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Reconciling catch differences from multiple fishery independent gill net surveys

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ABSTRACT

Fishery independent gill net surveys provide valuable demographic information for population assessment and resource management, but relative to net construction, the effects of ancillary species, and environmental variables on focal species catch rates are poorly understood. In response, we conducted comparative deployments with three unique, inter-agency, survey gill nets used to assess walleye *Sander vitreus* in Lake Erie. We used an information-theoretic approach with Akaike's second-order information criterion (AIC_c) to evaluate linear mixed models of walleye catch as a function of net type (multifilament and two types of monofilament netting), mesh size (categorical), Secchi depth, temperature, water depth, catch of ancillary species, and interactions among selected variables. The model with the greatest weight of evidence showed that walleye catches were positively associated with potential prey and intra-guild predators and negatively associated with water depth and temperature. In addition, the multifilament net had higher average walleye catches than either of the two monofilament nets. Results from this study both help inform decisions about proposed gear changes to stock assessment surveys in Lake Erie, and advance our understanding of how multispecies associations explain variation in gill net catches. Of broader interest to fishery-independent gill net studies, effects of abiotic variables and ancillary species on focal specie's catch rates were small in comparison with net characteristics of mesh size or twine type.

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1. Introduction

For fishery independent population assessments, gill nets provide a highly selective method to capture a particular size range of fish. Gill net size selectivity is well understood on both empirical and theoretical grounds, and the size of the mesh opening relative to fish morphology (e.g., girth, potential for mouth entanglement, and presence of body protrusions such as scales and spines) primarily determines the expected size distribution of the catch (Hamley, 1975; Hansen et al., 1997; Millar and Fryer, 1999). The magnitude of the catch is dependent on many other factors including net characteristics (e.g., monofilament versus multifilament material), hang ratio, environmental conditions (e.g., turbidity, illuminance), catch of ancillary species (i.e., by-catch), and local abundance of focal species, which is typically the factor about which we wish to draw inferences (Hamley, 1975). While net characteristics and environmental effects have been the subject of many investigations (reviewed by Hamley, 1975), less attention has been paid to interactions with ancillary species (Jester, 1977; Olin et al., 2004), and the comparative influences of all these factors on the catch rate of focal species is poorly understood.

The lack of understanding of the myriad of factors that can influence gill net catch is particularly important for walleye *Sander vitreus* fishery management in Lake Erie, where the spatial segregation of different types of gill nets, obsolescence of one net type, and relatively high catches of ancillary species complicates inter-jurisdictional efforts to assess the stock with fishery independent data. Net type differences among jurisdictions exist because of historical factors with each management agency, and they persist out of concern for altering long time-series of data. One survey conducted in U.S. waters uses a net constructed with (now) obsolete

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multifilament netting, and it has been dependent upon a diminishing stock of spare netting. Thus, there is an urgent need to define how the multifilament net performs relative to commercially available monofilament nets to support a necessary gear change (Vandergoot et al., 2011). Despite some evidence that multifilament netting is more visible to fish and has lower catch efficiency (Cui et al., 1991; Henderson and Nepszy, 1992), our anecdotal observations suggest the opposite, because multifilament ensnares spines, scales and other body protrusions more efficiently than monofilament. Further, a second net type used in Canadian waters of Lake Erie is constructed of relatively thin diameter monofilament, and in contrast again with the literature (Hamley, 1975; Yokota et al., 2001) we questioned whether this net catches larger walleye less efficiently because the strands of monofilament break more easily allowing fish to escape. Finally, there is a dearth of information on the effects of ancillary species catches on focal species. Although Olin et al. (2004) observed reduced catch rates as total catch increased through time, our qualitative observations from several decades of Lake Erie gill net surveys suggested a positive correlation between ancillary species and walleye catches. This situation highlights that our understanding of focal species population dynamics might be conditioned on the population variability of ancillary species.

Our objective was to determine how gill net catch rates of walleye in Lake Erie were related to net material, mesh size, other species, and environmental factors. Here, we report on four seasons of field investigations in Lake Erie in which we deployed all three net types simultaneously for comparative analysis of abiotic and biotic variables on the catch rate of walleye. This model system illustrates both practical and fundamental issues for understanding catchability of fish in gill nets that cannot be resolved in the existing literature. We used an information-theoretic approach (Burnham and Anderson, 2002) to evaluate candidate linear mixed models of walleye catch and quantify the relative importance of key variables. We also followed management agency protocols for deployment and mesh size configuration so that the results can inform immediate practical decisions about gear differences that face Lake Erie fishery managers.

