pigmentation, necessary for identification, they were kept alive until preserved in 10-percent formalin.

Identification of ammocoetes

The various species[5] of ammocoetes were identified by characters described by Vladykov (1950), Hubbs and Lagler (1947), and observations of the authors. These characters are presented below.

[5] In addition to the sea lamprey, three other species (Lampetra lamottei, Ichthyomyzon unicuspis, and I. fossor) occur in Lake Superior tributaries, as noted by Hubbs and Lagler (1947).

The genus Ichthyomyzon is distinguished from the genera Lampetra and Petromyzon by large myomeres (trunk myomere count usually 49-54) and the presence of a continuous dorsal fin.

Both Lampetra and Petromyzon are characterized by small myomeres (trunk myomere count of 63-74) and a divided dorsal fin. Lampetra lamottei is further identified by several features in color pattern. There is a lack of pigment on the lower edge of the oral hood and the lower one-half of the upper branchial region. A sharp line of demarcation between the pigmented sides and nearly unpigmented ventral surface is especially evident posterior to the anal opening. Chromatophores in the caudal fin are confined to a small intensively pigmented area (absent in small specimens) adjacent to the apex of the trunk. The over-all color pattern of this species is light. Petromyzon marinus, on the other hand, has a darker, nearly black appearance. The pigmentation in the head region extends down almost to the lower edge of the oral hood and in the upper branchial region nearly to the gill openings. No sharp line of demarcation separates the pigmented sides from the nearly unpigmented ventral surface. A particularly clear character which differentiates the sea lamprey from L. lamottei is the diffuse black pigment on the caudal fin, extending from the trunk to the extremity of the caudal rays.

Ecological factors related to the abundance of ammocoetes

During the surveys of Lake Superior tributaries for sea lamprey ammocoetes, certain physical and biological data were collected at each station. A preliminary examination of these data suggests relationships between different ecological factors and the abundance of ammocoetes. Some of the associations observed may be helpful in evaluating streams as potential ammocoete habitat, or in predicting the distribution of ammocoetes in portions of streams which have not been surveyed.

The occurrence of sea lamprey ammocoetes was closely associated with the presence of ammocoetes of other species of lampreys. These other species

occurred at 93 percent of the 86 stations at which sea lamprey larvae were collected, and no sea lampreys were found in the 21 stream systems where other species of ammocoetes were absent.

Sea lamprey larvae were most numerous in streams with summer water temperatures of 50° to 79° F. and were relatively rare at temperatures outside this range; they rarely occurred in cool spring-fed streams and/or where brook trout (Salvelinus fontinalis) and slimy sculpins (Cottus cognatus) were abundant.

Ammocoetes occurred more frequently (at 33 of 58 stations) in waters with volumes over 30 cubic feet per second than in streams with volumes under 10 cubic feet per second (lamprey larvae found at only 15 of 122 stations). Except for the Two Hearted River, they were usually found only in the main stream.[6]

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[6] A partial survey of Lake Michigan tributaries for ammocoetes indicated that the larvae are not confined to large main-stream waters. This suggests that eventually Lake Superior stream systems may also be utilized to a greater degree (if the sea lamprey population continues to increase).

Ammocoetes tended to be more abundant in portions of streams with a heterogeneous bottom, composed of soft and hard bottom types, each an entity in itself (thus meeting the requirements both for spawning and for larval life). Intensive sampling of three bottom types (silty sand, sand, and gravel) in seven major stream systems showed a progressive decrease in abundance of ammocoetes from soft to hard bottom types. Applegate (1950) also noted that ammocoetes were most commonly found in soft bottom types which contain a combination of silt and sand, with silt predominating.

Distribution of ammocoetes

The locations of our collecting stations in the State of Michigan tributaries of Lake Superior are shown in Figures 1 and 2. Estimates of relative abundance of sea lamprey larvae, which are indicated in parentheses following the names of the streams, were derived primarily from the number of ammocoetes collected. Secondary criteria in estimating abundance were the extent of spawning grounds as reported by Loeb and Hall (1952), and the amount of suitable larval habitat observed during the survey. For streams which were extensively surveyed (Figs. 3-8), estimates of abundance, based on catch per hour by shocker, are indicated at each station ("rare" = 1-25 ammocoetes per hour, "common" = 26-99 per hour, and "abundant" = 100 or more per hour).

Each stream surveyed is discussed in the order in which it is numbered in Figures 1 and 2, progressing from east to west along the Lake Superior shore of the Upper Peninsula; identifying stream numbers shown in the figures are identical to those in the text and Table 1. In addition to the results of the sampling, further evidence of the presence or absence of ammocoetes, when available, is presented in the text.[7] Game fish popula-

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[7]Additional data include: (1) ecological factors described above, (2) size of spawning runs of adult sea lampreys, and (3) barriers and amount of spawning grounds as described by Loeb and Hall (1952).

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tions are mentioned because of their possible importance in the selection and application of larvicides.

Figure 1.--Collection stations for sea lamprey ammocoete surveys in Michigan tributaries of eastern Lake Superior. Letters in parentheses following stream names indicate general abundance of ammocoetes (A = abundant; C = common; R = rare; N = none).

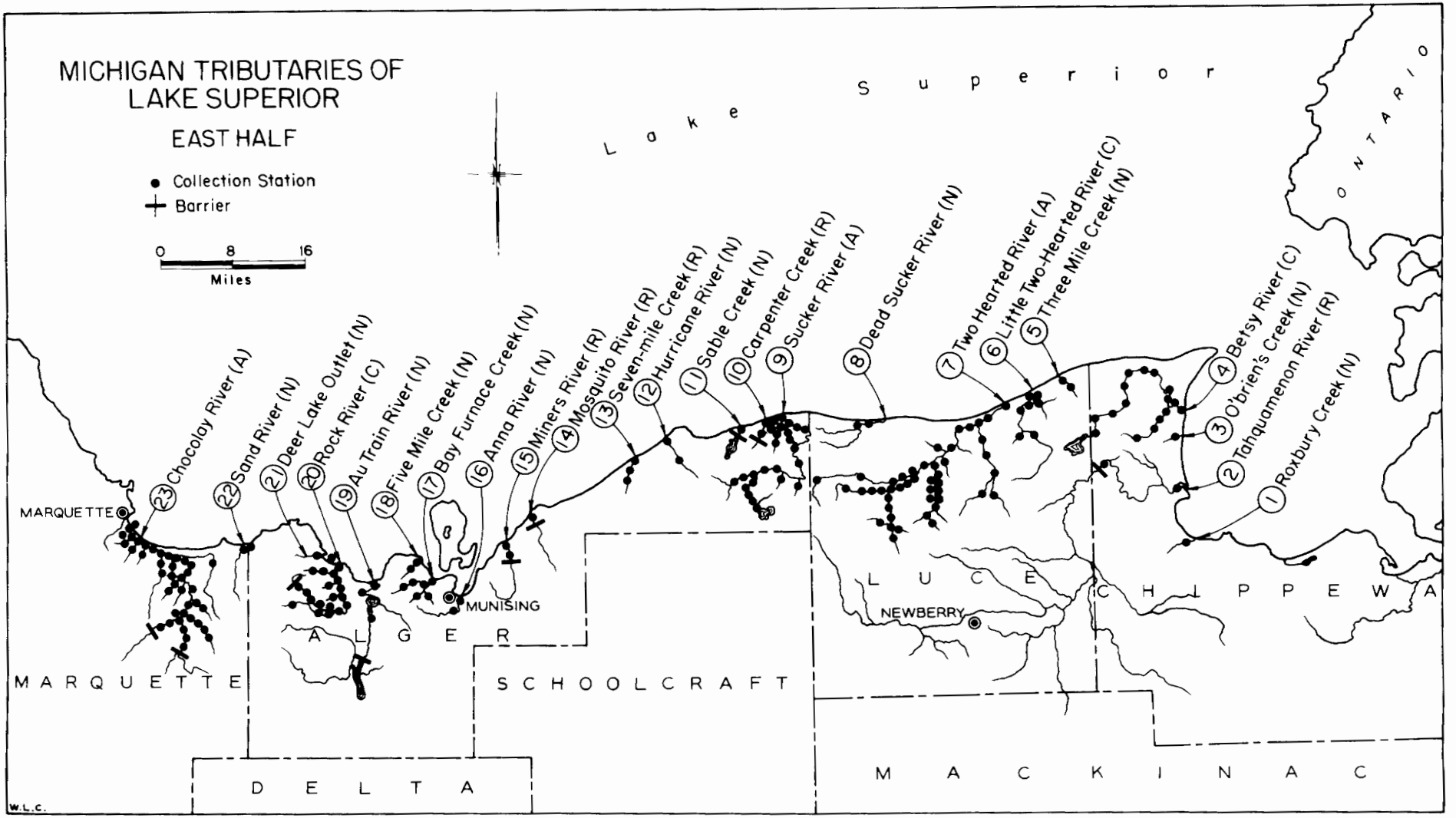
MICHIGAN TRIBUTARIES OF
LAKE SUPERIOR
EAST HALF
Collection Station
Barrier
0 8 16
Miles
Lake Superior
ONTARIO
(23) Chocolay River (A)
(22) Sand River (N)
(21) Deer Lake Outlet (N)
(20) Rock River (C)
(19) Au Train River (N)
(18) Five Mile Creek (N)
(17) Bay Furnace Creek (N)
(16) Anna River (N)
(15) Miners River (R)
(14) Mosquito River (R)
(13) Seven-mile Creek (R)
(12) Hurricane River (N)
(11) Sable Creek (N)
(10) Carpenter Creek (R)
(9) Sucker River (A)
(8) Dead Sucker River (N)
(7) Two Hearted River (A)
(6) Little Two-Hearted River (C)
(5) Three Mile Creek (N)
(4) Betsy River (C)
(3) O'brien's Creek (N)
(2) Tahquamenon River (R)
(1) Roxbury Creek (N)
MARQUETTE
MUNISING
NEWBERRY
MARQUETTE
ALGER
SCHOOLCRAFT
LUCE
CHIPPEWA
DELTA
MACKINAC
W.L.C.

