In situ temperature and salinity data for use in stock assessments

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Introduction

Much of the variability in fish population abundance is attributable to recruitment variability and there is a long history of research to understand the sources of recruitment variability (Rothschild 1988). There is a large body of literature supporting the idea of temperature-mediated recruitment. These issues can be important to stock assessment when developing forecasts of stock status under different fishing mortalities (see Miller et al. 2016). Differences in temperature caused by climate variability (e.g., NAO, AMO) or climate change can affect future recruitment.

Research on a number of flounder species in the Northeast U.S. indicates links between temperature and recruitment. Sullivan et al. (2005) hypothesized that Southern New England Yellowtail Flounder recruriment is related to the Cold Pool – an area of cold water near the bottom on the Mid-Atlantic Bight shelf during summer. The hypothesis is that the Cold Pool is used as a juvenile nursey habitat in the Mid-Atlantic. This hypothesis was supported by Miller et al. (2016) who demonstrated a relationship between Cold Pool magntitude and Yellowtail Flounder recruitment. In addition, Bell et al. (2016) indicated the Winter Flounder productivity has been decreasing over time and linked the decrease to warming temperatures in spawning and nursey habitats. These analyses agreed with an earlier study by Manderson (2012).

Here we describe in situ temperature data that will be used in subsequent investigations related to the effect of temperature on witch flounder recruitment.

Data and Indices

The Northeast Fisheries Science Center has conducted hydrographic measurements since the 1960's. Complete seasonal and spatial coverage started in the late 1970's and has continued to the present, with the exception of a several year break in the late-1980s. The hydrographic observations are described in annual Hydrographic Atlases (see Fratantoni et al. 2015) and the data are stored by the NEFSC in the Oceanography Database (OCDBS). Data are also deposited into oceanographic databases maintained by the NOAA National Centers for Environmental Information. The oceanographic, climate, and fisheries communities broadly use the data.

Between 1500 and 3000 CTD casts are made per year and the NEFSC is the largest contributor of hydrographic data to national archives for the Northeast U.S. Shelf.

Looking at the scale of Ecological Production Units (Figure 1), long-term warming trends are observed at the surface and bottom in the Mid-Atlantic Bight, Gulf of Maine, and Georges Bank regions and at the surface in the Scotian Shelf region (Figure 2). Waters have warmed by 1°-1.5°C over the length of the records. Even larger warming trends have been observed in recent years, with the surface and bottom waters warming by more than 2 degrees since 2004 within all regions except the Mid-Atlantic Bight. Perhaps most notable, 2012 temperatures were the warmest observed in the 35-year record at the surface and bottom over all regions of the Northeast U.S. shelf, exceeding long-term annual mean values by up to 2 degrees at the surface and 1 degree at the bottom.

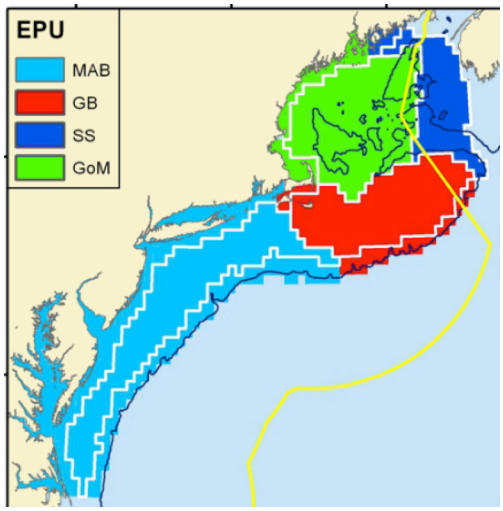

Figure 1. Map of the Northeast continental shelf of the United States, showing the Ecological Production Units. The core of each EPU is bounded by white, and the nearshore and shelf break special considerations areas are to the west or east of the core areas respectively. MAB - Mid-Atlantic Bight; GB - Georges Bank; SS - Scotian Shelf; GoM - Gulf of Maine. (from http://www.nefsc.noaa.gov/ecosys/ecosystem-status-report/introduction.html).

