Environmental Pollution 228 (2017) 416–424

Contents lists available at ScienceDirect

Environmental Pollution

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

Through the sands of time: Beach litter trends from nine cleaned north cornish beaches☆

Andrew J.R. Watts [a, *, 1], Adam Porter [a, 1], Neil Hembrow [b], Jolyon Sharpe [c], Tamara S. Galloway [a], Ceri Lewis [a]

[a] College of Life and Environmental Sciences: Biosciences, Geoffrey Pope Building, University of Exeter, Stocker Road, Exeter EX4 4QD, United Kingdom
[b] Keep Britain Tidy, Elizabeth House, The Pier, Wigan, WN3 4EX, United Kingdom
[c] Environment Service, Pydar House, Room 4A, Truro, Cornwall TR1 1XU, United Kingdom

ARTICLE INFO

Article history:
Received 24 January 2017
Received in revised form
18 April 2017
Accepted 4 May 2017
Available online 27 May 2017

Keywords:
Marine litter
Plastic
Fishing litter
Tourism
Un-sourced litter

ABSTRACT

Marine litter and its accumulation on beaches is an issue of major current concern due to its significant environmental and economic impacts. Yet our understanding of spatio-temporal trends in beach litter and the drivers of these trends are currently limited by the availability of robust long term data sets. Here we present a unique data set collected systematically once a month, every month over a six year period for nine beaches along the North Coast of Cornwall, U.K. to investigate the key drivers of beach litter in the Bude, Padstow and Porthcothan areas. Overall, an average of 0.02 litter items m^{-2} per month were collected during the six year study, with Bude beaches (Summerleaze, Crooklets and Widemouth) the most impacted (0.03 ± 0.004 litter items m^{-2} per month). The amount of litter collected each month decreased by 18% and 71% respectively for Padstow (Polzeath, Trevone and Harlyn) and Bude areas over the 6 years, possibly related to the regular cleaning, however litter increased by 120% despite this monthly cleaning effort on the Padstow area beaches. Importantly, at all nine beaches the litter was dominated by small, fragmented plastic pieces and rope fibres, which account for 32% and 17% of all litter items collected, respectively. The weathered nature of these plastics indicates they have been in the marine environment for an extended period of time. So, whilst classifying the original source of these plastics is not possible, it can be concluded they are not the result of recent public littering. This data highlights both the extent of the marine litter problem and that current efforts to reduce littering by beach users will only tackle a fraction of this litter. Such information is vital for developing effective management strategies for beach and marine litter at both regional and global levels.

1. Introduction

Marine litter is one of the most indiscriminate and pervasive pollution issues facing our seas and oceans today (Galloway and Lewis, 2016). Many recent studies have documented both the extent of marine litter throughout the world's coastal waters and open oceans (e.g. Cózar et al., 2014; van Sebille et al., 2015) and the damage that it can cause to marine wildlife via entanglement and ingestion (e.g. Wright et al., 2013; Cole et al., 2015; Watts et al., 2015). UNEP describes marine litter or marine debris as "any persistent, manufactured or processed solid material discarded, disposed of, abandoned or lost in the marine and coastal environment" (UNEP, 2005). Beach litter has two main sources; it can originate from the sea as a result of shipping, recreational boating, navigation, fisheries, aquaculture and other offshore activities, or it can originate from land-based sources such as recreational activities on the beach, rivers, from drainage systems (such as Combined Sewage Overflows (CSOs)), sewage inputs, as well as from anthropogenic activities adjacent to the beach (domestic, agricultural, landfill, shipyards, harbours, etc.) (Gabrielides et al., 1991; Semeoshenkova and Williams, 2011; Kordella et al., 2013; Thiel et al., 2013; Fauziah et al., 2015; Schulz et al., 2015). Hence, litter on beaches can comprise a wide range of litter types including various plastics, metal, timber and large items like fishing gear, and come from a variety of sources.

The issue of beach litter and marine debris has recently become

☆ This paper has been recommended for acceptance by Maria Cristina Fossi.
* Corresponding author.
E-mail address: a.j.r.watts@exeter.ac.uk (A.J.R. Watts).
[1] Joint first authors.

http://dx.doi.org/10.1016/j.envpol.2017.05.016
0269-7491/

an issue of heightened concern for both the general public and policy makers due to the increasing evidence of the harm it can cause to wildlife and the socioeconomic implications that it causes for beach users and tourism. Plastic, a large constituent of marine litter, has been found in the stomachs and entangled around stranded whales (Jacobsen et al., 2010), turtles (Tourinho et al., 2010) and sea birds (Avery-Gomm et al., 2012). Economically, up to 97% of a beach's value can be lost by a drop in cleanliness standards (Ballance et al., 2000). One study calculated that the economic benefits for Orange County, California in the United States associated with a 100% reduction in marine debris at all sites could be as much as $148 million and a reduction in only 25% could render as much as $32 million dollars to the economy (Leggett et al., 2014).