Figure 1

Figure 2.--Collection stations for sea lamprey ammocoete surveys in Michigan tributaries of western Lake Superior. Letters in parentheses following stream names indicate general abundance of ammocoetes (C = common; R = rare; N = none).

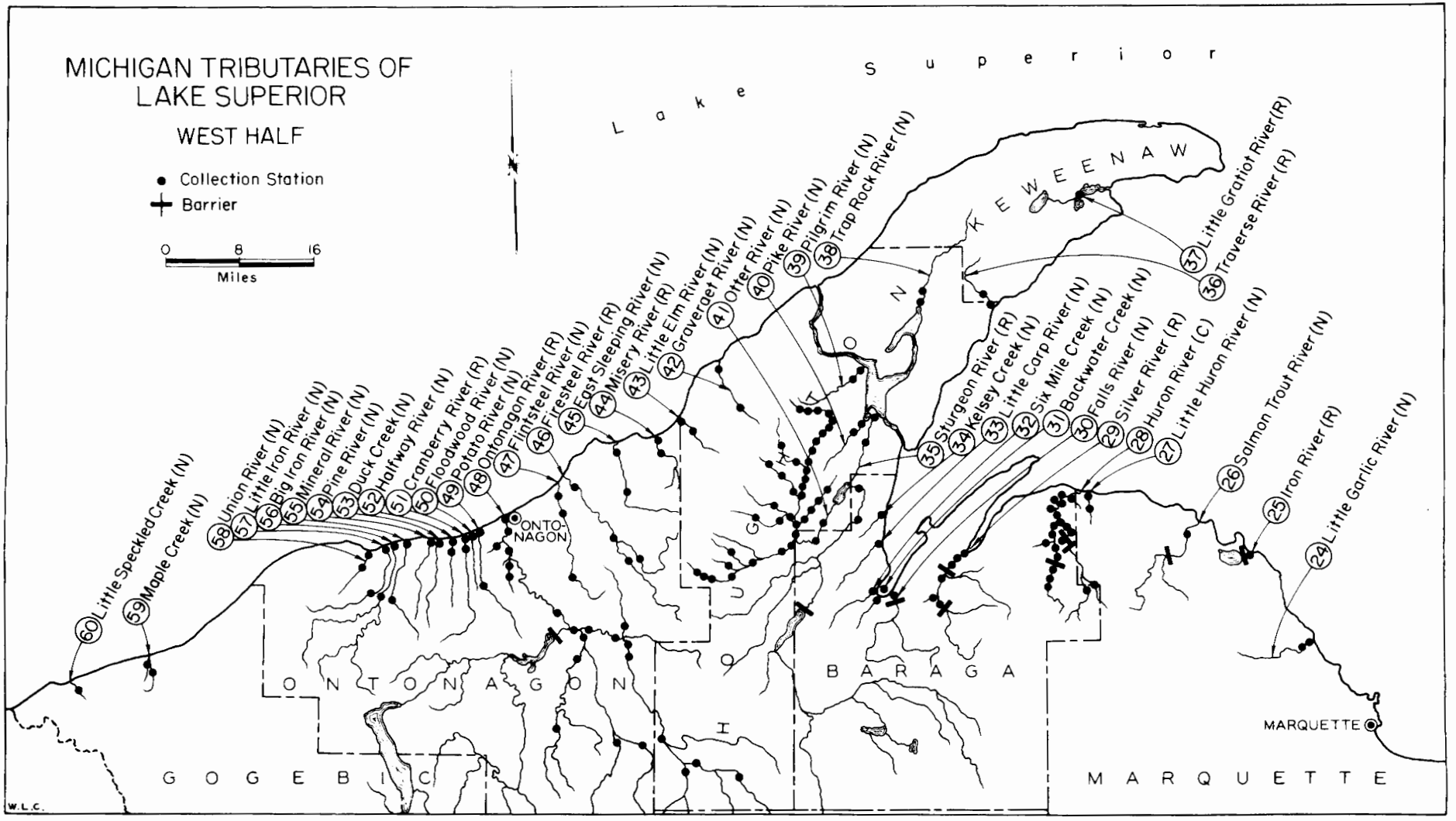
MICHIGAN TRIBUTARIES OF
LAKE SUPERIOR
WEST HALF
Collection Station
Barrier
0 8 16
Miles
Lake Superior
KEWEENAW
ONTONAGON
GOGEBIC
BARAGA
MARQUETTE
ONTO-
NAGON
MARQUETTE
(60) Little Speckled Creek (N)
(59) Maple Creek (N)
(58) Union River (N)
(57) Little Iron River (N)
(56) Big Iron River (N)
(55) Mineral River (N)
(54) Pine River (N)
(53) Duck Creek (N)
(52) Halfway River (N)
(51) Cranberry River (R)
(50) Floodwood River (N)
(49) Potato River (N)
(48) Ontonagon River (N)
(47) Flintsteel River (N)
(46) Firesteel River (R)
(45) East Sleeping River (N)
(44) Misery River (R)
(43) Little Elm River (N)
(42) Graveraet River (N)
(41) Otter River (N)
(40) Pike River (N)
(39) Pilgrim River (N)
(38) Trap Rock River (N)
(37) Little Gratiot River (R)
(36) Traverse River (R)
(35) Sturgeon River (R)
(34) Kelsey Creek (N)
(33) Little Carp River (N)
(32) Six Mile Creek (N)
(31) Backwater Creek (N)
(30) Falls River (N)
(29) Silver River (R)
(28) Huron River (C)
(27) Little Huron River (N)
(26) Salmon Trout River (N)
(25) Iron River (R)
(24) Little Garlic River (N)
W.L.C.

Figure 2

1. Roxbury Creek.--No ammocoetes were collected at the single station sampled on this small stream. Low water temperatures, as indicated by a reading of 53° F. on August 15, 1956, and the presence of an exclusively cold-water fish population suggest that sea lampreys do not utilize this stream.

2. Tahquamenon River.--Sampling (two stations) on this large stream was confined to the area downstream from the Lower Falls, which constitutes a barrier to upstream migrating lampreys. Three ammocoetes were collected 500 feet below the falls but none near the mouth of the river. The relative abundance of ammocoetes was difficult to determine because of the small number of samples. However, the apparent paucity of available spawning grounds may limit reproduction. This stream has a large resident game fish population of northern pike (Esox lucius), smallmouth bass (Micropterus dolomieui), and rock bass (Ambloplites rupestris) and supports a sizeable run of yellow perch (Perca flavescens) from Lake Superior.

3. Obriens Creek.--No ammocoetes of any species were found at the single station on this small stream. The small volume (two to three cubic feet per second) and low temperatures (56° F. on August 7, 1956) also suggest that sea lampreys do not use this stream.

4. Betsy River.--This stream, which was extensively sampled (16 stations), contained a moderate population of ammocoetes. Concentrations of ammocoetes were confined to the main stream below the "wide waters" where they were rare at four stations and common at one (Fig. 3). Although one ammocoete was collected seven miles above the "wide waters," extensive sampling and the apparent lack of spawning grounds suggested that the ammocoete population in this area was sparse. No ammocoetes were found at

Figure 3.--Collection stations on the Betsy River, Chippewa County. Open circles are stations at which no sea lamprey larvae were taken. Letters within circles indicate the abundance of ammocoetes (C = common; R = rare).

