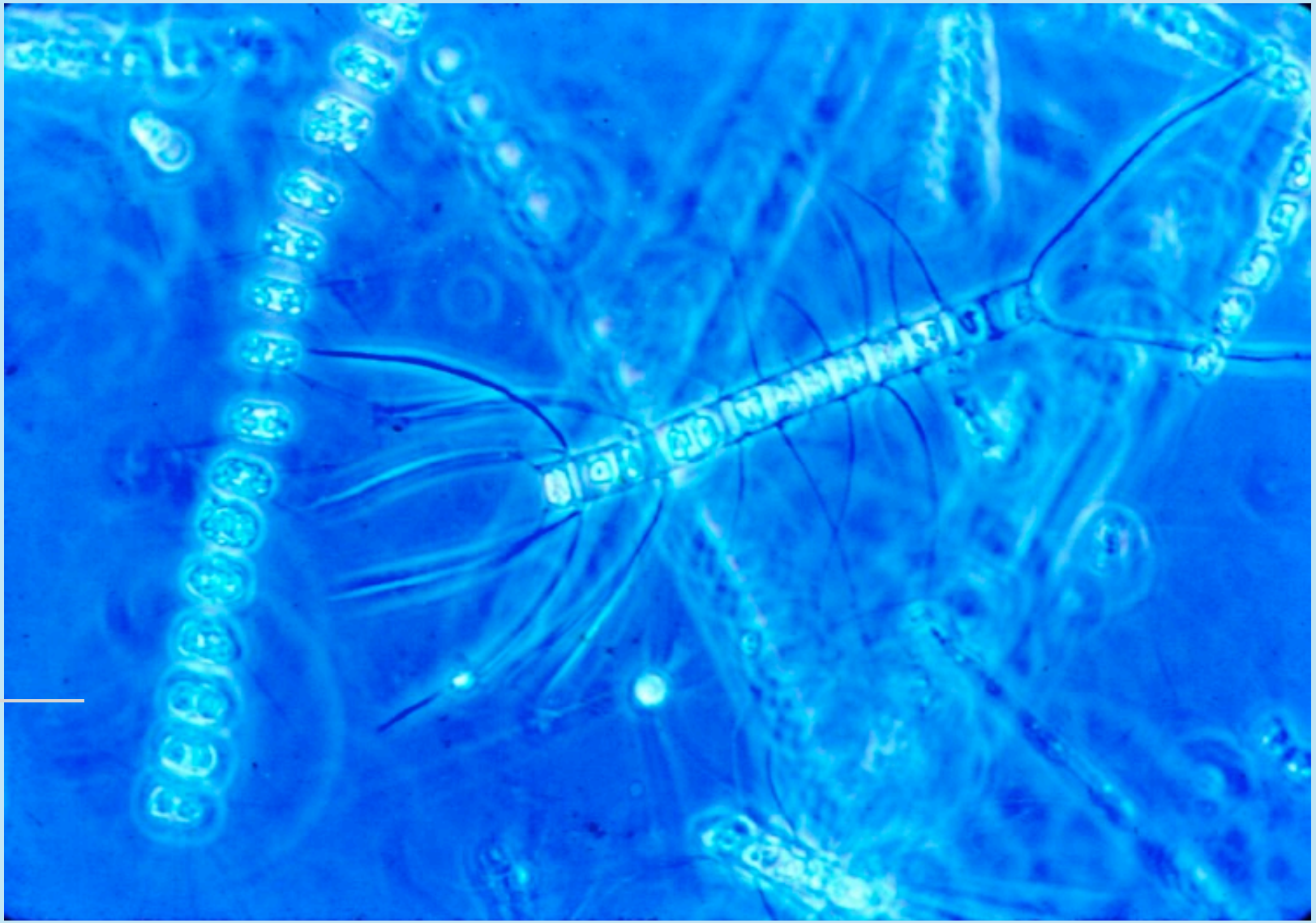
Phytoplankton Research Challenges and Priorities in a Changing Ocean

