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# LAKE TROUT ANGLING ON KEWEENAW BAY IN 1964[1]

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Predation by sea lampreys (Petromyzon marinus) has severely reduced the abundance of lake trout (Salvelinus namaycush) in Lake Superior. The decline began in 1951, and by 1960 their abundance was down to about 10% of its former level.[2] Procedures taken to restore the lake trout population to its former size include poisoning of sea lamprey larvae in streams, banning of commercial fishing for lake trout (effective June 1962), and large-scale stocking of hatchery-reared fish during 1958-1964. Poisoning of larvae began in 1958, and a drastic reduction in the sea lamprey population became apparent in 1962.[3]

The planting of lake trout has resulted in a localized concentration of these fish in Keweenaw Bay which is attracting an increasing number of anglers. There has been some concern that the catch of lake trout will jeopardize the recovery of the species. A census was taken here in 1964 to obtain an estimate of the sportsmens' catch and determine whether or not such concern is justified.

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* Institute for Fisheries Research Report No. 1723.

1 A contribution from Dingell-Johnson Project F-27-R-3, Work Plan 5, Job 9, Michigan.

2 Great Lakes Fishery Commission, Report of Annual Meeting, June 19-20, 1962.

3 Great Lakes Fishery Commission, Report of Annual Meeting, June 26-27, 1963.

Keweenaw Bay (Fig. 1), located in southern Lake Superior, has water depths mostly of 100 to 400 feet. Its southern end, L'Anse Bay, is between 50 and 100 feet deep. L'Anse Bay is closed to commercial fishing south of Baraga. Falls River, the only important tributary of Keweenaw Bay, enters L'Anse Bay at L'Anse. It has a normal summer flow of 10-30 c.f.s. It receives a spawning run of rainbow trout (Salmo gairdneri) from Lake Superior in the spring, and a spawning run of brown trout (Salmo trutta) in the fall.

Before 1951, "jigging" ("bobbing") produced excellent catches of lake trout on Keweenaw Bay, although few fish larger than 18.0 inches were taken. This fishery declined rapidly thereafter until 1962 when the fishing improved markedly. An estimated 1,200 lake trout that averaged about 2 pounds were caught between June 1962 and June 1963. This catch evidently consisted entirely of hatchery trout which had been planted in 1960 and 1961 (Table 1). Most of these fish were caught through the ice in relatively shallow water (less than 100 feet deep) near the mouth of the Falls River, an area formerly unproductive for lake trout. Considerable numbers of rainbow trout, some coregonids, and a few brown trout and northern pike (Esox lucius) also were caught in 1962-63.[4]

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[4] Personal communication, Thomas B. Durling, Regional Fish Biologist, Mich. Dept. Cons., Lansing, Mich., 1964.

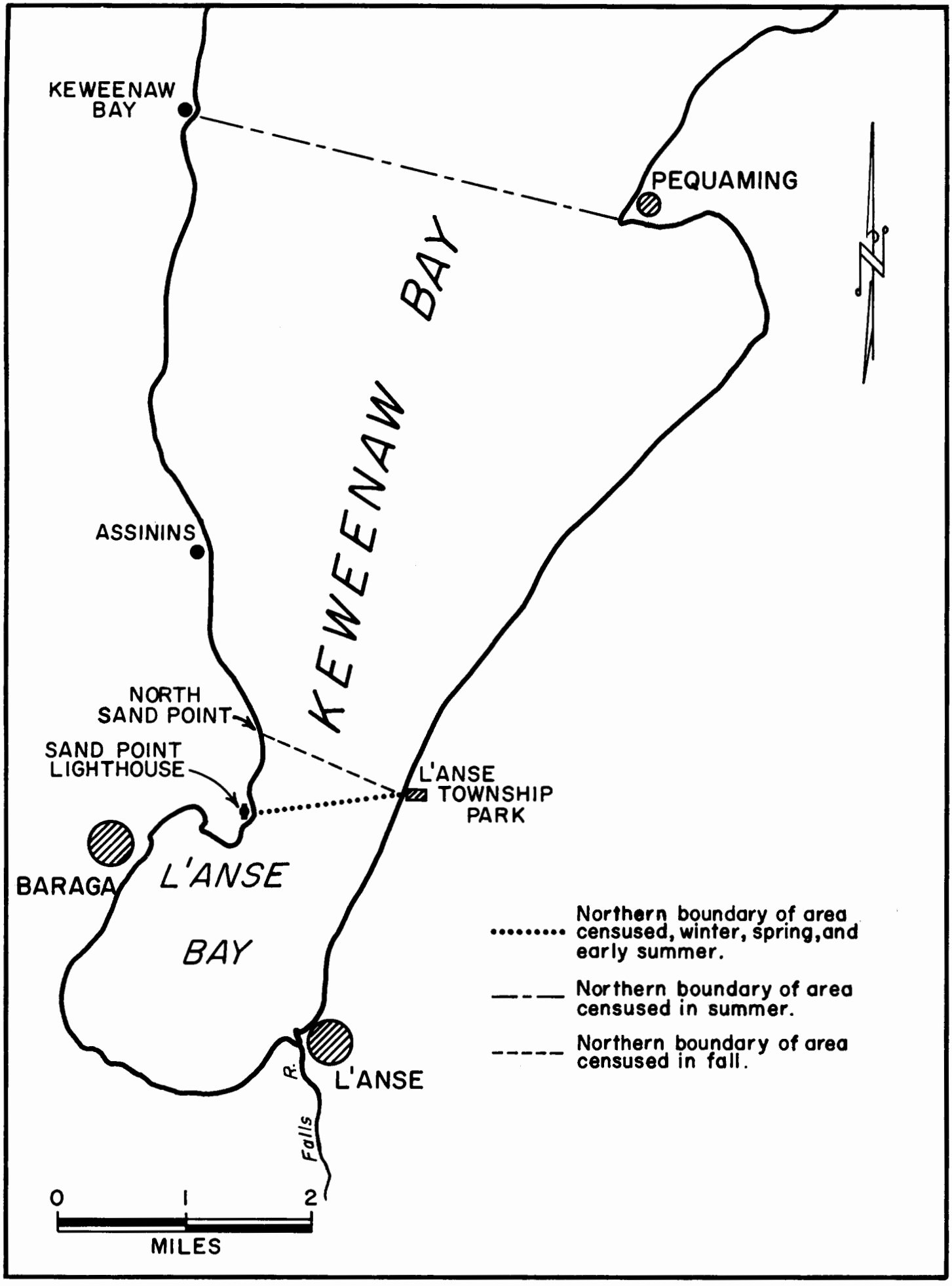


Figure 1.--Creel census areas in southern Keweenaw Bay, 1964.

