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Evaluating alternative harvest policies for yellow perch in southern Lake Michigan

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ABSTRACT

In the southern basin of Lake Michigan, yellow perch (*Perca flavescens*) are ecologically and economically important. However, there is no explicit harvest policy for the management of this resource, the authority for which is shared among four U.S. states. We used decision analysis and projections from a stochastic simulation model to aid managers in formulating a harvest policy. In workshops that included management agency personnel and other experts, critical uncertainties relevant to the population (e.g., alternatives for future stock–recruitment relationships and mixing of recruits among management areas) were identified as well as potential harvest policies (using constant fishing mortality or state-dependent control rules) and associated performance statistics. Our simulation model acknowledged uncertainty in the stock–recruitment relationship, parameter uncertainty given such a relationship, stochastic process variation, and uncertainty associated with assessment and implementation errors. We used the model to project age-, sex-, size-, and spatial-dynamics of the yellow perch population, and thus predicted likely distributions of performance statistics for different harvest policies. Performance statistics included time averages of recreational harvest, remaining spawning stock biomass (SSB), and length of harvested fish as well as the frequency of how often such measures were below desirable thresholds. Results indicate that state-dependent policies produce higher average harvests and lower frequency of years with low SSB, but sometimes more frequent years with low harvest, than constant-*F* policies that lead to similar depletion of average SSB.

1. Introduction

1.1. Background on the yellow perch fishery in the southern basin of Lake Michigan

Yellow perch (*Perca flavescens*) are ecologically important given their intermediate role in the aquatic food web and economically important given their contribution to Lake Michigan fisheries since the late 1800s (Wells and McLain, 1972; Wells, 1977). They are a shared resource in Lake Michigan, spanning the boundaries of four U.S. states (Wisconsin, Illinois, Indiana, and Michigan), each of which has management jurisdiction over its own waters (Fig. 1). Commercial fisheries for yellow perch have operated continuously throughout the last century (Baldwin et al., 2002), although commercial fishing has been restricted to Green Bay since 1998. In addition, yellow perch have dominated the harvests of recreational anglers in recent decades (Bence and Smith, 1999). The recreational fishery in the southern basin of Lake Michigan targets what is thought to be a distinct population from that in Green Bay (Miller, 2003). This paper evaluates harvest policies only for the yellow perch population in the southern basin of Lake Michigan (Fig. 1).

The yellow perch population in southern Lake Michigan declined substantially during the early 1990s (Marsden and Robillard, 2004; Wilberg et al., 2005). The causative factors behind the reduced abundance of the Lake Michigan yellow perch population are still not entirely clear, and multiple factors may have acted in concert to produce the observed decline (Clapp and Dettmers, 2004). Candidate factors include: unfavorable changes in zooplankton density and species composition (Bremigan et al., 2003; Clapp and Dettmers, 2004); competition, predation, and spawning interference by alewife (*Alosa pseudoharengus*; e.g., Shroyer and McComish, 2000); ecosystem alteration from zebra mussels (*Dreissena polymorpha*; Marsden and Robillard, 2004); and overfishing at levels that limited subsequent spawning potential (Wilberg et al., 2005).

To better understand and respond to the declining yellow perch population and coordinate management in Lake Michigan, the Lake Michigan Committee, the body charged with coordinating fishery management efforts on Lake Michigan, formed the Yellow Perch

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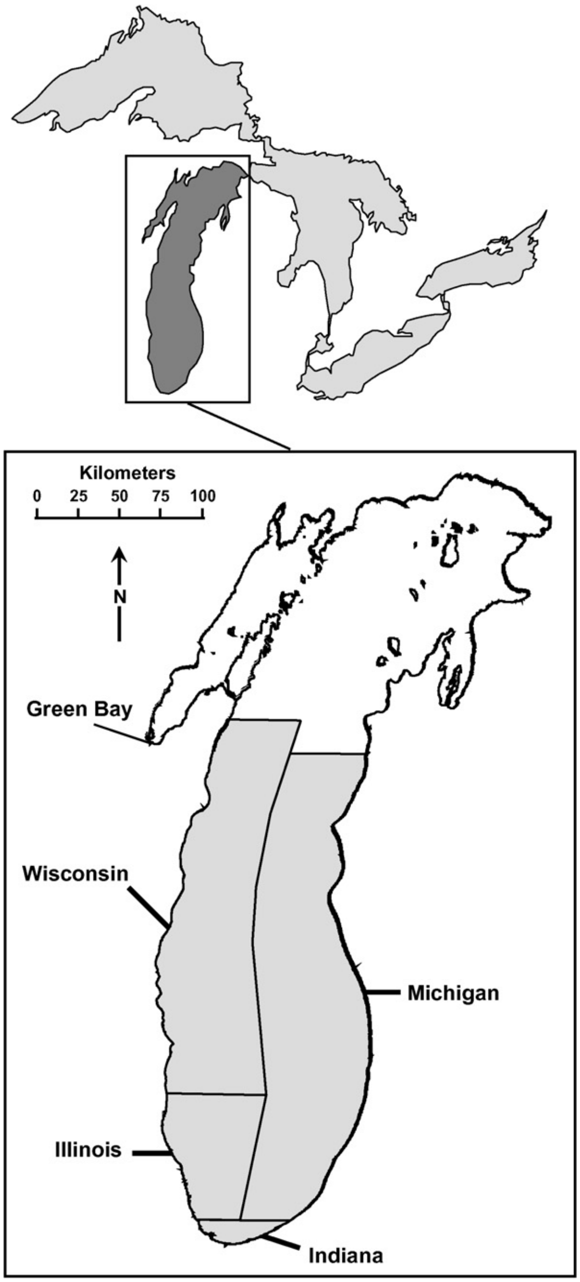

