SEA LAMPREY SPAWNING:
Wisconsin and Minnesota Streams Of Lake Superior

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 97

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

Explanatory Note

The series embodies results of investigations, usually of restricted scope, intended to aid or direct management or utilization practices and as guides for administrative or legislative action. It is issued in limited quantities for the official use of Federal, State or cooperating Agencies and in processed form for economy and to avoid delay in publication.

Washington,D. C.
June, 1953

United States Department of the Interior, Douglas McKay, Secretary
Fish and Wildlife Service, John L. Farley, Director

SEA LAMPREY SPAWNING: WISCONSIN AND MINNESOTA STREAMS OF LAKE SUPERIOR

by

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Fishery Biologist

Special Scientific Report: Fisheries No. 97

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ILLUSTRATIONS

The 1952 sea lamprey stream survey in the Lake Superior Basin was organized as a continuation of the 1950-51 survey. Immediate objectives during the 1952 season were as follows:

1. To extend the surveyed area to include all Wisconsin and Minnesota watersheds in the Lake Superior basin.

2. To identify further, those streams which are producing or may produce sea lampreys in the future.

3. To determine the general characteristics of those streams in which control measures may be required.

The standards and methods used in 1952 differed from those of 1950 and 1951 only in that the stream examinations were less intensive (Loeb and Hall, 1952).

All of the streams in Minnesota (Cook, Lake, and St. Louis Counties) and a portion of those in Wisconsin (Iron, Ashland, and Bayfield Counties) were surveyed. In addition, all of the streams on Grand Island, Alger County, Michigan, were examined.

The Wisconsin streams were examined during the month of June. Operations in Minnesota began on July 11 and terminated on August 8.

Personnel included, in addition to the author, Clifford Brynildson, Robert Braem, Earl Schaedig, and George Simmons. The map of Iron County, Wisconsin was prepared by Bernard Smith. All other maps are the work of Robert Braem.

Appreciation is extended to the Minnesota Department of Fish and Game for data concerning the North Shore watersheds, and to the Wisconsin Conservation Department for the offer of their patrol boat for the survey of inaccessible streams.

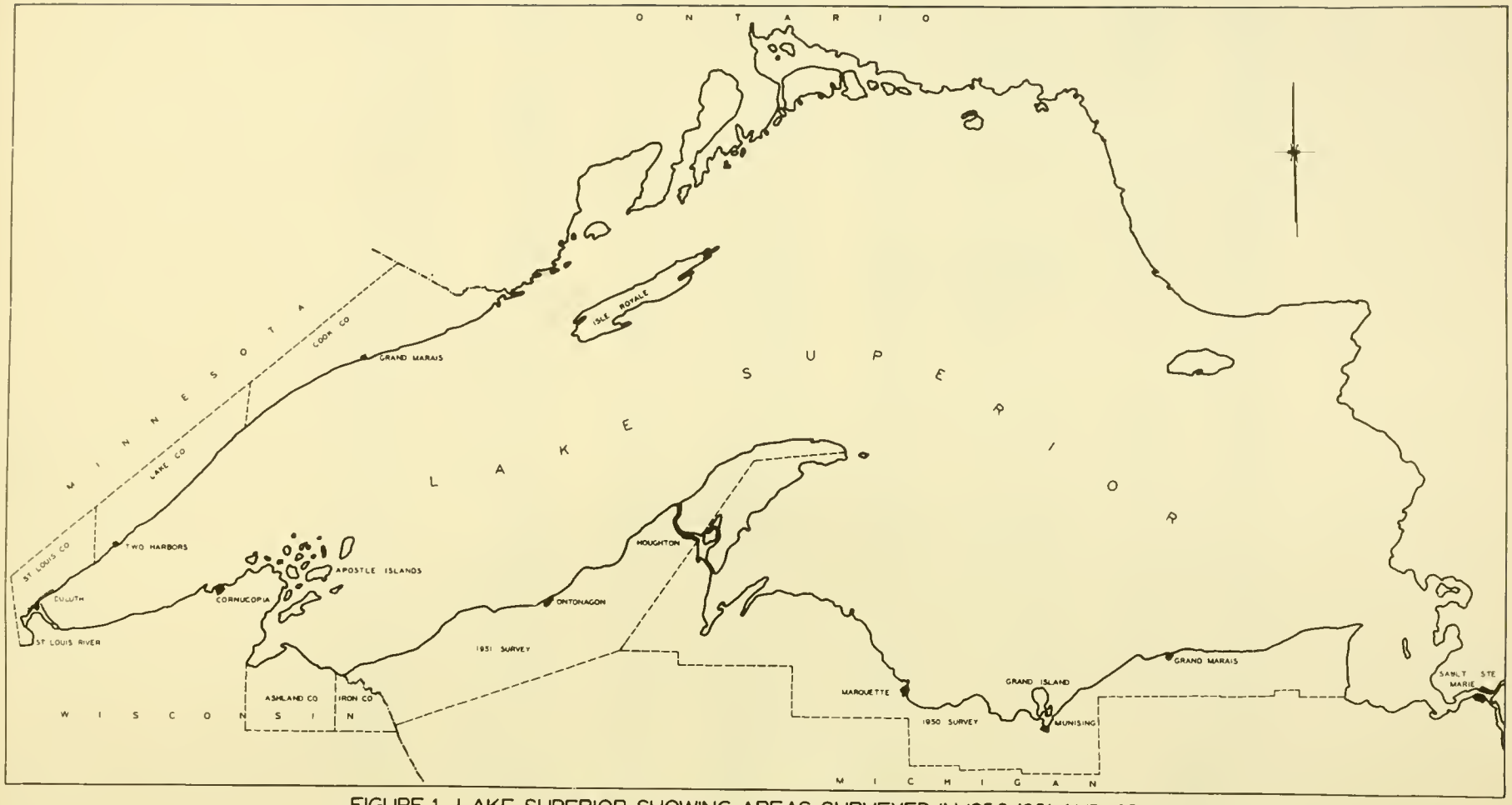


FIGURE 1. LAKE SUPERIOR, SHOWING AREAS SURVEYED IN 1950, 1951, AND 1952

Examination of streams on Grand Island

Of 23 streams on the island, 21 cannot be utilized by sea lampreys because of one or more of the following limiting factors: small size, low temperatures, and the presence of bedrock barriers ranging from 8 to 100 feet in height.

North Light Creek (at the northern end of the island), a stream approximately 3 miles in length, flows from a tag alder swamp and is soft bottomed throughout; this stream is unsuitable for spawning lampreys due to a lack of spawning gravel.

Echo Lake Creek (T 47 N, R 19 W, S 4, on the western side of the island), the outlet of Echo Lake, is approximately 1/2 mile in length, 10 to 15 feet in width, and up to 10 inches in depth. Water temperature on June 21 was 60° F. Spawning medium for 25 or more nests is present. Sea lampreys can be blocked from this stream by a 25-foot wide concrete barrier placed at the mouth. Power lines are present only at the south end of the island, a distance of at least 3 miles. The stream can be reached by automobile. The proposed weir site is approximately 300 feet from the road.

Examination of streams in Wisconsin

Iron County: Contains 8 small streams (Fig. 2), 4 of which can probably be utilized by sea lampreys (Table 1). The productive potentials of the latter range from small to medium (Loeb and Hall, 1952). Electrical control devices are recommended.

All of the streams are subject to rapid fluctuations in water levels and several to a resulting heavy turbidity. Bottom irregularity and scouring by sudden freshets may limit the extent of utilization by sea lampreys even in the streams considered to have a productive potential.

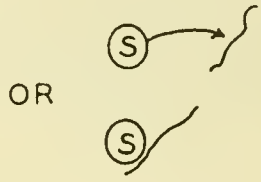
Installation and operation of control devices will be hindered by the relative inaccessibility of two streams, and by occasional excessive turbidity (lake clay).

