ORIGINAL PAPER

Microplastics accumulation by spionid polychaetes in Thai waters

Laongdow Jungrak[a], Siriluck Rongprakhon[a], Makamas Sutthacheep[a], Wiphawan Aunkhongthon[a], Sittiporn Pengsakun[a], Manoch Wongsuryrat[b], Montaphat Thummasan[c], Thamasak Yeemin[a*]

[a]Marine Biodiversity Research Group, Department of Biology, Faculty of Science, Ramkhamhaeng University, Bangkok 10240

[b] Hat Chao Mai National Park, Department of National Parks, Wildlife and Plant Conservation, Sikao, Trang 92150

[c]Green Biology Research Division, Research Institute of Green Science and Technology, Shizuoka University, Shizuoka 422-8529, Japan

*Corresponding author: *thamasakyeemin@hotmail.om*

Received: 09 November 2018 / Revised: 27 November 2018 / Accepted: 22 December 2018

Abstract. Marine debris and microplastics are among interesting research topics in the ASEAN community. Contamination of microplastics through the food web in various coastal and marine ecosystems is recognized as a significant problem nowadays. This study aimed to examine the abundance of microplastics in the spionid polychaetes sampled from Hat Pak Meng, Trang Province, in the Andaman Sea, and Pak Nam Lang Suan, Chumphon Province, in the Gulf of Thailand. The microplastics were extracted using hydrogen peroxide digestion method and counted using a stereoscopic microscope. The microplastics accumulation in polychaetes at Pak Nam Lang Suan (2.86±1.04 items/individual) was higher than that at Hat Pak Meng (1.91±0.41 items/individual) (p<0.05). The majority of particles varied between 501-1,000 μm in size, whereas the plastic fragments in a range of 1,501-2,000 μm had the lowest abundance. Pak Nam Lang Suan is an estuary influenced by a large river, resulting in a high quantity of microplastics compared to Hat Pak Meng. This study provides baseline data of microplastics contamination in wild annelids living in coastal habitats in Thailand.

Keywords: annelid, microplastics, pollution, polychaete, Gulf of Thailand, Andaman Sea

1. Introduction

Pollution by plastic litter in the marine environment, moving from the shallow coastal areas to the open oceans, is a global environmental concern and has been well documented. (Thompson et al. 2004; Law and Thompson 2014; Ivar do Sul and Costa 2014; Naidu et al. 2017). A growing demand, usage pattern, production trends and the improper disposal of plastic waste will lead to an increase in plastics debris in the oceans. (Thompson et al. 2009; Eriksen et al. 2014; Naidu et al. 2017) In recent years, several studies have revealed that microplastics are widespread and ubiquitous within the marine environment. (Cole et al. 2011; Van Cauwenberghe et al. 2013; Ivar do Sul and Costa 2014; Naidu et al. 2017). Additional studies suggest that the hydrophobic pollutants available in the seawater could be adsorbed onto plastic debris under ambient environmental conditions (Thompson et al. 2009; Cole et al. 2011; Naidu et al. 2017).

The fragmentation of such debris into microplastics could cause negative effects, such as increased microplastic ingestion by organisms and enhanced leaching of chemical components into the aquatic environment (Naidu et al. 2017; Jang et al. 2018). Most microplastics in the marine environment are thought to be secondary microplastic. (Andrady 2005; Hidalgo-Ruz et al. 2012; Jang et al. 2018).

Spionidae is a family of marine worms within the Polychaeta and it is known as the most-abundant family found on estuarine and sandy beach habitats. Some common species of polychaetes include *Hediste diversicolor*, *Marphysa sanguinea* and *Ophryotrocha labronica* (Jang et al. 2018). Several studies showed the impact of microplastic ingestion on marine organisms because microplastic particles are similar to or could contaminate their food source, especially sediment. Microplastics can accumulate in the digestive system of marine organisms, leading to longer digestion time and slow growth rate. For this reason, microplastic accumulation in polychaetes becomes a major concern as microplastics could be transferred to higher lower trophic levels in the food chain. Therefore, this study aimed to determine the microplastic accumulation of spionid polychaetes collected from Hat Pak Meng, Andaman Sea and Pak Nam Lang Suan, the Gulf of Thailand.