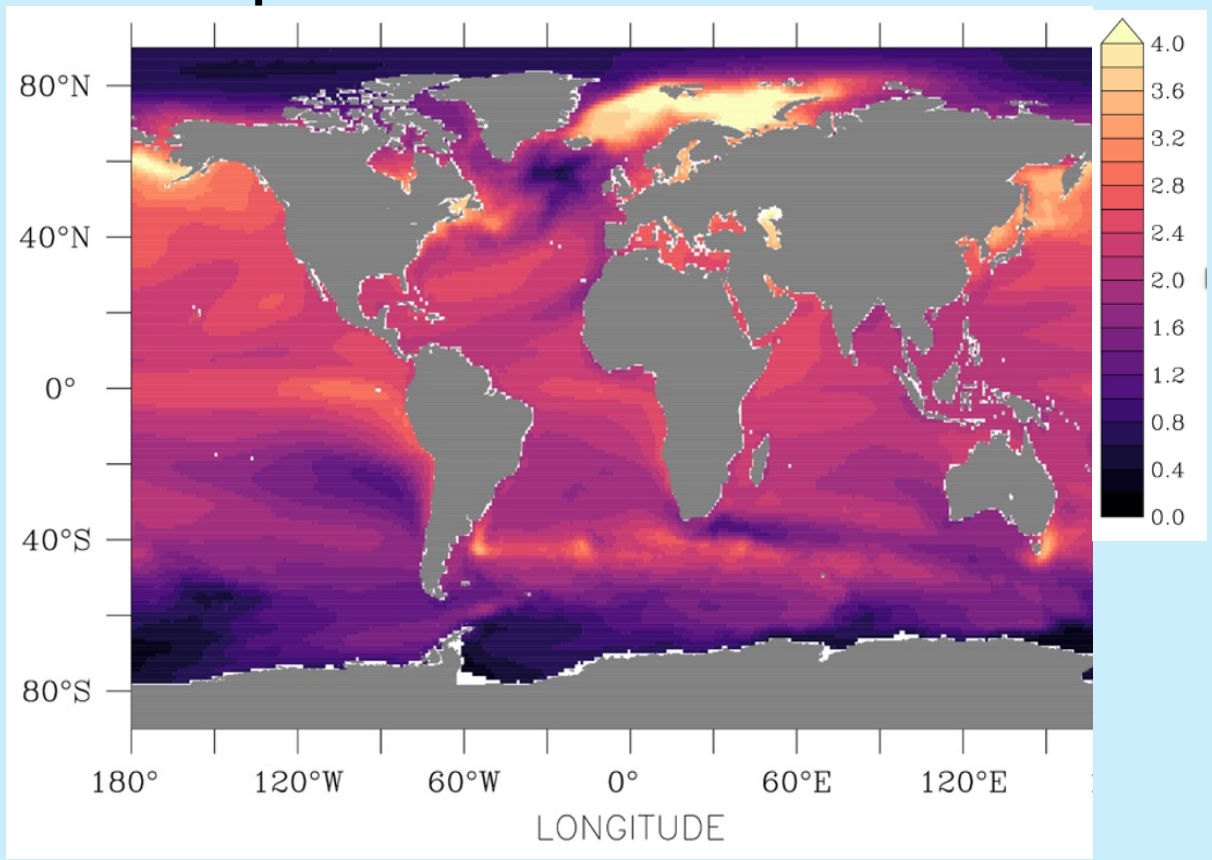


Dave Hutchins

University of Southern California

Ocean warming, future and current

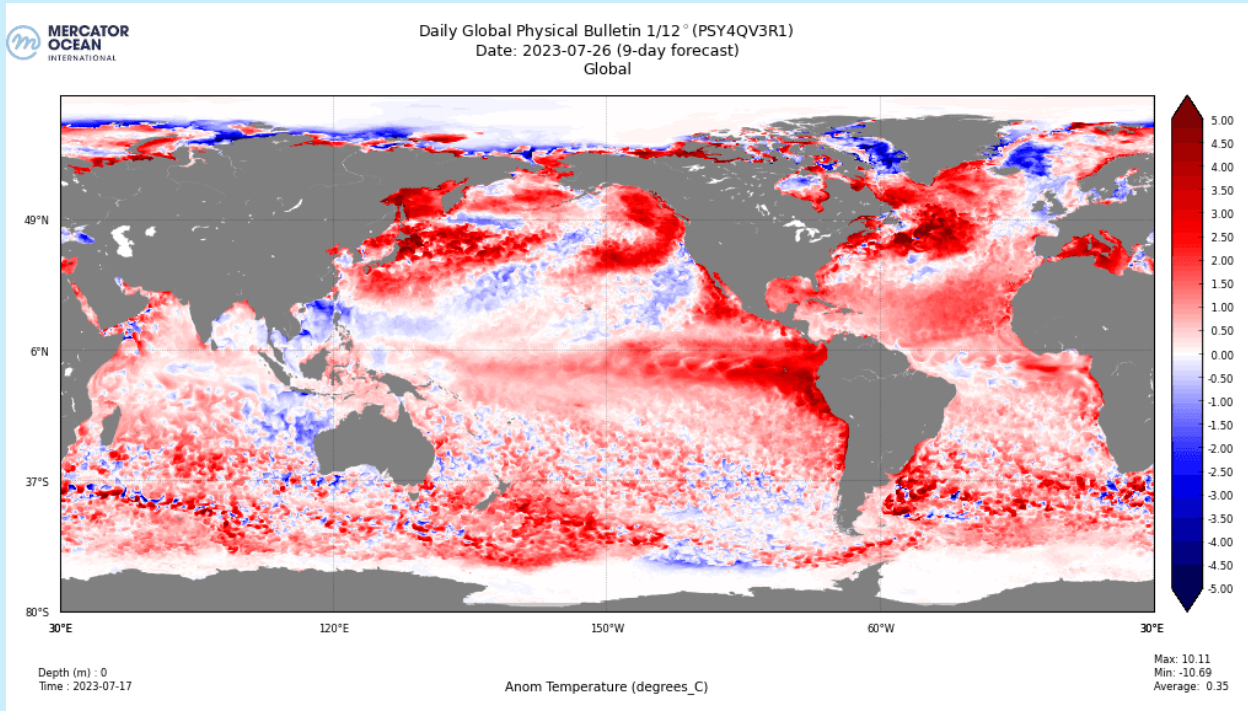
2100 predictions: +2 to +3.5°C



Multi-model projection of mean sea surface temperature change in 2081-2100 (relative to 1850-1900, SSP2-45, IPCC AR6 Atlas, 28 models).

