Quantifying Temperature Dependence of Planktonic Herbivores Growth Rates

Rhode Island NSF EPSCoR

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Motivation

Herbivorous protists (HP) are the major consumers of primary production in the ocean and key mediators of biogeochemical cycles [1,2,3]. Lack of knowledge of temperature sensitivity of HP physiological rates can preclude insights into cross-biome comparisons and future primary production trends. Data for HP growth rates at temperatures <5°C are virtually non-existent. Empirically-rooted algorithms of plankton physiology are essential to accurately model food webs, ecosystem function and global biogeochemical cycles [e.g.4]. This study will fill critical knowledge gap providing data for robust and dependable predictions of herbivorous protist growth rates for polar and winter time waters.

Functional and Numerical Response of Laboratory Cultures

Growth rates (μ) of three heterotrophs culture were determined at seven incubation temperatures 0, 2, 5, 10, 15, 18, 22°C. Cultures were gradually moved from the initial temperature of 15°C across the range of target temperatures with transitions that never exceeded 2°C and proceeded only after at least 3 divisions were completed. Changes in cell concentration and biovolume over 24h were used to determine *O. marina*, *G. dominans* and *P. bipes* growth rates based on abundance and biomass.

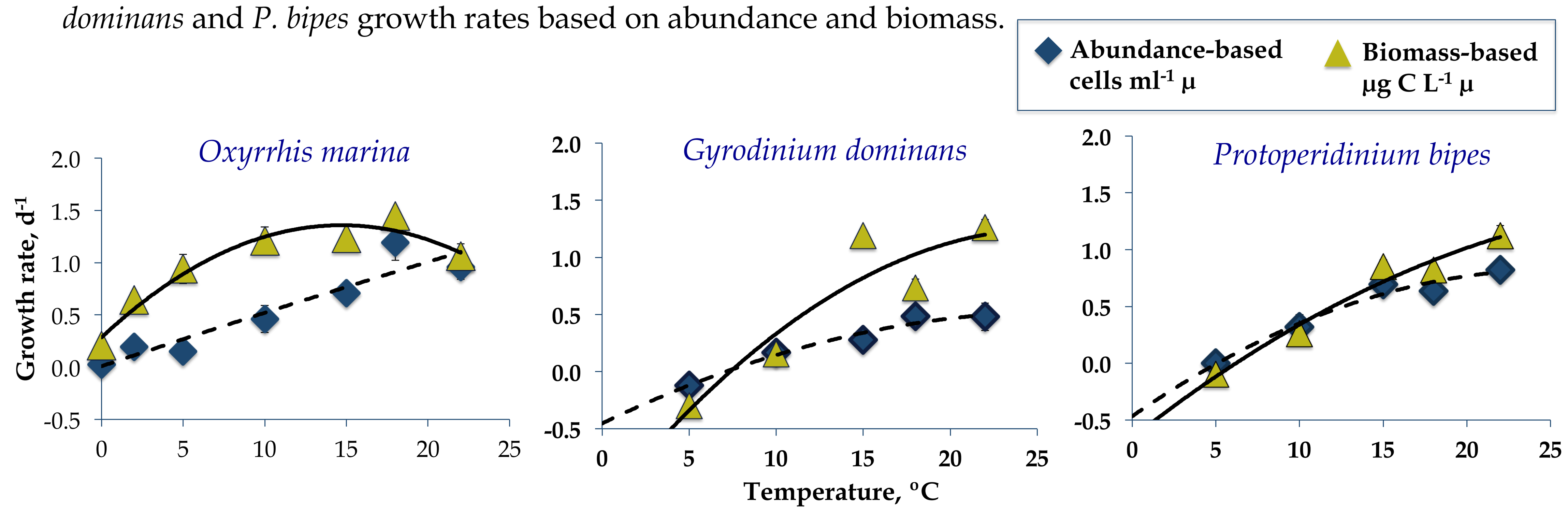

Figure 1: Increased growth rates with increasing temperature was observed for all three heterotrophic species. For some species, estimates differed significantly depending on whether rate estimates were based on abundance (cells ml^{-1}) or biomass (μg C L^{-1}).

