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When are biomass estimates of pelagic fishes improved by considering spatial population structure?

By its nature, a model is an approximation of natural phenomena—one that is based in part on the modelers' assumptions about those phenomena. But when might a model's assumptions be too few or too approximate for its own good? When could it stand to be a little more detailed? These questions have an added urgency when management strategies are based on models that ignore key elements of a species' natural history.

Such may be the case with the Pacific herring. Although a pelagic schooling species that aggregates by the millions, when herring spawn, their populations are spatially organized: the fish spread themselves among any number of small bays, inlets, and estuaries when they spawn. Those sites are independent from one another. Some have more fish, some are more productive, etc.

The problem comes when the models used both to assess herring stocks and determine harvest rules make incorrect assumptions about the herring population's spatial structure. This can lead to inaccurate or imprecise estimates of spawning stock biomass, mortality due to fishing, and recruitment. "Beyond the performance of stock assessment models," write Andre Punt and his coauthors in their recent paper, these mismatches "can have consequences throughout the social-ecological system, including loss of trust in management bodies and conflict..."

Punt et al. set out to show how taking a fish population's spatial structure into account helps a model make more accurate estimates of spawning stock biomass. They built a series of models to predict past and future spawning stock for a fishery that mimics the circumstances of Pacific herring in British Columbia. Following the natural history of herring, their models assumed ten sub-stocks. They then used several estimation methods that accounted for those sub-stocks in a variety of ways. One completely ignored the sub-stock structure, some grouped the stocks in different combinations, some considered each sub-stock separately.

When they ran the models under these scenarios, Punt et al. found that while all the models were generally able to capture the broad trends in spawning stock biomass, the models that did not consider the sub-stock spatial structure at all performed the worst. Importantly, when the ten sub-stocks were considered as two groups—that is, when a little spatial structure was considered—the models did not perform much better. Only when five or more sub-stocks were considered did the models' performance improve.

For Pacific herring, the implications seem fairly straightforward. "Overall," the authors write, "the results of this study further support efforts to develop spatially-structured population dynamics models for small pelagic fishes, particularly when there is a reasonable likelihood of identifying species sub-stocks for inclusion in the assessment."

January 15, 2019 Punt AE, et al. 2018. *Fisheries Research* 206:65-78