Dispersal of Lake Trout Fry from an Artificial Spawning Reef in Lake Superior

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DISPERSAL OF LAKE TROUT FRY FROM AN ARTIFICIAL SPAWNING REEF IN LAKE SUPERIOR[1]

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Abstract

Dispersal of lake trout fry from a spawning area in Presque Isle Harbor during May-July 1976 was determined from weekly sampling with a 5-m otter trawl. The eight sampling stations were located 0-3000 m from the spawning area at depths of 2-36 m. Most fry were caught on sand and rock bottom at depths of 2-12 m and water temperatures of 6-15 C. Many lake trout fry remained in Presque Isle Harbor until the end of July. They did not migrate immediately to deep water as has been reported by other scientists. Abundance was greatest at stations within 500 m of the spawning area until mid-June then shifted to stations 900-3000 m away but at depths comparable to the spawning area. Average total length of fry increased from 26 mm to 36 mm (4 May-12 July) at stations on and near the spawning area and from 26 mm to 45 mm (17 May-26 July) at stations 900-3000 m away. Water temperatures in excess of 15 C, random dispersal, and a preference for deep water 12 weeks after hatching were judged to be responsible for dispersal of lake trout from Presque Isle Harbor, with the latter factor appearing to be most responsible. Sampling for fry to assess success of natural reproduction would be most easily done on and near the spawning area during May-July.

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[1]Contribution from Dingell-Johnson Project F-35-R, Michigan.

Introduction

The lake trout (Salvelinus namaycush) is an important sport and commercial fish in the Upper Great Lakes. Lake trout stocks in these waters were severely depleted by excessive commercial fishing and sea lamprey (Petromyzon marinus) predation during the 1940's and 1950's, but by the 1970's, stocks had been restored in lakes Superior and Michigan through massive annual plantings of yearling hatchery trout, sea lamprey control, and restrictions on sport and commercial fisheries (Pycha and King 1975, Rybicki and Keller 1978). However, natural reproduction by planted lake trout has ranged from nonexistent to mediocre. Information on habits and habitat of lake trout fry is needed to assess the reasons for poor reproduction.

Eschmeyer (1956) conducted the only study of lake trout fry in the Great Lakes prior to extinction or near extinction of native stocks. He found fry abundant in Lake Superior on sand bottom 20-73 m deep near an extensive rocky area where lake trout spawned. It was not known whether fry were more or less abundant on the rocky area because the collecting gear (trawls) was restricted to smooth bottom. Eschmeyer concluded that fry were most abundant at depths less than 36 m during summer but moved to deeper water after the equinoctial storms of fall. Lake trout fry have not been studied extensively in other waters because of cryptic habits and an affinity for deep water. Fry reportedly remain in rock crevices of the spawning reef until absorption of the yolk sac, then move immediately to deeper water (Royce 1951, Martin 1957, Eschmeyer 1964, DeRoche 1969).

I studied lake trout fry in Presque Isle Harbor, Lake Superior, in 1976. The objectives were to determine (1) how long lake trout fry remained on the principal spawning area, (2) their habitat after leaving the spawning area, and (3) the factors associated with movement of fry from the spawning area and harbor.

Study area

Presque Isle Harbor is on the south shore of Lake Superior at Marquette, Michigan (46° 31'N latitude and 87° 24'W longitude). The harbor is used for fishing, swimming, recreational boating, commercial shipping (iron ore, coal, and petroleum) and intake and discharge of cooling water for a fossil-fuel electrical generating plant. Maximum water depth is about 15 m. The substrate is mostly sand with some bedrock and boulders in undisturbed portions of the harbor (Hatch 1976). The substrate is silt covered sand in the commercial boat slips and turning basin which are routinely dredged. Cobble and boulder size granite quarry rock cover the power plant water intake and discharge pipes that were installed in 1974.

