Effects of zebra mussels (*Dreissena polymorpha*) on lake trout (*Salvelinus namaycush*) fry recruitment in Otsego Lake

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Abstract: Zebra mussels (*Dreissena polymorpha*) became established in Otsego Lake in 2007 and by 2010 carpeted the lake trout (*Salvelinus namaycush*) spawning shoal at Bissel Point. Numerous papers suggest that the presence of zebra mussels on lake trout spawning shoals would negatively impact fry recruitment, because of reduced attractiveness of the substrate and the degradation of interstitial water quality within the substrate. In this 3-year study, lake trout fry recruitment was characterized in the presence of zebra mussels and compared to recruitment levels observed (2003-2004) before the zebra mussel invasion. Emergent fry traps were used to capture lake trout fry swimming up from the substrate at Bissel Point during April and May (2013 – 2015). Twelve emergent fry traps (diameter=81 cm; area=0.52 m^2) were set on four linear transects in depths of 30, 60 and 90 cm, across the entire inshore shoal area. Fry recruitment was highest (70%) in the shallowest depth, where zebra mussel density was lowest. Overall, both the highest (4.83 m^2/day) and lowest (1.59 fry/m^2/day) recruitment levels occurred in the presence of zebra mussels. Fry recruitment was 3.44-3.96 fry/m^2/day in the absence of zebra mussels. During the peak fry emergence period, 29-April-15 May, when 90% of the fry emerged, significantly more fry were captured in the presence of zebra mussels (2014-2015) than in their absence (2003-2004). Therefore, contrary to expectations from the literature, there was not clear evidence that zebra mussels were hindering lake trout fry recruitment in Otsego Lake.

INTRODUCTION

Zebra mussels (*Dreissena polymorpha*) became established in Otsego Lake in 2007 (Waterfeild 2009) and by 2010 carpeted the lake trout (*Salvelinus namaycush*) spawning shoals (Anonymous 2010). Zebra mussels may negatively impact fry recruitment by covering shallow rocky shoals, deep water cobbles and exposed stony lakeshores were lake trout spawn (Marsden et al. 1995). Lake trout broadcast their eggs over these rocky substrates, where they settle into interstitial spaces to incubate overwinter (Muir et al. 2012). For natural fry recruitment to occur, enough eggs must be deposited to survive predation (Gunn 1995). When high densities of zebra mussels thickly encrust the rocky substrates, interstitial spaces may be occluded, making eggs more vulnerable to predation (Marsden & Chotkowski 2001). Excessive mortality during the incubation period is believed to be responsible for recruitment failures in lake trout populations throughout most of the Great Lakes (Jones et al. 1995; Savino et al. 1999).

Recruitment of lake trout into the Otsego Lake fishery is largely dependent on natural reproduction (McBride and Sanford 1997, Tibbits 2007). Although Otsego Lake has been stocked annually by the New York State Department of Environmental Conservation (NYSDEC) with approximately 5,000 fingerlings per year, gill net surveys have shown that natural recruitment accounts for 75% of the adult lake trout population.

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The goal of this study was to characterize lake trout fry recruitment in Otsego Lake and compare current recruitment levels to fry recruitment before the invasion of zebra mussels. In order to meet that goal, soft mesh-emergent fry traps were deployed in April-May 2013-2015 to capture lake trout fry emerging from the Bissel Point spawning shoal. The data collected here and in earlier studies (Sawick & Foster 2013; Lucykanish & Foster 2014), were compared to Tibbits (2007) study conducted at Bissel Point in the absence of zebra mussels.

MATERIALS & METHODS

This study was carried out at Bissel Point, Otsego Lake (W74° 54.141; N42° 45.550, Township of Otsego, Otsego County, New York), following Tibbits (2007), Sawick & Foster (2013) and Lucykanish & Foster (2014). The 2015 study was conducted over 42 days starting at ice-out (9 April 2015) and extending to 21 May 2015.

The twelve emergent fry traps (81 cm diameter, .52 m^2 area) used in this study were the same ones used by Tibbits (2007), Sawick & Foster (2013) and Lucykanish & Foster (2014). They were centered at depths of 30, 60 and 90 cm along four linear transects perpendicular to the shoreline (Figure 1). Traps were checked at 48 hour intervals. Captured fry were counted and released. Water temperature was measured using a HANNA temp/pH electronic meter.

Figure 1. Emergent fry traps were set at depths of 30, 60 and 90 cm along four linear transects off Bissel Point, Otsego Lake, NY.

RESULTS

A total of 786 lake trout fry were captured between 2013 and 2015. Overall, 70% of the fry emerged at a depth of 30 cm, 24% at 60 cm, and 6% at 90cm. While there was some variability between years, the pattern of emergence was consistent (Figure 2). No significant difference was observed in the number of fry emerging from different depths in the absence of zebra mussels (2004) or in the presence (2013-2015) of zebra mussels (chi square test, P > .05).

