Potential Climate and Ocean Acidification Effects on Young Life-Stages of Summer Flounder

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The effects of excess atmospheric CO_2, a greenhouse gas, from carbon combustion on our living marine resources are expected to range from subtle to profound. Researchers at the NOAA Fisheries Howard Laboratory, Highlands NJ, have been investigating two key challenges from a changing climate on fishes of the Mid-Atlantic and New England waters: responses to changing thermal conditions and to increased ocean acidity. Summer flounder (*Paralichthys dentatus*) is one of our focal species. It is the most economically valuable flatfish in U.S. Atlantic waters and has peak recreational landings in NY and NJ. Further, as a consumer of forage species and of young life-stages of economically important fishes, it is also a keystone species in shelf and inshore habitats.

We know that temperatures of ocean waters are central to marine ectotherm physiology but we know far less about the potential effects of elevated CO_2 in ocean waters (i.e., ocean acidification) on fish health, recruitment processes, and survival. The waters used by summer flounder for spawning and occupied by early life-stages (ELS) of their offspring are at risk for very rapid climate change (Saba et al. 2016. *J. Geophys. Res. Oceans*, 121, 118–32). A climate vulnerability assessment of LMRs of the Northeast Shelf Large Marine Ecosystem found that summer flounder has a very high risk of climate exposure, a high potential for changes in geographic distribution, and a high vulnerability of its early life-stages which are critical to recruitment and stock distributions (Hare et al. 2016. doi:10.1371/journal.pone.0146756). Recent studies suggest that the summer flounder stock already exhibits a northward shift (Nye et al. 2009 *MEPS* 393:111-129). Prior analyses of summer flounder thermal relations, however, have employed descriptive or correlative methods, have been mostly restricted to adults, and have not identified mechanism(s) driving these changes. Our recent research shows evidence of i) regional heterogeneity in summer flounder genotype associated with local conditions including bottom temperatures (Hoey et al., *in prep*.) and ii) a broad range of thermal tolerance by summer flounder ELS in experimental trials, but with significant and ecologically important responses to future climate regimes (Chambers et al. *in prep.*). Among other notable responses of ELS to higher temperatures is rapid development and smaller sizes at hatching and settlement.

Our recent experimental analyses of elevated CO_2 effects on summer flounder ELS (Chambers et al. 2014 *Biogeoscience* 11:1613-1626, Candelmo et al. *in prep*.) show significant negative effects of several key life processes. Responses to CO_2 levels expected by 2100 include 1) reduced fertilization rate (up to 30% reduction with an amplification of negative effects at elevated temperatures), 2) lower hatching success (> 50% reduction), and 3) a smaller size at ingress and settlement. The reduced fertilization and embryo survival rates would directly affect recruitment rates. The effect of elevated CO_2 on larval ontogeny (growth and developmental rates) would be expected to alter the prey field and predator risks of young juveniles as they enter the nursery habitat. These results, the context for the research, and plans for future experiments will be presented.