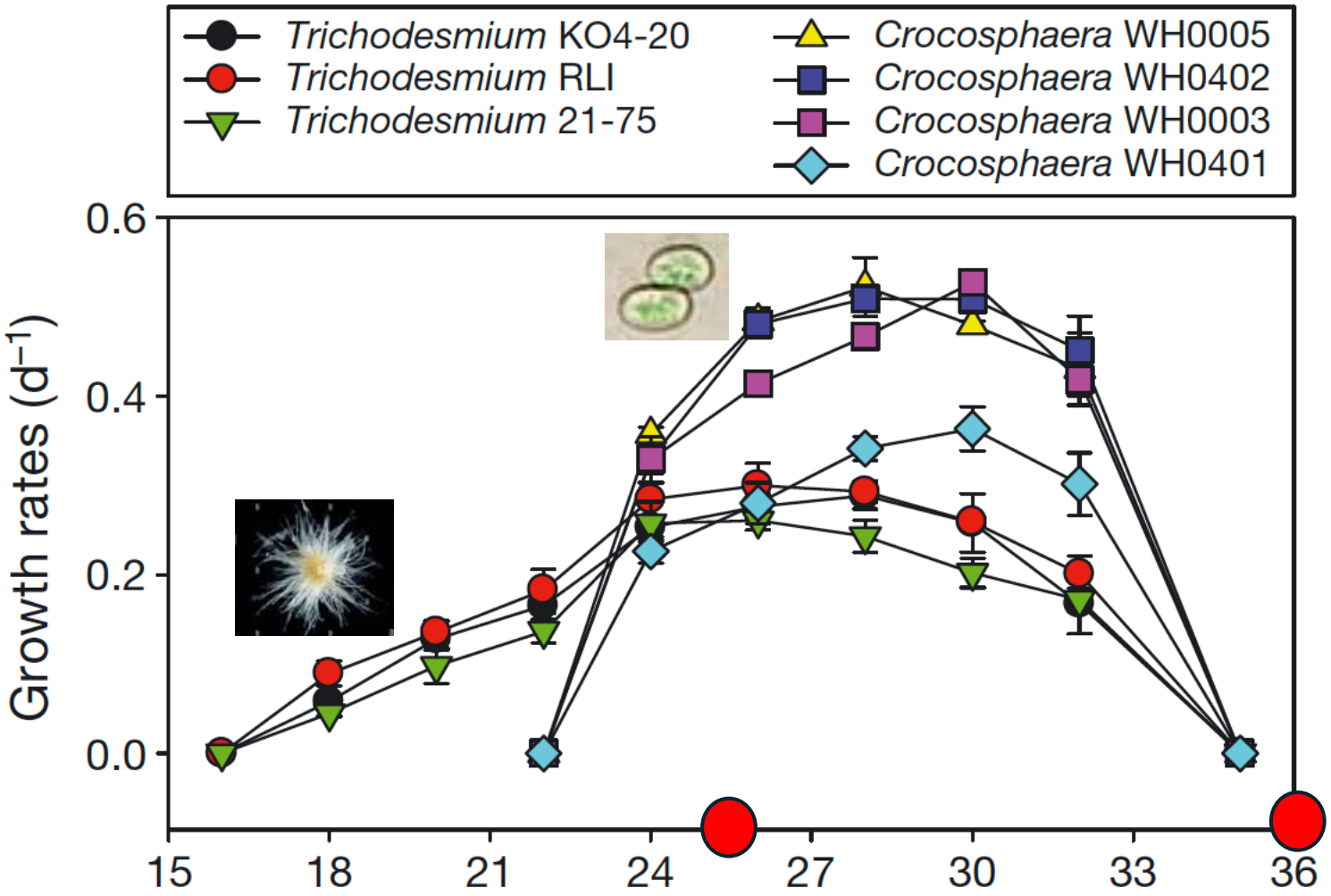
But last summer,
the year 2100 arrived
77 years early...

