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Quantifying the Impacts of Climate Change on Growth, Survival, Recruitment, and Production to Enable Sustainable Management of Yellow Perch in Lake Erie

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ABSTRACT:
Environmental change is reshaping both the physical and ecological conditions of large lakes, with important implications for fish population dynamics. In Lake Erie, climate warming and changing nutrient loads have altered thermal habitats and ecosystem productivity, potentially affecting Yellow Perch (*Perca flavescens*) through multiple demographic pathways. Using high-resolution lake surface temperature data from 1995 to 2023, we quantified seasonal and spatial changes in thermal conditions in Lake Erie relative to biologically relevant thermal metrics for Yellow Perch (*Perca flavescens*), including optimal temperatures for growth, spawning, egg development, and upper lethal limits. Lake Erie has warmed substantially over this period, with the fastest warming occurring in winter and early summer and the strongest spatial trends in the eastern basin. These changes have altered thermal habitat availability in contrasting ways: thermal habitat optimal for growth declined slightly, habitat exceeding upper lethal temperatures increased markedly, and habitat optimal for reproduction showed modest increases during the spawning season. Interannual variation in spawning habitat was positively associated with recruitment in some survey indices, such as the age 1 fish from the Fall Ontario Partnership Gill Net Survey (Appendix MS 1). To link the environmental changes to population-level responses, we developed a multi-model framework linking environmental changes in population productivity to specific demographic processes. Environmental change can influence fish populations through recruitment, somatic growth, natural mortality, and overall productivity, yet most studies either assess aggregate productivity without identifying mechanisms or examine individual processes in isolation. Our framework combines models for recruitment, somatic growth, natural mortality, and environment-dependent surplus production to identify how environmental drivers affect population productivity through different pathways. We applied this approach to Yellow Perch in Lake Erie, focusing on two major environmental drivers: winter ice-on duration and nutrient loading. Both ice-on duration and nutrient loading were positively associated with population productivity, but through different mechanisms. Ice-on duration primarily enhanced productivity via increased recruitment and adult growth, with partially offsetting increases in natural mortality. In contrast, nutrient loading showed consistent positive effects across pathways, including higher recruitment, lower natural mortality, and increased growth. These results demonstrate that environmental drivers can influence fish populations through different combinations of demographic mechanisms. The proposed framework provides a structured approach for identifying the mechanisms linking environmental variability to fish population productivity (Appendix MS 2).