Inexpensive Method for Quantitative Assessment of Lake Trout Egg Deposition

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Abstract.—Little evidence exists for extensive natural reproduction by lake trout Salvelinus namaycush stocked in the Great Lakes, except in Lake Superior. An obstacle to the systematic study of the fate of eggs produced by stocked fish has been the inability to inexpensively detect egg deposition and to measure egg deposition rates. We have developed a low-cost (US$7.00 per egg net), reusable egg-collection device (egg net) that can be set and recovered from shipboard. Egg nets placed on spawning substrate prior to spawning collect eggs passively and protect the eggs until their retrieval. The nets were tested on a shallow reef in Lake Ontario and on a deep reef in Lake Michigan. In Lake Ontario, 24 nets captured 261 eggs (336 eggs/m²) from October 13 to November 13, 1987, and 23 nets captured 1,830 eggs (2,455 eggs/m²) from November 13 to November 24, 1987. Over 50% of the eggs recovered were alive. Storms overturned some nets at the shallow-water site. No eggs were recovered in Lake Michigan, but inspection by a remotely operated video camera confirmed that 90% of the nets were upright 19 d after placement. With appropriate modifications for eggs of other sizes, the egg nets may also be useful for assessment of spawning by other species of fish.

During the 1940s and 1950s, lake trout Salvelinus namaycush disappeared from all of the Laurentian Great Lakes except Lake Superior. Stocking has established large populations of adult fish, and natural reproduction by stocked fish has been noted in all of the Great Lakes except Lake Erie (Jude et al. 1981; Nester and Poe 1984; Peck 1986; Marsden et al. 1988). However, substantial lake trout reproduction has occurred only in Lake Superior.

Many hypotheses have been advanced to explain the limited reproduction by stocked lake trout (Eshenroder et al. 1984). Most of these hypotheses have not been adequately tested, in part because widely acceptable methods have been lacking for inexpensively collecting eggs where they are spawned before possible predation by predators. Lake trout, unlike other salmonids, do not build a redd. Eggs are released within half a meter of the substrate and passively settle into the substrate (Martin and Olver 1980). Dorr et al. (1981) used diver-assisted pumps to recover lake trout eggs in southeastern Lake Michigan, but this method of egg recovery has two shortcomings: it is feasible only in shallow water, and it allows recovery of only those eggs that have survived predation. Stauffer (1981) collected spawned eggs on an artificial spawning reef in Marquette Harbor, Lake Superior, by burying rock-filled pails in the substrate. Eggs that settled into the pails were recovered by bringing the pails to the surface. This method requires extensive use of scuba and is therefore expensive on a large scale and is not feasible in deep water.

This paper describes a low-cost technique for the passive capture of demersally spawned eggs during spawning. Results are presented of field tests of this technique on lake trout spawning reefs in Lakes Ontario and Michigan.

Study Sites

We conducted field tests of egg nets on Julian’s Reef in Lake Michigan in 1985–1987 and near Stony Island in Lake Ontario in 1987 (Figures 1, 2). Julian’s Reef (Figure 1) is a bedrock prominence that rises to a minimum depth of 29 m (1983 sounding) 23 km east of the Illinois shoreline on Lake Michigan. Before 1945, gravid lake trout were captured over Julian’s Reef during several spawning seasons (Coberly and Horrall 1982); thus, native lake trout probably used the area for spawning. Since 1981, over one million yearling lake trout have been stocked directly over Julian’s Reef. Spawning assessments with gill nets have shown that some of those fish, as well as fish stocked earlier in other areas, have reached sexual maturity and aggregated in the immediate vicinity of Julian’s Reef during past spawning seasons. In
FIGURE 1.—Study site at Julian's Reef, Lake Michigan (adapted from Holm et al. 1987) and transect locations of egg nets deployed for the capture of lake trout eggs during 1985–1987. Depths are in meters. Loran C reference lines are shown.
FIGURE 2.—Study site at Stony Island Reef, Lake Ontario (based on a survey by P. Sly, Canada Centre for Inland Waters) and transect locations of egg nets deployed for the capture of lake trout eggs during 1987. Depths are in meters. Loran C reference lines are shown.
COLLECTION DEVICE FOR LAKE TROUT EGGS

1986, the viability of gametes produced by fish captured near Julian's Reef was confirmed by successful in vitro fertilization (R. Hess, Illinois Department of Conservation, personal communication).

