Role of Habitat in Moderating Species Distributions and Interactions

ICES/PICES
Early Career Scientist Conference
April 2012
Palma de Mallorca, Spain

Matt Baker—Alaska Fisheries Science Center, JISAO/NOAA; Anne Hollowed—Alaska Fisheries Science Center, NOAA; M. Elizabeth Clarke—Northwest Fisheries Science Center, NOAA; Ray Hilborn—University of Washington

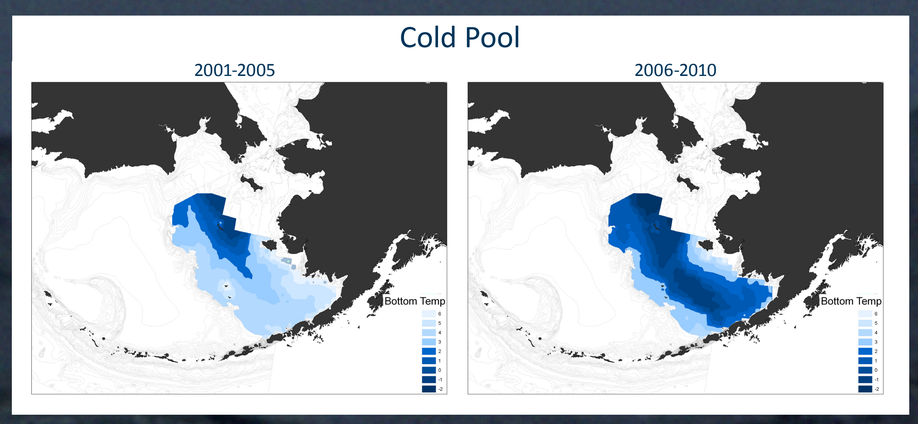

Figure 1

Summary

Several mechanisms drive ecosystem structure and stability in marine systems, including competition between species, climate, and fisheries extraction. Many systems subject to perturbation show stability in total biomass and structure, despite shifts in relative species abundance. This suggests sequential replacement related to compensatory dynamics. We examine species dynamics within and between functional guilds to weigh evidence for compensation, resource partitioning and common forcing via external drivers and examine how habitat governs species interactions.

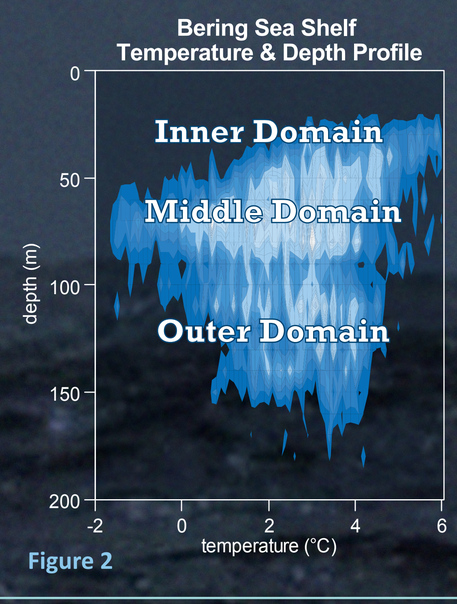

Figure 2

Species Distribution by Temperature & Depth

Temperature and depth influence species distributions and interactions and also partition ecosystems, segregating species or lifestages with effects on prey availability, predator avoidance, and competitive exclusion. The eastern Bering Sea is defined by depth, substrate, and cold waters related to residual ice melt, which shift in intensity and extent (cold pool, Fig. 1). Temperature and depth profiles for the Bering Sea shelf are displayed (center figures, system profile for reference, Fig. 2). Demersal piscivores (cod, halibut) range across the shelf and their distributions have considerable overlap. In contrast, pelagic piscivores (turbot, flounder) are constrained by temperature gradients, which restrict access to the middle shelf. In years with a reduced cold pool, pelagic piscivores increasingly access the middle shelf and age classes of walleye pollock susceptible to predation (Fig. 3).

Shifts In Species Distribution & Community Composition Along Environmental Gradients

Temperature and depth influence species distribution (Fig.3). We applied random forests to determine the importance of environmental variables on individual species distributions. We display the main environmental driver for five species (partial dependency plots, Fig. 3). We extended methods to species assemblages synthesizing cross-validated coefficient of determination and accuracy importance measures from univariate analyses to quantify compositional turnover along environmental gradients. Stations are displayed in transformed multi-dimensional biological space as a biplot and the weighted mean biomass of individual species are overlayed in circles (Fig. 3). Results suggest pervasive distribution of cod. Halibut prefer coarser substrates. Both Greenland turbot and arrowtooth flounder prefer deeper habitat, but turbot associate with mud, whereas flounder prefer coarser substrate and warmer waters. We delineate ecoregions within the Bering Sea (i.e. partition the ecosystem) according to clustering of survey stations reflecting gradient output of community structure and physical habitat variables (Fig.4)