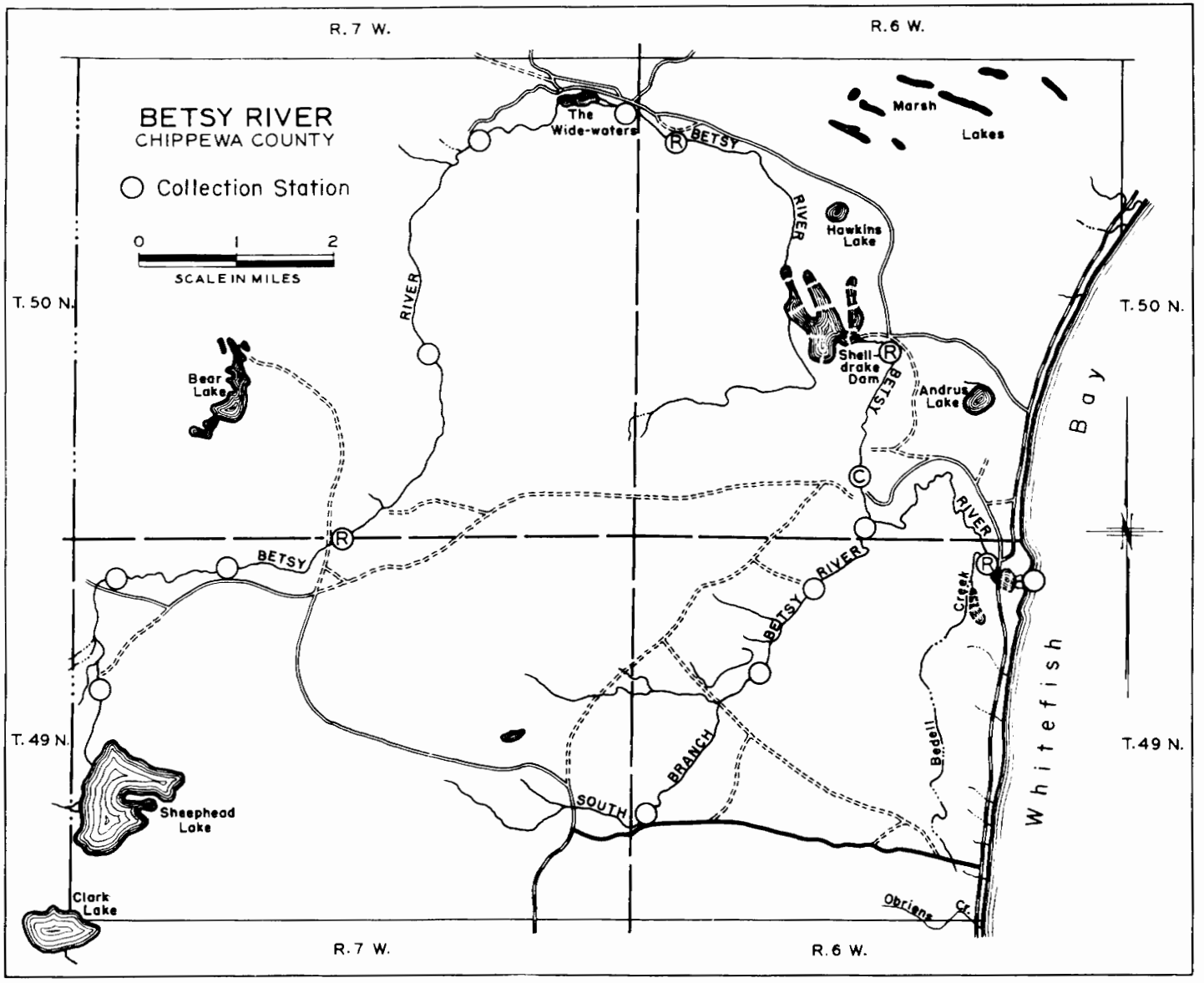
BETSY RIVER
CHIPPEWA COUNTY
Collection Station
0 1 2
SCALE IN MILES
R. 7 W.
R. 6 W.
T. 50 N.
T. 49 N.
The Wide-waters
BETSY
RIVER
Marsh
Lakes
Hawkins Lake
Shell-drake Dam
Andrus Lake
Bear Lake
Whitefish Bay
Sheephead Lake
Clark Lake
SOUTH BRANCH
Bedell Creek
Obrien Cr.

Figure 3

four stations in the South Branch. Their absence may have been due to prohibitively low stream temperatures (49° to 59° F. between August 6 and 21, 1956). No game fish populations of any consequence were found in the Betsy River.

5. Three Mile Creek.--No ammocoetes were found at the two sampling sites in this stream. Low water temperatures (56° to 59° F., August 7-8, 1956) and small volume (about one cubic foot per second) also suggested that sea lampreys do not use this stream.

6. Little Two Hearted River.--Seven collections in the lower one-half of this stream indicated that it contained a moderate population of ammocoetes. They were common at three stations in the lower one-half mile of stream. Additional sampling upstream produced only one ammocoete at a station two miles above the mouth and one in Pike Lake Outlet (a tributary entering from the west) near its junction with the main stream (7 miles above the mouth). Failure to collect ammocoetes at a main-stream station located one-half mile above Pike Lake Outlet further indicated a relatively sparse population in the upper portions of this stream (probably due to insufficient spawning grounds).

No important game fish species were observed in the section of stream examined. However, round whitefish (Coregonus cylindraceus) run into this stream each spring and fall.

7. Two Hearted River.--An extensive study (45 stations) of distribution demonstrated that the Two Hearted River is one of the three largest producers of sea lampreys among the Michigan tributaries of Lake Superior. Ammocoetes were found throughout the main stream, the lower portion of the East Branch, the West Branch upstream to the junction with the South Branch, the lower half

Figure 4.--Collection stations on the Two Hearted River, Luce County. Open circles are stations at which no sea lamprey larvae were taken. Letters within circles indicate the abundance of ammocoetes (C = common; R = rare).

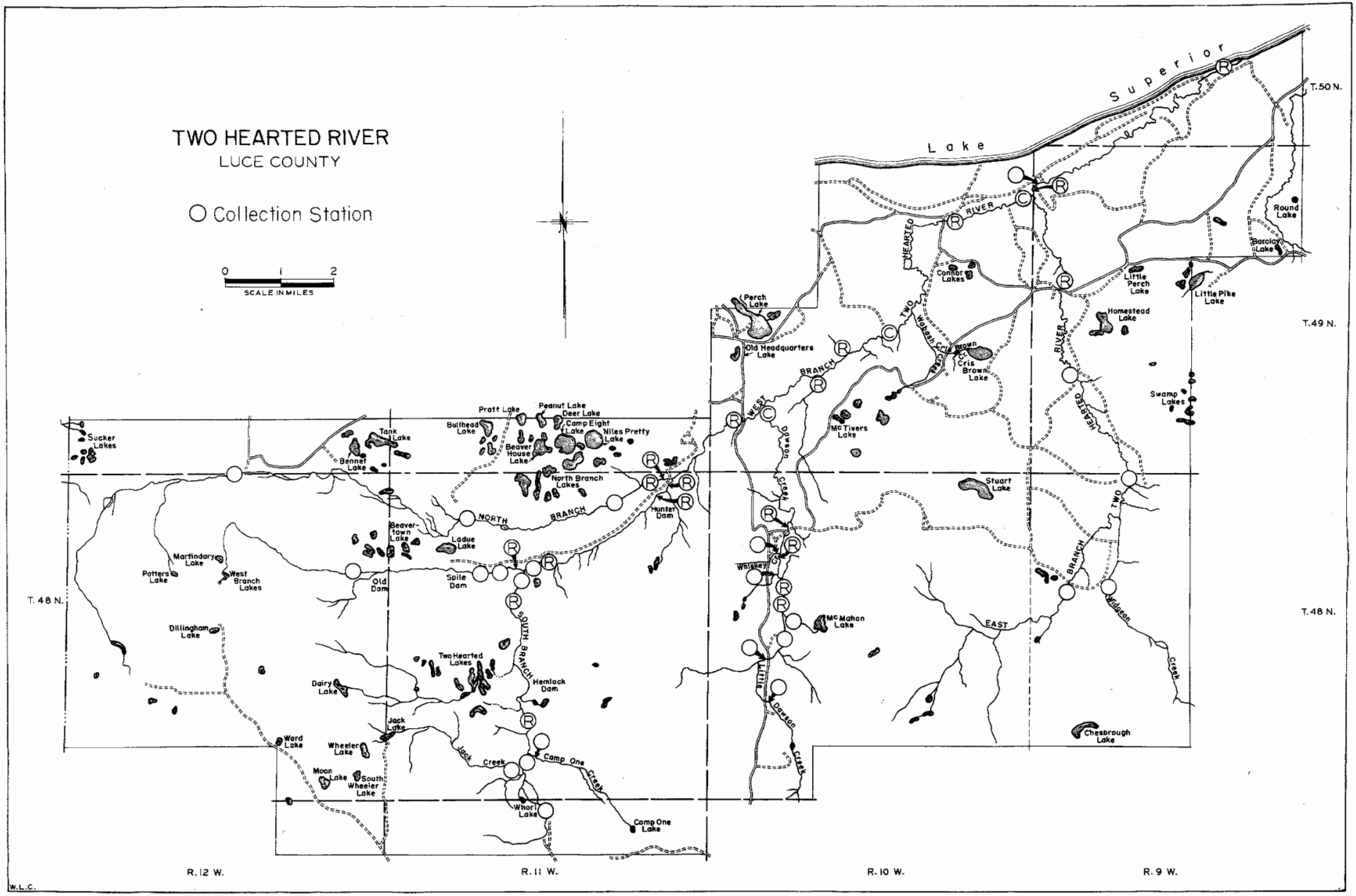
TWO HEARTED RIVER
LUCE COUNTY
Collection Station
0 1 2
SCALE IN MILES
Lake Superior
T. 50 N.
T. 49 N.
T. 48 N.
R. 12 W.
R. 11 W.
R. 10 W.
R. 9 W.
W.L.C.
Sucker Lakes
Tank Lake
Bennet Lake
Pratt Lake
Peanut Lake
Deer Lake
Bullhead Lake
Camp Eight Lake
Niles Pretty Lake
Beaver House Lake
North Branch Lakes
Hunter Dam
NORTH BRANCH
Beaver-town Lake
Ladue Lake
Martindary Lake
Potters Lake
West Branch Lakes
Old Dam
Spile Dam
SOUTH BRANCH
Dillingham Lake
Two Hearted Lakes
Dairy Lake
Hemlock Dam
Jack Lake
Ward Lake
Wheeler Lake
Moon Lake
South Wheeler Lake
Jack Creek
Camp One Creek
Whor Lake
Camp One Lake
Perch Lake
Old Headquarters Lake
WEST BRANCH
Dawson Creek
McTivers Lake
Stuart Lake
Whiskey Creek
McMahon Lake
Dawson Creek
TWO HEARTED RIVER
Conner Lakes
Brown Cr.
Cris Brown Lake
MEADOW RIVER
Round Lake
Barclay Lake
Little Perch Lake
Little Pike Lake
Homestead Lake
Swamp Lakes
TWO HEARTED RIVER BRANCH
EAST
Widgeon Creek
Chesbrough Lake

