Marine Pollution Bulletin 79 (2014) 94-99

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Widespread distribution of microplastics in subsurface seawater in the NE Pacific Ocean

Jean-Pierre W. Desforges^a, Moira Galbraith^b, Neil Dangerfield^b, Peter S. Ross^{c,*}

^a School of Earth and Ocean Sciences, University of Victoria, PO Box 1700, Victoria, BC, Canada ^b Institute of Ocean Sciences, Fisheries and Oceans Canada, PO Box 6000, Sidney, BC, Canada

^c Vancouver Aquarium, PO Box 3232, Vancouver, BC V6E 3G2, Canada

A R T I C L E I N F O

Keywords: British Columbia Pacific Ocean Microplastic Tsunami debris Litter Plastic

ABSTRACT

We document the abundance, composition and distribution of microplastics in sub-surface seawaters of the northeastern Pacific Ocean and coastal British Columbia. Samples were acid-digested and plastics were characterized using light microscopy by type (fibres or fragments) and size (<100, 100–500, 500–100 and >1000 μ m). Microplastics concentrations ranged from 8 to 9200 particles/m³; lowest concentrations were in offshore Pacific waters, and increased 6, 12 and 27-fold in west coast Vancouver Island, Strait of Georgia, and Queen Charlotte Sound, respectively. Fibres accounted for ~75% of particles on average, although nearshore samples had more fibre content than offshore (p < 0.05). While elevated microplastic concentrations near urban areas are consistent with land-based sources, the high levels in Queen Charlotte Sound appeared to be the result of oceanographic conditions that trap and concentrate debris. This assessment of microplastics in the NE Pacific is of interest in light of the on-coming debris from the 2011 Tohoku Tsunami.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

The marine environment is host to increasing quantities of waste debris from human activities in and around the ocean (Arthur and Baker, 2011). Any persistent or manufactured solid material discarded in the marine or coastal environment is termed marine debris, of which a large fraction (60–80%) consists of plastic (GESAMP, 2010; UNEP, 2005). An estimated 1.3 plastic items can be found for every m² of shoreline worldwide, based on a review of 201 beach surveys on five continents (Bravo et al., 2009). This debris is increasingly recognized as a threat to marine biota. For instance, through ingestion or entanglement, more than 267 species worldwide are estimated to be impacted by marine debris, including the majority of sea turtle species and almost 50% of all seabird and marine mammal species (Derraik, 2002).

Over the past decade, efforts to document microplastics in the marine environment have increased. Microplastics have been defined as plastic particles <5 mm and typically over 333 μ m, while smaller particles (>1 μ m) are also included but less often detected (Arthur et al., 2009). Several plastic classes exist, but the most commonly found micro-debris particles include polyethylene (PE), polypropylene (PP), and polystyrene (PS) (Andrady, 2011). Microplastics are now ubiquitous in the marine environment, having

been found in seawater at the surface and at depth, and in oceans and coastlines from the equator to the poles (Barnes et al., 2009). Despite the growing number of publications on the topic, large gaps still remain in our understanding of the source, transport and fate of microplastics in the marine environment.

Microplastics consist of either deliberately manufactured commercial micro-particles, including scrubbers, abrasives, and precursor pellets (primary sources), or as fragments and fibres derived from the deterioration of larger products (secondary sources) (Hidalgo-Ruz et al., 2012). Plastic debris can originate from marine-based sources (i.e. fishing, aquaculture, shipping, etc.) or land-based sources (i.e. wastewater effluent, run-off, rivers), but the majority is believed to derive from the latter (Andrady, 2011). Regardless of origin, plastics are manufactured to be durable and thus persist in the environment, particularly in water where degradation can occur over decades (Hidalgo-Ruz et al., 2012). The abundance and distribution of microplastics in the marine environment are believed to be governed by prevailing surface circulation and winds, plastic density, colour and shape, and proximity to urban centres (Andrady, 2011; Browne et al., 2011, 2010; Doyle et al., 2011).

Although the harmful effects of large plastic debris on marine wildlife have been well documented (i.e. Derraik, 2002), little is known about the effects of microplastics. Potential threats to biota may include physical harm from ingestion, leaching of toxic additives, and desorption of persistent, bioaccumulative and toxic







^{*} Corresponding author. Tel.: +1 604 659 3400; fax: +1 604 659 3562. *E-mail address*: Peter.Ross@vanaqua.org (P.S. Ross).

(PBT) chemicals (GESAMP, 2010). Small plastic fragments are available to organisms at the base of the food web as they may be in the same size-range as natural food items. Recent studies have shown that plankton and several classes of invertebrates and vertebrates can ingest and accumulate microplastics (see review by Wright et al., 2013). Furthermore, microplastics have been found to concentrate a wide-range of organic contaminants in the aquatic environment due to their hydrophobic nature. Contaminants that have been adsorbed include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), dichlorodiphenyltrichloroethane (DDT), polybrominated diphenylethers (PBDEs), and bisphenol A (BPA) (Mato et al., 2001; Rios et al., 2007; Teuten et al., 2009). Few studies have examined the bioaccumulation of PBT chemicals from plastics, although some studies suggest that PCB concentrations rose in lugworms (Arenicola marina) and seabirds (Puffinus gravis, Calonectris leucomelas) exposed to contaminated plastic particles (Rvan et al., 1988; Teuten et al., 2009, 2007).

