Management and Conservation Of Atlantic Bluefin Tuna (Thunnus Thynnus) And Other Highly Migratory Fish In The Gulf Of Mexico Under IPCC Climate Change Scenarios: A Study Using Regional Climate And Habitat Models

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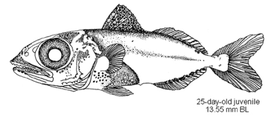


INTRODUCTION:

This "applications" research project focuses on enhancing the management of multiple important highly migratory pelagic fish species in the Gulf of Mexico and surrounding waters, with particular focus on Atlantic bluefin tuna (Thunnus thynnus) and other highly migratory tunas and billfishes. This study is leveraging our collaborative research with NOAA fisheries scientists and managers to develop and refine habitat classification models from 30+ years of historical fish, physical, and satellite data. The fish data are derived from derived primarily from the NOAA NMFS SEAMAP and some other spring larvae cruises along with the NMFS pelagic longline observer data. The physical data are derived from the in-situ ship data from the larvae surveys and from satellite data (sea surface temperature, ocean color, sea surface height), along with additional NOAA buoy data.

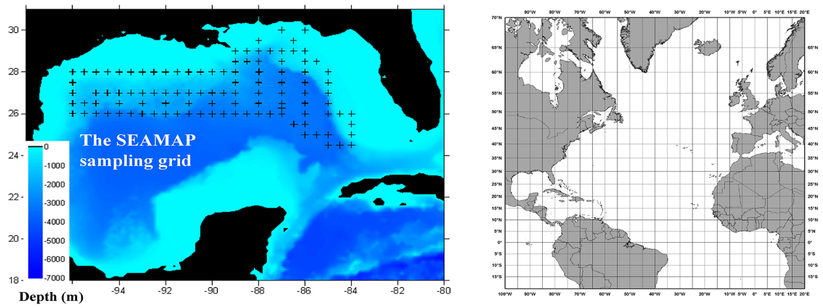
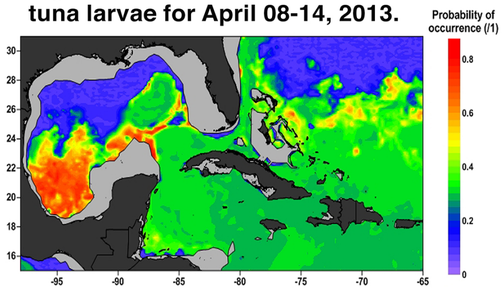


Figure 1. Left: The NOAA NMFS standard SEAMAP sampling grid. In recent years the samling has extended to the southern Gulf of Mexico and Caribbean Sea. Right: model domain for the downscaling of the IPCC_AR4 and IPCC_AR5 modeling.

The GOAL is to assess the potential changes in spawning habitat and population dynamics using outputs from the numerical simulations constructed for the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC AR4), which are being refined in preparation for the fifth assessment report (IPCC AR5). To achieve this we developed a downscaled model using 0.1° resolution MICOM/HYCOM to reproduce the natural variability of the Gulf of Mexico. Then we projected the conditions for the 2041-2060 period and 2081-2100 period under RCP4.5 and RCP 8.5 forcing to evaluate the ocean temperature habitat at the surface, 100m and 200m.

Figure 2. Habitat model for bluefin tuna larvae for April 08-14, 2013.



The habitat model is derived using multivariate, non-parametric, neural networks modeling techniques from DTREG. Satellite derived sea surface temperature, chlorophyll, sea surface height, along with T°200m and surface velocity (HYCOM) data are used. The model is being used to evaluate the overall spawning habitat conditions and the probability of finding larvae. Analyses derived from real-time sst and chlorophyll are used by the NOAA research vessel for targeted sampling.