Planned Analyses for Model Meeting

We plan to develop a juvenile witch flounder temperature index based on the area occupied by these fish. We will use data from the Spring Bottom Trawl Survey and Ecosystem Monitoring Surveys as these represent the season when both juvenile and adult witch flounder have shown a significant increase in mean stratified bottom water. Over the past 40 years, mean bottom water temperature (^{o}C) occupied by adults (p-val ≤ 0.04, df = 46, r^2 = 0.09, slope = 0.03) and juveniles (p-val ≤ 0.02, df = 46, r^2 = 0.11, slope = 0.04) have increased significantly during the spring (Figure 3). Preliminary analyses will follow the procedures used by Hare et al. (2014). Briefly, SSB and R pairs will be obtained from the preliminary stock assessment model; estimates of uncertainty will be used if available. A stock recruitment function with a temperature term will be fit using ADMB and compared to a stock recruitment function without temperature. If the analyses indicate a

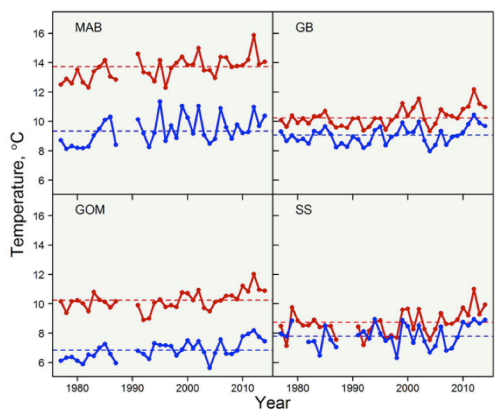

Figure 2. Annual mean surface (red) and bottom (blue) water temperatures from the NEFSC survey programs from the four Ecological Production Units (from http://www.nefsc.noaa.gov/ecosys/ecosystem-status-report/physical-pressures.html)

significant relationship between bottom water temperatures and witch flounder recruitment, this relationship could be integrated into an assessment model (Miller et al. 2016).

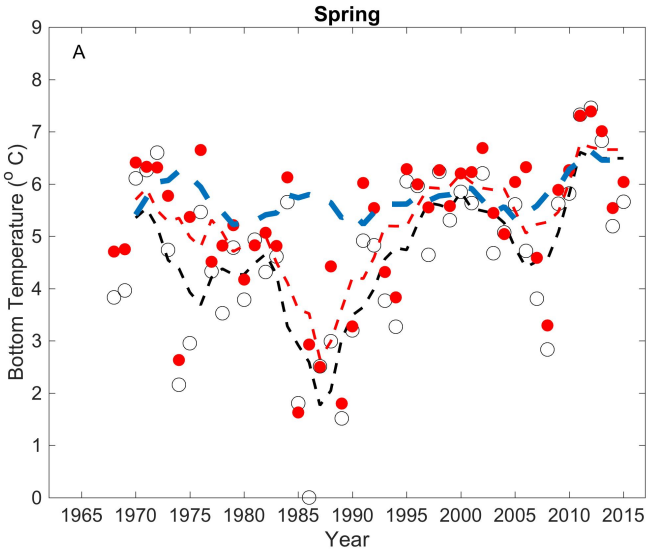

Figure 3. Stratified mean bottom water temperature (symbols) and 5-year moving average (line) of juvenile (< 30 cm; O) and adult witch flounder (>= 30 cm; •) collected in the Gulf of Maine during the NEFSC spring bottom trawl survey. Mean bottom water temperature of all stations sampled in the region is shown as a 5-year moving average (-)

References

Bell, R. J., Hare, J. A., Manderson, J. P., & Richardson, D. E. (2014). Externally driven changes in the abundance of summer and winter flounder. ICES Journal of Marine Science: Journal du Conseil, 71(9), 2416-2428.

Fratantoni, P. S., Holzworth-Davis, T., Bascuñán, C., & Taylor, M. H. (2015). Description of oceanographic conditions on the Northeast US Continental Shelf during 2014. US Dept Commer, Northeast Fish Sci Cent Ref Doc, 15-21.

Hare, J. A., Brooks, E. N., Palmer, M. C., & Churchill, J. H. (2015). Re-evaluating the effect of wind on recruitment in Gulf of Maine Atlantic Cod (Gadus morhua) using an environmentally-explicit stock recruitment model. Fisheries Oceanography, 24(1), 90-105.

Manderson, J. P. (2008). The spatial scale of phase synchrony in winter flounder (Pseudopleuronectes americanus) production increased among southern New England nurseries in the 1990s. Canadian Journal of Fisheries and Aquatic Sciences, 65(3), 340-351.

Miller, T. J., Hare, J. A., & Alade, L. A. (2016). A state-space approach to incorporating environmental effects on recruitment in an age-structured assessment model with an application to southern New England yellowtail flounder. Canadian Journal of Fisheries and Aquatic Sciences, 73(999), 1-10.

Rothschild, B. J. (1986). Dynamics of marine fish populations. Havard university press.

Sullivan, M. C., Cowen, R. K., & Steves, B. P. (2005). Evidence for atmosphere–ocean forcing of yellowtail flounder (Limanda ferruginea) recruitment in the Middle Atlantic Bight. Fisheries Oceanography, 14(5), 386-399.