



A 30-year monitoring of changes in coral community structure following anthropogenic disturbances in Tolo Harbour and Channel, Hong Kong



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ABSTRACT

Coral communities in Tolo Harbour and Channel, northeastern Hong Kong, suffered from tremendous degradations in 1980s due to excessive sewage pollutions. This study examined changes in coral community structures over the last 30 years including period before, at the height of and after implementation of abatement measures of pollution impacts. Signs of coral degradations finally stopped in inner harbour and some corals started to reappear, likely due to sewage export scheme since 1998. Yet, the coral cover remained very low (< 2%) in 2012. Natural recovery is limited by very low coral recruitment success other than that of *Oulastrea crispata*. The outer coral communities, which suffered least in 1980s, continued to decline, possibly due to new biological disturbances like sea urchin predation and bioerosion. This long-term study clearly revealed how coral communities could so easily be destroyed and yet natural recovery could be so difficult and unlikely.

1. Introduction

Anthropogenic disturbance has been one of the greatest factors causing decline in coral cover and diversity around the world. Some of these disturbances include sewage discharge (Chazottes et al., 2002) and coastal development (Loya et al., 2004). The resulted increase in nutrients changes the trophic structure in coral reefs, favoring growth of macroalgae, bioeroders and filter feeders to compete with corals (Fabricius, 2005). On the other hand, coastal development is often associated with land reclamation. The increased water turbidity and sedimentation lead to reduced coral recruitment, growth, depth distribution and coral diversity (Fabricius, 2005).

Hong Kong, located in southern China, is naturally marginal to hard coral growth with winter seawater temperatures that could be as low as 14–16 °C and with highly fluctuating salinity that could drop to 15 psu during summer monsoon (Ang, 2010). Nonetheless, coral communities of over 80 scleractinian species persist in eastern and northeastern Hong Kong waters which are away from the impact of freshwater discharge from Pearl River in the west.

Tolo Harbour and Channel is a 15 km semi-enclosed embayment in northeastern Hong Kong (Fig. 1A). Tolo Harbour receives freshwater discharge from three rivers. It is connected to a much broader Mirs Bay via the narrow Tolo Channel (Fig. 1B). This bottlenecked topography resulted in poor flushing rate of tidal waters, thus forming a natural gradient of increasing salinity and exposure to

currents towards the mouth of Tolo Channel. The presence of this gradient exacerbates the extreme conditions for coral growth in inner harbour. In spite of this, coral communities with high coral covers (around 70%) and with > 30 coral species were once found inside this harbour (Scott and Cope, 1982). Over the last 30 years, however, progressive large-scale mortalities of corals were recorded in this harbour and channel.

Tolo Harbour and Channel was originally a rural area with a population of only 45,000 in 1971. Since 1973, the inner Tolo Harbour was reclaimed with dredging and dumping to build the new towns of Sha Tin and Tai Po. Human population exploded to 0.5 million in 1986. With this was the increased amount of uncontrolled sewage discharged from the residents, agriculture, piggery and industries that heavily polluted the harbour (McCorry and Blackmore, 2000). A pollution gradient thus existed, with greater nutrient and pollution levels recorded in the inner Tolo Harbour that gradually decreased towards the outer Tolo Channel. Different levels of impact on coral communities were also reflected along this gradient. Decline in coral diversity and a reduction of 80% of coral coverage in inner Tolo Harbour to mid-section of Tolo Channel was recorded within just six years after the first survey in 1980 (Scott and Cope, 1990). This was associated with a gradual change in community structure to be dominated by foulers like oysters, mussels, barnacles and tubeworms.

This deterioration in marine environmental condition was described as ‘Hong Kong first marine ecological disaster’ (Morton, 1988). To

