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Influence of fishing practices on lake trout bycatch in the Canadian lake-whitefish commercial fishery in Lake Huron

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ABSTRACT

Rehabilitation of lake trout (*Salvelinus namaycush*) populations is a priority for fisheries management in the upper Laurentian Great Lakes. In Lake Huron, lake trout are frequently caught as bycatch in the commercial fishery for lake whitefish (*Coregonus clupeaformis*). Given the frequency of lake trout capture and the importance of limiting mortality for achieving rehabilitation goals, understanding factors that affect lake trout bycatch is valuable. We used catch and effort data from commercial logbooks and onboard observer reports to assess potential effects of factors in the operation of the lake whitefish fishery on lake trout bycatch and to develop standardized indices of lake trout abundance. Factors considered in our analysis were season, mesh size, region, and license holder, which were recorded in both datasets, and set type and depth, which were only recorded in the observer dataset. In general, we found that environmental factors affected whether lake trout bycatch occurred, but that if bycatch occurred, factors related to the fishing gear affected its magnitude. Although we observed seasonal interactions with depth and mesh size, the probability of bycatch was lowest in shallow waters, and the magnitude of bycatch was lowest in shallow waters, alternative set types, and larger mesh sizes. Standardized indices of lake trout abundance from both datasets gave comparable estimates of relative trends; an increase in abundance up to 2004–2005 followed by a decline. Our findings show utility for the use of the observer dataset from the lake whitefish fishery as part of lake trout management in Lake Huron.

Introduction

Rehabilitation of lake trout (*Salvelinus namaycush*) populations is a priority for fisheries management in the upper Laurentian Great Lakes. Lake trout supported an important commercial fishery in Lake Huron from 1890 to 1940, with annual yields ranging between 2000 and 3500 mt (Baldwin et al., 2009). A combination of increased sea lamprey (*Petromyzon marinus*) predation and high fishing mortality led to the collapse of the lake trout fishery by the 1950s, and the near extirpation of lake trout in Lake Huron (Berst and Spangler, 1973; Eshenroder et al., 1995). Success of control measures for sea lamprey led to the initiation of stocking of lake trout in 1969 (Eshenroder et al., 1995), which continues to this day. A rehabilitation plan for lake trout in Lake Huron guides the process for restoring lake trout populations in the lake (Ebener, 1998; Ministry of Natural Resources and Forestry (MNRF), in press). Stocking, control of mortality from sea lamprey and fishing as well as maintaining habitat quality were identified as important steps in rebuilding lake trout populations. The overall objective for the rehabilitation plan is to achieve self-sustaining populations of lake trout that are capable of supporting harvest by 2020 (Ebener, 1998; MNRF, in press).

Lake trout are frequently caught as bycatch in the lake whitefish (*Coregonus clupeaformis*) commercial fishery, which represents a substantial source of fishing mortality for lake trout in Lake Huron. Lake whitefish harvest increased substantially from the 1970s up to a peak of 5800 mt in 1998 (Baldwin et al., 2009), and despite declining since 1998 remains the primary fishery in Lake Huron, presenting tradeoffs for managers between lake whitefish harvest and lake trout mortality. In the past, mortality rates of lake trout in the lake whitefish fishery were small compared to sea lamprey induced mortality rates (Sitar et al., 1999); however, fishing mortality of lake trout has increased in relation to sea lamprey mortality over time, and since 2000 has even surpassed sea lamprey mortality for many ages of lake trout (Ji He, Michigan Department of Natural Resources (MDNR), personal communication). Other sources of fishing mortality include recreational harvest and directed commercial harvest in treaty-ceded waters.

Management actions have been implemented to limit lake trout bycatch in the lake whitefish fishery. For example, non-tribal large-mesh gill nets were banned in Michigan waters in the 1970s, large-mesh gill net effort in treaty-ceded waters of the northern main basin has been reduced, and lake trout refuges have been established in parts of the

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lake (Ebener et al., 2008). Even with management actions to reduce lake trout bycatch in the lake whitefish fishery, concern remains about lake trout mortality, especially because limiting adult mortality has been identified as key to the protection of newly recruited wild spawning stock that has developed in Lake Huron over the past decade (He et al., 2012).

Given the relative contribution of bycatch to overall lake trout mortality, and the importance of limiting mortality for achieving rehabilitation goals, understanding factors that affect the magnitude of lake trout bycatch in the lake whitefish fishery is valuable. Management restrictions on season, mesh size, and area for the lake whitefish fishery infer that these factors affect lake trout bycatch (Ebener et al., 2008). Johnson et al. (2004) found that lake trout bycatch in gill nets was highest in the summer and lowest in the spring and fall, supporting the notion that season is important and should be accounted for when analyzing bycatch data. Similarly, the size selective nature of gill nets (Hansen et al., 1997) would suggest that the mesh-size of the nets used by the commercial fishery targeting lake whitefish could have a substantial influence on the incidental catch rate of lake trout. Additionally, the catch of lake trout is likely to be influenced on a regional basis by stocking history and intensity, and progress towards rehabilitation (i.e., natural reproduction) in that region. Other factors such as depth, set type, and practices of individual license holders have been shown to influence catch of other species and as such could reasonably be expected to affect lake trout bycatch as well (Berger et al., 2012; Deroba and Bence, 2009; Mata, 2009). Although the depth distributions of lake whitefish and lake trout are similar, they have changed over time (Riley and Adams, 2010), and fishers have suggested that lake trout harvest increases with depth. With respect to set type, preliminary findings comparing bottom set and legged gill nets, which are nets floated up from the bottom, have indicated that gear configuration can influence lake trout bycatch (Ebener, 2011). Finally, the influence of boat operator has been shown to be important for trawl fisheries (Maunder and Punt, 2004) and was also found to explain the most variation in lake whitefish harvest in gill net fisheries in the upper Great Lakes (Deroba and Bence, 2009). As such, it would seem plausible that individual fisher preferences and habits are likely to influence lake trout bycatch as well.

