SEA LAMPREY SPAWNING RUNS IN THE GREAT LAKES 1951

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 68

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

SEA LAMPREY SPAWNING RUNS IN THE GREAT LAKES 1951

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 68

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.
March 1952

Special Scientific Report - Fisheries
No. 68

SEA LAMPREY SPAWNING RUNS IN THE GREAT LAKES, 1951

By

Vernon C. Applegate, Bernard R. Smith, and
Alberton L. McLain
Fishery Biologists

and

Matt Patterson
Supervisor, Commercial Fishing
Wisconsin Conservation Department

CONTENTS

	Page
Installation and operation of sea lamprey control structures in 1951	1
Lake Huron	1
Lake Michigan	4
Lake Superior	4
Numbers of lampreys taken by control devices	4
Relative abundance of sea lampreys	5
Lake Huron	5
Lake Michigan	5
Lake Superior	8
Other species of fish taken in the weirs and traps and degree of scarring among them	9
Some biological characteristics of the sea lamprey runs	9
New developments and further evaluation of mechanical control devices	31
Barrier dams	31
Portable-type weirs and traps	33
Operating costs in 1950 and 1951	33
Literature cited	36
List of common and scientific names of fishes mentioned in this report	37

ILLUSTRATIONS

Figure		Page
1.	Map of upper Great Lakes showing the location of sea lamprey control devices operated in 1951.	2
2.	Rate of increase of sea lampreys in Lakes Huron and Michigan as reflected by weir and trap catches in the Ocqueoc River, Presque Isle County, Michigan (Lake Huron basin) and Hibbard's Creek, Door County, Wisconsin (Lake Michigan basin)	7
3.	Experimental sea lamprey barrier dam in the Black River, Mackinaw County, Michigan	32
4.	Black River barrier dam. Close-up of barrier dam showing overhanging, curved lip of sheet steel attached to wall of dam.	32
5.	Portable-type weir and trap in Carp Creek, Presque Isle County, Michigan, after installation of permanent sills, trap base, and abutments of concrete	34
6.	Diagramatic plans of concrete sills, trap base, and abutments used to provide permanent base for portable-type sea lamprey weir and trap.	35

Since the inauguration of the sea-lamprey investigations as a part of the Service's Great Lakes Fishery Investigations, in October 1949, considerable progress has been made in the long-term program for the development of methods of suppressing or controlling the parasitic sea lamprey. The sea-lamprey investigations may be divided broadly into the following phases: development and testing of control devices and procedures, including the accumulation of reasonably exact data on costs of installation and operation of various structures; extension of studies on the life history and habits of the sea lamprey with a view toward determining better the vulnerable stages of the life history; surveys of streams to ascertain the distribution of sea-lamprey runs and the extent of available spawning grounds; and, studies of species subject to attacks by sea lampreys to learn the incidence of attacks and the effects on abundance.

Selected from the preceding investigative program for inclusion herein are summarizations of data collected in 1951 concerning: a second year of experimental control operations in Control Zone H-1 (in northern Lake Huron) and in the Wisconsin waters of Lake Michigan; abundance of sea lampreys in the three upper lakes; a comparison of the biological characteristics of the sea-lamprey spawning runs of 1951 with those of previous years; and developments and further evaluation of mechanical devices for sea-lamprey control.

Similar data for the 1950 season and information basic to this report have been presented by Applegate and Smith (1951).

These particular operations and investigations were conducted as in the previous year, with the cooperation of the Wisconsin Conservation Department and the Michigan Department of Conservation.

Installation and operation of sea-lamprey-control structures in 1951

Lake Huron.--In northern Lake Huron 12 trapping devices were operated in Control Zone H-1 which was established in 1950; 11 of these structures were operated in the same streams as in the previous year (Applegate and Smith, 1951). In addition, a trap was installed in the bottom compartment of the fish ladder at the paper-mill power dam on the Cheboygan River (fig. 1). All installations were the standard, portable-type sea-lamprey weir and traps with the exception of the permanent-type Ocqueoc River installation and the aforementioned Cheboygan River trap which was a device manufactured especially to fit a fish-ladder compartment. Complete runs were captured in all but two streams, and in one of these only a minor escapement occurred. In the Cheboygan River only a small part of the total run was taken because the trap could not be located near the main spill of the water and consequently the majority of the lampreys were attracted away from the trap. However, the dam prevented the upstream movement of the lampreys not taken by the trap.

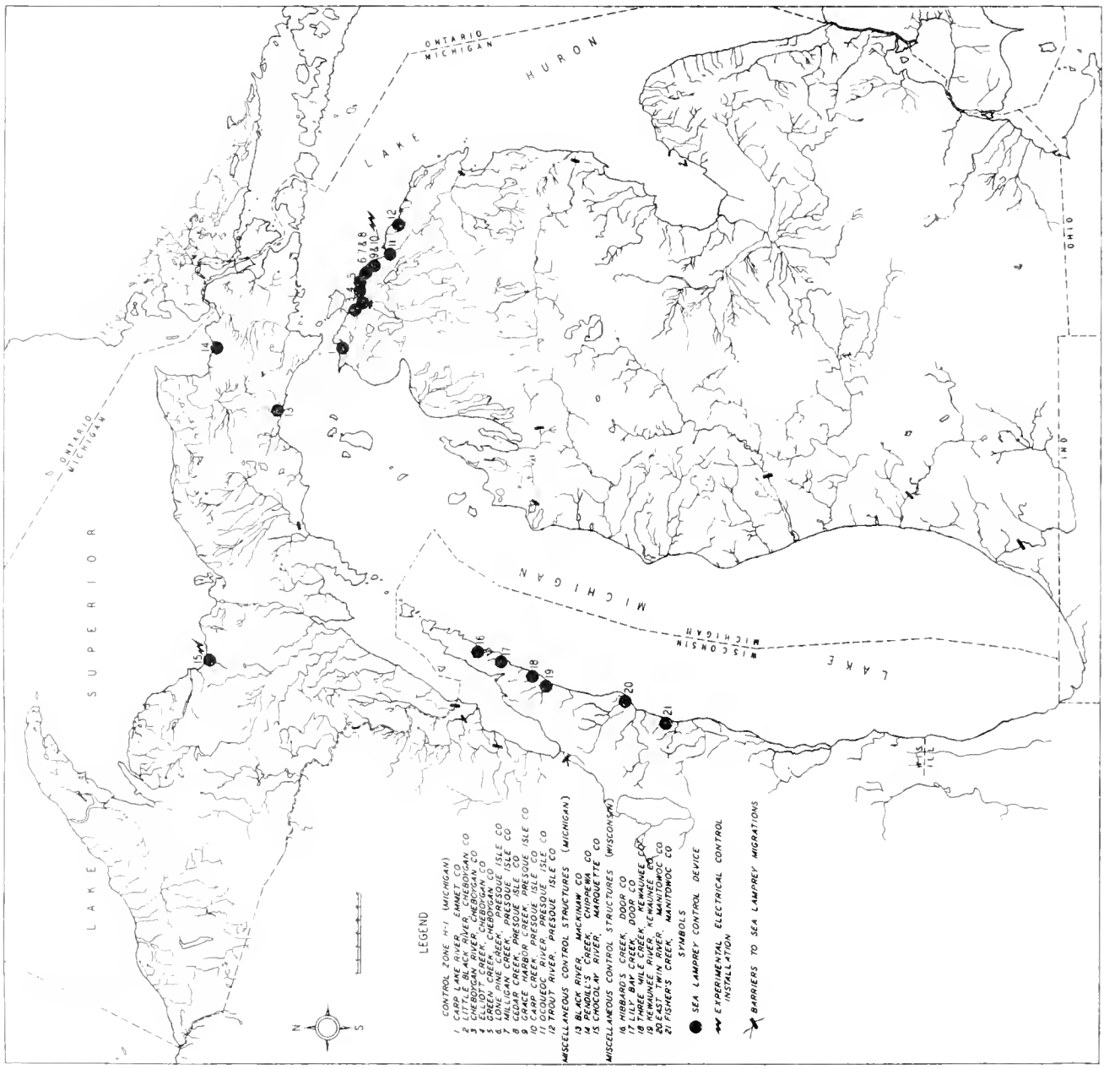

Figure 1.--Map of upper Great Lakes showing the location of sea-lamprey control devices operated in 1951.

Table 1.--Number of spawning-run sea lampreys taken by control devices during the 1951 season

[Structures listed below may be located on map in figure 1]

Stream	Number taken
Lake Huron tributaries: (Control Zone H-1)	
Carp Lake River, Emmet County, Michigan	4,918
Little Black River, Cheboygan County, Mich.	909
Cheboygan River, Cheboygan County, Mich.	2,368
Elliott Creek, Cheboygan County, Mich.	70
Green Creek, Cheboygan County, Mich.	785
Lone Pine Creek, Presque Isle County, Mich.	0
Milligan Creek, Presque Isle County, Mich.	527
Cedar Creek, Presque Isle County, Mich.	0
Grace Harbor Creek, Presque Isle County, Mich.	32
Carp Creek, Presque Isle County, Mich.	1,266
Ocqueoc River, Presque Isle County, Mich.	19,393
Trout River, Presque Isle County, Mich.	1,903
Total, Lake Huron	32,171
Lake Michigan tributaries:	
Hibbard's Creek, Door County, Wis.	12,640
Lily Bay Creek, Door County, Wis.	128
Three Mile Creek, Kewaunee County, Wis.	2,407
Kewaunee River, Kewaunee County, Wis.	3,270
Mishicot River, Manitowoc County, Wis.	21,080
Fischer Creek, Manitowoc County, Wis.	3,455
Total, Lake Michigan	42,980
Lake Superior tributaries:	
Pendill's Creek, Chippewa County, Mich.	20
Chocolay River, Marquette County, Mich.	301
Total, Lake Superior	321
GRAND TOTAL	75,472

An electromechanical weir was installed below the Ocqueoc River weir and was operated and tested continuously for 6 weeks during the height of the upstream migration of sea lampreys. 1/

The objectives in operating this Control Zone another year are summarized briefly as follows:

(1) To gain additional experience in the operation of this type of control and to obtain information on administrative and operational problems and costs.