Figure 4

of Dawson Creek, the lower one-half mile of the North Branch, and the South Branch upstream to Camp One Creek (Fig. 4). They were also present near the mouths of two small tributaries of the West Branch. Although they were generally rare (25 or fewer larvae taken per hour of shocking) in the collections, the large area occupied by this species indicates that the total population is large. The determination of distribution on this stream is believed to be complete, with the possible exception of the tributaries of the South Branch. Persistent rumors of sea lampreys spawning in Jack Creek and the occurrence of occasional ammocoetes in the South Branch, where no spawning grounds were found, suggests contamination from upstream areas, possibly Jack Creek.

Ammocoetes were not found in the upper three-fourths of the East Branch. Although spawning grounds are available, low water temperatures (evidenced by the abundance of slimy sculpins) may preclude sea lamprey use. With the exception of the lower one-half mile, ammocoetes were apparently also absent from the North Branch. Although other conditions appeared suitable, spawning grounds may be inadequate. No ammocoetes were collected in the West Branch above its confluence with the South Branch, except for one collected 40 feet upstream from the junction. Low water temperatures (52° to 53° F., August, 1956) and the apparent lack of spawning grounds presumably limit sea lamprey use.

Areas inhabited by ammocoetes contain medium to high populations of small rainbow trout (Salmo gairdneri) and brook trout. In the spring and fall, a large run of migratory rainbow trout enters these areas. Round whitefish from Lake Superior are also present in the main stream in the spring and fall.

8. Dead Sucker River.--Two collections in 1954 on the main stream shortly below the junction of the Blind Sucker River produced no ammocoetes

of any species. In addition, no adult sea lampreys were caught in an electrical weir operated by the U. S. Fish and Wildlife Service in 1953-1954. Although the habitat appeared suitable, utilization of this system by sea lampreys is therefore doubtful.

9. Sucker River.--Extensive sampling (29 stations) of the Sucker River, one of the three largest producers of sea lampreys encountered in this study, showed that ammocoetes occurred in the main stream from the mouth to within three miles of its origin in Nawakwa Lake (Fig. 5). They were rare to abundant at stations in this area with the greatest concentrations observed in the two miles of stream ~~near the mouth~~, immediately above Grand Marais Creek, and also near the confluence of the West Branch and the main stream. Ammocoetes were rare to common at stations below the mouth in East Bay, West Bay, and the connecting channel. No ammocoetes were collected from Baker, Grand Marais, Harvey, and Klondike creeks, and the West Branch. As these streams are small and contain dominant brook trout populations (suggesting low water temperatures), the likelihood of their use by sea lampreys is slight.

Brook trout and rainbow trout were present in moderate numbers in the main stream, and a variety of game fish occur in East and West bays. Large rainbow trout from Lake Superior also migrate up the main stream in the spring.

10. Carpenter Creek.--The single sample at the mouth of Carpenter Creek, a small tributary of West Bay, produced one ammocoete. Since this stream offers little spawning ground, the specimen collected may have originated from the Sucker River. Rainbow and brook trout were abundant.

11. Sable Creek.--No ammocoetes of any species were collected although a pair of sea lampreys was observed spawning at the single station near the mouth of this small stream. A barrier located one-quarter mile upstream from

Figure 5.--Collection stations on the Sucker River, Alger County. Open circles are stations at which no sea lamprey larvae were taken. Letters within circles indicate the abundance of ammocoetes (A = abundant; C = common; R = rare).

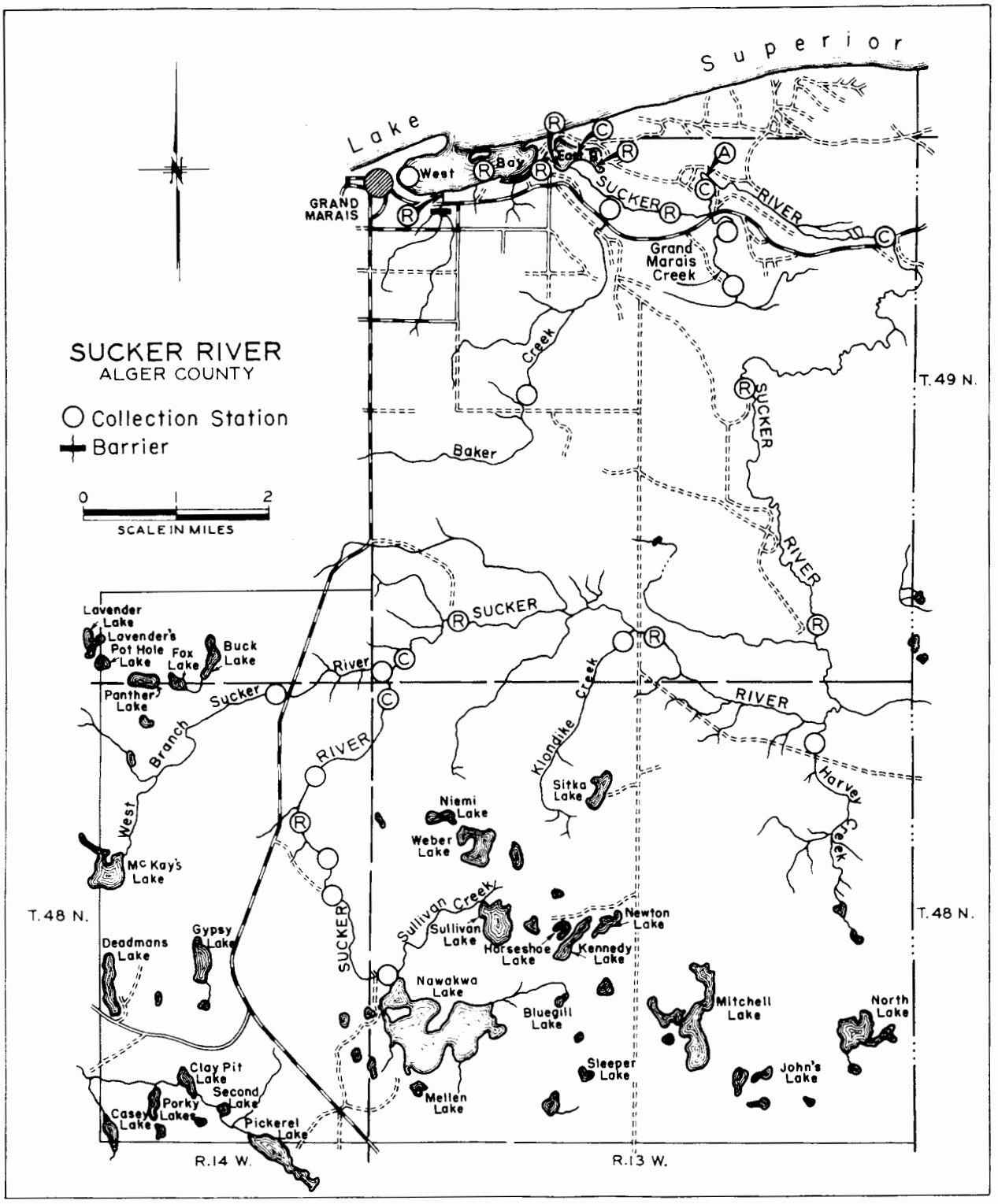
SUCKER RIVER
ALGER COUNTY
Collection Station
Barrier
0 1 2
SCALE IN MILES
Superior
Lake
West Bay
East Bay
GRAND MARAIS
SUCKER RIVER
Grand Marais Creek
Baker Creek
T. 49 N.
SUCKER RIVER
Lavender Lake
Lavender's Pot Hole Lake
Fox Lake
Buck Lake
Panther Lake
Sucker River
Branch
West
McKay's Lake
SUCKER RIVER
Klondike Creek
Sitka Lake
Harvey Creek
Niemi Lake
Weber Lake
T. 48 N.
Deadmans Lake
Gypsy Lake
Sullivan Creek
Sullivan Lake
Horseshoe Lake
Kennedy Lake
Newton Lake
Nawakwa Lake
Bluegill Lake
Mitchell Lake
North Lake
Sleeper Lake
John's Lake
Clay Pit Lake
Second Lake
Porky Lakes
Casey Lake
Pickerel Lake
Mellen Lake
R. 14 W.
R. 13 W.

