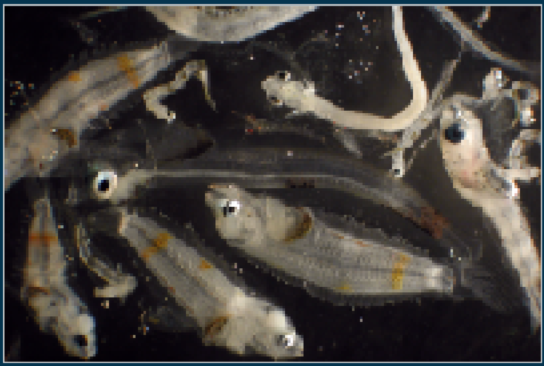
New Metrics for Ecosystem Change: Bio-diversity and Dynamics of Ichthyoplankton Assemblages

Wiebke J. Boeing
University of Washington
Joint Institute for the Study of Atmosphere & Oceans
Seattle, WA 98195 USA
Wiebke.Boeing@noaa.gov

Janet T. Duffy-Anderson, Kevin M. Bailey, Ann Matarese, Jeffrey M. Napp, Susan Picquelle & Bern Megrey
Alaska Fisheries Science Center
National Marine Fisheries Service
7600 Sand Point Way NE
Seattle, WA 98115 USA



Introduction

Environmental perturbations might not be reflected in adult biomass and higher trophic levels (e.g. Steller Sea Lions) for several years. Early life-stages might be more sensitive to changes in the environment and show responses to perturbations more quickly. Thus, it may be possible to detect climate change more quickly by focusing on lower trophic levels. We are in the process of identifying metrics using ichthyoplankton and zooplankton information that could be useful as ecosystem indicators. We hypothesize that meaningful ecosystem metrics for early detection of climate shifts can be found. We will also explore linkages between ichthyoplankton and adult spawning biomass to further investigate effects at multi-trophic levels. We will extrapolate these results to assess whether environmental changes have altered the composition of the fish community or reduced local production and prey abundance for Steller Sea Lions.

Long term data sets are necessary in order to best evaluate possible decadal-scale environmental changes. Fortunately, we can make use of a long-term (20+ years) ichthyoplankton database that spans the 1977 and 1989 regime shifts in the North Pacific (Hare and Mantua 2000). This allows us a unique opportunity to begin to evaluate the ichthyoplankton community prior to, during, and after several major "regime shifts" in the North Pacific.

Materials and Methods

The ichthyoplankton samples were collected by the Recruitment Processes Program of the Alaska Fisheries Science Center. Sampling started in 1972 and a continuous dataset is available from 1981 until the present. Samples were taken with oblique tows from bottom to surface by a (diameter) 60 cm bongo-net (333 and 505 µm mesh). We analyzed the data (January to June) collected in the Gulf of Alaska (GOA), dividing the region into seven strata (Fig. 1). We calculated Shannon-Wiener indices for the entire region and each strata according to the formula: $H' = -\sum p_i \ln p_i$ where p is the proportion of each species i.

We are interested in determining whether certain geographic strata are more sensitive to environmental fluctuations than others.

Similarly, species richness (total number of species) and abundance of 25 individual species were calculated for each year. The indices time series were then correlated to the Pacific Decadal Oscillation (PDO) index (Fig. 2) with canonical correlation coefficient analysis.

Results

The Shannon-Wiener index shows significant negative correlations to the PDO index in some cases and time lag increases from North-East towards South-West (Table 1).

Species richness responds significantly only once and in three species, there is a negative correlation between abundance and PDO index (Table 1).

Discussion

All significant correlations are negative, indicating an inhibiting effect of warmer water temperature on species diversity, richness, and biomass.

This work presents the first stages of this project. Additional indices we will develop and test include estimates of larvae survival (number of large larvae over total abundance), occurrence of rare species, and dynamics of fish guilds (e.g., feeding habits, habitat, physiology).

We anticipate building on the preliminary results presented here, adding new variables (zooplankton displacement volume, taxanomic information, nutrient and chlorophyll data, and climate information). We hope to be able to utilize these metrics to evaluate the impacts of climate change in various sub-species within a single system (GOA) and between systems (GOA, BS and West Coast).

Literature Cited

Hare, S.R. and N.J. Mantua. 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. Progress in Oceanography 47: 103-145.

Figure 1. Geographical strata of the Gulf of Alaska

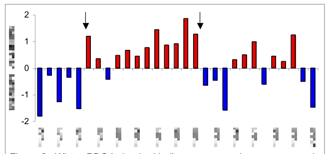


Figure 2. Winter PDO index (red indicates warmer than average and blue colder than average: arrows mark regime shifts. (http://jisao.wasington.edu/pdo)

Table 1: Significant correlation coefficients between various indices and PDO index

Index	Strata / Species	Correlation Coefficient	Time Lag (years)
Shannon-Wiener	East of Upper Shelf	-0.93	0
Shannon-Wiener	Kodiak Shelf	-0.55	1
Shannon-Wiener	Outer Shelikof	-0.52	3
Species Richness	Middle Shelf	-0.52	1
Abundance	GOA / *Gadus macrocephalus*	-0.52	1
Abundance	GOA / *Hippoglossoides elassodon*	-0.60	1
Abundance	GOA / *Lepidopsetta polyxystra*	-0.46	0

poster design by Karna McKinney, AFSC Graphics Unit