Ashland County: Contains 11 watersheds (Fig. 3), 5 of which have productive potentials ranging from small to large (Table 2).

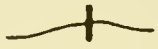
The condition of Denomie Creek could not be determined because of continual heavy turbidity, and the Kakagon River and Wood Creek Slough were incompletely examined for the same reason. Heavy and continual turbidity also prevented the survey of the main portion of the Bad River except in the portion between the mouth and U. S. Highway 2; spawning habitat was found in three tributaries, however, during a brief period when they were clear.

LEGEND FOR FIGURES 2-6

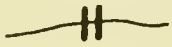
SPAWNING HABITAT



NATURAL BARRIER



MAN-MADE BARRIER



BASE MAPS — STATE HIGHWAY COMMISSION OF WISCONSIN

ST. LOUIS CO. HIGHWAY DEPT

OFFICIAL MAP OF LAKE CO.

OFFICIAL MAP OF COOK CO.

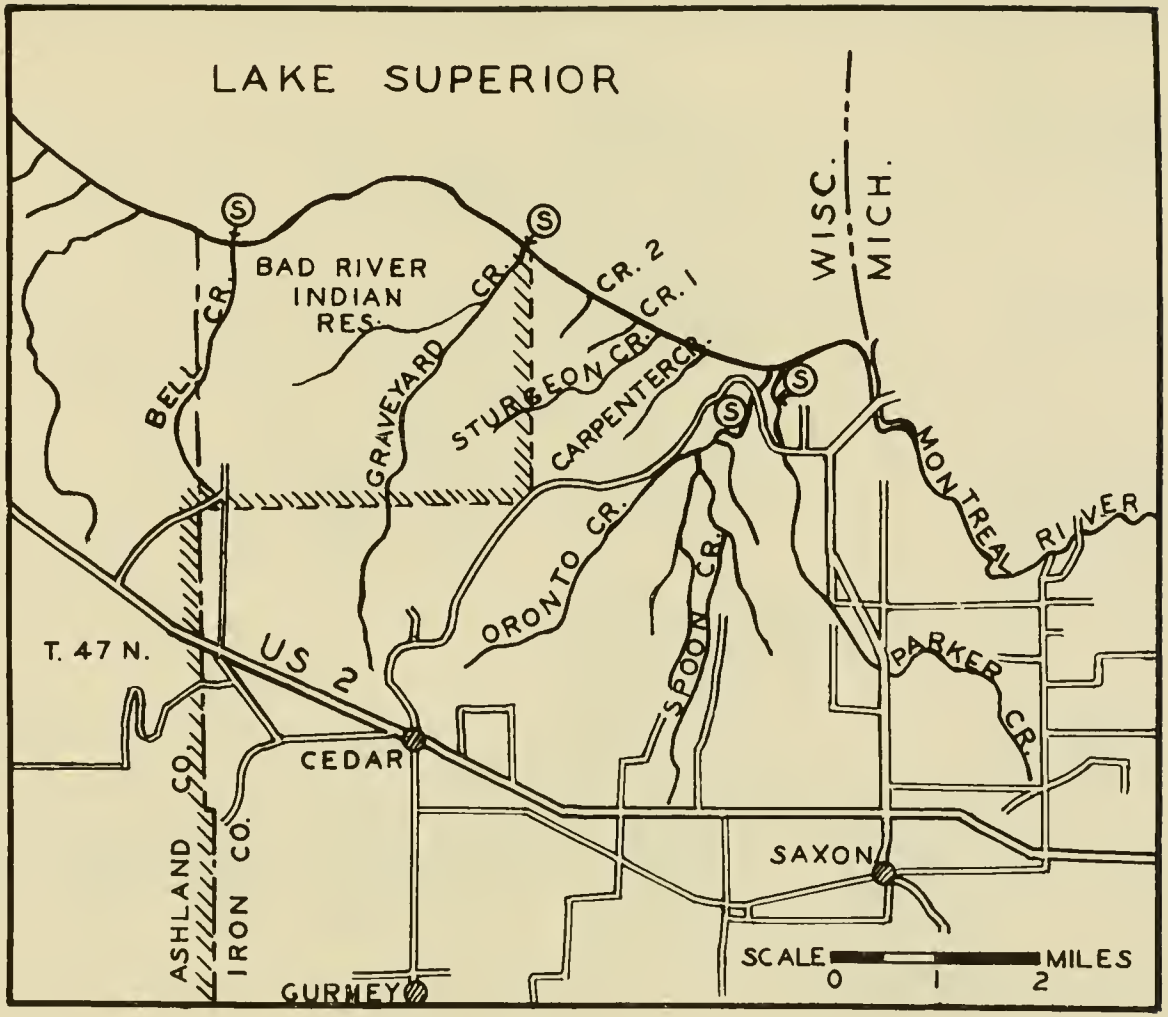


FIGURE 2. SHORELINE OF IRON COUNTY, WISCONSIN

Table 1.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Iron County, Wisconsin
(Survey made in 1952)

Name of stream 1/ and mouth location	Total length in mi.	Aver. width feet 2/	Aver. depth feet 2/	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Parker Cr. 47N-1W-12	13	4	0.3	60 (6-10)	Small	Drying, scouring, water level fluctuations, temporary barrier at mouth, irregular bottom	---	24' electrical device 150' above mouth; power lines within 150'
Oronto Cr. 47N-1W-12	30	10	0.5	68 (6-10)	Small	Drying, scouring, water level fluctuations, irregular bottom	---	24' electrical device at bridge 0.1 miles above mouth; power lines within 25'
Graveyard Cr. 47N-1W-9	10	10?	1.0?	--- (6-11)	Small	Drying, scouring, water level fluctuations	---	Relatively inaccessible; barrier control unlikely
Bell Cr. 47N-1W-6	3	5	0.3	63 (6-11)	Medium	Water level fluctuations, irregular bottom	---	25' electrical device, 200' above mouth; power lines not available; relatively inaccessible

1/ List includes only those streams which appear to have a productive potential.
2/ Applicable only to the surveyed portion of the stream.

