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Visualizations of groundfish distributions from the Alaska Fisheries Science Center bottom trawl surveys

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Abstract

Visualization of the distribution and centroids of groundfish surveyed during the Alaska Fisheries Science Center standardized bottom trawl surveys of the eastern Bering Sea (EBS) shelf, Gulf of Alaska shelf, Aleutian Islands shelf and eastern Bering Sea Slope are provided. During these surveys researchers have collected species composition and bottom temperature for all tows as well as measurements from all fish species encountered. These data have been used to create visualizations of spatial distribution and distribution by bottom depth and temperature by length bins for all available surveys for groundfish and skate species where adequate length data have been collected (2000 specimen per species per survey). This provides a unique look at the spatial and environmental preferences of a wide variety of species, as well as ontogenetic shifts in spatial distribution and environmental preferences. The visualizations provided are meant to facilitate a better understanding of the life histories of these species over time and space and provide clues to how climate change may potentially impact species at different life stages.

Methods

All retrieval and processing of data were done in R (R Core Team 2015). Bottom trawl survey data were recovered from the AFSC Oracle database using the R package **RODBC** (V 1.3-8, Ripley and Lapsley, 2013). Data were plotted using the R package **ggplot2** (Wickham 2009).

The catch per unit effort (CPUE number km^{-2}), weighted mean location (eastings and northings in UTM zone 2), weighted mean depth, and weighted mean bottom temperature were calculated for each species and length category for each year. For each species the length data were binned into five percentile length categories: 0-10%, 10%-30%, 30%-70%, 70%-90%, and 90%-100% of the raw length frequency distribution for the full time series.

For each individual haul, *h*, and species, *s*, CPUE was calculated as

$$CPUE_{sh} = \frac{K_{sh}}{W_h * D_h},$$

where K is the total number of fish of species *s* in haul *h* , W is the average net width of haul *h* in kilometers and *D* is the tow length of haul *h* in kilometers. The proportion, *p*, of fish of species *s* in length category *l* in haul *h* was calculated as

$$p_{slh} = \frac{n_{slh}}{n_{sh}},$$

where n_{slh} is the number of fish of species *s* in length category *l* for haul *h*, and n_{sh} is the number of fish of species *s* in haul *h*. The number of fish of species *s* in length category *l* for haul *h* per km^2, N_{slh}, was calculated as

$N_{slh} = p_{slh} * CPUE_{sh}$.

The weighted mean latitude, longitude, bottom depth, or bottom temperature (centroids) for each length category by year, M_{xly}, was calculated as the weighted mean by year, *y*, as

$$M_{xsly} = \frac{\sum N_{slhy} x_{shy}}{\sum N_{slhy}},$$

where x_{shy} is the location of a haul in latitude, longitude, bottom depth, or bottom temperature.

The mean shelf-wide bottom temperature for each year, $\overline{ty}$,were calculated following the methods presented in Spencer (2008) as

$$\overline{ty} = \sum_{i=1}^{b} \sum_{j=1}^{n_{iy}} \frac{f_i}{m_{iy}} x_{jiy}$$

where f_i is the proportion of the survey area in strata *i*, m_{iy} is the number of hauls in strata *i* for year *y*, x_{jiy} is bottom temperature in haul *j* and strata *i* and year *y*, and *b* is the number of strata. Each year was categorized as warm, cold, or medium (above, below, or within 0.66 standard deviations of the overall years shelf mean bottom temperatures for each region.

Four sets of analyses were produced using the centroid method for each species. In the first set the centroids were computed and shaded by length category for location or bottom depth and bottom temperature. In the second and third analyses a single R function is defined. In these analyses each figure shows a set of graphs, one for each length category, with the centroids of location or bottom temperature and depth for each year shown. The second analysis shades the data by year of collection, the third by whether the mean shelf-wide bottom temperature for the year as defined by the methods presented in Spencer (2008; Temps. tab) is above or below the overall mean for the available regional data. In the fourth set of analysis the data were shaded by sex. The R function used for this analysis is presented in Appendix A, those fish measured but sex left undetermined were not included.

In all the centroid figures variance of the weighted mean ($\sigma^2_{M_{xsly}}$) were based on Cochran (1977) where the mean weight was

$\overline{N}_{sly} = \frac{\sum N_{slhy}}{\sum n_{slhy}}$, and

$\sigma^2_{M_{xsly}} = \frac{\sum n_{slhy}}{(\sum n_{slhy}-1)(\sum N_{slh})^2} [\sum (N_{slh}x - \overline{N_{sly}} M_{xsly})^2 - 2M_{xly} \sum ((N_{slh} - \overline{N_{sly}})(N_{slh}x - \overline{N_{sly}} M_{xsly})) + M^2_{xsly} \sum (N_{slh} - \overline{N_{sly}})^2]$.

All confidence bounds shown in the visualizations are $CI = 1.96\sqrt{\sigma^2_{M_{xsly}}}$.

R Code

Shiny Files:

- ui.R
- server.R
- global.R

Functions:

- Get_DATA.R - Function to pull bottom trawl survey length and CPUE data from AFSC database.
- Get_TEMP.R - Function to calculate and plot the mean annual bottom trawl temperatures for the groundfish surveys

- plot_DISTRIBUTIONS.R - Function to plot distribution by location and depth and temperature of AFSC bottom trawl survey data by size categories.
- plot_CENTROIDS.R - Function to plot species centers of gravity (weighted means, centroids) by location and depth and temperature of AFSC bottom trawl survey data by size categories. Options include plotting by shelf-wide temperature, annual, all years combined, and sex.

Citations

Cochran, W. G. 1977. Sampling techniques (3rd ed.). New York: John Wiley & Sons

R Core Team. 2015. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Spencer, P. D. 2008. Density-independent and density-dependent factors affecting temporal changes in spatial distributions of eastern Bering Sea flatfish. Fish. Oceanogr. 17:396-410.