Ingestion of plastics at sea: does debris size really matter?

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Most of our knowledge on plastic ingestion by zooplankton comes from experiments exposing invertebrates to plastic particles smaller than their feeding apparatus. By examining millimetre-sized marine plastics using a scanning electron microscope, we putatively identified some surface textures as feeding marks produced by invertebrates grazing upon the plastic biofilm. We observed sub-parallel linear scrapes with 5-14 μm spacing, which is similar to typical distances between teeth of the mandibular gnathobases of copepods. We also observed peculiar rounded marks close to an unidentified marine worm. Small portions of the plastic particles were apparently removed, and perhaps ingested, during these putative grazing activities. Thus, we suggest that (1) plastic biofouling induces plastic ingestion, and (2) plastic pieces must not necessarily be smaller than the organism for a feeding interaction to occur. Experiments exposing invertebrates to millimeter-sized plastics may support these suggestions.

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Ingestion of plastics at sea: does debris size really matter?

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Marine microplastics (< 5mm in length) can contain high loads of additives and adsorbed pollutants, and may be a threat to marine food webs due to their ingestion by organisms at the base of the food chain (http://www.unep.org/yearbook/). Most of our knowledge on plastic ingestion by zooplankton has been obtained through experiments assuming that plastic particles have to be smaller than the organism's feeding apparatus for this type of interaction to occur (Cole et al. 2013). However, we propose that this is not a rule.

By examining the surface of millimetre-sized marine plastics using a scanning electron microscope, we observed a diverse range of fouling microorganisms and invertebrates, and a variety of intriguing pits and scraping marks of unknown origin - see details in (Reisser et al. 2014b) and SEM images at (Reisser et al. 2014a). Here we suggest that some of these plastic surface textures are feeding marks produced by invertebrates grazing upon the plastic biofilm.

We observed sub-parallel linear scrapes with 5-14 μm spacing, which is similar to typical distances between teeth of the mandibular gnathobases of copepods (Figure 1a,c). The thinner and shallower marks around the linear scrapes could have been formed by filamentous microstructures present on their gnathobases (Michels et al. 2012). Copepods are an abundant planktivorous group and possess strong feeding apparatuses to feed upon organisms such as diatoms (Michels et al. 2012). Some pelagic species have flexible feeding habits, and can feed on sea-ice algae (Brierley & Thomas 2002), faecal pellets (Gonzalez & Smetacek 1994), and marine snow particles (Turner 2002). We suggest that these copepods could also feed upon biofilm of plastic debris, which is often rich in 'epiplastic' diatoms (Carson et al. 2013; Reisser et al. 2014b).

We also observed peculiar rounded marks close to an unidentified marine worm (Figure 1b,d), which was partially covered by an unknown structure (indicated by the arrow) possibly secreted by the animal. These unique scraping marks were also noted on two other plastic pieces that did not have any visible animals, but possessed structures similar to the one covering the worm in Figure 1b. At-sea invertebrate-plastic feeding interactions does not seem to be restricted to zooplankton, possibly occurring with rafting organisms such as amphipods, gastropods, and chitons, which are known to associate with floating debris such as plastics (Winston et al. 1997).

Small portions of the plastic particles were apparently removed, and perhaps ingested, during these putative grazing activities (Figure 1). Thus, our hypotheses are that (1) plastic biofouling induces plastic ingestion, and (2) plastic pieces must not necessarily be smaller than the organism for a feeding interaction to occur. The latter hypothesis has already been suggested for large items, as 15.8% of drifting plastic objects in Hawaii displayed a variety of vertebrate bite marks (Carson 2013).

To confirm this interaction, laboratorial experiments exposing zooplanktonic organisms to microplastics with biofilm should be conducted to document whether they are capable of creating such feeding marks. By exposing neustonic zooplankton to fresh pieces of brittle millimetre-sized plastic debris, researchers could possibly document this new type of feeding behaviour (e.g. by filming) and detect plastic bits co-ingested with biofilm grazing (e.g. by examining faecal pellets).

