WHY WAS THERE A HARMFUL ALGAL BLOOM IN 2015: THE RELATIVE GROWTH OF TOXIC AND NON-TOXIC DIATOMS AS A FUNCTION OF TEMPERATURE

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INTRODUCTION

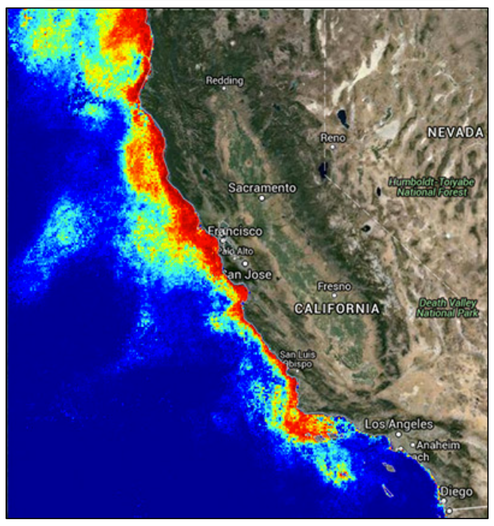

Figure 1. A forecasting model depicting the 2015 Harmful Algal Bloom (HAB). *Pseudo-nitzschia* diatoms are represented in red. Credit to the Central and Northern California Observing System.

A record breaking harmful algal bloom (HAB) composed of the domoic acid (DA) producing diatom *Pseudo-nitzschia australis,* occurred along the U.S. West Coast in the spring/summer of 2015 (FAQ: Harmful Algal Blooms and California Fisheries, 2016). The scientific community suggested that warmer ocean temperatures were the main cause of this HAB, but with little evidence to support the relationship between temperature and the growth of *Pseudo*-nitzschia spp. The research presented here represents the second half of a project to understand the effects of temperature on phytoplankton growth and toxicity, of low and non-toxic phytoplankton strains isolated from the 2015 HAB under a range of temperatures.