2. Materials and Methods

2.1 Study sites and sample collection

Study sites were located at two sandy beaches, namely Hat Pak Meng in the Andaman Sea and Pak Nam Lang Suan, the Gulf of Thailand. Marine sediment samples were collected using PVC core (10 cm high and 3.5 cm wide) then glided with a sieve filter with a mesh size of 0.5 mm. Each sample was preserved with 10 % formaldehyde-seawater solution. The spionid polychaetes were sorted from the preserved sediment, and their body lengths were measured. Polychaetes samples were identified to the orders, families, and genera characteristics using the identification reference, ‘The Polychaete Worms’ (Fauchald 1977).

2.2 Microplastics Isolation

A total of 40 samples of spionid polychaetes (20 samples from at each study site) were cleaned by distilled water, then were digested with 30% hydrogen peroxide (H2O2) and heated up to 55-65 ºC until completely digested. The microplastics were separated from the digested samples by flotation in saturated sodium chloride solution (250 g/ml) (Mathalon and Hill 2014). After 24 Hr of floatation at room temperature, the overlying water was filtered through a 20 µm pore size filter paper using a vacuum pump. Each filtered sample was placed into a clean glass petri dish for stereoscopic microscope observation, and photographs were taken with a digital camera. All microplastic items were visually identified, counted and measured their sizes and classified into four size classes: 101–500 µm; 501–1000 µm; 1001–1500 µm and 1501-2000 µm. The microscope selection and FTIR analysis was also conducted to identify the type of microplastics.

2.3 Statistical Analyses

Student’s t-test was used to identify significant differences at $p<0.05$ between the mean values of microplastic accumulation in polychaetes and body length of polychaetes under R program version 3.5.0. The spearman’s correlation was used to explore the relationship between the body length of polychaetes and microplastic length found in polychaetes between two study sites.

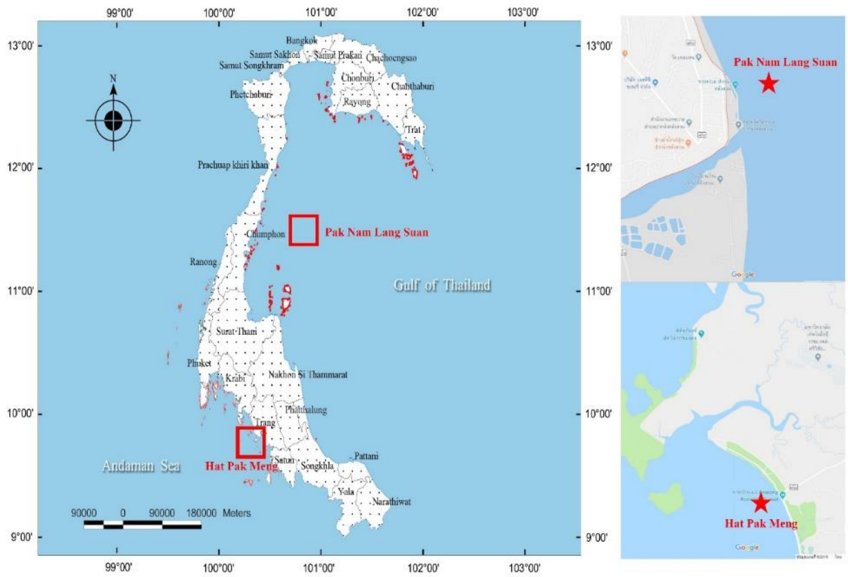

Figure 1. Location of study sites at Hat Pak Meng and Pak Nam Lang Suan

3. Results

The number of microplastics ingested by spionid polychaetes at different study sites is presented in Figure 2. The results showed that the average microplastic particle in spionid polychaetes at Pak Nam Lang Suan (2.90±1.86 items/individual) was higher than that observed at Hat Pak Meng (2.10±1.45 items/individual) ($p<0.05$). Microplastics abundance in polychaete samples was likely varied due to the different land use of these two study sites. Fibres were the main character of microplastics found in spionid polychaetes. The variation of microplastics abundance in polychaete samples between study sites may be influenced by different land use and the intensity of land-based activities.

The sizes of microplastics in polychaete samples ranged from 100-2,000 μm. The highest frequency of microplastics measured was in a range of 501-1,000 μm (up to 45%) in both study sites, while the lowest one fell in a range of 1,501-2,000 μm and was found only at Hat Pak Meng (as shown in Figure 3). According to the distribution of microplastics among size classes, more size classes of microplastics at Hat Pak Meng were found compared with those at Pak Nam Lang Suan.