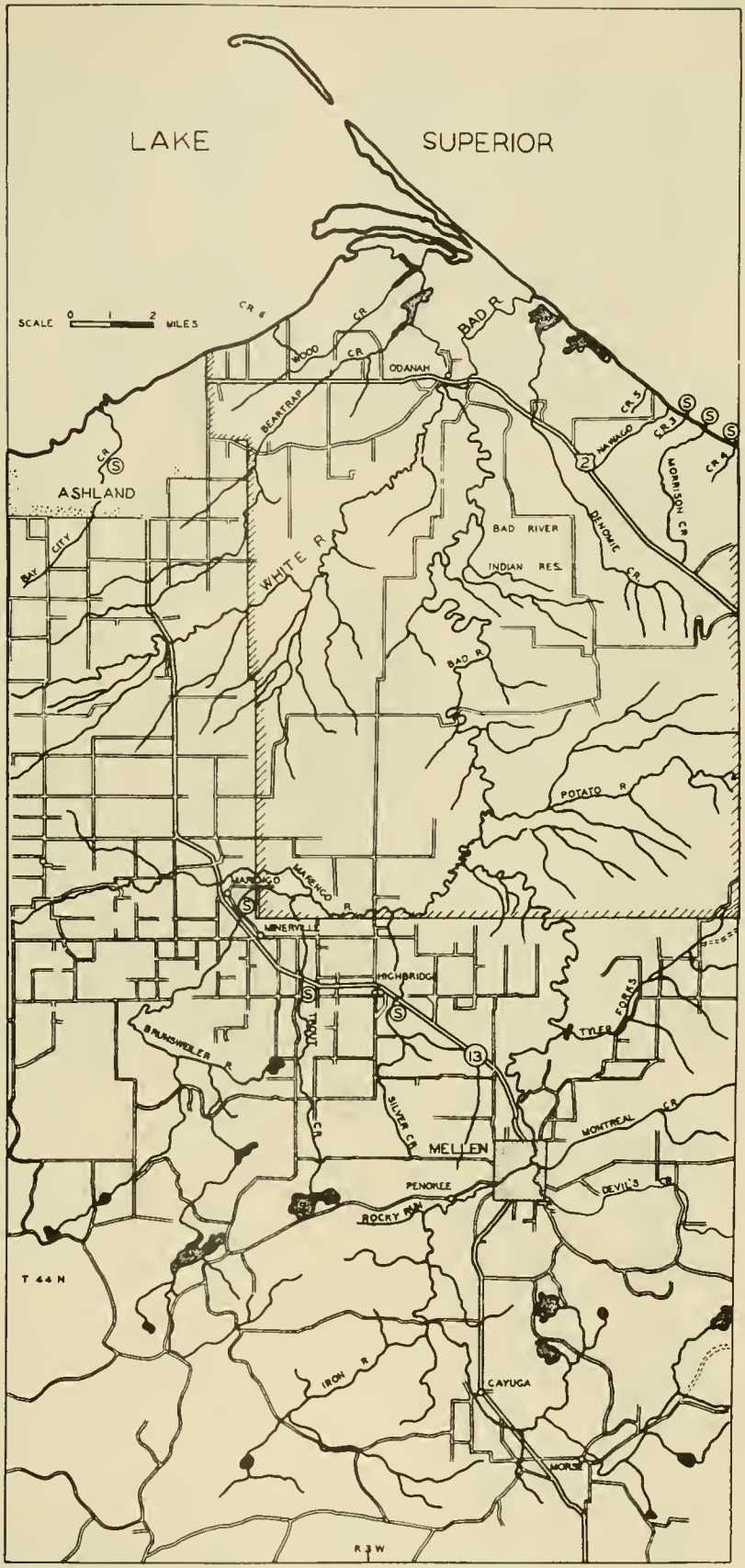


FIGURE 3. SHORELINE OF ASHLAND COUNTY, WISCONSIN

Table 2.—Productive potential, recommended control devices, and miscellaneous factors concerning streams in Ashland County, Wisconsin
(Survey made in 1952)

Name of stream 1/ and mouth location	Total length in mi.	Aver. width feet 2/	Aver. depth feet 2/	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Creek No. 4 47N-2W-1	2	3	0.3	64 (6-11)	Small	Small size, occasionally blocked at mouth by sand bar	---	12' electrical device 100' above mouth; relatively inaccessible
Morrison Cr. 48N-2W-36	10	8	0.4	59 (6-11)	Medium	Lowering of water level, blocking of mouth by sand bar	---	50' electrical device 200' above mouth; relatively inaccessible
Creek No. 3 48N-2W-35	2	2	0.3	60 (6-11)	Small	Small size	---	16' electrical device 150' above mouth; relatively inaccessible
Denomie Cr. 48N-2W-20	12	10	---	59 (6-18)	---	---	?	Stream not completely checked because of continual turbidity
Bad R. system 48N-2W-17	100+	250	10.0	66 (6-18)	Large	---	?	290' electrical device at highway bridge 4 miles above mouth; control difficult due to large size, almost continual turbidity, and run of walleye used by Indians

Table 2, continued

Name of stream 1/ and mouth location	Total length in mi.	Aver. width feet 2/	Aver. depth feet 2/	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Kakagon R. system 48N-3W-11	40	40	---	63-66 (6-18)	---	Low velocity	---	System not completely checked because of continual turbidity
Wood Cr. Slough 48N-3W-11	12	10	---	59 (6-18)	---	Low velocity	---	Stream not completely checked because of continual turbidity
Bay City Cr. 47N-4W-33	10	6	0.4	60 (6-18)	Small	Low velocity, low water levels	---	Stream not completely checked because of continual turbidity

1/ List includes only those streams which appear to have a productive potential.

2/ Applicable only to the surveyed portion of the stream.

As judged from the rocky character of the Bad River watershed, the main river and its larger tributaries such as the White, Narengo, and Potato Rivers probably contain large amounts of spawning habitat. Complete and partial barriers may be present in relatively inaccessible areas.

Electrical control devices are recommended for all streams with a productive potential. Control will be rendered difficult due to the relative inaccessibility of Morrison Creek and Creeks 3 and 4, to the large size of the Bad River, and to the high degree of turbidity of several of the streams.

Bayfield County: A total of 10 streams was surveyed, but examination was incomplete because of almost continual heavy turbidity. Several of these streams can probably be utilized by sea lampreys. At least 25 streams were not examined because of the turbidity factor.

Douglas County: At least 38 watersheds are present; none was examined because of continual heavy turbidity. Several can probably be utilized by sea lampreys.

Apostle Islands (Ashland County): Not examined; may contain several small streams suitable for sea lamprey spawning.

Almost all of the Wisconsin streams flowing into Lake Superior are affected by rapid fluctuations in water levels and extremely heavy turbidity (lake clay). The latter condition appears to accompany even light rains, and as a result the streams are often turbid for weeks.

Thr present study was greatly hindered by both conditions. Only limited portions of the larger watersheds could be examined, and these relatively ineffectually. Adult lampreys and nests, if present, were of course, not observed. Stream bottoms were visible only in isolated instances. The turbid condition could well account for the lack of reports concerning sea lamprey spawning along the Wisconsin shoreline.

Electrical control techniques are practical in these streams, but construction, operation, and maintenance will be impeded by both turbidity and water level fluctuations. It is recommended that an effort be made to determine the bottom conditions of the remaining streams only during the periods when they are clear, and that mechanical control devices be constructed initially on certain streams to ascertain the extent of sea lamprey spawning runs, if any.

Cook County: Contains 77 separate watersheds (Fig. 4). At least 46 of these are unsuitable for sea lamprey spawning because of the following limiting factors: low temperatures, scouring, bottom irregularity, barriers, small size, rapid fluctuations in water levels, etc.

Twenty-two streams are considered to be marginal (Table 3). Spawning gravel for a varying number of nests is present, but other factors are likely to be unfavorable enough to seriously hamper spawning efforts.

Nine streams with productive potentials ranging from medium to large are believed to be quite suitable for sea lampreys, despite the presence of limiting factors (Footnote 2, Table 3). Six of these streams are large; three others averaged 5, 8, and 15 feet in width in the sections examined. Electrical control devices are recommended for all of them.

The geology and surface features of the Cook County watershed have been described in detail in a publication of the Minnesota Department of Conservation (Smith and Moyle, 1944). Suffice it to say that most of the streams in the Cook County watershed flow over rocky, rugged terrain, often cliff-like in gradient. Barriers and partial barriers to fish are numerous. Run-off is rapid and great fluctuations in water levels are the rule. The majority of streams is small. A number of them are probably intermittent in character.

Any type of control operation will be aided by the accessibility of the majority of streams in the watershed. A few streams in the northern portion of the county are relatively inaccessible.

Installation of electrical devices will be difficult in the Pigeon and Arrowhead Rivers due to large size, reversing currents, shifting sand bars, and pulp wood operations.

Lake County: Contains 50 separate watersheds (Fig. 5). At least 13 of these are unsuitable for sea lamprey spawning because of the presence of barriers, small size, irregularity of bottom, etc.

Twenty-eight streams are considered to be marginal (Table 4). Spawning gravel for a varying number of nests is present, but other factors are likely to be unfavorable enough to impede spawning efforts.

