

# RESEARCH BRIEF

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## Arctic Ecosystems: Synergistic Effects of Ocean Stressors

*Synergistic interactions among multiple ecosystem stressors can greatly increase the risk of population collapse in vulnerable regions like the Arctic.*

### Background

Stressors such as overexploitation of natural resources, pollution, habitat destruction, and climate change all cause harmful ecosystem changes. These effects often interact, both amplifying and dampening impacts. In vulnerable regions such as the Arctic Ocean, warming is causing rapid ecological change and loss of sea ice is opening up a 'new ocean' for shipping, fishing, and oil exploration. These interacting stressors affect the entire ecosystem, from polar bears to phytoplankton, and are of particular concern because of the great potential for harm of their combined effects.

The world urgently needs a better understanding of how suites of multiple co-occurring stressors impact entire food webs, to anticipate possible tipping points and focus management interventions on the most harmful stressor combinations. To address this gap, researchers from multiple institutions led by Stanford University developed and applied a new model to study stressor interactions in the Chukchi Sea in the Arctic Ocean. The Arctic Ocean was selected for study because its ecosystems are simultaneously impacted by rapid changes in temperature, freshwater content, seawater chemistry, nutrient concentrations, pH, and sea ice cover. Unprecedented Arctic warming is increasing the production rate

### POINTS FOR POLICY MAKERS

- ▶ **Synergistic interactions among key stressors can cause a combined impact that is much greater than the sum of their individual effects. In some cases, accounting for synergistic interactions more than doubled the estimated population collapse for key species.** For the Pacific salmon, for example, the probability of population collapse represents a 3.7-fold increase where interactions between stressors are most synergistic.
- ▶ **As stressors increase, with escalating climate change and expanded human activities, the impact of synergies will become even more significant.** In the coming decades, the sheer magnitude and changing nature of threats present an unprecedented risk for permanent alteration of the Arctic Ocean ecosystems and ecosystem functioning. While precautionary ocean management efforts are necessary, model results suggest that local protection and management may not be sufficient.
- ▶ **Synergies make population and ecosystem responses more unpredictable.** More research into synergies among stressors is critical to allow for informed and responsible ocean management and decision-making, especially under future scenarios of climate warming and expanding human activities.
- ▶ **Chronic stressors such as sea ice loss, decreased pH, and warming are more harmful to ecosystems than acute stressors, including shipping noise and subsistence harvesting.** These results highlight the urgency of global climate mitigation and local adaptive measures.



of phytoplankton, while endangering iconic species and disrupting global ocean circulation, but how these effects combine and are potentially exacerbated by other stressors is unknown.

Using the Chukchi Sea ecosystem as a case study, researchers modeled future changes over a 20-year period and were able to account for each possible stressor-pairings' impact on each organism. The model revealed that combined stressors can have a much larger collective impact than the sum of their individual impacts.



## ABOUT THE AUTHORS



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This brief is based on the paper “**Synergistic interactions among growing stressors increase risk to an Arctic ecosystem,**” published in *Nature Communications*.

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## FOR MORE INFORMATION

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