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Integrating the effects of environmental variability in models of population dynamics of Atlantic herring stocks in the Gulf of St. Lawrence, Canada

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It is increasingly recognized that stock assessments would benefit from ecosystem-based management to achieve long-term sustainability in marine fisheries. In the Gulf of St. Lawrence, recent studies revealed that changes in zooplankton dynamics mediated by variations in bottom-up forcing at different temporal scales could be key drivers of the productivity of Atlantic herring stocks. In particular, strong recruitment episodes that support fisheries for several years may depend on high abundance of key copepod prey during specific time windows. Consequently, our objective was to integrate the effect of bottom-up processes in analytical models of these stocks. We developed multivariate indices of the physical and biological environment using large-scale climatic indices, monitoring data (seasonal ice over, temperature, salinity) as well as zooplankton data representing key prey of herring in the region. We then incorporated these environmental variables in statistical catch-at-age models, either by introducing a direct functional relationship with biological parameters (e.g., recruitment, growth), or by defining environmental regimes for which parameters were estimated separately. Our results illustrate how integrating environmental variables can improve model fit and reduce uncertainty in parameter estimation. Moreover, the existence of distinct environmentally-driven regimes in stock productivity has direct implications for projections of future stock abundance. Therefore we projected population dynamics under different environmental scenarios to provide examples of how management strategies can account for changing climate and ecosystem conditions.

Keywords: physical environmental conditions, zooplankton dynamics, Atlantic herring, statistical catch-at-age models, recruitment, Gulf of St. Lawrence

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