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Lake trout spawning habitat suitability at two offshore reefs in Illinois waters of Lake Michigan

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ABSTRACT

In Illinois waters of Lake Michigan, Julian's and Waukegan reefs were once-productive offshore commercial fishing sites. Currently, both reefs are stocked and naturally reproduced lake trout aggregate at these reefs during the spawning season. Attempts to document natural reproduction of lake trout at deep-water spawning sites in southwestern Lake Michigan have been hampered, in part, by a lack of detailed information on suitable spawning habitat and imprecise placement of egg collection devices. We developed high-resolution substrate and bathymetric maps for Julian's and Waukegan reefs using geo-referenced bathymetry readings, sidescan sonar, and underwater video. Spawning activity was evaluated at suitable and unsuitable habitat using egg traps deployed during the 2009 and 2010 spawning seasons. Sidescan sonar data allowed identification of suitable substrate at Waukegan (1%) and Julian's (2%) reefs as well as previously undocumented Waukegan South Reef (6%). Small, discrete areas with suitable spawning habitat (substrate and slope) were found and in total constituted <1% of all hard surfaces mapped at both the Waukegan Reef complex and Julian's Reef. No eggs were collected either year, due in part to difficulty sampling small, localized patches of suitable spawning habitat and extensive coverage of *Dreissena* and *Cladophora* species. In the future, use of this high-resolution habitat data combined with more precise egg or fry sampling equipment will allow for a more comprehensive evaluation of natural reproduction at these once-productive offshore reefs.

Introduction

Historically, lake trout *Salvelinus namaycush* was the dominant predator and one of the most valued game fish throughout the Great Lakes. Annual commercial harvest of native lake trout in Lake Michigan exceeded 5.0 million lb during 1900–1950 (Baldwin et al., 2009; Hudson and Ziegler, 2014) and was consistently higher per surface area than that of any other Great Lake (Holey et al., 1995). A combination of overfishing and sea lamprey *Petromyzon marinus* predation resulted in the extirpation of lake trout from Lake Michigan by the 1960s (Coble et al., 1990; Eshenroder et al., 1983; Hansen, 1999). Reintroduction efforts began in 1965 when hatchery-reared lake trout were introduced to Lake Michigan through extensive stocking efforts (Eshenroder et al., 1983; Holey et al., 1995). Despite on-going stocking, re-establishment of self-sustaining, naturally reproducing populations has been slow and met with limited success (Bronte et al., 2008; Eshenroder et al., 1995).

Numerous studies have investigated spawning aggregations, habitat suitability, and egg deposition of stocked lake trout at historical spawning grounds and man-made structures in an effort to ascertain factors which attracted native lake trout to spawning grounds (Edsall and Kennedy, 1995; Holey et al., 1995; Marsden and Janssen, 1997; Marsden et al., 1995; Marsden et al., 2005). Evaluation of historical spawning sites suggested native lake trout spawned at nearshore and offshore sites with depths ranging from 3 to at least 80 m (Brown et al., 1981; Goodyear et al., 1982). Stocked lake trout have reportedly spawned on man-made rock piles <5 m in diameter (Marsden et al., 1995) to natural reefs as large as several km^2 (Marsden et al., 2005). While the size, depth and substrate of sites used by lake trout for spawning varies by location, areas consisting of rubble (65–256 mm) and/or cobble (257–999 mm) with interstitial spaces at least 20 cm deep and slopes ranging from 15° to 60° are thought to provide optimal spawning habitat (Fitzsimons et al., 2003; Marsden et al., 1995).

In southwestern Lake Michigan, Julian's and Waukegan reefs, two Silurian bedrock reefs approximately 14 km east and 28 km southeast of Waukegan Harbor, IL, were historically productive commercial offshore fishing sites for lake trout during fall spawning (Collinson et al., 1979). Julian's Reef was one of the last known reefs in Lake Michigan to support spawning of native lake trout and is believed to have been a significant source of natural reproduction (Goodyear et al., 1982). In an effort to restore spawning populations, Julian's Reef has received annual stockings

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since 1981 (no lake trout were stocked during 1990, 2000, and 2007), while Waukegan Reef, with the exception of 1977 through 1979 and 1997, has remained unstocked (FWS/GLFC, 2010). Recent analysis of fall lake trout assessments indicated the presence of mature female and male lake trout on both reefs during the spawning season and that the proportion of unclipped (not of hatchery origin) lake trout has been increasing since the mid-2000s (Patterson et al., 2016). Thus, both of these offshore reefs could play an important role in the successful recovery of lake trout in Illinois waters of Lake Michigan by providing suitable spawning habitat.