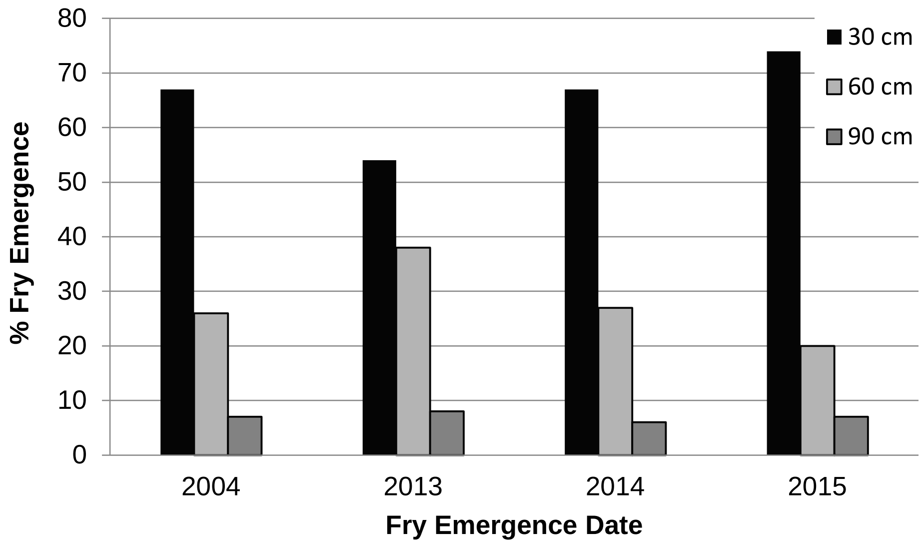

Figure 2. The percent of lake trout fry emerging at three depths in the absence of zebra mussels (2004) and in their presence (2013-2015).

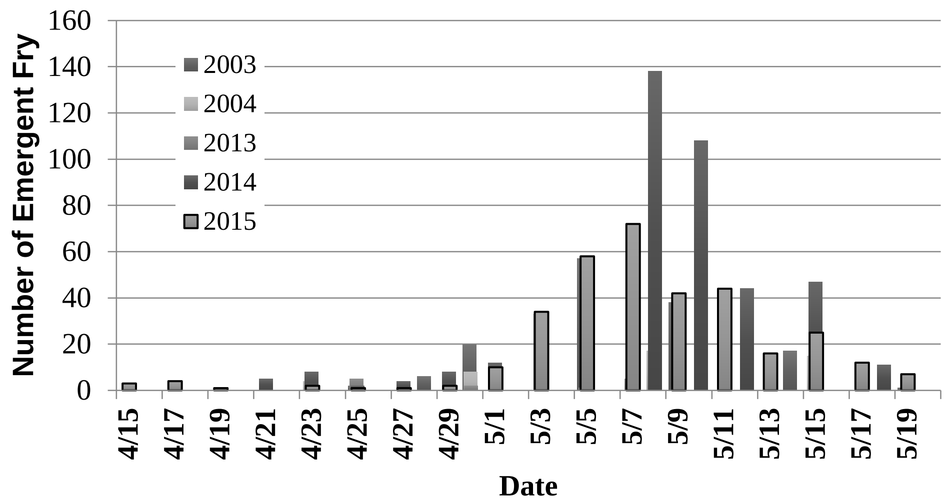

Figure 3. The number of emergent lake trout fry compared to date of emergence (2003, 2004 and 2013-2015).

Throughout the 5 years of this study, peak fry emergence was almost identical (Figure 3). Peak fry emergence occurred on 7 May (2003, 2013, 2015) and 8 May (2004, 2014). Over 90% of the fry emerged over a 17 day period (29 April–15 May).

Peak fry emergence seems to be triggered when the water temperature reaches $8^{o}C$. In 2015, 93% fry emerged between $8.3^{o}C$ and $14.9^{o}C$, while in 2014, 94% fry emerged between $8^{o}C$ & $11.1^{o}C$ (Figure 4 & 5).

