Ocean acidification increases iodine accumulation in kelp-based coastal food webs

Dong Xu[1], Georgina Brennan[2], Naihao Ye[2,*]

[1]Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Qingdao, China
[2]Molecular Ecology and Fisheries Genetics Laboratory, School of Biological Sciences, Bangor University, Bangor LL57 2UW, UK

Abstract

Kelp are main iodine accumulators in the ocean, and their growth and photosynthesis are likely to benefit from elevated seawater CO_2 levels due to ocean acidification. However, there are currently no data on the effects of ocean acidification on iodine metabolism in kelp. As key primary producers in coastal ecosystems worldwide,any change in their iodine metabolism caused by climate change will potentially have important consequences for global geochemical cycles of iodine, including iodine levels of coastal food webs that underpin the nutrition of billions of humans around the world. Here, we found that elevated pCO_2 enhanced growth and increased iodine accumulation not only in the model kelp *Saccharina japonica* using both short-term laboratory experiment and long-term in situ mesocosms, but also in several other edible and ecologically significant seaweeds using long-term in situ mesocosms. Transcriptomic and proteomic analysis of S. japonica revealed that most vanadium-dependent haloperoxidase genes involved in iodine efflux during oxidative stress are down-regulated under increasing pCO2, suggesting that ocean acidification alleviates oxidative stress in kelp, which might contribute to their enhanced growth. When consumed by abalone (*Haliotis discus*), elevated iodine concentrations in *S. japonica* caused increased iodine accumulation in abalone, accompanied by reduced synthesis of thyroid hormones. Thus, our results suggest that kelp will benefit from ocean acidification by a reduction in environmental stress however; iodine levels, in kelp-based coastal food webs will increase, with potential impacts on biogeochemical cycles of iodine in coastal ecosystems.

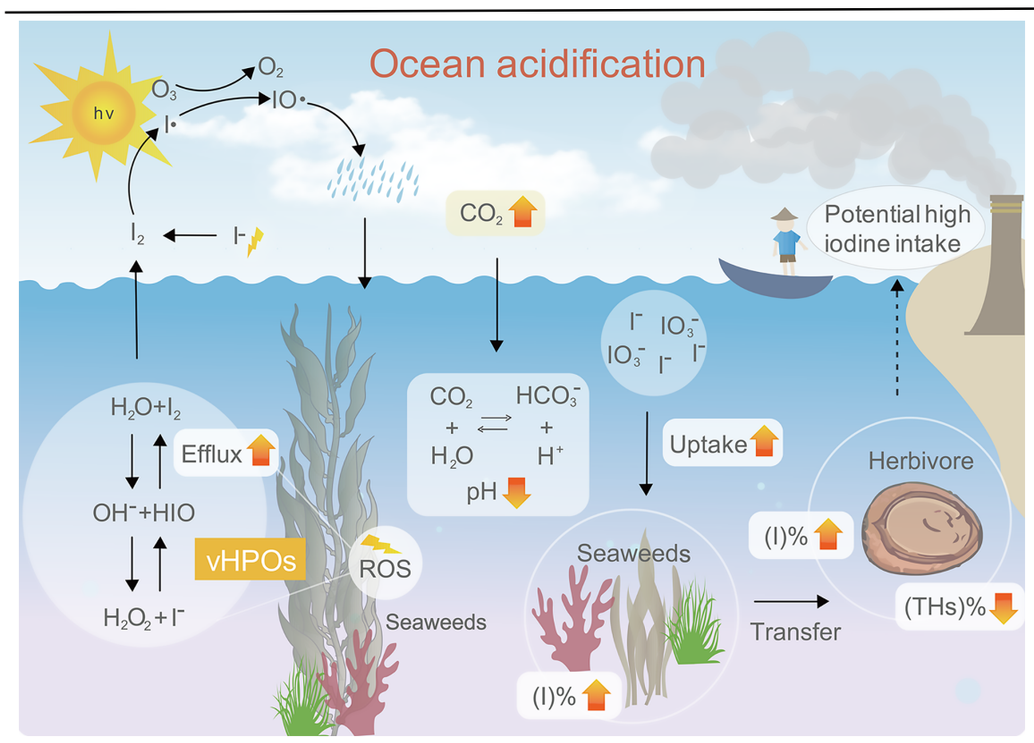

Figure 1. Conceptual diagram showing altered iodine metabolic pathway and global iodine geochemical cycle under ocean acidification.