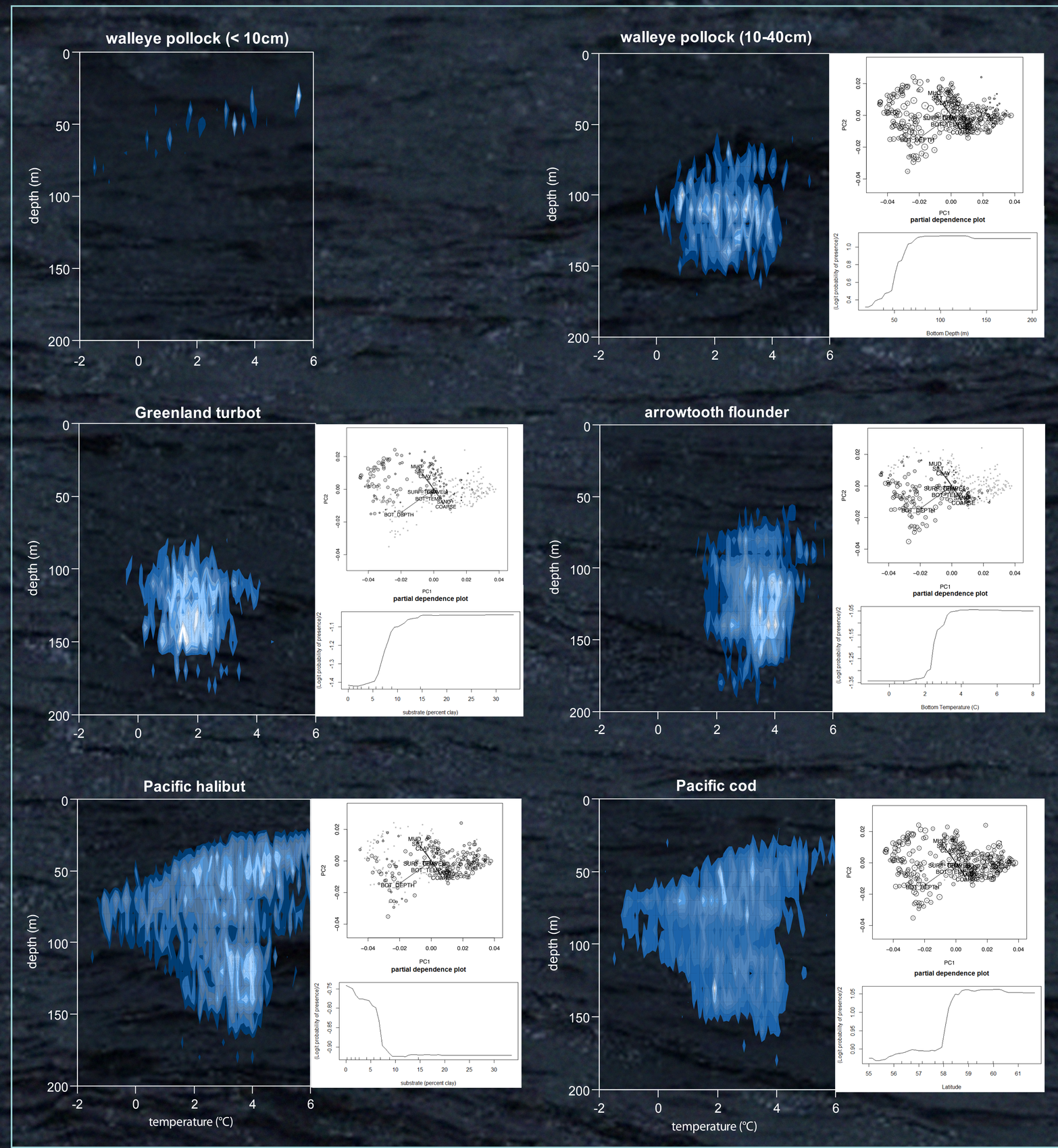

Figure 3

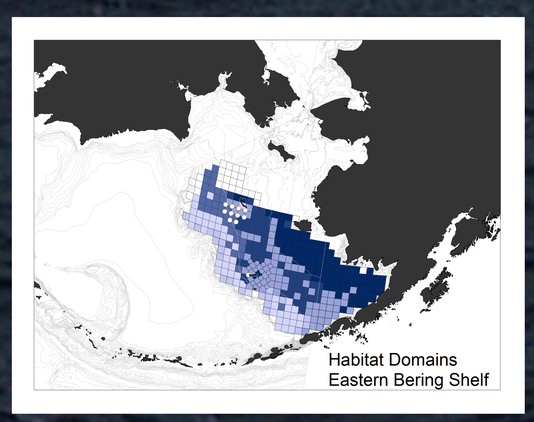

Figure 4

Variance Ratio Tests: Compensatory Dynamics

We applied variance ratio tests to identify compensatory dynamics among species within functional guilds.

$$VR = \frac{\sigma^2_{Community}}{\sum_i^n \sigma^2_{Population_i}}$$

We noted compensatory dynamics in planktivores, benthivores, and demersal piscivores, but positive correlation in pelagic piscivores, suggesting resource partitioning or common responses to external drivers (Fig. 5).