(2) To ascertain further the effects of the prevention of reproduction by sea lampreys in the streams tributary to a limited area of shoreline.

(3) To continue the development and testing of improvements in design and construction of mechanical control structures; and

(4) To provide sites where adequate checking devices (weirs and traps) were present for testing other equipment, primarily of an electrical nature.

Lake Michigan.—Six portable-type weirs and traps were again installed and operated by the Wisconsin Conservation Department in streams tributary to Lake Michigan. Because of high waters these devices were installed late and consequently some escapement occurred, but the majority of the sea lampreys entering these streams were captured. Two structures were relocated to eliminate spawning which occurred in areas below weir locations used in 1950.

The checking weir and traps unit in the Black River, Mackinaw County, Michigan, was installed at a new location above the barrier dam in that stream for operation by personnel of the Michigan Department of Conservation. The purpose of these structures was to determine the effectiveness of a specially designed, low-head barrier dam in blocking upstream movement of spawning-run sea lampreys. The operation of this unit was continuous throughout the season. Although a large run entered the river, no lampreys were taken in the checking weir. The barrier dam was completely effective in blocking the migrants.

Lake Superior.—In the Lake Superior basin the weir and trap in Pendills Creek, Chippewa County, was operated for the second year and captured the entire run. An electrical fish screen and a portable-type weir and trap (checking weir) were operated in the Chocolay River, Marquette County, Michigan.

Numbers of lampreys taken by control devices.—A total of 75,472 spawning-run sea lampreys was captured in 1951 in 21 control devices. In nearly all streams, the entire spawning runs were captured. Of the

---

1/A detailed report of the development of electrical and electromechanical sea-lamprey-control devices will be presented elsewhere.

total catch, 32,171 individuals were taken in Control Zone H-1, 42,980 were captured in the Wisconsin control devices, and the remaining 321 lampreys were taken from the two streams tributary to Lake Superior. Biological data were recorded for many of these lampreys; all individuals were subsequently destroyed. These catches are summarized in table 1 where the individual totals by stream and by lake basin are given.

Relative abundance of sea lampreys

Lake Huron.--The sea-lamprey population in northern Lake Huron, as indicated by the size of the spawning runs captured, apparently continued to maintain itself at the peak level of its abundance for another season. The total run in the Ocqueoc River was 19,393 sea lampreys in the 1951 season as compared to 18,822 in 1950 and 24,645 in 1949. As in 1950, a considerable number of migrants from the adjacent lake area was "siphoned-off" by trapping operations in other streams in the vicinity; this reduced the total catch in the Ocqueoc River to a certain extent. Consideration of all factors would indicate that, numerically speaking, the runs in the three seasons were of comparable size.

Most of the catches in the small streams of Control Zone H-1 were considerably less than for the previous year. At first thought this decrease would seem to indicate a decline in the sea-lamprey population. Actually, these small catches were the result of the blocking of the stream mouths by sand bars several times during the period of upstream migration. High lake levels, low stream discharges, and strong winds all contributed to unusual barrier-bar formations during the 1951 season.

All available records of spawning runs of sea lampreys into the streams of northern Lake Huron (United States waters) are assembled in table 2. Those records for the Ocqueoc River demonstrate the phenomenal increase in the population in the years 1944 to 1949 and the subsequent leveling-off of that population when fish stocks in the northern areas of the lake were reduced almost to the point of disappearance (fig. 2).

Lake Michigan.--In the streams tributary to northwestern Lake Michigan, weir and trap catches continued to reflect the explosive increase of the species in these waters. In 1951, sea-lamprey spawning runs in six Wisconsin streams were nearly three times as large as those entering the same streams the previous year. In 1950, 16,410 spawning migrants were taken in six control devices; in 1951, 42,980 individuals were captured. All available records of spawning runs entering these six streams are presented in table 3. The spawning runs captured in Hibbards Creek, Door County, Wisconsin demonstrate most dramatically the enormous increase in the numbers of sea lampreys in the lake since 1945 (table 3 and fig. 2).

The data collected in 1951 give no indication that the sea lamprey population in Lake Michigan has yet attained the peak of its abundance. Maximum abundance and a leveling-off in numbers of the lamprey population in northern Lake Huron followed by several years the virtual

Table 2.—Number of spawning-run sea lampreys taken in weirs and traps in streams tributary to Lake Huron, 1944 - 1951

Stream	Year							
	1944	1945	1946	1947	1948	1949	1950 3/	1951
Ocqueoc River	1/ 3,366	1/ 4,608	...	2/ 10,000	2/ 13,000	2/ 24,643	18,822	19,393
Carp Creek	...	...	...	2/ 1,617	2/ 2,939	2/ 2,763	1,161	1,266
Trout River	...	...	...	...	...	...	1,702	1,903
Grace Harbor Creek	...	...	...	...	...	...	52	32
Cedar Creek	...	...	...	...	...	...	0	0
Milligan Creek	...	...	...	...	...	...	700	527
Lone Pine Creek	...	...	...	...	...	...	0	0
Green Creek	...	...	...	...	...	...	1,945	785
Elliott Creek	...	...	...	...	...	...	266	70
Little Black River	...	...	...	...	...	...	953	909
Cheboygan River	...	...	...	...	...	...	...	2,368

1/ Shetter (1949): partial capture of run; examination of Shetter's data suggests that these catches represent about three-quarters of the run entering the stream each year.

2/ Applegate (1950): data for Ocqueoc River for 1947 and 1948 are estimates based on counts of total number of nests in watershed with consideration given for observed spawning habits and sex ratio in those years; other data are based on entire runs captured in weirs and traps.

3/ Applegate and Smith (1951): all data based on entire runs captured in weirs and traps.

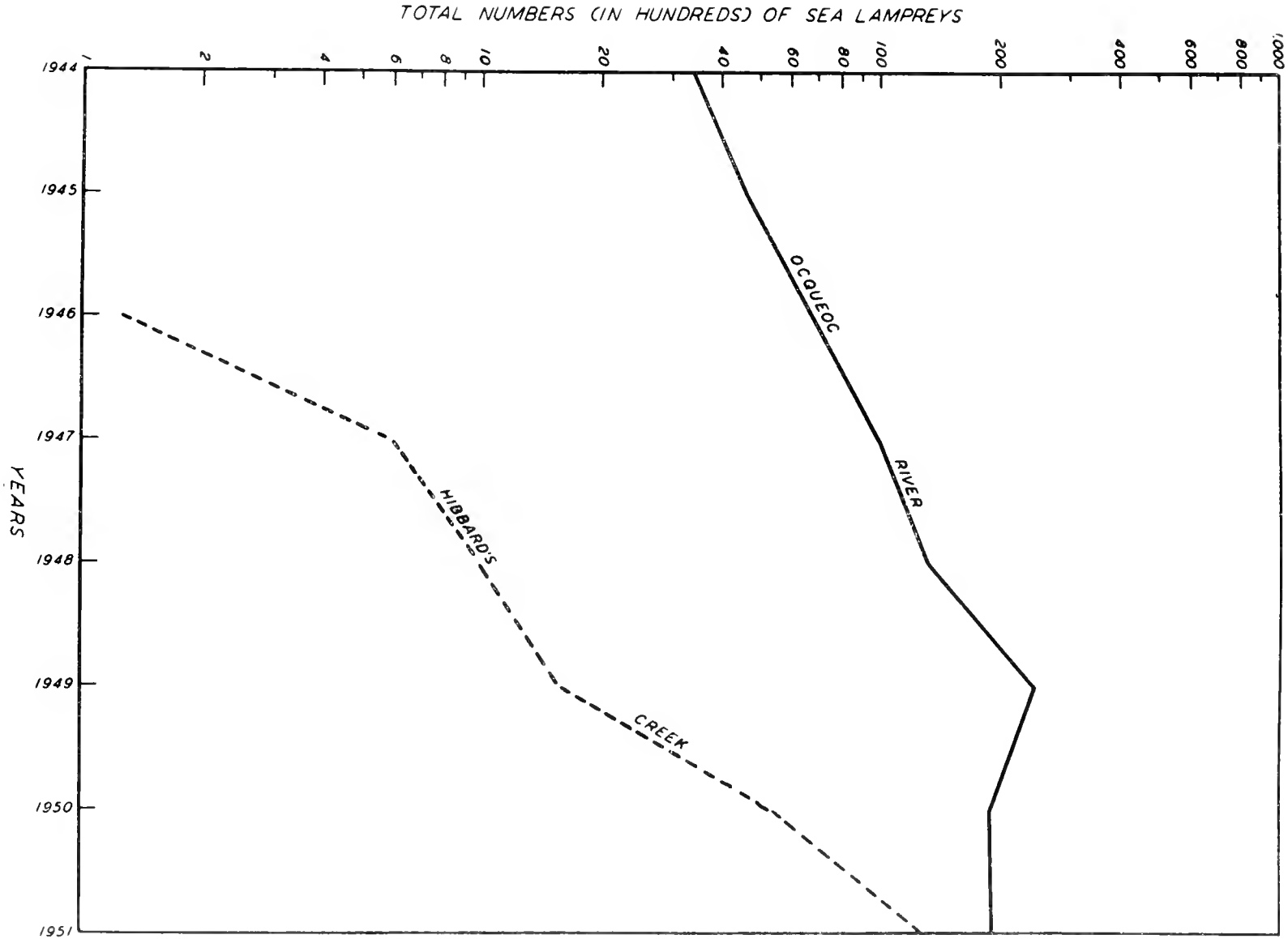

Figure 2.--Rate of increase of sea lampreys in Lakes Huron and Michigan as reflected by weir and trap catches in the Ocqueoc River, Presque Isle County, Michigan (Lake Huron basin) and Hibbards' Creek, Door County, Wisconsin (Lake Michigan basin).