Table 1.--Lake trout planted in or near Keweenaw Bay, 1959-1963

| Date of planting | Fin clip | Origin of stock | Area planted[a] | Number planted | Average total length (inches) | Age (months) |
|---|---|---|---|---|---|---|
| June 1959 | Adipose - left pectoral | Isle Royale | Baraga | 27,000 | -[b] | 26 |
| May-June 1960 | Adipose - left or right pelvic | Michigan inland lakes | Baraga | 261,000 | 4.5 | 16 |
| June 1961 | Left pelvic | Michigan inland lakes | Baraga, Big Traverse Bay, Pequaming | 172,000 | 5.0 | 16 |
| May-June 1962 | Right pectoral | Eastern Lake Superior | Bete Grise Bay | 323,000 | 5-6 | 16 |
| June 1963 | Left pelvic | Eastern Lake Superior | Pequaming | 273,000 | 5-6 | 16 |
| September 1963 | Right pelvic | Eastern Lake Superior | Pequaming | 267,000 | 6.1 | 19 |

[a] Baraga and Pequaming are shown in Figure 1; Big Traverse Bay and Bete Grise Bay are 35 and 50 miles north of L'Anse Bay, respectively.

[b] Average length undetermined; the range was 9-14 inches.

## Methods

A stratified sampling plan similar to that used on the Black River[5] was used to determine the catch of fish from Keweenaw Bay. The catch per hour (Table 2) was determined from interviews of a sample of the anglers (Table 3). Fishing pressure (hours of fishing) was determined by instantaneous counts of anglers and/or boats on the fishing grounds. The average catch per hour multiplied by the estimated hours of fishing gave an estimate of the number of fish taken (Table 4). Confidence intervals of one standard error for these estimates also are shown in Table 4. Census effort was apportioned according to anticipated fishing effort, derived mostly from observations made on the fishery in 1962-63 by T. B. Durling and Richard Beach, Department employees. Because of limited means, all of Keweenaw Bay could not be censused; rather, the census was confined to the bay south of Pequaming (Fig. 1) where most of the angling occurred. The census was taken during daylight hours, when all of the fishing was done. There was little fishing before February 11 or after October 5.

Based on the type of angling, expected pressure, and location of angling, the census was divided into five major periods as follows: (1) winter, February 11-April 11; (2) early spring, April 4-24; (3) spring and early summer, April 25-July 3; (4) summer, July 4-September 13; and (5) fall, September 14-October 5. During the

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[5] Mich. Dept. Cons. 1961. A problem on stratified sampling for creel census of trout fishing, Black River, Mackinac County, April 25 to July 15, 1959. Inst. Fish. Res. Methods Memo No. 20, (mimeographed).

Table 2.--Estimated catch per hour of several species of fish, Keweenaw Bay, 1964

| Periods | Catch per hour | | | | |
|---|---|---|---|---|---|
| | Lake trout | Rainbow trout | Core-gonids | Brown trout | Yellow perch |
| Winter (Ice fishing) | | | | | |
| Feb. 11-28 | 0.05 | - | <0.01 | - | 0.00 |
| Feb. 29-March 18 | 0.06 | - | <0.01 | - | 0.00 |
| March 19-April 11 | 0.03 | 0.06[a] | 0.02 | 0.00 | 0.00 |
| Feb. 11-April 11 | 0.05 | 0.06[a] | 0.01 | 0.00 | 0.00 |
| Spring (April 4-24) | | | | | |
| Boat | 0.00 | 0.07 | <0.01 | 0.02 | 0.00 |
| Shore | 0.02 | 0.06 | 0.00 | <0.01 | 0.00 |
| All fishing | 0.01 | 0.06 | <0.01 | 0.01 | 0.00 |
| Spring-early summer (April 25-July 3) | | | | | |
| Boat | 0.17 | 0.01 | 0.01 | <0.01 | 0.00 |
| Shore | 0.02 | 0.05 | 0.03 | <0.01 | 0.00 |
| All fishing | 0.14 | 0.02 | 0.01 | <0.01 | 0.00 |
| Summer (July 4-Sept. 13) | | | | | |
| Boat | 0.11 | <0.01 | 0.00 | 0.00 | 0.05 |
| Shore | 0.00 | 0.01 | 0.00 | 0.00 | 0.30 |
| All fishing | 0.09 | <0.01 | 0.00 | 0.00 | 0.10 |
| Fall (Sept. 14-Oct. 5) | | | | | |
| Boat | 0.08 | <0.01 | 0.00 | 0.00 | 0.00 |
| Shore | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 |
| All fishing | 0.07 | 0.01 | 0.00 | 0.00 | 0.00 |
| Grand average | 0.09 | 0.02 | 0.01 | <0.01 | 0.02 |

[a] Based on the period when rainbow trout could be legally kept (April 4-11).

