SEABED BIODIVERSITY:
THE ROLE OF PHYSICAL ENVIRONMENTAL VARIABLES IN SHAPING BIODIVERSITY PATTERNS IN THE GULF OF MAINE

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INTRODUCTION

The distribution and abundance of marine species and assemblages is of fundamental interest to science and of considerable importance to management and conservation. For most marine species, such information is severely lacking, partly due to the great expense and time required for biological surveys. This has created an interest in determining the extent to which physical environmental variables can be used as surrogates for biological variables. However, a prerequisite to using physical environmental variables as surrogates is gaining general understanding of the importance and influence of different physical variables on biological community structure. As a contribution to the synthesis phase of the International Census of Marine Life (CoML), we aim to characterize the major bio-physical relationships of benthic community data from different biogeographic regions and a range of sampling gear types. Here we focus on the Gulf of Maine - similar analyses are underway on physical and biological datasets from the Gulf of Mexico and the Great Barrier Reef.

METHODS

We have analyzed benthic mesoscale datasets from three shelf biogeographic regions including temperate Gulf of Maine, using a modified version of Random Forests (a bootstrapped randomized classification/regression tree method (4)). Each region has collated broad-scale biological survey datasets comprised of site-by-species abundance data from trawls, benthic sleds, and grabs/corets (Figure 1), as well as site-by-physical datasets comprised of available physiographic variables thought to be important for influencing marine distributions (Figure 2). The modified Random Forest analysis collates split points from regression trees and change in deviance information for each species and physical variable (5). The results are expressed as cumulative frequency distributions of splits, weighted by deviance, summed over multiple species within different levels of aggregation.

RESULTS

To illustrate our analytical approach we show outputs from analyses of one of the component physical data sets, the Fisheries and Oceans Canada (DFO) Scotian Shelf Ecosystem Survey. The overall importances of physical drivers, averaged over all species (Figure 3a), indicate the principal influence of depth and temperature variables. The modified Random Forests R scripts collate split values from the regression trees into visualized critical values for each physical variable, as ratios of weight ed split density to predictor value density peaking above 1.0 (Figure 3b).

FIGURE 1. We accessed three biological datasets, originally acquired by federal agencies in Canada and the United States. The following datasets represent the three most extensive biogeographic regions and a range of sampling gear types. Here we focus on the Gulf of Maine - similar analyses are underway on physical and biological datasets from the Gulf of Mexico and the Great Barrier Reef.

FIGURE 2. Physical habitat variables for the time period of each biological dataset were also collected including bathymetry and derivables, coastal current series, sediment characteristics, benthic irradiance, nutrients, temperature, salinity and chlorophyll. Conceptual representation adapted from (4) Wright et al. (2007)

FIGURE 3. (a) Overall importances of the physical drivers averaged over all species. Accuracy importance is the average increase in mean square error (MSE) when a predictor is removed, expressed in the range [0, 1]. The y-axis indicates the # of unique split points. (b) Accuracies for each split point to visualize critical values for each physical variable, as ratios of weighted split density to predictor value density, in the range [0, 1].

DISCUSSION

Using results from an analysis of Scotian Shelf ecosystem survey data we have shown how a modified Random Forests statistical approach can be applied to represent patterns of change in biological assemblages along physical gradients of a comprehensive range of shelf-scale variables that may be derived from contemporary oceanographic and hydrographic sampling, and remote-sensing. These outputs also summarize the overall prediction performance of physical surrogates and identify the physical variables that contribute most to the prediction. The statistical techniques being developed in this work should also allow a first-order prediction of macrofaunal benthic and demersal fish biodiversity and community patterns based on seabed and environmental characteristics.

WORKS CITED

(5) Contact Pitcher (roland.pitcher@csiro.au) for information on the planned publication process, and expected availability of an R package for these outputs.