Table 3.---Number of spawning-run sea lampreys taken in weirs and traps in streams tributary to northwestern Lake Michigan (1945 - 1951)

Stream	Year						
	1945	1946	1947	1948	1949	1950	1951
Hibbard Creek	1/ 25	125	596	989	1,579	5,422	12,640
Lily Bay Creek	...	...	...	...	...	16	128
Three Mile Creek	...	...	...	...	...	1,051	2,407
Kewaunee River	...	...	...	...	...	1,353	3,270
Mishicot River	...	...	...	...	...	7,712	21,080
Fischer Creek	...	...	...	...	...	847	3,455

1/ The number of lampreys trapped in 1945 is not the complete run into the stream; trapping operations were intermittent in that year.

disappearance of the lake trout (a preferred prey species) from the commercial fishery. Maintenance of the population in Lake Huron at peak abundance is attributed to the ability of the remaining fish stocks to support, at least temporarily, the peak lamprey population. Those species to which the lamprey has transferred its attentions are currently suffering a severe decline. This same situation may apply to Lake Michigan.

Lake Superior.--The sea-lamprey population in Lake Superior continues to increase. A recheck of streams, tributary to the eastern third of Lake Superior, in which evidence of spawning activity was noted in 1950 revealed considerable increase in spawning activity in the 1951 season; several streams in which no activity was observed in 1950 contained evidences of spawning in 1951.2/ The number of spawning migrants taken in at least one of the two experimental control structures operated in Lake Superior tributaries indicates that very effective (productive) spawning runs are even now present in the most suitable tributaries; the progeny

2/ A comprehensive report of a survey of the streams tributary to the south shore of Lake Superior which was made in 1950 and 1951 is now in press.

of these runs, when they enter the lake some years hence, will be numerous. Further surveys of tributaries of the lake conducted in 1951 indicate that extensive, but as yet unused, spawning grounds of something less than optimum quality exist for the species at least on the south shore of the lake. A considerable expansion of the population, therefore, appears imminent. Adequate warning of the effects of such an expansion upon the lake trout and other commercially valuable species in the lake may be found in the present condition of fish stocks in Lakes Huron and Michigan.

Other species of fish taken in weirs and traps and degree of scarring among them

Counts by species were made of fish entering 10 of the weirs and traps in Control Zone H-1 and in Pendill's Creek which flows into Lake Superior. In addition to the sea lampreys captured, a total of 79,091 fish was taken in 10 streams in Control Zone H-1; 307 fish were captured in Pendill's Creek (table 4). Data were also collected on the numbers of lamprey-scarred suckers of several species taken in 7 streams in Zone H-1 (table 5). Records of scarring were collected for other food and game species but these records were generally incomplete or based on too few individuals to warrant inclusion here.

From the data available it is difficult to say whether the food and game species are still declining in northwestern Lake Huron. Trap records indicate a stabilized condition might have been reached.3/ However, commercial fishermen report that fewer suckers and other food species were taken in their nets in 1951 as compared with 1950. Furthermore, the incidence of scarring at least among the suckers, continues to rise. For example, in 1951, 34.6 percent of the suckers entering the Ocqueoc trap, as well as those collected in our nets, were scarred. This compares with 30.0 percent in 1950 and 25.5 percent in 1949.

Some biological characteristics of the sea lamprey runs

Nearly all of the sea lampreys taken in eight streams in Control Zone H-1 were examined to determine the sex of the individuals (table 6); similar records were made for all sea lampreys entering one tributary of Lake Superior. Examination of these data collected in 1951 indicates that the sex ratio of entire runs in northern Lake Huron continues to

---

3/ It might be observed here that any further decline of, for example, the suckers below the levels indicated by the weir and trap catches in the preceding year, 1950, would have required the near disappearance of this species from adjacent areas of the lake; see Applegate and Smith (1951).

Table 4.--Numbers and kinds of fish (upstream migrants) taken along with sea lampreys in weirs and traps in ten streams in Control Zone H-1 and in Pendill's Creek (Lake Superior Basin) during the 1951 season

Species of fish	Stream											
	Trout River Presque Isle Co.	Ocqueoc River Presque Isle Co.	Carp Creek Presque Isle Co.	Grace Harbor Creek Presque Isle Co.	Cedar Creek Presque Isle Co.	Milligan Creek Presque Isle Co.	Green Creek Cheboygan Co.	Elliott's Creek Cheboygan Co.	Little Black River Cheboygan Co.	Carp Lake River Emmet Co.	Pendill's Creek Chippewa Co.	Total
White suckers:												
Mature	115	954	521	...	...	23	44	26	1,840	861	9	4,392
Immature	235	52	10	4	2	3	6	78	24	...	6	420
Longnose suckers	664	1,351	141	...	...	43	1	3	1	343	16	2,563
Smelt	5,941	2,232	1,973	4,530	8,046	12	5,555	...	3,063	279	...	31,631
Yellow perch	2	18	...	...	...	...	...	...	1	3	...	24
Rainbow trout	6	32	1	...	...	...	17	...	2	7	20	85
Brook trout	2	...	4	...	...	...	16	245	2	2	101	372
Brown trout	...	...	...	...	...	...	...	...	...	...	4	4
Walleye	...	1	...	...	...	...	...	...	...	...	...	1
Northern pike	1	6	6	...	...	...	2	...	8	5	...	28
Smallmouth bass	...	1	...	...	...	...	...	...	...	2	...	3
Rock bass	35	9	13	...	...	...	...	...	29	29	5	120
Pumpkinseed sunfish	2	...	6	...	...	...	5	...	2	...	...	15
Black bullheads	7	47	25	...	...	...	2	1	1	482	2	567
Lake chubs	4,304	159	3,590	2,648	5,004	6,029	5,179	14	19	229	...	27,175
Great Lakes longnose dace	4,082	40	1,222	26	9	268	915	7	66	649	144	7,428
Pearl dace	2	...	...	...	...	3	7	292	1	...	...	305
Common shiners	226	11	120	...	...	15	3	7	277	1,620	...	2,279
Creek chubs	6	...	6	...	1	17	5	107	287	...	...	429
Muddlers	1,161	60	88	4	1	...	54	3	82	14	...	1,467
Log perch	...	2	...	...	...	...	...	...	...	...	...	2
Darters	...	...	...	...	...	...	...	...	3	...	...	3
Mudminnows	2	...	...	...	1	...	...	3	4	...	...	10
Other Cyprinids	...	...	...	...	...	19	...	23	1	...	...	43
Trout perch	3	...	...	...	...	...	2	...	12	...	...	17
Sticklebacks	3	1	...	...	...	...	1	...	...	...	...	5
Silver lampreys	2	...	...	...	...	...	1	...	1	3	...	7
Burbot	1	...	...	...	...	...	...	...	...	...	...	1
Carp	...	1	...	...	...	...	...	...	...	...	...	1
Herring	...	1	...	...	...	...	...	...	...	...	...	1
Total	16,802	4,978	7,726	7,212	13,064	6,432	11,814	809	5,726	4,528	307	79,398

Table 5.—Total catch, number scarred, and percentage scarred of migrant white and longnose suckers taken in seven tributaries to northern Lake Huron during the 1951 season

Stream	White suckers			Longnose suckers		
	Total trapped	Number scarred	Percentage scarred	Total trapped	Number scarred	Percentage scarred
Trout River, Presque Isle Co.	115	70	60.9	664	325	48.9
Ocqueoc River, Presque Isle Co.	954	286	30.0	1,351	511	37.8
Carp Creek, Presque Isle Co.	521	135	25.9	141	53	37.6
Milligan Creek, Presque Isle Co.	23	6	26.1	43	16	37.2
Green Creek, Cheboygan Co.	44	16	33.4	1	0	0.0
Elliott's Creek, Cheboygan Co.	26	9	34.6	3	0	0.0
Little Black River, Cheboygan Co.	1,840	624	33.9	1	0	0.0
Total	3,523	1,146	32.5	2,204	905	41.1

Table 6.--Sex ratio of sea-lamprey runs in eight tributaries of northern Lake Huron during 1951 season

Stream	Total catch	Total for which sex determined	Number of males	Number of females	Ratio of males to females
Trout River, Presque Isle County	1,903	1,903	1,375	528	260:100
Ocqueoc River, Presque Isle County	19,393	19,322	13,949	5,373	260:100
Carp Creek, Presque Isle County	1,266	1,266	901	365	247:100
Grace Harbor Creek, Presque Isle County	32	32	25	7	357:100
Milligan Creek, Presque Isle County	527	527	367	160	229:100
Green Creek, Cheboygan County	785	783	572	211	271:100
Elliott Creek, Cheboygan County	70	70	52	18	289:100
Little Black River, Cheboygan County	913	913	645	268	241:100
Total	24,889	24,816	17,886	6,930	258:100

shift toward a higher percentage of males. The rate of change, however, has diminished appreciably from that displayed in the two preceding yeeears. This point is illustrated in the following records of the sex ratios of entire sea-lamprey runs entering tributaries of northern Lake Huron during the past 5 years 4/:

	Sex ratio
1947.....	165 males : 100 females
1948.....	169 males : 100 females
1949.....	211 males : 100 females
1950.....	252 males : 100 females
1951.....	258 males : 100 females

The sex ratio of the run entering Pendill's Creek in the Lake Superior basin was 110 males : 100 females; the run in that stream in 1950 displayed a ratio of 111 males : 100 females. This proportion of males to females among the spawning runs appears indicative of a rather recently established population. Judging from what has occurred among the sea lampreys in Lake Huron, it is likely that this ratio will shift increasingly in favor of the males if the population increases to the levels of overabundance attained by the species in Lakes Huron and Michigan. The reasons for these striking shifts in sex ratio with increasing population density are a mystery.

Individual lengths and weights of sea lampreys were recorded according to a predetermined sampling schedule from the runs in Carp Creek and the Ocqueoc River: 49.7 percent of the Carp Creek run and 22.0 percent of the Ocqueoc River run were measured and weighed (tables 7, 8, 9, and 10).