Fig. 1. Map of Lake Michigan with modeled management areas of the southern basin identified by U.S. state name. Green Bay lies outside of the modeled region and is also identified on the map. The inset shows the location of Lake Michigan in a regional map of the Laurentian Great Lakes.

Task Group (YPTG) in 1994 (Clapp and Dettmers, 2004). The YPTG includes representatives from U.S. state, U.S. federal, and tribal agencies, as well as members of academic institutions (Clapp and Dettmers, 2004). In an emergency response to reduced yellow perch abundance, more restrictive harvest limits were implemented for recreational fisheries and southern-basin commercial fisheries were closed (and continue to remain closed; Francis et al., 1996; Marsden and Robillard, 2004). The emergency restrictions of yellow perch harvest across management jurisdictions signified increased interagency cooperation (Francis et al., 1996; Clapp and Dettmers, 2004) and almost certainly helped to curtail the severity of overfishing in the short term. However, these regulations were not viewed as providing for optimal future performance for the yellow perch fishery.

For this population, critical uncertainties exist in relation to its future recruitment potential, as well as the degree of spatial independence among spawning stocks in the four management areas. Horns (2001) suggested geographic segregation of the yellow perch population based on regional differences in measurements of sagittal otoliths related to first-year growth. Conversely, Miller (2003) found little genetic differentiation among spawning groups of yellow perch within southern Lake Michigan, suggesting a single genetic stock. Adults are thought to generally remain within areas much smaller than those managed by each state, and thus most mixing of the population across management-area boundaries likely occurs during early life stages because larvae are pelagic and disperse via passive drift (Dettmers et al., 2005; Beletsky et al., 2007). As a result, mature yellow perch may be contributing to recruitment in areas other than where they reside (also see Wilberg et al., 2008). Indeed, there is substantial correlation in yellow perch recruitment among management areas (Wilberg, unpublished data), although this may also be influenced by regional-level drivers.

1.2. Decision analysis and scope of this paper

Decision analysis provides a comparative framework useful for explicitly including known uncertainties and selecting among multiple management options (Powers et al., 1975; Peterman and Anderson, 1999). The basic approach is to identify performance statistics related to broad fishery objectives, alternative management policies, and critical uncertainties, and then develop a model that predicts distributions of performance statistics that can be expected from a given policy choice. There are a number of fishery applications, including several aimed at evaluating alternative harvest polices (Robb and Peterman, 1998; Peterson and Evans, 2003; Vasconcellos, 2003; Haeseker et al., 2007). This approach is similar to management strategy evaluation (Smith et al., 1999; Sainsbury et al., 2000; Rademeyer et al., 2007). Previous fishery policy evaluations that can be described as decision analysis have integrated uncertainty about model hypotheses or parameter values into the resulting distributions of performance statistics but have generally not explicitly accounted for assessment or implementation uncertainty (but see Vasconcellos, 2003) as is more commonly done with management strategy evaluation.

In this paper, we describe the use of decision analysis to evaluate alternative harvest policies for yellow perch in the southern basin of Lake Michigan. First, we summarize a series of interactive project workshops, then describe a stochastic simulation model, and finally present and discuss comparative results across multiple performance statistics. Overall, our work was designed to provide information to the Lake Michigan Committee and its constituent agencies to allow them to select among different harvest policies to better meet their objectives for the fishery. Despite the focus on a specific application, we believe this work provides information of general interest with regard to the performance of harvest policies based on alternative control rules, as well as highlighting some of the benefits of working closely with managers during the process of model development.

2. Workshops and process of obtaining input from managers and stakeholders

2.1. Overview of the workshops

An important part of our process was to work with managers and other experts in a series of three project workshops and less formally in-between and after these workshops. The purpose of the