An Improved Trap for Passive Capture of Demersal Eggs during Spawning: An Efficiency Comparison with Egg Nets

J. ELLEN MARSDEN AND CHARLES C. KRUEGER
Department of Natural Resources, College of Agriculture and Life Sciences
Fernow Hall, Cornell University, Ithaca, New York 14853, USA

HARRY M. HAWKINS
Center for Innovative Technology Transfer
209 Park Hall, SUNY College at Oswego, Oswego, New York 13126, USA

Abstract.—Assessment of spawning activity in deep water would be facilitated by egg collection devices that could be deployed and retrieved from the surface, were resistant to severe weather conditions, and protected eggs after capture. The egg trap described herein fulfills these criteria. Moreover, eggs are easily removed from the trap after retrieval, and the trap can be manufactured inexpensively in large quantities (US$8 per trap). Laboratory tests indicated the trap excluded more eggs than did previously described egg nets but retained eggs more effectively after capture. In field trials of paired nets and traps during natural spawning, the traps captured almost three times more eggs than the nets (P < 0.05) and damaged a smaller percentage of the eggs.

Fisheries managers often require information on where fish are spawning, which fish are spawning, and the extent of reproductive success to make effective decisions. For species that spawn in shallow inshore waters or in streams, spawning activity often can be assessed by means of observations from the surface or by collecting eggs with hand-operated devices such as suction samplers. However, information on reproductive activity of deepwater lake-spawning species is more difficult to obtain. For example, gillnetting near traditional spawning reefs is used to assess spawning activity of stocked lake trout Salvelinus namaycush. The capture of ripe and spent females is used to infer that spawning has taken place at the reef. Although gillnetting provides important information about spawning aggregations of fish, it does not provide evidence that spawning has occurred. In addition, gillnetting data do not yield estimates of the density of egg deposition, the viability of spawned eggs, the strains of fish that successfully mated, or the specificity of spawning with respect to substrate type.

Confirmation of spawning activity is best accomplished by observing or collecting spawned eggs. An ideal egg collector would be (1) easy to deploy and retrieve, (2) easy to process, (3) unimpaired by severe weather, (4) protective of eggs after capture, (5) not avoided by spawning fish, (6) durable, and (7) inexpensive. Low cost is particularly important in the Great Lakes, where reefs encompassing several square kilometers require deployment of large numbers of egg collectors. Most techniques used to assess spawning have involved equipment operated or placed by divers, such as egg collection pails buried in the substrate (Stauffer 1981), various suction samplers and pumping devices (e.g., Dorr et al. 1981; Stauffer 1981), and corers and grabs (Viljanen 1980 and references therein). However, use of divers is expensive, time-consuming, and generally restricted to shallow water (<25 m) and calm weather. Horns et al. (1989) recently described egg nets for capturing demersally spawned eggs. These nets are simple and inexpensive to build, and they can be deployed and retrieved from the surface. However, when the nets are used in shallow (<10 m), unprotected water, they can be damaged or turned upside down by currents and storm surge. In addition, netted eggs are relatively unprotected against physical damage, and opening and emptying the nets is time-consuming and problematic if many nets are deployed.

In this paper we describe a new egg trap that fulfills the criteria listed above. Also, we present the results of laboratory and field comparisons of the trap and the egg net developed by Horns et al. (1989).

Methods

Trap design.—To permit ease of comparison, the trap design was based on the same proportions...
as the egg net described by Horns et al. (1989). The trap was constructed by vacuum-molding two white polystyrene plates, each in the shape of a petri dish, to fit on either side of a polyvinyl chloride (PVC) collar 20.3 cm in diameter and 3.8 cm high (Figure 1). The surface of each plate was indented with two cone-shaped depressions with 1.3-cm-diameter holes in their centers. One plate was permanently attached to the PVC collar, and the other was held in place by a friction fit and could be readily removed. The two plates were oriented so that the axes running through the pairs of cones were at right angles to each other (Figure 1). The traps were painted dark brown to blend with stony substrates (Figure 2). Each trap had an eyebolt in the PVC collar to permit attachment to a line or chain. The traps were designed to be deployed from a boat by paying out a buoyed line to which the traps were sequentially attached. The traps were processed after retrieval by lifting off one side of the trap and removing the contents.

Laboratory tests.—To test the egg-catching efficiency of the new trap in the laboratory, we submerged it with the egg net described in Horns et al. (1989) in a tank of water 27.5 cm deep, and we poured 100 lake trout eggs from the surface directly over each net or trap. The eggs were obtained from feral adults in Lake Ontario and had been fertilized 3 d before the tests. The number of eggs that entered each device was recorded. To test how many eggs could be lost from a trap during movement in currents or storm surge, the trap was filled with 100 eggs and overturned 10 times underwater by means of a line attached to the eyebolt on the side of the trap. Afterward, the number of eggs remaining in the trap was recorded. A single trap and a single net were each tested 10 times with this procedure.

