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Changes in sea lamprey size and fecundity through time in the Great Lakes

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ABSTRACT

Sea lamprey (*Petromyzon marinus*) are an aquatic nuisance species that cause great harm to fishes in the Great Lakes. Control of sea lamprey is vital to protecting the Great Lakes fishery, and designing an effective control program depends on accurate knowledge of their demographics. This study compared historical and current data on female sea lamprey length, weight, fecundity, gonadosomatic index (GSI) and egg weight in the Great Lakes. Female sea lamprey captured in 2011 were compared with studies conducted in 1960 and 1981 on Lake Superior and in 1981 and 1999 on Lake Ontario, as well as available data from Lakes Huron, Michigan and Erie. In Lake Superior, mean length and weight of female sea lamprey increased by approximately 13% and 45%, respectively, while mean fecundity increased 17% and individual egg weights increased 43%. There was no difference in mean sea lamprey GSI in Lake Superior. In Lake Ontario, female sea lamprey length increased by 7%, but there were no differences in the other metrics. Across the Great Lakes, there was a general increase in fecundity from the period before the 1980s to more recent years. An increased population of larger parasitic sea lamprey will have higher feeding rates and thus a higher impact on commercially and ecologically important fishes. Managers may need to reconsider control targets and lampricide treatment frequency for lakes where sea lamprey growth and fecundity have increased.

Introduction

Sea lamprey (*Petromyzon marinus*) are anadromous fish native to the Atlantic Ocean and are considered an invasive, nuisance species in the Great Lakes causing great harm to native and introduced fish communities (Smith and Tibbles, 1980). Sea lamprey presumably invaded the upper Great Lakes through the Welland Canal. They were first found in Lake Erie in 1921 and by the 1930s were firmly established in the upper Great Lakes (Creaser, 1932). Due to the parasitic nature of the sea lamprey, they were partly responsible for crashes in lake trout (*Salvelinus namaycush*) and other economically important fish populations during the 1950s (Smith and Tibbles, 1980). During their 12 to 18 month parasitic phase, sea lamprey adults on the average kill 18 kg of fish (Sullivan et al., 2016), predominantly salmonids in the Great Lakes (Harvey et al., 2008).

The Great Lakes fishery provides angling opportunities for 5 million people and generates approximately $7 billion dollars for the region annually, providing over 75,000 jobs (Southwick Associates, 2013). But the fishery is at risk because sea lamprey contribute to declines in lake trout, lake whitefish (*Coregonus clupeaformis*), burbot (*Lota lota*), suckers (*Catostomus* spp.), and many other species (Lawrie, 1970; Smith and Tibbles, 1980). In fact, despite recent declines in the abundance of spawning-phase adults in many of the Great Lakes (Sullivan et al., 2016) sea lamprey induced mortality remains a significant source of mortality on lake trout, in some areas exceeding the mortality associated with fisheries (Caroffino and Lenart, 2016). Current sea lamprey control methods, which include barriers, treatments of streams with lampricides (3-trifluoromethyl-4-nitrophenol; Bayluscide) have lowered the number of sea lamprey in the Great Lakes, but their abundance remains high enough to be a concern (Smith and Tibbles, 1980). Therefore, continuing and improving control of sea lamprey is vital to maintaining the Great Lakes fishery.

Understanding the reproductive potential and growth of sea lamprey is important in designing an effective sea lamprey control program. Due to the warming temperatures and changes in prey availability, reproductive potential of Great Lakes sea lamprey could be increasing compared to earlier periods when temperatures were cooler and large prey were scarce. Increased surface water temperatures in Lake Superior have resulted in increased sea lamprey growth and feeding rates (Cline et al., 2014). Sea lamprey were likely smaller when their population densities were higher and their prey scarce. Following restoration efforts for lake trout and continued stocking of Pacific salmon; however, sea lamprey grew larger as prey populations increased (Heinrich et al., 1980; Houston and Kelso, 1991). In their native range, the size and fecundity of female sea lamprey are higher than in the Great Lakes, in

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part due to increased availability of large-sized prey (Beamish and Potter, 1975). Declines in sea lamprey abundance due to treatment efforts may also have reduced intraspecific competition and resulted in more prey per sea lamprey.

Understanding how growth and fecundity have changed can be used to improve population models, which can inform damage to the fishery, how often streams are treated and what treatment methods are used (Manion and Hanson, 1980). Thus, the objectives of this study were to compare sea lamprey length, weight, fecundity, and egg weights in 2011 with the same data from previous studies conducted on Lake Superior in 1960 (Manion, 1972) and Lake Ontario in 1999 (O'Connor, 2001). We also made comparisons with other lakes and time periods when data were available. We hypothesized that female sea lamprey size, fecundity, and egg weight have increased compared to past studies because of increased water temperatures and prey availability, but we did not examine the specific mechanisms for the changes.

