

# OFFICIAL ABSTRACT and CERTIFICATION

## Environmental Effects on Pelagic Fish Using Generalized Additive Models: Clupea harengus Case Study

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The Gulf of Maine (GOM) Atlantic herring (*Clupea harengus*) stock supports major commercial fisheries and is the main source of prey and bait for groundfish. Current stock forecasts neglect climate variables, but quantifying environmental effects on herring is critical in light of climate change as the recruitment, spawning patterns, and growth rates of herring are strongly dependent on environmental variables. An investigation was completed to improve GOM Atlantic herring spawning stock biomass (SSB) forecasts by accounting for relationships between SSB and environmental variables using generalized additive models (GAMs). For the period 1988-2018, Pearson's correlations were calculated between spring and fall SSB and lagged seasonal means of temperature, salinity, and climate indices. Climate-based GAMs were developed using past SSB and any combination of 3 environmental variables ( $p < 0.05$ ) and compared with controls that only used past SSB. The 6 climate-based models with the lowest REML values for each season were evaluated with hindcasting. The top spring and fall models explained 81% and 72% of the deviance in SSB and had root mean square errors (RMSEs) of 12% and 21%, while the spring and fall controls had RMSEs of 80% and 30%, respectively. The models can make 3-year climate-based forecasts of herring SSB using available climate data and can make longer-term predictions based on predicted values of environmental variables from climate models. The forecasts can be applied to harvest control rates to help minimize the effects of climate change. Similar modeling exercises can account for environmental effects on other fish stocks.

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