PROGRESS REPORT:

Harmful Algal Bloom Dynamics in the Gulf of Maine

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Adding Real-Life Data to the Model

This week, I began to add real-life data to the harmful algal bloom model by using the website database GoMOOS. The address of the site is <http://gomoos.org>. The GoMOOS project describes itself as a "national pilot program designed to bring hourly oceanographic data from the Gulf of Maine to all those who need it." I added daily average water temperature and salinity data for the past year from GoMOOS' Buoy E to the model. Currently the simulation repeats the one-year data three times to create a three-year simulation. Soon, I will download data for three years from GoMOOS is order to make a more correct simulation.

Solutions to Previous Problems

The "Other Phytoplankton" group was thriving during simulation, while *Alexandium fundyense* declined to zero immediately. In nature, the other phytoplankton tend to bloom earlier than *A. fundyense* because they need less sunlight to thrive, so in the model, the other phytoplankton (correctly) bloomed first. Because there was not immediately enough sunlight to support *A. fundyense* during simulation, the concentration of *A. fundyense* dropped to zero. Since the rate of growth of *A. fundyense* depends on *A. fundyense* concentration in the model, the growth rate remained zero and the *A. fundyense* population could not recover.

As a solution to the problem of the crashing *A. fundyense* population, I created a lower bound of 10^-6 concentration of *A. fundyense* in the model. This prevented the *A. fundyense* population from dropping to zero, so that the growth rate could recover after the "other phytoplankton" spring bloom so *A. fundyense* could bloom during the correct time. Setting a lower bound should be acceptable in the model since there is always a small concentration of *A. fundyense* in the water, and the species blooms every season shortly after the other phytoplankton. During dormant periods, *A. fundyense* exists in the water as cysts, the germination of which I hope to model in more detail during Week 5.

After setting the lower bound on *A. fundyense* concentration, my 5-box model looked much more realistic, with recurring blooms for *A. fundyense* and "other phytoplankton" in spring and fall, with the "other phytoplankton" having earlier blooms. A large bloom in the spring, a smaller bloom in the fall, and a relative lag in the bloom of *A. fundyense* are typical of algal bloom behavior in the Gulf of Maine.

Increasing Model Complexity

During this week, I completed the 5-box model of *A. fundyense* and the Gulf of Maine ecosystem using Stella software. This model includes parameters for *A. fundyense*, "Other Phytoplankton," available nutrients, unavailable ("deep") nutrients, and zooplankton predators. The model output exhibits the typical behavior of algal blooms in the Gulf of Maine, but further accuracy can be achieved by adding more complexity to the model. On Friday of this week, I graduated my Stella model from 5-box to 10-box, and began constructing the framework for the more advanced model. The species groups included in the model are small phytoplankton, large phytoplankton (diatoms), *A. fundyense* (which are also large phytoplankton), microzooplankton (which only consume small phytoplankton), and mesozooplankton (which consume large phytoplankton, microzooplankton, and nitrate matter). Instead of simply including a "nutrient" parameter, the new 10-box model includes the natural cycles of ammonium, nitrate, and silicate in the Gulf of Maine. In addition to improving the model's accuracy, adding complexity will allow the analysis of the interactions between more well-defined groups in the ecosystem. I am particularly interested in the relationship between *A. fundyense* and the diatoms, which have similar niches.

Overall Assessment of the Project

Currently the project is moving ahead as scheduled. The next step will be to finish the 10-box Stella model by adding parameters for the marine ecosystem (Chai et al.) and for

A. fundyense (McGillicuddy et al.). During Week Four, I aim to produce a working 10-box model which includes both *Alexandrium fundyense* and other the phytoplankton and zooplankton species as well as incorporating Gulf of Maine data for light, water temperature, salinity, and nutrient (ammonium, nitrate, and silicate) content. During Week Five, I will work on adding the *A. fundyense* germination parameter to my model and on creating visualizations for the simulation output. Later, I will take part in building a three-dimensional model with a post-doc under Dr. Chai. I will then compare the 2- and 3-D models and analyze the output for interactions between species.

References

Chai, F., R. C. Dugdale, T-H Peng, F. P. Wilkerson, and R. T. Barber (2002): One Dimensional Ecosystem Model of the Equatorial Pacific Upwelling System, Part I: Model Development and Silicon and Nitrogen Cycle. Deep-Sea Res. II, Vol. 49, No. 13-14, 2713-2745.

McGillicuddy Jr., D.J., D.M. Anderson, D.R. Lynch, D.W. Townsend (2005). Mechanisms regulating large-scale seasonal fluctuations in *Alexandrium fundyense* populations in the Gulf of Maine: Results from a physical–biological model. Deep-Sea Res. II 52 (19-21): 2698-2714.