In the U.K., beach litter abundances have risen by 20% between 1994 and 2014 (Marine Conservation Society, 2015; Nelms et al., 2017). In the South West (in which our study beaches are situated), litter on beaches cleaned under the 'Great British Beach Clean' scheme was observed to be 89% higher in 2013 compared to 2014 (Marine Conservation Society, 2015) with these beaches amongst the most littered in the U.K. (Nelms et al., 2017). The cost of removing beach litter to all coastal municipalities in the U.K. is estimated to be in the region of €18–19 million per annum (Mouat et al., 2010). The costs of marine litter goes further than just that of a clean-up effort,, as demonstrated by the Royal National Lifeboat Institution (RNLI). In 2008, they made 286 rescue operations to vessels with tangled propellers costing the charity between €877,000 and €2,313,000 (Mouat et al., 2010). Furthermore, beaches provide social benefits and the presence of litter can undermine the psychological benefits of a visit to the beach (Wyles et al., 2016). Managing beach litter and reaching targets for reducing both the environmental and economic impacts of litter and its clean-up requires a much better understanding of the current trends in both the types of litter present and their sources (Unger and Harrison, 2016).

The factors affecting the accumulation of litter on beaches may vary with both location and season. To analyse beach litter trends in any detail requires long-term data sets with limited variation in the methodology applied over time and with little gaps in the data. Beach cleans have become a powerful and useful tool with which the academic community is beginning to engage with in order to gather large volumes of data about the state of our global shorelines. The U.K. has a long heritage of beach clean efforts including 21 years of Beachwatch (Marine Conservation Society, 2015) clearing 150 tonnes of litter since 1994, Surfers Against Sewage's current commitment to reduce beach litter by 50% by 2020 (Surfers Against Sewage, 2014), and Keep Britain Tidy have accrued 15,000 volunteer hours in cleaning beach in the South West (Keep Britain Tidy, 2015). The interaction of beach cleans and scientists is paramount as the data collected, if it is to be useful, is best done in a representative, systematic way with good aims and a robust standard method.

Identifying the root causes rather than just managing the consequences of marine littering is clearly of critical importance if we are to improve the state of our seas and oceans. Most of the data currently available for understanding spatio-temporal trends in the accumulation of beach litter comes from beach cleans run by local authorities or charities using volunteers (e.g. Nelms et al., 2017). As a result, data is often collected by a large number of people, with different people collecting the data at each sampling time and/or location. Whilst this is a fantastic way to get a large amount of information for a wide area, and can produce useful insight into generalised trends, this understandably also introduces a level of uncertainty and variability into any data set and often makes robust statistical analysis difficult. The litter collected is then generally categorised into a number of simplified litter types. The classical approach has just been to categorise litter by material (plastic, timber, rope etc.). However, classifying by source or original user is a much more effective way of directing management strategies towards stopping the problem at source rather than just measuring it (Schulz et al., 2015). Common litter types now used typically include sewage-related debris, fishing-related litter, shipping-related litter, beach user related litter (tourism or animal faeces), fly-tipped, and medical and then an 'uncategorisable litter items' category for those items that are too fragmented or degraded to be allocated to an original source (OSPAR, 2009; Williams et al., 2003, 2014).

The aim of this study was firstly to produce a unique data set from nine beaches around the north coast of Cornwall, U.K., using a systematic method over a six year period using consistent litter category definitions and undertaken by the same team of trained professionals on a monthly basis. The beach cleans conducted for this study were undertaken with source attribution in mind and thus work towards looking at root causes rather than just cleaning up. These beach cleans were done by hand to minimise any ecological damage associated with more mechanical methods. We then use this high quality dataset to identify the driving factors of marine litter on beaches in the South West of England, identify any seasonal or annual trends in litter type and abundance and ultimately to suggest how this knowledge can be applied to improve beach litter management.

2. Material and methods

2.1. Beach cleans

Nine beaches on the North Cornwall coast were surveyed and cleaned by the same five trained council workers during the first week of each month over a period of 6 years between January 2005 and December 2011 using the recognised OECD guidelines (OSPAR, 2010). The beaches chosen lie within a 60 km stretch of coast line

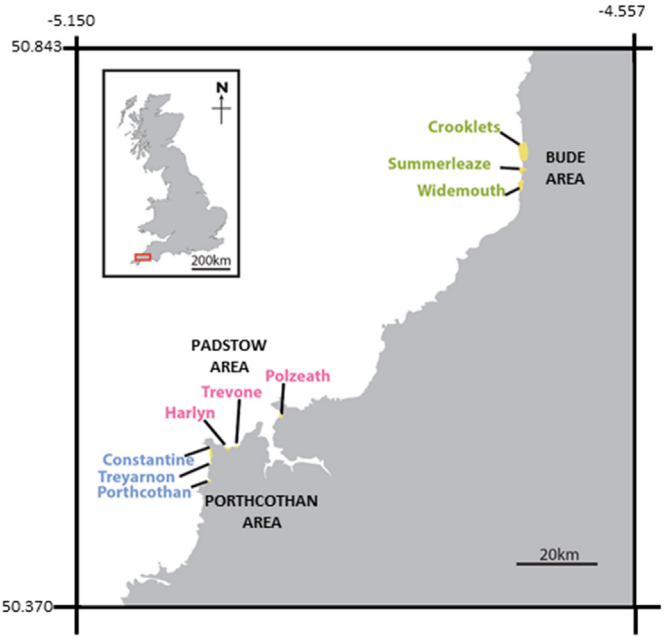

Fig. 1. Map of beach clean sites. North coast of the South West region of Cornwall, U.K. Three areas: Bude area (Crooklets, Summerleaze, Widemouth); Padstow area (Polzeath, Trevone, Harlyn); Porthcothan area (Constantine, Treyarnon, Porthcothan). Crooklets and Porthcothan beaches are 57 km part along the coastline.