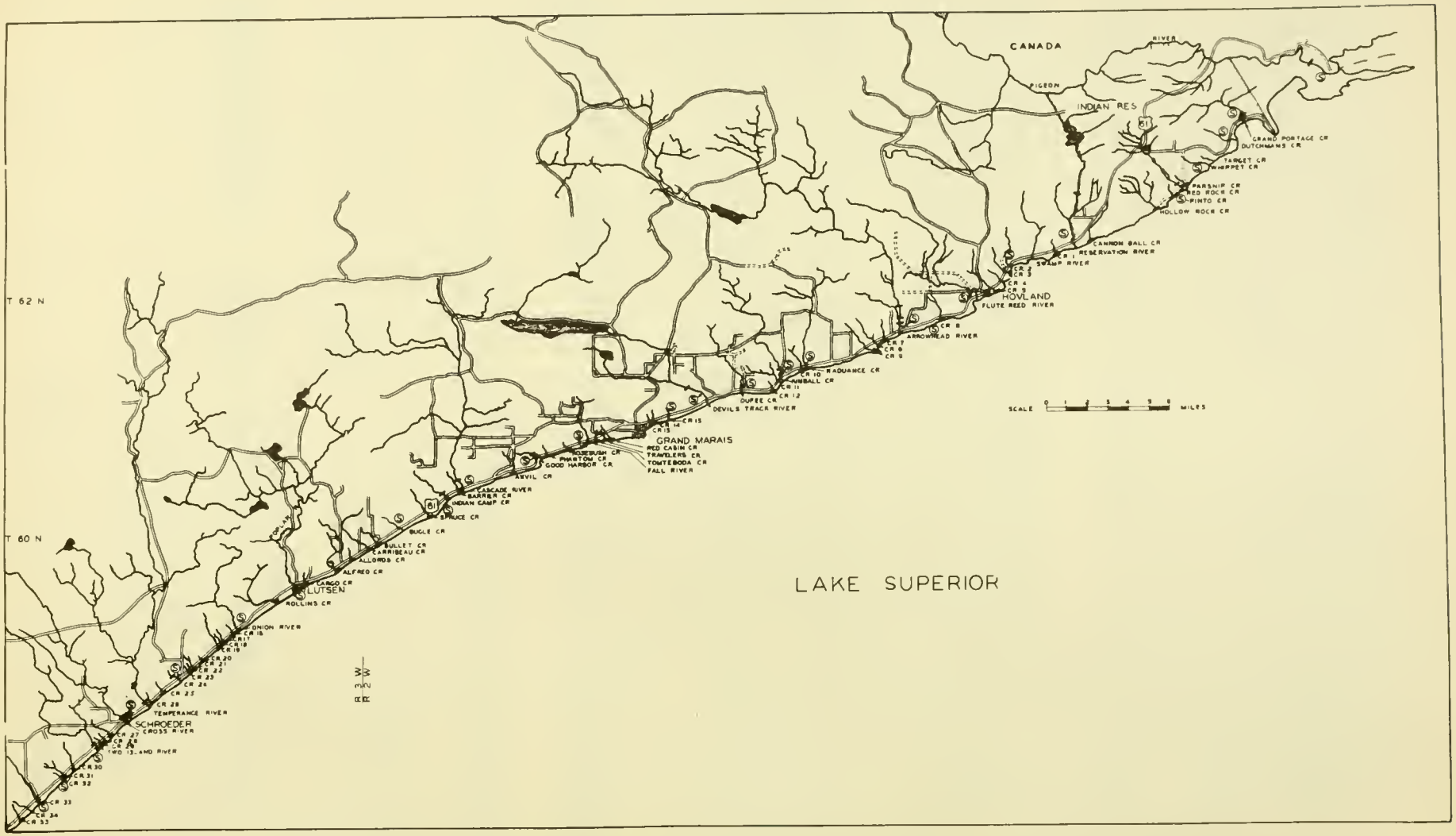


FIGURE 4. SHORELINE OF COOK COUNTY, MINNESOTA

Table 3.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Cook County, Minnesota
(Survey made in 1952)

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp, F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Pigeon R.[2] Canadian Border	40+	250	5.0?	67-70 (7-11)	Medium	None	2.0 mi.	Main spawning area in riffle area just below falls. Control difficult due to reversing current from mouth to riffle, and floating of pulp sticks over falls
Grand Portage Cr. 63N-6E-4	5+	10	0.8	57-62 (7-12)	Medium	Steep gradient, high velocity, irregular bottom, scouring, water level fluctuations	---	18' electrical device at mouth; power line within 0.25 mile
Dutchman's Cr. 63N-6E-9	4	5	0.5	54 (7-14)	Medium	Low temperature, irregular bottom, drying, scouring, water level fluctuations, partial blocking at mouth by bar	---	0.5 mile walk to 10' electrical device at mouth; power line within 0.5 mile
Whippet Cr. 63N-6E-19	3	5	0.5	53-61 (7-14)	Small	Irregular bottom, partial barriers, scouring, lack of larval habitat	---	3' x 20' concrete barrier at mouth; reached by 0.5 mile canoe ride on lake, power not available

Table 3, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Red Rock Cr. 63N-5E-25	9	20	0.7	57 (7-15)	Medium	Irregular bottom, steep gradient	0.5 mi.	25' electrical device at mouth; power lines within 0.1 mile; road almost to mouth
Reservation R.[2] 62N-5E-6	16	25	1.0	61 (7-14)	Large	None	4.5 mi.	30' electrical device 50' above the mouth; power lines and road 300' above site
Creek No. 2[2] 62N-4E-10	2	8	0.5	61 (7-14)	Medium	Scouring, small size	---	25' electrical device 225' above mouth; power lines and road at site
Flute Reed R.[2] 62N-4E-20	20	15	0.8	60 (7-15)	Large	Irregular bottom, scouring	---	25' electrical device 60' above mouth; power lines and road 250' above site
Creek No. 6 62N-3E-25	3	4	0.5	56 (7-15)	Medium	Steep gradient, scouring, small size	0.2 mi.	15' electrical device 40' above mouth; power lines and road 0.2 mile above site
Arrowhead R.[2] 62N-3E-27	120	60	2.0	72 (7-15)	Medium	Steep gradient, scouring, high velocity, irregular bottom	0.75 mi.	Electrical device difficult due to width of estuary, and shifting of gravel bar at mouth
Kadunce R. 61N-2E-2	10	12	0.8	62 (7-15)	Medium	Irregular bottom, scouring, partial barrier 0.5 mile above mouth	---	25' electrical device 50' above mouth; power lines and road 100' above site

Table 3, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Kimball Cr. 61N-2E-10	12	15	0.8	60 (7-17)	Medium	Irregular bottom, scouring, partial barrier 0.5 mile above mouth	---	30' electrical device 75' above mouth; power lines and road 225' above site
Dufee Cr. 61N-2E-8	8	8	0.6	63 (7-17)	Medium	Steep gradient, water level fluctuations, small size, partial barrier	---	2' x 20' concrete barrier in culvert at highway, 75' above mouth
Devil's Track R.[2] 61N-1E-13	51	30	1.0	65 (7-17)	Large	Scouring	2.0 mi.	110' electrical device, 100' above mouth; power lines 50' from site
Creek No. 13 61N-1E-22	1+	3	0.4	56 (7-17)	Medium	Low temperature, small size, scouring	---	3' x 10' concrete barrier, 50' above mouth; 0.5 mile walk downstream from highway
Fall R. 61N-1W-33	7	20	2.0	61 (7-17)	Medium	Scouring, lack of larval habitat, high velocity	200 ft.	50' electrical device (largely on sand bar) at mouth; power lines and road 0.2 mile above
Good Harbor Cr. 61N-1W-34	3	15	0.5	58 (7-17)	Medium	Submarginal spawning medium, no sand present	0.75 mi.	10' electrical device at mouth power line within 100'; road within 200'