The aim of this study was to investigate the abundance, composition and distribution of marine microplastics in the NE Pacific Ocean in areas in and near the coastal waters of British Columbia (BC), Canada. Microplastics were quantified according to size (62–5000 μ m) and shape (fibres or fragments) in sub-surface seawater. This study is particularly timely given the present movement of marine debris across the Pacific as a result of the 2011 Tohoku earthquake and resulting tsunami.

2. Materials and methods

2.1. Sampling

Sampling was conducted aboard two oceanographic research cruises: the CCGS John P. Tully cruise of the Line P time series program in August 2012, and the La Perouse Monitoring Program cruise of September 2012 conducted by the Institute of Ocean Sciences (Fisheries and Oceans Canada). The sampling regime was developed to create a low cost, long-term monitoring program that is integrated into existing oceanographic programs. As such, sampling was conducted during standard cruise operations at scheduled Line P and La Perouse stations. Line P cruises collect transect data from coastal BC to approximately 1200 km offshore in the NE Pacific Ocean, while La Perouse regularly samples stations off coastal Vancouver Island (Fig. 1).

Seawater was collected at 4.5 m below the surface using the saltwater intake system of the vessel. A flow-meter measured the volume of water pumped from the saltwater intake at each site, and the readings were converted to cubic meters of water filtered. Water was typically pumped for 10–20 min at each station, but this varied as a function of other oceanographic sampling taking place aboard the vessel. Water was first passed through a coarse 5 mm filter to remove large debris and organisms before entering the intake system, then run through a series of copper sieves of diminishing pore size: 250 μ m, 125 μ m, and 62.5 μ m. The material on each sieve was rinsed with seawater into labelled 20 ml glass vials and stored refrigerated with 5–10% HCl at 4 °C at the Institute of Ocean Sciences (Sidney, BC).

2.2. Plastic analysis

In the laboratory, organic material in the water samples were acid digested at 80–90 °C for 3 h using concentrated HCl. Nile red dye $(3 \ \mu g/ml)$ was added each sample prior to being filtered through an HA Millipore mixed cellulose ester filter paper (47 mm, 0.45 μ m pore size; EMD Millipore Corporation, Billerica, MA) under vacuum filtration. Filter paper was placed on solvent

rinsed foil and covered until analysis (same day). Samples were examined visually using optical microscopy (Zeiss stereoscope, Discovery V8; Carl Zeiss Canada Ltd., Toronto, ON) by counting plastics in 8 of 16 squares of a 7.8×7.5 mm grid. Plastics were identified according morphological characteristics and physical response features (e.g. response to physical stress; microplastics were bendable or soft) described by Hidalgo-Ruz et al. (2012). Particle size was measured and plastics were counted and categorized into two broad categories: fibres/filaments and fragments (i.e. pellets, thin films, fragments). Plastic data obtained from the three sieves was combined in order to better categorize the particles by size. Size categories were based on length measurements of the longest dimension of each particle: $<100 \,\mu\text{m}$ (62–100 μm), 100-500 μm, 500-1000 μm, or >1000 μm (1000-5000 μm). Particle counts were converted to number of particles per cubic meter of seawater for each station.

2.3. Statistical analysis

Regional comparisons were accomplished by grouping sites into oceanographic regions: NE Pacific Ocean, west coast Vancouver Island (WCVI), Queen Charlotte Sound (QCS), and Strait of Georgia (SoG). Regional differences were evaluated by ANOVA followed by Tukey's HSD where significant using SPSS software (SPSS 16, IBM Inc.). Maps and contour plots were created using Ocean Data View 4 (Schlitzer, R. 2013, http://odv.awi.de).

3. Results

3.1. Microplastic abundance

Microplastics were detected at 34 stations, but concentrations varied considerably and ranged from 8 to 9180 particles/m³ (Table 1, Fig. 1). The concentration of microplastics was 4–27 times greater at sites nearshore (SoG, WCVI, and QCS) than sites offshore in the NE Pacific Ocean (Fig. 1, Table 1). Locally, the inland waters of QCS and the SoG had higher microplastic levels than the WCVI (p = 0.015 and p = 0.007 respectively, Table 1). A localized area of low concentrations southwest of Vancouver Island was evident, where levels were far below the average for coastal regions (Fig. 1).

3.2. Plastic size distribution

The mean size of microplastic particles was $606 \pm 221 \,\mu$ m. The smallest particle documented was $64.8 \,\mu$ m, and the largest was $5810 \,\mu$ m (Table 1). Particle sizes increased linearly from the coast to approximately 600 km offshore, resulting in greater particle sizes in the NE Pacific Ocean and WCVI regions compared to the inland waters of QCS (p < 0.001, Table 1). The 100–500 μ m size fraction was the most abundant of all size classes at most sampling stations, and largely explained the high total plastic concentrations observed in QCS (Table 1).

3.3. Plastic composition

The majority of identified particles were fibres/filaments and angular plastic fragments, with few cases of other types of plastics (thin films or round fragments). Very brittle, brightly coloured fibres were abundant in most samples, but were not quantified as the acid digestion readily eliminated these. The colours of particles varied widely, but blue, red, black and purple were the most common. Fibres/filaments accounted for approximately three quarters of the identified particles in the collective dataset (Fig. 2). The fibre/filament concentrations followed total plastic patterns, with lowest concentrations offshore (NE Pacific < all Download English Version:

https://daneshyari.com/en/article/6358855

Download Persian Version:

https://daneshyari.com/article/6358855

Daneshyari.com