

NOTE

Evidence of Widespread Natural Reproduction by Lake Trout *Salvelinus namaycush* in the Michigan Waters of Lake Huron

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ABSTRACT. Localized natural reproduction of lake trout *Salvelinus namaycush* in Lake Huron has occurred since the 1980s near Thunder Bay, Michigan. During 2004–2006, USGS spring and fall bottom trawl surveys captured 63 wild juvenile lake trout at depths ranging from 37–73 m at four of five ports in the Michigan waters of the main basin of Lake Huron, more than five times the total number captured in the previous 30-year history of the surveys. Relatively high catches of wild juvenile lake trout in bottom trawls during 2004–2006 suggest that natural reproduction by lake trout has increased and occurred throughout the Michigan waters of the main basin. Increased catches of wild juvenile lake trout in the USGS fall bottom trawl survey were coincident with a drastic decline in alewife abundance, but data were insufficient to determine what mechanism may be responsible for increased natural reproduction by lake trout. We recommend further monitoring of juvenile lake trout abundance and research into early life history of lake trout in Lake Huron.

INDEX WORDS: Lake trout, spawning, natural reproduction, Lake Huron, Great Lakes, fish management.

INTRODUCTION

Lake trout *Salvelinus namaycush* populations in Lake Huron collapsed in the 1940s, primarily due to overfishing and sea lamprey predation, and efforts to restore these populations have been undertaken since the 1970s (Eshenroder *et al.* 1995, Krueger and Ebener 2004). Despite widespread stocking and seal lamprey control, however, there has been little evidence of natural recruitment of lake trout in the main basin (Eshenroder *et al.* 1995), although some recruitment has occurred in areas of Georgian Bay and the lake trout population in Parry Sound (Ontario) has been considered restored since 1997 (Reid *et al.* 2001). The restora-

tion of lake trout populations in the Great Lakes remains an important priority in Great Lakes fisheries management (Eshenroder *et al.* 1999, Krueger and Ebener 2004).

Naturally produced juvenile lake trout have been captured in Lake Huron since the early 1980s near Thunder Bay, Michigan (Nester and Poe 1984, Johnson and Van Amberg 1995) and since 1994 on offshore reefs (DeSorcie and Bowen 2003). Although naturally produced eggs or fry have been noted in all of the Great Lakes since the 1980s (Jude *et al.* 1981, Marsden *et al.* 1988, Hansen *et al.* 1995, Fitzsimons and Williston 2000, Jonas *et al.* 2005), little evidence of sustained recruitment to older age classes exists outside of Lake Superior.

A number of potential impediments may prevent the reestablishment of widespread natural reproduc-

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tion of lake trout in the Great Lakes, including low spawning habitat availability and quality (Krueger *et al.* 1995b), predation of eggs and juveniles (Krueger *et al.* 1995a, Savino *et al.* 1999, Jonas *et al.* 2005), contaminants (Zint *et al.* 1995), and thiamine deficiency of spawning adults (McDonald *et al.* 1998). Here we present the first evidence, based on data collected by the U. S. Geological Survey (USGS) and the Michigan Department of Natural Resources (MDNR), that natural reproduction of lake trout has occurred throughout the Michigan waters of Lake Huron.

METHODS

USGS Bottom Trawling

The USGS Great Lakes Science Center has monitored fish abundance annually from 1973–2005 using 12 m (1973–1991) and 21 m (1992–2006) headrope bottom trawls at a set of fixed transects at up to eleven depth strata (9, 18, 27, 36, 46, 55, 64, 73, 82, 92, and 110 m) at five ports (Detour, Hammond Bay, Thunder Bay, Au Sable Point, and Harbor Beach) in the Michigan waters of Lake Huron (Fig. 1). Trawls were fished from the R/V *Kaho* during 1973–1977, and from the R/V *Grayling* during 1978–2005, with the exception of 1990, when some transects were fished from the R/V *Cisco*. Fall trawl surveys on Lake Huron were completed annually between 3 October and 15 November, except in 1992 and 1993, when surveys were completed in September; the fall survey was not conducted in 2000 due to mechanical problems. Spring trawl surveys were conducted between 20 April and 25 May in 1973–1985, 1987, 1998–2002, and 2004–2006.