Figure 5

the mouth and the near absence of larval habitat restricts reproduction, if any, in this stream.

12. Hurricane River.--No ammocoetes were found at the two collecting sites on this stream. However, in view of the apparently suitable habitat and the presence of a known spawning run (320 individuals taken in a U. S. Fish and Wildlife Service weir in 1954-1957), the existence of a small ammocoete population is not precluded.

13. Seven Mile Creek.--Ammocoetes were rare at a station near the mouth, but were not collected at two stations located one mile and three miles upstream. Low water temperatures in the upper two-thirds of the stream, as evidenced by the predominance of brook trout, may restrict ammocoetes to the lower reaches of this stream.

14. Mosquito River.--Ammocoetes were rare at the one sampling station near the mouth of this stream. The habitat available to sea lampreys is limited by a barrier located one and one-half miles upstream from the mouth. Migratory rainbow trout were abundant below the barrier.

15. Miners River.--A total of 17 ammocoetes were collected near the mouth, but none were taken at a station one-half mile upstream. A barrier located one and one-half miles above the mouth limits habitat available to sea lampreys. Migratory rainbow trout were abundant below the barrier.

16. Anna River.--No sea lamprey ammocoetes were taken at two stations on this stream, one near the mouth and the other two miles upstream. Low water temperatures, as evidenced by an exclusively cold-water fish population, further suggest that sea lampreys do not use this stream.

17. Bay Furnace Creek.--Six samples, taken at stations dispersed throughout this small system, failed to produce ammocoetes. The relatively

large number of samples strongly indicate that no ammocoetes were in this stream, although an annual spawning run of adult sea lampreys occurs (614 taken in U. S. Fish and Wildlife Service structures in 1953-1957). Low water temperatures, suggested by the dominance of brook trout in the fish population, may prevent successful sea lamprey reproduction.

18. Five Mile Creek.--No ammocoetes were collected at two stations near the mouth of this small stream. Low water temperatures (56° F., July 24, 1956) and the extremely small flow in dry summers support the results of the sampling.

19. Au Train River.--Three samples taken in the main stream (two below Au Train Lake and one above) produced no ammocoetes, although this stream supports a moderate run of spawning adults (2,392 taken in weirs in 1953-1957). Because of the relatively few collections and lack of evidence that the stream is unsuitable for sea lampreys, more sampling is necessary to determine if ammocoetes are present.

20. Rock River.--An extensive survey (20 samples) of the Rock River showed that it contained a moderate population of ammocoetes. They were rare to common in the main stream from the mouth to a point 500 feet above the junction of Silver Creek, but were not found in the five major tributaries (Fig. 6). In the largest tributary, Silver Creek (flow, eight cubic feet per second), gross conditions appeared suitable. In three tributaries (Nelson Creek and two unnamed tributaries, one a mile above Nelson Creek and the other just below the junction of Silver Creek), however, flows were less than three cubic feet per second and brook trout dominated the fish population. The remaining tributary (about one mile above Nelson Creek) dries up during the summer.

Moderate populations of small rainbow trout and brook trout were present in the main stream, and lake-run rainbow trout enter the Rock River in the spring.

Figure 6.--Collection stations on the Rock River, Alger County. Open circles are stations at which no sea lamprey larvae were taken. Letters within circles indicate the abundance of ammocoetes (C = common; R = rare).

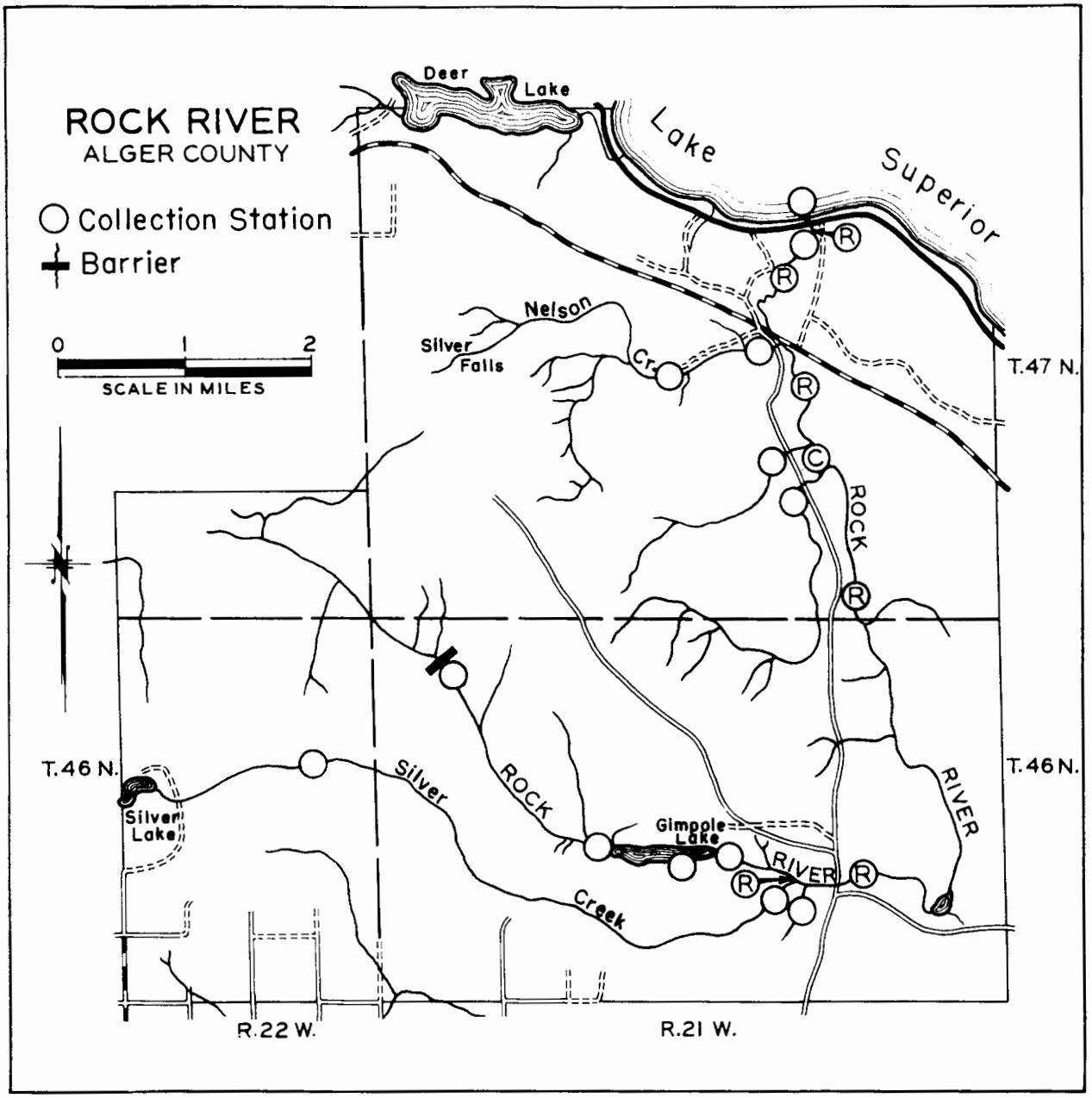
ROCK RIVER
ALGER COUNTY
Collection Station
Barrier
0 1 2
SCALE IN MILES
Deer Lake
Lake Superior
Nelson
Silver Falls
Cr.
T.47 N.
ROCK
RIVER
T.46 N.
T.46 N.
Silver Lake
Silver
ROCK
Gimpole Lake
RIVER
RIVER
Creek
R.22 W.
R.21 W.