The rock substrate covering the power plant intake and discharge pipes was the principal lake trout spawning area in Presque Isle Harbor in the fall of 1975. Stauffer (unpublished data, Marquette Fisheries Research Station) observed that lake trout were much more abundant on the intake pipe than at four other known or suspected spawning areas during 29 October-7 November 1975. All of the 1975 spawners sampled were of hatchery origin. Hatch (1976) made scuba explorations of suspected spawning areas on 7 November 1975, and found lake trout and eggs only on the intake. Lake trout eggs and newly hatched fry were pumped from the substrate on the intake and discharge pipes in April 1976 (Stauffer 1980).

Materials and methods

I established seven sampling stations (1-7) in Presque Isle Harbor at depths of 2-12 m and one deeper station (8) just outside the harbor in 24-36 m (Fig. 1, Table 1). Since rubble covering the intake and discharge pipes was presumed to be the principal spawning area, Station 1 was set up to sample across these pipes and the remaining stations in the harbor were located at increasing distances from the spawning area. Stations 1-4 were within 500 m of the spawning area and stations 5-7 were 900-3000 m from the spawning area. Station 8, the deep-water station, was 2500 m from the

principal spawning area. Substrate at the sampling stations was either sand, sand and silt-sand, sand and rock, or silt-sand and rock. The rock at stations 1, 3, and 4 was described by scuba divers as cobbles and boulders of relatively uniform size.

Most sampling for lake trout fry was done with a 5-m, four-seam nylon try trawl; minnow traps and emergent fry traps provided supplemental information (Stauffer 1980). Trawl stations usually were sampled once each week during May-August 1976. Trawling was done on the bottom at night (2230-0100 hours). Each trawl sample consisted of two consecutive 5-minute tows at each station. Trawling speed was about 8 km per hour so each sample covered 1300 m. The trawling warp was about four times the maximum depth at each station. A bottom water temperature was taken at the time of sampling. Strings of 15-25 minnow traps were fished overnight on the intake pipe on 10 different dates during 13 May-22 July 1976. A bottom water temperature was taken at each lift. Two to three emergent fry traps were fished on the offshore end of the intake pipe during 19 May-26 July 1976. These traps were examined at intervals of 4 to 29 days.

Lake trout fry in the samples were preserved immediately in 10% formalin for later counts and measurement of total length (mm).

Results

Lake trout fry were captured in Presque Isle Harbor during 6 May-27 July 1976 (Table 2). Average number of fry caught per trawl sample for stations 1-4 increased to 9.5 on 1-3 June mainly due to increases at stations 1 and 2 which were nearest the principal spawning area. The catch at stations 1-4 then declined to practically nil after 22-23 June. The average catch for stations 5-7 peaked at 13 on 12-13 July due mainly to an increased catch at Station 6. Only four fry were caught at Station 8. More fry were caught at stations 1-4 in May-June than in June-July, while at stations 5-7, more were captured in June-July than in May-June (Table 2).

Although identical for the first three weekly sampling periods, average length of fry from stations near the spawning area (1-4) was

significantly less ($t = 3.97$, $p < 0.01$) than length of fry from the more distant stations (5-7) for nine weekly sampling periods from 17-18 May to 12-13 July (Table 3). The average length of lake trout fry increased from 25 mm on 10-11 May to 36 mm by 12-13 July at trawl stations 1-4. At stations 5-7, average length of fry increased from 26 mm in May to 45 mm by 26-27 July. The four lake trout fry captured at Station 8 were 30-49 mm.

Emerging lake trout fry were captured on the principal spawning area in minnow traps during 21 May-11 June and in emergent fry traps during 19 May-21 June (Table 4). Fry captured during the peak emergence period, which occurred between 19 May and 17 June, were 26 to 27 mm in length with a range of 24-30 mm (Table 4). Fry emergence apparently continued through June as some 26- to 27-mm fry were taken at trawl stations until the end of the month.

Bottom temperatures increased irregularly from 4 to 18 C in Presque Isle Harbor during May-August 1976 (Table 3). Water temperature on the principal spawning area was 6-10 C during 13 May-11 June when fry were captured in minnow traps. Water temperature was 7 C during 24 May-3 June when fry were most abundant at trawl stations 1-4 and 6-15 C during 14-21 July when they were most abundant at stations 5-7. Temperatures were 16-18 C at all stations during August.