METHODS

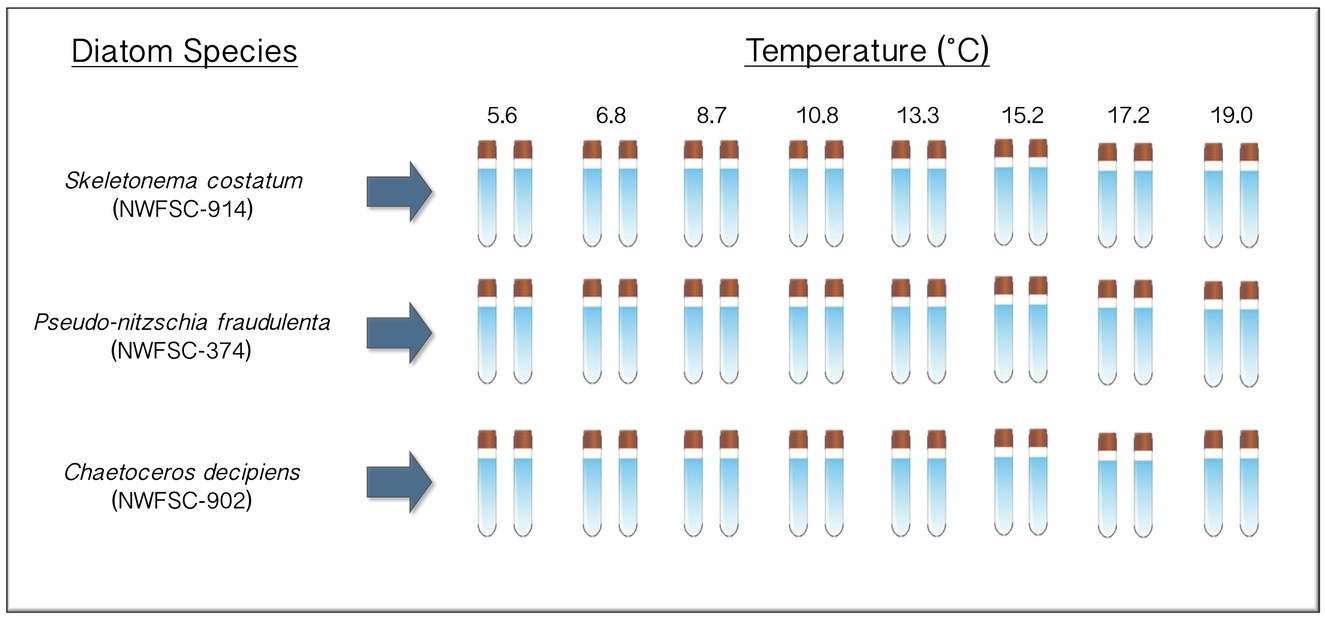

Figure 2. Cultures were grown within a temperature-controlled incubator, and exposed to 215 µmol photons · m^{-2} · s^{-1} of light on a 14:10 h light: dark cycle. Cultures were maintained within 50-mL borosilicate tubes containing 40 mL of 0.2-µm filtered seawater. The seawater was enriched with ESNW medium modified from Harrison et al. (1980).

Experimental Design

Three Experimental Runs Per Culture:
-Each experimental run included the exponential and subsequent nutrient-depleted stationary growth phase. After the 2nd day of stationary growth, the culture was re-inoculated into fresh ESNW medium and grown under the same experimental condition to initiate the next experimental run.

Exponential and Stationary Growth:
-Culture growth was estimated daily at 18:00 for relative changes of measured *in vivo* fluorescence, which is a proxy for algal biomass.

Nutrient and Domoic Acid Samples:
-At the end of Run 2 and Run 3, nutrient samples were taken for all cultures (n=96).
-At the end of Run 3, domoic acid samples were taken for only *P. nitzschia fraudulenta* cultures (n=16).

RESULTS

Result 1. At temperatures above 15˚C, the non-toxic diatom *S. costatum* had a lower growth rate than *C. decipiens, P. fraudulenta,* and all three toxic strains of *Pseudo-nitzschia australis*.

Result 2. At temperatures below 6˚C, the non-toxic diatom *C. decipiens*, and all three toxic strains of *P. australis* had no measurable growth.

Result 3. At temperatures greater than 10˚C, the low-toxic diatom *P. fraudulenta* had greater than or equal growth rates in comparison to the three toxic strains of *P. australis*.