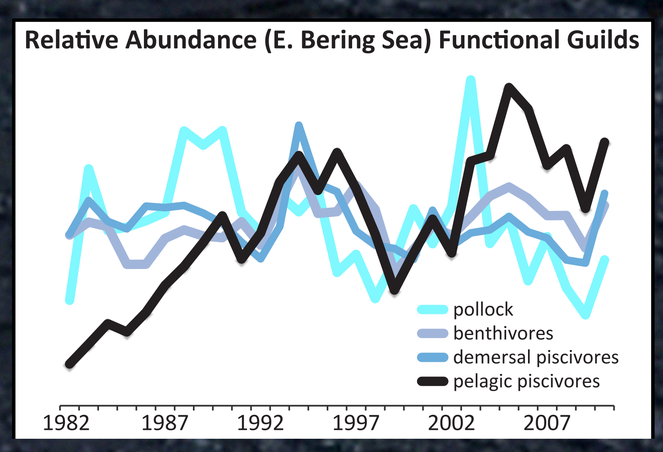

Figure 5

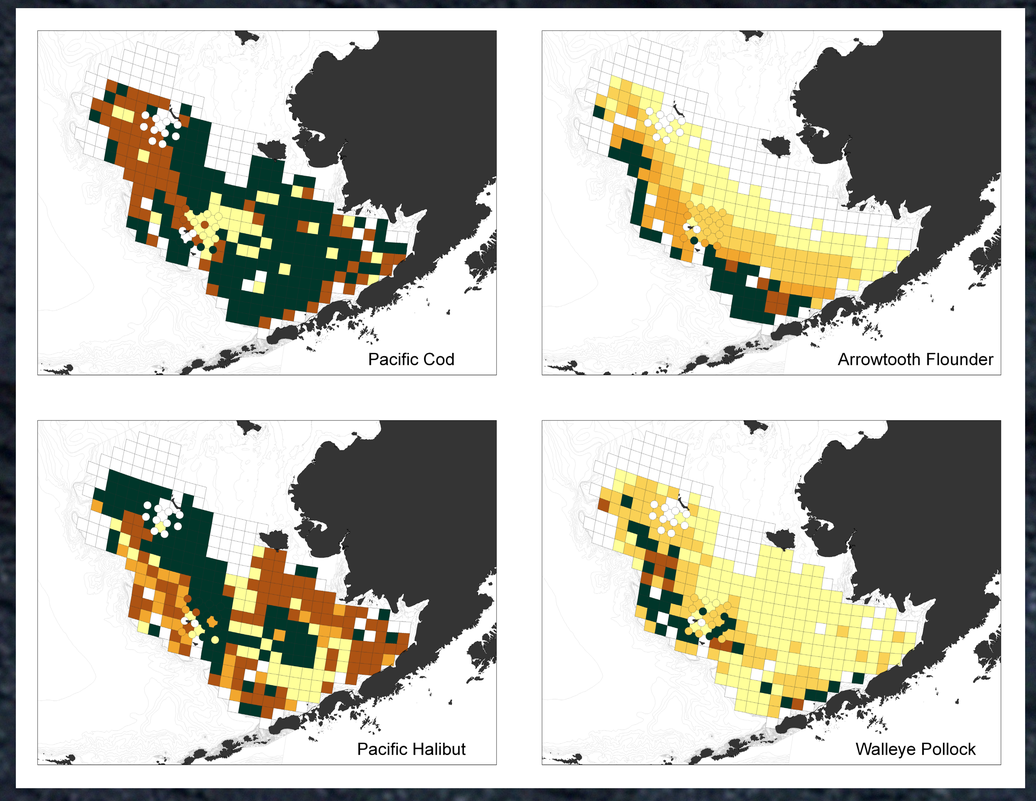

Figure 6

Cluster Analyses and Stock Substructure

We applied centroid-based clustering methods to time series trends of species abundance to explore evidence for sub-structure in exploited stocks (Fig. 6). We noted distinct trends in arrowtooth flounder across the shelf from shallow to deeper gradients. Walleye pollock appear to behave as one aggregate stock, with distinct dynamics in the northern outer shelf, which likely reflects patterns related to age structure. Stock structure in dominant demersal piscivores (cod and halibut) was less distinct and subpopulations exhibited considerable overlap and exchange.

The recommendations and general content presented in this poster do not necessarily represent the views or position of the Department of Commerce, the National Oceanic and Atmospheric Administration, or the National Marine Fisheries Service.