Daily Forecast Model of Washington Waters
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Have you ever seen a painting so realistic that on first glance you assumed it was a photograph, where each colorful, textured stroke on the canvas perfectly matched the scene spread out before the artist?

In the same way that landscape artists represent the natural world with paint, scientists seek to represent the world through computer simulation models. These models integrate different natural forces to recreate dynamic environments such as Puget Sound, giving us a better idea of what’s happening now and what might happen in the future.

Over the past four years, the Washington Ocean Acidification Center’s (WOAC) forecast modeling team has developed the region’s first daily forecast of oceanic conditions. Similar to the daily weather forecasts we use to plan for a rainstorm, WOAC’s LiveOcean model can warn shellfish growers of stressful ocean conditions three days in advance.

Through the NANOOS-NVS online platform, growers can access information on the timing and location of harmful seawater to help them avoid conditions where shellfish are unlikely to grow. Washington’s coastal and inland waters are highly variable, so ocean chemistry can change sharply in a matter of days.

While the LiveOcean model was designed with the shellfish industry in mind, it has several potential applications that could help protect the wellbeing of Washington’s citizens and marine resources. Realistic current movement could help track the flow of oil in the event of a spill or forecast the movement of a toxic algal bloom that threatens public safety. It could also be used as an educational tool for students and marine stakeholders to showcase complex marine processes.

The main architects of the model, UW scientists Parker MacCready and Samantha Siedlecki, utilize forecasting data provided by other agencies as the foundation of their model. These variables, referred to as forcing data, fall into four major categories:

- **Rivers** – freshwater input from rivers and streams significantly impacts local water chemistry and is one of the most significant inputs of corrosive water. Seawater typically has pH slightly above 8, but freshwater has a higher acidity with a pH much closer to 7.5. Rivers also carry nutrients from the land that can influence plant and animal life.

- **Atmosphere** – this broad category encompasses several weather-related variables such as wind speed and direction, cloud cover, temperature, precipitation, and evaporation rates. Forecasting data specific to this area comes from a model run by UW atmospheric scientist Cliff Mass.

- **Tides** – the strength, direction, and timing of tidal currents partially dictate how water moves around the coastal zone. Strong tidal currents can cause increased mixing, while weak currents leave water masses relatively stagnant.

- **Open Ocean** – As water flows eastward across the Pacific, it’s important to know what properties it has, to understand how it might influence local waters. The U.S. Navy’s forecast is the most reliable model of open ocean conditions, which don’t change as quickly as they do along the coast.
Integrating all these data everyday into one automated, reliable model takes a huge amount of computing power. The model is made up of over 20 million grid points that cover the region in a network of boxes about one mile on each side. LiveOcean also predicts what will happen below the surface water where most marine organisms live, so the computer that runs the forecast must be very powerful.

“The one down the hall that I’m running right now has 144 separate computers all working together on this one calculation,” MacCready said. “We put a lot of effort into using just fine enough resolution that we can still make progress computationally.”

If the resolution is too fine then the computers get overwhelmed with data, but if the resolution is too broad then the model won’t be very useful for local management. MacCready thinks the current resolution works well for the Pacific coast, but Puget Sound’s narrow, curving waterways require a higher-definition approach. Within the next few months, the team plans to make the Puget Sound forecast available using grid boxes 300 m on each side instead of the current 1500 m resolution.

The WOAC team is also developing a high-resolution model for Willapa Bay, on Washington’s outer coast. The bay is situated near the mouth of the Columbia River and may be exposed to corrosive waters year-round. Not only is the area flushed with relatively low pH freshwater from the river, corrosive water from deeper areas rises towards the surface along the coast through a process called upwelling. Adding these local factors to global ocean acidification makes wild and farmed shellfish in Willapa Bay especially susceptible to sustained corrosive events.

One advantage LiveOcean has is its wide geographic reach compared to sensors like monitoring buoys that are anchored in one place. Moored sensors are especially valuable because they tell researchers exactly what’s happening at a particular location, but they don’t offer much insight into what’s happening elsewhere or what that area might look like tomorrow. MacCready and Siedlecki consistently compare their model’s predictions to data from sensors moored on buoys to see how well it represents the real world.

“If I was trying to model this region and I had all my forcing data but I didn’t have any validation data from the moorings, then I couldn’t do it because I wouldn’t know if anything was right at all,” MacCready said. “You can’t model without observations, and luckily around here we have a lot of observations.”

This validation process highlights what aspects of the model work well and what processes need to be improved. When the model strays from actual observations, MacCready and Siedlecki try to figure out why and write code to prevent that from happening again. Once when the Columbia River gauge malfunctioned, the code read that as negative river flow, sucked all the water out of the channel, and crashed the model. In response, the code now has an extensive system of backups and ‘Plan Bs’ written into it.

Another aspect the team is working to improve is increasing the current 3-day forecast to a 7 or even 10-day projection that would enable users to better plan for harmful ocean conditions.
Many of the forcing data forecasts are available as 10-day forecasts, but the unpredictability of weather conditions undermines how reliable those projections would be.

“The three-day weather forecast might be okay; you can start to make some plans based on the three-day forecast,” MacCready said. “But if I look a week into the future and see sunny on Friday, I’m not going to count on that, nobody does.”

In addition to increasing the resolution and reliability of the model, the team is stepping up their outreach efforts with the shellfish industry to see how this tool could be best utilized for growers. They recently partnered with a team of computer scientists so develop an intuitive website where the public can interact with the forecasts.

“This forecast is an exercise in developing trust with the community to help them realize how to use the information in a way that’s relevant to them,” Siedlecki said.

Over the next two years, the WOAC forecast model team will improve upon the incredibly powerful tool they’ve created and work with stakeholders to package that information in a way that is most relative to different industries. Continued support for this project is integral to the continued success of resource managers and marine industries impacted by our rapidly changing ocean.