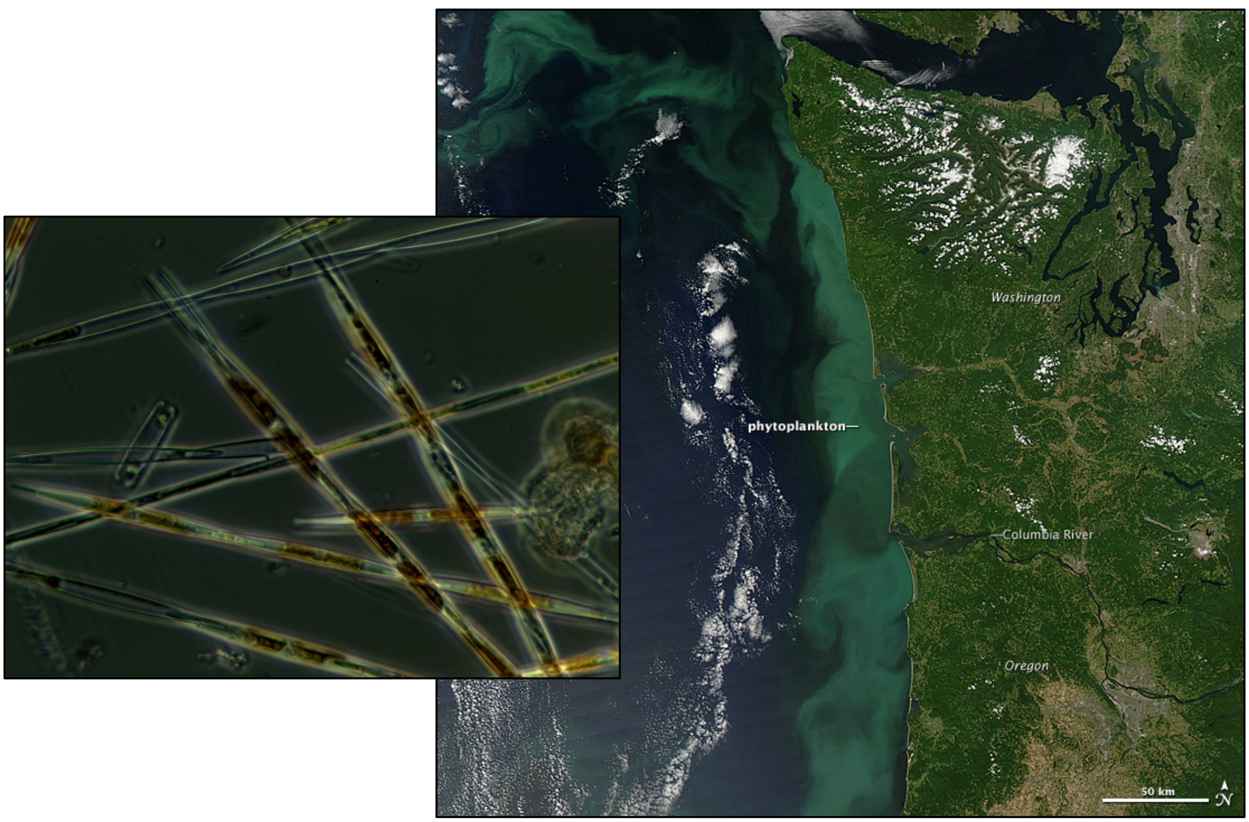
Teaching Climate Science Using a Local Phenomenon:
Harmful Algal Blooms

Climate science is inherently interdisciplinary and complex. Physical processes at a molecular level cascade upward to drive global-scale events. Decisions at a local level impact the health of the global population. How can we effectively teach a topic as complicated as climate science to middle-school students? We did by focusing on a local phenomenon that they themselves can experience, see, touch, and feel. We taught middle-school students in Seattle about how a recent harmful algal bloom (HAB) right off their own coast influenced what they could eat for dinner.

In 2014, a blob of abnormally warm water persisted off the US West Coast. In 2015, tiny marine plants called phytoplankton bloomed and turned the coastal ocean a vibrant green. Then, scientists found alarmingly high levels of toxins in many species like razor clams and green crabs. Animals that were once a popular main dish became avenues for toxins that could damage our brains. To prevent these toxins from rising up the food chain and making humans sick, many fisheries were closed and these animals were kept off our plates.