Table 3.--Number of anglers interviewed, hours of fishing, and fish caught in Keweenaw Bay during the various sampling periods in 1964

| Periods | Number of anglers | Hours of fishing | Catch | | | | |
|---|---|---|---|---|---|---|---|
| | | | Lake trout | Rainbow trout | Core-gonids | Brown trout | Yellow perch |
| Winter (Ice fishing) | | | | | | | |
| Feb. 11-28 | 308 | 874 | 47 | 0 | 5 | 0 | 0 |
| Feb. 29-March 18 | 307 | 1,132 | 62 | 0 | 1 | 0 | 0 |
| March 19-April 11 | 335 | 1,365 | 47 | 37[a] | 15 | 0 | 0 |
| Totals | 950 | 3,371 | 156 | 37 | 21 | 0 | 0 |
| Spring (April 4-24) | | | | | | | |
| Boat | 144 | 377 | 0 | 26 | 2 | 7 | 0 |
| Shore | 176 | 338 | 5 | 21 | 0 | 2 | 0 |
| Totals | 320 | 715 | 5 | 47 | 2 | 9 | 0 |
| Spring-early summer (April 25-July 3) | | | | | | | |
| Boat | 793 | 2,466 | 376 | 25 | 15 | 11 | 0 |
| Shore | 313 | 616 | 15 | 34 | 20 | 3 | 0 |
| Totals | 1,106 | 3,082 | 391 | 59 | 35 | 14 | 0 |
| Summer (July 4-Sept. 13) | | | | | | | |
| Boat | 237 | 734 | 92 | 1 | 0 | 0 | 39 |
| Shore | 64 | 88 | 0 | 1 | 0 | 0 | 23 |
| Totals | 301 | 822 | 92 | 2 | 0 | 0 | 62 |
| Fall (Sept. 14-Oct. 5) | | | | | | | |
| Boat | 115 | 344 | 26 | 1 | 0 | 0 | 0 |
| Shore | 57 | 61 | 0 | 3 | 0 | 0 | 0 |
| Totals | 172 | 405 | 26 | 4 | 0 | 0 | 0 |
| Grand totals | 2,849 | 8,395 | 670 | 149 | 58 | 23 | 62 |

[a] Rainbow trout were legal only during April 4-11.

Table 4. --Estimated angling hours and catch, Keweenaw Bay, 1964

| Periods | Hours of fishing | Catch[a] | | | | |
|---|---|---|---|---|---|---|
| | | Lake trout | Rainbow trout | Coregonids | Brown trout | Yellow perch |
| Winter (Ice fishing) | | | | | | |
| Feb. 11-28 | 3,069 | 160 ± 31 | - | 16 ± 9 | - | 0 |
| Feb. 29-March 18 | 4,367 | 247 ± 82 | - | 5 ± 5 | - | 0 |
| March 19-April 11 | 3,398 | 112 ± 23 | 55 ± 13[b] | 51 ± 25 | 0 | 0 |
| Totals | 10,834 | 519 ± 90 | 55 ± 13 | 72 ± 28 | 0 | 0 |
| Spring (April 4-24) | | | | | | |
| Boat | 906 | 0 | 62 ± 17 | 4 ± 3 | 16 ± 6 | 0 |
| Shore | 1,044 | 16 ± 11 | 66 ± 19 | 0 | 6 ± 4 | 0 |
| Totals | 1,950 | 16 ± 11 | 128 ± 26 | 4 ± 3 | 22 ± 7 | 0 |
| Spring-early summer (April 25-July 3) | | | | | | |
| Boat | 8,162 | 1,388 ± 171 | 92 ± 23 | 64 ± 40 | 40 ± 12 | 0 |
| Shore | 1,982 | 47 ± 12 | 97 ± 29 | 62 ± 19 | 10 ± 5 | 0 |
| Totals | 10,144 | 1,435 ± 171 | 189 ± 37 | 126 ± 45 | 50 ± 13 | 0 |
| Summer (July 4-Sept. 13) | | | | | | |
| Boat | 5,718 | 638 ± 116 | 8 ± 8 | 0 | 0 | 286 ± 161 |
| Shore | 1,591 | 0 | 17 ± 17 | 0 | 0 | 470 ± 292 |
| Totals | 7,309 | 638 ± 116 | 25 ± 18 | 0 | 0 | 756 ± 334 |
| Fall (Sept. 14-Oct. 5) | | | | | | |
| Boat | 1,334 | 102 ± 25 | 6 ± 5 | 0 | 0 | 0 |
| Shore | 95 | 0 | 4 ± 2 | 0 | 0 | 0 |
| Totals | 1,429 | 102 ± 25 | 10 ± 5 | 0 | 0 | 0 |
| Grand totals | 31,666 | 2,710 ± 227 | 407 ± 51 | 202 ± 53 | 72 ± 15 | 756 ± 334 |

[a] Plus or minus one standard error.

[b] Based on the period when rainbow trout could be legally kept (April 4-11).

8-day overlap of the winter and early spring periods, there were two separate censuses to cover anglers on the ice (winter) and the open-water anglers (early spring). Between February 11 and April 24, individual anglers were interviewed and counted. From April 25 to October 5, the basic sampling units were either individual anglers or boats. Shore anglers were interviewed and counted individually, while anglers in boats were interviewed and counted as "boat groups." Catch estimates were made for three substrata during the winter season, and for shore and boat anglers during the periods of open water. The following data were recorded during interviews: residence of angler or boat owner, lures used, hours fished, number and kinds of fish caught, total length of trout, and lamprey scars. Rainbow and brown trout caught after April 19 were scale sampled. The average total length of trout caught in each time period and the percentage of trout bearing lamprey scars is shown in Table 5. All trout also were examined for fin clips to determine the proportion of the catch contributed by the previous plantings (Table 6).

### Winter fishery (February 11-April 11)

This period included all ice fishing. In 1964, safe ice was confined only to L'Anse Bay, but usually the ice is safe as far out as Pequaming. Occasionally Keweenaw Bay freezes over firmly as far north as Traverse Point and the Huron Islands. Ice fishermen usually fish in portable tents and shanties and jig either a "Rapala" lure, whole American smelt (Osmerus mordax), or pieces of smelt or sucker