On-contour trawl tows were conducted for 10 minutes during daylight hours at each transect each year. Tow duration was occasionally less than 10 minutes; catch was corrected to be equivalent to 10 minute tows in these cases. Although the surveys were primarily designed to provide annual estimates of prey fish abundance, all lake trout captured were routinely measured (total length to the nearest mm), weighed (nearest gram), and inspected for fin clips. The catch of unclipped juvenile lake trout less than or equal to 120 mm in length was expressed as the mean catch per tow for all tows conducted each year. Although two different trawls were used for the survey, catch rates of juvenile lake trout were too low to develop a correction for catches in the different nets, and catches were not corrected.

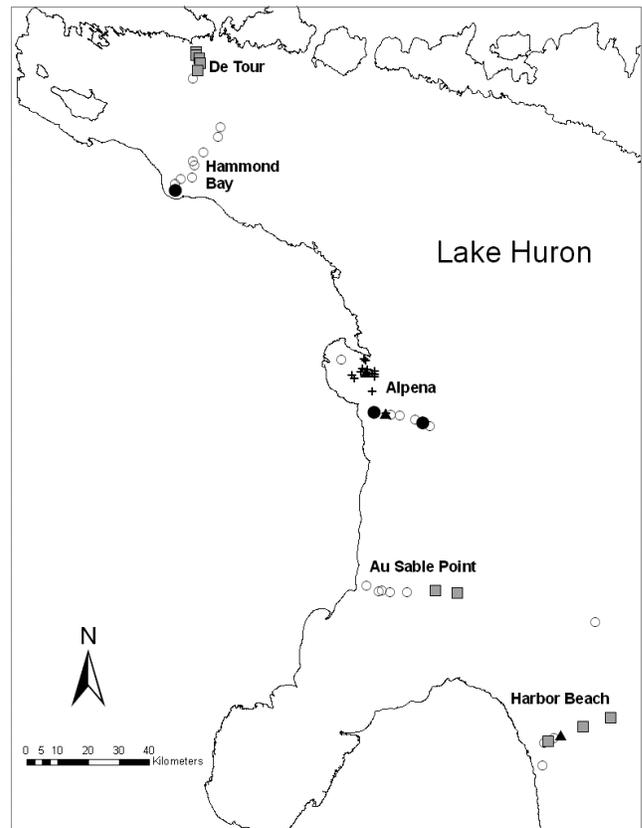


FIG. 1. Locations of sampling sites for USGS spring and fall bottom trawl surveys and MDNR summer trawl surveys in Lake Huron. Symbols show locations where wild juvenile lake trout were caught in USGS trawls prior to 2004 (solid circles), during 2004–2006 (shaded squares), and during both periods (solid triangles). Hollow circles indicate USGS trawl locations where wild juvenile lake trout have never been captured. Crosses indicate the locations of MDNR trawls in Thunder Bay.

We used 120 mm as a length cut-off to ensure that lake trout were wild, as the majority of hatchery-reared lake trout are stocked at sizes larger than 120 mm. For simplicity, we refer to naturally-produced juvenile lake trout as “wild,” although they may be the progeny of hatchery-reared adults. All lake trout that are stocked in the Michigan waters of Lake Huron have a fin clipped (the specific fin varies from year to year) to allow identification of stocked fish (Ebener 1998). The clipping efficiency in lake trout hatcheries has averaged approximately 94 percent (Bronte *et al.* 2007), which means that

six percent of hatchery fish might be unclipped. We did not capture any clipped lake trout less than or equal to 120 mm in length in any survey during 2004–2006, suggesting that hatchery-reared lake trout in this size range are rare. Because very few hatchery-reared lake trout would be stocked at less than 120 mm, and because only approximately six percent would be unclipped, it is highly unlikely that any unclipped lake trout less than 120 mm in length in Lake Huron would be of hatchery origin. Moreover, the majority of the juvenile lake trout that we captured during 2004–2006 were much smaller than 120 mm; 93 percent of juvenile lake trout caught during the fall survey were less than 80 mm in length, and 70 percent of those caught during the spring survey were less than 90 mm. We refer to unclipped lake trout less than 120 mm as wild juvenile lake trout; these fish would be age-0 if captured in the USGS fall survey and age-1 in the USGS spring survey. Juvenile lake trout captured in the MDNR surveys were all 93 mm or smaller and were thus considered to be age-0.

