Preventing collapse after catastrophe

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As the impacts of climate change escalate, ecosystems will likely undergo events that will disrupt entire populations. In marine ecosystems, anthropogenic warming has subjected organisms to elevated temperatures, oxygen loss, and acidification. The increased frequency and severity of catastrophic events may inhibit a population's ability to recover and, in turn, may spur collapse.

Mass mortality events can exacerbate the risk of extinction for species that are prone to Allee effects, particularly species harvested commercially. When species experience Allee effects, they exhibit diminished reproductive success at decreased population density. Managed fisheries frequently keep populations at low densities.

In "Catastrophic Mortality, Allee Effects, and Marine Protected Areas," published in *The American Naturalist*, Emilius A. Aalto, Fiorenza Micheli, Charles A. Boch, Jose A. Espinoza Montes, C. Broch Woodson, and Giulio A. De Leo focus on one marine species impacted by Allee effects—the green abalone (Haliotis fulgens) near Baja California Sur, Mexico. Using the Isla Natividad fishery as an example, the authors examine whether spatial management strategies are more effective than nonspatial management strategies in alleviating the damage caused by catastrophic events. In particular, the authors seek to ascertain whether designating marine protected areas (MPAs) in fisheries will help combat collapse when a population facing catastrophe is also susceptible to Allee effects.

While recent hypoxic events led to significant abalone decreases at Isla

Natividad, the "no-take reserves" in the region sustained a higher density of abalones and produced higher recruitment levels after the disruption in comparison to the areas where fishing occurs.

The authors propose that the implementation of marine protected areas (MPAs) that incorporate "no-take reserves" offers a spatial management strategy that ensures available resources to restore depleted populations and encourage recruitment in low-density areas after a disaster.

When a fishery is devastated by a mass mortality event, there are also nonspatial strategies that can be employed. A fishery, in response, could temporarily close to give the population a recovery period. The authors refer to this strategy as a "dynamic post-catastrophe fishery closure," or the DC strategy. Another option is for the fishery to forgo closing down entirely. The authors refer to this strategy as the "no-closure (NC) management strategy."

Utilizing a spatially explicit integral projection model (IPM), the authors ran simulations to determine how each of these three management strategies would influence recovery after a mass mortality event. The simulations measured the number of instances where a catch was able to return to a level above the threshold of collapse. The authors also conducted sensitivity analyses to determine how other factors, such as dispersal distance, MPA size, and catastrophe severity, impacted population recovery.

Results indicate that the implementation of MPAs significantly aids in preventing population collapse.

"Our model predicts that a network of protected areas that reduce or possibly eliminate anthropogenic disturbances can minimize the risk of population collapse caused by large-scale extreme climatic events for species whose dynamics at low density are characterized by an Allee effect. Networks of protected areas can effectively increase resilience if their size and spatial layout are able to maintain a breeding population sufficient to rebuild the reproductive potential despite the presence of Allee effects," the authors write.

More information: Emilius A. Aalto et al, Catastrophic Mortality, Allee Effects, and Marine Protected Areas, *The American Naturalist* (2019). DOI: 10.1086/701781

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