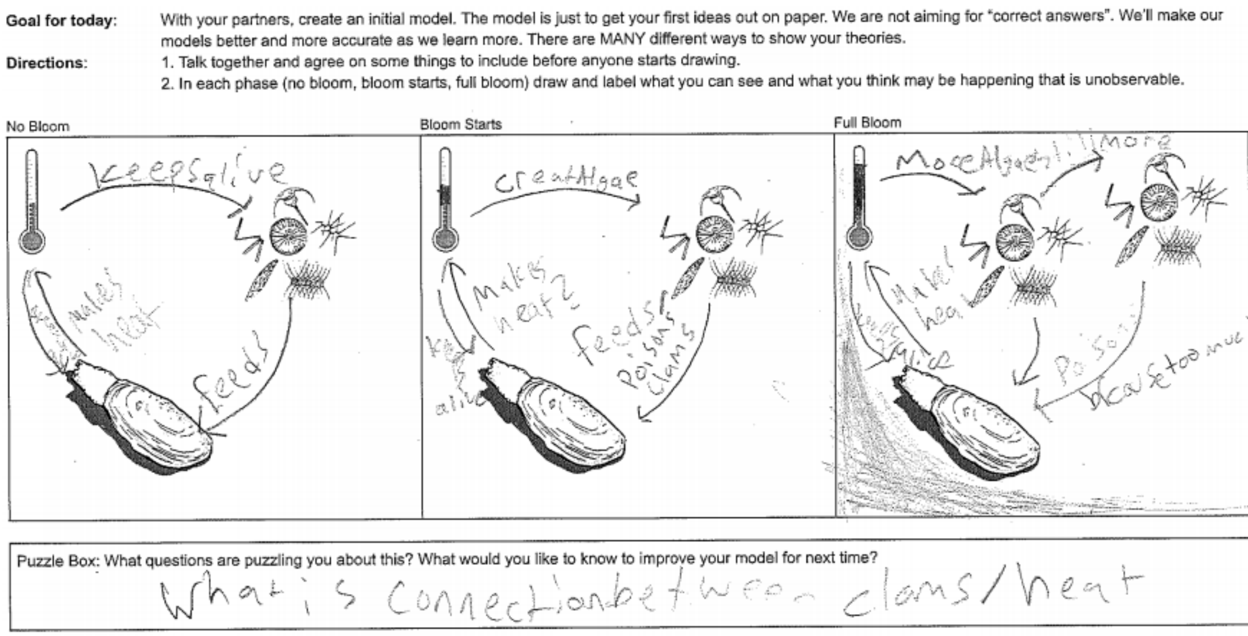


Phytoplankton, like this microscopic species called *Pseudo-nitzschia*, are so small that they are invisible to the naked eye. During an algae bloom, there can be so many individuals in the water that the water appears green, as shown in this satellite image. (Images from NOAA)