Stony Island Reef in Lake Ontario is a flat plateau 4–5 m in depth that lies near the northeastern end of Stony Island, Lake Ontario (Figure 2). Records from the Cape Vincent Fisheries Station (New York) suggest that this area was a spawning site for native lake trout (C. P. Schneider, New York Department of Environmental Conservation, personal communication). No fish have been stocked directly over this site, although extensive stockings of yearlings have been made within several kilometers (Schneider, personal communication). Fall gillnetting in this area has yielded catch rates of mature lake trout two to three times higher than those recorded from assessments over Julian's Reef in Lake Michigan. However, gill-net mesh sizes used were different between the two sites so that the lake trout catches cannot be compared directly between the two sites. Spawning in the study area near Stony Island was confirmed in 1986 when 75 lake trout fry were captured with emergent fry traps (Marsden et al. 1988).

Methods

Egg net design.—Egg nets were designed to passively collect spawned eggs and to protect the eggs until retrieval (Figures 3, 4). We tested these egg nets in Lake Michigan in 1985–1987, and in Lake Ontario in 1987. Each egg net had a collection surface of 324 cm$^2$ and consisted of a 20.3-cm-diameter rigid cylindrical polyvinyl chloride (PVC) collar covered by a rigid screen. A nylon net with approximately 150 g of lead tied into the bottom was suspended from the PVC rim. The lead weights held the egg nets upright during placement and retrieval. Eggs were retained during recovery in the nylon nets, which collapsed under egg nets that landed upright and allowed the collars to lie flat. The rigid screen allowed the passage of eggs and also protected eggs from predators. Egg nets were rigged for deployment and recovery from shipboard by tying the nets at intervals of 1–3 m to a...
single connecting line (Figure 4). Nets were deployed in gangs of 25 (Lake Ontario) or more (Lake Michigan) nets per line. Both ends of each gang were anchored and marked with buoys. During placement, one anchor was attached to a buoy and to one end of a gang line and lowered from the boat. As the boat moved away from the buoy, the net gang was paid out, and the nets were carried in sequence to the bottom. Tension on the line was just sufficient to keep the line of egg nets straight. The trailing end of the net gang was tied to a second anchor, which was also marked at the surface by a buoy.

Egg-net construction materials differed slightly between lakes. In Lake Ontario, the nylon netting was dyed brown, and the rigid screen was galvanized wire cloth with 5-mm-square meshes, whereas in Lake Michigan, the nylon netting was white, and the rigid screen was translucent white polypropylene mesh with 6-mm-square meshes. In Lake Ontario, removal of eggs from the nets and reclosing of the nets were facilitated by the addition of a drawstring at the bottom of the nylon mesh cone. This drawstring was also used to fasten the lead weight at the bottom of the net. Before 1987, minor variations in construction materials were tried in Lake Michigan. The rigid screen was made of galvanized wire cloth with mesh sizes of 8 or 12 mm in 1985 and 1986. In 1985, the PVC collars were 4 and 8 cm high; in 1987, collars used at both sites were 4 cm high. In 1986, the rigid screens of some egg nets were coated with Jennite, a black driveway sealer. Egg nets were constructed for under US$7.00 per net, which included the costs of all buoys, buoy lines, anchors, and connecting lines.

**Egg collections.**—Egg nets were placed on Julian’s Reef prior to the spawning seasons in 1985–1987 (Table 1). The nets were recovered each year when gillnetting by the Illinois Department of Conservation indicated that the spawning season was over. During those 3 years, 1,890 egg nets were deployed, and 1,470 were recovered with a commercial fishing boat (Table 1; Figure 1). Placement of egg nets in 1985 was guided only by a topographic map of the reef; no information was available about the substrate. Egg-net placement in 1986 and 1987 was guided by maps developed from side-scan sonar and video camera reconnaissance of the reef. In each year, the locations of net placement was specified in advance and placement was guided by loran C navigation. Eight egg nets were examined by divers 23 d after placement in 1986, and 100 egg nets were examined by remotely operated video camera 19 d after placement in 1987.

