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# Dynamics of mesozooplankton assemblages in subtropical coastal waters of Hong Kong: A comparative study between a eutrophic estuarine and a mesotrophic coastal site

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ABSTRACT

A monthly comparative study of mesozooplankton biomass and composition between a eutrophic Pearl River estuarine site (WE) and a mesotrophic coastal-oceanic site (EO) in Hong Kong waters was conducted to examine the response of mesozooplankton to nutrient-rich riverine discharge. Although the annual average mesozooplankton biomass was higher at WE than at EO, they were not statistically significant. Variations of mesozooplankton biomass at both stations followed similar trends of Chl *a* concentrations, with the exception of July at WE where mesozooplankton biomass was low but total Chl *a* was high. This mismatch may be due to the high flushing effect of the Pearl River discharge in summer and a time lag in mesozooplankton population growth. On the other hand, the composition of mesozooplankton was significantly modified by riverine discharge and eutrophication conditions. While small copepods dominated at both sites, the eutrophic estuarine water had a high abundance of barnacle and polychaete larvae, while cladocerans, bivalve larvae, gastropod larvae and chaetognaths mainly occurred at EO. Eutrophication increased the top-down role of copepods in the grazing community, revealed by an increase in the percentage of copepods in the total metazoan mesozooplankton, especially during the period of high river discharge. Moreover, mesozooplankton diversity at the two stations was similar, and they both showed relatively higher diversity during autumn and winter and lower diversity during summer, especially at WE. These results suggest that, despite high nutrient and Chl *a* concentrations in estuarine waters, mesozooplankton biomass were not enhanced compared to coastal waters with no river impact, possibly due to poor food quality and increased predation in the eutrophic estuarine waters.



## 1. Introduction

Mesozooplankton (0.2–2 mm) are key components in coastal ecosystems; they link the microbial food web to the classic food chain and transfer materials and energy from primary producers to higher trophic levels. Moreover, mesozooplankton grazing plays an important role in controlling phytoplankton biomass (Calbet, 2001), helps to shape the microbial food web structure through selective feeding (Calbet and Landry, 1999; Liu et al., 2005; Dagg et al., 2009), and contributes to the downward flux of biogenic carbon (Roy et al., 2000). In particular, intense grazing could contribute to the suppression of the initiation of phytoplankton blooms and also to the decline of the bloom by directly feeding on bloom organisms of suitable size (Fileman et al., 2007). However, the overall grazing impacts are also depending on the composition and size structure of the grazers (González et al., 2000; Slaughter et al., 2006).

Mesozooplankton composition and abundance in coastal waters has profound temporal–spatial patterns due to high variability of hydrological properties (Roman et al., 2005; Ramfos et al., 2006). Temperature and salinity can directly influence the growth conditions of both phytoplankton and mesozooplankton, and hence they usually become dominant factors in determining the seasonal and spatial distribution of mesozooplankton (Badylak and Phlips, 2008). Low salinity due to high freshwater discharge of an estuary is usually a dominant process that controls biological processes within a planktonic food web (Marques et al., 2007; Kelble et al., 2010), especially in tropical and subtropical regions where the ecosystem experiences less seasonal differences in temperature and solar radiation (Araujo et al., 2008). However, since coastal waters experience both anthropogenic and natural influences such as river

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discharge, upwelling, coastal and tidal currents and pollution, salinity alone may not be suitable to explain the annual patterns of mesozooplankton distribution. For example, Uriarte and Villate (2004) reported that mesozooplankton composition and abundance were significantly different between estuaries with different degrees of pollution in the same salinity regimes.

Nutrients and light are key factors in most pelagic ecosystems that determine the composition, abundance and size structure of phytoplankton, and indirectly control the abundance and composition of zooplankton through a bottom-up effect (McQueen et al., 1989; Verheye and Richardson, 1998). Particularly, the increased nutrient loadings from river discharge favor large-sized phytoplankton, providing abundant food for herbivores (e.g. copepods and fish larvae) and hence subsequently increase the production of grazers. However, the effect of eutrophication on mesozooplankton remains unclear because there are relatively few studies on the response of mesozooplankton to enhanced eutrophication (e.g. Park and Marshall, 2000; Marcus, 2004; Telesh, 2004; Vidjak et al., 2006). Nevertheless, we can predict that mesozooplankton biomass and composition in eutrophic coastal area are highly variable because mesozooplankton are also subject to the changes of food quality and predation. Generally, the coupling between phytoplankton and mesozooplankton is weak in response to anthropogenic nutrient loadings because of increased inedible algae and fish predation that are usually associated with high nutrient loadings (Micheli, 1999).