July 26, 2023: +2-3.5°C



July 2023 SST anomaly

Diazotrophic Cyanobacteria in the Warming North Atlantic Ocean

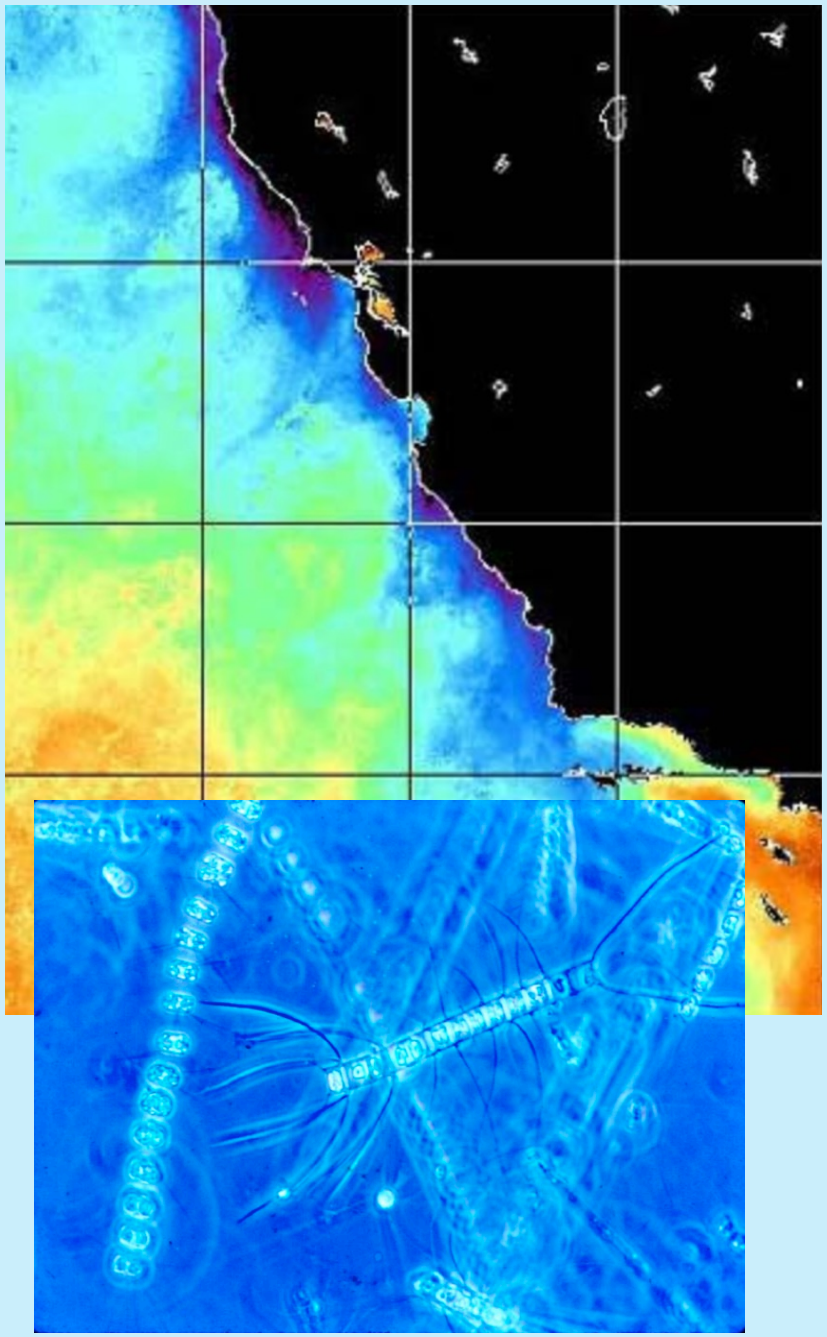


Summer 2023 North Atlantic Mean SST

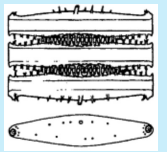
Summer 2023 extreme heat wave, Florida Atlantic shelf