Greater distances from shore, increased water depth, and harsh weather conditions during the spawning season make evaluation of deep-water lake trout spawning sites difficult. However, technological advances in mapping tools have increased data collection capabilities and enabled scientists to overcome these logistical challenges, while minimizing time spent sampling in suboptimal conditions. Sidescan sonar provides images of acoustic reflectivity from surficial features at the sediment-water interface. These images can be pieced together in adjacent positions to produce a continuous map of the seafloor (mosaicing) and substrate types are discriminated through differing backscatter (reflected acoustic energy) characteristics (Meadows et al., 2005). Bathymetric data make it possible to render a three-dimensional depiction of bottom relief and can be used to evaluate localized changes in slope that represent a crucial component of lake trout spawning habitat. Combining sidescan sonar and bathymetric surveys along with substrate validation through ground truthing efforts (i.e., underwater video survey or physical substrate collection) enables detailed identification and quantification of substrate type as well as an evaluation of slope and substrate complexity, which collectively make up key components of lake trout spawning habitat.

Portions of Julian's Reef have been mapped (Holm et al., 1987; Horns et al., 1991), and subsequently data from Horns et al. (1991) were used to evaluate potential lake trout spawning habitat (Edsall et al., 1996) prior to the establishment of *Dreissena* species. In a more recent report, Redman et al. (2012) developed substrate and bathymetry maps of Julian's and Waukegan reefs, but their interpretation of suitable lake trout spawning habitat was limited by spatial analysis which relied on the intersection of ideal slope and suitable substrate information at discrete points. The purpose of this current study is to present sidescan sonar, bathymetry, and underwater video data collected previously by Redman et al. (2012) following a more rigorous and comprehensive evaluation of suitable lake trout spawning habitat at Julian's and

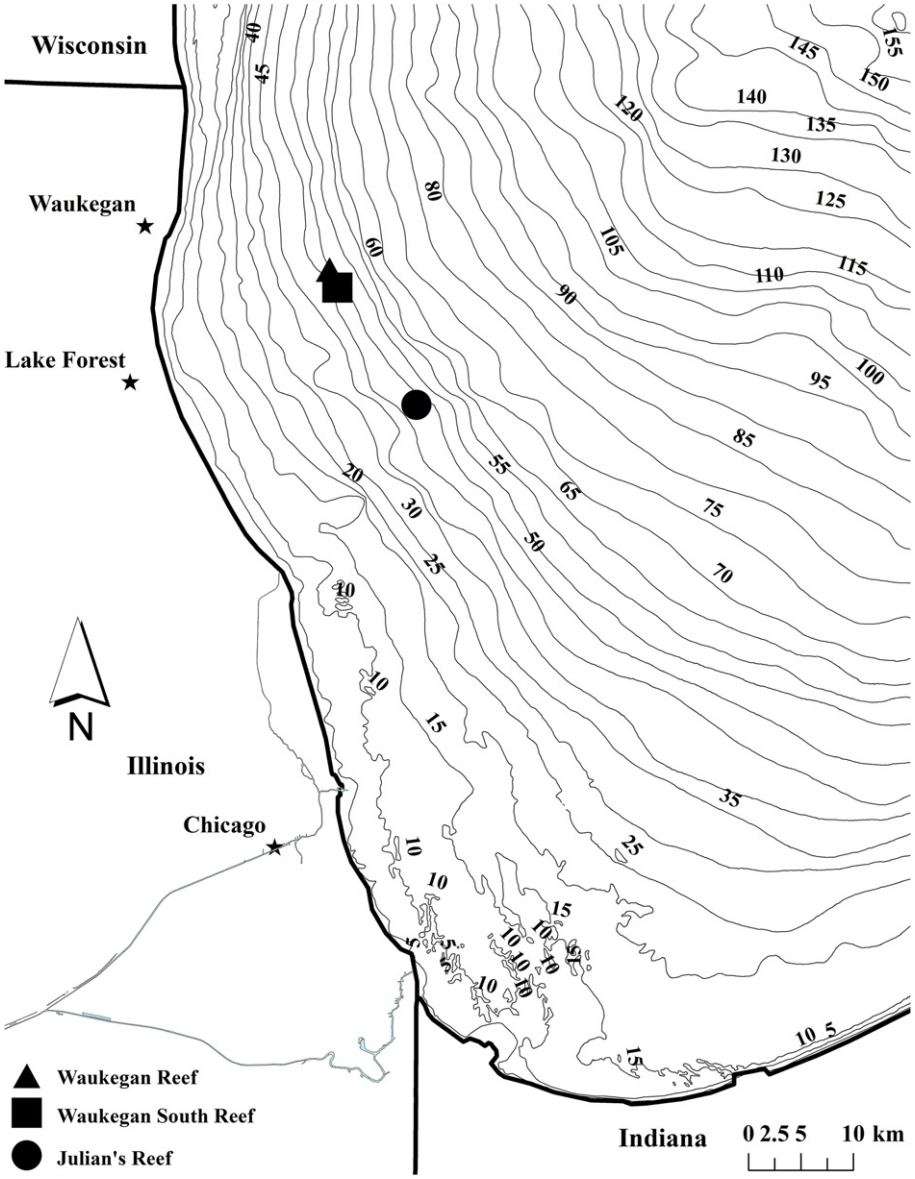

Fig. 1. Location of Julian's and Waukegan reefs and surrounding water depths (5 m contours) within the southern basin of Lake Michigan.