Variations in climate conditions affect reproductive success of Antarctic krill, study finds

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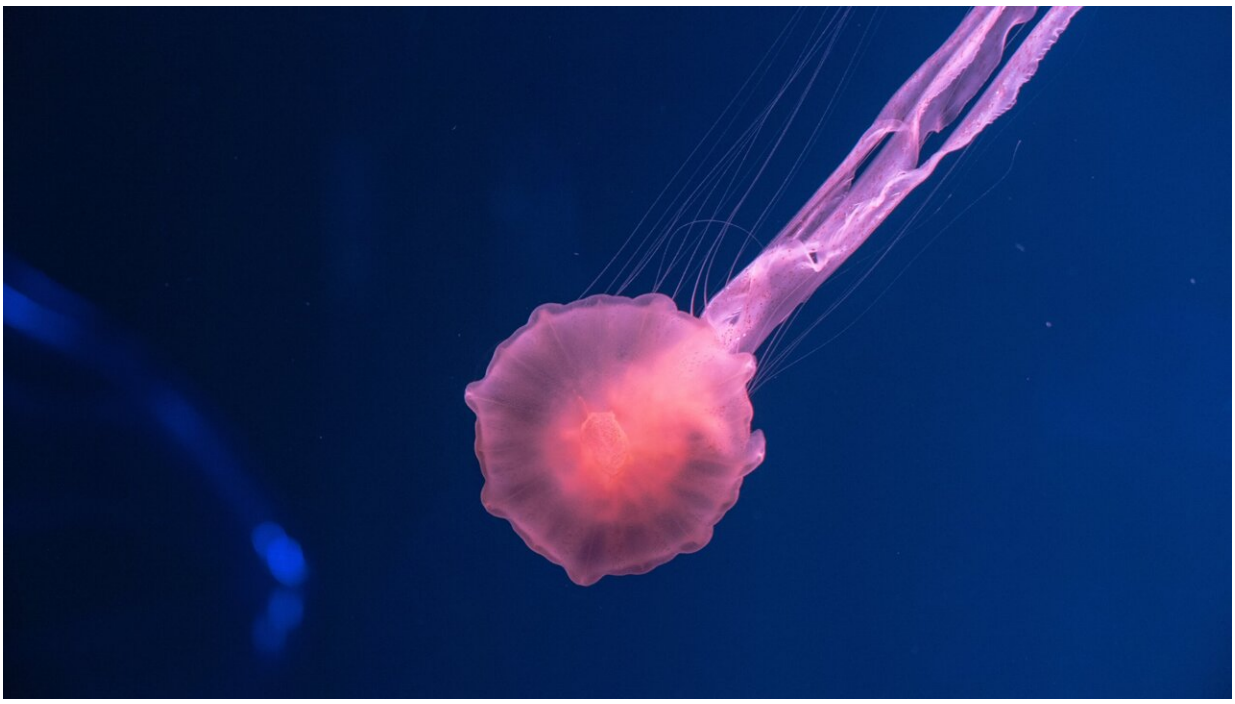

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Climate conditions play a significant role in the reproductive success of mature female Antarctic krill and are a factor in fluctuations of the population that occur every five to seven years, a new study from Oregon State University has found.

Environmental factors, including large-scale climate patterns that affect availability of food, influence the females' overall health during the spawning season. While those climate patterns are natural, they are trending warmer and more intense due to climate change, which is likely to have a negative impact on the krill population, said Kirsten Steinke, a doctoral student working with biological oceanographer Kim Bernard at Oregon State.

"This ecologically important species serves as the base of the food web in the Antarctic peninsula, supporting everything from whales to penguins to seabirds," said Steinke, the study's lead author. "Understanding the connection between the environment and population health is critical for predicting future demographic patterns and responses to climate change in the krill population."

The findings were published recently in the journal *Marine Ecology Progress Series*. Co-authors are Bernard, an associate professor in OSU's College of Earth, Ocean, and Atmospheric Sciences; and Robin M. Ross and Landgon B. Quetin of the University of California, Santa Barbara.

Antarctic krill, also known as Euphausia superba, is a type of zooplankton that can live five to seven years and grow to a length of a little more than two inches.

The western Antarctic Peninsula is home to a significant portion of Antarctic krill biomass. It is also where the bulk of the krill fishery occurs; it is the largest fishery in the Southern Ocean, with an estimated 313,000 tons harvested in 2018. Krill are used as feed for fish farms and as a source of supplements such as omega-3 oil.

"This region is critically important because it is both a popular fishing spot and one of the biggest spots for krill spawning and it is also warming more quickly than other parts of Antarctica," Steinke said.

"There has been a notable poleward contraction of the population and a decrease in population size in recent years."

Past research has shown that the Antarctic krill population fluctuates on a five- to seven-year cycle. The focus of this new research was to better understand the factors that influence the population fluctuations.

"You tend to see two years of high krill recruitment, meaning a high proportion of juvenile krill in the population, and then a crash, and then the population starts to rebound again," said Bernard, who has spent significant time in Antarctica studying krill, including a winter at Palmer Station with Steinke. "Understanding what is driving that cycle is critical."

Using krill population data from 1993 to 2008, the researchers found a relationship between the condition of the female krill of reproductive age during spawning season and the proportion of juvenile krill the following year; when mature females were in better condition, there were more juveniles in the population the next year.

The degree of krill's reproductive output is affected by the length of spawning season, batch size per female per spawning event, number of mature females in the population, the presence of older mature females in the population, or a combination of those things.

The researchers also found that fluctuations in large-scale climate patterns and seasonal variations in the climate are the predominant drivers of the health of mature female krill during spawning season.

The climate in the western Antarctic Peninsula is primarily driven by the Southern Annual Mode, or SAM, and the Multivariate El Niño Southern Oscillation Index, or MEI. Both of these climate patterns have the ability to affect the availability of food for Antarctic krill, and in particular,

resources for the mature females.

SAM and MEI are natural climate patterns but they are changing as the planet warms. The SAM in particular has been trending positive, meaning it has been warmer and more intense. That positive phase is projected to continue under climate change, Bernard said.

"The SAM was found to be really important to driving the health of the female krill," she said. "As the SAM continues to trend positive, it will continue to get warmer, and that suggests a negative effect on the overall condition of female krill during their spawning season."

The researchers also found that seasonal variations in the SAM and the MEI can affect the health of mature female krill. That is likely due to the way that the SAM and MEI are known to affect environmental conditions, Bernard said. Overall, warmer conditions tend to have a negative impact on the health of female krill of reproductive age, but those impacts can vary depending on the season in which they occur.

Understanding those nuances could help fisheries managers make decisions when conditions in spring, fall or winter lead to a less than ideal spawning season. The research underscores the importance of considering the impact of climate change as part of fisheries management for Antarctic krill, Bernard said.

"It is really critical to start including climate change impacts as part of the plan," Bernard said. "Antarctic krill are a super unique and fascinating species. So many predators feed on them. If you have a collapse of the krill population, you would be putting all of those populations at risk."

Adélie penguins, for example, feed on the mature, female krill, because they are rich in lipids, a nutritional benefit that helps penguin chicks

survive their first year.

"If there are a lot of mature female krill, the chicks can bulk up and survive the winter," Bernard said. "But the Adélie penguin population has plummeted at the northern parts of the Antarctic Peninsula in recent years, in part because of changes in the krill population."

More information: KB Steinke et al, Environmental drivers of the physiological condition of mature female Antarctic krill during the spawning season: implications for krill recruitment, *Marine Ecology Progress Series* (2021). DOI: 10.3354/meps13720

Provided by Oregon State University