Fu et al. 2014 AME

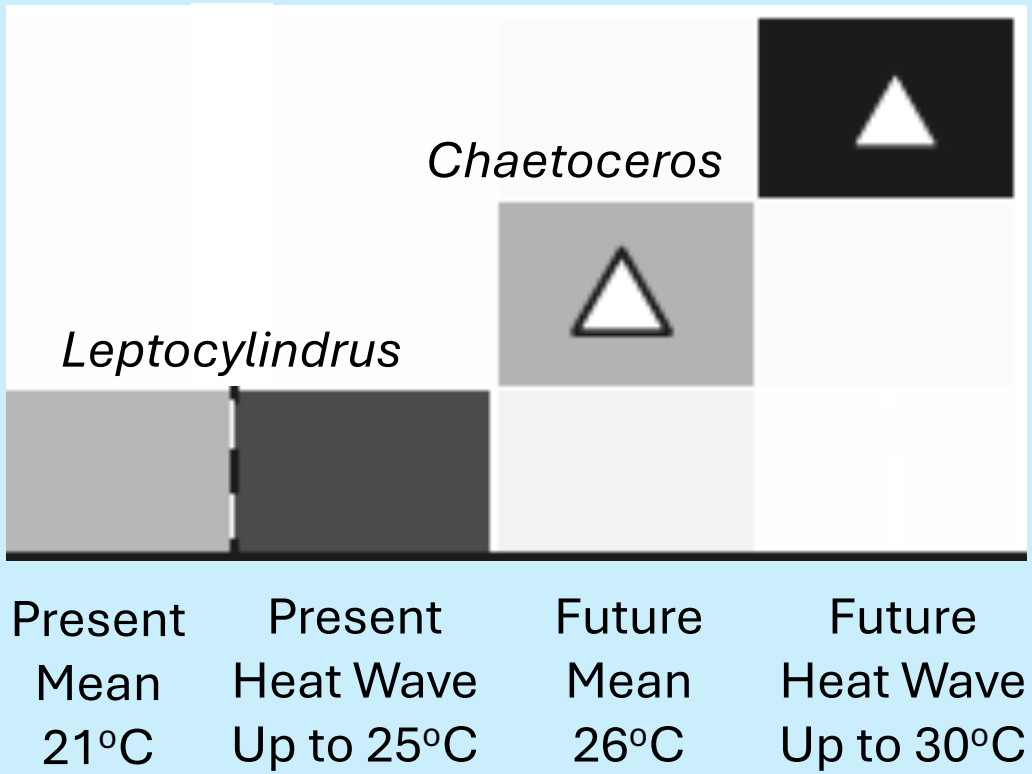
California Upwelling System



Unprecedented heat waves lead to unprecedented phytoplankton communities

