Impact of Climate Change on the Marine Environment of Taiwan's Offshore Islands

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Blue Carbon refers to the entirety of carbon sequestered and stored within the marine environment by marine organisms, which effectively absorbs atmospheric carbon dioxide emissions and thereby serves as a vital mechanism to mitigate the impacts of climate change. Coastal blue carbon ecosystems, such as seagrass meadows, have garnered increasing attention due to their extensive distributions, high efficiency in the organic carbon metabolism, and remarkable adaptability to high-salinity seawater. Although seagrass ecosystems are of considerable importance to humanity, they have not received commensurate levels of protection, leaving them susceptible to uncertain impacts within the context of climate change. This may result in substantial losses of the natural carbon sink stored within seagrass meadows. Therefore, gaining a thorough comprehension of climate variability in the vicinity of seagrass meadows assumes pivotal importance. This study focuses on two offshore islands in Taiwan with the most extensive distribution of seagrass meadows, namely the Dongsha Atoll (116°-117°E, 20°-21°N) and Penghu Archipelago (119°-120°E, 23°-24°N). The investigation entails a long-term assessment of changes in the marine environment, utilizing daily Sea Surface Temperature (SST) data and Degree Heating Week (DHW) data from NOAA Coral Reef Watch (CRW) spanning a period of 38 years from 1985 to 2022, with a spatial resolution of 5 km. The analysis of DHW data reveals that in the regions surrounding Dongsha Atoll and the Penghu Archipelago, there were 11 and 7 years, respectively, during which the heat stress alert level 1 (i.e., DHW exceeding 4°C-weeks) was achieved. Remarkably, the majority of these occurrences were concentrated after 2015. The analysis of SST data indicates a significant increase in the frequency of Marine Heatwave (MHW) events annually in both locations, with a more pronounced rise observed in Penghu compared to Dongsha Atoll. Specifically, the average occurrence of MHW events in the Penghu has escalated from one per year during the period from 1985 to 1994 to seven times per year during the period from 2015 to 2022. The average duration of each MHW event in Penghu (from 7 days to 17 days) did not show a notably significant increase, whereas in the vicinity of Dongsha Atoll, it increased fivefold from 5 days to 25 days. The cumulative number of days throughout the year indicates a remarkably intense increase in both Dongsha and Penghu over the past eight years. On average, Dongsha experienced approximately 152 days, and Penghu approximately 118 days, which is approximately fifteen times and twelve times higher, respectively, compared to the corresponding figures from three decades ago. Subsequently, the variations in ocean acidification were investigated utilizing data on carbon dioxide surface partial pressure, surface organic and inorganic carbon concentration, and other relevant parameters. With the aforementioned results, it is anticipated to explore the multi-temporal and spatial impacts of ocean warming and acidification on seagrass ecosystems.

Keywords: Seagrass meadows, Marine Heatwave, Ocean warming, Ocean acidification