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New tools for dynamic ocean management: EcoCast vs. Marxan and more

Editor's note: Heather Welch is a research associate with the University of California at Santa Cruz and the (US) NOAA Southwest Fisheries Science Center's Environmental Research Division. The Skimmer spoke with her about her research, which focuses on understanding and planning for the spatial and temporal dynamics of large-scale marine processes.

The Skimmer: We last covered dynamic ocean management and dynamic ocean management tools in 2014. Can you tell us a bit about how the field has progressed since then?

One area of progress is that dynamic ocean management is now better located within the larger field of dynamic management, allowing us to borrow concepts and methodologies from more established disciplines. Weather science has been developing dynamic management tools such as weather forecasts and hurricane forecast tracks for over a century. While on land, established dynamic management tools track floods, wildfires, and disease outbreaks. Understanding the parallels between dynamic ocean management and dynamic management in other realms allows us to leverage lessons learned and avoid reinventing the wheel.

Another area of advancement is that dynamic ocean management tools are moving towards producing forecasts. Initially, tools were producing hindcasts and nowcasts, i.e., predicting where species were last month and where species are today, respectively. Now, dynamic ocean management tools are forecasting species distributions days to seasons in advance. For example, the Atlantic Sturgeon Risk Model predicts Atlantic sturgeon habitat one to three days in advance to help fishers avoid the bycatch of these endangered fish. A seasonal forecasting system in the Great Australia Bight predicts the distribution of Southern bluefin tuna several months into the future to help fishers efficiently locate and harvest their target species. These types of forecasts give end-users time to plan ahead for future conditions.

Lastly, dynamic ocean management is moving from single-species tools to multi-species tools that can address greater proportions of biodiversity. Single-species management was a natural starting point for the field, but established methodologies and technological advances now allow for more complex tools. For example, TurtleWatch helps fishers avoid the bycatch of loggerhead and leatherback turtles. On the US west coast, EcoCast helps fishers maintain their target catch of swordfish while avoiding the bycatch of loggerhead turtles, California sea lions, and blue sharks.

The Skimmer: Can you tell us about your new research and what you found?

As dynamic ocean management continues to shift towards multi-species management, decision support tools will be critical to help determine which areas to prioritize for protection. In a paper that we just published in *Conservation Biology*, we compared two decision support tools: the algebraic algorithm that underpins EcoCast and the simulated annealing algorithm that powers the reserve design software Marxan. While EcoCast's algebraic algorithm was explicitly designed for dynamic ocean management and Marxan was developed as a conservation planning tool, Marxan has functionality (e.g., consideration of cost and boundary complexity) that could confer advantages over EcoCast. We compared the performance of both tools over time using a dynamic ocean management scenario for fisheries sustainability. We found that the relationship between EcoCast solutions and the underlying species distributions was more linear and less noisy, while Marxan solutions had more contrast between waters that were good to fish and poor to fish.

The Skimmer: When might a manager use one of these tools versus the other?

One of the biggest drivers of decision support tool selection is managers' preferences for how species importance is assigned. In EcoCast's algebraic algorithm, species importance is assigned relatively, e.g., species X is twice as important as species Y. In Marxan, species importance is assigned absolutely, e.g., protect 20% of species X's habitat and 15% of species Y's habitat.

Both decision support tools were designed to be responsive to changing management priorities. For example, a recent bycatch event might change management priorities. We found EcoCast's algebraic algorithm was better able to reflect changing management priorities, meaning that it might be the more appropriate tool for management scenarios that emphasize flexibility. On the other hand, Marxan outperformed EcoCast's algebraic algorithm as more species were added, meaning that it might be the more appropriate tool for management scenarios that aim to manage many species. Table 4 in the paper (figure below) outlines 10 considerations that could affect manager preference regarding tool selection.

The Skimmer: Are there other possible marine management situations where a dynamic Marxan might be useful?

Certainly. The dynamic configuration of Marxan could be useful to any dynamic ocean management scenario that aims to manage multiple features. These features might be species, hydrological events such as temperature anomalies or seasonal upwelling, or socio-economic factors such as fishing ground quality and shipping channel efficiency. In addition, Marxan will be particularly useful in dynamic ocean management scenarios where there is a cost constraint.

The Skimmer: What are your next steps for this research?

One area of future development will be moving towards dynamic marine protected areas. Most dynamic management scenarios produce continuous risk surfaces, e.g., bycatch risk in EcoCast or shipstrike risk in WhaleWatch. Moving towards binary open/closed areas is a logical next step. Doing this in a dynamic capacity, however, will require exploring trade-offs between protection levels and opportunity cost across time and ensuring that the locations of closed areas do not change drastically from day to day.

Secondly, Marxan is part of a family of decision support tools designed for conservation planning, and it would be worthwhile to explore how other tools such as Zonation, C-Plan, and prioritizr perform in a dynamic capacity.

Want to learn more?

- Tune in for an upcoming OCTO webinar *EcoCast: A dynamic ocean management tool to reduce bycatch and support sustainable fisheries* on October 31
- Watch an animation of how EcoCast and Marxan results change over time

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