The range in length of 4,899 migrant sea lampreys, sexes combined, that were measured in 1951 was 10.7 to 23.7 inches. The range in weight for the same specimens was 32 to 400 grams (1.1 to 14.1 ounces). The average size, sexes combined, differed slightly between the two runs studied. The average total length was 15.8 inches for the Carp Creek individuals and 16.2 inches for the Ocqueoc River sample. The mean weight of sea lampreys taken in Carp Creek was 115.6 grams (4.1 ounces) while migrants from the Ocqueoc River averaged 132.5 grams (4.6 ounces).

Comparison of the preceding averages with similar data collected since 1947 shows a definite diminution in the size of mature spawning migrants in northern Lake Huron tributaries (table 11). For example, the

---

4/ Where data for runs in more than one stream are available in any year, an average has been obtained for the combined runs.

Table 7.--Length frequencies of sea lampreys collected in Carp Creek and the Ocqueoc River, Presque Isle County, Michigan, in 1951

Midpoint of length group (inches)	Carp Creek			Ocqueoc River		
	Males	Females	Total	Males	Females	Total
10.7	1	...	1	...	...	...
.9	...	...	...	1	...	1
11.1	...	...	...	...	...	...
.3	...	...	...	...	...	...
.5	...	...	...	1	1	2
.7	...	...	...	...	1	1
.9	...	...	...	2	...	2
12.1	1	1	2	5	...	5
.3	2	...	2	4	2	6
.5	1	1	2	14	1	15
.7	1	...	1	17	2	19
.9	4	2	6	26	4	30
13.1	6	2	8	46	12	58
.3	9	3	12	45	7	52
.5	19	1	20	62	11	73
.7	12	3	15	70	25	95
.9	15	2	17	92	20	112
14.1	18	3	21	125	36	161
.3	21	6	27	118	44	162
.5	24	7	31	162	44	206
.7	26	10	36	118	44	162
.9	17	7	24	123	35	158
15.1	21	12	33	172	56	228
.3	18	7	25	131	47	178
.5	28	12	40	165	54	219
.7	36	12	48	121	49	170
.9	11	13	24	104	42	146
16.1	13	7	20	97	47	144
.3	12	7	19	116	40	156
.5	20	3	23	107	43	150
.7	16	4	20	76	41	117
.9	6	6	12	66	33	99
17.1	15	6	21	88	38	126
.3	12	2	14	71	41	112
.5	11	1	12	82	46	128
.7	7	7	14	49	37	86
.9	3	4	7	49	32	81
18.1	4	5	9	59	32	91
.3	4	2	6	57	27	84
.5	4	3	7	61	35	96
.7	5	4	9	49	24	73
.9	2	4	6	34	25	59

Table 7 (continued)

Midpoint of length group (inches)	Carp Creek			Ocqueoc River		
	Males	Females	Total	Males	Females	Total
19.1	4	3	7	53	25	78
.3	4	4	8	26	25	51
.5	5	1	6	37	19	56
.7	1	2	3	25	18	43
.9	...	...	...	25	12	37
20.1	2	1	3	19	14	33
.3	...	3	3	13	8	21
.5	2	...	2	18	10	28
.7	...	2	2	15	7	22
.9	1	1	2	6	8	14
21.1	1	...	1	3	5	8
.3	...	...	...	1	4	5
.5	...	...	...	1	1	2
.7	...	...	...	2	2	4
.9	...	...	...	3	1	4
22.1	...	...	...	...	...	...
.3	...	...	...	...	...	...
.5	...	...	...	...	...	...
.7	...	...	...	...	...	...
.9	...	...	...	...	...	...
23.1	...	...	...	...	...	...
.3	...	...	...	...	...	...
.5	...	...	...	...	...	...
.7	...	...	...	1	...	1
Total	445	184	629	3,033	1,237	4,270
Mean length	15.6	16.2	15.8	16.0	16.6	16.2
Standard deviation	± 1.66	± 1.74	± 1.70	± 1.87	± 1.93	± 1.91

Table 8.--Weight frequency of sea lampreys collected in Carp Creek and the Ocqueoc River, Presque Isle County, Michigan in 1951

Weight interval (grams)	Carp Creek			Ocqueoc River		
	Males	Females	Total	Males	Females	Total
30 - 39	1	...	1	...	...	...
40 - 49	3	...	3	5	2	7
50 - 59	6	2	8	33	7	40
60 - 69	27	6	33	122	21	143
70 - 79	56	9	65	259	74	333
80 - 89	66	24	90	337	87	424
90 - 99	54	23	77	373	111	484
100 - 109	58	23	81	333	102	435
110 - 119	39	16	55	233	85	318
120 - 129	35	11	46	224	81	305
130 - 139	23	11	34	165	86	251
140 - 149	14	9	23	135	66	201
150 - 159	13	3	16	124	57	181
160 - 169	8	4	12	110	50	160
170 - 179	5	8	13	86	60	146
180 - 189	9	9	18	100	56	156
190 - 199	4	4	8	70	49	119
200 - 209	2	3	5	60	41	101
210 - 219	4	7	11	59	33	92
220 - 229	3	1	4	52	37	89
230 - 239	2	3	5	38	38	76
240 - 249	4	2	6	32	24	56
250 - 259	2	1	3	28	27	55
260 - 269	4	...	4	23	13	36
270 - 279	...	1	1	15	9	24
280 - 289	...	1	1	4	11	15
290 - 299	...	1	1	6	5	11
300 - 309	...	...	...	2	...	2
310 - 319	...	...	...	3	2	5
320 - 329	...	...	...	1	...	1
330 - 339	...	...	...	1	2	3
340 - 349	...	...	...	...	...	...
350 - 359	...	...	...	...	...	...
360 - 369	...	...	...	...	...	...
370 - 379	...	...	...	...	...	...
380 - 389	...	...	...	...	...	...
390 - 399	...	...	...	...	...	...
400 - 409	...	...	...	...	1	1
Totals	442	182	624	3,033	1,237	4,270
Mean weight	110.8	128.3	115.6	123.3	146.9	132.5
Standard deviation	± 41.4	± 49.9	± 44.3	± 51.3	± 57.0	± 53.1

Table 9.--Mean water temperatures, number, average length and average weight by sexes, of samples of sea lampreys, and total number of sea lampreys taken in Carp Creek, Presque Isle County, Mich., by dates and by periods in 1951

Date (1951)	Mean water temperature (F.°)	Males			Females			Number with no data recorded	Total ♂♂ and ♀♀ taken
		Number of specimens	Average length (inches)	Average weight (grams)	Number of specimens	Average length (inches)	Average weight (grams)		
April 13-21	(Weir operation continuous - no lampreys taken)								
April 22	38.0	1	15.1	82	...	...	...	0	1
23	40.0	...	...	...	...	...	...	...	0
24	44.0	3	16.0	114	3	17.0	142	0	6
25	42.0	5	16.8	119	2	17.9	...	0	7
April 22-25	...	9	16.4	110	5	17.4	142	0	14
26	43.5	1	16.5	150	...	...	...	0	1
27	49.0	8	15.5	105	1	17.7	184	0	9
28	55.5	4	15.7	112	4	16.3	121	0	8
29	59.0	9	14.5	87	4	15.8	98	2	15
30	56.5	47	16.3	119	17	16.4	138	0	64
April 26-30	...	69	16.0	121	26	16.4	132	2	97
May 1	56.0	...	...	...	...	...	...	15	15
2	58.5	8	15.2	94	3	17.1	164	0	11
3	53.5	...	...	...	...	...	...	31	31
4	53.5	15	16.4	122	5	15.9	124	0	20
5	56.0	...	...	...	...	...	...	27	27
May 1-5	...	23	15.9	116	8	16.5	133	73	104
6	56.5	36	16.2	123	11	16.3	130	0	47
7	56.0	...	...	...	...	...	...	65	65
8	59.0	19	15.6	113	9	16.6	135	0	28
9	59.0	...	...	...	...	...	...	25	25
10	53.5	9	15.2	110	3	19.4	229	0	12
May 6-10	...	64	15.9	119	23	16.9	145	90	177

Table 9, continued

Date (1951)	Mean water temperature (F.°)	Males			Females			Number with no data recorded	Total ♂♂ and ♀♀ taken
		Number of specimens	Average length (inches)	Average weight (grams)	Number of specimens	Average length (inches)	Average weight (grams)		
May 11	54.0	...	...	...	...	...	...	40	40
12	55.5	80	15.5	106	28	16.2	125	0	108
13	54.5	...	...	...	...	...	...	37	37
14	59.0	13	16.2	118	3	16.2	111	0	16
15	65.0	...	...	...	...	...	...	13	13
May 11-15	...	93	15.6	107	31	16.2	123	90	214
16	57.5	2	15.5	106	4	17.4	156	0	6
17	57.0	...	...	...	...	...	...	19	19
18	58.0	16	16.0	118	4	16.8	141	0	20
19	61.0	...	...	...	...	...	...	25	25
20	62.0	15	15.8	111	4	17.8	169	0	19
May 16-20	...	33	15.5	114	12	17.3	119	44	89
21	66.0	...	...	...	...	...	...	39	39
22	60.0	17	15.1	96	15	15.8	118	0	32
23	56.5	...	...	...	...	...	...	35	35
24	61.5	12	15.2	99	2	16.3	146	0	14
25	65.5	...	...	...	...	...	...	...	0
May 21-25	...	29	15.1	98	17	15.9	120	74	120
26	65.0	1	13.0	58	4	15.9	114	0	5
27	60.0	...	...	...	...	...	...	18	18
28	57.5	10	15.3	110	5	16.7	144	0	15
29	62.0	...	...	...	...	...	...	38	38
30	67.0	15	15.9	120	7	15.9	122	0	22
31	65.5	...	...	...	...	...	...	14	14
May 26-31	...	26	15.6	114	16	16.2	128	70	112
June 1	62.5	28	15.6	116	8	15.7	120	0	36
2	58.0	...	...	...	...	...	...	100	100
3	58.0	36	15.2	107	12	15.8	124	0	48
4	57.5	...	...	...	...	...	...	45	45
5	60.5	7	15.8	91	4	14.1	70	0	11
June 1-5	...	71	15.1	108	24	15.6	112	145	240

