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Percentage of microbeads in pelagic microplastics within Japanese coastal waters

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ABSTRACT

To compare the quantity of microbeads with the quantity of pelagic microplastics potentially degraded in the marine environment, samples were collected in coastal waters of Japan using neuston nets. Pelagic spherical microbeads were collected in the size range below 0.8 mm at 9 of the 26 stations surveyed. The number of pelagic microbeads smaller than 0.8 mm accounted for 9.7% of all microplastics collected at these 9 stations. This relatively large percentage results from a decrease in the abundance of microplastics smaller than 0.8 mm in the upper ocean, as well as the regular loading of new microbeads from land areas, in this size range. In general, microbeads in personal care and cosmetic products are not always spherical, but rather are often a variety of irregular shapes. It is thus likely that this percentage is a conservative estimate, because of the irregular shapes of the remaining pelagic microbeads.

1. Introduction

Plastic litter that has degraded into fragments smaller than 5 mm in diameter is referred to as microscopic plastics (Thompson et al., 2004) or microplastics (e.g., Ryan et al., 2009; "secondary microplastics" according to Cole et al., 2011). It is thought to be impossible to retrieve these small fragments, once they have spread widely across the world's oceans. In fact, microplastics have been reported in the open oceans (Thompson et al., 2004; Cózar et al., 2014; Eriksen et al., 2014), in marginal seas at mid-latitudes (Isobe et al., 2015; Barboza and Gimenez, 2015; Deudero and Alomar, 2015), and in the Arctic Ocean (Lusher et al., 2015), as well as in coastal waters (Reisser et al., 2013; Isobe et al., 2014). Microplastics may act as transport vectors of chemical pollutants into the marine ecosystem, owing to the absorption of pollutants onto the plastic surface (Mato et al., 2001; Teuten et al., 2009) and the ingestion of tiny microplastics by organisms as small as zooplankton (Desforges et al., 2015). Such pollution will be unavoidable in the future if microplastics continue to be discharged into the oceans.

Industry uses the term "microbeads" to describe microplastic particles present as ingredients in personal care and cosmetic products (PCCPs); they are also called microspheres, nanospheres, plastic particulates (UNEP, 2015; Napper et al., 2015), and primary microplastics (Cole et al., 2011). Likewise, microbeads have been recognized as a source of marine plastic pollution (UNEP, 2015). Indeed, the environmental damage of plastic scrubbers in skin cleansers was pointed out by Zitko and Hanlon (1991); Gregory (1996), and Fendall and Sewell (2009). A recent experimental trial demonstrated that microbeads act as transport vectors of sorbed chemicals (Napper et al., 2015). However, to date, there are few peer-reviewed publications on suspected microbeads collected in oceans and/or lakes. An example of such research is that of Eriksen et al. (2013), who found colored spherical plastic particles during an expedition to the Laurentian Great Lakes. The plastic particles they found were of similar size, shape, color, and polymer materials to microbeads contained in facial cleansers, and thus, the particles were likely derived from PCCPs. However, it is a difficult task to identify microbeads (primary microplastics) in the environment unless they take a spherical shape unlikely to be formed by natural degradation, because microbeads cannot be tracked from their sources. The present study also uses the term "suspected microbeads" in line with Eriksen et al. (2013).

In the present study, pelagic microbeads were collected in Japan's coastal waters to compare the microbeads' quantity with that of pelagic microplastics collected concurrently. If microbeads account for a nonnegligible fraction of pelagic microplastics in nature, microbeads are likely to contribute to present marine plastic pollution to some extent. Even if their fraction is negligibly small, they may still have an important environmental effect in the future, in the absence of public awareness and/or legal regulation.

As mentioned above, there is no way of distinguishing microbeads from secondary microplastics in nature, unless they take a spherical shape unlikely to be formed by natural degradation. The sizes and elemental composition (mostly polyethylene) of microbeads do not allow the microbeads to be distinguished from secondary microplastics that usually have similar sizes (shown later in Fig. 3) and elemental composition (Reisser et al., 2013; Isobe et al., 2014); thus, microbeads were only identified in terms of their spherical shape. In the following analyses, spherical pellets (nurdles) are not included because they are

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typically at least several millimeters in diameter and thus much larger than the microbeads collected (shown later in Fig. 3). However, as pointed out by Zitko and Hanlon (1991); Gregory (1996); Fendall and Sewell (2009), and Napper et al. (2015), microbeads in PCCPs are not always spherically shaped; microbeads in PCCPs available in Japanese supermarkets, pharmacies, etc. also have a variety of irregular shapes (shown later in Fig. 4). The present study thus provides a conservative estimate of the microbead percentage in pelagic microplastics in the coastal waters of Japan. In the following descriptions, the term "microplastics" (without the terms "primary" or "secondary") includes both microbeads and secondary microplastics, unless otherwise stated.