Discussion

Lake trout fry resided in Presque Isle Harbor from May through July in 1976. Initial fry abundance was greatest on and near the principal spawning area where some remained until 12-13 July and grew to an average length of 36 mm. However, many fry dispersed to other parts of the harbor soon after emergence. This was indicated by a similarity in average size of fry from stations near the spawning area (1-4) and those farther away (5-7) during the peak emergence period. Lake trout fry that dispersed to other parts of the harbor were most abundant at Station 6 which had a smooth sand bottom and was 2-8 m deep. I do not know why fry were more abundant at this station than at other smooth bottom stations (5 and 7), but they may have

been attracted by currents or a concentration of food organisms. Lake trout fry remained at stations 5-7 until 26-27 July and grew to an average length of 45 mm. The small catch of fry at Station 8 suggests that few fry migrated to deep water immediately after emergence. The two fry taken at Station 8 in early July were 30-31 mm long which is somewhat larger than the 26-27 mm average size I recorded for emerging fry.

I conclude that increasing water temperature, random dispersal, and an increased preference for deep water as fry grew older all could be involved in the eventual movement of lake trout fry out of the harbor. McCauley and Tait (1970), in a laboratory study, found that yearling lake trout preferred a temperature of 11.7 C and avoided water 15 C and higher. They further stated that their results were in agreement with field observations from other studies that lake trout move out of shallow water in spring when surface temperatures reach 12-15 C. The findings of McCauley and Tait (1970) for yearlings generally correspond with mine for lake trout fry in Presque Isle Harbor. Fry were abundant in the harbor in May-July when water temperatures generally averaged less than 15 C.

Lake trout fry in Presque Isle Harbor did not exhibit the immediate preference for deep water as reported or implied in most other studies. DeRoche (1969), studying lake trout in a Maine inland lake, concluded that lake trout leave the spawning beds soon after absorption of the yolk sac and move rapidly into deep water. He reported that fry were no longer present on the spawning beds after 4 May. Royce (1951) and Martin (1957) also indicated that fry left the spawning beds before the end of May. Eschmeyer (1964) indicated that young lake trout leave the spawning reef for deeper water about one month after hatching. Lake trout fry in Presque Isle Harbor were present on the principal spawning area until near the end of June and many fry that dispersed to other parts of the harbor were found at depths no deeper than the spawning area. In fact, fry were least abundant at the deepest trawl stations (4 and 8).

The behavior of fry in Presque Isle Harbor more closely resembles the behavior of fry in a laboratory study (Stauffer 1978). Stauffer observed that lake trout fry dispersed randomly from the hatching site and did not

exhibit a preference for deep water until after they were 12 weeks old. In Presque Isle Harbor, lake trout fry were captured at all trawl stations indicating a widespread, if not random, dispersal from the spawning area. Lake trout eggs in Presque Isle Harbor began hatching in mid-April (Table 2, Stauffer 1980) so departure of fry from the harbor during late July would be about 12 weeks after hatch and this corresponds to the observations of Stauffer.

This study shows that many lake trout fry resided on and near the spawning area in Presque Isle Harbor and at shallow depths for 1-2 months after emergence. Wagner (1980) also caught many lake trout fry during May and June in 2-6 m of water in Grand Traverse Bay, Lake Michigan, where hatchery lake trout had spawned. Sampling for fry to determine success of lake trout reproduction should be done on and near the spawning reefs from time of emergence in May through mid-July when fry are most abundant.

Acknowledgments

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Table 1.--Characteristics of 5-m otter trawl stations in or near Presque Isle Harbor, Lake Superior, sampled during May-August 1976.