The coastal waters of Hong Kong in the northern part of the South China Sea are influenced by several water masses. The western waters of Hong Kong are primarily influenced by the Pearl River, the second largest river in China in terms of freshwater discharge. The Asian monsoonal winds cause a pronounced seasonality in both the amount and flow of the river plume. The influence of river discharge is much more pronounced during the wet summer during which high freshwater discharge reduces the salinity of the estuary and carries large amounts of nutrients and subsequently enhances the degree of eutrophication. High phytoplankton growth and biomass were observed at the edge of the plume (Yin et al., 2000; Chen et al., 2009). In contrast, the eastern waters of Hong Kong are not influenced by the river plume, but are affected by the shelf waters of the South China Sea. The nutrient levels in eastern water are significantly lower than western waters due to the dilution of oceanic currents and reduced anthropogenic impacts. Phytoplankton biomass in eastern waters can be limited by the availability of macronutrients during summer when thermal stratification occurs (Xu et al., 2008; Chen et al., 2009). However, strong northeast monsoon winds during late autumn and early winter causes the intrusion of the nutrient rich China Coastal Current, which, together with increased vertical mixing, result in an increase in phytoplankton biomass during winter (Yin, 2002; Chen et al., 2009).

Impacts of eutrophication on marine phytoplankton, fisheries and benthic organisms in coastal waters of Hong Kong have received much attention during the last few decades (Wu, 1988; Yin and Harrison, 2007), while studies of mesozooplankton composition in coastal waters of Hong Kong and adjacent waters are surprisingly sparse (Wong et al., 1993). Tan et al. (2004) suggested that salinity was an important factor in influencing the seasonal variation in mesozooplankton composition in the Pearl River estuary. However, it is difficult to distinguish the effect of eutrophication from salinity effects in estuarine systems because high nutrient loading is typically associated with low salinity. In this study, we attempt to compare the patterns of mesozooplankton biomass and composition at two coastal sites in Hong Kong waters with contrasting trophic conditions (eutrophic vs. mesotrophic) and examine the respective dominant environmental factors that are responsible for the temporal variability of mesozooplankton in each system.

## 2. Materials and methods

### 2.1. Sampling and analysis

Sampling was carried out monthly at two contrasting sites in Hong Kong waters (Fig. 1) from May 2007 to February 2008. The western estuarine site (22°21.324′N, 113°56.783′E), WE, is located at the edge of the Pearl River estuary on the west side of Hong Kong. The eastern coastal-oceanic site (22°20.453′N, 114°17.703′E), EO, is located in Port Shelter on the east coast of Hong Kong. Both sites have a water depth of about 17 m.

Temperature and salinity were recorded with a multi-probe sensor YSI 6600 (YSI Inc.). Duplicate seawater samples of both surface and 10 m were collected by filtering through GF/F filters and frozen for further analysis of inorganic nutrients (nitrate, nitrite, ammonium, phosphate and silicate), which were determined by a SKALAR autoanalyzer (San Plus). Size-fractionated Chl *a* was determined by filtering duplicate 250–500 ml of seawater onto 20 and 2 μm PC membrane filters and GF/F glass-fiber filters by a cascading filtering device under low vacuum pressure. After extraction with 90% acetone, Chl *a* was determined by a Turner Design fluorometer (Strickland and Parsons, 1972). Secchi disk depth, turbidity and total suspended solids were reported by Environmental Protection Department (EPD) of the Hong Kong SAR government (http://www.epd.gov.hk/epd/english/environmentinhk/water/marine_quality/mwq_report.html). Basically, total suspended solids were measured by filtering 1–2 l seawater on pre-weighed glass-fiber filter and dried at 103–105 °C according to standard methods for the examination of water and wastewater by the American Public Health Association (20 ed). Turbidity was measured by optical backscatter method using the OBS3 sensor equipped to a Seacat19+CTD.

Mesozooplankton samples were collected by net tows using a plankton net (0.5 m diameter, 167 μm mesh size) equipped with a digital flow meter (HYDRO-BIOS, Kiel). The plankton net was first obliquely towed from 10 m and then gently hauled horizontally at

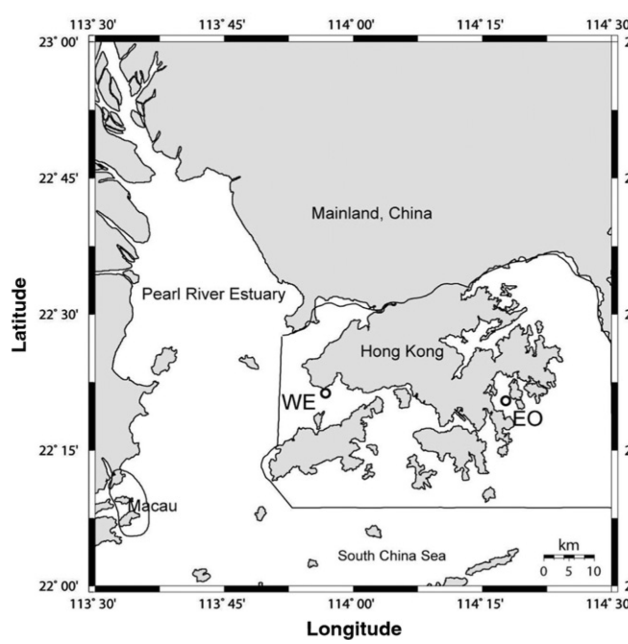


**Fig. 1.** Map of Hong Kong waters showing two stations, WE in western estuarine waters and EO in eastern coastal waters.