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Beach litter sourcing: A trawl along the Northern Ireland coastline

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ABSTRACT

Fourteen non-recreational coastal locations in Northern Ireland were investigated as to whether beach litter deposition was related to seasonal or site specific factors. Litter items were counted in 100 m width transects and 1 km strand-line surveys over a five-season period (autumn to autumn). Survey sites comprised fishing ports; estuarine areas, north (high energy) and east coast (low energy) beaches. Fishing ports accumulated the most litter. In the 100 m beach surveys, plastics, string and cord, bottle caps, food items, rope, and drink containers dominated. In strand-line surveys, large plastic pieces were dominant, followed by rope, string and cord, strapping bands (absent on beach surveys), cloth, wood (mainly pallets, fish boxes) and metal items. Multivariate analyses revealed major litter category differences between the ports and all other sites, with a lesser distinction between exposed and estuarine sites. There was no simple coastline trend and no apparent effect of seasonality between samples.

1. Introduction

Marine debris (litter) is a fundamental ubiquitous problem which arises from human activity, either intentional or unintentional (Slavin et al., 2012; Williams et al., 2016a) and includes any manufactured or processed solid waste material that enters the marine environment from any source (Coe and Rogers, 1997). It has become a serious problem of rising magnitude (Tudor and Williams, 2004; Barnes et al., 2009) and debris can originate from land or sea sources, but most researchers postulate that the dominant input comes from land (Coe and Rogers, 1997), although Sheavly and Register (2007) argued that some 50% is of marine origin. Global studies of marine litter over the past two decades have shown that plastic - synthetic organic polymers derived from polymerisation of monomers obtained from oil or gas - is the modal litter type, with more being found in the northern than southern hemisphere (Moore et al., 2001; Ivar do Sul and Costa, 2007; Thompson et al., 2009; Corcoran et al., 2009; Williams et al., 2014; Erikssen et al., 2014; Poeta et al., 2016). Plastics appeared on the world scene in 1907 with 'Bakelite' and since the start of mass plastic production in the 1950s, they can be found globally on beaches (Thiel et al., 2013; Eriksson et al., 2013); not only on the surface but buried beneath sediments (Barnes et al., 2009; Williams and Tudor, 2001). They are extremely versatile and can be tailored to meet very technical needs, i.e. they are light in weight, durable, inexpensive, resistant to chemicals, have good safety, hygiene, thermal and electrical insulation properties and Andrady (2011) showed that demand for plastics is increasing with an annual global production at 245 million tonnes, The packaging industry utilises some 40%, building and construction 20% and landfill takes 30–50% of all plastics produced (www.plastics). OSPAR (2007b), and Cheshire (UNEP/IOC, 2009) have been among the forerunners in assessing the marine debris problem on a global basis; whilst other workers e.g. Galgani et al. (2013, 2015) studied large regional areas. Plastic marine debris is very mobile and can spread over vast areas, as it can float, as well as sink to the sea bed (Morrison, 1999; Carson et al., 2013). Therefore, they dominate marine litter and represent a significant threat to the marine envirnment as a result of their longevity, abundance and ability to cross large distances (Thompson et al., 2009) and constitute between 40 and 80% (Kuase and Noda, 2003); 50–80% of all marine litter (Barnes et al., 2009). Management of this litter is a massive issue (Earll et al., 2000) and McIlgorm et al. (2008) has given a sound review of the economic costs involved.

Plastic litter occurs as whole manufactured products (e.g. cartons, bottles), or as fragments/pellets, with high socio-economic costs and constitutes a huge threat to biota (Gregory, 2009; Mouat et al., 2010;

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Potts and Hastings, 2012; Thompson et al., 2009):

- via ingestion/entanglement for mammals, sea birds, fish, (Gregory, 2009; Williams et al., 2013).
- by accumulating in plankton and subsequently passing up the food chain to a host of sea creatures (Setälä et al., 2014).
- by absorption of chemicals that can persist in organisms (Fossi et al., 2014) and cause later problems.

In many cases, beach debris originates from outside sources (Nixon and Barnea, 2010) and accumulates due to wave/current action, but is usually left to local authorities to remove it (Liu et al., 2013). An excellent resume of the issue is given by Potts and Hastings (2012), whilst Pilkey and Cooper (2014) offer a discussion on litter as a threat to beaches, writing about the plastisphere.