The average body length of spionid polychaetes found at Pak Nam Lang Suan was significantly greater than that found at Hat Pak Meng ($p<0.01$). The body length of spionid polychaetes and the length of microplastics found in spionid polychaetes were not significantly correlated (Table 1 and Figure 4). The microscope selection and FTIR analysis showed various types of microplastics, suggesting that dominant fibre microplastics in polychaete samples were polyethylene terephthalate (PET) and polyethylene (PE) (Figure 5).

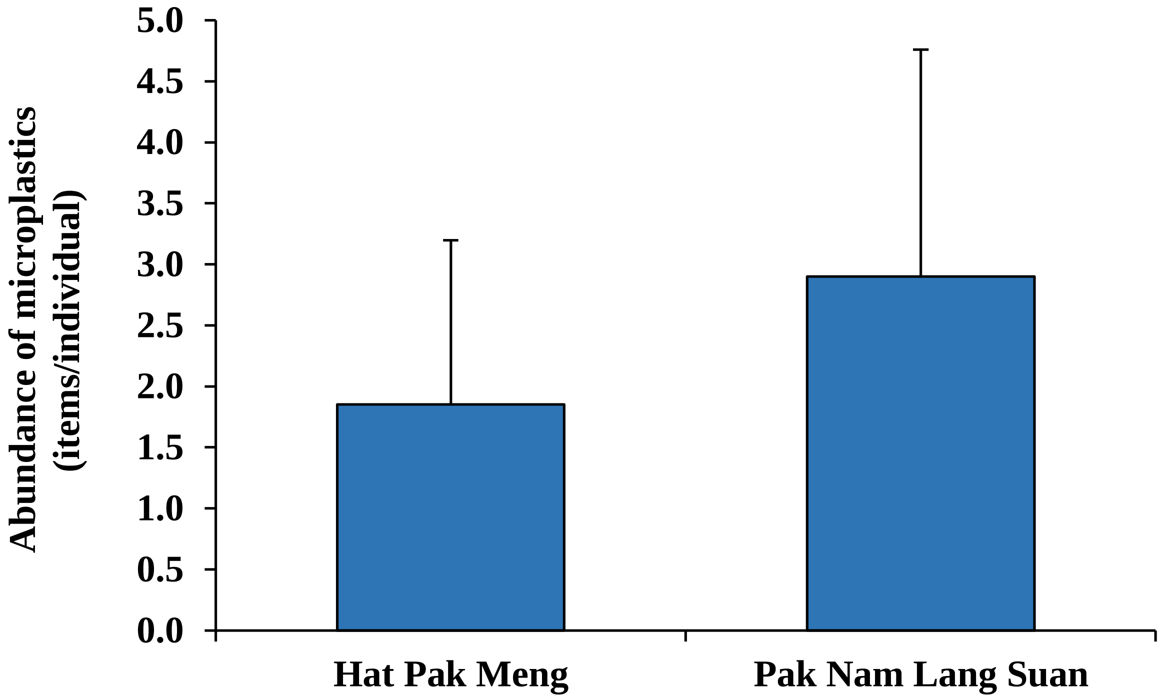

Figure 2. The abundance of microplastics in spionid polychaetes at the study sites (Mean±SD)

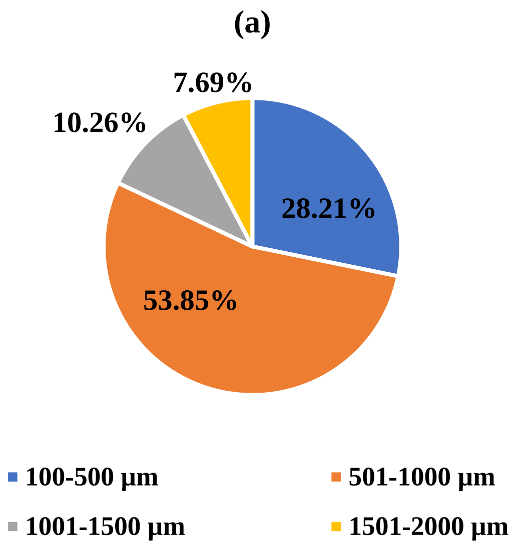

Figure 3. Distribution of microplastics found in the spionid polychaetes among size-classes (a) Hat Pak Meng (b) Pak Nam Lang Suan