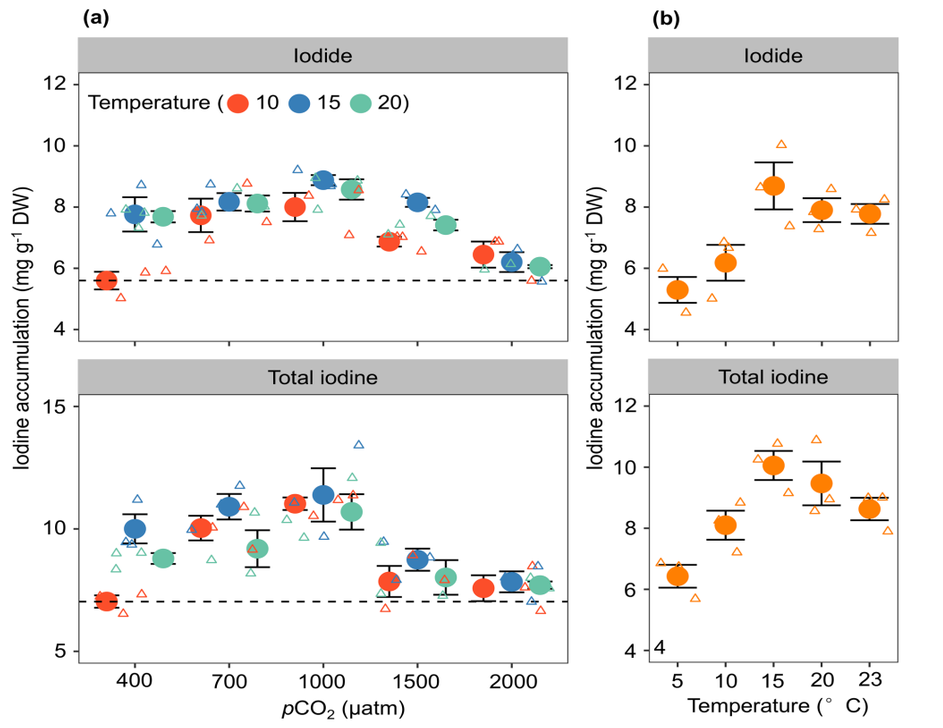

Figure 2. The combined effect of increasing pCO_2 and temperature and the effect of increasing temperature alone on iodine accumulation in the kelp *S. japonica*.

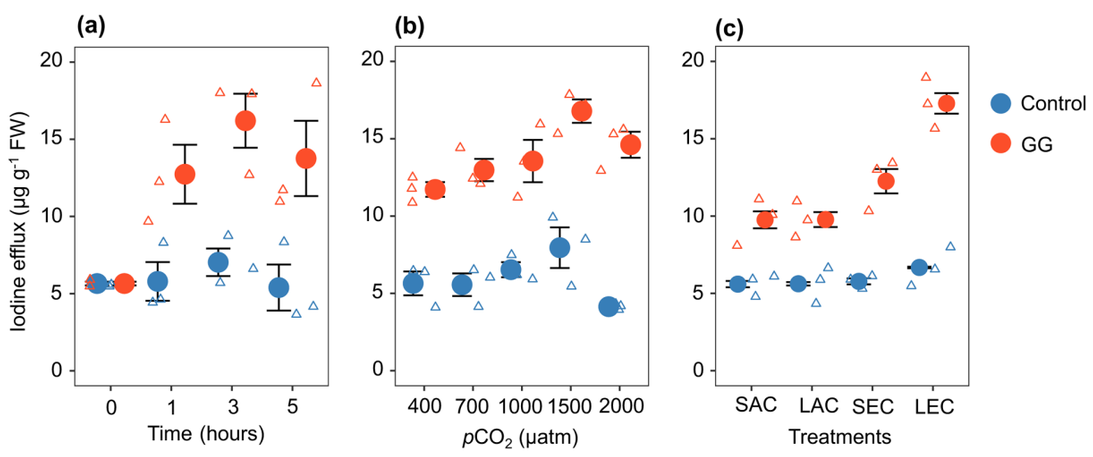

Figure 3. The effect of increasing pCO_2 on iodine efflux of *S. japonica* upon oligoguluronate-triggered oxidative burst in laboratory experiment.