Table 9, continued

Date (1951)	Mean water temperature (F.°)	Males			Females			Number with no data recorded	Total ♂♂ and ♀♀ taken
		Number of specimens	Average length (inches)	Average weight (grams)	Number of specimens	Average length (inches)	Average weight (grams)		
June 6	61.5	...	...	...	...	...	...	5	5
7	61.5	...	...	...	...	...	...	5	5
8	61.0	...	...	...	...	...	...	2	2
9	58.5	19	14.4	79	18	16.0	127	0	37
10	60.0	...	...	...	...	...	...	27	27
June 6-10	...	19	14.4	79	18	16.0	127	39	76
11	62.5	2	13.7	73	1	15.6	106	0	3
12	64.0	...	...	...	...	...	...	1	1
13	63.0	...	...	...	...	...	...	1	1
14	65.5	...	...	...	...	...	...	...	0
15	67.0	...	...	...	...	...	..	...	0
June 11-15	...	2	13.7	73	1	15.6	106	2	5
16	66.5	...	...	...	...	...	...	...	0
17	69.5	...	...	...	...	...	...	...	0
18	71.0	...	...	...	...	...	...	...	0
19	67.0	...	...	...	...	...	...	...	0
20	67.0	...	...	...	...	...	...	1	1
June 16-20	...	0	...	...	...	...	...	1	1
21	62.5	1	14.8	128	...	...	...	0	1
22	64.0	...	...	...	...	...	...	...	0
23	65.5	...	...	...	1	13.1	72	0	1
24	65.0	...	...	...	...	...	...	...	0
25	65.0	...	...	...	...	...	...	...	0
June 21-25	...	1	14.8	128	1	13.1	72	0	2
26	62.5	...	...	...	...	...	...	...	0
27	65.0	...	...	...	...	...	...	...	0
28	64.0	...	...	...	...	...	...	...	0
29	64.5	...	...	...	...	...	...	...	0
30	66.5	...	...	...	...	...	...	...	0
June 26-30	...	0	...	...	...	...	...	...	0

Table 9, continued

Date (1951)	Mean water temperature (F.°)	Males			Females			Number with no data recorded	Total ♂♂ and ♀♀ taken
		Number of specimens	Average length (inches)	Average weight (grams)	Number of specimens	Average length (inches)	Average weight (grams)		
July 1	65.0	...	...	...	...	...	...	...	0
2	64.0	...	...	...	...	...	...	...	0
3	60.0	...	...	...	...	...	...	...	0
4	56.5	...	...	...	...	...	...	...	0
5	61.0	1	13.4	58	...	...	...	0	1
July 1-5	...	1	13.4	58	0	...	...	0	1
6	68.0	...	...	...	...	...	...	1	1
7	67.5	...	...	...	...	...	...	...	0
8	69.5	...	...	...	...	...	...	...	0
9	72.0	...	...	...	...	...	...	...	0
10	70.0	...	...	...	...	...	...	1	1
July 6-10	...	0	...	...	0	...	...	2	2
11	66.5	2	13.9	61	...	...	...	0	2
12	66.5	...	...	...	...	...	...	1	1
13	70.5	1	13.1	60	...	...	...	0	1
14	72.0	...	...	...	...	...	...	1	1
15	72.0	1	17.6	174	...	...	...	0	1
July 11-15	...	4	14.6	89	0	...	...	2	6
16	67.0	...	...	...	...	...	...	1	1
17	66.0	...	...	...	...	...	...	...	0
18	68.0	...	...	...	...	...	...	...	0
19	61.5	...	...	...	...	...	...	...	0
20	65.5	...	...	...	...	...	...	1	1
July 16-20	...	0	...	...	...	...	...	2	2
21	65.0	...	...	...	...	...	...	...	0
22	68.0	...	...	...	...	...	...	...	0
23	67.0	...	...	...	...	...	...	...	0
24	70.0	...	...	...	...	...	...	1	1
25	71.5	...	...	...	...	...	...	...	0
July 21-25	...	0	...	...	0	...	...	1	1

Table 9, continued

Date (1951)	Mean water temperature (F.°)	Males			Females			Number with no data recorded	Total ♂♂ and ♀♀ taken
		Number of specimens	Average length (inches)	Average weight (grams)	Number of specimens	Average length (inches)	Average weight (grams)		
July 26	73.0	...	...	...	...	...	...	...	0
27	69.0	...	...	...	...	...	...	...	0
28	68.5	...	...	...	...	...	...	...	0
29	72.5	1	10.6	32	...	...	...	0	1
30	74.0	...	...	...	...	...	...	...	0
31	73.0	...	...	...	...	...	...	...	0
July 26-31	...	1	10.6	32	0	...	...	0	1
August 1	68.5	...	...	...	...	...	...	...	0
2	69.5	...	...	...	...	...	...	...	0
3	65.5	...	...	...	...	...	...	...	0
4	63.0	...	...	...	1	12.9	54	0	1
5	63.5	...	...	...	1	12.1	60	0	1
6	62.0	...	...	...	...	...	...	...	0
August 1-6	...	0	...	...	2	12.5	57	0	2
Total or average		445	15.6	110.8	184	16.2	128.3	637	1,266

Table 10.—Mean water temperatures, number, average length and average weight by sexes of samples of sea lampreys and total number of sea lampreys taken in Ocqueoc River, Presque Isle County, Mich., by dates and by periods in 1951

Date (1951)	Mean water temperature (F°)	Males			Females			Number with no data recorded	Total ♂♂ and ♀♀ taken
		Number of specimens	Average length (inches)	Average weight (grams)	Number of specimens	Average length (inches)	Average weight (grams)		
April 12-16 (Weir operation continuous - no lampreys taken)									
April 17	39.5	...	...	...	1	17.0	148	0	1
18	38.5	...	...	...	...	...	...	0	0
19	39.5	1	18.9	188	0	...	...	0	1
20	38.5	...	...	...	...	...	...	0	0
17-20	...	1	18.9	188	1	17.0	148	0	2
21	38.0	...	...	...	...	...	...	0	0
22	39.0	1	19.2	202	0	...	...	0	1
23	40.0	4	19.4	231	2	19.1	224	0	6
24	40.0	3	19.5	203	...	...	...	0	3
25	40.5	...	...	...	...	...	...	0	0
26	42.5	2	17.0	131	2	15.8	105	0	4
27	43.0	1	15.8	130	1	18.5	180	0	2
28	48.5	37	17.6	160	14	18.3	162	0	51
29	50.0	3	16.0	115	5	17.6	179	765	773
30	53.5	161	16.2	129	65	17.1	162	659	885
April 21-30	...	212	16.5	138	89	17.3	169	1,424	1,725
May 1	55.5	...	...	...	...	...	...	890	890
2	56.0	154	16.3	136	49	17.1	171	425	628
3	54.0	...	...	...	...	...	...	217	217
4	55.5	84	16.2	135	26	17.5	172	0	110
5	55.0	...	...	...	...	...	...	168	168
6	55.5	114	16.9	151	46	17.5	170	4	164
7	55.5	...	...	...	...	...	...	722	722
8	57.5	142	17.0	150	58	17.7	180	449	649
9	57.0	...	...	...	...	...	...	399	399
10	56.0	94	16.4	142	40	17.3	166	47	181
May 1-10	...	588	16.6	143	219	17.4	173	3,321	4,128

Table 10, continued

Date (1951)	Mean water temperature (F.°)	Males			Females			Number with no data recorded	Total ♂♂ and ♀♀ taken
		Number of specimens	Average length (inches)	Average weight (grams)	Number of specimens	Average length (inches)	Average weight (grams)		
May 11	56.0	...	...	...	...	...	...	300	300
12	56.0	116	16.4	138	31	17.1	159	105	252
13	54.5	...	...	...	...	...	...	335	335
14	58.5	140	15.9	115	55	17.1	159	707	902
15	61.5	...	...	...	...	...	...	683	683
16	59.0	138	16.2	130	62	16.8	153	438	638
17	60.0	...	...	...	...	...	...	203	203
18	60.5	113	15.9	125	44	16.8	148	29	186
19	63.5	...	...	...	...	...	...	209	209
20	64.0	129	15.9	130	43	16.5	146	102	274
May 11-20	...	636	16.1	128	235	16.8	152	3,111	3,982
21	65.5	...	...	...	...	...	...	232	232
22	61.0	138	15.8	126	56	16.8	148	103	297
23	62.0	...	...	...	...	...	...	353	353
24	63.5	138	15.7	115	51	16.3	137	185	374
25	65.0	...	...	...	...	...	...	563	563
26	66.5	168	15.7	121	61	16.5	155	1,539	1,768
27	65.0	...	...	...	...	...	...	758	758
28	63.0	141	16.0	126	50	16.5	149	50	241
29	64.0	...	...	...	...	...	...	359	359
30	66.0	116	16.0	122	42	16.5	147	378	536
31	65.0	...	...	...	...	...	...	443	443
May 21-31	...	701	15.8	121	260	16.5	147	4,963	5,924
June 1	63.0	99	15.6	118	44	16.9	152	213	356
2	62.0	...	...	...	...	...	...	439	439
3	62.5	132	16.2	133	68	16.9	133	56	256
4	60.5	...	...	...	...	...	...	281	281
5	61.5	73	15.3	108	30	16.4	143	59	162
6	62.5	...	...	...	...	...	...	271	271
7	62.5	67	15.5	124	34	15.6	134	1	102
8	64.0	...	...	...	...	...	...	139	139
9	61.0	70	15.2	108	31	15.2	117	13	114
10	63.5	...	...	...	...	...	...	130	130
June 1-10	...	441	15.7	121	207	16.1	136	1,602	2,250