RESULTS:

The results from the downscaled high resolution HYCOM/MICOM simulations showed that the Loop Current transport is reduced by 20-25% for the 21st century under the A1B climate scenario. This weakening of the current is evidenced by a reduction in the velocity and penetration of the Loop Current - eddy system as shown in Figure 3. As the natural variability in the sst of the Gulf of Mexico is a function of this, the simulations suggest that the northern Gulf of Mexico will undergo a reduced warming (as little as 1°C) compared with the rest of the Gulf. The IPCC-AR4 global model predicts warming of ~2°C. This illustrates the benefit of using a regionalized downscaled model compared with the global model (Figure 4).

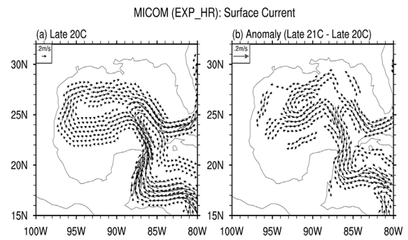


Figure 3. (a) Long-term mean surface current in the late 20th century during Apr. May, June; (b) Anomalous (i.e., late 21st century to late 20th century).

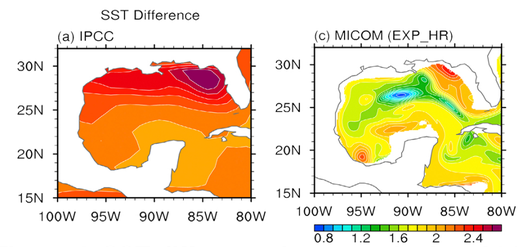


Figure 4. SST difference between the late 21st century and late 20th during AMJ obtained from (a) the weighted ensemble of 11 IPCC-AR4

The results of the fish habitat modeling along with simulations of the future sst based spawning habitat conditions in the Gulf of Mexico for bluefin tuna (Figure 5) showed that during the late 20th century, bluefin tuna spawned in the northern Gulf of Mexico in May and June, with less activity in April. Larvae were rarely collected from within the Loop Current or warm eddies. By the end of the 21st century, habitat in the northern Gulf was slightly more suitable in March and April, however, much of the May and June habitat was predicted to disappear. In Figure 6 the results for the spawning habitat changes for yellowfin/blackfin tuna showed that during the late 20th century, these Thunnus spp. increased spawning activity throughout spring. By the end of the 21st century, warming temperatures are predicted to increase the suitability of spawning habitat in all spring months.

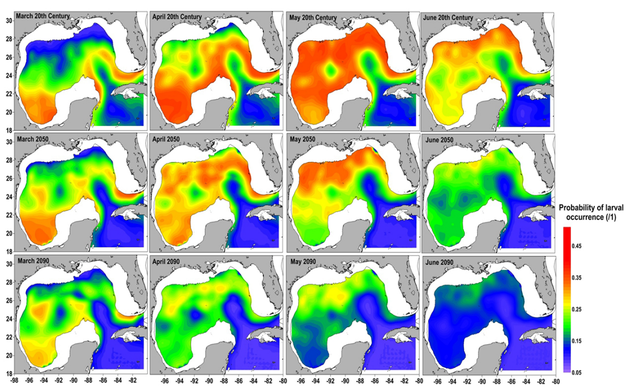


Figure 5. Probability of bluefin tuna larvae during March -June 20th - 21st centtury.

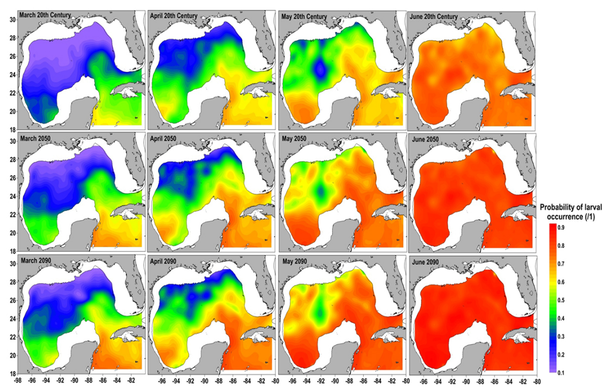


Figure 6. Probability of yellowfin/blackfin larvae during March -June 20th - 21st century.