Figure 6

21. Deer Lake Outlet.--No ammocoetes of any species were found at the single station located near the mouth of this small stream. High stream temperatures (86° F., August 2, 1957) and a lack of suitable spawning grounds also suggested that sea lampreys do not utilize this stream.

22. Sand River.--Sampling on this stream at two stations near the mouth produced no ammocoetes of any species, even though spawning grounds are abundant. No spawning migrants were caught in an electrical weir operated in 1954, and the water temperature on August 2, 1957 was high (86° F.). Sea lampreys apparently do not use this stream.

23. Chocolay River.--The Chocolay River is one of the three largest producers of sea lampreys among Michigan streams tributary to Lake Superior. An extensive survey consisting of 41 samples disclosed the presence of ammocoetes throughout much of the main stream, upstream to a low falls, one-quarter mile below the confluence of the East and West branches (Fig. 7). The ammocoete population in the upper one-half of this area was the largest encountered in any stream, but was considerably smaller in the lower portion. In addition, sparse populations occurred near the mouths of two small tributaries. Ammocoetes were not collected from the remaining tributaries and the East and West Branches of the main stream. Since Silver, Cherry, Cedar, and Big creeks are extremely cold (indicated by water temperatures of 50° to 59° F. in July, 1956, and an exclusively cold-water fish population), it is unlikely that sea lampreys use these streams. Voce Creek's small volume (one cubic foot per second) minimizes the possibility of sea lamprey utilization. The absence of ammocoetes in Mud Creek may be due to the blocking effect of two shallow warm-water lakes (Kawbawgam and Mud), through which it flows, and/or to its small size (5-10 cubic feet per second at high-water stage). Two tributaries of Mud Creek--Dorrow

Figure 7.--Collection stations on the Chocolay River, Marquette County. Open circles are stations at which no sea lamprey larvae were taken. Letters within circles indicate the abundance of ammocoetes (A = abundant; C = common; R = rare).

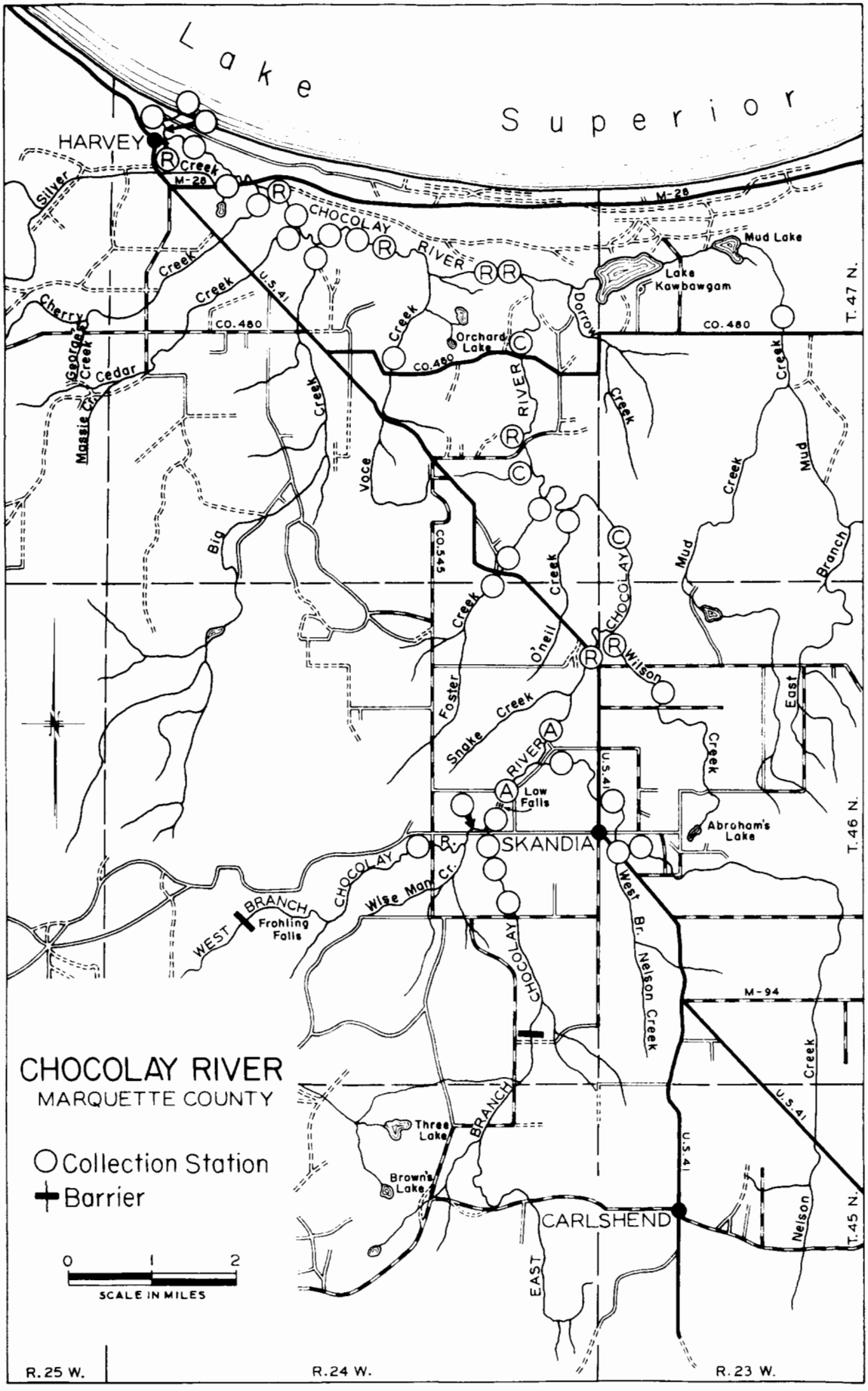
Lake Superior
HARVEY
Silver Creek
M-28
CHOCOLAY RIVER
Cherry Creek
George Creek
Cedar Creek
Massie Cr.
U.S.41
CO.480
Orchard Lake
Mud Lake
Lake Kawbawgam
Darrow Creek
Voce Creek
Big Creek
CO.545
Mud Creek
Mud Branch
O'neil Creek
Foster Creek
Wilson Creek
Snake Creek
East Creek
Low Falls
Abraham's Lake
SKANDIA
Wise Man Cr.
WEST BRANCH CHOCOLAY
Frohling Falls
West Br. Nelson Creek
M-94
Three Lake
Brown's Lake
CARLSHEND
EAST BRANCH CHOCOLAY
Nelson Creek
T.47 N.
T.46 N.
T.45 N.
R.25 W.
R.24 W.
R.23 W.
CHOCOLAY RIVER
MARQUETTE COUNTY
Collection Station
Barrier
0 1 2
SCALE IN MILES

Figure 7

Creek and the East Branch--are reportedly dry or nearly so during the summer months. In Foster Creek, spawning grounds and ammocoete habitat were ample, but dominant brook and rainbow trout populations suggest an unfavorably low water temperature. Although Nelson Creek contained abundant spawning grounds, the absence of all species of ammocoetes from the collections suggested that the habitat was unsuitable for sea lampreys. Since the East and West branches offer grossly suitable habitat, the abrupt termination of ammocoete populations at the low falls mentioned above suggests that this falls is a barrier (not so indicated in Figs. 1 and 7) which prevents sea lamprey use of these streams.

Moderate populations of rainbow trout, brown trout (Salmo trutta), brook trout and northern pike occur in the main stream and lake-run rainbow trout enter the stream in the spring and fall.

24. Little Garlic River.--Two collections on this stream produced no ammocoetes of any species. No spawning adult sea lampreys were taken by the U. S. Fish and Wildlife Service during the operation of an electrical weir in 1954-1955.

25. Iron River.--One collection (300 yards below Lake Independence) demonstrated that ammocoetes were rare in this area. A barrier at Lake Independence prevents sea lampreys from entering this lake and its tributaries. No important game fish populations were found below the barrier.

26. Salmon Trout River.--Absence of ammocoetes in the single collection on this stream and of spawning migrants in the catch of an electrical weir in 1955-1956 (although one was captured in 1954) indicate that sea lampreys do not use this stream.

27. Little Huron River.--No ammocoetes were found at the two stations on this stream and no spawning adults were captured in an electrical weir operated in 1954.