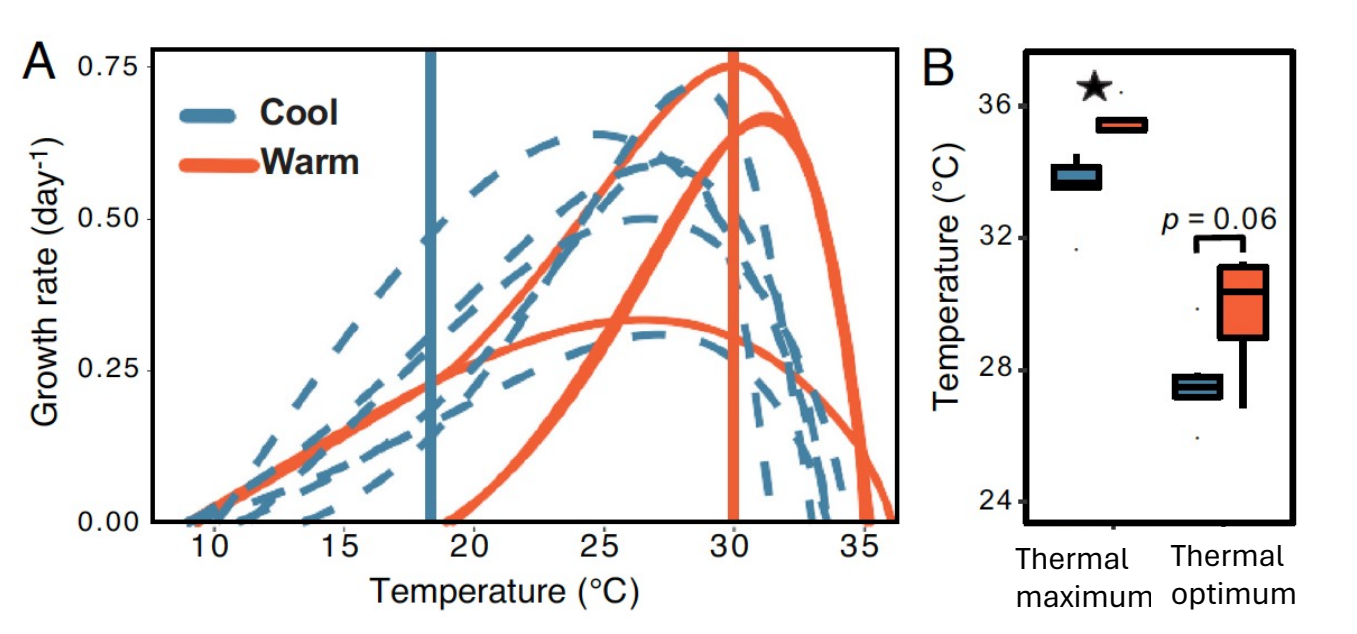


***A. mammifer* is a rare tropical diatom never reported before from California waters**



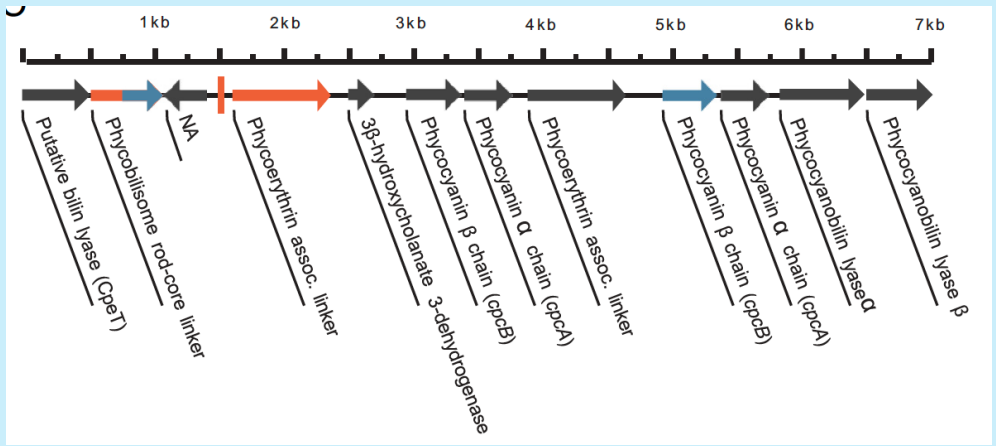
Kling et al. 2020 ISME J.