Catch and effort data from the lake whitefish commercial fishery in Lake Huron can be used to determine how certain factors in the operation of the fishery influence lake trout bycatch. Catch and effort data are often used to estimate relative abundance trends over time based on the assumption that catch-per-effort (CPE) is proportional to biomass (Hilborn and Walters, 1992). Yet, CPE is rarely proportional to biomass (Harley et al., 2001), in which case statistical models are used to “standardize” data by adjusting for changes in CPE caused by factors other than abundance (e.g., depth, gear, season; Maunder and Punt, 2004). Within the Great Lakes, catch data have been standardized for siscowet lake trout in Lake Superior (Mata, 2009), lake whitefish in the upper Great Lakes (Deroba and Bence, 2009), and walleye (*Sander vitreus*) in Lake Erie (Berger et al., 2012).

Lake trout CPE from the commercial lake whitefish fishery is currently used by Ontario's MNRF to infer regional trends in lake trout abundance as part of the annual quota setting process, but CPE values are not standardized and therefore do not account for changes in the operation of the fishery. Statistical catch-at-age models are currently used to model lake trout abundance in the main basin of Lake Huron. Aggregate commercial harvest and effort data is included in these models, but are not used to infer relative abundance. Rather, data from fishery independent surveys are used to scale lake trout harvests to absolute abundances (Sitar et al., 1999; Modeling Subcommittee, Technical Fisheries Committee, 2009). Although fishery independent surveys use similar gears and fishing practices that are consistent through time, they have a much smaller spatial and temporal extent than that of the commercial fishery. Fishery independent surveys also provide little information as to what factors affect bycatch of lake trout in the commercial fishery. On the other hand, bycatch of lake trout in the fishery dependent data may be inaccurate due to incomplete reporting or changes in fishing behavior to avoid lake trout (Burns and Kerr, 2008). Without accounting for these factors, reductions in reported CPE could erroneously be interpreted as a reduction in lake trout abundance when in fact some aspect of the fishery has changed.

In addition to self-reported harvest data, the MNRF maintains an onboard fishery observer program for the commercial fisheries in Lake Huron. Onboard fishery observers collect information on fishing practices that may not otherwise be reported and independently record catches of all species caught in commercial fishing efforts. The program covered 5–21% of the commercial fishery trips annually in Canadian waters of Lake Huron from 1985 to 2012. The commercial catch sampling program closely emulates the commercial fishery to the greatest extent possible; however, commercial catch samples have been unavailable for some parts of Georgian Bay and the central portion of the main basin of the lake since the mid-1990s. Although the onboard observer program is not without its own caveats, the dataset provides a previously unused data source that covers a greater spatial extent than the fishery independent surveys, and is less susceptible to reporting issues that likely affect self-reported harvest data.

In this study, we used catch and effort data on the Canadian lake whitefish fishery to develop relative indices of lake trout abundance. Our objectives were to: 1) assess potential factors in the operation of the fishery that affect lake trout bycatch in the Canadian commercial lake whitefish fishery in Lake Huron, 2) develop indices of relative abundance for lake trout based on bycatch observed by onboard fishery observers and bycatch reported in commercial logbooks, and 3) compare trends from the observer index to trends from the commercial index. Comparisons between the indices were used to infer whether the observer program comparably represented dynamics within the fishery. Having a sound understanding of factors that influence bycatch of lake trout will help managers implement effective management actions to reduce lake trout mortality while minimizing any adverse effects on the lake whitefish fishery in places where lake trout mortality has been identified as a problem.

Methods

Study site

Lake Huron is the second largest of the five Laurentian Great Lakes (Beeton et al., 1999). Lake Huron is divided by the border between the United States and Canada, and is comprised of three distinct basins: the main basin, Georgian Bay, and the North Channel (Fig. 1). Both the

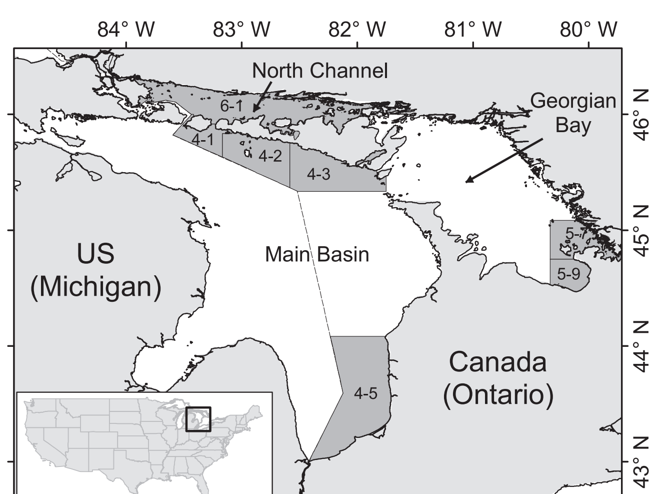

Fig. 1. Map of Lake Huron, including lake basins (main basin, Georgian Bay, and North Channel), as well as Canadian lake whitefish management units within each basin where observer data were available.