Table 5. --Average total length (inches) of trout and percentage of lamprey-scarred trout in the catch, Keweenaw Bay, 1964

| Periods | Lake trout | | Rainbow trout | | Brown trout | |
|---|---|---|---|---|---|---|
| | Average length | Percentage scarred | Average length | Percentage scarred | Average length | Percentage scarred |
| Winter (Ice fishing) | | | | | | |
| Feb. 11-28 | 18.7 | 5 | - | - | - | - |
| Feb. 29-March 18 | 17.4 | 12 | - | - | - | - |
| March 19-April 11 | 18.2 | 10 | 15.5 | 0 | - | - |
| Feb. 11-April 11 | 18.0 | 9 | 15.5 | 0 | - | - |
| Spring (April 4-24) | | | | | | |
| Boat | - | - | 13.8 | 4 | 16.1 | 14 |
| Shore | 20.0 | 0 | 14.9 | 0 | 14.5 | 0 |
| All fishing | 20.0 | 0 | 14.4 | 2 | 15.7 | 10 |
| Spring-early summer (April 25-July 3) | | | | | | |
| Boat | 19.2 | 10 | 18.4 | 0 | 17.2 | 20 |
| Shore | 19.6 | 6 | 15.4 | 9 | 15.5 | 0 |
| All fishing | 19.2 | 10 | 16.9 | 5 | 16.9 | 16 |
| Summer (July 4-Sept. 13) | | | | | | |
| Boat | 15.6 | 5 | - [a] | - [a] | - | - |
| Shore | - | - | 9.6 | 0 | - | - |
| All fishing | 15.6 | 5 | 9.6 | 0 | - | - |
| Fall (Sept. 14-Oct. 5) | | | | | | |
| Boat | 18.4 | 11 | 11.6 | 0 | - | - |
| Shore | - | - | 11.4 | 0 | - | - |
| All fishing | 18.4 | 11 | 11.5 | 0 | - | - |
| Grand average | 18.1 | 9 | 15.4 | 3 | 16.5 | 14 |

[a] Rainbow trout recorded in this substratum were not measured or examined for lamprey scars.

Table 6.--Estimated percentages of the several plants of lake trout and wild lake trout in the angler catch, Keweenaw Bay, 1964

| Periods | Year of planting | | | | | | Wild trout | Estimated total catch |
|---|---|---|---|---|---|---|---|---|
| | 1959 | 1960 | 1961 | 1962 | 1963 | Unknown | | |
| Winter (Ice fishing) | | | | | | | | |
| Feb. 11-28 | 0 | 41 | 59 | 0 | 0 | 0 | 0 | 160 |
| Feb. 29-March 18 | 0 | 39 | 53 | 2 | 0 | 5 | 1 | 247 |
| March 19-April 11 | 0 | 48 | 52 | 0 | 0 | 0 | 0 | 112 |
| Feb. 11-April 11 | 0 | 42 | 55 | 1 | 0 | 2 | tr | 519 |
| Spring (April 4-24) | | | | | | | | |
| Boat | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shore | 0 | 0 | 19 | 0 | 0 | 81 | 0 | 16 |
| All fishing | 0 | 0 | 19 | 0 | 0 | 81 | 0 | 16 |
| Spring-early summer (April 25-July 3) | | | | | | | | |
| Boat | 2 | 59 | 34 | tr | 0 | 4 | 1 | 1,388 |
| Shore | 0 | 23 | 77 | 0 | 0 | 0 | 0 | 47 |
| All fishing | 2 | 58 | 35 | tr | 0 | 4 | 1 | 1,435 |
| Summer (July 4-Sept. 13) | | | | | | | | |
| Boat | 2 | 31 | 52 | 8 | 2 | 5 | 0 | 638 |
| Shore | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| All fishing | 2 | 31 | 52 | 8 | 2 | 5 | 0 | 638 |
| Fall (Sept. 14-Oct. 5) | | | | | | | | |
| Boat | 0 | 40 | 57 | 0 | 0 | 0 | 3 | 102 |
| Shore | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| All fishing | 0 | 40 | 57 | 0 | 0 | 0 | 3 | 102 |
| Grand average and totals | 2 | 47 | 43 | 2 | 1 | 4 | 1 | 2,710 |

(Catostomus spp.). Fishing is reported to be best right after ice formation and just before the breakup.

The area censused between February 11 and March 4 was the bay south of Pequaming and the town of Keweenaw Bay. After March 4, when it appeared that there would be little good ice outside L'Anse Bay, only L'Anse Bay was censused. Subsequently, ice formed adjacent to L'Anse Bay and a few anglers fished outside the modified census area. Observations by the census clerks indicated that these anglers represented less than 5% of those who fished in Keweenaw Bay. There were three concentrations of anglers in L'Anse Bay. About 70% of them fished near the Falls River for lake trout or rainbow trout, 20% fished near the outside boundary (lighthouse) for lake trout, and 10% fished along the west side of the bay for northern pike. When the rainbow trout season opened on April 4, anglers fished through the ice for both rainbows and lake trout near the mouth of the Falls River.

Because of the claim that fishing success differed according to the stage of the season, the winter census period was subdivided into three substrata: February 11-28, February 29-March 18, and March 19-April 11. To obtain catch-per-hour estimates, a clerk spent 83 randomly selected, 4-hour periods interviewing anglers as they left the ice. This sample comprised 31% of the total estimated fishing effort. The clerk was based at L'Anse because about 70% of the anglers entered the bay there. Anglers observed leaving from other points also were scheduled for interviews, but frequently left before the clerk could

contact them. Thus, a higher percentage of anglers who fished near the Falls River were interviewed than those who fished near the lighthouse. Because the rate of success in the two areas was reported to have been different, there may be a small error in the estimated total catch of lake trout.

To determine total angling hours, 78 instantaneous counts were made of exposed anglers, tents, and shanties. Shortly after a count, each tent and shanty in the Falls River area and along the west side of the bay was checked to determine the number of anglers it contained. Tents in the lighthouse area were checked for occupancy until February 22 when it became apparent that they almost invariably contained one man. Thereafter, these tents were not examined but assumed to contain one angler.

An estimated 519 lake trout were caught through the ice. These fish averaged 18.0 inches in length, and most of them (97%) were from the 1960 and 1961 plantings made in Keweenaw Bay. Nine per cent of the trout were lamprey scarred. It was estimated that anglers fished 10,834 hours and caught lake trout at a rate of 0.05 fish per hour. There was little difference in fishing quality between the three winter substrata. All the lake trout that were checked had been caught by jigging Rapalas, whole smelt, or pieces of smelt or sucker.