Cryptic thermal microdiversity within an estuarine *Synechococcus* population

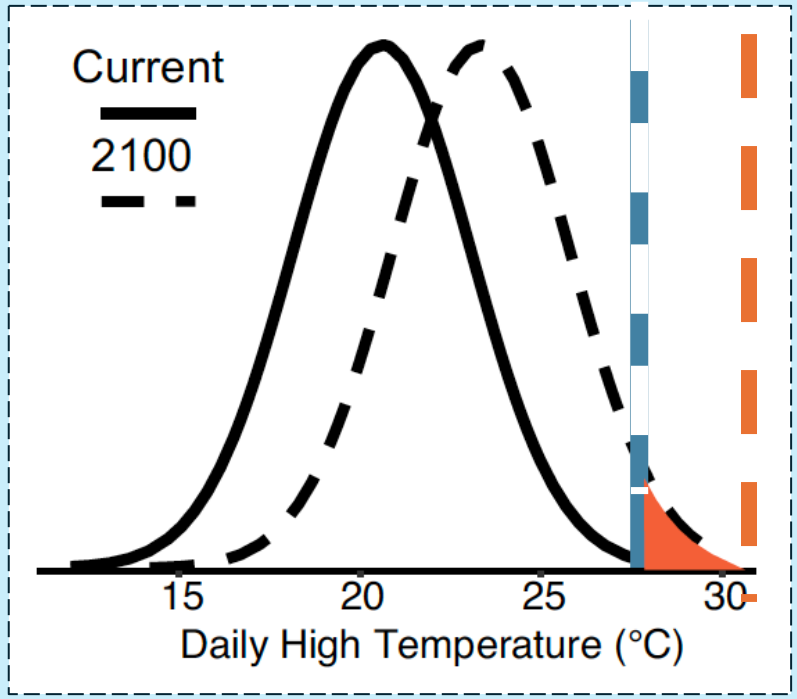


Incubations at 18°C and 30°C sorted the population into "cool" and "warm" thermotypes

These two thermotypes are >99.99% identical across >99% of the genome- the only difference appears to be minor epigenetic methylation changes



The cool thermotype should dominate at all current summer temperatures- but a niche for the warm thermotype will progressively open with continued future warming



Kling et al. 2023 PNAS

Key Unresolved Questions About Phytoplankton in a Warmer Ocean

1. How do phytoplankton communities recover from local extinctions following extreme heating events?
2. At what point do heat-stressed algal assemblages undergo major (or permanent) restructuring and reorganization?
3. How are differences in thermal tolerance related to phytoplankton diversity at the functional group or major taxonomic level?
4. Can cryptic thermal microdiversity within phytoplankton populations provide resiliency that will allow them to persist in a warming ocean?

Research Priorities for Phytoplankton Climate Change Studies

- Rapid response studies are needed to evaluate shifts in phytoplankton community structure and function due to heat waves, including dedicated shiptime and work at time series sites.
- Ideally, these would assess phytoplankton assemblages both before and during heat waves- and most importantly, follow the recovery process afterwards.
- Co-stressors like nutrient limitation, pH and pO_2 can modulate phytoplankton responses to heat stress, and need to be included in these studies.
- Phytoplankton thermal resilience may reside in microdiversity that cannot be captured by amplicon sequencing or metagenomics. There is a need for studies of thermal regulatory strategies at the transcriptional and translational levels, and for isolation of clonal cultures for in-depth physiological and molecular characterization in the lab.