MDNR Bottom Trawling

The MDNR has used a 10.3 m (headrope) semi-balloon otter trawl to sample stations in Thunder Bay, Michigan (Fig. 1) for the presence of juvenile lake trout. Trawls were conducted annually from 1986 to the present. From 1986 to 1989, trawling was conducted during July through September at depths of 18.3, 21.3, 24.4, and 27.4 m. From 1990 to 2003, annual trawling was conducted in middle and late August at the first three depth strata above. In 1994, trawling was also conducted in early September, and in 1995 in late July. Three replicate 10 minute tows were completed at each depth, and at least 36 tows were completed annually.

Since 2004, MDNR trawling depths were expanded to include depths of 12.2 through 36.6 m, with step of 3.05 m. Trawling was discontinued in water deeper than 27.4 m if no lake trout were caught in two consecutive strata beyond that depth. Annual trawling was conducted two times in late July and early August, respectively. Two replicate 10 minute tows were completed each time at each depth. All lake trout captured were inspected for fin clips.

RESULTS

Wild juvenile lake trout were not caught in USGS or MDNR trawls until 1984, when they were

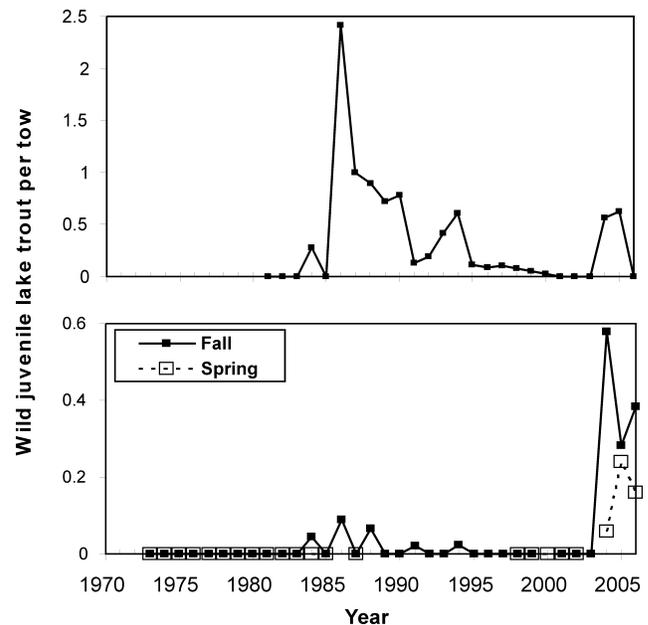


FIG. 2. Mean annual catch per tow of wild juvenile lake trout in Michigan Department of Natural Resources (top panel) and U. S. Geological Survey (bottom panel) trawl surveys in Lake Huron.

captured in the MDNR trawl survey and the USGS fall survey (Fig. 2). Wild juvenile lake trout were caught in low numbers in the USGS fall trawl survey in 1984, 1986, 1988, 1991, and 1994 (Fig. 2). Of the eleven wild juvenile lake trout captured in the USGS fall survey between 1984–1994, nine (82%) were captured near Thunder Bay and two near Hammond Bay (Fig. 1). Juvenile lake trout ranged in length from 82–117 mm.

Catch rates of wild juvenile lake trout in the USGS fall trawl survey increased dramatically in 2004–2006 (Fig. 2). A total of 46 juvenile lake trout ranging in length from 52–107 mm was captured in these three years; 42 near Detour, two near Thunder Bay, and one each near Au Sable Point and Harbor Beach (Fig. 1). Juvenile lake trout were captured at depths ranging from 37–73 m, with 43% being captured at depths greater than 37 m.

No wild juvenile lake trout were caught in the USGS spring trawl survey prior to 2004 (Fig. 2). A total of 17 juvenile lake trout ranging in length from 74–96 mm was captured in the 2004–2006 spring surveys, seven (39%) each from Detour and Harbor Beach, two near Au Sable Point, and one near Thunder Bay. Juvenile lake trout were caught at depths ranging from 37–73 m, although 14 (82%) were captured at depths greater than 37 m.