An estimated 55 rainbow trout were caught during April 4-11 and they averaged 15.5 inches in length. Most of the observed catch consisted of immature lake-run fish but a few larger mature fish were

caught. None were lamprey scarred. Anglers fished a total of 674 hours for rainbows or lake trout during these 8 days and caught rainbow trout at a rate of 0.06 per hour. Rainbow trout anglers fished on the ice at the edge of open water near the mouth of the Falls River. The most effective bait was salmonid eggs, used either singly or in small nylon bags.

The estimated catch of coregonids was 72 fish caught at the rate of 0.01 fish per hour. The coregonids were mostly lake herring (Coregonus artedii) and round whitefish (Prosopium cylindraceum), plus a few lake whitefish (Coregonus clupeaformis). Lake herring were caught on Rapalas or Kalas while angling for lake trout, and the round whitefish were caught on spawn bags while angling for rainbow trout. Generally, the whitefish were taken near the Falls River, whereas the herring were caught in various parts of the bay. None of the coregonids examined had been scarred by lampreys.

Northern pike spearers fished an estimated 1,135 hours (± 191), but their catch could not be computed because none were interviewed. However, observations made during the counts indicated that no more than about 50 pike plus a few coregonids were speared.

### Early spring (April 4-24)

This period extended from the opening of the rainbow and brown trout season on the Great Lakes (April 4) to the start of the trout season on inland waters (April 25), and involved only angling done on open water--mostly for rainbows. The census was confined to L'Anse Bay where over

95% of the angling on Keweenaw Bay occurred. During April 4-11, the open-water area was limited to 1 or 2 acres at the mouth of the Falls River and the anglers still-fished with spawn bags by wading or from boats. After the spring breakup on April 12, they fished further out in L'Anse Bay but still concentrated near the river casting from shore and trolling from boats with artificial lures.

A census clerk interviewed anglers during 33 randomly selected, 4-hour periods at L'Anse and made 132 instantaneous counts. Practically all of the anglers entered and left the bay at L'Anse. Thirty-seven per cent of the estimated total number of anglers were interviewed. The estimated catch of lake trout was 16. These fish averaged 20.0 inches in length and none were lamprey scarred. All were caught from shore.

The estimated catch of rainbow trout was 128. Their average length was 14.4 inches. Immature lake-run fish made up about 80% of the observed catch; ripe fish, 20%. The average age of fish observed in the catch was 2.8 years. Two per cent of the rainbow trout were lamprey scarred. The rate of catch was 0.06 fish per hour which was somewhat higher than for lake trout. Salmonid eggs were the most popular and effective bait, and there was little difference in success between shore and boat anglers.

Four coregonids were estimated to have been caught and those observed were lake whitefish caught on spawn bags.

The estimated catch of brown trout was 22. They averaged 15.7 inches in length and all those observed had spent at least one

growing season in Lake Superior. These trout were between 2 and 4 years old. One of the nine fish examined was lamprey scarred. All brown trout observed were caught on salmonid eggs. The low catch rate (0.01) was identical to that for lake trout. Boat anglers apparently were more successful than shore anglers.

Spring and early summer (April 25-July 3)

During this period about 65% of the boat anglers fished within 1 mile of the Falls River, 35% were scattered over the remainder of L'Anse Bay, and a few were outside L'Anse Bay. About 90% of the shore anglers fished at L'Anse; the remainder were scattered around L'Anse Bay. Practically all of the angling was done with artificial lures for trout, either trolling or casting. Anglers who fished for yellow perch (Perca flavescens) at Baraga during the latter part of the period were not censused.

The census area was L'Anse Bay where over 95% of the angling occurred. A clerk spent 100 randomly selected, 4-hour periods at L'Anse for interviews and counts. This sample of the fishing quality amounted to 30% of the total estimated boat effort and 31% of the shore effort. The catch rate could be slightly biased because about 20% of the anglers entered and left the bay at places other than L'Anse. There were 400 instantaneous counts. Boat anglers could be counted easily, but about 10% of the shore anglers could not be seen from L'Anse.

The catch of lake trout (average length, 19.2 inches) was estimated at 1,435 fish. The 1960 and 1961 hatchery fish made up 93%

of the catch. Ten per cent of the fish were lamprey scarred. The catch per hour of lake trout (0.14) was the highest of the entire census period. Fishing from boats was much more productive than that done from shore. Most of the lake trout were taken by trolling a medium-sized red and white Dardevle. The best fishing occurred at the end of May and the beginning of June.

An estimated 189 rainbow trout were caught that averaged 16.9 inches. Practically all fish observed had spent at least one growing season in Lake Superior and their average age was 3 years. About 50% were immature, 40% were ripe, and 10% were spent. Five per cent of the catch was lamprey scarred. Rainbow trout were caught at the rate of 0.02 fish per hour, and shore anglers apparently were more successful than boat anglers. Boat anglers used mostly medium-sized Dardevles and salmonid eggs, and shore anglers used salmonid eggs and worms. Boat-caught fish averaged larger than shore-caught fish. Most of the rainbow trout were caught during April 25-May 15.

The estimated catch of 126 coregonids was taken at the rate of 0.01 fish per hour. Three per cent of the observed coregonids were lamprey scarred. About equal numbers were taken from boat and shore, but the rate of catch for shore anglers was higher. Only round whitefish were caught from shore, but both species of whitefish were caught from boats. Coregonids were taken only on worms or salmonid eggs and presumably were caught incidentally while fishing for rainbow or brown trout.

An estimated 50 brown trout were caught that averaged 16.9 inches. Observed fish had spent at least one growing season in the lake and were 2 to 5 years old. Sixteen per cent of the catch was lamprey scarred. The catch rate ( $< 0.01$) was considerably lower than for lake trout and rainbow trout. Boat and shore anglers were about equally successful. Most of the brown trout were caught in May on salmonid eggs and Dardevles.

