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TITLE: Quantifying Patterns of Change in Marine Ecosystem Response to Multiple Pressures

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ABSTRACT:

The ability to understand and ultimately predict ecosystem response to multiple pressures is paramount to successfully implement ecosystem-based management. Threshold shifts and nonlinear patterns in ecosystem responses can be used to determine reference points that identify levels of a pressure that may drastically alter ecosystem status, which can inform management action. However, quantifying ecosystem reference points has proven elusive due in large part to the multi-dimensional nature of both ecosystem pressures and ecosystem responses. We used ecological indicators, synthetic measures of ecosystem status and functioning, to enumerate important ecosystem attributes and to reduce the complexity of the Northeast Shelf Large Marine Ecosystem (NES LME). Random forests were used to quantify the importance of four environmental and four anthropogenic pressure variables to the value of ecological indicators, and to quantify shifts in aggregate ecological indicator response along pressure gradients. Anthropogenic pressure variables were critical defining features and were able to predict an average of 8-13% (up to 25-66% for individual ecological indicators) of the variation in ecological indicator values, whereas environmental pressures were able to predict an average of 1-5 % (up to 9-26% for individual ecological indicators) of ecological indicator variation. Each pressure variable predicted a different suite of ecological indicator's variation and the shapes of ecological indicator responses along pressure gradients were generally nonlinear. Threshold shifts in ecosystem response to exploitation, the most important pressure variable, occurred when commercial landings were 20 and 60% of total surveyed biomass. Although present, threshold shifts in ecosystem response to environmental pressures were much less important, which suggests that anthropogenic pressures have significantly altered the ecosystem structure and functioning of the NES LME. Gradient response curves provide ecologically informed transformations of pressure variables to explain patterns of ecosystem structure and functioning. By concurrently identifying thresholds for a suite of ecological indicator responses to multiple pressures, we demonstrate that ecosystem reference points can be evaluated and used to support ecosystem-based management.

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