Completion report
for the project MCEF21006

"Identifying Lantau's "hotspots": developing thermal and salinity profiles to assess the current and future distributions of key marine species"

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Executive summary

Lantau island represents a sharp hydrological transition in the western water of Hong Kong. With direct exposure to the Pearl River outflux, northern Lantau is estuarine while southern Lantau, being sheltered by the island landmass itself, is more oceanic. This has created a natural gradient in physical environments which may act as an ecological filter to shape species performance and distribution. Rocky shores on Lantau and surrounding islands further experience diverse thermal regimes due to variations in geomorphological features such as rock type, aspect, slope and sun-exposure which, in some cases, have led to extreme heat stress which are lethal to most rocky shore organisms. Species on these shores are, therefore, challenged by a combination of thermal and salinity stress and their prevalence on the shore is expected to be determined by physiological tolerances to these combined stressors. To test this hypothesis and gain a comprehensive understanding of rocky shore physical environments in this region, this project investigated the spatio-temporal variations of thermal and salinity conditions of twenty rocky shores on Lantau and surrounding islands, and estimated habitat suitability of these shores to ten key rocky shore species (including a variety of functional guilds: grazers, predators and filter-feeders) based on their physiological tolerances to combined thermal and salinity stress.

Geomorphological features of the shore are strong drivers of rock temperature. Whilst rock with large sky view factor (SVF, proportion exposure to the sky) was hotter (attaining 61 °C in Tsin Yue Wan) than those with low SVF, such relationship was, however, not linear along the mid tidal level where rock temperature increased with SVF only when SVF was greater than ~ 45%. Rock temperature was also dependent on shore aspect, but only in winter where more south-facing shores were significantly hotter than north-facing ones. During the summer, however, the influence of aspect on rock temperatures reduced substantially likely due to the longer low tide periods during the day in summer which allow heat flux to equilibrate on shores irrespective of their aspects. As such, shores with > 60% SVF and a southernly aspect (e.g. Cheung Sha) were thermally stressful (reaching 60 °C) while those with a low SVF of < 40% and a northernly aspect (e.g. Sam Chuen) were benign (refuge habitats reaching at most 32 °C during the summer). Strong spatio-temporal variations were also evident for nearshore salinity, where northern shores were more hyposaline than southern ones only during the summer (by 2.5 psu on average in terms of the maximum salinity), but much less so during the winter (by < 0.2 psu) when the maximum salinity reached 37 psu on average at either side of Lantau. Episodes of hyposaline stress (< 13 psu) were found for both northern sites and sites at the island's tip during the summer, with an average return time of 8.3 weeks. None of such episodes were found for southern sites, or for all the sites during the winter.

Under such complex environmental conditions, a strong distribution partitioning was found for some species, including the nerites, limpets, chitons and mussels. These species were predominantly found on either the northern or southern side of Lantau, but not both, despite other species such as periwinkles, topshells and dogwhelks were common on either side of the island. Physiological tolerances of these species to combined thermal and salinity stress were highly species-specific and, in general, littorinidae and neritidae were the most tolerant (= less mortality, overall mortality ranging from < 1% to 31%), while *Cellana* limpets the least (overall mortality ranging from 67% – 87%). Habitat suitability was calculated based on these species-specific mortality models and on-shore recordings of thermal and salinity conditions, and subsequently compared to species distribution on the shores. Calculated suitability was a variable predictor of species distributions across the ten target species, with good fits for the dogwhelk and limpet *Cellana toreuma* (R^2 > 78% between calculated suitability and on-shore incidence), but not so for the nerites (R^2 < 35%), implying other processes were at play in determining on-shore distribution patterns. If extreme events increase in frequency under future climate change scenarios, however, habitat suitability decreases for all species and *Cellana toreuma* will be the most vulnerable due to its high reduction in daily survival under more frequent extreme events.

Overall, this project has accrued a comprehensive database on thermal and salinity profiles of rocky shores, a dominant coastal habitat, on Lantau and surrounding islands. This information, as well as species distribution and habitat suitability mapping, have been uploaded and visualized on an online GIS platform for public access (https://hkrise-lantau.vercel.app/#/). The integration of on-shore physical recordings and laboratory physiological assays has revealed that species physiological tolerance can only partially explain species distribution in this dynamic region. Some species were not found in where they are predicted to be. Build upon such conclusion, and given the fact that the hydrological regime around Lantau is strongly affected by the outflux of the Pearl River, the next inquiry into biodiversity patterns on Lantau's coastline should focus on available species pool, settlement and supply side ecology. As such, this project has contributed to marine conservation by establishing an open-access physical database for scientists and planners, and highlighting the variable importance of physiology in driving species distribution pattens, information fundamental to gauge future changes and identify biodiversity enhancement measures for Lantau and surrounding islands such as those in central waters of Hong Kong.