Wild juvenile lake trout (length range: 51–93 mm) were captured in MDNR trawls near Thunder Bay in all years since 1983 except 1985, 2001–2003, and 2006 (Fig. 2). Catch per tow in the MDNR survey was highest in 1986 and declined gradually until reaching zero in 2001, and remained low until 2004–2005, when catch rates approached the levels observed in the late 1980s. Prior to 2001, 78% of wild juvenile lake trout were captured at depths of 18.3 and 21.3 m. In 2004 and 2005, they were captured at every depth from 12.2 through 30.5, with highest catch rate at 27.4 m. No wild juvenile lake trout were captured in MDNR trawls in 2006.

DISCUSSION

Previous work has suggested that recent natural reproduction of lake trout in the main basin of Lake Huron first occurred in the early 1980s near Thunder Bay (Nester and Poe 1984) and wild juvenile lake trout were consistently captured by trawls in this area through the 1990s (Johnson and Van Amberg 1995). Catches of wild juvenile lake trout in USGS and MDNR trawl surveys suggest that the incidence of natural reproduction of lake trout in the Michigan waters of Lake Huron was sporadic, primarily confined to areas near Thunder Bay, and may have declined over time until 2004.

Beginning in 2004, the two independent USGS trawl surveys recorded catches of wild juvenile lake trout that were much higher than previously observed in Lake Huron outside of Thunder Bay. The total catch of wild juvenile lake trout in the USGS fall trawl survey from 2004–2006 was more than four times the total number captured in the previous 30 years of the survey, and these fish were never captured in the spring trawl survey prior to 2004. Moreover, catches of wild juvenile lake trout in the USGS spring and fall bottom trawl surveys in 2004–2006 were highest in areas outside Thunder Bay and were distributed throughout all ports sampled except Hammond Bay, which suggests that natural reproduction by lake trout was occurring throughout the lake. The most productive station for catching wild lake trout shifted from Thunder Bay during earlier sampling to Detour in recent years. Prior to 2004 no wild lake trout were caught in USGS trawl stations north of Hammond Bay; from 2004–2006, most (78%) of the catch was north of Hammond Bay at the Detour station.

Although increased capture rates of wild juvenile lake trout suggest that natural reproduction may be occurring in the Michigan waters of Lake Huron, it

is important to note that catch rates reported here are much lower than reported for Lake Superior (Bronte *et al.* 1995), where lake trout populations have been restored. While these increased capture rates may be an encouraging sign for Lake Huron lake trout populations, juvenile densities may not be sufficient to result in substantial recruitment to older age classes.

The occurrence of evidence of widespread natural reproduction by lake trout in the main basin of Lake Huron coincided with a dramatic decline of alewife populations in the lake in 2004, and alewife populations have remained at low levels since that time (Roseman *et al.* 2007). Alewife have been implicated as a potential impediment to lake trout reproduction in the Great Lakes due to predation on eggs and fry (Krueger *et al.* 1995a) or low egg thiamine levels associated with alewife in the diet of adults (Tillitt *et al.* 2005). The fact that increased catches of wild juvenile lake trout were coincidental with the collapse of the alewife population in Lake Huron suggests that lake trout reproduction in Lake Huron may be facilitated by low alewife abundance.

Alternatively, reproduction may have benefited from increasing spawning stocks of lake trout, which in turn has been attributed to enhanced control of sea lampreys and fishing-induced mortality (Johnson *et al.* 2004). Gains in sea lamprey control effectiveness were focused on the St. Marys River, which enters Lake Huron immediately north of Detour, after 1998. The reductions in fishing mortality were in the Northern Lake Huron lake trout management unit that encompasses Detour, and became effective after 2000. The appearance of relatively high numbers of wild lake trout after 2003 at Detour is congruent with these two management initiatives.

The USGS spring and fall bottom trawl surveys were not designed to monitor juvenile lake trout abundance. Other than annual MDNR trawling in and near Thunder Bay, MI, no program currently exists to monitor the abundance of wild age-0 and age-1 lake trout in the main basin of Lake Huron. We suggest that annual monitoring of the abundance of juvenile lake trout, combined with research addressing survival of early life stages, would be useful in determining what impediments may currently exist to natural reproduction by lake trout in Lake Huron.

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