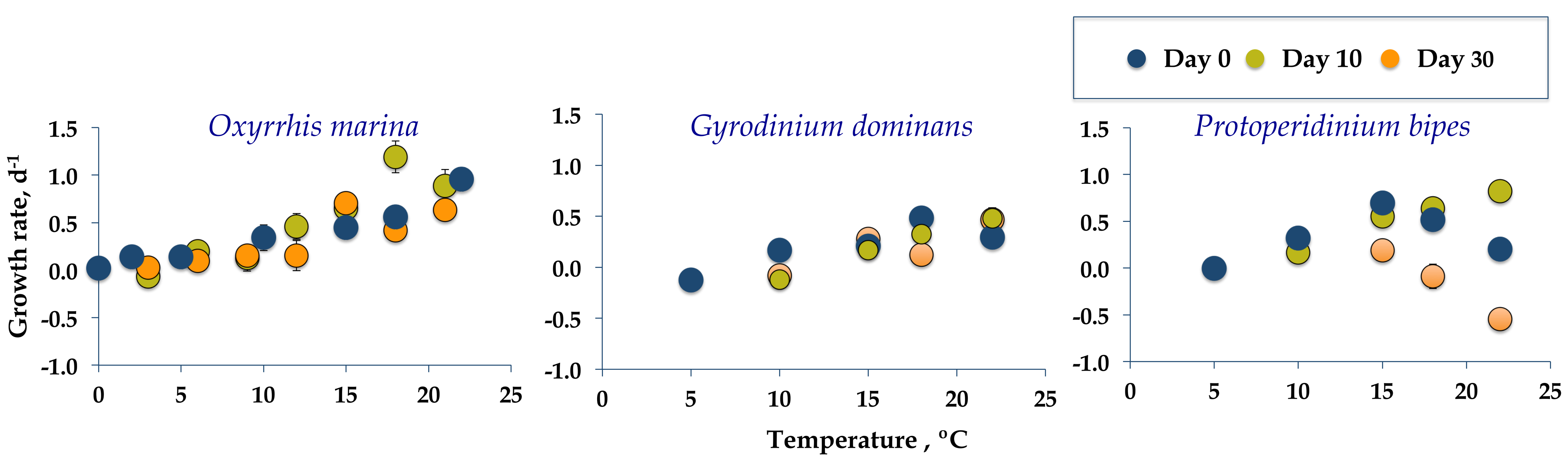

Figure 2. Herbivores exposed to sequential temperature shifts of 2 °C over the entire range of ocean surface temperatures showed a general excellent capacity to grow at a broad range of temperatures and sustain that growth over periods of up to a month. Only *O. marina* grew at all temperatures it was exposed to. *P. bipes* tolerated only a 10 day shift from the initial temperature.

