Marine Pollution Bulletin 63 (2011) 376–384

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Response of meiofaunal community with special reference to nematodes upon deployment of artificial reefs and cessation of bottom trawling in subtropical waters, Hong Kong

Xiao-Shou Liu [a,b], Wen-Zhe Xu [a], S.G. Cheung [a,c], Paul K.S. Shin [a,c,*]

[a] Department of Biology and Chemistry, City University of Hong Kong, Kowloon, Hong Kong
[b] College of Marine Life Science, Ocean University of China, Qingdao, China
[c] State Key Laboratory in Marine Pollution, City University of Hong Kong, Kowloon, Hong Kong

ARTICLE INFO

Keywords:
Meiofauna
Free-living marine nematodes
Community composition
Biological traits analysis
Bottom trawling

ABSTRACT

The response of meiofaunal communities, especially nematodes, upon the deployment of artificial reefs and cessation of bottom trawling at a designated Marine Protected Area (MPA) in Hong Kong was studied through comparison of meiofaunal samples collected inside and outside the MPA. Total organic carbon (TOC), total Kjeldahl nitrogen (TKN), total phosphorus (TP), water content and silt–clay fraction in sediments were also analyzed. The level of TOC and TKN, and total meiofaunal and nematode abundance were significantly lower inside than that outside the MPA. Multivariate analysis also indicated differences in community structure. Biological traits analysis revealed that the proportions of nematodes with a clavate tail shape, longer adult length, stout body shape and *k*-strategy life history were higher inside than that outside the MPA. Such changes in nematode community structure could be a result of the presence of the artificial reefs and closure of the MPA from bottom trawling.

1. Introduction

Bottom trawling is one type of large-scale, anthropogenic disturbance which occurs in many of the world's most productive marine environments. The most evident effects of trawling on bottom sediment are the alteration of distribution and abundance of target and non-target species by means of non-selective, destructive trawling methods (Jennings and Kaiser, 1998; Hall, 1999; Kaiser and de Groot, 2000) and the strong collateral impacts on physical and biological habitats (Freese et al., 1999; Chuenpagdee et al., 2003). Such disturbances affect the diversity, abundance, size structure and production of benthic communities in our oceans (Kaiser and Spencer, 1996; Bergmann and Moore, 2001; Jennings et al., 2001, 2002; Hermsen et al., 2003).

Meiofauna have been regarded as an important component in benthic ecosystems due to their small size, high abundance and fast turnover rates (Heip et al., 1985; Coull, 1999). This component of benthos exhibits high abundance, diversity and productivity in most sedimentary habitats, and plays an important role in marine benthic food chains (Gee, 1989). In particular, they respond rapidly to environmental changes such as grain size, redox potential and food availability (Soyer, 1985; Danovaro, 1996). They can resist disturbances due to trawling because their small body size may allow them to be re-suspended during the trawling operation (Gilkinson et al., 1998). Their short life-cycles (Schwinghamer et al., 1986) would also allow them to withstand high mortality due to trawling.

Although the effects of trawling on benthic communities are well documented, studies about benthic communities, especially the recovery for meiofauna from trawling, are very limited. Kaiser et al. (2006) pointed out that the direct effects of different types of fishing gear were strongly habitat-specific after a meta-analysis of 101 different fishing impact manipulations. The biota of soft-sediment habitats, particularly muddy sands, was most vulnerable, with predicted recovery time measured in years. Dernie et al. (2003) also revealed that clean sand communities had the most rapid recovery rate following a disturbance, whereas communities from muddy sand habitats had the slowest physical and biological recovery rates. Johnson et al. (2007) found that meiofaunal recovery occurred very quickly after the cessation of trampling associated with crab-tiling in a temperate estuary. However, no studies about the response of meiofaunal and nematode community upon recovery from bottom trawling have been reported in tropical and/or subtropical waters thus far.

Designation of Marine Protected Areas is one means of protecting biological resources from trawling operations (Rogers and Beets, 2001). In Hong Kong, artificial reefs have been deployed on the sea bottom to restore the declining fishery resources (Wilson

* Corresponding author at: Department of Biology and Chemistry, City University of Hong Kong, Kowloon, Hong Kong. Tel.: +852 27887720; fax: +852 27887406.
E-mail address: bhpshin@cityu.edu.hk (P.K.S. Shin).

0025-326X/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.marpolbul.2010.11.019

et al., 2002). Such reef sites can also serve as non-trawled areas for the study of the response of benthic communities upon the cessation of bottom trawling. This investigation thus aimed to examine the response of meiofaunal communities, with special reference to nematodes, upon the deployment of artificial reefs and cessation of bottom trawling in the subtropical waters of Hong Kong. In view of the short life-cycles and fast turnover rates of meiofauna, particularly for nematodes, this is of ecological interest in understanding the changes of a community's structure over the recovery process.

2. Materials and methods

2.1. Study area and field sampling

The study area was located in the outer Port Shelter on the east side of Hong Kong's coastal waters at a water depth of about 20 m (Fig. 1). This area was heavily trawled in the past. However, since 2006, approximately 12 km^2 of this area has been earmarked as a Marine Protected Area (MPA) where trawling is discouraged by the government through the positioning of concrete blocks with steel spikes along the boundary to deter entry of trawl boats. Inside the MPA, artificial reefs made of concrete boats and tyres were deployed strategically to make bottom trawling infeasible by damaging the trawl nets.

