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Comparative assessment of water quality parameters of mariculture for fish production in Hong Kong Waters

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ABSTRACT

The objective of the study is to evaluate the effect of fish cultivation on water quality in fish culture zone (FCZ) and analysed by Principle Component Analysis (PCA). 120 surface water samples were collected from Hong Kong Waters (60 samples in Victoria Harbour and another 60 in Ma Wan FCZ). Significant difference was found in dissolved oxygen (MW: 59.6%; VH: 81.3%), and *Escherichia coli* (MW: 465 CFU/100 ml; VH: 162.5 CFU/100 ml). Three principle components are responsible for water quality variations in the studying sites. The first component included *E. coli* (0.625) and dissolved oxygen (0.701). The second included *E. coli* (0.387) and ammonical-nitrogen (0.571). The third included *E. coli* (0.194) and ammonical-nitrogen (0.287). This framework provides information to assess the relative contribution of eco-aquaculture to nutrient loads and the subsequent risk of eutrophication. To conclude, a rigorous monitoring of water quality is necessary to assess point and nonpoint source pollution. Besides, appropriate remediation techniques should be used to combat water pollution and achieve sustainability.

The Pearl River Delta (PRD) is the main region for fish culture in Guangdong Province, and fish export has been a major source of economic revenue (Ding et al., 2014). Thousands of tonnes of fish are exported to Hong Kong every year. However, it had been found that samples from fish farms (Zhou and Wong, 2000) and local markets (Cheung et al., 2008) contained 17.5–267 ng/g dry wt THg and 70–340 ng/g wt THg, respectively. Hence, rather high levels of Hg were found in fish from the PRD, if not also other environmental pollutants. On average, Hong Kong people consume fish or shellfish at least four times a week, the above findings agree with that of Dickman and Leung (1998) that fish consumption is a major source of dietary exposure to pollutants in Hong Kong.

From the stand point of productivity, a good water quality is important to support various activities of fish and that include feeding, breeding, digestion, excretion and reproduction. Apart from the feed quality and feeding method, water quality is one of most critical factors affecting the fish production (Bronmark and Hansson, 2005). Water quality parameters can be divided into three main categories: physical (salinity, temperature); chemical (pH, conductivity, dissolved oxygen) and biological (Delince, 1992; Mood, 2004). All living organisms have an optimal zone for water quality parameters in which they perform optimally. A sharp drop or rise beyond this zone has adverse effects on their body functions (Davenport, 1993). As water quality is one of the most critical factors in fish productivity, access to an adequate, regular and constant supply of good quality water is necessary in mariculture. However, the influence of water quality in mariculture may be due to deposition of heterogeneous organic wastes resulting from the degradation of food supplies and fish excretion. The subsequent increase in oxygen consumption causes progressively anoxic conditions at the water interface, which may lead to the mobilisation of various pollutants such as heavy metals (Zhang et al., 2014) and persistent organic pollutants (Wang et al., 2015). Therefore, close monitoring and adequate management of water quality are fundamental to the success of mariculture.

The objective of this study was to assess marine water quality in the fish culture zone (FCZ), in an attempt to evaluate the effect of fish cultivation on water quality in FCZ.

Ma Wan (MW) is an small island with an area of 0.97 square kilometres (240 acres) located between Lantau Island and Tsing Yi Island in the southern waters of Hong Kong (Fig. 1). There are 13,200 m^2 of estaurine aquaculture (Wong and Cheung, 2003) rafts in the MW FCZ operated by about 50 aquaculturists. Fish species of

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higher market value, such as orange-spotted grouper (*Epinephelus coioides*), goldlined seabream (*Rhabdosargus sarba*), and giant grouper (*Epinephelus lanceolatus*) are cultivated there.

Totally 120 marine water samples were taken at six sites in MW FCZ and six sites in Victoria Harbour (VH). Ten water samples were taken in each site. Samples were filled up into the plastic bottom to prevent air trap into the sample and transported it to laboratory as soon as possible. Samples were then mixed thoroughly for homogeneity before being measured. Physical parameters, which include sea temperature (measured *in situ)*, dissolved oxygen (DO), pH, electrical conductivity (EC), salanity, were measured immediately by a calibrated Horiba Water Quality Mulitmeter. Chemical and biological parameters, i.e. ammonia, phosphorus-phosphate, Biological oxygen Demand (BOD) and *Escherichia coli*, in water samples were analysed subsequently by USEPA standard methods.