2. Materials and methods

2.1. Field surveys

A field campaign to sample microplastics was conducted by the Ministry of Environment, Japan, from 15 September to 30 October 2015. Sampling surveys were conducted using fishery boats, at 26 stations in Tokyo Bay, Suruga Bay, Ise Bay, and the Seto Inland Sea, Japan (Fig. 1). Neuston nets (5552; RIGO Co., Ltd., Tokyo, Japan) were used to collect small plastic fragments near the sea surface. The mouth dimensions, length, and mesh size of each net were 75 × 75 cm, 3 m, and

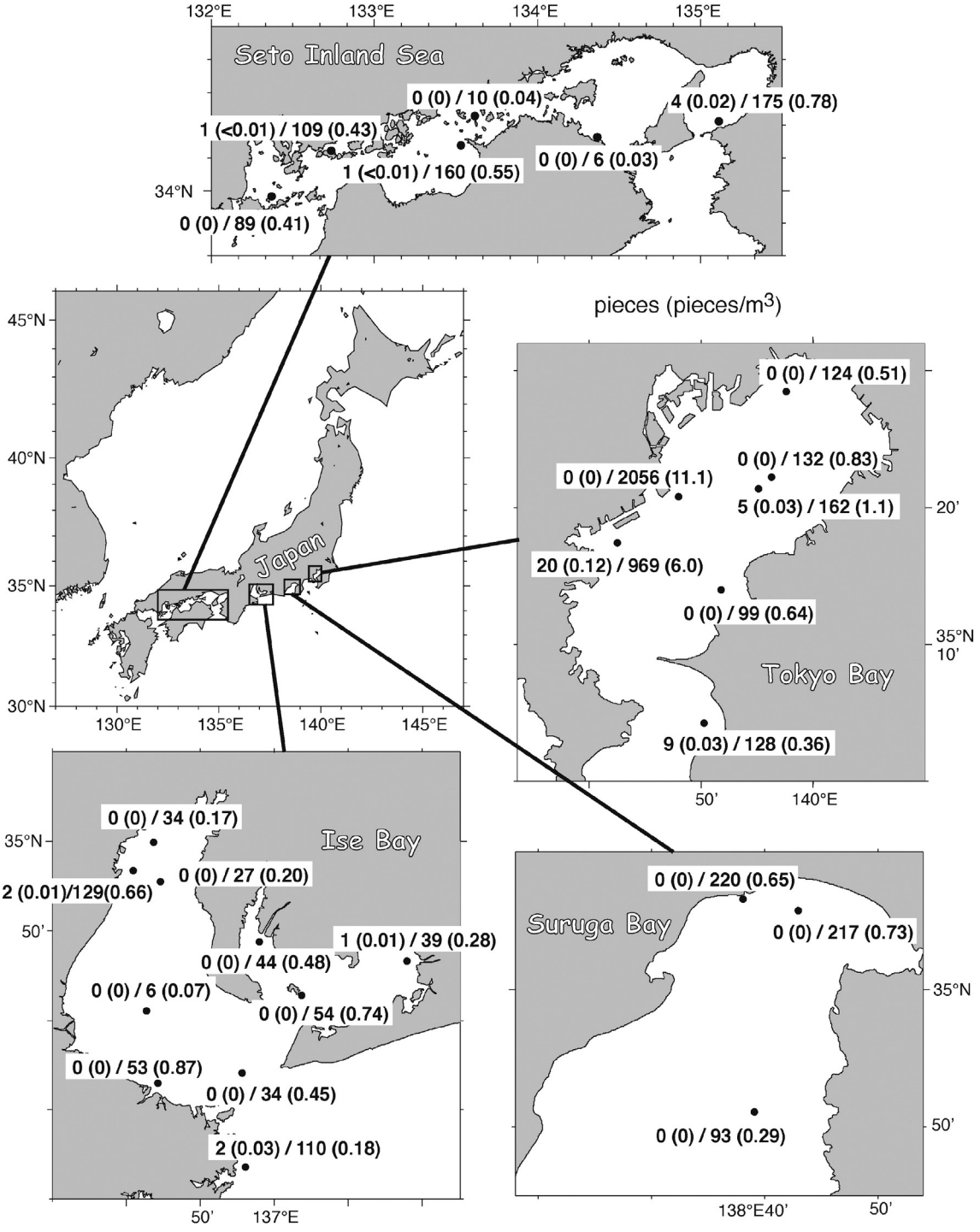

Fig. 1. Sampling stations. The values next to dots are quantities (concentrations) of microbeads, followed by those of microplastics, at each station.

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