Field tests.—Egg nets and traps were placed on a lake trout spawning reef at the north end of Stony Island in the eastern basin of Lake Ontario. Capture of newly hatched lake trout fry at this site in previous years confirmed that lake trout spawn on the reef (Marsden et al. 1988). In 1988, eight
pairs of traps and nets were set in water 5 m deep on level rubble 15–40 cm in diameter. The traps and nets were attached with S-hooks to a nylon rope such that adjacent pairs were 1.5 m apart, and each trap and net within a pair was less than 0.3 m apart. Nets were attached to the line as described in Horns et al. (1989). The line of nets and traps was deployed from the surface, with a buoyed cinder-block anchor at either end, and sonar was used to locate the reef. The line was in place on the substrate from October 31 to December 8. During this time the line was retrieved, checked, and replaced approximately every 7 d. Severe storms during the fall resulted in the loss of some traps and movement of entire lines of traps and nets with their attached anchors. Egg captures in the remaining pairs of nets and traps were compared by means of the sign test (Conover 1980).

In 1989, as part of an ongoing study of lake trout spawning, traps were deployed attached 1.3 m apart by metal snaps on swivels to 5-mm gauge proof coil chain. The swivels permitted the traps to move independently of the chain so that tangling did not occur. A buoy was attached with line to either end of the chain. The placement of the lines of traps was checked after deployment and before retrieval by scuba or free divers.

**Results**

**Laboratory Tests**

In laboratory tests, the traps captured fewer eggs than the nets (98 versus 100% on average), and the traps retained eggs more effectively than nets after capture (99 versus 58%; Table 1). The high variability in egg loss from the nets (Table 1) was due to the manner in which eggs were lost. If the eggs rolled into the distal end of the net when the net was overturned, they were retained; but if they were caught by the bunched netting, they were carried towards the opening of the trap and fell out. These tests of egg-capture efficiency did not take into account the periods of zero egg capture when nets would be upside down in the field. Periodic observations of egg nets in the field (175 individual net observations) indicated that nets may be upside down 42% of the time on a shallow reef. However, on a deep reef (approximately 35 m), 90 of 100 nets were upright 19 d after deployment (Horns et al. 1989).

Eggs occasionally clumped in the surface depressions of the trap and blocked the holes. However, any movement of water in the test tank increased the probability that eggs resting on the trap surface or blocking the holes would enter the trap. In the wild, eggs are not apt to be released in high densities over a trap unless a female happens to spawn directly over it. In addition, movement of eggs by currents and removal of eggs by predators will reduce the blockage problem. A larger hole would alleviate the problem but would increase the potential for predators such as sculpins *Cottus* spp. to enter the trap.

**Field Tests**

During field trials of paired nets and traps in 1988, the traps captured 65 eggs whereas the nets captured 22 eggs ($P < 0.05$; Table 2). Several nets and traps were lost, and only five pairs were retrieved intact. Overall catch rates for paired and unpaired collectors indicated that, on average, traps captured over twice as many eggs per unit effort (Table 3). Captured eggs were either opaque, indicating that the chorion had been broken and the egg had subsequently died, or translucent, indicating that the egg was undamaged. Of the eggs captured in traps, 51–63% were undamaged upon retrieval, whereas only 32% of the eggs captured in nets were undamaged (Table 3). Some damage in nets occurred when eggs were crushed between the netting and the PVC rim.

The highest egg captures reported to date were in nets set on Stony Island reef in 1987 (Horns et al. 1989). However, our subsequent (unpublished) work on this reef has shown that those nets were deployed in an area where dislodged debris tends to accumulate, so many of the eggs probably drifted into the nets from adjacent areas.

**Table 1.—Numbers of lake trout eggs captured and lost by nets and traps in laboratory tests. Excluded eggs did not fall into the collector during the test; lost eggs fell out of the collector during agitation. Values are means of 10 tests ± 1 SE.**

<table>
<thead>
<tr>
<th>Collector</th>
<th>% eggs excluded</th>
<th>% eggs lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg net</td>
<td>0.0</td>
<td>41.9 ± 8.7</td>
</tr>
<tr>
<td>Egg trap</td>
<td>1.9 ± 0.6</td>
<td>1.0 ± 0.5</td>
</tr>
</tbody>
</table>

**Table 2.—Numbers of lake trout eggs captured in paired nets and traps deployed on Stony Island reef, Lake Ontario, 1988. Pairs were fished an average of 14 d.**

