Study offers hope for the resilience of the American lobster fishery

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Ph.D. candidate Abigail Sisti works in the Seawater Research Lab at VIMS. Credit: Brittany Jellison

According to a study by researchers at William & Mary's Batten School of Coastal & Marine Sciences, the American lobster may be more resilient to the effects of climate change than expected. For the first time, experiments performed at the Virginia Institute of Marine Science (VIMS) have documented how female American lobsters groom their

offspring, providing evidence that these behaviors are not significantly impacted by temperature and acidity levels forecasted for Maine's coastal waters by the end of the century.

The findings are published in the journal *Marine Ecology Progress Series*.

Despite being one of the largest commercial fisheries in the U.S. with an annual economic impact of more than $460 million in Maine alone, few studies have documented the reproductive behavior of female American lobsters. With the Gulf of Maine warming faster than nearly any other ocean surface on the planet, it's important to understand how the effects of climate change will impact the sustainability of the species and the fishery it supports.

"Brood grooming by female lobsters has been anecdotally observed, but it had not been quantitatively recorded before," said Abigail Sisti, who is completing her Ph.D. in Marine Science at the Batten School and is lead author on the study. "In other crustaceans, these behaviors can have a significant impact on the survival of their offspring. Because the environment supporting the lobster fishery is rapidly changing, we wanted to understand how it might impact the way they care for their offspring."

Female American lobsters can produce thousands of eggs that they hold under their tails for long periods of time, between five to 12 months, as the embryos develop. In other crustaceans, grooming behaviors help clear out parasites, remove dead eggs and facilitate the flow of water carrying oxygen and nutrients through the densely packed egg masses.

The study was part of a larger effort to determine how multiple stressors affect the reproductive success of the species. In this study, the researchers were testing whether increases in water temperatures and acidity had an impact on grooming behaviors and embryo survival.

"The long-term nature of this experiment required somewhat of a moonshot approach," said Rivest, whose seawater aquarium laboratory at VIMS has been specifically designed to control multiple environmental variables over long periods of time. "The conditions of our control group were set to match current conditions in the Gulf of Maine, while our experimental groups corresponded to temperature and pH predictions for the end of the century."

In addition to their research outcomes, Sisti and others produced an educational curriculum to involve students and teachers in the research. The research as well as the lesson plans are documented through a story map produced by the National Oceanic and Atmospheric Administration's Sea Grant and Ocean Acidification Program.

Documenting grooming behavior

The researchers partnered with officials from Maine's Department of Marine Resources to secure lobsters from commercial operations for use in the study. They obtained female lobsters at a marketable size with intact legs, which are frequently lost in the wild or when they are caught. In total, they observed the behavior of 24 lobsters for five months, or until the embryos matured. Sisti and other students had the daunting task of reviewing dozens of hours of recordings from underwater cameras and documenting the frequency and type of grooming behaviors as well as the overall survival of the embryos.

Lobsters in experimental groups experienced temperature increases of 4 degrees Celsius and acidification levels of -0.5 pH from present conditions. Oxygen levels remained constant for all animals to isolate the effects of temperature and acidity.

Rivest, Sisti and others expected to observe several different grooming behaviors, and they hypothesized that grooming would increase in

response to environmental stressors.

"We did observe a number of grooming behaviors that increased in frequency during embryo development," said Sisti. "However, neither water temperature nor acidification at the levels in our experiments caused significant behavioral changes or impacted embryo survival. This is encouraging because it shows lobsters may be reproductively resilient to forecasted environmental changes."

Three distinct grooming behaviors were observed by the researchers:

- Tail fanning, where the lobsters elongate and retract their tails. This promotes water movement throughout the eggs.
- Pleopod fanning, where the lobsters use small fins called pleopods on their tails to circulate water around and through the egg mass.
- Pereopod probing, where lobsters use one of their five pereopods, or walking legs, to poke and probe the eggs. This is thought to help remove parasites and dead eggs while jostling the embryos, although excessive probing can damage embryos or completely strip the egg mass.

Despite the optimistic outcomes, questions remain

The researchers are optimistic about the results of the study for the future of the fishery. However, they caution there are still many other variables to consider.

"While this study focused primarily on maternal behavior, future studies will explore other factors like how the embryos themselves are affected over time by different stressors," said Rivest. "We also want to explore how these factors are impacting the overall well-being of egg-bearing female lobsters as well as conditions that exist in microenvironments

frequented by lobsters."

The variables in the study were determined using forecasts for open ocean conditions. However, wild lobsters often prefer specific habitats like rock crevices and sand mounds that provide cover from predators. There, the conditions may differ dramatically from those in open water.

"In our experiments, control temperatures were akin to spring and summertime conditions in the Gulf of Maine, which may have accelerated embryo development. We recommend future experiments explore behavioral changes during winter-time conditions," said Sisti.

While questions remain, these are positive findings for the American lobster. However, they stand in contrast to findings in other crustacean species.

"Our results highlight the need for species-specific investigations of behavior and reproduction under climate change conditions," said Rivest. "Further understanding of how co-occurring environmental factors influence all aspects of reproduction will be essential for predicting and managing the long-term success of the American lobster fishery."

More information: AR Sisti et al, Brood-grooming behavior of American lobsters Homarus americanus in conditions of ocean warming and acidification, *Marine Ecology Progress Series* (2024). DOI: 10.3354/meps14667

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