Table 10, continued

Date (1951)		Mean water temperature (F°)	Males			Females			Number with no data recorded	Total ♂♂ and ♀♀ taken
			Number of specimens	Average length (inches)	Average weight (grams)	Number of specimens	Average length (inches)	Average weight (grams)		
June	11	62.5	72	15.1	123	29	16.3	141	37	138
	12	63.0	...	...	...	...	...	...	92	92
	13	65.5	35	15.8	122	19	16.1	141	0	54
	14	65.5	...	...	...	...	...	...	145	145
	15	66.5	64	15.4	116	19	16.3	133	0	83
	16	67.5	...	...	...	...	...	...	76	76
	17	69.5	47	15.7	123	20	15.7	124	0	67
	18	70.5	...	...	...	...	...	...	60	60
	19	69.0	26	14.6	92	17	15.4	111	0	43
	20	69.5	...	...	...	...	...	...	76	76
June	11-20	...	244	15.4	113	104	16.1	130	436	834
	21	66.5	36	15.0	104	20	15.1	110	1	57
	22	66.5	...	...	...	...	...	...	40	40
	23	68.0	19	16.5	135	5	14.2	86	0	24
	24	68.0	...	...	...	...	...	...	35	35
	25	67.5	31	15.1	113	13	15.1	109	0	44
	26	67.0	...	...	...	...	...	...	26	26
	27	69.0	13	14.0	85	6	14.6	87	12	31
	28	68.0	27	15.1	108	18	16.0	120	0	45
	29	68.0	14	15.3	112	11	15.5	112	0	25
	30	69.5	...	...	...	...	...	...	20	20
June	21-30	...	140	15.3	111	73	15.6	111	134	347
July	1	...	10	15.1	97	8	14.8	97	0	18
	2	...	...	...	...	...	...	...	7	7
	3	...	6	15.0	97	4	13.9	71	0	10
	4	...	...	...	...	...	...	...	3	3
	5	...	18	15.0	111	14	14.8	105	0	32
	6	...	...	...	...	...	...	...	20	20
	7	...	11	15.9	131	7	14.4	80	0	18
	8	...	...	...	...	...	...	...	19	19
	9	...	11	15.4	109	6	14.7	90	0	17
	10	...	...	...	...	...	...	...	13	13
July	1-10	...	56	15.3	111	39	14.6	94	62	157

Table 10, continued

Date (1951)	Mean water temperature (F°)	Males: Number of specimens	Males: Average length (inches)	Males: Average weight (grams)	Females: Number of specimens	Females: Average length (inches)	Females: Average weight (grams)	Number with no data recorded	Total ♂♂ and ♀♀ taken
July 11	...	5	14.5	100	3	15.1	98	0	8
12	...	...	...	...	...	...	...	9	9
13	...	1	18.6	224	2	17.1	167	0	3
14	...	...	...	...	...	...	...	4	4
15	...	3	14.4	79	0	...	...	0	3
16	...	...	...	...	...	...	...	2	2
17	...	1	12.7	40	0	...	...	0	1
18	...	...	...	...	...	...	...	1	1
19	...	1	18.6	206	0	...	...	0	1
20	...	...	...	...	...	...	...	1	1
July 11-20	...	11	15.0	109	5	15.9	126	17	33
21	...	0	...	...	0	...	...	...	0
22	...	0	...	...	0	...	...	3	3
23	...	0	...	...	1	15.5	100	0	1
24	...	0	...	...	0	...	...	...	0
25	...	0	...	...	1	13.1	54	0	1
26	...	0	...	...	0	...	...	...	0
27	...	0	...	...	0	...	...	...	0
28	...	0	...	...	1	14.0	78	0	1
29	...	0	...	...	0	...	...	...	0
30	...	1	17.1	124	0	...	...	0	1
31	...	0	...	...	0	...	...	...	0
July 21-31	...	1	17.1	124	3	14.2	77	3	7
August 1	71.5	0	...	...	1	16.1	132	0	1
2	71.0	1	17.7	184	0	...	...	0	1
3	70.5	0	...	...	0	...	...	...	0
4	68.5	0	...	...	0	...	...	...	0
5	69.5	1	13.9	56	1	16.6	178	0	2
6	68.5	0	...	...	0	...	...	0	0
August 1-6	...	2	15.8	120	2	16.4	155	0	4
Totals or averages		3,033	16.0	123.3	1,237	16.6	146.9	15,123	19,393

Table 11.--Average lengths and average weights of samples of sea lampreys taken in Carp Creek and the Ocqueoc River, Presque Isle County, Michigan, by years, 1947-1951

Stream and year	Males		Females		♂♂ and ♀♀	
	Average length	Average weight	Average length	Average weight	Average length	Average weight
Carp Creek:						
1947[1]	17.4	181.6	17.4	186.6	17.4	...
1948[1]	16.7	...	16.9	...	16.8	...
1949[1]	16.9	...	17.4	...	17.1	...
1950	16.4	...	16.9	...	16.5	...
1951	15.6	110.8	16.2	128.3	15.8	115.6
Ocqueoc River:						
1947[1]	[2]16.2	...	[2]16.3	...	...	...
1949[1]	17.0	...	17.2	...	17.1	...
1950	16.4	...	16.7	...	16.5	...
1951	16.0	123.3	16.6	146.9	16.2	132.5

1/ Applegate, 1950.

2/ Sample selective for smaller individuals; see Applegate (1950).

Table 12.--Daily minimum, maximum, and mean water temperatures (°F.) and water gauge readings (feet) for the Ocqueoc River (Presque Isle County, Michigan) with mean air temperature and wind and weather records for the locality, April 12 - August 6, 1951

Date 1951	Water temperature[1] Min.	Mean	Max.	Water gauge[2]	Mean air temperature	Sky	Weather	Wind
April 12	40	40.5	41	1.7	42.5	Overcast	Rain	Light
13	40	41.0	42	2.4	43.0	"	Lt. rain	"
14	40	41.0	42	2.8	40.0	"	Fair	"
15	40	41.0	42	2.5	41.0	"	Snow	Moderate
16	39	39.5	40	2.2	38.0	"	"	Light
17	39	39.5	40	1.9	40.0	"	"	"
18	38	38.5	39	1.7	35.5	"	Fair	"
19	38	39.5	41	1.6	46.0	Ptly. o'cast	"	Calm
20	37	38.5	40	1.7	42.5	Clear	"	"
21	37	38.0	39	1.7	37.5	Overcast	Snow	Light
22	39	39.0	39	1.5	41.0	"	Lt. rain	"
23	38	40.0	42	1.9	45.5	Ptly. o'cast	Fair	Strong
24	39	40.0	41	1.7	44.0	"	"	Light
25	40	40.5	41	1.5	38.0	Overcast	Fog	Calm
26	40	42.5	45	1.7	50.0	Clear	Fair	Light
27	40	43.0	46	1.8	53.5	"	"	"
28	45	48.5	52	1.7	71.5	"	"	"
29	48	50.0	52	1.7	60.5	Ptly. o'cast	"	"
30	51	53.5	56	1.5	55.0	Clear	"	Moderate
May 1	53	55.5	58	1.5	62.5	Clear	Fair	Light
2	54	56.0	58	1.5	60.5	Ptly. o'cast	"	"
3	53	54.0	55	1.4	50.0	Overcast	Lt. rain	"
4	53	55.5	58	1.5	55.0	Clear	Fair	"
5	53	55.0	57	1.5	56.5	Overcast	"	Calm
6	53	55.5	58	1.5	56.0	Ptly. o'cast	"	Light
7	52	55.5	59	1.7	60.5	Clear	"	Moderate
8	53	57.5	62	1.7	67.0	Ptly. o'cast	"	Light
9	54	57.0	60	1.6	54.5	Overcast	"	"
10	53	56.0	59	1.4	48.0	Clear	"	"
11	53	56.0	59	1.5	58.0	Ptly. o'cast	"	"
12	52	56.0	60	1.5	52.5	Overcast	"	"
13	51	54.5	60	1.5	47.0	Clear	"	"
14	53	58.5	64	1.5	63.5	Clear	"	"
15	58	61.5	65	1.5	67.5	Ptly. o'cast	"	Moderate
16	57	59.0	61	1.5	51.5	Overcast	Lt. rain	Calm
17	56	60.0	64	1.4	49.0	Clear	Fair	Light
18	56	60.5	65	1.4	55.0	Ptly. o'cast	"	"
19	59	63.5	68	1.4	66.0	Clear	"	"
20	62	64.0	66	1.5	64.5	Ptly. o'cast	"	"
21	61	65.5	70	1.5	63.0	"	"	"
22	59	61.0	63	1.5	50.5	Overcast	"	Calm

