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Environmental and ecological drivers of harmful algal blooms revealed by automated underwater microscopy

Kasia M. Kenitz[1], Clarissa R. Anderson[2], Melissa L. Carter[2], Emily Eggleston[3], Kristi Seech[2], Rebecca Shipe[4], Jayme Smith[5], Eric C. Orenstein[1,6], Peter J.S. Franks[1], Jules S. Jaffe[1], Andrew D. Barton[1,7]

[1]Scripps Institution of Oceanography, University of California San Diego, La Jolla, California
[2]Southern California Coastal Ocean Observing System, Scripps Institution of Oceanography, University of California San Diego, La Jolla, California
[3]Department of Biological Sciences, University of Southern California, Los Angeles, California
[4]Institute of the Environment and Sustainability, University of California Los Angeles, Los Angeles, California
[5]Southern California Coastal Water Research Project Authority, Costa Mesa, California
[6]Monterey Bay Aquarium Research Institute, Monterey, California
[7]Department of Ecology, Behavior and Evolution, University of California San Diego, La Jolla, California

ABSTRACT

In recent years, harmful algal blooms (HABs) have increased in their severity and extent in many parts of the world and pose serious threats to local aquaculture, fisheries, and public health. In many cases, the mechanisms triggering and regulating HAB events remain poorly understood. Using underwater microscopy and Residual Neural Network (ResNet-18) to taxonomically classify imaged organisms, we developed a daily abundance record of four potentially harmful algae (Akashiwo sanguinea, Chattonella spp., Dinophysis spp., and Lingulodinium polyedra) and major grazer groups (ciliates, copepod nauplii, and copepods) from August 2017 to November 2020 at Scripps Institution of Oceanography pier, a coastal location in the Southern California Bight. Random Forest algorithms were used to identify the optimal combination of environmental and ecological variables that produced the most accurate abundance predictions for each taxon. We developed models with high prediction accuracy for A. sanguinea (R2 ¼0:79_0:06), Chattonella spp. (R2 ¼0:63_0:06), and L. polyedra (R2 ¼0:72_0:08), whereas models for Dinophysis spp. showed lower prediction accuracy (R2 ¼0:24_0:07). Offshore nutricline depth and indices describing climate variability, including El Niño Southern Oscillation, Pacific Decadal Oscillation, and North Pacific Gyre Oscillation, that influence regional-scale ocean circulation patterns and environmental conditions, were key predictor variables for these HAB taxa. These metrics of regional-scale processes were generally better predictors of HAB taxa abundances at this coastal location than the in situ environmental measurements. Ciliate abundance was an important predictor of Chattonella and Dinophysis spp., but not of A. sanguinea and L. polyedra. Our findings indicate that combining regional and local environmental factors with microzooplankton populations dynamics can improve real-time HAB abundance forecasts.