Table 3, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Cascade R. 60N-2W-1	78	50	3.0	68 (7-17)	Medium	Submarginal spawning medium, high velocity, lack of larval habitat, scouring	0.75 mi.	30' electrical device at mouth; power lines and highway at mouth
Indian Camp Cr.[2] 60N-2W-11	4	5	0.5	60 (7-17)	Medium	None	0.75 mi.	20' electrical device at mouth; power lines within several hundred yards
Bugle Cr. 60N-2W-17	2+	5	0.3	52 (7-18)	Medium	Poor larval habitat, small size, low temperature, partial barrier at mouth	---	Barrier at mouth by rock removal; power lines and road within 600'
Cargo Cr. 60N-3W-34	1	4	0.6	56 (7-18)	Small	Poor larval habitat, small size, low temperature, partial drying, partial barrier at mouth	0.5 mi.	3' x 15' concrete barrier at mouth; power lines and road within 100 yards
Poplar R. 60N-3W-33	65	50	4.0	66 (7-18)	Small	Spawning possible only on beach gravel	250 ft.	Electrical device, 50'-100' long; power lines and road at site
Onion R. 49N-4W-12	14	30	2.0	59 (7-18)	Small	Irregular bottom, high velocity, scouring	0.3 mi.	Possibly no productive potential

Table 3, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Creek No. 24 59N-4W-21	1	5	0.5	57 (7-18)	Medium	Small size, drying, scouring, water level fluctuations	0.5 mi.	6' electrical device; 50' above mouth; power lines and road at site
Cross R.[2] 58N-5W-1	55	30	1.0	65 (7-18)	Medium	Some scouring	0.25 mi.	50'-75' electrical device at mouth; power lines and road 150 yards
Two Island R.[2] 58N-5W-9	21	30	1.0	62 (7-18)	Medium	None	175 ft.	45' electrical device at mouth; power lines 0.25 mile; road 0.1 mile
Creek No. 30 58N-5W-15	2	4	0.25	58 (7-23)	Medium	Partial barrier at mouth, scouring, small size	---	3' x 10' concrete barrier 20' above mouth
Creek No. 31 58N-5W-16	2	4	0.3	58 (7-23)	Small	Small size, scouring, lack of larval habitat	35 ft.	3' x 10' concrete barrier at mouth; road 0.1 mile
Creek No. 32 58N-5W-16	1+	3	0.2	56 (7-23)	Small	Small size, low temperature, irregular bottom, poor spawning medium	---	3' x 7' concrete barrier at mouth; road 0.1 mile
Creek No. 33 58N-5W-29	4	4	0.4	59 (7-23)	Medium	Small size, scouring, partial barrier at mouth	0.1 mi.	3' x 20' concrete barrier at mouth; road at site

Table 3, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Creek No. 34 58N-5W-29	1	2	0.3	59 (7-23)	Medium	Small size, scouring, partial barrier at mouth	---	3' x 8' concrete barrier 40' above mouth; at highway

1/ List includes only those streams which appear to have a productive potential.

2/ Stream is one of a group of 22 in Minnesota which appear to be more suited to sea lamprey spawning than the other streams with a productive potential. These streams should be closely checked for spawning in the future since they will probably be the first to be utilized.

3/ Applicable only to the surveyed portion of the stream.

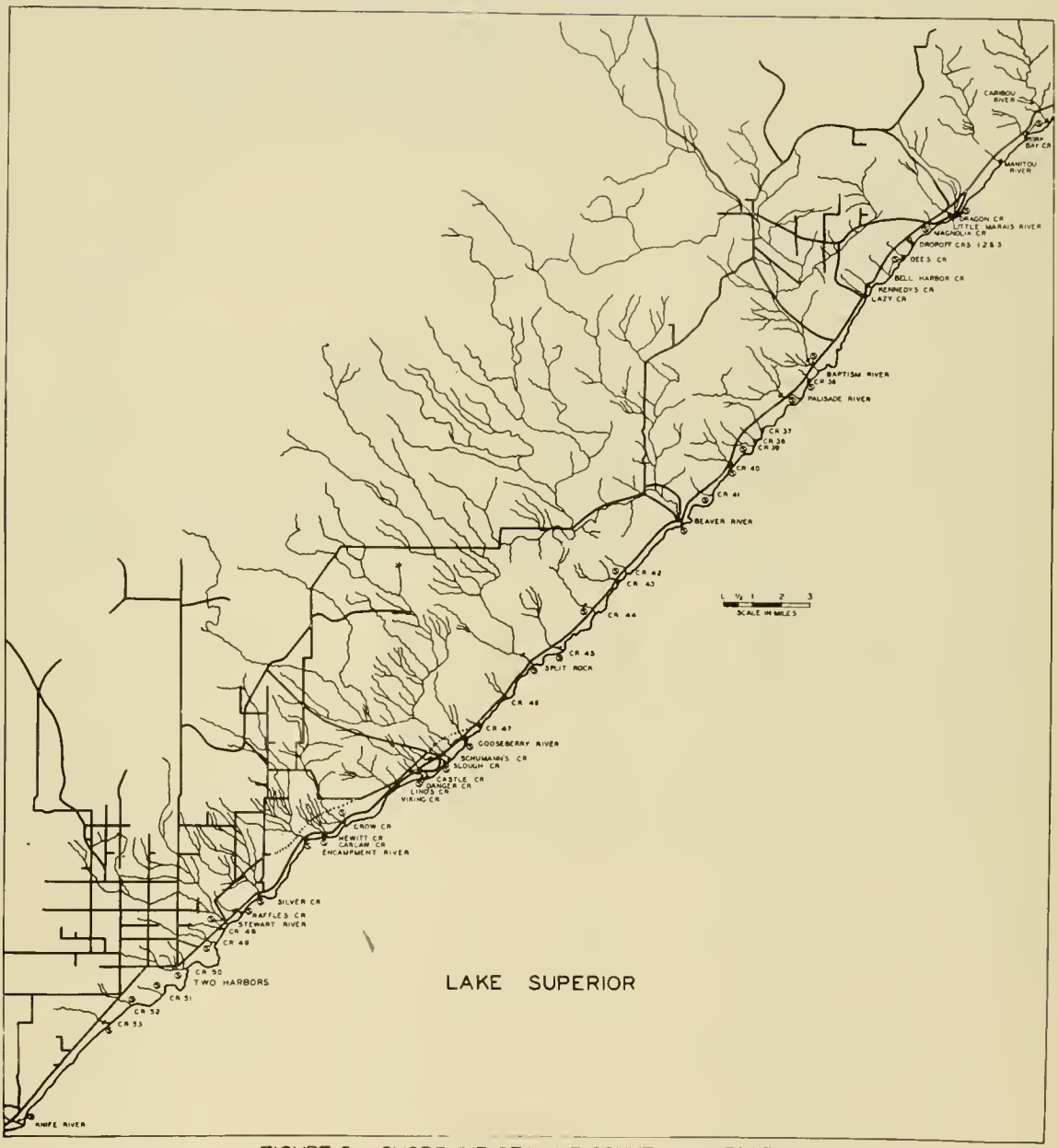


FIGURE 5. SHORELINE OF LAKE COUNTY, MINNESOTA

Table 4.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Lake County, Minnesota
(Survey made in 1952)