Table 12, continued

Date 1951		Water temperature[1] Min.	Mean	Max.	Water gauge[2]	Mean air temperature	Sky	Weather	Wind
May	23	57	62.0	67	1.5	49.5	Clear	Fair	Light
	24	60	63.5	67	1.[illegible]	66.5	Overcast	"	"
	25	60	65.0	70	1.6	70.5	Clear	"	Moderate
	26	63	66.5	70	1.6	68.0	Ptly. o'cast	"	Light
	27	63	65.0	67	1.6	50.[illegible]	Overcast	"	"
	28	62	63.0	64	1.6	52.0	Overcast	Lt. rain	Calm
	29	60	64.0	68	1.6	60.0	Ptly. o'cast	Fair	Light
	30	60	66.0	72	1.[illegible]	65.0	Clear	"	"
	31	61	65.0	69	1.6	58.5	Ptly. o'cast	"	"
June	1	61	63.0	65	1.6	54.5	Overcast	Fair	Calm
	2	60	62.0	64	1.[illegible]	58.[illegible]	"	"	Moderate
	3	60	62.5	65	1.6	[illegible].0	"	"	Light
	4	58	60.5	63	1.[illegible]	5[illegible].0	"	"	"
	5	56	61.5	67	1.5	54.0	Clear	"	"
	6	58	62.5	67	1.7	58.5	"	"	"
	7	58	62.5	67	1.[illegible]	50.0	Ptly. o'cast	"	"
	8	59	64.0	69	1.6	54.[illegible]	Clear	"	"
	9	60	61.0	62	1.6	47.5	Overcast	"	Calm
	10	59	63.5	66	1.7	56.[illegible]	Clear	"	Moderate
	11	57	62.5	68	1.[illegible]	[illegible].0	"	"	Light
	12	59	63.0	67	1.[illegible]	[illegible].0	Ptly. o'cast	"	"
	13	61	65.5	70	1.8	57.5	Overcast	"	"
	14	60	65.5	71	1.[illegible]	58.[illegible]	Clear	"	"
	15	61	66.5	72	1.[illegible]	[illegible].5	"	"	"
	16	63	67.5	72	1.6	67.0	"	"	"
	17	65	69.5	74	1.6	[illegible].5	Hazy	"	"
	18	67	70.5	74	1.[illegible]	72.5	"	"	"
	19	68	69.0	70	1.[illegible]	[illegible].0	Overcast	"	Calm
	20	67	69.5	72	1.9	[illegible].5	"	"	Moderate
	21	64	66.5	69	2.[illegible]	[illegible].[illegible]	Clear	"	Light
	22	64	66.5	69	1.[illegible]	[illegible].0	Overcast	"	"
	23	63	68.0	73	1.8	[illegible].[illegible]	Clear	"	"
	24	65	68.0	71	1.7	[illegible].5	Cloudy	Rain	"
	25	63	67.5	72	1.8	[illegible].0	Clear	Fair	"
	26	66	67.0	68	...	[illegible].5	...	...	...
	27	65	69.0	73	1.8	[illegible].0	Clear	Fair	Light
	28	66	68.0	70	1.9	[illegible].5	Overcast	"	"
	29	64	68.0	72	1.9	[illegible].0	Clear	"	Moderate
	30	66	69.5	73	1.[illegible]	[illegible].5	"	"	Light
July	1	65	68.5	72	1.8	[illegible].0	Clear	Fair	Light
	2	64	64.5	73	2.0	[illegible].5	"	"	"
	3	64	66.5	69	1.8	[illegible].5	"	"	"

Table 12, continued

Date 1951		Water temperature[1] Min.	Mean	Max.	Water gauge[2]	Mean air temperature	Sky	Weather	Wind
July	4	63	64.5	66	1.9	5[illegible].0	Overcast	Lt. rain	Light
	5	61	64.0	67	2.1	60.0	Clear	Fair	"
	6	61	65.5	70	2.1	67.0	"	"	"
	7	64	67.0	70	2.1	67.0	Overcast	"	"
	8	66	68.5	71	2.[illegible]	7[illegible].0	"	"	"
	9	67	71.0	75	2.3	71.0	"	"	"
	10	67	70.0	73	2.0	6[illegible].5	"	"	"
	11	66	68.0	70	2.0	57.0	Overcast	Fair	Calm
	12	66	70.0	74	2.0	6[illegible].0	"	"	"
	13	66	71.0	76	2.1	66.0	Clear	"	Light
	14	68	73.5	79	2.[illegible]	7[illegible].5	"	"	Calm
	15	70	74.5	79	2.[illegible]	7[illegible].5	"	"	Light
	16	69	71.5	74	2.1	59.5	Overcast	"	"
	17	67	71.0	75	2.0	61.5	Clear	"	"
	18	69	72.0	75	2.0	69.0	Ptly. o'cast	"	"
	19	66	68.5	71	2.0	61.5	"	"	"
	20	64	69.0	74	2.2	63.5	Clear	"	"
	21	67	69.0	71	2.2	66.5	Overcast	Rain	Strong
	22	67	70.5	74	2.1	65.5	Ptly. o'cast	Fair	Moderate
	23	65	70.5	76	2.1	63.5	Clear	"	Light
	24	68	73.0	78	2.1	69.5	"	"	"
	25	71	74.5	78	2.2	75.5	Ptly. o'cast	"	Moderate
	26	73	76.5	80	2.3	76.5	Clear	"	Light
	27	69	71.5	74	2.1	60.0	Ptly. o'cast	"	"
	28	68	73.0	78	2.2	64.5	Clear	"	"
	29	70	74.0	78	2.2	75.5	Ptly. o'cast	"	"
	30	72	74.5	77	2.2	74.5	"	"	"
	31	72	75.0	78	2.1	70.0	"	"	"
Aug.	1	67	71.5	76	2.2	62.5	Clear	Fair	Moderate
	2	69	71.0	73	2.1	68.5	Ptly. o'cast	"	Light
	3	67	70.5	74	2.3	58.0	"	"	Strong
	4	64	68.5	73	2.2	59.0	"	"	Calm
	5	65	69.5	74	2.2	61.5	Clear	"	"
	6	67	68.5	70	2.3	61.5	Overcast	"	Light

1/ Thermograph station at weir

2/ Water-gauge readings are absolute depths in feet across the deck of weir

Table 13.--Cost of installation and operation of five units of experimental control structures operated in 1950 and 1951 1/

Operational unit	1950		1951	
	Initial installation and repair	Annual operation	Reinstallation and repair	Annual operation
1 - Trout River group (1 control structure)	$540	$1,053	$321	$1,061
2 - Ocqueoc - Carp Creek group (2 control structures)	2/ 14,721	3,172	1,096	2,641
3 - Cheboygan group (8 control structures)	1,951	2,793	583	2,260
4 - Carp Lake River group (1 control structure)	213	824	220	835
Control Zone H-1 (12 control structures) Sub-total	17,425	7,842	2,220	6,797
5 - Pendills Creek group (1 structure)	529	856	130	554
Grand total (13 control structures)	17,954	8,698	2,350	7,351

1/ Does not include cost of engineering supervision or administrative overhead

2/ Includes $12,800 for construction of permanent-type Ocqueoc River weir and traps which was installed in 1948

average total length of the runs in Carp Creek has decreased 9 percent (1.6 inches) from a maximum of 17.4 inches in 1947 to 15.6 inches in 1951. In samples from both Carp Creek and the Ocqueoc River, the average total length declined between 0.8 and 0.9 inch in the period 1949 to 1951. The average weight of migrants entering Carp Creek has decreased about 38 percent (approximately 70 grams) during the 5-year period.

Any further decline in the size of mature spawning migrants will profoundly affect any proposed control program based on the operation of weirs and traps. Further reduction of weir screen or grate aperatures below the 1/2-inch spacing now required will create extremely difficult operational problems during spring floods.

The spawning runs in Carp Creek and the Ocqueoc River in 1951 did not differ in character or in their response to certain factors in the environment vary from those runs occurring in the same streams in previous years. Data pertaining to the runs in these two streams in 1951 are presented in tables 9, 10, and 12; similar information for the runs occurring in 1950 has been presented by Applegate and Smith (1951) and for the years 1947, 1948, and 1949 by Applegate (1950). Strict comparisons of the character of the Ocqueoc River run in 1951 in relation to time of migration and response to various environmental factors should not be made with those runs of former years. Daily and periodic catches in this river (as detailed in table 10) were strongly influenced by the operation of an experimental electromechanical weir and trap located below the permanent Ocqueoc River installation. Experimentation with this new device was carried on intermittently from May 1 to June 15. During the periods of effective operation of the electromechanical weir, many or all lampreys were blocked below the electrodes and did not enter the traps in the permanent installation until the electrical device became inoperative.

New developments and further evaluation of mechanical control devices 5/

Barrier dams.—The experimental barrier dam in the Black River, Mackinaw County, Michigan, which was designed to block and divert spawning runs of sea lampreys was rebuilt by the Michigan Department of Conservation during the winter of 1950-51 (figs. 3 and 4). A trap, which was installed in the wall of the original dam, was removed and the curved steel lip attached to the face of the dam was extended further across the stream. These changes enabled the structure to handle with greater facility the large discharge of the Black River during the spring runoff.

5/Five types of mechanical control devices have been developed to date: (1) large, permanent type weirs and traps for capturing spawning runs, (2) and (3) portable-type weirs for use in medium- and small-sized streams for capturing spawning runs, (4) dams and inclined-screen trap units for capturing young, downstream migrants, and, (5) barrier dams for blocking and diverting spawning runs. The essential characteristics and the limitations of these devices have been described in an earlier report (Applegate and Smith, 1951).

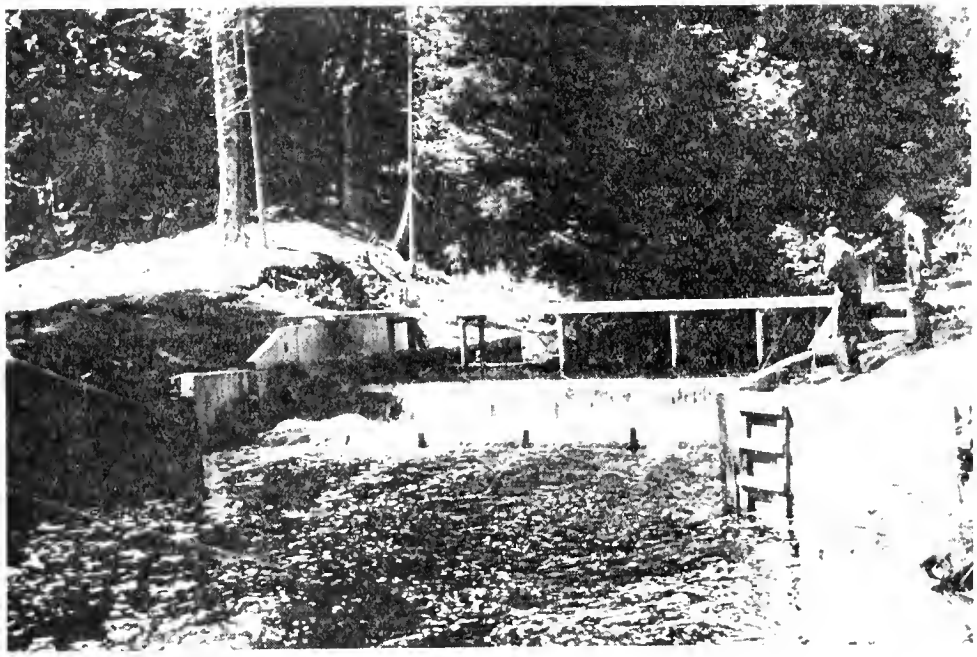

Figure 3.--Experimental sea-lamprey barrier dam in the Black River, Mackinaw County, Mich.