Fifty egg nets were placed on Stony Island Reef in 1987 at a depth of 5 m along the edge of a plateau (Figure 2). The substrate was composed of large cobble, 14–45 cm in diameter. From previous captures of fry and scuba surveys, this area was believed to be the best spawning substrate in the immediate area (Marsden et al. 1988). Two gangs of 25 nets each were placed on the reef. The first gang was set on October 13, and 24 nets were recovered on November 13. The second line was set on November 13, and 23 nets were recovered on November 24 (Table 1). Net placement and recovery was done from a small open boat and was guided by diver-placed buoys that marked the target area. Divers also confirmed placement of the egg nets over the desired substrate, examined the egg nets frequently during the time they were in the lake, and righted any that were overturned.

**Results**

The 24 nets recovered from Lake Ontario on November 13, 1987, collected 261 lake trout eggs (mean = 10.9 eggs/net, maximum = 71 eggs/net, number of empty nets = 7). The 23 nets recovered on November 24, 1987, collected 1,830 lake trout eggs (mean = 79.6 eggs/net, maximum = 333 eggs/net, number of empty nets = 1). No eggs were collected by the 1,470 egg nets recovered from Lake Michigan in 1985–1987.

At the Lake Ontario site, divers found that 22 of the 25 nets deployed on October 13 landed upright; the number landing upright on November 13 is not known. After storms, some nets were upside down. Divers righted upside-down nets during periodic dives, but we do not know the number of nets fishing on any day nor the number

<table>
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<th>Year</th>
<th>Deployed</th>
<th>Recovered</th>
<th>Number of eggs captured</th>
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<tr>
<td>Julian’s Reef</td>
<td>1985</td>
<td>728 (Oct 18-22)</td>
<td>510 (Nov 18)</td>
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<tr>
<td>1986</td>
<td>280 (Oct 14)</td>
<td>68 (Dec 5)</td>
<td>0</td>
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<tr>
<td>1987</td>
<td>900 (Oct 15-16)</td>
<td>892 (Dec 2)</td>
<td>0</td>
</tr>
<tr>
<td>Stony Island Reef</td>
<td>1987</td>
<td>25 (Oct 13)</td>
<td>24 (Nov 13)</td>
</tr>
<tr>
<td>25 (Nov 13)</td>
<td>23 (Nov 24)</td>
<td>1,830</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 1.—Harvests of lake trout eggs in nets deployed on Julian’s Reef, Lake Michigan, and Stony Island Reef, Lake Ontario, 1985–1987.**

**TABLE 1.—Harvests of lake trout eggs in nets deployed on Julian’s Reef, Lake Michigan, and Stony Island Reef, Lake Ontario, 1985–1987.**
of days fished by each net. Of the eight egg nets examined by divers 23 d after placement in Lake Michigan in 1986, all were upright. In 1987, 90 or 100 egg nets were upright when examined by video camera 19 d after placement.

Divers at Stony Island observed several eggs resting on the rigid screen tops of the egg nets. Many of these eggs fell through the mesh into the nets when the nets were jostled slightly; however, several nets had eggs wedged in the rigid screen when the nets were brought to the surface.

Discussion

The egg nets described in this paper are effective for capturing demersally spawned eggs during egg deposition. Although the egg nets used in Lake Ontario excluded a few eggs that could not pass through the rigid screen (mesh, 5 mm), the egg capture rates at Stony Island were comparable to or higher than those documented elsewhere. Our capture rates (averaged over all egg nets) were 336 eggs/m² from October 13 through November 13 and 2,455 eggs/m² from November 13 through November 24. The maximum density of eggs in a single trap were equivalent to 10,278 eggs/m². Peck (1986) used submerged rock-filled pails in Lake Superior and captured lake trout eggs at rates (averaged over all pails) of 553 eggs/m² in 1977, 130 eggs/m² in 1978, and 244 eggs/m² in 1979. Martin and Olver (1980) cited similar deposition rates in Ontario lakes. Peck (1978) also reported egg densities as high as 13,400 eggs/m². However, these studies assessed egg deposition over an entire spawning season. In contrast, our egg-net captures reflect egg deposition rates over shorter segments of the spawning season (a 30-d and an 11-d period in Lake Ontario in 1987).