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Caribou R. 58N-6W-36	40	30	0.7	61 (7-23)	Medium	Scouring, no larval habitat	200 ft.	Electric device 90' long; power lines available
Pork Bay Cr. 57N-6W-2	2	8	0.5	56 (7-23)	Medium	No larval habitat, low temperature, drying	---	25' electrical device, 50' above mouth; power lines 0.25 mile above at highway
Dragon Cr.[2] 57N-6W-16	5	10	0.7	59-60 (7-23)	Medium	None	0.3 mi.	20' electrical device, 15' above mouth; power lines at adjacent resort
Little Marais R. 57N-6W-16	4	20	0.8	62 (7-23)	Medium	Scouring, proximity of spawning habitat to mouth	0.1 mi.	20' electrical device, 30' above mouth; power lines at resort at mouth
Magnolia Cr. 57N-6W-20	0.5	5	0.3	59 (7-24)	Small	Drying, small size	---	18' electrical device at mouth; power lines at highway 400' above mouth
Dee's Cr. 57N-6W-30	1	4	0.1	56 (7-24)	Small	Drying, small size, spawning habitat at mouth, low temperature	30 ft.	---
Bell Harbor Cr. 57N-6W-31	1	10	0.5	59 (7-24)	Small	Drying, little larval habitat	---	3' x 30' concrete barrier at mouth; power lines within 300' of mouth

Table 4, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Baptism R.[2] 56N-7W-15	125	40	1.0	66 (7-23)	Large	Scouring, spawning medium fair	1.25 mi.	100' electrical device 20' above mouth; power lines 600' at highway
Creek No. 36 56N-7W-15	1+	2	0.3	58 (7-24)	Medium	Scouring, small size	---	6' electrical device 50' above mouth; power lines 450'
Palisade Cr.[2] 56N-7W-22	5	7	0.5	62 (7-24)	Medium	Small size, irregular bottom	1.5 mi.	30' electrical device at mouth; power lines 0.25 mile above at highway
Creek No. 39 56N-7W-32	2	4	0.5	65 (7-24)	Medium	Small size, irregular bottom	---	16' electrical device at mouth; power lines 100' above
Creek No. 40 56N-7W-32	2	4	0.4	71 (7-24)	Small	Small size, irregular bottom	0.1 mi.	10' electrical device 50' above mouth; power lines 0.1 mile above at highway
Creek No. 41 55N-7W-7	2	2	0.3	60 (7-24)	Medium	Small size, irregular bottom and mouth	---	Possible barrier at mouth; possible electric device 75' above mouth; power lines 50' above site
Beaver R.[2] 55N-8W-12	143	30	1.5	66 (7-25)	Medium	Lake effect	0.25 mi.	60' electrical device 900' above mouth; power lines 300' above at highway; possible spawning in area of reversing current below site

Table 4, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Creek No. 42 55N-8W-22	1.5	3	0.1	59 (7-25)	Small	Small size, scouring, steep gradient	---	8' electrical device 20' above mouth; power lines 300'
Creek No. 44 55N-8W-33	3	7	0.4	61 (7-25)	Medium	Small size, scouring, partial barrier at mouth, irregular bottom	1.5 mi.	12' electrical device 100' above mouth; power lines 600'
Creek No. 45 54N-8W-5	5	5	0.2	65 (7-25)	Small	Small size, irregular bottom, scouring, water level fluctuations	0.2 mi.	25' electrical device 600' above mouth; power lines 0.25 mile above at highway
Split Rock R.[2] 54N-8W-7	44	20	0.7	65 (7-28)	Large	None	1.0 mi.	75' electrical device 150' above mouth; power lines 150' above site
Gooseberry R.[2] 54N-9W-22	86	125	4.0	65 (7-25)	Large	None	0.75 mi.	Control difficult due to size and reversing current
Schumanns Cr. 54N-9W-27	2	5	0.9	62 (7-25)	Small	Small size, irregular bottom	---	2' x 30' concrete barrier 60' above mouth
Slough Cr. 54N-9W-27	2.5	7	0.8	66 (7-25)	Small	Scouring, small size	1.5 mi.	20' electrical device at mouth; power lines 300'

Table 4, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Castle Cr. 54N-9W-33	2.5	6	0.5	64 (7-25)	Small	Small size, irregular bottom, drying	---	Barrier at mouth
Danger Cr. 54N-9W-33	1.5	8	0.5	60 (7-28)	Medium	Small size, water level fluctuations, little larval habitat	---	16' electrical device at mouth; power lines 150'
Crow Cr. 53N-10W-1	12	50	0.5	63 (7-28)	Medium	Scouring, water level fluctuations, no larval habitat	---	65' electrical device 40' above mouth; power lines several hundred yards
Hewitt Cr. 53N-10W-12	2	5	0.5	60 (7-28)	Small	Irregular bottom, water level fluctuations, scouring, drying, small size, little larval habitat	---	3' x 18' barrier at mouth; power lines 150'
Carlaw Cr. 53N-10W-2	2	5	0.5	62 (7-28)	Small	Same	---	3' x 6' barrier at mouth; power lines 150'
Encampment R. 53N-10W-11	17	75	4.0	67 (7-28)	Medium	Reversing current in mouth area	0.25 mi.	Control difficult due to reversing current
Silver Cr.[2] 53N-10W-21	16	30	0.8	64 (7-28)	Medium	Scouring	---	70' electrical device 100' above mouth; power lines readily available; possible reversing current

Table 4, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Raffles Cr. 53N-10W-28	1.5	5	0.2	60 (7-28)	Small	Irregular bottom, scouring, lack of sand and larval habitat	0.25 mi.	3' x 6' concrete barrier at mouth
Stewart R.[2] 53N-10W-29	34	20	0.5	70 (7-28)	Large	Irregular bottom	---	75' electrical device 100' above mouth; power lines 75'
Creek No. 48 53N-10W-29	1+	3	0.3	64 (7-28)	Medium	Small size, irregular bottom, scouring, drying, partial barrier	---	13' concrete barrier 60' above mouth
Creek No. 49 53N-10W-32	2	4	0.4	64 (7-28)	Medium	Small size	---	10' electrical device just above mouth; power lines 300' at highway
Creek No. 50 52N-10W-6	1+	4	0.3	60 (7-28)	Medium	Irregular bottom, small size	---	35' electrical device 50' above mouth; power lines 225' above site
Creek No. 51 52N-10W-1	2	4	0.3	57 (7-29)	Medium	Drying, partial barrier, small size	---	Concrete barrier at mouth; power lines 300'
Creek No. 52 52N-10W-11	3	2	0.1	58 (7-29)	Medium	Small size, water level fluctuations	---	12' concrete barrier 15' above mouth; power lines 0.5 mile above

Table 4, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Creek No. 53 52N-10W-15	3	3	0.3	59 (7-29)	Medium	Small size, scouring	0.1 mi.	Concrete barrier 10' above mouth; power lines 0.5 mile at highway
Knife R.[2] 52N-11W-31	94	75	2.0	64 (7-29)	Large	Partial barrier, scouring, high velocities, water level fluctuations	---	130' electrical device at highway 61; power lines at highway

1/ List includes only those streams which appear to have a productive potential.

2/ Stream is one of a group of 22 in Minnesota which appear to be more suited to sea lamprey spawning than the other streams with a productive potential. These streams should be closely checked for spawning in the future since they will probably be the first to be utilized.

3/ Applicable only to the surveyed portion of the stream.

Nine streams with productive potentials ranging from medium to large are considered quite suitable for sea lampreys, despite the presence of limiting factors (Footnote 2, Table 4). Five of these streams are large, from 30 to 125 feet in width in the areas examined. The remaining 4 streams average from 7 to 20 feet in width. Electrical control devices are recommended for all but the Gooseberry River. Control in this stream will be difficult due to its large size, and the presence of a reversing current resulting from lake seiches.

The geology, surface features, and stream characteristics of Lake County are, in general, similar to those described for Cook County.

Control operations will be aided by the relative accessibility of all streams. Installation and operation of devices will be made difficult by rapid fluctuation in water levels in almost all of the streams involved.

