MCEF Project Completion Report

Submitted to Marine Conservation Enhancement Fund

1. Project Details

Project Name: Applications of Coastal Bivalves in Water Quality Improvement, Ecological Restoration, and Carbon Neutralization (MCEF22001)

Project Period: 01/06/2023 - 31/05/2026

Organization / Project Leader: City University of Hong Kong / Prof. Wang Wen-Xiong

Executive Summary

The first part of the project quantified the water clearance capacity of local bivalves under different environmental conditions. Green mussel *Perna viridis*, oyster *Crassostrea hongkongensis*, and oyster *Crassostrea angulata* all showed measurable filtration capacity, but their performance depended strongly on body size, food availability, salinity, and dissolved oxygen. Larger individuals generally showed higher clearance rates. *P. viridis* cleared approximately 2 to 3.5 L of water per hour per individual under suitable conditions, equivalent to about 48 to 84 L per day. Oysters showed even higher filtration capacity. *C. hongkongensis* cleared approximately 4 to 8 L per hour per individual, equivalent to about 96 to 192 L per day. These values demonstrate the strong potential of bivalves to process large volumes of water when environmental conditions are favourable. However, mussels and oysters were also highly sensitive to hypoxia, showing reduced shell opening and lower clearance rates under low-oxygen conditions.

The second part of the project evaluated the capacity of oysters to accumulate metals under controlled exposure. Both *C. hongkongensis* and *C. angulata* accumulated Cd, Cr, Ni, Cu, and Zn in metal-specific and tissue-specific manners. In *C. hongkongensis*, Cd and Ni accumulated strongly in the gills, while Cu and Zn showed the greatest overall accumulation potential. Under higher exposure levels, Cd in the gills reached approximately 65 μg/g dry weight, Ni reached about 57 μg/g, and Cu and Zn accumulated to much higher levels, with Cu exceeding 1,000 μg/g in some tissues and Zn reaching approximately 4,700 μg/g in the gills. Salinity also affected metal uptake. Lower salinity generally enhanced Cd, Cr, Cu, and Zn accumulation in *C. hongkongensis*, whereas Ni accumulation was highest at moderate salinity. *C. angulata* showed similar but generally lower accumulation capacity than *C. hongkongensis*.

The third component examined calcium accumulation and shell formation in juvenile *C. hongkongensis*. Mantle calcium concentration increased from 334 μg/g dry weight at baseline to 3,156 to 4,646 μg/g after 21 days. The highest calcium accumulation occurred under 25 PSU salinity with high food supply, indicating that food availability and salinity jointly supported shell formation physiology. Shell height increased from 57.0 mm to 64.0 to 67.0 mm during the same period. Based on mantle calcium pools, the estimated CO_2-equivalent storage potential increased with salinity and food supply, with the highest treatment reaching 274.22 μg CO_2 equivalent after 21 days of cultivation. Although the value at the individual scale is small, oyster restoration may be considered as part of broader ecosystem-service and carbon-related assessments when scaled up to large populations.

The final component tested oyster transplantation under field conditions. *C. hongkongensis* were deployed at two downstream sites in the Jiulong River Estuary, Fujian Province, China, and oysters were sampled every two weeks over three months. Diffusive Gradients in Thin-films (DGT) devices were deployed for 48 hours before each sampling event to measure labile metal exposure in the water. The field sites showed measurable but not severe metal exposure. Metal concentrations in water followed the general order Zn > Ni > Cu > Cd > Cr. Zn ranged from 8.55 to 35.34 μg/L, while Cd remained below 0.5 μg/L, and Cr, at 0.02 to 0.21 μg/L, was the lowest measured metal. The tissue results confirmed that transplanted oysters accumulated metals under realistic estuarine conditions. Cd and Ni showed the clearest accumulation among metals present at lower concentrations. In the gills, Cd increased from 3.77 μg/g to 50.8 μg/g at Site 1 and 36.6 μg/g at Site 2 after two weeks of transplantation, while gill Ni increased from 3.74 μg/g to 27.0 μg/g and 17.8 μg/g at the two sites, respectively. Cu and Zn showed much higher tissue concentrations. Gill Cu increased from 165.6 μg/g to 1,031 μg/g at Site 1 and 840 μg/g at Site 2, while gill Zn increased from 1,217 μg/g to peak values of 6,621 μg/g and 6,007 μg/g. Bioaccumulation factors (BCFs) calculated using DGT-measured concentrations further confirmed the strong accumulation capacity of *C. hongkongensis*. Cu showed the highest BCF values, averaging 1,140 L/g dry weight in the gills, 1,155 L/g in mantle tissue, and 868 L/g in the gonad. Zn (110–784 L/g) and Cd (36.3–239 L/g) also showed high BCF values, while Ni (3.40–20.8 L/g) showed the lowest values. Gills were most informative for Cd and Ni uptake, whereas mantle tissue and gonad contributed substantially to Cu and Zn storage.

Overall, the project successfully achieved its objectives. It generated quantitative evidence that oysters and mussels can provide filtration services, identified environmental constraints on these services, demonstrated strong metal accumulation by oysters under laboratory and field conditions, and provided preliminary data on calcium accumulation and carbon storage. This project provides a scientific basis for using bivalves as natural tools for water quality improvement, biomonitoring, and ecological restoration in Hong Kong and adjacent estuarine waters.