Figure 4.--Close-up of barrier dam showing overhanging, curved lip of sheet steel attached to wall of dam.

The dam functioned satisfactorily throughout the spring of 1951, blocked all lampreys entering the stream from reaching the spawning grounds in that river, and, offered no significant barrier to the upstream migrations of game fishes.

Control structures of this type will be especially useful in many streams on the southwestern shore of Lake Superior which are characterized by steep gradients and very stable substrata and where poor accessibility precludes the installation of devices which must be serviced daily.

Portable-type weirs and traps.--Screen, trap, and bracing units of the several portable-type weirs were operated in the streams of Control Zone H-1 and in Lake Superior tributaries in 1951 with no major structural changes. Wearing quality of the original units, as designed, has been found to be excellent. Most portable-type screen and trap units apparently will give from 4 to 5 years of service under reasonable stream conditions before any replacement becomes necessary.

One innovation tested in Carp Creek, Presque Isle County, Mich., was the use of permanent sills, trap base, and abutments which were constructed of reinforced concrete (figs. 5 and 6). This stable substructure proved extremely effective. It practically eliminated danger of undercutting or bank-cutting and provided continuous trouble-free operation through a spring season of unusually high floods.

Similar concrete sills and abutments were installed in Hibbards Creek, Door County, Wis., by the Wisconsin Conservation Department. This installation likewise proved to be much more effective than the wooden substructures used in previous years.

The specific advantages of these concrete substructures appear to be as follows: (1) elimination of occasional replacement of substructure; (2) reduction of maintenance of substructure to a minimum; (3) reduction of wear on portable screen and trap units; and, (4) reduction of operating costs through increased ease of weir operation (fewer man-hours required for inspection and servicing). It would seem advisable, therefore, in a long-term control program to install this more stable weir and trap base in all streams where the portable-type structures are to be used. Although initial capital outlay would obviously be greater than for similar wood substructures, the advantages indicated above should effect more than compensating savings over a period of years.

Operating costs in 1950 and 1951 for Control Zone H-1 and one stream tributary to Lake Superior.--Detailed records have been kept through two seasons of operations of the costs incurred in installing, operating, and maintaining the 12 weirs and traps of Control Zone H-1 and the Pendills Creek weir. Briefly, these 13 control structures were installed at an aggregate cost of $17,954 and operated successfully during the 1950 season for $8,698. They were reinstalled in 1951 at a cost of $2,350 and operated throughout that season for $7,351. The cost of reinstallation in 1951 is not typical of a normal season since it includes funds expended

in the experimental installation of reinforced concrete sills and abutments in Carp Creek (Unit 2). Had this additional construction been omitted, reinstallation costs would have been approximately $1,000.

The figures presented above are broken down in Table 13 where they are presented by operational units. An operational unit is any weir and trap or group of such structures which, when geography and work load are considered can be most economically and efficiently operated by a single crew of men. Unit crews consist of night and day shifts of one to four men per shift depending on the season and the size of the unit.

The expenditures indicated here for individual operational units are believed to be representative of the costs of installing and operating such units (comprised of one or more mechnical control devices) in any other similar areas in the Lake Huron and Lake Michigan basins. Gross costs in other unit geographic areas such as Control Zone H-1 will vary widely from the costs indicated for that Zone depending on the number of large, permanent-type weirs and traps required, the extent of the area (control zone), and the dispersion of all required control structures within the area. Operating unit costs in Control Zone H-1 will not apply, for example, in the Lake Superior basin where the accessibility of most streams requiring control devices is very poor. No data are available concerning installation and operating costs in streams in the more remote and wild areas bordering on that lake.

Figure 5.--Portable-type weir and trap in Carp Creek, Presque Isle County, Mich., after installation of permanent sills, trap base, and abutments of concrete.

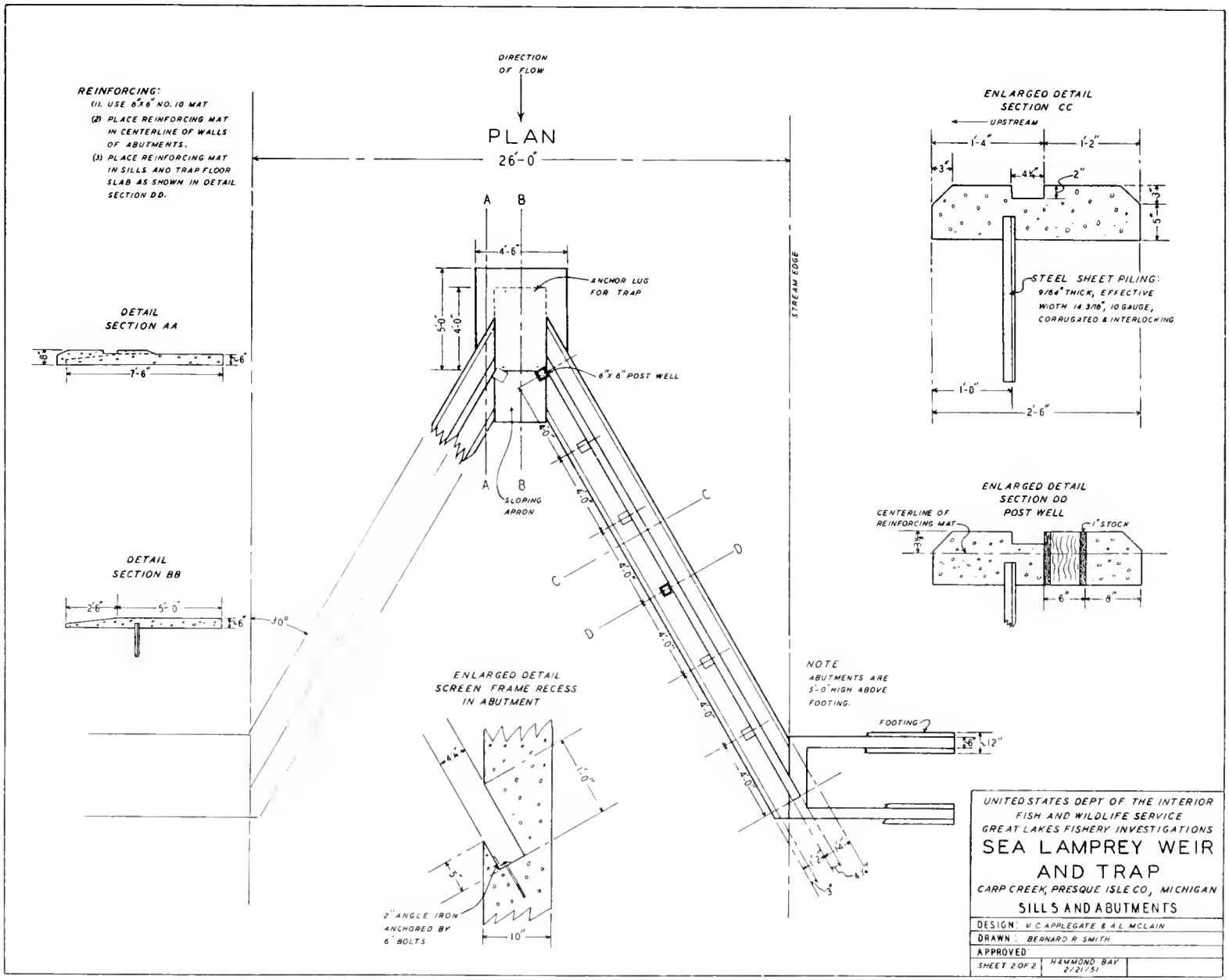

Figure 6.--Diagrammatic plans of concrete sills, trap base, and abutments used to provide permanent base for portable-type sea-lamprey weir and trap.

Literature cited

Applegate, Vernon C.

1950. Natural history of the sea lamprey (Petromyzon marinus) in Michigan. U. S. Dept. of Int., Fish and Wildl. Serv., Spec. Sci. Rept.: Fisheries No. 55: 237 pp.

Applegate, Vernon C. and Bernard R. Smith

1951. Sea lamprey spawning runs in the Great Lakes in 1950. U. S. Dept. of Int., Fish and Wildl. Serv., Spec. Sci. Rept.: Fisheries No. 61: 49 pp.

Shetter, David S.

1949. A brief history of the sea lamprey problem in Michigan waters. Trans. Amer. Fish. Soc., Vol. 76 (1946), pp. 160-176.

List of common and scientific names of fishes mentioned in this report

Black bull head	Ameiurus m. melas
Brook stickleback	Eucalia inconstans
Brook trout	Salvelinus f. fontinalis
Brown trout	Salmo trutta
Burbot	Lota l. maculosa
Carp	Cyprinus carpio
Common shiners	Notropis cornutus frontalis
Creek chubs	Semotilus a. atromaculatus
Great Lakes longnose dace	Rhynichthys c. cataractae
Lake chub	Couesius plumbeus
Lake herring	Leucichthys artedii
Lake trout	Salvelinus (Cristivomer) n. namaycush
Logperch	Percina caprodes
Longnose sucker	Catostomus c. catostomus
Muddler	Cottus b. bairdi
Mudminnow	Umbra limi
Northern pike	Esox lucius
Pumpkinseed	Lepomis gibbosus
Rainbow trout	Salmo gairdneri
Rock bass	Ambloplites rupestris
Sea lamprey	Petromyzon marinus
Silver lamprey	Ichthyomyzon unicuspis
Smallmouth bass	Micropterus d. dolomieui
Smelt	Osmerus mordax
Yellow perch	Perca flavescens
Walleye	Stizostedion v. vitreum
White sucker	Catostomus c. commersoni