A number of the streams examined in Lake County would probably have been bypassed if the survey had taken place during a period of dry weather.

St. Louis County: Contains 29 streams (Fig. 6), at least 6 of which are unsuitable for sea lamprey spawning because of the presence of barriers, steep gradients, industrial wastes, etc.

Nineteen streams are considered to be marginal (Table 5). Spawning gravel for a varying number of nests is present, but other factors are likely to be unfavorable enough to obstruct spawning efforts. Several of these streams flow underground in the business district of the City of Duluth. Barriers may be present in the underground portions. The mouths of these streams are not located easily.

Nine of the streams examined flow into the St. Louis River. Twenty streams are located within the Duluth city limits.

Four streams with productive potentials ranging from medium to large are considered to be quite suitable for sea lampreys despite the presence of partial barriers, irregular bottom, and the possible limiting effects of low oxygen in the St. Louis River (Footnote 2, Table 5). Three of these streams are medium sized, averaging from 15 to 20 feet in width in the sections examined. The remaining stream averages 50 feet in width. Electrical control devices are recommended for these streams. Control in one stream will be hindered by the presence of a reversing current, resulting from lake seiches.

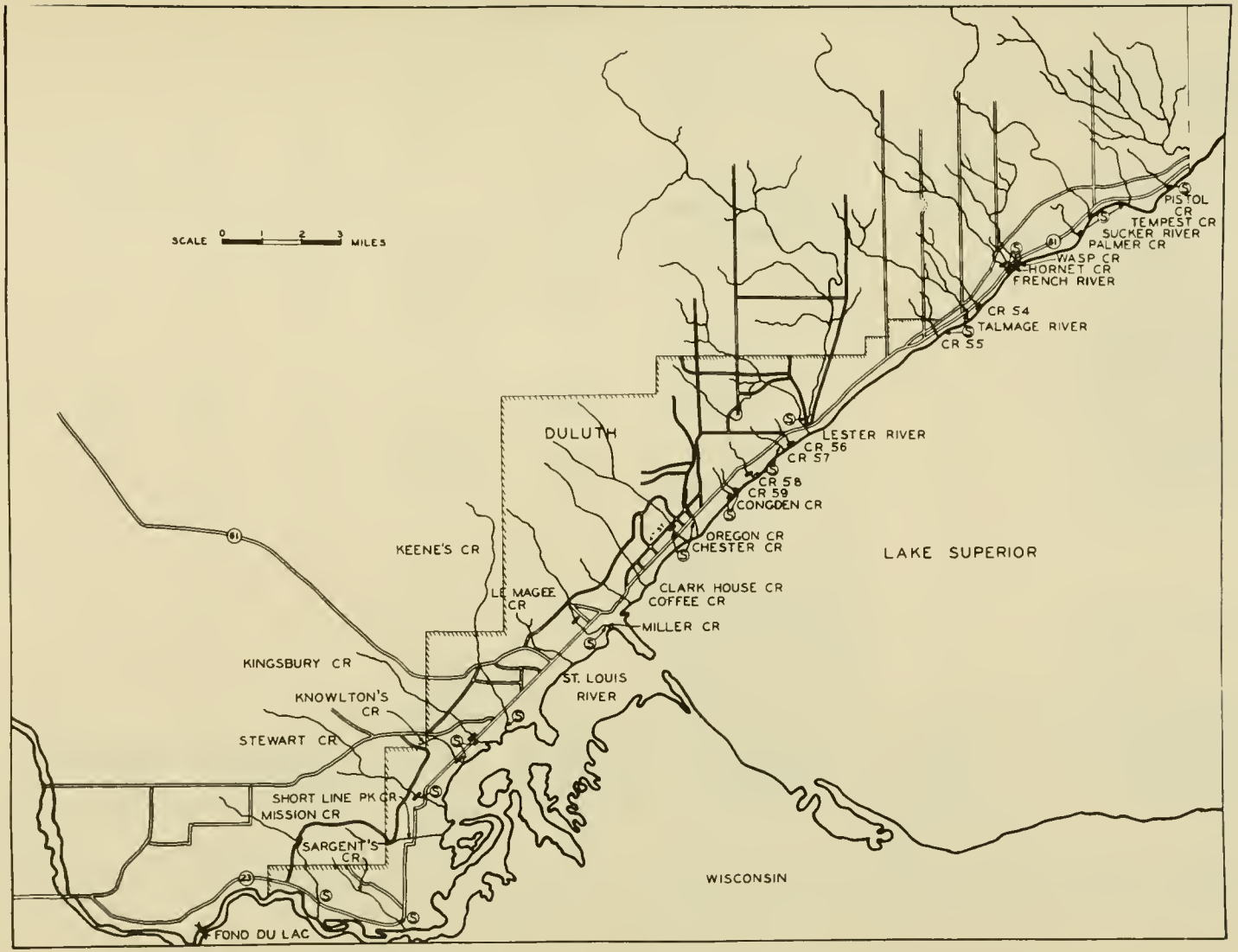


FIGURE 6. SHORELINE OF ST LOUIS COUNTY, MINNESOTA

Table 5.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in St. Louis County, Minnesota
(Survey made in 1952)

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Pistol Cr. 52N-12W-1	1	5	0.1	58 (7-29)	Small	Small size, irregular bottom, scouring, water level fluctuations, drying, lack of larval habitat	---	2' concrete lip in culvert
Tempest Cr. 51N-12W-2	3	10	0.5	61 (7-29)	Small	Same as above	---	1' x 15' concrete barrier in culvert
Sucker R.[2] 51N-12W-3	33	50	1.5	58 (7-30)	Medium	Partial barrier	---	75' electrical device 200' above mouth; power lines 0.25 mile above mouth
Palmer's Cr. 51N-12W-10	2	7	0.5	57 (7-30)	Small	Poor spawning medium, small size, water level fluctuations, scouring	---	10' concrete barrier in culvert
Wasp Cr. 51N-12W-17	6	30	0.3	62 (7-30)	Medium	Small size, drying, partial barrier	---	20' concrete barrier in culvert; possible spawning below culvert
Hornet Cr. 51N-12W-17	2	6	0.3	60 (7-30)	Small	Small size, scouring, water level fluctuations, drying, poor spawning medium	---	20' electrical device 50' below bridge

Table 5, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
French R. 51N-12W-17	18	15	0.7	61 (7-29)	Medium	Scouring, irregular bottom	0.1 mi.	20' electrical device; power lines at site
Talmage R. 51N-12W-19	6	10	0.5	64 (7-29)	Medium	Scouring, irregular bottom	---	30' electrical device; 150' above mouth; possible spawning below
Creek No. 55 51N-13W-25	3	3	0.2	61 (7-29)	Medium	Small size, scouring, water level fluctuations	---	12' electrical device 70' above mouth; power lines at site
Lester R.[2] 50N-13W-8	43	15	0.7	59 (7-30)	Large	Irregular bottom, scouring	---	130' electrical device 100' above mouth; lake effect problem
Creek No. 57 50N-13W-8	1+	2	0.2	59 (7-30)	Medium	Irregular bottom, scouring, partial barrier occasionally at mouth	---	18' electrical device 70' above mouth; power lines at highway
Creek No. 58 50N-13W-18	5	2	0.2	59 (7-30)	Small	Small size, irregular bottom, scouring, drying	0.25 mi.	10' concrete barrier 40' above mouth
Creek No. 59 50N-14W-13	1+	1	0.2	59 (7-30)	Medium	Small size, irregular bottom, scouring, partial barrier occasionally at mouth	---	11' electrical device 100' above mouth; power lines 225'