Table.1 Average body length of spionid polychaetes and average length of microplastics found in spionid polychaetes

Study sites	Body length (mm)	Microplastics (µm)
Hat Pak Meng	3.46±1.37	841.46±466.42
Pak Nam Lang Suan	8.32±6.15	653.66±357.56

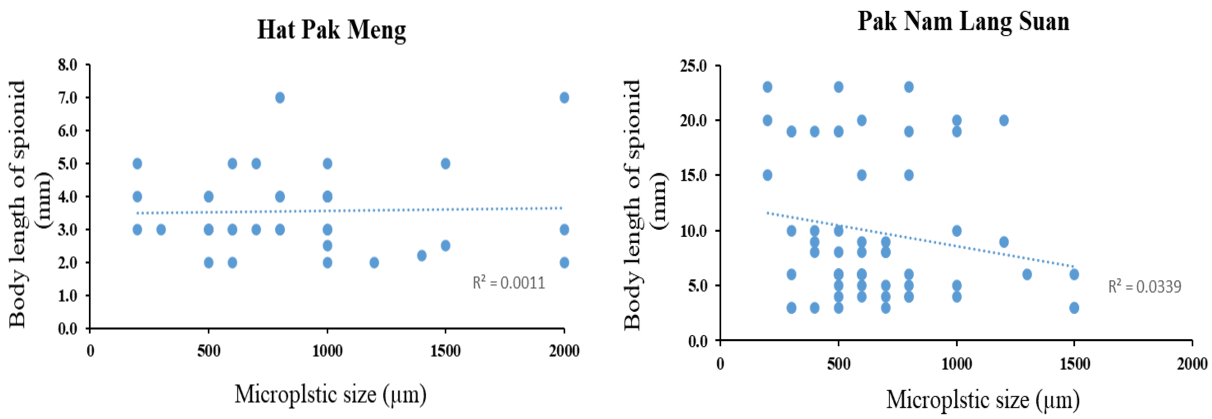

Figure 4. Correlation between the microplastic size in polychaete and body length of polychaete at Hat Pak Meng and Pak Nam Lang Suan.

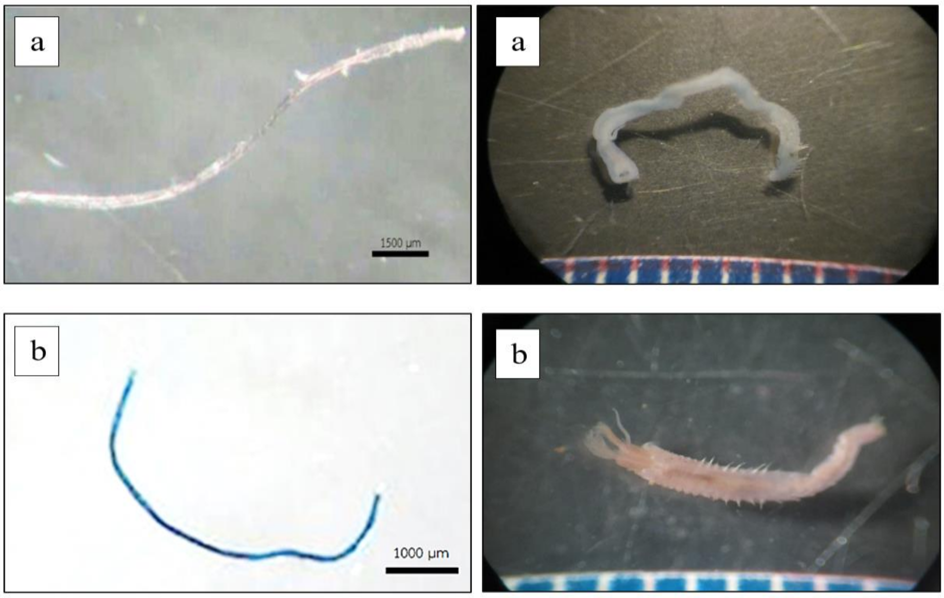

Figure 5. Microplastics found in the spionid polychaetes at Hat Pak Meng (a) and Pak Nam Lang Suan (b)