Due to their rapid growth and nutritional value, biofilms on plastic debris may be a significant new food source for invertebrates, particularly in the oligotrophic surface waters within subtropical gyres where plastic contamination levels are particularly high. The impacts related to this new type of feeding interaction remain unclear, but are likely negative since plastics pose chemical and physical threats to their 'predators/grazers' (Wright et al. 2013). These impacts could include effects on food webs, since plastic-associated pollutants and additives could be transferred to the biofilm and moved up the food chain of plastic 'predators/grazers'. The implications of plastic biofilm ingestion, particularly in terms of pollutant transfer and health effects should also be investigated.

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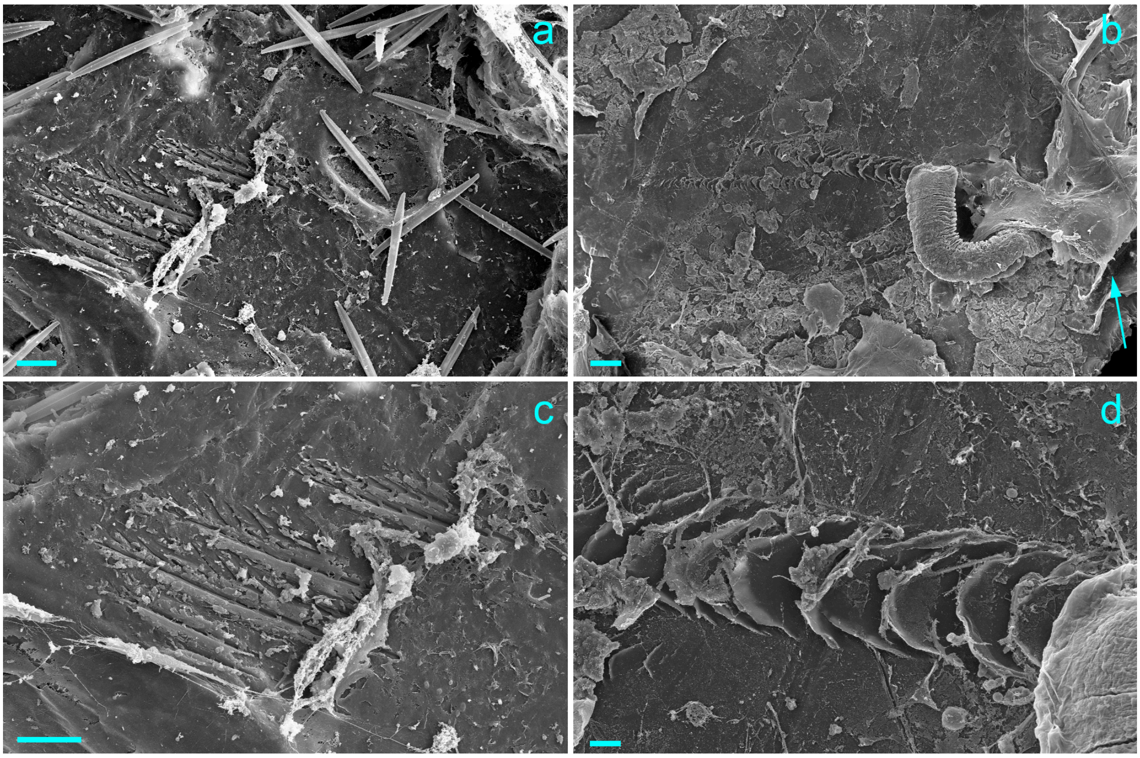

Figure 1 Scrapes putatively identified as feeding marks.

a: Linear scrape marks on a 2.3 mm long plastic debris with a high load of diatoms. b: Rounded scrape marks on a 6 mm long plastic with a unidentified marine worm. Arrow indicates unknown structure partially covering the worm. c: zoom on scraping displayed in ‘a’. d: zoom on scraping shown in ‘b’. Scale bars = 10 µm (a, c), 100 µm (b), 20 µm (d)