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Defining the Tipping Point of Tolerance to CO_2-Induced Ocean Acidification in Larval Dusky Kob Argyrosomus japonicus (Pisces: Sciaenidae)

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Abstract : Increased CO_2 production and the consequent ocean acidification (OA) have been identified as one of the greatest threats to both calcifying and non-calcifying marine organisms. Traditionally, marine fishes, as non-calcifying organisms, were considered to have a higher tolerance to near-future OA conditions owing to their well-developed ion regulatory mechanisms. However, recent studies provide evidence to suggest that they may not be as resilient to near-future OA conditions as previously thought. In addition, earlier life stages of marine fishes are thought to be less tolerant than juveniles and adults of the same species as they lack well-developed ion regulatory mechanisms for maintaining homeostasis. This study focused on the effects of near-future OA on larval Argyrosomus japonicus, an estuarine-dependent marine fish species, in order to identify the tipping point of tolerance for the larvae of this species. Larval A. japonicus in the present study were reared from the egg up to 22 days after hatching (DAH) under three treatments. The three treatments, (pCO_2 353 µatm; pH 8.03), (pCO_2 451 µatm; pH 7.93) and (pCO_2 602 µatm; pH 7.83) corresponded to levels predicted to occur in year 2050, 2068 and 2090 respectively under the Intergovernmental Panel on Climate Change (IPCC) Representative Concentration Pathways (IPCC RCP) 8.5 model. Size-at-hatch, growth, development, and metabolic responses (standard and active metabolic rates and metabolic scope) were assessed and compared between the three treatments throughout the rearing period. Five earlier larval life stages (hatchling – flexion/post-flexion) were identified by the end of the experiment. There were no significant differences in size-at-hatch ($p > 0.05$), development or the active metabolic ($p > 0.05$) or metabolic scope ($p > 0.05$) of fish in the three treatments throughout the study. However, the standard metabolic rate was significantly higher in the year 2068 treatment but only at the flexion/post-flexion stage which could be attributed to differences in developmental rates (including the development of the gills) between the 2068 and the other two treatments. Overall, the metabolic scope was narrowest in the 2090 treatment but varied according to life stage. Although not significantly different, metabolic scope in the 2090 treatment was noticeably lower at the flexion stage compared to the other two treatments, and the development appeared slower, suggesting that this could be the stage most prone to OA. The study concluded that, in isolation, OA levels predicted to occur between 2050 and 2090 will not negatively affect size-at-hatch, growth, development, and metabolic responses of larval A. japonicus up to 22 DAH (flexion/post-flexion stage). The present study also identified the tipping point of tolerance (where negative impacts will begin) in larvae of the species to be between the years 2090 and 2100.

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