<table>
<thead>
<tr>
<th>Pair</th>
<th>Trap</th>
<th>Net</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>34</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>22</td>
</tr>
</tbody>
</table>
Table 2.—Numbers of lake trout eggs captured in paired nets and traps deployed on Stony Island reef, Lake Ontario, 1988. Pairs were fished an average of 14 d.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sampling collector</th>
<th>Total collectors retrieved</th>
<th>Total eggs captured</th>
<th>% undamaged eggs</th>
<th>Eggs per collector-day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>Net</td>
<td>15</td>
<td>59</td>
<td>32.2</td>
<td>0.018</td>
</tr>
<tr>
<td>1988</td>
<td>Trap</td>
<td>20</td>
<td>232</td>
<td>62.5</td>
<td>0.041</td>
</tr>
<tr>
<td>1989</td>
<td>Trap</td>
<td>268</td>
<td>756</td>
<td>51.3</td>
<td>0.290</td>
</tr>
</tbody>
</table>

In 1988, when traps and nets were deployed on nylon line, severe weather moved entire gang lines with their anchors over 7 m in the interval between deployment and retrieval. In 1989, when traps were deployed on chain, no appreciable movement of the lines occurred. One line remained in place at 5 m depth at the edge of a steep drop-off for 30 d, during which time several severe storms passed over the reef. Observations by divers confirmed that the traps always rested horizontally on the substrate. However, the traps must have experienced considerable agitation during storms, because many of them had lost most of their paint through abrasion by the time they were retrieved.

Discussion

The new trap design was more effective than egg nets for collecting lake trout eggs during natural spawning. In the field the traps captured eggs even when overturned; thus some traps fished up to twice as long as some nets, which were ineffective when upside down. This factor makes the traps especially effective in shallow and unprotected water where the probability of movement and overturning is high. Also, the traps were more durable and easier to deploy and process than the egg nets and they protected eggs more effectively. Live eggs collected in the field can be used to assess natural fertilization rates, egg development, percent hatch, and genetic profiles. Movement of traps during storms was reduced by deploying the traps on chains. The chief limitation of the traps is that they need to lie nearly horizontally to work effectively. Thus, the traps will be less effective on steep contours or in areas of very large boulders where they may rest at an angle between rocks. We found that gang lines of traps should not be drawn tight during deployment; instead, they should be set with enough slack to allow the chain to conform to the irregularities of the substrate. The traps could be improved with a fastener designed to hold the two sides of each trap together. This would eliminate the need for a tight friction fit, thus would make the traps easier to open. A plastics manufacturer has recently created a U-shaped PVC clip, which can be slipped around the rim of the trap to hold the two sides together (Randy Eshenroder, Great Lakes Fishery Commission, personal communication).

Egg nets remain a viable device for egg capture, especially in deep water where they are beyond the reach of waves and storm-generated surge. In addition, they can be readily constructed with few tools, whereas the egg traps must be obtained from a plastics manufacturer. However, because the traps can be mass-produced inexpensively ($8 per trap; Randy Eshenroder, personal communication), they offer the potential for uniform assessment of lake trout spawning throughout the Great Lakes. Preliminary tests of the traps by other researchers resulted in the first evidence of lake trout spawning on Grimsby shoal (28 eggs; J. Fitzsimons, Canada Centre for Inland Waters, personal communication), Yorkshire shoal (1 egg; J. M. Casselman, Ontario Ministry of Natural Resources, personal communication), and Galloo and Charity shoals (1 egg each; C. P. Schneider, New York Department of Environmental Conservation, personal communication) in Lake Ontario and in Alpena Harbor, Lake Huron (260 eggs; Jim Johnson, Michigan Department of Natural Resources, personal communication) and Duluth Harbor, Lake Superior (4 eggs; D. Schreiner, Minnesota Department of Natural Resources, personal communication). Previously, lake trout had been captured in gill nets in the fall near several of these sites; however, those captures provided only circumstantial evidence of spawning at the sites. The traps may also be useful for spawning assessment and capture of eggs of other demersally spawning species.

Acknowledgments

We thank Randy Eshenroder of the Great Lakes Fishery Commission for facilitating this project. Don Feck of the Center for Innovative Technology Transfer, David Lansky of Cornell University, and Roger Bergstedt and Randy Owens of the U.S. Fish and Wildlife Service contributed ideas to help design the egg traps. Elizabeth and Matthew Mahoney constructed the traps. Lianna Jarecki, Peter Grewe, and Henry VanOffelen assisted with the field tests. This work was funded by a grant from the Great Lakes Fishery Commission. Additional support was provided by the New York Agricultural Experiment Station, New York State College.
of Agriculture and Life Sciences, Cornell University, Hatch projects 1476402 and 1477402.

References