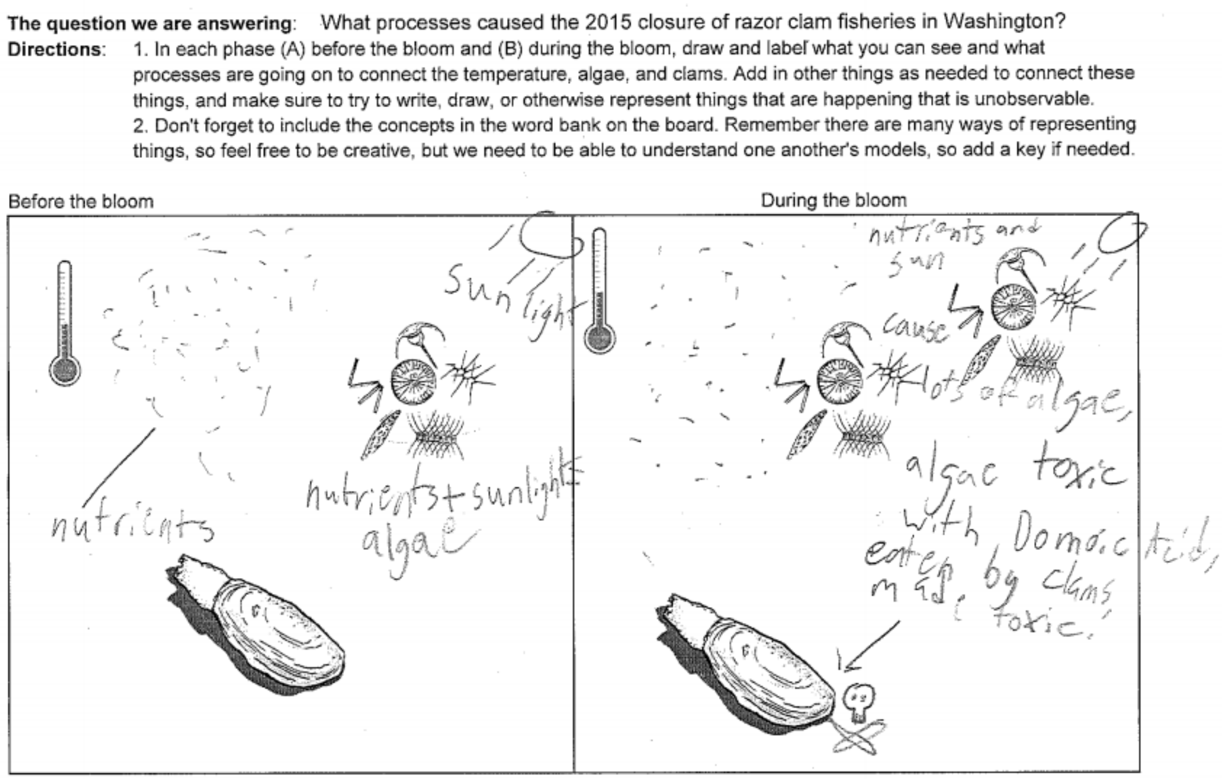
So, what is the link here? What does ocean temperature have to do with toxins in our food? This is what a I asked middle-school students on the first day of a week-long curriculum. Our goal was for them to understand the many socio-ecological factors that drive algal blooms and then predict how these blooms may develop in a warming climate. Instead of giving them the answer, we asked them to discuss what they already knew and what questions they still had. Then, over the next several days, we approached this phenomenon through several lenses: through games, through biology experiments, through group discussions, and through the actual lenses of microscopes. By the end of the week, the students developed an answer.

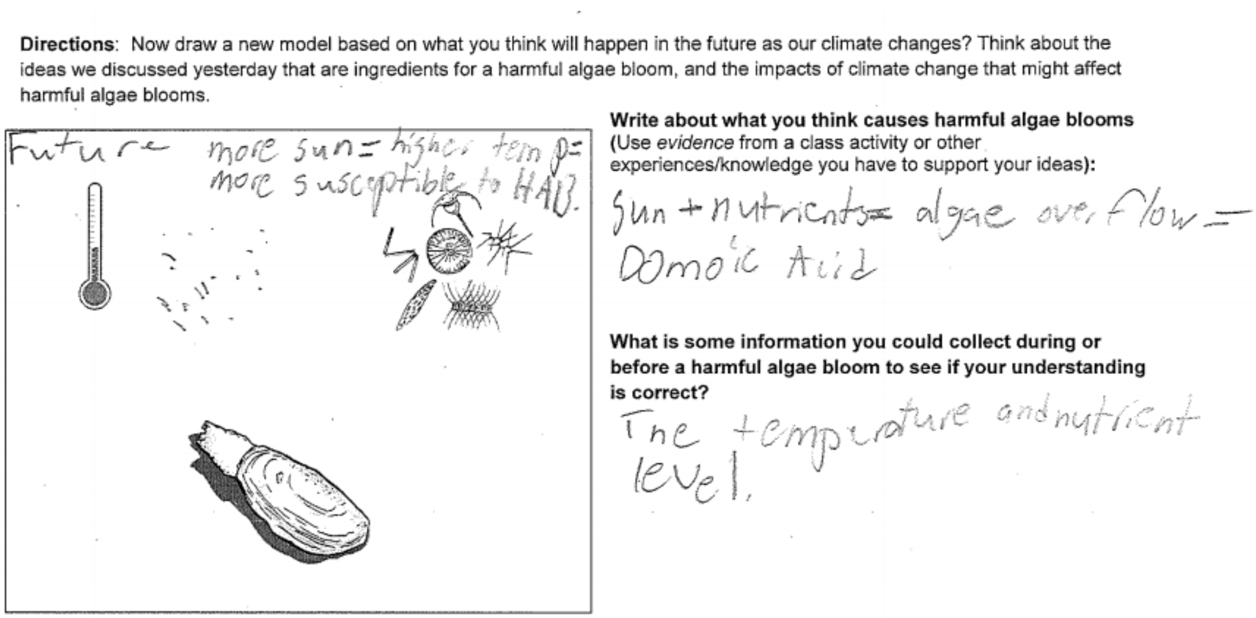
Algal blooms occur when water conditions are ideal for phytoplankton growth, and algae tend to like warm water that is full of nutrients. These blooms can become harmful when the phytoplankton produce toxins. The species *Pseudo-nitzschia* produces a neurotoxin called domoic acid which becomes concentrated as it travels through the food chain from phytoplankton to zooplankton to fish and so on. With humans at the top of the food chain, we can receive doses high enough to cause vomiting, diarrhea, cramping, and even death. These risks to humans are being exacerbated by climate change – warmer climate leads to warmer ocean water and more chances for HABs to restrict our diet.

