

Tradeoffs and uncertainty in herring fisheries management: insights from management strategy evaluation and ecosystem modelling

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This paper analyzes the ecological and socioeconomic impacts of fishing strategies for northeast Pacific herring, and the potential tradeoffs between management objectives, in relation to herring trophodynamics and recent calls for ecosystem-based management. The operating model was constructed in Ecopath with Ecosim (EwE) for the marine ecosystem of northern British Columbia (BC, Canada). Ecological impacts of multiple herring fishing strategies were investigated with a powerful management strategy evaluation (MSE) algorithm available as a plugin for EwE. This tool accounts for ecosystem parameter uncertainty as well as stock assessment and strategy implementation errors. The MSE results indicate that both herring and predator biomasses are moderately impacted by the management strategies currently employed in BC and Alaska. The more precautionary management strategies suggested by the Lenfest Forage Fish Task Force could substantially mitigate these impacts at the cost of low catches and frequent fishery closures. A maximum sustainable yield strategy could exert noticeable impacts on both herring and predators while generating high catches and moderate fishery closure probability. The tradeoff between herring and predator biomasses on the one hand and catches and fisheries openings on the other could apparently be resolved by reducing target fishing mortality within existing management strategies. However, consideration of multiple sources of uncertainty shows that herring and predator biomasses could decrease under all strategies. By clarifying the tradeoff between ecological and socioeconomic management goals in herring fisheries management, this study identifies precautionary, ecosystem-based strategies and compromise solutions for forage fish fisheries.

Keywords: management strategy evaluation, MSE, ecosystem-based fisheries management, EBFM, ecosystem modelling, Ecopath with Ecosim, tradeoffs, forage fish, Pacific herring, *Clupea pallasii*, northeast Pacific, Canada

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