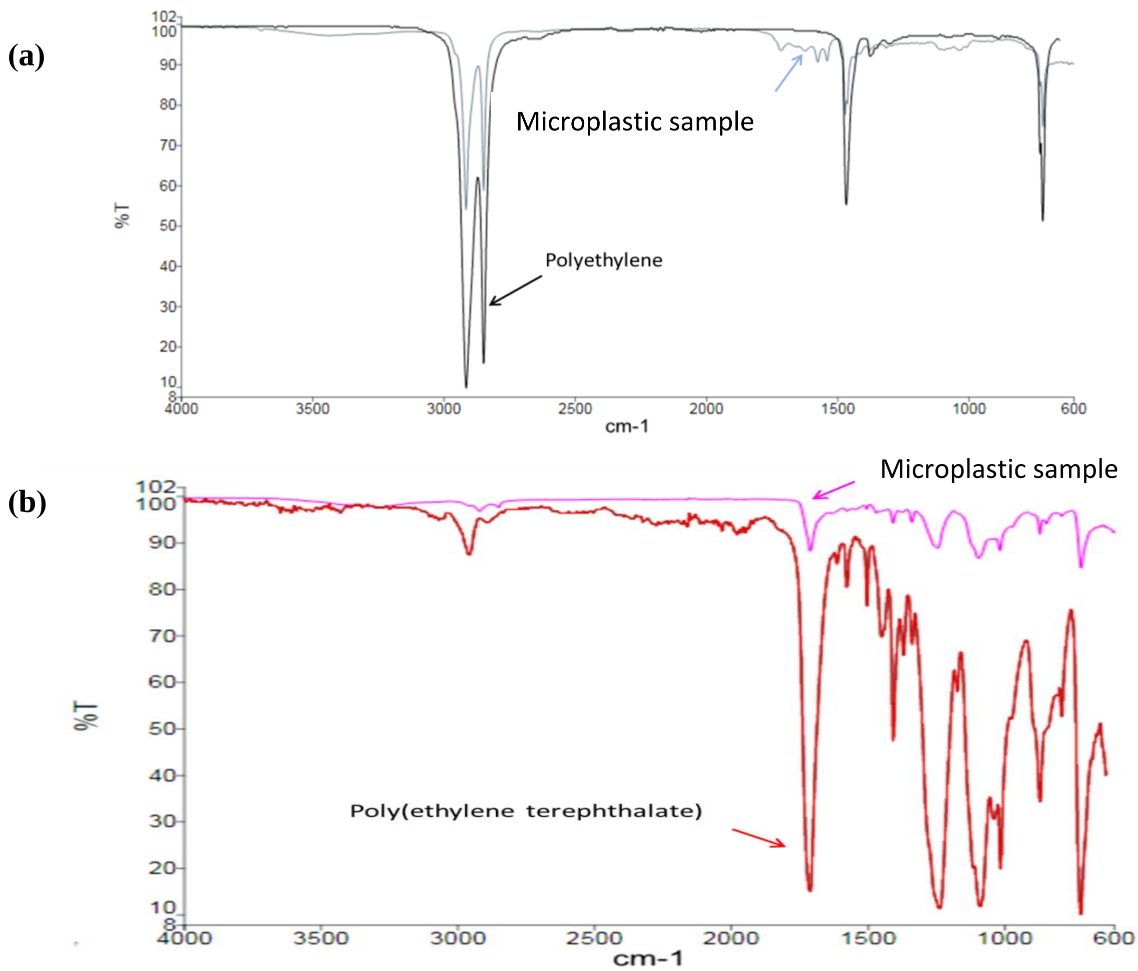

Figure 6. Fourier transform infrared spectroscopy (FTIR) spectra of Polyethylene (a) and Polyethylene terephthalate (b)

4. Discussion

The consumption and production of plastics increased over the past years; it has been expected that plastic litter could be a major environmental problem in the near future and that aquatic organisms might ingest and accumulate microplastics (Naidu et al. 2017). Polychaetes that feed from suspended and deposited materials are likely to ingest microplastics present in the water column and sediments because of their non-selective feeding behavior (Thompson et al. 2004; Browne et al. 2013; Wright et al. 2013; Naidu et al. 2017). The breakdown of the plastic litter into smaller size particles which are subsequently ingested by aquatic organisms may become a pathway for these materials to eventually accumulate and transfer to the higher trophic levels through the food chain (Green 2016; Murray and Cowie 2011; Naidu et al. 2017). The average size of microplastics at Pak Nam Lang Suan was smaller than that observed at Hat Pak Meng, which might be resulted from microbial biodegradation, or oxidants and physical stress that accelerate microplastics degradation. On the other hand, Hat Pak Meng is a sandy beach where degradation rates could be moderate to high due to exposure to high solar UV radiation, high temperature and oxygen availability, resulting in a high variability on microplastics size (Andrady 2015; Andrady 2017; Cooper and Corcoran 2010; Corcoran et al. 2009; Gewert et al. 2015; Gong et al. 2018; Song et al. 2017; UNEP 2016).