**** Toxic results from B. Hansen***

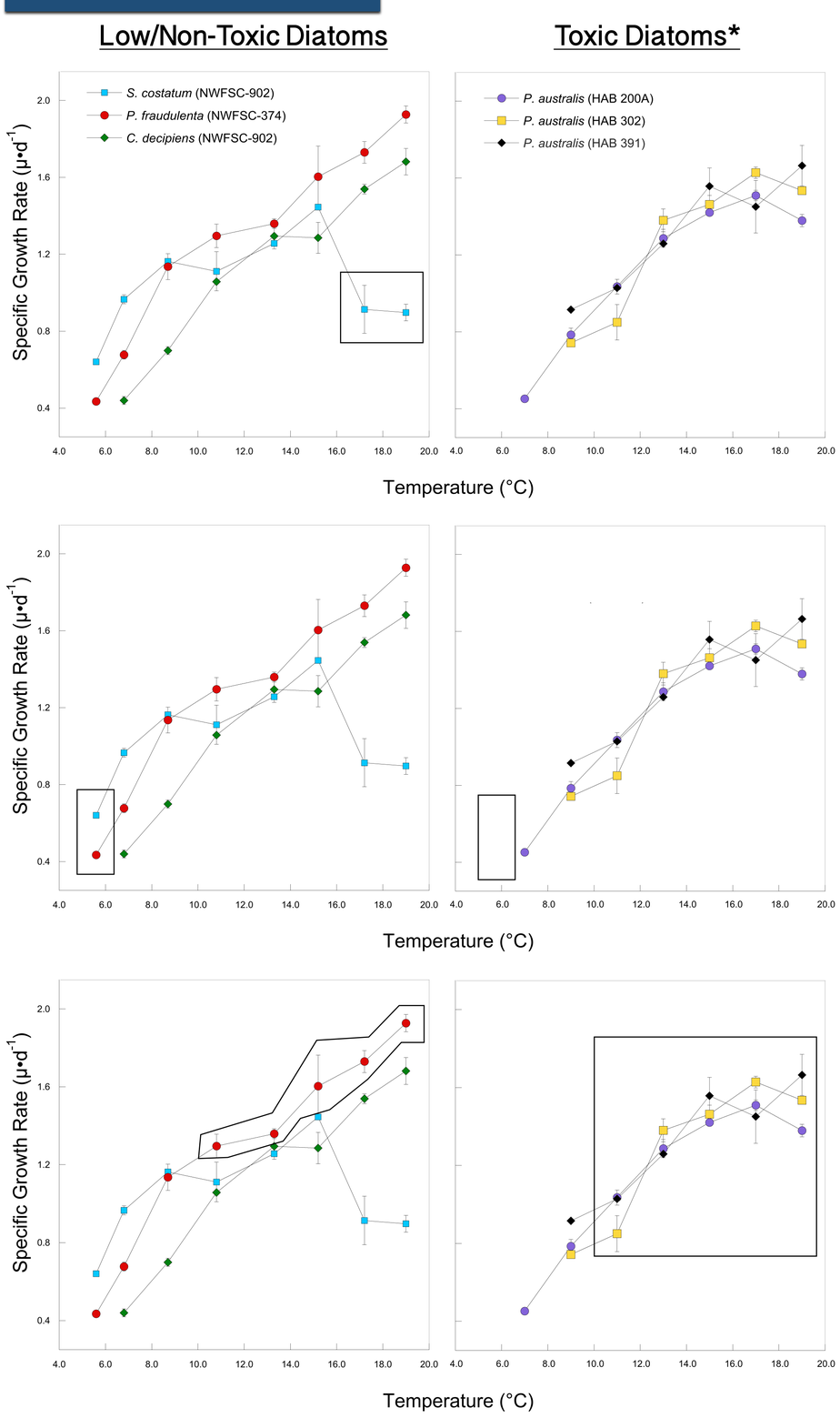

Figure 3. Growth rates of low/non-toxic and toxic diatoms as a function of temperature. Growth rates for toxic diatoms were measured by Bridget Hansen, and are shown here to compare to the low/non-toxic diatoms. Specific growth rates are reported as the average of duplicate (n=2) cultures, with the error bars indicating the range.

CONCLUSIONS

Higher temperatures affect diatom growth rates:
-Above 15˚C, the growth rate of *Skeletonema costatum* declined substantially. All other species in this and B. Hansen's experiment either increased or maintained relatively high growth rates (Result 1). Therefore, *S. costatum* may not be competitive with these other diatom species in ocean temperatures above 15˚C.

Very low temperatures inhibit diatom growth:
-Below 6˚C, *C. decipiens* and all three strains of *P. australis* exhibited no measurable growth (Result 2).
-In areas with ocean temperatures at or below 6˚C, oceanographers could expect to find low concentrations of low and/or non-toxic diatom species.

If temperature was the main cause of HABs, *P. fraudulenta* should have dominated the phytoplankton assemblages of the 2015 Bloom:
-Above 10˚C, the low-toxic diatom *P. fraudulenta* had equivalent or greater growth rates than all three toxic strains of *P. australis* at the range of temperatures tested (Result 3).
-In hot spots of *P. australis*, *P. fraudulenta* should have been as prevalent using temperature as the only explanation for a HAB.
-Temperature is not enough; other factors contribute to these HABS!

REFERENCES
Frequently Asked Questions: Harmful Algal Blooms and California Fisheries, Developed in Response to the 2015-2016 Domoic Acid Event. 2016. California Ocean Science Trust, Oakland, CA

Harrison P.J., Waters R.E., and Taylor F.J.R. 1980. A broad spectrum artificial seawater medium for coastal and open ocean phytoplankton. *Journal of Phycology*. 16: 28-35.

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