Table 5, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Congdon Cr. 50N-14W-13	1+	5	0.4	60 (7-30)	Medium	Irregular bottom	---	40' electrical device 200' above mouth; power lines 300' at highway
Oregon Cr. 50N-14W-23	1+	6	0.5	57 (8-4)	Small	Small size, drying, scouring, steep gradient	---	Mouth not found; lower portion of stream underground
Chester Cr. 50N-14W-23	6	12	0.7	57 (8-4)	Small	Steep gradient, scouring, no larval habitat, water level fluctuations	0.25 mi.	3' x 8' concrete barrier just above mouth; lower stream partly underground
Millers Cr. 50N-14W-33	10	5	---	71 (8-1)	Medium	Irregular bottom, oil pollution	0.5 mi.	18' electrical device 300' above mouth; power lines just below at railroad
Keene's Cr. 49N-14W-19	9	5	0.3	68 (8-1)	Medium	Irregular bottom, drying	---	10' electrical device 400 yards above mouth; power lines 750'
Kingsbury Cr. 49N-15W-13	3	6	0.4	69 (8-1)	Small	Irregular bottom	0.2 mi.	10' concrete barrier in railroad culvert
Knowlton's Cr. 49N-15W-23	5	4	0.2	62 (8-1)	Medium	Water level fluctuations	0.25 mi.	25' electrical device at railway bridge 750' above mouth

Table 5, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Stewart Cr. 49N-15W-23	3	10	0.5	55 (8-4)	Small	Irregular bottom, drying, water level fluctuations	0.25 mi.	10' electrical device at mouth; power lines 200'
Sargent's Cr.[2] 48N-15W-10	5	15	1.0	63 (7-31)	Medium	Possible pollution in St. Louis River	---	15' electrical device 150' above mouth; dikes necessary
Mission Cr.[2] 48N-15W-5	5	20	0.9	63 (7-31)	Medium	Possible pollution in St. Louis River	---	Electrical device at mouth

1/ List includes only those streams which appear to have a productive potential.

2/ Stream is one of a group of 22 in Minnesota which appear to be more suited to sea lamprey spawning than the other streams with a productive potential. These streams should be closely checked for spawning in the future since they will probably be the first to be utilized.

3/ Applicable only to the surveyed portion of the stream.

The geology, surface features, and stream characteristics of St. Louis County are, in general, similar to those described for Cook County.

Control operations will be aided by the relative accessibility of all streams. Installation and operation of devices will be impeded by rapid fluctuations of water levels. Those streams situated in the center of Duluth will present difficulties unique to them alone.

Several of the St. Louis County streams are probably intermittent.

The survey included all streams from the Lake County border, south to Mission Creek which enters the St. Louis River just below the Fond du Lac Dam, which is a positive barrier in the St. Louis River itself.

Discussion

Lampreys have been reported from the St. Louis, Sucker, and Knife Rivers in Minnesota in recent years. Although actual spawning records are absent from both Minnesota and Wisconsin, the persistent and general increase in scarring of lake trout and other fish along both shorelines is an indication of actual utilization of the local streams for spawning purposes.

Lampreys are occasionally taken by commercial fishermen of both States, although reports are scanty. As many as 10 percent of the fish in certain catches have been scarred. It is likely that the sea lampreys which cause the scarring would attempt to use the local streams for spawning (unless the scarred fish migrated from the eastern portions of the lake where large lamprey populations are known to exist).

Many streams in Wisconsin appear to be suitable for sea lamprey spawning, even as judged from the inadequate examination of 1952. Minnesota streams appear to be generally less suitable, as determined from a much more thorough examination. Nevertheless, at least 22 of the 156 streams examined along the north shore of Minnesota are considered to be quite suitable for spawning, despite the fact that some of them contain barriers a short distance above the mouths or are subject to rapid fluctuations in water levels.

All of the suitable streams in both Wisconsin and Minnesota and also those considered to be marginal should be rechecked in the future to determine the actual extent of utilization by sea lampreys. (Rechecks of certain Michigan streams surveyed in 1950 have revealed a slight increase in the numbers of nests present).

It is suspected from our observations to date, that the streams of Wisconsin and Minnesota (although less suitable than those in Michigan) can support spawning runs of considerable size. The 1952 survey of the streams of Wisconsin was inadequate insofar as it told us little about the productive potentials of the streams, and nothing about the actual extent of utilization of the streams; little control work of any nature is possible in this area until a great deal more information is gained.

The inadequacies of the survey of the streams of the Minnesota area were the result of the extreme rapidity of the survey, and the probability that sea lampreys are not utilizing the streams to the extent which they may in the future. In any event, no lampreys or nests were found. The actual evaluation of the importance of the streams is based on single examinations. Generally speaking, it is doubtful if many of the streams considered to have a large productive potential (room for 75 or more nests) can provide room for nests in the quantities (several hundred nests or more) already observed in some of the streams of eastern Lake Superior or Lakes Huron and Michigan. Even in the 22 streams considered to be the most favorable of the 156 examined, areas for hundreds of nests are probably not available. However, construction of as many as 75 nests in any single stream will (if spawning and survival are successful) demand serious control operations.

A number of the 22 favorable streams contain spawning habitat for less than 75 nests, and have a medium productive potential; it is likely that lampreys will spawn more successfully in these streams than many others with a large productive potential (productive potential is based upon the number of nest sites available and not the final production of the stream in adult lampreys, since the latter is more or less an unknown quantity; i.e. a stream with an area suitable for 25 nests and possessing favorable temperatures will be suitable for lampreys, whereas a stream with room for 125 nests with temperatures hovering around the minimum spawning temperature of 53 to 56 is likely to be unfavorable much of the time at least).

I have been asked to list the 22 most favorable Minnesota streams in the order of their importance, and from an efficient initial control operations standpoint (i.e. in which streams should the first control structures be constructed?). The listing is, of course, an educated guess; the order has been influenced by the relative productive potentials, the general favorability, the size of the streams, and the probable relative difficulties which will hinder construction, maintenance, and operation of control structures. (Lampreys have been observed in the Sucker and Knife Rivers in recent years but their presence has not been used as a criterion for intitial control, since lampreys are also probably present in some of the other streams.) The suggested order of construction is as follows:

Most favorable streams: (Tables 3 and 4)

1. Split Rock River: Large productive potential, 75' electrical device.

2. Reservation River: Large productive potential, 30' electrical device.

3. Indian Camp Creek: Medium productive potential, 20' electrical device.

4. Palisade Creek: Medium productive potential, 30' electrical device.

5. Gooseberry River: Large productive potential, control difficult due to large size of river and reversing current.

6. Arrowhead River: Medium productive potential, control difficult due to large size of mouth area and shifting sand bars.

7. Pigeon River: Medium productive potential, control difficult due to large size of river, reversing current, and pulp wood operations.

Slightly less favorable streams: (Tables 3 and 4)

8. Flute Reed River: Large productive potential, 25' electrical device.

9. Stewart River: Large productive potential, 75' electrical device.

10. Baptism River: Large productive potential, 100' electrical device.

11. Devil's Track River: Large productive potential, 110' electrical device.

12. Knife River: Large productive potential, 130' electrical device.

13. Lester River: Large productive potential, 130' electrical device, control difficult due to lake effect.

14.	Sucker River:	Medium productive potential, 75' electrical device.
15.	Cross River:	Medium productive potential, 65' electrical device.
16.	Two Island River:	Medium productive potential, 45' electrical device.
17.	Dragon Creek:	Medium productive potential, 20' electrical device.
18.	Creek No. 2:	Medium productive potential, 25' electrical device.
19.	Sargent's Creek:	Medium productive potential, 25' electrical device.
20.	Mission Creek:	Medium productive potential, 25' electrical device.
21.	Silver Creek:	Medium productive potential, 70' electrical device, control difficult due to reversing current.
22.	Beaver River:	Medium productive potential, 60' electrical device, control difficult due to reversing current.

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