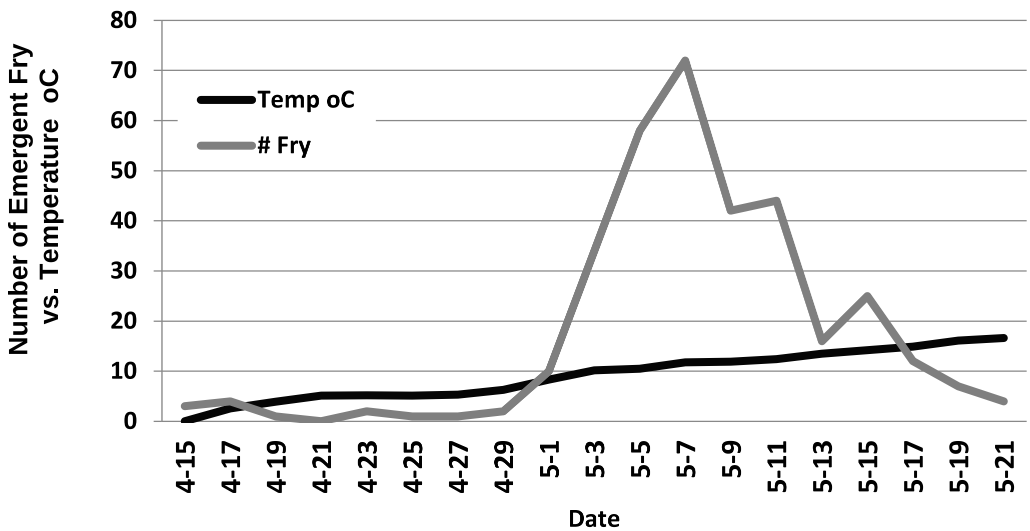

Figure 4. The relationship between date, water temperature and the number of emergent lake trout fry in 2015.

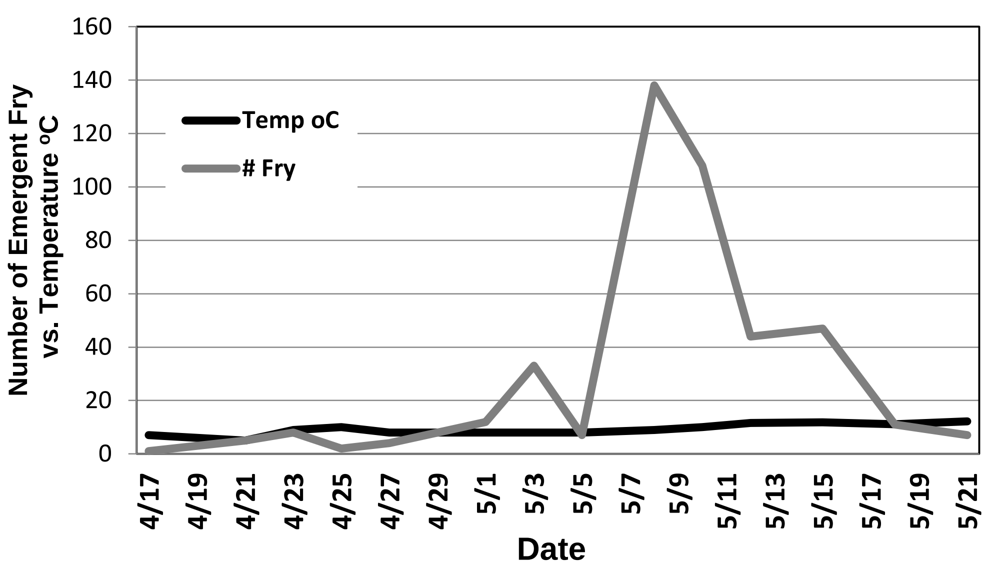

Figure 5. The relationship between date, water temperature and the number of emergent lake trout fry in 2014.

Fry recruitment between years was variable (Figure 6). When emergence was measured by the average number of fry captured per m^2 of substrate per day, both the highest and lowest fry recruitment levels (4.83 and 1.59, respectively) occurred in the presence of zebra mussels. In 2015 the average number of fry per m^2/day was 2.41, lower than 4.83 fry/m^2/day captured in 2014, and higher than the 1.59 fry/m^2/day captured in 2013.