Summer (July 4-September 13)

Anglers were scattered all over Keweenaw Bay during this period. Because of limited man power, only that portion of the bay south of Pequaming and the town of Keweenaw Bay could be censused. I estimated that upwards of 50% of the total angling in Keweenaw Bay occurred here, and most of the fishing for lake trout was done near the lighthouse. A small amount of shore fishing for trout, yellow perch, and northern pike occurred at L'Anse, Baraga, Pequaming, and the mouths of Six Mile and Menges creeks.

The clerk's effort (100 four-hour interview periods, 300 counts) was apportioned among the three main points of entry (L'Anse, Baraga, and Pequaming) according to prior estimates of use each would receive. The creel census sample encompassed 13% of the estimated fishing done from boats and 6% of that done from shore. The catch rate was derived from a sample drawn from about 50% of the anglers in the census area because approximately half of the total entered from isolated points and Portage Entry. It was assumed that the success of the latter anglers

was the same as that of the others. All fishing boats in the area could be counted readily, but only shore anglers near L'Anse, Baraga, and Pequaming were counted.

An estimated 638 lake trout were caught at a rate of 0.09 trout per hour. The fish averaged 15.6 inches in length and their size increased progressively during this period. Trout of the 1960 and 1961 plantings again made up the bulk of the catch (83%); those from the 1962 and 1963 plantings, 10%. More of these latter fish were caught at this time than in any other period. Five per cent were lamprey scarred. Boat anglers, who trolled Dardevles or spoons and jigged with pieces of suckers near Sand Point lighthouse, accounted for most of the catch.

Most of the rainbow trout were caught from shore at L'Anse, but a few were caught incidentally by fishing done from boats. The estimated number caught was 25 and only two fish were examined.

An estimated 756 yellow perch were caught; those in the sample averaged 8.1 inches. Most of them were caught from the Baraga and Pequaming docks with worms. The remainder were taken by boat anglers at unknown locations.

Fall season (September 14-October 5)

Anglers during this period concentrated in the area immediately south of North Sand Point and L'Anse Township Park, which were the northern limits of the census area. Few anglers went north of this boundary. Most of the boat anglers trolled for lake trout between Baraga

and Sand Point lighthouse and a few jigged in the vicinity of the lighthouse. Shore angling for trout occurred only at L'Anse.

The census clerk conducted interviews and made counts at L'Anse; 30 periods of 4 or 4 1/2 hours each were spent on interviews and 150 counts were made. Data were obtained on 26% of the total estimated boating effort and 64% of the shore effort. About 75% of the fishing boats docked at L'Anse and the remainder at Baraga. Because anglers docking at Baraga were not sampled, it was assumed that their success was the same as that for anglers who docked at L'Anse.

The estimated catch of lake trout amounted to 102 fish. These trout averaged 18.4 inches long, and 40% had been planted in 1960, 57% in 1961, and 3% were wild. Eleven per cent of the catch were lamprey scarred. The catch per hour was 0.07. Boat anglers, who mainly trolled with spoon lures, caught all the trout.

The estimated number of rainbow trout caught was 10, but the small number examined did not warrant any further analysis of the catch.

## Residence of anglers

Most of the fishing was done by local people from L'Anse and Baraga (Table 7) but anglers from other areas of the Upper Peninsula comprised 16% of the total number. Only 7% came from the Lower Peninsula and other states. During the vacation season (July 4-September 13) fishermen from outside the Upper Peninsula comprised only 24% of the total.

Table 7. --Source of anglers on Keweenaw Bay, 1964, expressed as percentages of total number of anglers interviewed

| Periods | Number of anglers interviewed | Upper Peninsula | | Lower Peninsula | Other states |
|---|---|---|---|---|---|
| | | Baraga County | Other counties | | |
| Winter (Ice fishing) | | | | | |
| Feb. 11-28 | 308 | 92 | 7 | 0 | 1 |
| Feb. 29-March 18 | 307 | 79 | 19 | 1 | 1 |
| March 19-April 11 | 335 | 70 | 27 | 1 | 2 |
| Feb. 11-April 11 | 950 | 80 | 18 | 1 | 1 |
| Spring (April 4-24) | | | | | |
| Boat | 144 | 64 | 26 | 0 | 10 |
| Shore | 176 | 85 | 10 | 2 | 3 |
| All fishing | 320 | 76 | 17 | 1 | 6 |
| Spring-early summer (April 25-July 3) | | | | | |
| Boat | 417[a] | 70 | 19 | 4 | 7 |
| Shore | 313 | 82 | 7 | 7 | 4 |
| All fishing | 730 | 75 | 14 | 5 | 6 |
| Summer (July 4-Sept. 13) | | | | | |
| Boat | 116[a] | 71 | 16 | 8 | 5 |
| Shore | 64 | 47 | 11 | 40 | 2 |
| All fishing | 180 | 62 | 14 | 20 | 4 |
| Fall (Sept. 14-Oct. 5) | | | | | |
| Boat | 63[a] | 73 | 25 | 2 | 0 |
| Shore | 57 | 100 | 0 | 0 | 0 |
| All fishing | 120 | 86 | 13 | 1 | 0 |
| Grand totals | 2,300 | 77 | 16 | 3 | 4 |

[a] The residence of the boat owner only was recorded.

## Summary of angling on Keweenaw Bay, 1964

The characteristics of the sport fishing and catch on Keweenaw Bay in 1964 are summarized below by species.

Lake trout. --An estimated 2,710 lake trout were caught by anglers on Keweenaw Bay between February 11 and October 5, 1964. The average size of the fish was 18.1 inches or about 1 3/4 pounds. Individual weights were taken from a length-weight curve (Van Oosten and Eschmeyer, 1956). The estimated total weight was 4,742 pounds. Fish from the 1960 and 1961 plantings (total planting, 433,000) contributed 90% of the total catch. Other planted lake trout comprised 9% and wild fish 1% of the catch. Nine per cent of the catch was lamprey scarred, which indicated moderate predation by lampreys. Most of the lake trout were immature fish (4-5 years old); only one mature trout (from the 1959 planting) was seen.