Temperature Sensitivity of New Heterotrophic Isolates

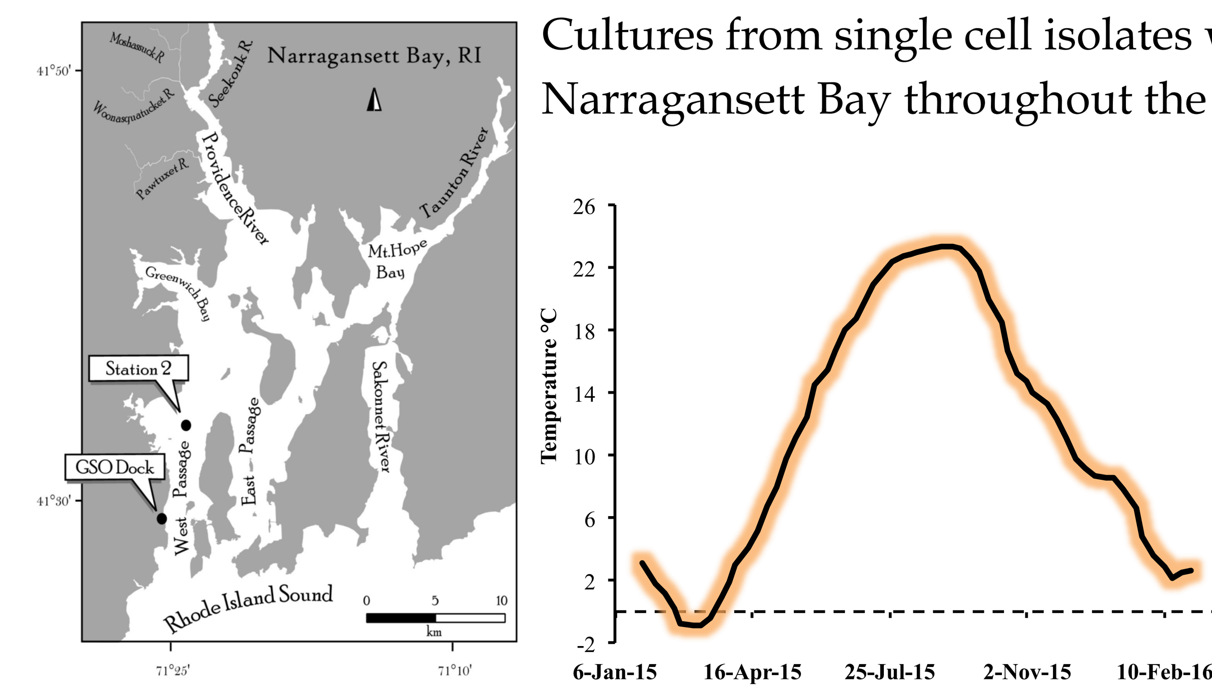

Figure 3

Cultures from single cell isolates were established from weekly samples in Narragansett Bay throughout the seasonal cycle (Fig.3), assuring that the new heterotrophic isolates were both cold and warm-adapted species. The successful isolates were used to perform temperature dependence growth experiments at collection temperature and at a range of temperature covering at least Δ -4°C and Δ +4°C.

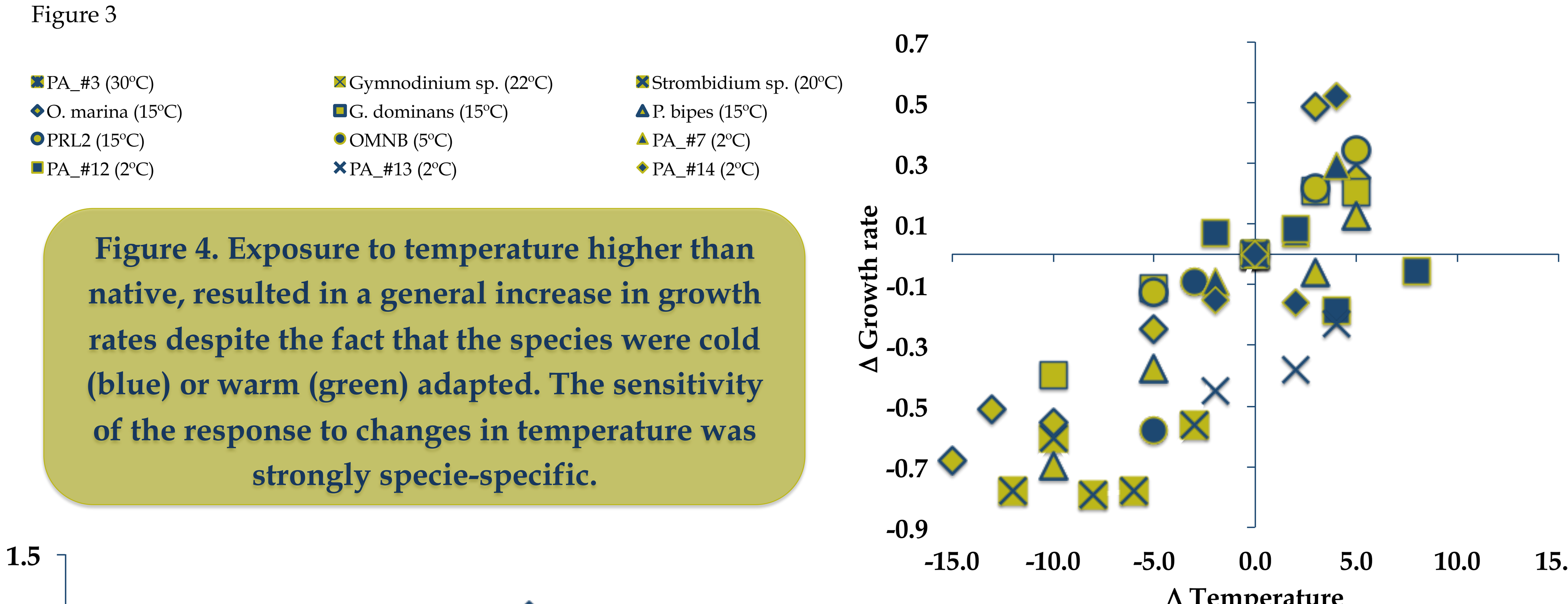

Figure 4. Exposure to temperature higher than native, resulted in a general increase in growth rates despite the fact that the species were cold (blue) or warm (green) adapted. The sensitivity of the response to changes in temperature was strongly specie-specific.