28. Huron River.--An extensive survey (total of 20 stations) demonstrated that this stream system contained a moderate ammocoete population. Ammocoetes were rare to common in the main stream from a point two miles above the mouth to a low waterfall 100 yards below the junction of the East and West branches (Fig. 8). This waterfall may block migrating adult sea lampreys since no ammocoetes were found in the stream above it. Barriers on the East and West branches, about two miles above their junction, prevent utilization of the upper portion of these streams by sea lampreys. The lower two miles of the main stream, which contain suitable habitat, were not sampled. Since ammocoetes tend to migrate downstream (Stauffer and Hansen, 1958) it is highly probable that this area also contains an ammocoete population.

Small rainbow trout were abundant, and large numbers of lake-run rainbow trout enter the stream in the spring and fall.

29. Silver River.--Six stations on this system showed that ammocoetes were rare in the lower two miles of the main stream (total of 15 collected at three stations). Ammocoetes are confined to this area by a barrier. Small rainbow trout were abundant, and moderate numbers of lake-run rainbow trout enter this stream in the spring. Lake-run brook trout are present in the fall.

30-34. Falls River, Backwater Creek, Six Mile Creek, Little Carp River, and Kelsey Creek.--Each of these streams was sampled ~~at one location~~ near the mouth. No ammocoetes of any species were taken, and it is unlikely that these streams are used by sea lampreys. Lamprey utilization of the Falls River is especially doubtful because of a barrier one-half mile from the mouth.

35. Sturgeon River.--Three sea lamprey ammocoetes were collected at a point five miles above the mouth of this large stream system, but none were found at three other stations. Although there is a barrier (Prickett Power Dam) on the main stream, its importance in limiting sea lamprey reproduction

Figure 8.--Collection stations on the Huron River, Baraga County. Open circles are stations at which no sea lamprey larvae were taken. Letters within circles indicate the abundance of ammocoetes (C = common; R = rare).

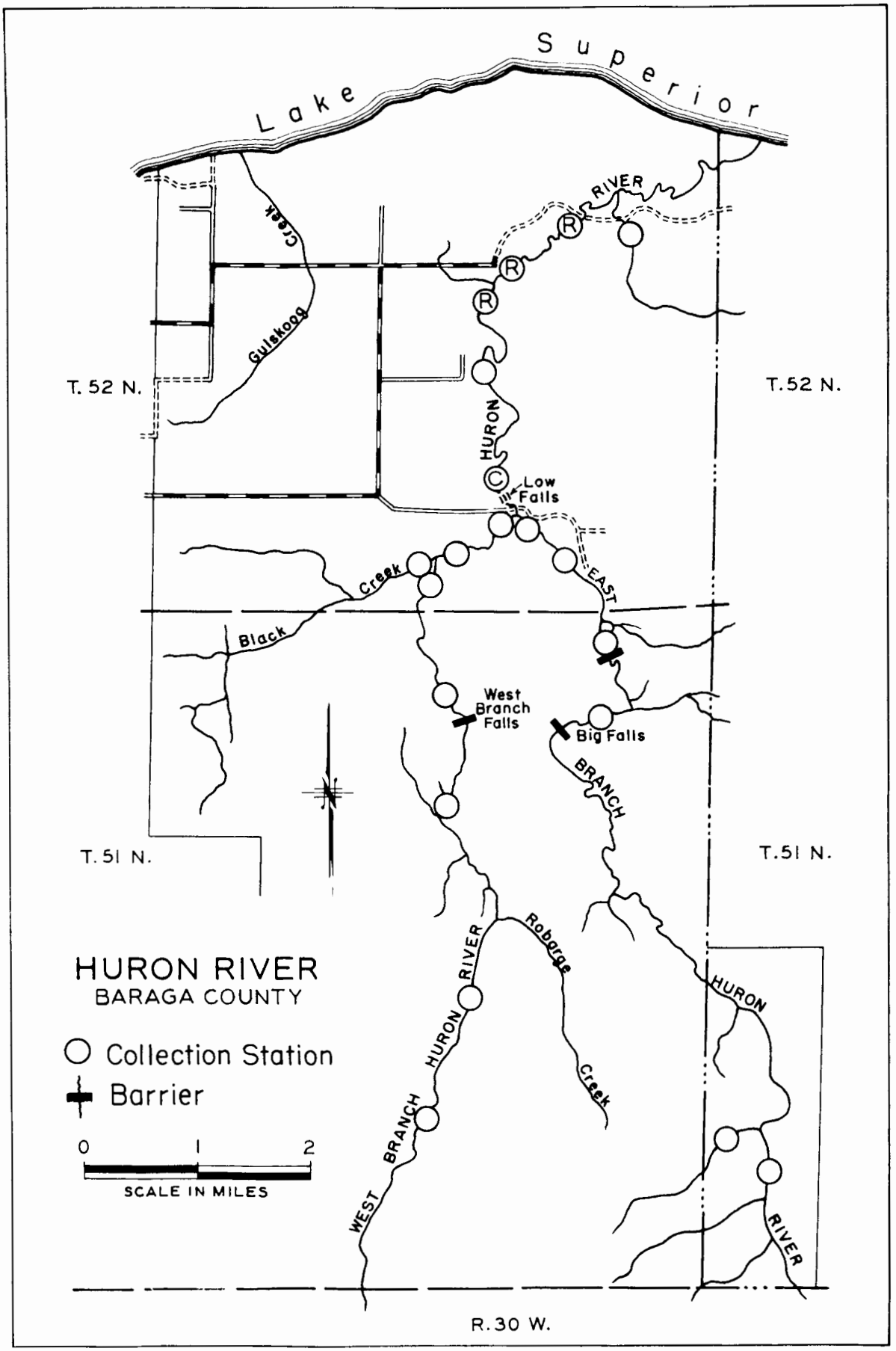
Lake Superior
RIVER
Creek
Gulskoog
T. 52 N.
T.52 N.
HURON
Low Falls
EAST
Creek
Black
West Branch Falls
Big Falls
BRANCH
T. 51 N.
T.51 N.
HURON RIVER
BARAGA COUNTY
Collection Station
Barrier
0 1 2
SCALE IN MILES
Robarge
RIVER
HURON
HURON
Creek
WEST BRANCH
RIVER
R.30 W.

Figure 8

is questionable because of its extreme distance (40 miles) from the mouth. The sampling was insufficient to determine the size and distribution of the ammocoete population. Fish present include northern pike, smallmouth bass, and a spring run of yellow walleyes (Stizostedion vitreum).

36. Traverse River.--Ammocoetes were not taken at one station near the mouth, but two were collected at a station located one mile upstream. This stream contains a small population of rainbow trout.

37. Little Gratiot River.--The single station, located one-third mile above Lac La Belle, produced one ammocoete. No important game fish populations were found.

38. Trap Rock River.--Two samples, in which no ammocoetes were found, and the lack of a spawning run in 1954-1955 (when an electrical weir was operated) indicated that sea lampreys do not use this stream.

39. Pilgrim River.--Our failure to collect ammocoetes at the two stations surveyed and the lack of a spawning run in 1954 (when an electrical weir was operated) indicated that sea lamprey reproduction does not occur in this stream.

40. Pike River.--Electrofishing at two stations on this stream produced no ammocoetes, although the habitat appeared suitable.

41. Otter River.--The fish population in this stream was sampled at 40 stations with a direct-current shocker in 1953. A total of 450 larvae of species of lampreys other than the sea lamprey were collected at 32 of these stations. Only one spawning migrant sea lamprey was taken in an electrical weir operated in 1954-1957, which further indicated that sea lampreys do not use this stream.

42. Graveraet River.--Since two collections on this stream failed to produce ammocoetes of any species and an electrical weir operated in 1954 took

no spawning migrants, it is unlikely that sea lampreys spawn in this stream. The abundance of brook trout and slimy sculpins suggested that low stream temperature may be a limiting factor.

43. Little Elm River.--The absence of ammocoetes of all species from two collections and the small size of this stream (under one cubic foot per second) strongly suggest that the habitat is unsuitable for sea lamprey reproduction.

44. Misery River.--Each of two stations on this stream, located one mile and two miles upstream from the mouth, produced one ammocoete. Moderate numbers of small rainbow trout were taken in the main stream and a large run of lake-run rainbow trout enters the stream in the spring.

45. East Sleeping River.--Utilization of this stream by sea lampreys appears doubtful as collections at two stations produced no ammocoetes of any species. Although it cannot be substantiated, the absence of ammocoetes may be due to a discharge of copper mine waste into the headwaters.

46. Firesteel River.--Four collections indicated that a small population of ammocoetes was present in the lower portion of the river. Ammocoetes were rare at a station two miles above the mouth, but were not caught at three stations above this point. Small numbers of rainbow and brown trout were collected.