The size range of the planted trout caught in 1964 was quite broad but the average length of angler-caught fish indicated that growth generally had been rapid when compared with the mean length when planted (Table 1). The estimated average lengths (inches) of trout from the 1961 and 1960 plantings caught in 1964 are shown below:

| Census period | 1961 planting (age IV) | | 1960 planting (age V) | |
|---|---|---|---|---|
| | Average | Range | Average | Range |
| February 11-April 11 (ice) | 16.8 | 11.5-21.8 | 19.7 | 14.1-23.6 |
| April 4-24 (open water) | 20.0 | 20.0-20.0 | - | - |
| April 25-July 3 | 17.3 | 12.0-23.3 | 20.3 | 15.1-24.9 |
| July 4-September 13 | 14.6 | 10.0-21.9 | 17.8 | 12.6-26.2 |
| September 14-October 5 | 17.1 | 10.5-21.7 | 19.9 | 16.5-24.6 |
| All combined | 16.4 | 10.0-23.3 | 19.8 | 12.6-26.2 |

The smallest fish were caught during July 4-September 13. During this period, lake trout were caught mostly outside L'Anse Bay, whereas those taken in other periods were caught in L'Anse Bay. It would appear, then, that there was some schooling by size group in Keweenaw Bay. However, since the size range was about the same in all periods (approximately 10 inches), such segregation was not clear-cut.

The average lengths of age-groups IV and V trout taken from Keweenaw Bay were compared with lengths of fish of the same age from other waters (Table 8). Age-group IV trout from Keweenaw Bay averaged 4.5 inches longer (and age-group V trout 5.9 inches longer) than wild trout of the same ages from southern Lake Superior. Among the populations listed, Keweenaw Bay trout grew faster than nine of them, about the same as three, and slower than three. The fast growth in Keweenaw Bay probably

Table 8.--Total length, in inches, of age IV and V lake trout from various localities

| Source of data | Locality | Age IV | Age V |
|---|---|---|---|
| Stauffer (1965) | Keweenaw Bay, Lake Superior | 16.4 | 19.8 |
| Rahrer[a] | South shore, Lake Superior | 12.0 | 14.0 |
| Rahrer (1965) | Isle Royale, Lake Superior | 8.5 | 10.4 |
| Cable (1956) | Northern Lake Michigan | 16.1 | 19.0 |
| Cable (1956) | Southern Lake Michigan | 15.3 | 18.4 |
| Van Oosten and Eschmeyer (1956) | Lake Michigan | 12.1 | 14.0 |
| Smith and Van Oosten (1940) | Lake Michigan | 19.8 | 22.2 |
| Fry (1953) | South Bay, Lake Huron | 17.8 | 20.3 |
| DeRoche and Bond (1957) | Cold Stream Pond, Maine | 15.1 | 17.0 |
| Cooper (1956) | Moosehead Lake, Maine | 14.6 | 16.1 |
| Cooper (1956) | Branch Pond, Maine | 15.4 | 18.1 |
| Webster, et al (1960) | Cayuga Lake, New York | 16.4 | 20.3 |
| Rawson (1961) | Lac La Ronge, Saskatchewan | 18.2 | 21.7 |
| Cuerrier (1954) | Lake Minnewanka, Alberta | 11.0 | 13.0 |
| Cuerrier (1954) | Lower Waterton Lake, Alberta | 19.0 | 21.0 |
| Cuerrier (1954) | Upper Waterton Lake, Alberta | 14.0 | 17.0 |

[a] Jerold F. Rahrer, U. S. Bur. Comm. Fish., Ashland, Wisconsin, personal communication, 1964.

was caused by an increase in the food supply associated with the decline in lake trout in preceding years.

In Keweenaw Bay in 1964, anglers caught lake trout at the rate of 0.09 fish or 0.16 pound per hour. Fishing quality was best during the April 25-July 3 period when the catch per angler hour by boat (0.17) was relatively high and the trout were relatively large (19.2 inches). Within this period, angling was best during the last half of May and in early June. In the July 4-September 13 period, the catch per angler hour by boat was nearly as good (0.11), but the fish averaged substantially smaller (15.6 inches). Boat fishing between September 14 and October 5 was the next best (0.08 trout per angler hour, 18.4-inch average), followed by ice fishing during February 11-April 11 (estimated catch per hour, 0.05; average length, 18.0 inches). The catch per hour of lake trout during April 4-24 was extremely low (0.01), probably because most of the fishing was done for rainbow trout.

Catch data for various lake trout sport fisheries are presented in Table 9. The Keweenaw Bay fishery ranks low in catch rate and intermediate in average size of fish caught, irrespective of the probable bias in censuses based on voluntary reports by anglers (such as those cited for Lake Superior and Cayuga Lake).

Rainbow trout. --The estimated number of rainbow trout caught in Keweenaw Bay in 1964 was 407 wild fish. They averaged 15.4 inches long, and all had spent at least one growing season in Lake Superior. The age composition of 62 trout scale sampled during April 19-June 14 was:

Table 9. --Catch rates and mean lengths of lake trout caught by anglers in various waters

| Source of data | Census method | Location | Year | Fish per hour | Average length (inches)[a] | Pounds per hour |
|---|---|---|---|---|---|---|
| Stauffer (1965) | Stratified sampling | Keweenaw Bay | 1964 | 0.09 | 18.1 | 0.16 |
| Crowe[b] | Voluntary reports | Western L. Superior | 1964 | 0.16 | 23.5 | 0.64 |
| Michigan biennial reports 1945-46 to 1949-50 | Voluntary reports | Lake Superior | 1945-49 | 0.16 | 27.0 | 0.96 |
| Schneberger[c] | Compulsory report | Apostle Islands, Lake Superior | Fiscal 1963-64 | 0.17 | 22.0 | 0.54 |
| DeRoche and Bond (1957) | Empirical data | Cold Stream Pond, Maine | 1952-53 | 0.05 | 18.2 | 0.08 |
| Rawson (1961) | Nearly complete | Lac La Ronge, Saskatchewan | 1950-60 | 0.28 | 28.0 | 2.05 |
| Webster (1958) | Cooperating anglers | Cayuga Lake, New York | 1952-57 | 0.34 | 23.0 | 1.26 |
| Schumacher (1961) | Complete | Clearwater L., Minnesota | 1954 | 0.17 | 14.8 | 0.14 |
| Schumacher (1961) | Complete | Mountain L., Minnesota | 1954 | 0.59 | 15.5 | 0.62 |
| Schumacher (1961) | Complete | West Pike L., Minnesota | 1954 | 0.38 | 15.8 | 0.40 |
| Schumacher (1961) | Complete | Trout Lake, Minnesota | 1953-60 | 0.27 | <13.1 | 0.17 |

[a] Lengths not originally given in tenths of inches were converted from a length-weight table (Eschmeyer, 1957).

