Temperature effects on cavitation bubble dynamics of snapping shrimp (*Alpheus heterochaelis*)

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Introduction

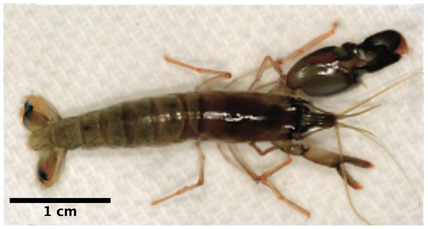


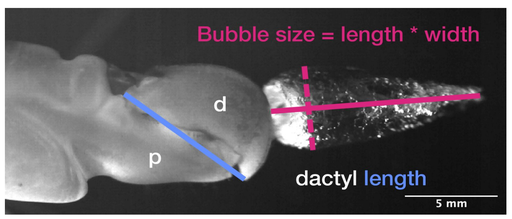
Image: *Alpheus heterochaelis*; Photo credit: Ben Schelling

- Snapping shrimp produce high intensity sounds via the collapse of cavitation bubbles generated from ultrafast strikes.[1]
- Snaps are important acoustic signals used by many marine taxa and can dominate coastal marine soundscapes.[2, 3, 4]
- Snap rate is positively correlated with temperature and sound pressure levels (SPL) of the local soundscape.[2, 3]

How does temperature affect:
a) cavitation bubble size and duration,
b) and sound production?

Materials & methods

- Collected shrimp at an intertidal oyster reef in Beaufort, NC (March–April 2022).
- Experimentally prompted snaps in natural temperatures (12-30°C; 33 individuals; n = 311 snaps), and in a projected +2°C rise in sea temperature (climate change) treatment (33°C; 9 individuals; n = 77 snaps).
- Filmed with high-speed camera and hydrophone; digitized footage to measure maximum bubble size and SPL.



- Used AIC for linear mixed model selection.

Δ AIC = (null hypothesis AIC – linear mixed model AIC)
*** Δ AIC > 10.0; ** Δ AIC > 6.0; * Δ AIC > 2.0
* = Significance (Sig.)

Results

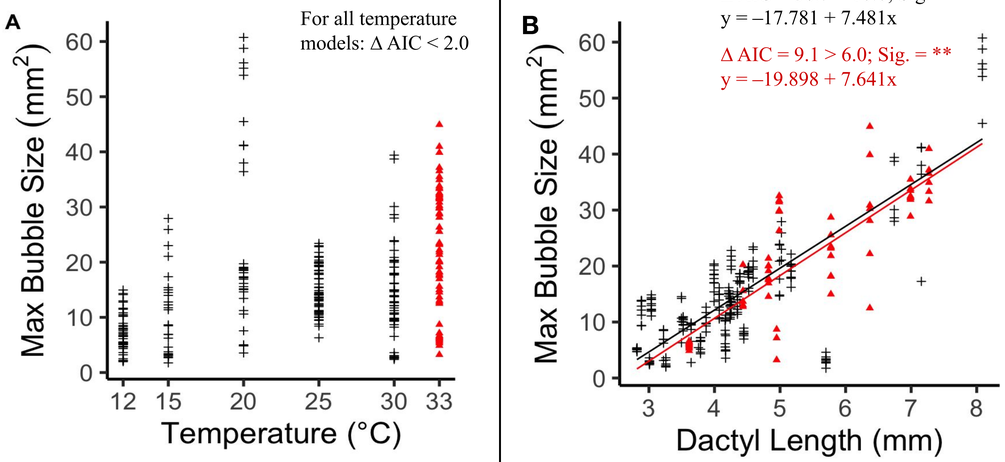
- Snapping shrimp were able to produce cavitation bubbles and consistent SPLs at all temperature treatments (12-33°C).

1. Temperature did not significantly predict SPL or any bubble metric:

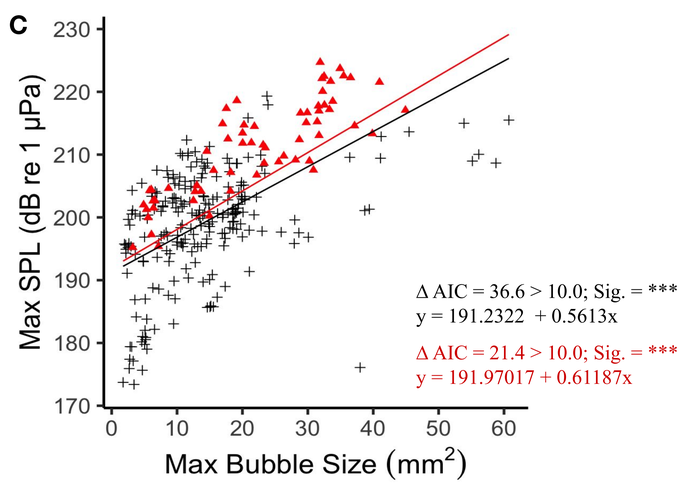
- bubble size (Fig. A);
- distance;
- and growth, collapse, and rebound durations.

2. Larger claws produced larger bubbles.

- Dactyl length was positively correlated with bubble size (Fig.B).
- Dactyl size was not a significant predictor of SPL.



3. Larger bubbles produced louder sounds.



- The 33°C treatment observations align with the positive linear correlations found in the 12-30°C treatments, indicating temperature does not influence bubble dynamics and sound production.

Discussion

- The temperature change between 12-33°C is likely negligible to the physical mechanisms of cavitation bubbles and sound generation, but, has behavioral impacts on snapping shrimp acoustic outputs (e.g., snap rates[3]).
- Snapping shrimp morphology has a direct impact on bubble dynamics and sound production, particularly claw size.
- Animal populations tend to have smaller body sizes in warmer temperatures (temperature-size-rule[5]); in elevated temperatures from climate change, snapping shrimp colonies' average body size may be smaller, and thereby produce quieter snaps but at higher rates.
- This study used short acclimation periods (24 and 72 hours) that may better reflect short-term temperature variation. Further studies could test body size and sound production in long-term exposure to warmer temperatures.
- The impact of changes to snapping shrimp acoustic outputs is unknown. Further research is needed on the impact of acoustic changes on marine taxa and at ecosystem levels.

References

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