Over 50% of the eggs captured in egg nets in Lake Ontario were alive and were raised to the fry stage in a hatchery. Some of the eggs probably died during handling or while the nets were in the lake because some of the eggs were crushed. Thus, the egg nets can be used to collect eggs for examination of fertilization rates, genetic analysis, or other studies.

We will not know if capture rates with egg nets accurately reflect spawning densities until it is shown that the egg nets are neither favored nor avoided by spawning fish, that all eggs spawned over the nets are captured, and that no eggs are lost during retrieval. In addition, because nets placed at a depth of 5 m near Stony Island were overturned during storms, we need to know the amount of time nets spend upside down. Various devices could be attached to each net that would measure the time spent right side up or upside down. Alternatively, the net rims could be made of heavier material than PVC so they would resist overturning.

Loss of captured eggs prior to retrieval is probably negligible. Similarly sheltered eggs suffered negligible mortality in short-term predation experiments in Trout Lake, Wisconsin, whereas 100% of unsheltered eggs disappeared (Horns and Magnuson 1981). In those experiments, eggs that died of causes other than predation were retained in the enclosures. This suggests that the egg nets will retain dead eggs as well as live ones.

Well over half of the egg nets land upright when properly deployed. In trial deployments in Lake Ontario, the percentage of nets landing upside down ranged from 12 to 60%. In separate trial deployments of 72 traps at a 6-m depth in Trout Lake, Wisconsin, more than 90% landed upright. Excessive tension on the line as the nets are lowered may increase the number failing to land properly in shallow water. In Lake Michigan, where nets were at depths of 29–45 m, we found that 90% of the nets examined were upright after 19 d in the lake. At this site, tension on the line was high during deployment of the nets. The 10% of nets that were upsidedown may have landed that way or may have been overturned later.

Failure to collect eggs on Julian's Reef in Lake Michigan despite the presence of spawners on the reef may simply reflect low rates of egg deposition but may also reflect highly localized spawning or net avoidance. Egg nets were set over most types of substrate available on Julian's Reef (Figure 1), but the possibility remains that areas selected by spawning lake trout were missed. Results from Lake Ontario (J. E. Marsden and C. C. Krueger, unpublished data) suggest that lake trout egg deposition is nonrandom with respect to substrate. The area of the Stony Island study site on which eggs were caught and where fry have been found in previous years (Marsden et al. 1988) is small (<1,500 m²), and constitutes less than 10% of the reef area. Intersite differences in egg-net construction could have caused the observed differences in catch rates between the two sites. In particular, differences in color may have been important, although the importance of color should not be great for these nocturnal spawners (Martin and Olver 1980) at the depth of Julian's Reef.

Because egg nets are inexpensive, simple to con-
struct, durable, and reusable, they are an economical method of routinely assessing egg deposition. With appropriate modification for eggs of other sizes, they may also be useful for collecting eggs and assessing spawning by other species of demersally spawning fish.

**Acknowledgments**

This work was conducted by the Illinois Natural History Survey, Illinois Department of Conservation (IDOC) and Cornell University. Funding was supplied, in part, by the Great Lakes Fishery Commission and Federal Aid in Sport Fish Restoration program (Project F-64-R). The assistance and encouragement of Richard Hess of the IDOC was essential in this work. Work in Lake Michigan was made possible through the assistance of Burt Atkinson and his commercial fishing vessel, Clifford J. The egg nets were invented by Nancy Horns. We thank Peter Grewe and the many individuals who assisted with equipment preparation, field work, and diving in Lakes Michigan and Ontario. We thank Richard Hess, Fred Binkowski, James Peck, Ross Horrall, Leon Carl, and David Jude for providing helpful suggestions on earlier versions of this manuscript.

**References**


