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A heuristic model of socially learned migration behavior exhibits distinctive spatial and reproductive dynamics

Knowing the ways animals move, especially when it bears on how they breed, is vital for their conservation. However, animal movement is not always well understood. For Pacific herring, many of the social, ecological, and economic benefits they provide are tied to their nearshore spawning grounds. As such, it is essential not only to understand how herring decide to spawn where they do, but also to incorporate that information into management decisions.

We know from traditional and other knowledge that herring migration behavior is socially learned. Particular herring stocks breed at known sites, and when fish head out to open water for the first time as juveniles, they join large schools. When the time comes for them to return to spawn, however, they do not necessarily return to their natal sites, as Pacific salmon do. Instead, herring seem to "learn by doing," joining older, more experienced fish and following them to their spawning areas.

What this all means from a management perspective has not been considered; managers tend to establish catch quotas based on the abundance of herring stocks when they are schooling, absent any data on the productivity of individual spawning areas. But in a recent paper, Alec MacCall and co-authors suggest some of the implications of this.

MacCall et al. compared the effects of fishing on spatially-structured species that employ one of two strategies: a diffusion migration strategy (DIFF) or, like herring, a "Go with the older fish" strategy (GWOF). For the DIFF strategy, young fish return to spawn in fixed proportions across neighboring sites, whether or not older fish are there to guide them. For GWOF, on the other hand, young fish join a school of older fish and adopt that school's migration route back to a spawning site.

When MacCall et al. ran the model under constant fishing pressure, they found the two behavioral strategies had distinct outcomes. Under the DIFF strategy, fish were more evenly dispersed around all their spawning sites. But under the GWOF strategy, some sites were highly productive, while others winked out. "Numerous such declines and local disappearances have occurred in the last three decades, necessitating implementation of a minimum stock size threshold in Pacific herring management," the authors note.

The problem is that current stock assessment and management models treat herring as if they follow the DIFF strategy, when really they follow the GWOF strategy. "This local loss of sites is potentially overlooked by standard stock assessment procedures," the authors write. "…In the case of Pacific herring, where a GWOF strategy is supported by traditional knowledge, sustainable harvest rates for Pacific herring stocks should be evaluated over periods of high and low stock productivity, where the evaluation is stock specific."

Moreover, as the authors note, under the GWOF strategy, easing fishing pressure does not necessarily lead to an immediate return of herring to abandoned sites. Re-establishment at former spawning sites may take a considerably long time. As Chief Gidansta (Guujaaw) of the Haida Nation explained to one of the authors, the impact of intense fishing on age structure can lead to a loss of migratory knowledge: "Once herring lost the elders," he said, "they lost their way to their spawning grounds."

 MacCall AD et al. 2018. *ICES Journal of Marine Science* doi:10.1093/icesjms/fsy091