The students came to the correct conclusion through a series of engaging and thought-provoking activities. They grew their own algae blooms in mason jars, looked at the algae they grew under a microscope, played as marine animals in an interactive trophic-cascade game, and discussed the cause and effects of real HAB events from around the world. Each activity was tailored to address a set of Next Generation Science Standards. These standards were recently adopted by Washington State and focus on exploring disciplinary core ideas through crosscutting concepts and applied science and engineering practices. We assessed student learning by evaluating the conceptual models they produced before and after the curriculum and through self-assessment surveys. The students clearly achieved the learning goals and had fun doing it. Unsurprisingly, they reported that they most enjoyed the activities where they got out of their seats and interacted through play.



An example of a student's conceptual diagram on the first day of class.




Directions: Now draw a new model based on what you think will happen in the future as our climate changes? Think about the ideas we discussed yesterday that are ingredients for a harmful algae bloom, and the impacts of climate change that might affect harmful algae blooms.

Future more sun = higher temp = more susceptible to HAB.

Write about what you think causes harmful algae blooms (Use *evidence* from a class activity or other experiences/knowledge you have to support your ideas):

Sun + nutrients = algae overflow = Domoic Acid

What is some information you could collect during or before a harmful algae bloom to see if your understanding is correct?

The temperature and nutrient level.

An example of a student's conceptual diagram on the last day of class.

The four graduate students that came together to develop, implement, and assess this curriculum brought diverse perspectives. We have different research focuses: marine geology, chemical oceanography, and civil engineering. We are different ages, genders, and races. We come from the East Coast and West Coast. We were each shaped by the landscape and community we grew up in. Me? I'm a young, white, middle-class female from South Carolina who began to study coastal geology after falling in love with a beach that was doomed by human-induced erosion. I personally experienced the struggle between human development, ecological response, and taxpayer decisions. I understood that complex socio-ecologic processes could be made personal by local events. I also understood that knowledge was perhaps the most important tool needed for communities to cope with these hazards. So, when I moved to a new community in the Pacific Northwest, I chose harmful algal blooms as a teaching tool.

The four UW graduate students that developed and implemented this curriculum as an interdisciplinary team. From left to right: Robin McLachlan, Angie Boysen, Christine Baker, Isaiah Bolden.

Now, I have a new experience to add to my unique perspective. I've learned that teaching a class of students takes a village. Us four graduate students offered our expertise as young scientists, but we also relied on the expertise of others. The middle-school teachers offered guidance on feasibility in the classroom. Faculty members in the UW College of Education offered their expertise on best teaching practices. Experts in the UW Office of Educational Assessment guided us on how to assess the effectiveness of this curriculum. The Program on Climate Change offered financial and academic support. Perhaps most importantly, the students offered their willingness to learn and grow.

If you would also like to learn from this curriculum and/or teach it to your own students, you can access the teacher packet. As we have learned, climate science can be made digestible when distilled down to a personal scale. This curriculum is framed around the 2015 HAB off the US West Coast, but it can be easily adapted to a different place and/or time. We hope you can use your own perspective and village of experts to best suite your classroom.

Robin McLachlan is a PhD Candidate in the UW School of Oceanography studying coastal sedimentary dynamics. She is also involved with many interdisciplinary programs at the UW that focus on community education and outreach. Through collaborations within these programs, she has developed several curriculum packets and lesson plans that can be accessed on her website *www.RobinMcLachlan.com. You can reach her at mclachlan.rl@gmail.com and follow her on twitter @RobinMcLachlan.*