Expanding Oxygen Minimum Zones, Tropical Pelagic Predators, and Atlantic Fisheries That Exploit Them

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ABSTRACT. This paper links 50 years of ongoing ocean scale deoxygenation trends in the tropical Atlantic Ocean to changes in vertical habitat use of large pelagic predators, and the Atlantic fisheries that exploited them. Climate induced warming in this large ocean area (Oxygen Minimum Zones, OMZs) has compressed the volumes of surface mixed layer habitat by about 1 m y^{-1} over the last 5 decades, concentrating predators, preferred prey, and influencing Atlantic-wide fishing effort patterns into progressively shallower surface zones. This phenomenon increases the catchability of these predators and may contribute to overly optimistic abundance estimates derived from surface fishing gears. Overall, deoxygenation is estimated to have caused a 15% reduction in suitable habitat for tropical pelagic tunas and billfishes in the tropical Atlantic during this time period. To demonstrate ocean scale changes in available habitat we use Hydrobase 3 database to compute decadal matrices of OMZ size (volume and surface area), as well as the reciprocal decline in surface mixed layer from 1955 through 2004. Further, we tracked fishing effort and catch inside and outside of the Atlantic OMZ for 9 major ICCAT assessment species to examine potential compression impacts. We found that during the last decade analyzed (1995-2004), longline fishing effort has coalesced on-top of the Atlantic OMZ, while hooks from outside the OMZ have decreased by about the same proportion. During the initial decade (1955-1964), 3 longline fleets deployed about 500,000 hooks, while by the last decade (1995-2004) longline effort had expanded to 94 fleets and almost 4.2 billion hooks. We determined that at least 7 out of 9 major ICCAT stock assessment species examined here are severely impacted by the OMZ expansion and resulting loss of available habitat. We also point out some significant ecosystem interactions between predators and preferred prey that appear to fuel predator assemblages.in progressively shallow OMZ areas, including some predators that are not sensitive to low ambient DO levels. As deoxygenation is expected to continue during the current cycle of climate change and global warming, and has been observed in other oceans as well, this suggests it may have broad-scale impacts on the sustainability of pelagic fisheries and their management. In order to maintain sustainable fisheries for tropical pelagic fishes, we feel its incumbent upon the assessment community to incorporate hypoxia-based habitat compression impacts for species of concern (identified here) into the assessment process. One potential approach might be accomplished during the Catch-Per-Unit-Effort standardization process, by scaling catchability coefficients

(by species and gear) using the progressive decadal decline in available surface mixed layer habitat (in volume) presented here.

Key words: hypoxia-based habitat compression, expanding oxygen minimum zones, pelagic predator management, catchability coefficients. CPUE standardization.