47. Flintsteel River.--Although physical conditions appear adequate for sea lamprey reproduction, no ammocoetes were collected at three stations in this stream. Only six spawning migrants were taken during the operation of an electrical weir in 1954-1957.

48. Ontonagon River.--Sampling at 22 stations on the Ontonagon system disclosed ammocoetes only at the mouth of a small tributary, Mill Creek, which enters the main stream five miles above the mouth. Since Mill Creek has no suitable spawning grounds, these ammocoetes presumably originated from an upstream location in the Ontonagon River. The distribution pattern could not

be determined because of failure to locate the upstream origin. This may have been due to adverse collecting conditions (turbid water) and/or the widely dispersed collecting stations. Three species of trout were found in this system, but they were generally confined to the headwaters and tributaries. Large spawning migrations of walleyes were reported in the lower river.

49. Potato River.--No ammocoetes were taken at two stations, one near the mouth and the other seven miles upstream. The mouth of the river was sealed by a sand bar at the time of survey (July 31, 1957). It is not known whether this bar is present during the spring spawning run of adults.

50. Floodwood River.--A single station located near the mouth of this stream produced no ammocoetes of any species, suggesting that sea lamprey reproduction does not occur. Like the Potato River, the mouth of this stream was blocked by a sand bar.

51. Cranberry River.--A station near the mouth of this small stream produced no ammocoetes, but one ammocoete was collected at a station one mile upstream. No important game fish were taken.

52-54. Halfway River, Duck Creek, Pine River.--No ammocoetes were collected at stations in these streams. Since the streams are small and intermittent during the summer, as indicated by lack of flow and sand bars which seal the mouths, the likelihood of use by sea lampreys is small. The possibility of sea lamprey utilization is further minimized in Duck Creek and the Pine River because no ammocoetes of any species were collected.

55. Mineral River.--Electrofishing at two stations produced no ammocoetes of any species. Discharge of copper wastes (White Pine Copper Mine) may discourage sea lamprey reproduction in this stream.

56. Big Iron River.--Two collections on this stream included no ammocoetes of any species. The stream bottom is predominantly bedrock, which undoubtedly limits or prevents sea lamprey reproduction.

57. Little Iron River.--Ammocoetes were not found in two collections. Because gross physical characters of this stream were suitable for sea lamprey reproduction, the absence of ammocoetes is unexplained.

58. Union River.--No ammocoetes were found in the two collections from this stream, nor were spawning migrants taken during operation of a weir in 1954-1955. Its small size (under five cubic feet per second) was the only apparent factor limiting sea lamprey reproduction.

59-60. Maple and Little Speckled creeks[8].--No ammocoetes of any species were found in two collections on Maple Creek and one collection on Little Speckled Creek. Dominance of cold-water fish populations also suggested that sea lampreys do not use these streams.

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[8]The following streams (not shown in Fig. 2) in Gogebic County were examined but not sampled because of small or non-existent flows: Nighthawk, Ghost, Ohman, Maki, Flink, Treasure, and four unnamed creeks. The Black and Montreal rivers were also examined but not sampled because barriers near their mouths prevent the use of these streams by sea lampreys.

Summary

Ammocoetes were present in 21 of the 60 stream systems examined. Lake Superior tributaries containing the largest populations were (in decreasing order of abundance): the Chocolay, Two Hearted, and Sucker rivers. Streams with somewhat smaller populations were (in decreasing order of abundance): the Rock, Betsy, Huron, and Little Two Hearted rivers. Streams which contained at least a small population were (from east to west): the Tahquamenon River, Carpenter and Seven Mile creeks, and the Mosquito, Miners Iron, Silver, Sturgeon, Traverse, Little Gratiot, Misery, Firesteel, Ontonagon, and Cranberry rivers.

The collection data for the surveys of State of Michigan tributaries of Lake Superior are summarized in Table 1.

Since the population of sea lampreys is increasing rapidly in Lake Superior, it is likely that, if uncontrolled, they will utilize additional streams and extend their range in streams already infested.

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Table 1.--Dates of surveys, amount of collecting effort, and numbers of sea lamprey ammocoetes collected in Michigan tributaries of Lake Superior, 1953-1957

Stream number*	Stream	Date of collection Month†	Year	Number of stations	Collecting time (minutes)	Total number of ammocoetes collected	Volume of stream‡ (c.f.s.)
1	Roxbury Creek	8	1956	1	25	0	5-6
2	Tahquamenon River	8	1956	2	65	3	> 30
3	Obriens Creek	8	1956	1	30	0	2-3
4	Betsy River	8	1956	16	755	75	30
5	Three Mile Creek	8	1956	2	60	0	1
6	Little Two Hearted River	8	1956	7	316	106	30-40
7	Two Hearted River	11	1955	8	460	6	150-200
		8	1956	33	1,328	155	100-150
		10	1957	4	170	1	...
8	Dead Sucker River	7, 8	1954	2	150	0	25
9	Sucker River	7, 8	1955	13	930	317	30
		7, 8	1956	16	945	113	...
10	Carpenter Creek	8	1956	1	45	1	1-2
11	Sable Creek	7	1956	1	40	0	5
12	Hurricane River	8	1955	2	90	0	7
13	Seven Mile Creek	7, 8	1955	3	185	21	5-6
14	Mosquito River	7	1956	1	65	10	15-20
15	Miners River	8	1955	2	120	17	14

Stream number*	Stream	Date of collection Month†	Year	Number of stations	Collecting time (minutes)	Total number of ammocoetes collected	Volume of stream‡ (c.f.s.)
16	Anna River	10	1957	2	75	0	20-25
17	Bay Furnace Creek	8	1955	6	320	0	5
18	Five Mile Creek	7	1956	2	65	0	4-5
19	Au Train River	6, 10	1957	3	115	0	144
20	Rock River	8	1955	12	670	79	20-30
		7	1956	8	260	3	20
21	Deer Lake Outlet	7	1956	1	35	0	5
22	Sand River	6	1956	2	130	0	15-25
23	Chocolay River	7, 8	1955	6	443	65	...
		6, 7	1956	35	1,325	370	> 30
24	Little Garlic River	7	1956	2	200	0	10-15
25	Iron River	6	1957	1	60	5	20-25
26	Salmon Trout River	7	1956	1	50	0	15
27	Little Huron River	9	1956	2	65	0	7-8
28	Huron River	10	1955	14	715	4	30
		9	1956	6	230	61	> 30
29	Silver River	10	1955	4	305	15	35
		9	1956	2	60	0	...
30	Falls River	8	1956	1	50	0	25-30
31	Backwater Creek	8	1956	2	115	0	< 5

Stream number	Stream	Date of collection Month	Year	Number of stations	Collecting time (minutes)	Total number of ammocoetes collected	Volume of stream (c.f.s.)
32	Six Mile Creek	8	1956	1	30	0	15-20
33	Little Carp River	8	1956	1	30	0	1-2
34	Kelsey Creek	8	1956	1	30	0	< 1
35	Sturgeon River	8, 9	1956	4	190	3	>30
36	Traverse River	8	1956	2	110	2	15-20
37	Little Gratiot River	8	1956	1	60	1	3-4
38	Trap Rock River	8	1956	2	75	0	20-25
39	Pilgrim River	8	1956	2	95	0	10-15
40	Pike River	8	1956	2	90	0	5-6
41	Otter River	6, 7, 8	1953	40	2,600	0	103
42	Graveraet River	8	1957	2	100	0	15-20
43	Little Elm River	8	1957	2	65	0	< 1
44	Misery River	8	1957	2	135	2	30
45	East Sleeping River	8	1957	2	60	0	<10
46	Firesteel River	7, 8	1957	4	235	11	10-15
47	Flintsteel River	7	1957	3	150	0	5
48	Ontonagon River	7, 8	1957	22	1,218	7	> 30
49	Potato River	7	1957	2	120	0	3-4
50	Floodwood River	7	1957	1	55	0	0

Stream number*	Stream	Date of collection Month†	Year	Number of stations	Collecting time (minutes)	Total number of ammocoetes collected	Volume of stream‡ (c.f.s.)
51	Cranberry River	7, 8	1957	2	120	1	<5
52	Halfway River	8	1957	2	45	0	0§
53	Duck Creek	8	1957	1	35	0	0§
54	Pine River	8	1957	1	30	0	0§
55	Mineral River	7, 8	1957	2	85	0	12
56	Big Iron River	8	1957	2	95	0	30
57	Little Iron River	8	1957	2	115	0	<10
58	Union River	8	1957	2	100	0	< 5
59	Maple River	8	1957	2	80	0	< 8
60	Little Speckled Creek	8	1957	1	45	0	5-8

*Stream number refers to the number arbitrarily assigned to each stream in the maps (Figs. 1 and 2) and text.

†Months are numbered consecutively from June (6) to November (11).

‡Estimated volume in cubic feet per second at station nearest the mouth.

§Streams were apparently stagnant.

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