Field sampling of sediment samples was conducted at quarterly intervals from April 2007 to January 2008, about one year from the deployment of the artificial reefs. Two sampling sites each, inside and outside the MPA, were selected using a global positioning system (Fig. 1). The MPA sampling sites were selected in sea bottom between the reef structures. To ensure that the outside-MPA sites were actually trawled, a local bottom trawler was hired to sweep the bottom once before each sampling. At each site, three replicate sediment samples were collected using a 0.1 m^2 van Veen grab. From each grab, one sub-sample for the study of meiofauna was collected using a cut-off syringe (3 cm diameter, 7.1 cm^2 surface area) to 8 cm depth and fixed with 4% formalin immediately, once the sample was on board. One replicate of surface sediment sample for water content and particle size analysis, and three replicates for chemical analysis, including total organic carbon (TOC), total Kjeldahl nitrogen (TKN) and total phosphorus (TP), were also collected in the same grab samples. Sediment samples for chemical analysis were stored in an ice box on board and later transferred to the laboratory for storage at −20 °C before analysis.

2.2. Sample processing in laboratory

Upon arrival to the laboratory, the sediment samples, except those for particle size analysis, were frozen at −20 °C for 24 h, followed by freeze-drying. The freeze-dried sediment was homogenized to less than 0.25 mm with a mechanical homogenizer (MF-10 Basic, IKA Werke, Germany) and stored in desiccators for further analyses. The TOC in the sediment was measured by the Walkley–Black wet titration method (Walkley and Black, 1934). The TKN and TP in the sediment were extracted by Kjeldahl acid digestion, followed by measurement using a Flow Injection Analyzer (QuikChem 8000, Lachat Instruments, USA). All these chemical parameters were presented as mg/kg dry weight sediment. For water content and the particle size of sediment, wet sediment samples with a known weight were dried at 40 °C for 72 h and the final dry weight was measured. The water content was calculated as the sediment weight loss before and after drying. Since the particle size of the sediment in the study area was extremely fine, its granularity was measured with the silt/clay fraction only, i.e., the fraction of sediment particles less than 63 μm in diameter by wet sieving, followed by oven drying and weighing.

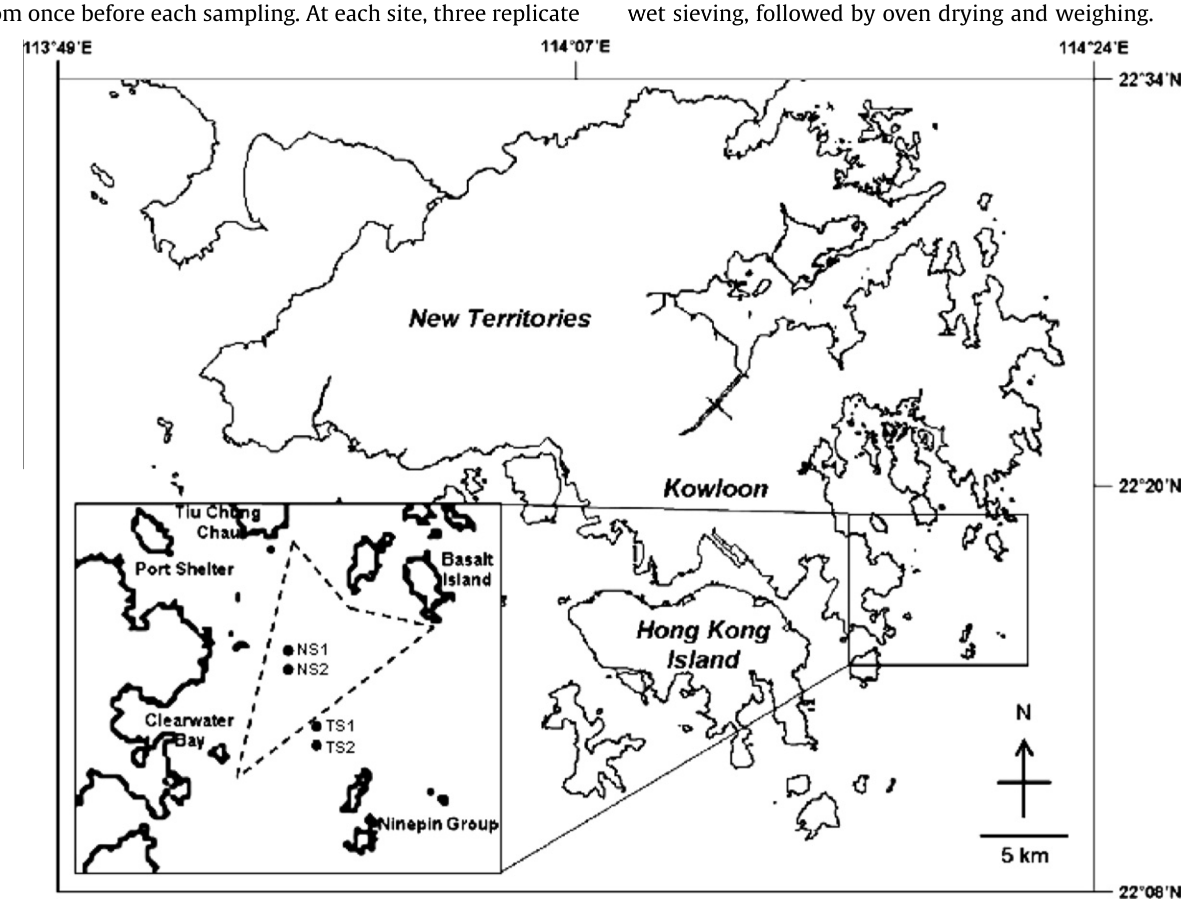

Fig. 1. Map of Hong Kong and Port Shelter, showing the sampling sites in the MPA (Sites NS1 and NS2) and trawled (Sites TS1 and TS2) area.