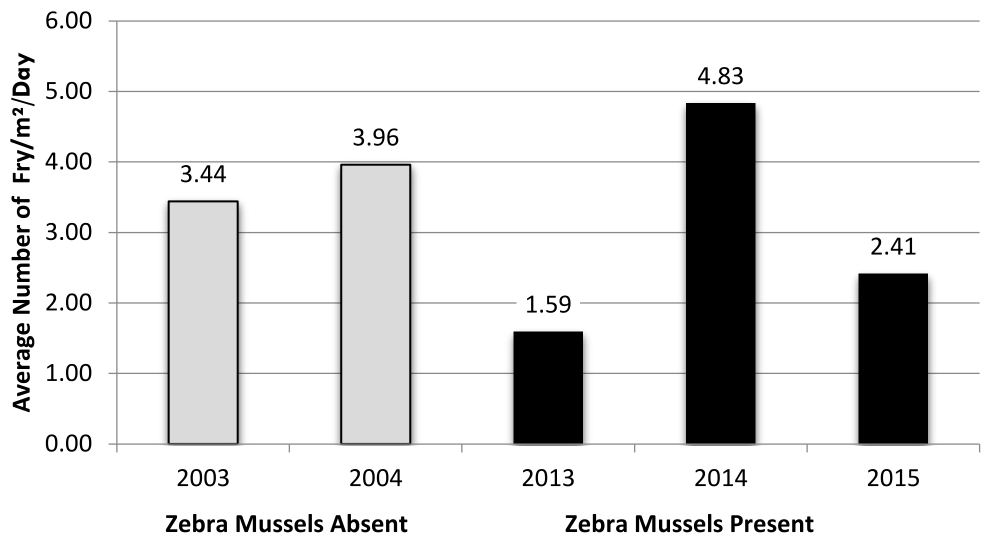

Figure 6. Average number of lake trout fry emerging per m^2 of substrate per day in the absence and presence of zebra mussels.

However, lake trout fry emergence in 2014 and 2015 was much higher than shown by the average number fry captured per m^2/day. In 2003 the sampling period was 21 days and in 2004 and 2013 it was 28 days. In 2014 and 2015 sampling was extended to 42 days. The extra days added in recent years were well outside the 29 April – 15 May peak emergence period, lowering the average number of fry caught per m^2/day. A better way to compare the data is to focus on the period 29 April – 15 May during peak fry emergence. In the presence of zebra mussels (2014-2015) a total of 700 fry were captured during the 29 April – 15 May peak emergence period, while in the absence of zebra mussels (2003-2004) only 222 fry emerged in that same period (chi square test, $P < .0001$). This would indicate that lake trout fry emergence was substantially higher in the presence of zebra mussels.

DISCUSION

The impact of zebra mussels on lake trout fry recruitment in Otsego Lake raised concerns shortly after zebra mussels became well established on the rocky spawning shoal at Bissel Point (Sawick & Foster 2013). The presence of zebra mussels on lake trout spawning shoals has been shown to interfere with the deposition of eggs, as well as their survival. The presence of zebra mussels have been reported to reduce egg deposition by discouraging adult lake trout from spawning. Further, zebra mussels have been reported to increase damage to lake trout eggs

(Marsden and Chotkowski 2001), as well as increase vulnerability of eggs to predators (Claramunt et al. 2005, Marsden 1997). Zebra mussels are also thought to degrade interstitial water quality within the substrate resulting in a decrease in lake trout egg viability (Marsden et al. 1995. Marsden 1997, Marsden & Chotkowski 2001).

However, other studies have not shown a clear-cut negative impact of zebra mussels on lake trout fry recruitment. For example, Marsden & Chotkowski (2001) showed that lake trout emergence was similar on substrates fouled and not fouled by zebra mussels. Further, Marsden et al. (2005) showed that lake trout fry hatch per egg had some of the highest rates on sites in Lake Champlain that were densely covered with zebra mussels.

There is also the possibility that zebra mussels have a positive impact on lake trout fry recruitment. The presence of zebra mussels increases the surface area and complexity of the substrate, which may provide more refuges from predators (Ozersky et al. 2011). Further, lake trout fry are mobile before swimming up, and they move within and above the substrate (Baird & Krueger 2000). If zebra mussels clog interstitial spaces in the substrate, then fry lateral movements may become restricted, making them more likely to move vertically into emergence traps (Marsden & Chotkowski 2001).

While this study provides an excellent characterization of lake trout fry emergence at Bissel Point, it does not provide an unequivocal answer to the question of whether zebra mussels are impacting lake trout fry recruitment in Otsego Lake. Evidence that there may be a negative impact comes from the negative correlation between fry recruitment and zebra mussel density. In Otsego Lake, trout fry emergence was highest at 30 cm in depth, where zebra mussels are least dense. Fry recruitment decreased at 60 cm and decreased further at 90 cm, as zebra mussel density increased. However, the same pattern of fry recruitment by depth occurred in 2004 in the absence of zebra mussels, indicating that the correlation between fry recruitment with depth had nothing to do with the density of zebra mussels. Evidence that zebra mussels had no impact on fry recruitment comes from the catch rate. Both the highest (4.83 m^2/day; Lucykanish & Foster 2014) and lowest (1.59 m^2/day; Sawick and Foster 2013) occurred in the presence of zebra mussels. Lake trout recruitment is variable between years and other factors besides the presence or absence of zebra mussels may have a greater impact on the natural year-to-year variation in fry emergence. For example, wave action, ice scour, and predation all impact lake trout fry recruitment and are expected to vary from year to year (Edwards et al. 1990, Krueger et al. 1995, Marsden et al. 1995). Evidence that lake trout fry recruitment was enhanced by the presence of zebra mussels is shown in the comparison of total lake trout fry recruitment during the peak emergent period. In that comparison, over 3 times more fry emerged in the presence of zebra mussels than in their absence. Therefore, quite possibly the presence of zebra mussels may increase lake trout fry recruitment in Otsego Lake.

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