The average size and density of microplastics in polychaetes collected from Pak Nam Lang Suan were larger and higher than those collected from Hat Pak Meng; however, no significant differences were detected. Impact severity could be influenced by the size of microplastics and the density in polychaetes. Figure 3 shows that most microplastics discovered at Pak Nam Lang Suan have been less than 500 µm in length (with 43.10% proportion and an average size of 653.66±357.56 µm). The size of microplastics is expected to be smaller in the future; it could be difficult to egest the smaller plastic particles out of the polychaetes' bodies. The findings indicate that future increases in the microplastic decomposition will cause a decrease in growth rate, prevalence rate, and size of polychaetes, which further affects the food chain because polychaetes play an important role as secondary producers in the estuary's food web (Wright et al. 2013a; 2013b). Long-term accumulation of microplastics in polychaetes has shown biological impacts, particularly small sublethal changes in the forms of altered feeding, reduced growth, oxidative stress, reduced fecundity, and offspring performance (Wright et al. 2013). Most of the microplastics identified from spionid polychaete were polyethylene terephthalate (PET) and polyethylene (PE) might result from the degradation of plastic ropes and fishing nets (Browne et al. 2011; Zhao et al. 2014; Veiga et al. 2016). Generally, polypropylene (PP), polyethylene (PE), and polyethylene terephthalate (PET) are used for producing several fishing gears (Donohue et al. 2005; Qiu et al. 2015). Food packaging (plastic containers) and pipes are also made from PP and PET (Park et al. 2004).

Regarding the potential hazard of microplastics, ingestion of sediment and deposit feeders provides a direct route for these contaminants that can transfer further up to the food chain (Naidu et al. 2017). Potential health effects to humans may link with particle localization, chemical toxicity and associated microbial toxins. This research provides preliminary evidence of the presence of microplastics in polychaetes within Thai waters. However, in-depth studies on the toxicity of the different types of microplastics in polychaetes should be conducted to identify any potential threats to the higher trophic level organisms. Microplastic pollution is a relatively new issue. Further extensive scientific investigations are needed to address the levels, sources and distribution, including the different types of plastic polymers in the marine environment and their effect on aquatic organisms and potential to endanger animals and human health.

Acknowledgments

We are most grateful to the staff of Hat Chao Mai National Park, Department of National Parks, Wildlife, and Plant Conservation, and Marine Biodiversity Research Group, Faculty of Science, Ramkhamhaeng University for their support and assistance in the laboratory and field surveys. This research was funded partly by the National Science and Technology Development Agency (NSTDA).

References

Andrady AL (2015) Persistence of plastic litter in the ocean. Marine Anthropogenic Litter 456:57–72

Andrady AL (2017) The plastic in microplastics: A review. Mar Pollut Bull 119:12–22

Browne MA, Crump P, Niven SJ, Teuten E, Tonkin A, Galloway T, Thompson R (2011) Accumulation of microplastic on shorelines woldwide: sources and sinks. Environ Sci Technol 45:9175–9179

Browne MA, Niven SJ, Galloway TS, Rowland SJ, Thompson RC (2013) Microplastic moves pollutants and additives to worms, reducing functions linked to health and biodiversity. Current Biology 23(23): 2388–2392

Cole M, Lindeque P, Halsband C, Galloway TS (2011) Microplastics as contaminants in the marine environment: A review. Mar Pollut Bull 62:2588–2597

Cooper DA, Corcoran PL (2010) Effects of chemical and mechanical processes on the degradation of plastic beach debris on the island of Kauai, Hawaii. Mar Pollut Bull 60:650–654

Corcoran PL, Biesinger MC, Grifi M (2009) Plastics and beaches: a degrading relationship. Mar Pollut Bull 58:80–84

Donohue MJ, Timmers MA, Oceanic N (2005) Marine Debris of the Northwestern Ha- waiian Islands: Ghost Net Identification.