Methods

Field data collection

In May and June of 2011, sea lamprey were collected from four rivers, two on Lake Superior, and two on Lake Ontario (Fig. 1). The Tahquamenon River and Betsy River (Lake Superior) were chosen due to the availability of sea lamprey and their proximity to streams sampled in earlier periods. Duffins Creek and Humber River (Lake Ontario) were sampled for this study because they were also sampled in 1999 (O'Connor, 2001). Using standard sea lamprey traps, the United States Fish and Wildlife Service (USFWS) collected 25 female sea lamprey per tributary from Lake Superior, and the Department of Fisheries and Oceans Canada collected 25 female sea lamprey per tributary from Lake Ontario during the spawning run of 2011. Fifty female sea lamprey from Lake Superior were used for length and weight calculations, but only thirty individuals were examined for fecundity, individual egg weights, and gonadosomatic index (GSI). The other samples, ten from both the Tahquamenon River and Betsy River, were discarded after accidental thawing prior to analysis. Fifty female sea lamprey from Lake Ontario were used for length and weight calculations, with 49 of those used for fecundity, individual egg weights, and GSI calculations. The remaining one ovary sample, from Duffins Creek, was used to practice the method of egg counting.

Upon capture, female sea lamprey wet weight was measured to the nearest 1 g for individuals from Lake Superior tributaries, and the nearest 0.5 g from Lake Ontario tributaries. Female sea lamprey total length was measured to the nearest mm. Ovaries were removed, cleaned of any connective tissue, and blotted with paper towels to remove blood and excess water (Manion, 1972). Ovaries were then weighed to the nearest 1.0 g for female sea lamprey from Lake Superior, and the nearest 0.01 g for Lake Ontario. Ovary samples were placed in plastic bags, labeled, and frozen. After collection, all data and ovary samples were sent to Lake Superior State University for additional analysis.

In the lab ovary samples were thawed, water and blood drained, and lightly blotted with paper towels to remove excess water (O'Connor, 2001). Samples were then reweighed to the nearest 0.01 g to account for the removal of excess water. Ovary samples weighed approximately 3–6 g (6–12%) less in the lab than in the field. Lab weights of ovary samples were used for all calculations. Three 0.5 g sub-samples of eggs were randomly taken from each ovary and enumerated. The mean eggs/g from each of the three sub-samples was used to estimate the average individual egg weight and the total number of eggs in each ovary. GSI was calculated as lab ovary weight/field wet weight.

Historical data

Current female sea lamprey size and fecundity were compared with various earlier studies (Fig. 1). In Lake Superior, data from individual female sea lamprey were available from 1960 (Chocolay River; Manion, 1972) and 1981 (Tahquamenon and Rock Rivers; T.J. Morse,

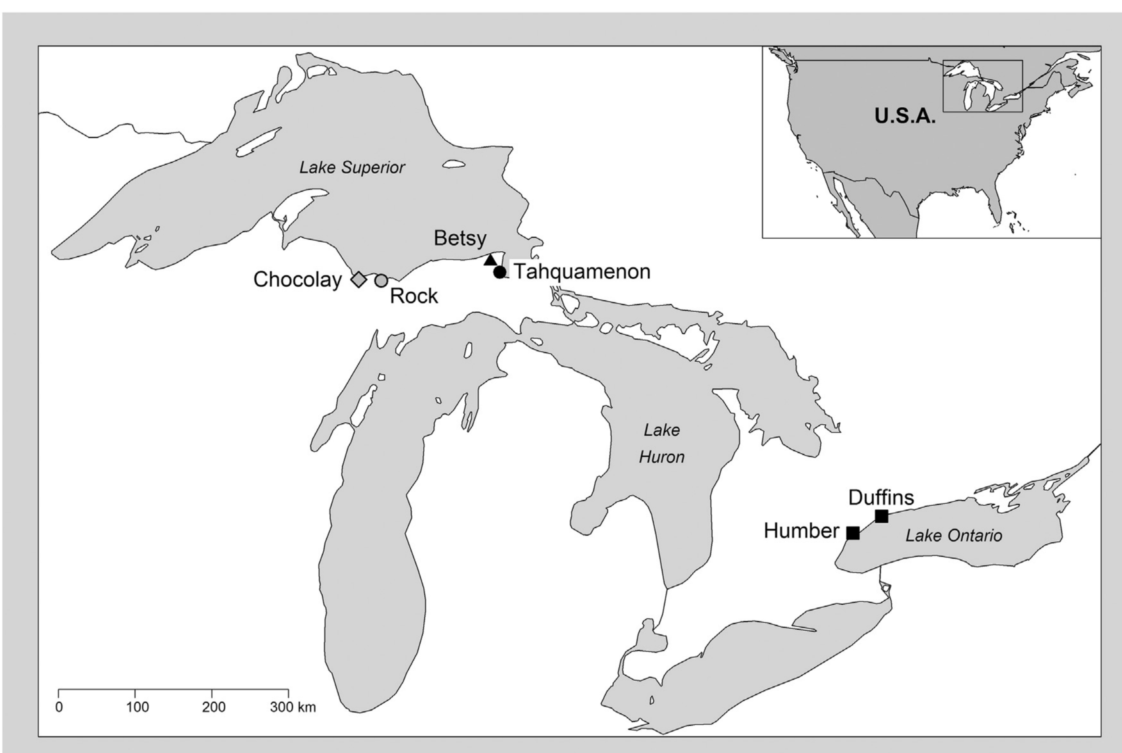

Fig. 1. Map of the Great Lakes showing rivers where detailed information on female sea lamprey size and fecundity were available in Lakes Superior and Ontario. Black symbols indicate sites where data were collected for this study only (triangle), this study and Morse (unpublished data; circle) or this study and O'Connor (2001; squares). Gray symbols indicate sites with only historical data: Manion (1972; diamond) and Morse (unpublished data; circle).