**Final Report to OLI and OCCI of Project 27071363**: Can changes in silver hake be related to and forecast by changes in the Gulf Stream path?

Terrence M. Joyce and Young-Oh Kwon, 27 May 2014

This project began soon after we had prepared a draft manuscript (Nye et al. 2011) detailing the changing spatial distribution of silver hake with changes in the average latitude of the Gulf Stream (GS) south of New England. This relationship accounts for a significant amount of year to year variability in where silver hake are caught in the spring and fall National Marine Fisheries Service (NMFS) stock assessments. It reflects an underlying dynamics that is consistent with the fact that 1) the GS is more offshore (onshore) when the temperature of the Slope Water and outer Shelf Water is cold (warm), and 2) the silver hake try to follow their preferred near bottom temperature of ca. 8$^{o}$C, by swimming to the northeast (warm years) or southwest (cold years) when their environmental temperature changes. Our work established a primary response of an important commercial fish stock to climatic changes in the ocean circulation offshore of the outer continental shelf. It also suggested that use could be made of the GS path to predict the future changes of the silver hake. Our internal WHOI proposal sought to explore this predictive potential.

With the efforts of a postdoctoral investigator (Xujing Davis), and the advice of Young-Oh Kwon and Terrence Joyce of the WHOI PO scientific staff, this idea was developed into a submitted manuscript to the Marine Ecology Progress Series (Davis et al, 2014). The abstract of this manuscript is included below as it is not yet accepted or even published. We have also attempted to extend our findings to other fish stocks and other biological drivers (eg. Nutrients and zooplankton) through two proposals to NOAA's FATE program, and one proposal to NSF's initiative for Earth Systems Models with NMFS scientists. While we have raised interest within our research community and within NMFS with these efforts, we have not been successful in raising externally-funded support, as of this date. Our only financial support thus far has been from internal funds generously offered by both the Ocean and Climate Change Institute and the Ocean Life Institute at WHOI.

**References:**

Nye, J.A., T.M. Joyce, Y.-O. Kwon, and J.S. Link, 2011. Gulf Stream position determines spatial distribution of silver hake. *Nature Commun.*, 2:412, doi:10.1038/ncomms1420.

Davis, Xujing Jia**,** Terrence M. Joyce, Young-Oh Kwon, 2014. Prediction of silver hake distribution on the Northeast U.S. shelf based on Gulf Stream path index, *Marine Ecology Progress Series*, submitted 2014.

Abstract:

Over the past ~40 years, the distribution of silver hake (SH) on the Northeast U.S. shelf is found to be closely related to changes in the latitude of the Gulf Stream (GS) path. The correlation coefficient

between the fall GS position and the center of biomass (COB) of spring SH reaches 0.75 when the GS leads the SH for 0.5 year. Based on this lead-lag relationship and low frequency variability of GS position with a dominant period of ~9-10 years, the GS path index is used as a predictor for the COB of SH in linear autoregressive (AR) models. The goal of this study is then to optimize the AR model for the prediction of SH based on the observed changes in GS position. Fall GS position is first predicted out to 5 years using a 5th order AR model and the observed GS position in preceding years. We propose an optimization process to choose best AR coefficients based on a new combined skill parameter. We then use this predicted GS position to further predict the COB of SH in subsequent spring. Three different AR models are compared for the SH prediction. The predicted SH time series can explain as much as 69% of the variance of the observation for the 1st year prediction and 41 % for the 5th year prediction. Our results indicate that including GS as a predictor produces better prediction skills of SH COB than the AR model prediction solely based on the observed SH time series