Eriksen M, Lebreton LCM, Carson HS, Thiel M, Moore CJ, Borerro MJ, Galgini F, Ryan PG, Reisser J (2014) Plastic pollution in the world’s oceans: More than 5 trillion plastic pieces weighing over 250,000 tons afloat at Sea. PLoS ONE 9:111913

Fauchald K (1973) Polychaetes from Central American Sandy Beaches. Bulletin of the South California Academy of Sciences 72(1):19–31

Gewert B, Plassmann MM, MacLeod M (2015) Pathways for degradation of plastic polymers floating in the marine environment. Environ Sci Process Impacts 17:1513–1521

Gong J, Kong T, Li Y, Li Q, Li Z, Zhang J (2018) Biodegradation of microplastic derived from poly (ethylene terephthalate) with bacterial whole-cell biocatalysts. Polymer 10:1326

Green, D.S., 2016. Effects of microplastics on European flat oysters, Ostrea edulis and their associated benthic communities. Environ. Pollut. 216:95–103

Hidalgo-Ruz V, Gutow L, Thompson RC, Thiel M (2012) Microplastics in the marine environment: A review of the methods used for identification and quantification. Environmental Science and Technology 46(6):3060–3075

Ivar do Sul JA, Costa MF (2014) The present and future of microplastic pollution in the marine environment. Environ Pollut 185:352–364

Jang M, Shim WJ, Han GM, Song YK, Hong SH (2018). Formation of microplastics by polychaetes (Marphysa sanguinea) inhabiting expanded polystyrene marine debris. Mar Pollut Bull 131:365-369

Law KL, Thompson RC (2014) Microplastics in the seas. Science 345:144–145

Mathalon A, Hill P (2014) Microplastic fibers in the intertidal ecosystem surrounding Halifax Harbor, Nova Scotia. Marine Pollution Bulletin 81(1):69–79.

Murray F, Cowie PR (2011) Plastic contamination in the decapod crustacean Nephrops norvegicus (Linnaeus, 1758). Marine Pollution Bulletin 62(6):1207–1217.

Naidu SA, Rao VR, Ramu K (2017) Microplastics in the benthic invertebrates from the coastal waters of Kochi, Southeastern Arabian Sea. Environ Geochem Health 40:1377–1383

Park CH, Kang YK, Im SS (2004) Biodegradability of cellulose fabrics. J Appl Polym Sci 94:248–253

Qiu Q, Peng J, Yu X, Chen F, Wang J, Dong F (2015) Occurrence ofmicroplastics in the coastal marine environment: first observation on sediment of China. Mar Pollut Bull 98:274–280

Song YK, Hong SH, Jang M, Han GM, Jung SW, Shim WJ (2017) Combined Effects of UV Exposure Duration and Mechanical Abrasion on Microplastic Fragmentation by Polymer Type. Environ Sci Technol 51:4368–4376

Thompson RC, Moore CJ, Vom Saal FS, Swan SH (2009) Plastics, the environment and human health: Current consensus and future trends. Philos Trans R Soc B: Biol Sci 364:2153–2166

Thompson RC, Olsen Y, Mitchell RP, Davis A, Rowland SJ, John AWG, McGonigle D, Russell AE (2004) Lost at sea: Where does all the plastic? Science 304:838

UNEP (2016). Marine plastic debris and microplastics–Global lessons and research to inspire action and guide policy change. United Nations Environment Programme

Van Cauwenberghe L, Vanreusel A, Mees J, Janssen CR (2013) Microplastic pollution in deep-sea sediments. Environ Pollut 182:495–499

Veiga JM, Fleet D, Kinsey S, Nilsson P, Vlachogianni T, Werner S, Galgani F, Thompson RC, Dagevos J, Gago J, Sobral P, Cronin R (2016) Identifying sources of marine litter. MSFD GES TG Marine Litter Thematic Report

Wright SL, Rowe D, Thompson RC, Galloway TS (2013a) Microplastic ingestion decreases energy reserves in marine worms. Curr Biol 23:1031-1033

Wright SL, Thompson RC, Galloway TS (2013b) The physical impacts of microplastics on marine organisms: A review. Environ Pollut 178:483–492

Zhao S, Zhu L, Wang T, Li D (2014) Suspendedmicroplastics in the surface water of the Yangtze Estuary System, China: first observations on occurrence, distribution. Mar Pollut Bull 86:562–568