[b] Walter R. Crowe, Mich. Dept. Cons., Lansing, Mich., personal communication, 1964.

[c] Edward Schneberger, Wis. Cons. Dept., Madison, Wis., personal communication, 1964.

age II, 45%; age III, 27%; age IV, 15%; age V, 10%; age VI, 3%. Age-II fish generally were immature, age-III were either immature or adult, and all older fish were adults. Generally, fish under 14.5 inches were immature and those over 16.9 inches were mature. Only 3% of the catch was lamprey scarred, indicating a low rate of predation.

Rainbow trout in Keweenaw Bay were caught at the rate of 0.02 per hour. Most of them were caught in the southeastern portion of L'Anse Bay near the Falls River during the spawning season (April-May). The best rate of catch (0.06 fish per hour) was achieved in April both by ice fishing and open-water angling. The greater success at this time resulted from the concentration of fish at the mouth of the Falls River just before and during the spawning season. Because of the concentration, anglers fished specifically for rainbow trout at this time. During the rest of the year rainbow trout were caught incidentally while seeking lake trout.

Coregonids. --The estimated number of coregonids caught was 202 fish. General observations indicated that lake herring averaged about 17.0 inches in length, round whitefish about 11.0 inches, and lake whitefish about 15.0 inches. Coregonids were caught at the rate of 0.01 per hour. Apparently, anglers caught them while fishing for trout, as the majority were taken on hardware lures or spawn bags. Lake herring were caught exclusively through the ice in L'Anse Bay, and whitefish were caught only during April and May, near the Falls River.

Brown trout. --The estimated number of brown trout caught in Keweenaw Bay in 1964 was 72 wild fish. The average length was 16.5 inches. The 20 fish scale sampled during April 19-June 14 had spent at

least one growing season in Lake Superior, and their age composition was: age II, 20%; age III, 55%; age IV, 20%; and age V, 5%. Maturity was not determined. Fourteen per cent of the catch was lamprey scarred.

Brown trout were caught at the rate of <0.01 per hour. Almost all of the brown trout were caught near the mouth of the Falls River during April and May.

## Discussion

It is difficult to assess the effect of angling on the recovery of lake trout in Lake Superior. Any substantial removal doubtless postpones their return to abundance, but it is extremely difficult to measure the magnitude of retardation. The data essential for evaluating the effect of exploitation are the total numbers of lake trout caught. To get some idea of the total angler catch of lake trout from United States waters of Lake Superior, information was solicited from several sources. For Michigan waters, information on angling was obtained from this census, district fisheries biologists,[6] reports of sport trollers,[7] and from the National Park Service at Isle Royale.[8] Information was also obtained from the permits required to fish for lake trout in the Minnesota[9] and Wisconsin[10] waters of Lake Superior.

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[6] Clifford Long, Escanaba, Mich.; Leland Anderson, Newberry, Mich.; and John Scott, Baraga, Mich. personal communications, 1964.

[7] Walter R. Crowe, Mich. Dept. Cons., Lansing, Mich., personal communication, 1964.

[8] John C. Raftery, Isle Royale Nat'l. Park, Houghton, Mich., personal communication, 1964.

[9] Hjalmer O. Swenson, Minn. Dept. Cons., St. Paul, Minn., personal communication, 1964.

[10] Edward Schneberger, Wis. Cons. Dept., Madison, Wis., personal communication, 1964.

In 1964, all the lake trout fisheries were located in the western half of Lake Superior. These areas and the number of lake trout reported caught in each were: Keweenaw Bay, 2,710; Isle Royale, unknown; Black River area (Gogebic County), 832; the Apostle Islands, 802; the Minnesota shore, 35. Some 2,000 of the people who visited Isle Royale National Park attempted lake trout angling, and an unknown number fished from boats that came from the mainland. Reports indicate that the angling is much better here than elsewhere in Lake Superior; daily catches of 50 lake trout per boat were made. Although the data from Isle Royale are scanty, they suggest that the angler catch was of sufficient magnitude that it could not be ignored in determining the 1964 angler catch from the United States waters of Lake Superior. The known catch of lake trout in Lake Superior was not less than 4,400. This catch equals about 10% of the United States assessment quota of 43,000. Even if the Isle Royale catch was as large as 5,000, the total U. S. catch did not exceed 10,000 fish, or 22% of the quota. It seems unlikely that the removal of less than 10,000 fish, which probably comprised a very small portion of the total population, would be harmful. The continued recent improvement of lake trout stocks[11] suggests also that angling has not seriously affected the recovery of the population.

I recommend that lake trout in the portion of Keweenaw Bay which lies south of Assinins be managed for sport fishing. To maintain or improve the quality of angling, I suggest: (1) continued planting of

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[11] Great Lakes Fishery Commission, Report of Annual Meeting, June 17-18, 1964.

hatchery-reared trout; (2) no restriction on tackle or on catch and size limits; (3) no commercial fishing for lake trout south of Assinins.

Since 99% of the 1964 catch was of hatchery origin, it appears necessary that lake trout be planted to maintain the fishery and hasten the reestablishment of natural stock. This program should continue until the catch consists largely of wild fish. Restrictions on tackle, size limit, and daily catch are not recommended because they could drastically reduce the rate of catch. Since the catch per hour in 1964 was rather low, restrictions might well decrease it to a point where the fishery would no longer attract anglers. Limiting the fishing in this area of the bay to angling only is required to maintain the stock of lake trout at a high level which will provide satisfactory angling quality.

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