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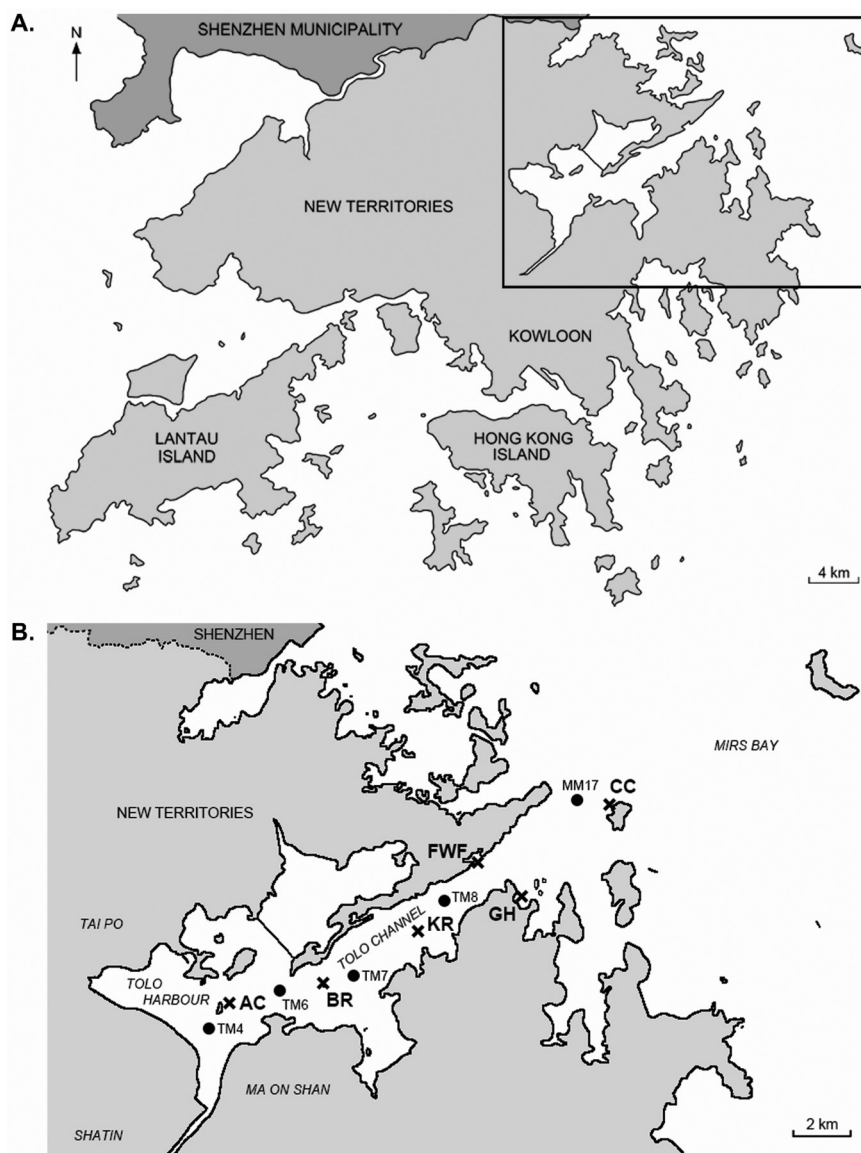


Fig. 1. A. Map of Hong Kong showing the location of Tolo Harbour and Channel. B. More detailed map of Tolo Harbour and Channel showing the locations of the six survey sites (indicated by crosses), including AC: A Chau, BR: Bush Reef, KR: Knob Reef, FWF: Fung Wong Fat, GH: Gruff Head, CC: Chek Chau, and water quality monitoring stations of EPD-HKSAR (indicated by circles), including TM4, TM6, TM7, TM8 and MM17.

reduce the pollution loadings, the Tolo Harbour Action Plan (THAP) was introduced by the Hong Kong Government in 1987 to control discharge of livestock and other domestic waste through upgrading sewage treatment works and public sewerage. Some immediate results of this action plan were apparent with a significant reduction of BOD₅ and the incidents of red tides (156 in 80s to 89 in 90s) within this harbour and channel (EPD-HKSAR, 2010). However, despite these efforts, the decline in coral cover and diversity continued in the harbour even a decade after the implementation of this pollution abatement programme. A near complete demise of the coral community was recorded in 1998 with degradation extended to the once unspoiled outer communities (McCorry and Blackmore, 2000).

With the inner coral communities being almost completely destroyed, coral recruitment would have been the only way for natural coral recovery to occur. Coral recruit is a fragile life stage which is most sensitive to pollution (Fabricius, 2005). Having a critical role in mediating adult population structures (Caley et al., 1996), recruitment rate becomes a good estimate of the potential of reef recovery (Barbara and Quinn, 2001). It is hypothesized that coral recruitment would decrease

towards inner section of Tolo Harbour, as recruitment density was found to drop towards eutrophication sources (Abelson et al., 2005). Study on diversity and abundance of coral juveniles could thus provide extra information about the environmental conditions and their impact to corals in recent years.

Treated effluent was fully diverted out of Tolo Harbour under Tolo Harbour Effluent Export Scheme (THES) since 1998. With an improvement of the water quality, a recovery of the coral communities with increase in coral cover and diversity was expected. This study compared the temporal changes in coral community structures of different sites along the pollution gradient in Tolo Harbour and Channel from 1980 to 2012. It covered the period in 1980 when there were limited human activities, to 1986 when there were heavy pollution impacts from excessive sewages, in 1998 after a decade of sewage treatment efforts, and in 2012, 15 years after the implementation of the sewage export scheme. Records of the diversity and abundance of coral juveniles were also examined to evaluate the recovery potentials of these impacted coral communities.

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