Predicting benthic biomass in the Bering Sea with environmental data and a RandomForest modelling algorithm

Micah Miller[1], Steffen Oppel[2] and Falk Huettmann[3]
Institute of Arctic Biology, Dept. of Biology & Wildlife, University of Alaska-Fairbanks, Alaska 99775 USA
[1]fsmwm4@uaf.edu, [2]fssjo3@uaf.edu, [3]fffh@uaf.edu

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Introduction

Benthic organisms are an important resource for numerous higher trophic level predators such as birds and mammals. Information on the availability and distribution of benthic organisms may therefore aid management of marine vertebrates dependent upon this resource.

Currently, no quantitative map exists for the spatial distribution of benthic organisms in the Bering Sea (but see Dunton *et al*. 2005 for Chukchi and Beaufort Seas). Here, we propose a spatially explicit quantitative model to predict the benthic biomass in the Bering Sea. This model is based on environmental and benthic survey data and relies on novel algorithms to provide an accurate prediction of benthic biomass given local environmental conditions.

Methods

We compiled the best available benthic data for the Bering Sea region, as well as a set of publicly available environmental data presumed to affect biomass of benthic communities, and related environmental data to benthic data using ArcGIS (1,2) at a resolution of 10x10km.

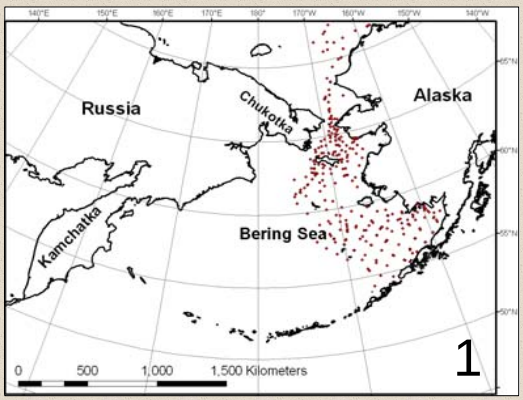
We then used an algorithmic RandomForest model to predict benthic biomass based on eight environmental predictors (2, 3). This modeling approach uses a large number of classification trees to most accurately classify the data based on the predictor variables (e.g. Cutler *et al*. 2007, Breiman 2001). We then applied this model to environmental data across the entire Bering Sea to predict the benthic biomass.

Results

Our RandomForest model predicted the benthic biomass at 75% of sampling stations correctly in cross-validation.

The predictor variables were ranked according to their influence in increasing the predictive ability of the model in the following order:

1. **Chlorophyll A (September)**
2. **Sea Depth**
3. **Sea Surface Temperature (August)**
4. **Sea Bottom Temperature**
5. **Distance to Coast**
6. **Sea Bottom salinity**
7. **Sea Ice Extent**
8. **Seafloor substrate**



Benthic sampling stations (red points) from which data were used to build the model.

Environmental variables used to predict benthic biomass (wet weight (g/m²) in the Bering Sea:

Sea Surface Temperature (August)	Chlorophyll A (September)
Sea Depth	Sea Ice Extent
Distance to Coast	Seafloor substrate
Sea Bottom Temperature	Sea Bottom salinity

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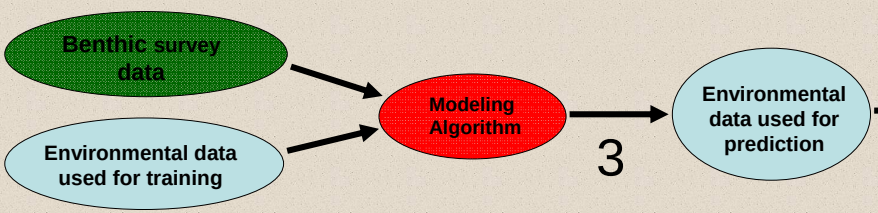
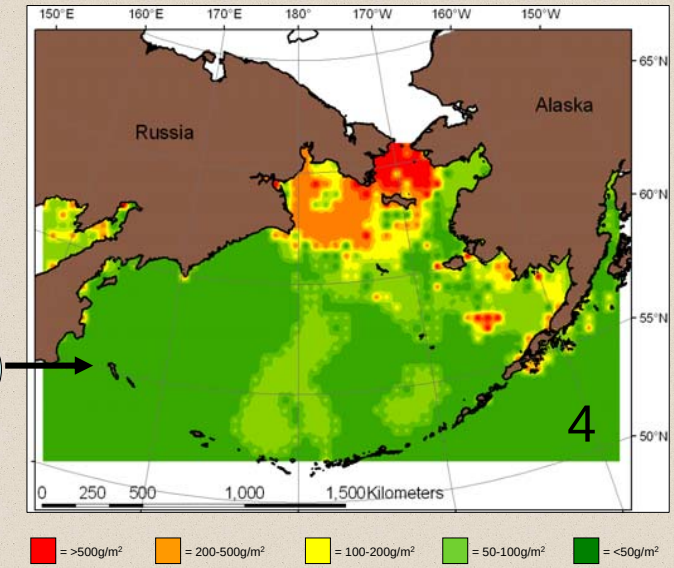


Survey and environmental data were used to train a predictive algorithm (3), which was then applied to environmental data across the Bering Sea to predict the benthic biomass distribution (4).



Future Directions

This innovative model extends previous research (Grebmeier et al. 2006), but requires further evaluation with alternative benthic data sets for validation. We have shown that our approach provides accurate predictions and encourage researchers to improve the predictive performance of the model by including additional environmental data such as zoo- and phyto-plankton, currents, detritus, and harvest rates for the Bering Sea. More data on benthos and sediment from the south-western Bering Sea would profoundly improve the model, as this region is currently data deficient.

Literature

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