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Spaced out: Investigating the impact of spatial structure and movement under climate change using management strategy evaluation

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Abstract

Fish frequently move, and consequently are often exposed to different ecological conditions and management areas. However, fisheries management rarely accounts for fish movement when estimating stock abundance and other related quantities such as the total allowable catch and maximum sustainable yield. Misinformation or changes in movement, such as distribution shifts or altered movement rates resulting from climate change, may induce bias or increase uncertainty for managers. Using the Pacific hake fishery, we apply management strategy evaluation (MSE) to evaluate how alternative hypotheses about spatial stock structure influence robust management choices. The MSE employs closed-loop simulations with an operating model that represents real life complexity of hake biology with spatial stock structure mediated by recruitment, age-based movement rates, and fisheries selectivity. The operating model is supplemented by a single-area estimation model similar to the stock assessment model currently used for hake management. By explicitly modeling spatial structure (i.e., movement and spatial recruitment), we show that climate-change-intensified movement of adult hake may cause a median decline in total annual catch, an increase annual catch variability, and a increase in the risk of fishery closure. The results of the MSE are contextualized in regards to improving current management and assessment of spatially structured fish stocks.

Keywords:

management strategy evaluation, Pacific hake, stock assessment uncertainty, spatial distribution, climate

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