Distribution of Limpet Genera Across Chemosynthetic Oases

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Introduction to Oceanography

Research Question & Background

Deep sea hydrothermal vents were first discovered in 1977 by scientists exploring the Galápagos Rift along the mid-ocean ridge in the eastern Pacific.

Hydrothermal vents are like geysers on the ocean floor, starting out as superheated sea water and dissolved minerals exiting the ocean crust, and as the minerals cool and solidify into mineral deposits, they form different types of hydrothermal vent structures.

The conversion of mineral-rich hydrothermal fluid into energy is a key aspect of these unique ecosystems. Through the process of chemosynthesis, bacteria provide energy and nutrients to vent species without the need for sunlight.

Limpets, marine gastropod mollusks made notable by their ability to populate in large masses even in the most extreme ocean environments, are seen just about all over the ocean. They reside in large numbers across Europe, East Asia, and the Americas, and are vital in keeping the algae populations low in their environments, preventing algal colonization (Dipper, 2022).

Limpets' large biomass in chemosynthetic regions leads to it being one of the most consistently documented hydrothermal, cold seep, and whale-fall marine animals.

For our research project we asked what are the distribution of Cocculina and Bathyacmaea limpets across deep sea hydrothermal vents and cold seeps, and what do their distributions tell us about their evolution?

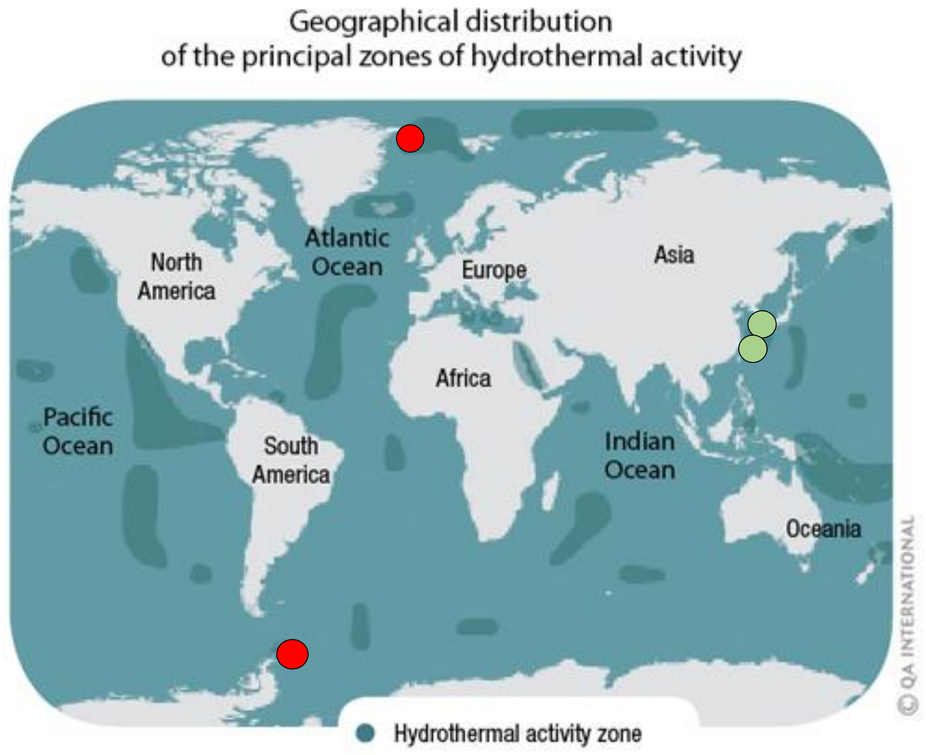

Figure 1. Known locations of Cocculina and Bathyacmaea limpets in hydrothermal vent fields and cold seeps

Methods

We performed a literature review of articles relating to limpets identified at chemosynthetic sites.

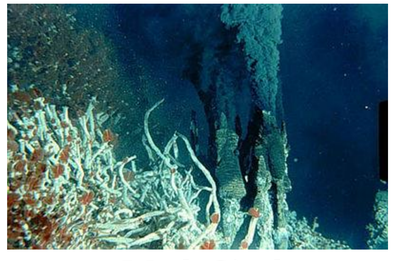

Figure 2. A hydrothermal vent along the Juan de Fuca Ridge

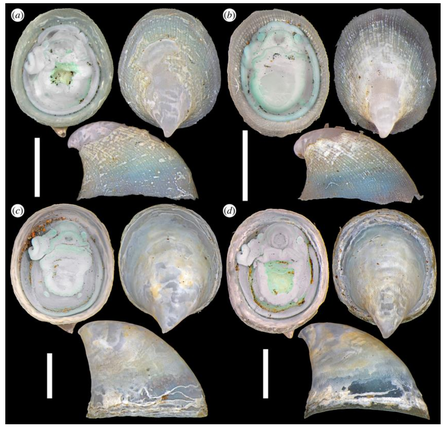

Figure 3. Cocculina aurora, a new species of limpet recently discovered in the Aurora vent field near Greenland.

Discussion

Cocculina

- The order Patellogastropoda, aka "true limpets", contains most limpet species forms a separate evolutionary "branch" from all other gastropods
- Cocculina limpets belong to the order Cocculinida, meaning they evolved separately from all Patellogastropoda limpets
- Cocculinida limpets typically live on sunken wood, bones, and other organic material at the bottom of the ocean
- Two new Cocculina species were recently discovered in hydrothermal vents
- The species were found on opposite sides of the world. *Cocculina aurora* was discovered in the Aurora vent field near the north pole, while *Cocculina enigmadonta* was found in the Arctic vent circle near the south pole
- These limpets likely came from nearby wood and whale falls and evolved to form new species when they dispersed to hydrothermal vent sites
- Most Cocculina species diet consists of wood and have large, strong outer teeth on their radula, or tongue, to for chewing wood. However, *C. aurora*'s diet is made up of bacteria and they have smaller outer teeth that are better adapted to contact vent surfaces where bacteria is found (Evans, 2022).

Bathyacmaea

- Bathyacmaea limpets are a genus in the order Patellogastropoda which are found mainly along the coasts of Japan and China in hydrothermal vents and cold seeps
- The species *Bathyacmaea nipponica* originally formed two genetic groups; one in the Kuroshima Knoll, and the second in the deeper Jialong Ridge
- Its thought larvae from the Kuroshima Knoll got swept up in the changing Kuroshio Current in the North Pacific, which shifted directions slightly during the glacial age, and entered the Okinawa Trough, eventually forming a third distinct genetic group there. (Yang et. Al, 2022)
- The group from Jiaolong Ridge recently split into two distinct groups in Jiaolong Ridge and Sagami Bay, forming a total of four genetically distinct limpet groups in the area. The barrier effect of the Luzon Strait and a reduction of methane over time in the Jiaolong ridge seep are likely preventing the populations from mating and caused the genetic divergence (Xu et. al, 2021)
- Another research group classified the limpets between the South China Sea and Sagami Bay as belonging to the same species with highly variable morphology (Chen et al., 2019)

Conclusion

From their locations on opposite poles, we can conclude that *C. aurora* and *C. enigmadonta* evolved separately of each other. Both species are hypothesized to have migrated to hydrothermal vent sites from nearby wood falls and have adapted to the new ecosystem.

Regardless of their classification, the Bathyacmaea genus has spread through the area on ocean currents and evolved distinct morphology and genetics as they distribute further.

Acknowledgements

We want to thank Monica Riess for their helpful guidance through the research process this quarter.

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