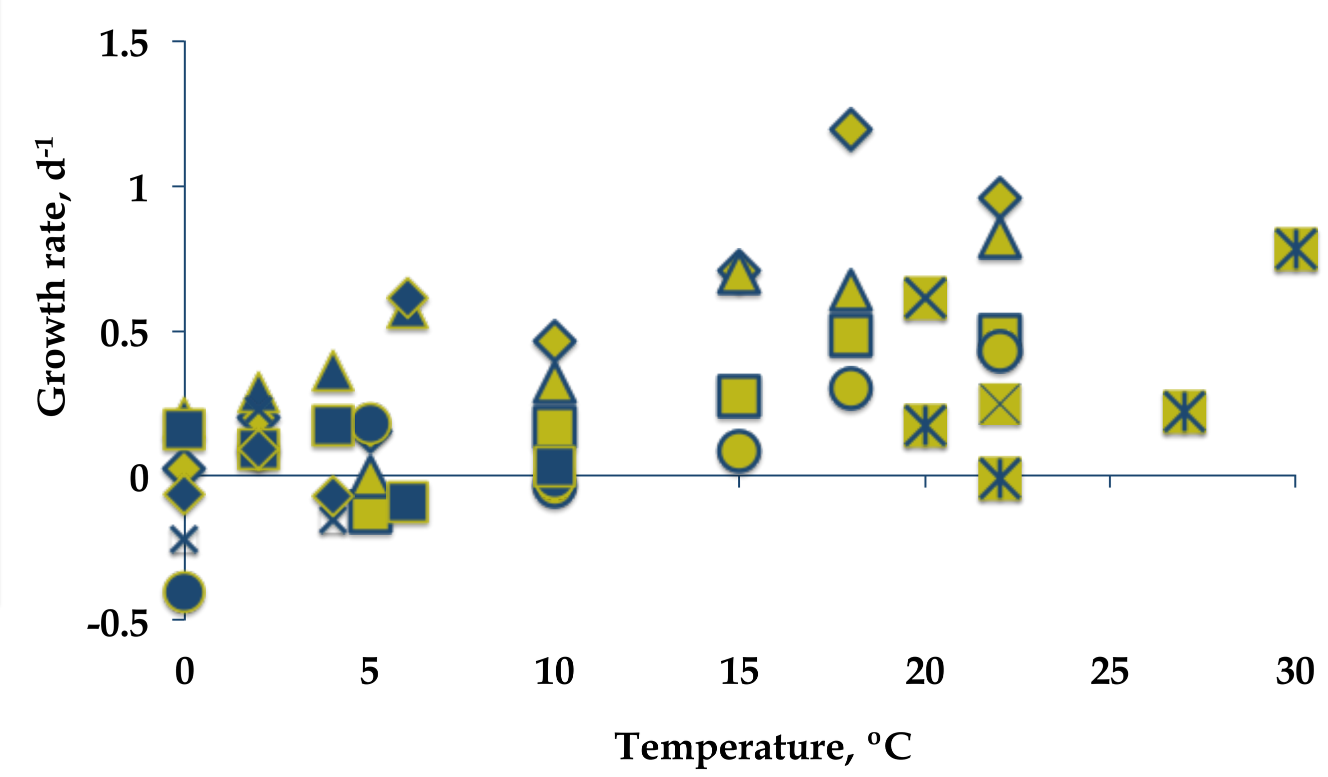

Figure 5. Despite the general decrease in growth rates with decreasing temperature, very few isolates failed to grow at lower temperature. Heterotrophic ciliates and dinoflagellates grew at temperature ≤6°C at rates ranging between 0.03±0.08 d^{-1} and 0.61±0.11 d^{-1}.

Conclusions

- HP adapted to colder temperature can grow at rates comparable to temperate species.
- Biomass-based growth rates, rather than abundance based rates, can provide more appropriate dynamics when modeling carbon flux in the ocean.
- Species-specific differences in HP acclimation capacity to lower and higher temperatures have implications for microbial food web structure and function.
- These empirically rooted estimates will enable integration of grazing losses over the global range of sea surface temperatures and eliminate bias in assessing food web dynamics in polar waters and wintertime conditions.

Acknowledgments

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References

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