Station number	Location [a]	Depth (m)	Bottom type
1	0	2-8	sand, rock
2	200	2-12	sand, silt-sand
3	400	3-12	silt-sand, rock
4	500	9-12	silt-sand, rock
5	900	3-5	sand
6	2000	2-8	sand
7	3000	2-9	sand
8	2500	24-36	silt-sand, rock

[a] Distance in meters from principal spawning area (power plant intake and discharge pipes) to center of trawl station.

Table 2.--Number of lake trout caught in 1300-m tows of a 5-m otter trawl in or near Presque Isle Harbor, Lake Superior, May-August 1976.

Dates of collection	Distance (meters) from principal spawning area and station number									
	0-500					900-3000				2500
	1	2	3	4	Average	5	6	7	Average	8
May										
4-6	0			1	0.5	0			0.0	
10-11	0	1	0	0	0.2	0			0.0	
17-18	1	2	2	0	1.2	1	0	0	0.3	0
24-25	15	13	1	3	8.0	1	1	2	1.3	0
June										
1-3	18	10	7	3	9.5	3	3	1	2.3	0
7-8	10	5	1	1	4.2	0	3	0	1.0	0
14-15	6	3	1	2	3.0	4	9	1	4.7	0
22-23	2	4	2	1	2.2	1	10	4	5.0	0
28-30	1	0	1	0	0.5	4	18	6	9.3	0
July										
6-7	1	1	1	0	0.8	0	15	2	5.7	1
12-13	0	1	1	3	1.2	9	27	3	13.0	1
20-21	0	0		0	0.0	3	13	2	6.0	0
26-27	0	0			0.0	0	3	2	1.7	0
August										
2-3		0			0.0	0	0	0	0.0	2
9-10						0	0	0	0.0	0
30-31						0	0	0	0.0	0
Total	54	40	17	14		26	102	23		4

Table 3.--Water temperature and average total length (± 95% confidence limits) of lake trout fry from 5-m otter trawl stations in Presque Isle Harbor, Lake Superior, May-August 1976.

Dates of collection	Average water temperature (C)			Average total length (mm) of fry[a]		
	Stations			Stations		
	1-4	5-7	8	1-4	5-7	8
May						
4-6	4	4		26		
10-11	5	6		25		
17-18	5	6	4	26 ± 0.6	26	
24-26	7	8	5	26 ± 0.4	26 ± 1.8	
June						
1-3	7	8	5	27 ± 0.8	27 ± 0.9	
7-9	7	8	5	27 ± 0.6	29 ± 6.2	
14-15	6	6	6	27 ± 1.1	30 ± 0.8	
22-23	9	10	8	29 ± 1.7	30 ± 1.2	
28-30	10	11	8	30 ± 6.4	32 ± 1.1	
July						
6-7	13	15	12	34 ± 6.6	35 ± 1.7	31
12-13	13	13	12	36 ± 4.4	39 ± 0.9	30
20-21	14	14	13		42 ± 1.4	
26-27	10	12	9		45 ± 6.3	
August						
2-3	17	18	17			44 ± 63.6
9-10		18	16			
30-31		16	16			

[a] Sample size as in Table 2.

Table 4.--Catch and length of lake trout fry in minnow traps and emergent fry traps on the principal spawning area in Presque Isle Harbor, Lake Superior, during May-July 1976.

Gear and date of lift	Lake trout fry		Total length (mm)	
	Number captured	Number per trap-day	Average ± 95%	Range
Minnow trap				
13 May	0	0.0		
21 May	3	0.1	27 ± 1.1	26-27
28 May	5	0.2	26 ± 1.0	25-27
4 June	3	0.1	27 ± 1.8	26-28
11 June	7	0.3	27 ± 1.0	25-28
19 June	0	0.0		
25 June	0	0.0		
1 July	0	0.0		
7 July	0	0.0		
22 July	0	0.0		
Emergent fry trap				
17 June	106	1.2	27 ± 0.2	24-30
21 June	4	0.5	26 ± 4.3	25-27
6 July	0	0.0		
20 July	0	0.0		
26 July	0	0.0		