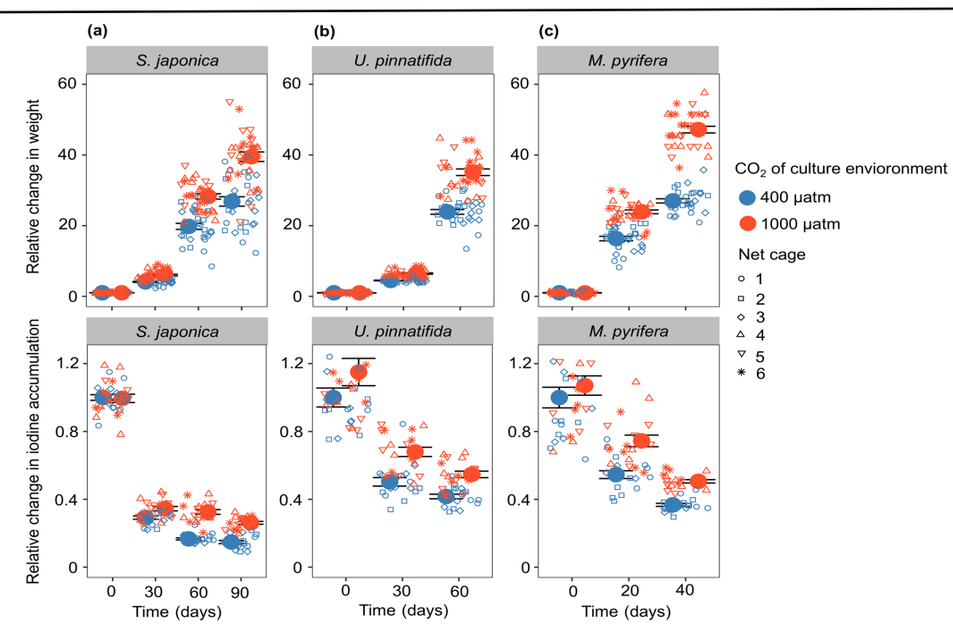

Figure 4. Relative changes in weight (top panels) and relative changes in iodine accumulation (bottom panels) under ambient pCO_2 (400 μatm, bubbled with air, blue) and elevated pCO_2 (bubbled with mix air of 1,000 μatm CO_2, red), in a mesocosm experiment.

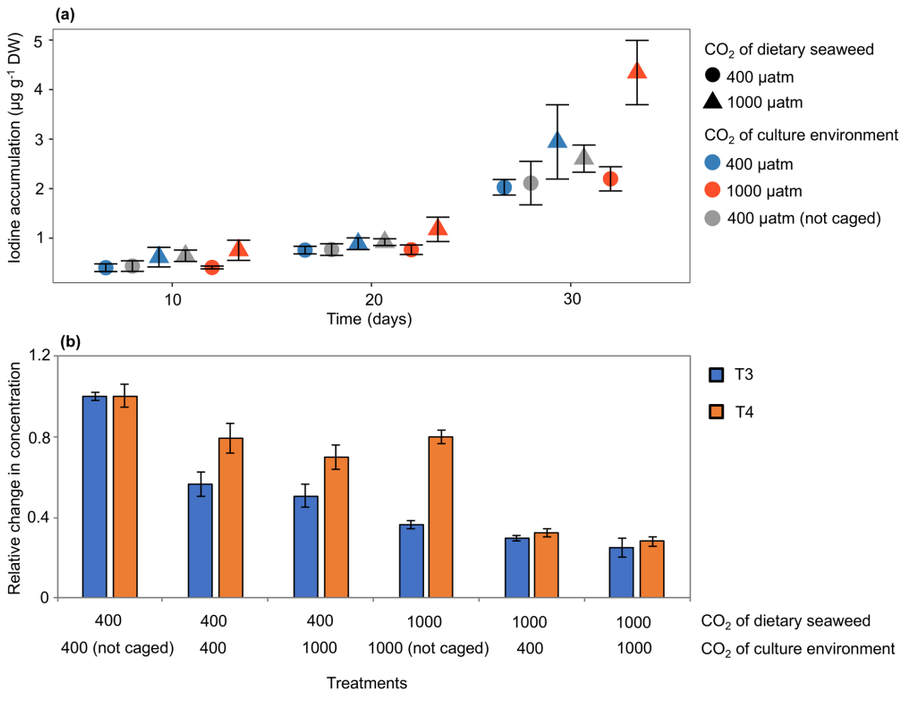

Figure 5. Changes in iodine accumulation and thyroid hormones (THs) synthesis in *H. discus* fed with seaweeds cultured under eitherambient and elevated pCO_2.

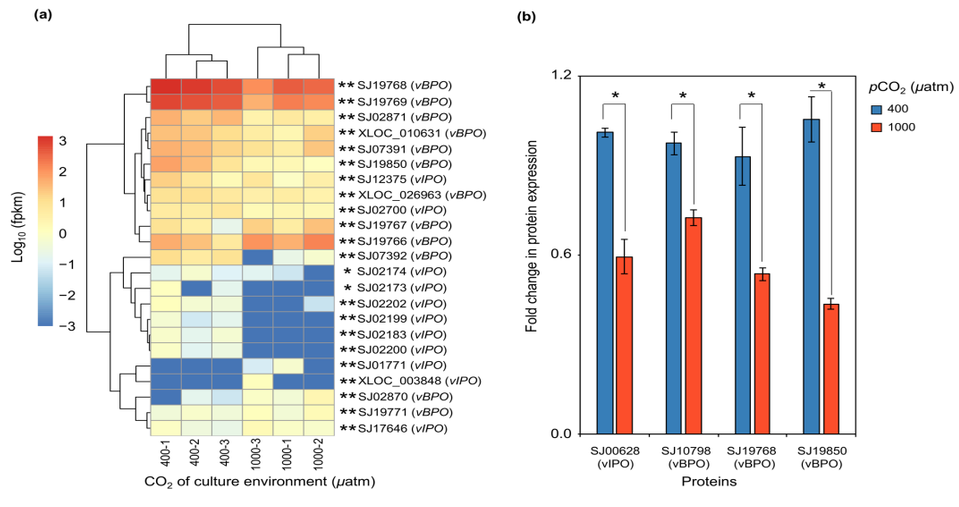

Figure 6. The effect of increasing pCO_2 on the relative expression of vHPO at transcriptomic or proteomic level in *S. japonica* cultured under ambient (400 μatm) or elevated (1,000 μatm) pCO_2 scenarios, using an in situ mesocosm experiment.