2. Materials and methods

2.1. Net descriptions and field sampling approach

Each of the three survey nets had a unique combination of mesh sizes, and the order of the panels was randomized at a previous time (the inception of each agency's survey). Multifilament nets were 1300 feet long (396 m) by 6 feet deep (1.8 m) with 13 100-foot long (30.5 m) panels with mesh sizes from 2 to 5 in. (51–127 mm, stretch measure) in 0.25-in. increments (6 mm), with a hang ratio of 0.5, and a twine diameter of 0.37 mm. The New Monofilament nets (termed so because they are intended to replace the Multifilament net; Vandergoot et al., 2011) were 1200 feet long (366 m) by 6 feet deep (1.8 m) with 12,100-foot long (30.5 m) panels with mesh sizes from 1.5 to 7 in. (38–178 mm) in 0.5-in. increments (12 mm), with a hang ratio of 0.5, and graded twine diameter. The diameters of the New Monofilament twine were 0.20 mm for 1.5 in. (38 mm) mesh, 0.28 mm for meshes 2–5 in. (51–127 mm), and 0.33 mm mesh sizes >5.5 in. (140–178 mm). The Partnership nets (termed so because it is fished cooperatively with commercial fishing industry in Ontario, Canada) were 1250 feet long (381 m) by 6 feet deep (1.8 m) with 25 50-foot long (15.2 m) panels with mesh sizes from 1.25 to 6 in. (32–152 mm), with a hang ratio of 0.5, and twine diameter of 0.23 mm. The number of panels for each mesh size varied: one panel each of 1.25 (32 mm), 1.5 (38 mm), and 1.75 (44 mm) in. mesh; two panels each of 2 (51 mm), 2.25 (57 mm), 2.5 (64 mm), 2.75 (70 mm), 3 (76 mm), 3.5 (89 mm), 4 (102 mm), 4.5 (114 mm), 5 (127 mm), 5.5 (140 mm), and 6 (152 mm) in. mesh.

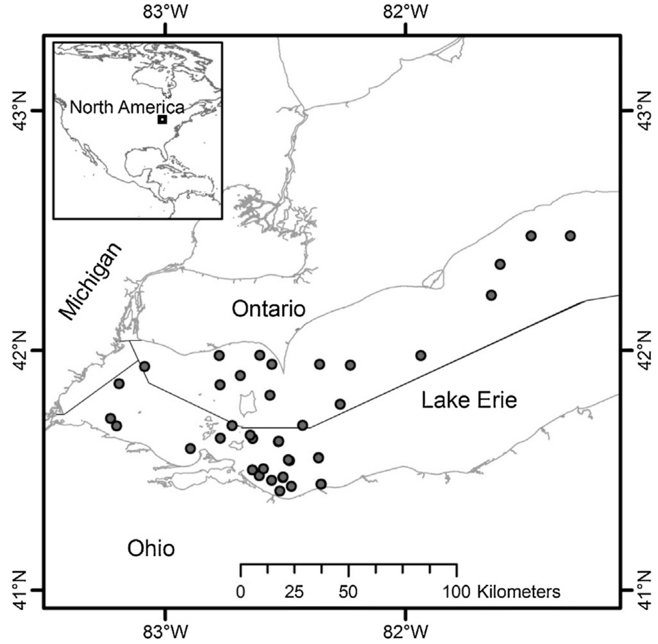

Fig. 1. Gill net sampling locations (dots) in Lake Erie showing political jurisdiction boundaries (black lines). The inset map shows the study area location (square) relative to North America.

From 2010 through 2013 during fall (September through November), all three nets were deployed overnight in a single gang at a random subset of sites (n = 48) that have been historically sampled in Ohio and Ontario waters of Lake Erie to monitor walleye populations (Fig. 1). Exceptions occurred in 2010 and 2011, when no sites in Canadian waters were sampled and in 2012 when sites (n = 9) in Canadian waters were only sampled with Multifilament and Partnership nets. Sites were distributed throughout Ohio, USA, and Ontario, Canada, jurisdictions of the western and central basins of Lake Erie. The order of nets in the gang was randomized at each site, and each net was separated by an anchor and distance of ∼60 m. According to established management agency protocols, nets were suspended from the surface by buoys with the headline at a depth of 6 feet (1.8 m). Buoys were attached between each net panel junction and on the ends of each net. Each gang of nets was deployed after noon during daylight and fished overnight. Water quality measurements (temperature, Secchi depth and dissolved oxygen) were recorded for each site on the deployment day. Captured fish were sorted by net type and mesh size, identified, measured (total length), and weighed.

2.2. Data analysis

We treated walleye as the focal species and examined catch as a function of net type (Multifilament, New Monofilament, and Partnership), water clarity (indexed by Secchi depth, continuous variable), and catch of ancillary species of selected groups (as covariates). We also included surface water temperature as a covariate based upon association with walleye catches in two previous analyses (Berger et al., 2012; Pandit et al., 2013). We did not examine dissolved oxygen effects because all of the surface water samples in our data were normoxic. The key assumption in our analysis was that the same local population of fish was available to all three nets at any particular site. Because site and inter-annual variability were expected but not of primary interest, we constructed