Variables input for the Principle Component Analysis (PCA) included temperature, DO, pH, EC, salanity, ammonical-nitrogen, BOD, phosphorus-phosphate and *E. coli*. Totally 1200 raw data were included, the data were first examined by Kaiser–Meyer–Olkin (KMO) statistics and Bartlett's test for suitability for PCA, before they were processed using the Primer 6 software. Those tests are measures of sampling adequacy that use the proportion of variance. The KMO value must be greater than 0.5, and the significance level of the Bartlett's test must be less than 0.05 (Wu et al., 2010; Gyawali et al., 2012). The number and importance of uncorrelated principal components extracted from the water quality parameters are presented in a scree plot. When the eigenvalue

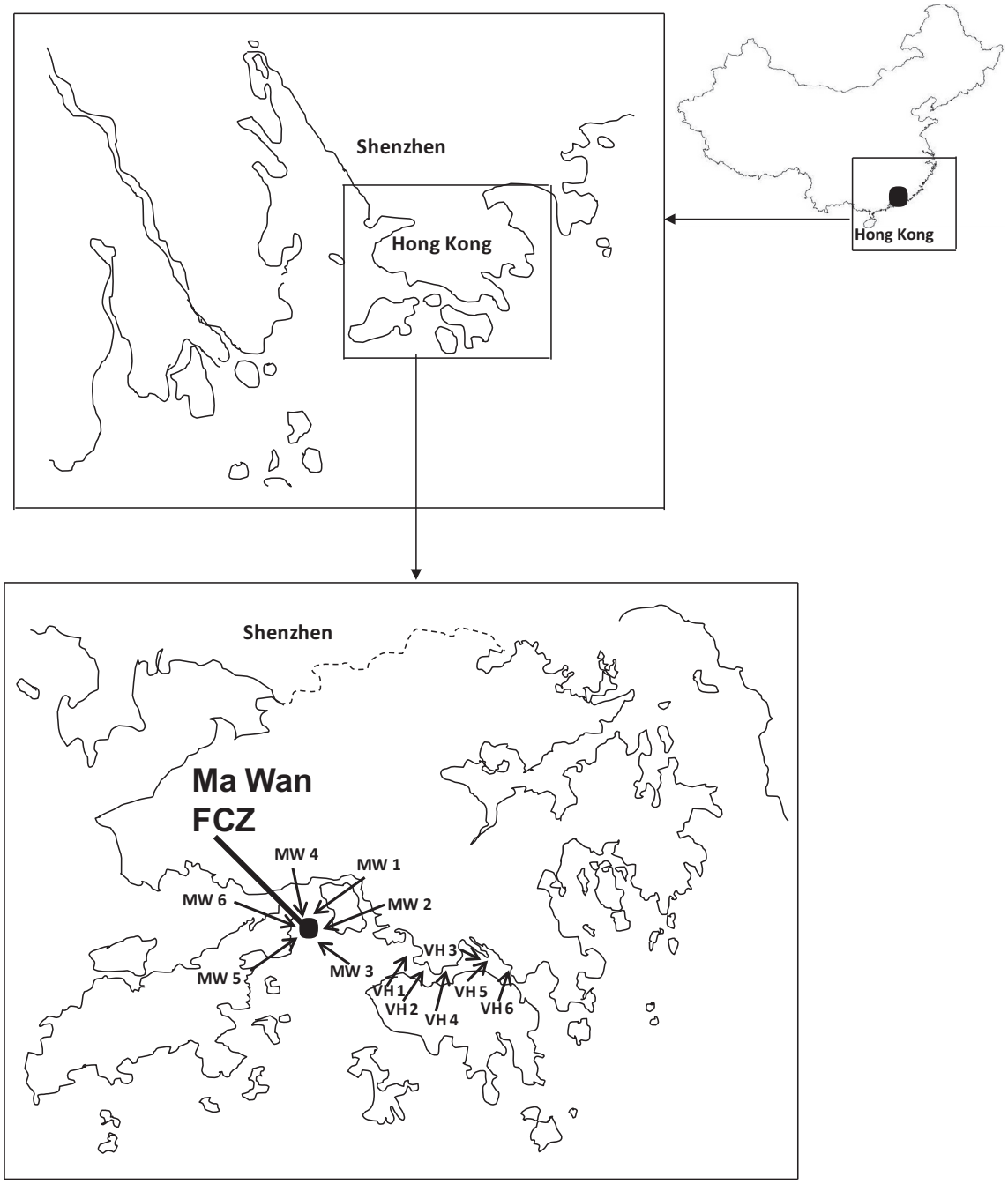

Fig. 1. Sampling sites: Ma Wan fish culture zone (MW-1, MW-2, MW-3, MW-4, MW-5, and MW-6) and Victoria Habour (VH-1, VH-2, VH-3, VH-4, VH-5, and VH-6).

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