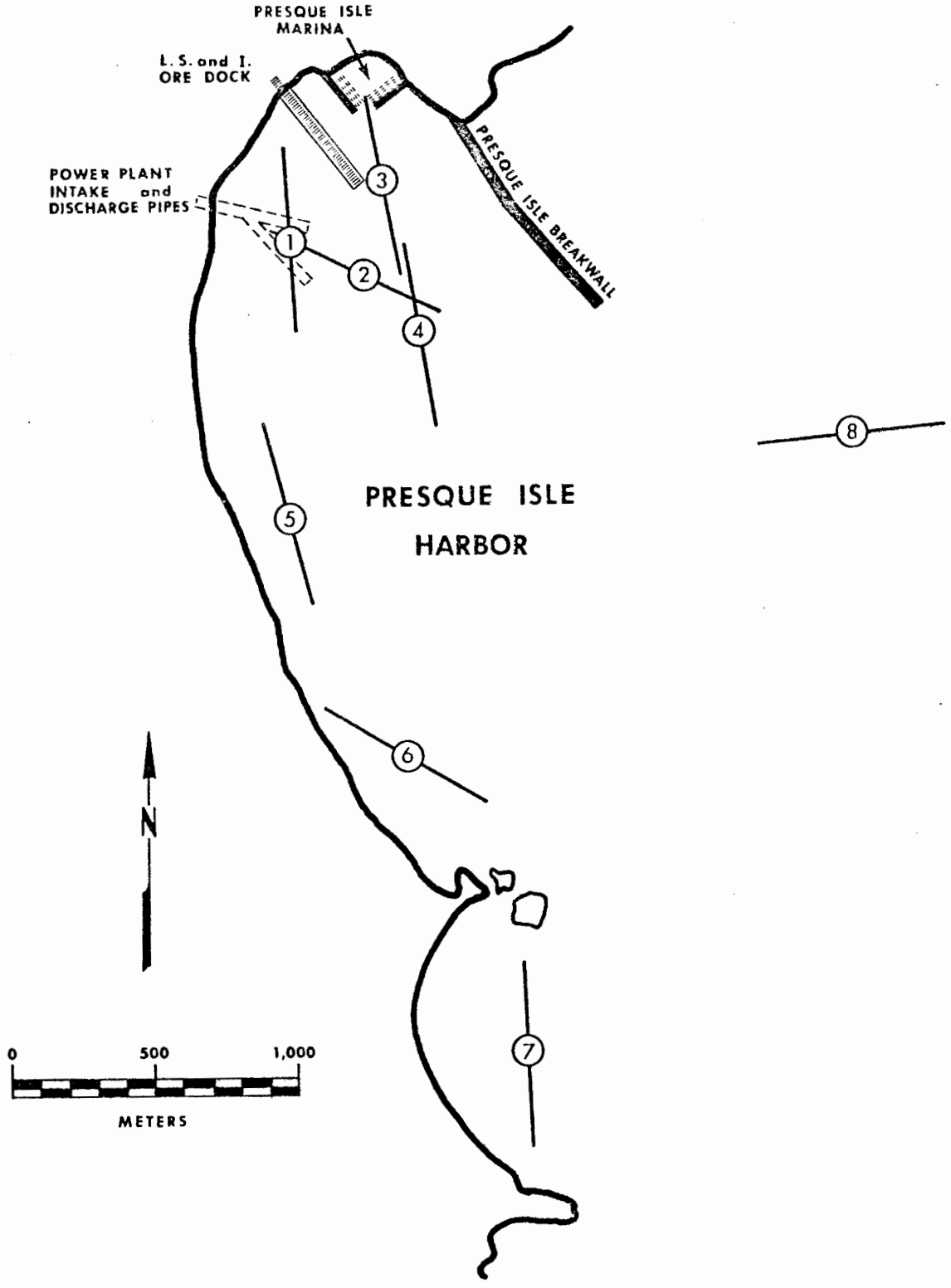

Figure 1.--Location of 5-m otter trawl stations (1-8) sampled during May-August 1976 in Presque Isle Harbor, Lake Superior.

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