This study aims to determine whether the categories and abundance of litter items deposited on some Northern Ireland beaches varies with respect to site-specific factors (coastal morphology, exposure, adjacent land use, etc), and whether consistent differences occur between seasons.

2. Physical background

In terms of wave and wind conditions, the Northern Ireland coast can be divided at its most north-easterly point, near Ballycastle, into two dynamic zones: the north and east coasts (Fig. 1a).

The North coast is primarily affected by refracted Atlantic swell waves, which approach the coast from the northwest and reduce in height toward the east, but seldom penetrate the Irish Sea beyond Ballycastle (Carter, 1990). Dominant waves (swell) refract from the west and so the dominant transport under waves is to the east as the winds are dominantly offshore here. Mean significant wave height exceeds 2 m between Magilligan and Ballycastle (Jackson and Cooper, 2010) and the 50-year maximum wave height reduces from 25 m at Magilligan to 15 m at Ballycastle (Carter, 1990). A much lower 50-year return wave (12–14 m) was estimated by Carter and Challenor (1989). Most waves are fully refracted at the shoreline and have created a series of headland-embayment cells (Jackson and Cooper, 2010). Winds on the north coast are predominantly from the SW and consequently are offshore-directed. Mean wind speed at Malin Head is 7 m/s, with gusts of 50 m/s likely to occur once every 50 years (Met Eireann, 2016). Tidal range reduces from Magilligan (2.5 m) to Ballycastle (1 m) in line with a degraded amphidromic point. Tidal flow into and out of the Irish Sea generates reversing tidal currents that have a slight easterly dominance at the surface and westerly dominance at depth (Knight and Howarth, 1999). Current speeds are maximized in the constrictions created by the narrowing of the North Channel and around Rathlin Island where whirlpools and tidal overflows are generated (Howarth, 2005). Currents in the region are difficult to assess, as reversing tidal currents that flow in both directions are common. The largest direct river discharge on the north coast derives from the Bann and Bush, whilst the rivers Roe, Foyle and Faughan, flow into Lough Foyle. In the Foyle estuary, along-shore transport is northwards under the dominant southerly winds.

The East coast gradually increases in tidal range from 1 m at Ballycastle to almost 5 m at Dundrum Bay. On this coast, sea waves dominate (Orford, 1989) and are relatively consistent from N to S (Hs = 1.2 m or less). Extreme wave heights reach 4.5 m (Cooper and Navas, 2004) and a 50-year return period wave was estimated at almost 8 m (Carter and Challenor, 1989). Waves are generated by dominant S-SE winds in the Irish Sea, producing the Irish Sea waves which are predominantly obliquely onshore and drive strong wave-driven longshore currents (Bowden and Orford, 1984). It is therefore safe to assume a net transport to the north at a macro scale. Wind speeds average 6 m/s and gusts of 45 m/s are expected once in 50 years (Met Eireann, 2016). Several small, steep rivers discharge directly to the coast between Glenarm and Ballycastle. South of Glenarm most rivers discharge into Larne, Belfast, Strangford and Carlingford Loughs.

In sheltered marine embayments (sea loughs), estuarine-type flow patterns (although not salinity patterns) are developed and the shoreline orientation strongly influences the degree to which wind-generated wave action affects the shoreline (Greenwood and Orford, 2007). Onshore winds are important in generating surges in these sheltered environments (Ryan and Cooper, 1998) whilst rivers of various sizes discharge into each of the sea loughs.

3. Investigated sites

a) Fishing ports (Fig. 1a, b); Ardglass; Kilkeel; Portavogie. These beaches are all on the East coast. The 100 m survey extends north from the harbour wall in each case. Portavogie is an extensive flat sand beach; Ardglass a narrow sand and shingle beach in a bay; and Kilkeel had a steeply sloping pebble beach.
b) Estuarine (Fig. 1a, b); Hazelbank; Minearny; Rostrevor. All three beaches are narrow (max width ~ 5 m) sand and shingle rising from extensive sand and mud flats. Hazelbank is the only beach surveyed close to a major population centre (Belfast metropolitan area).
c) East coast (low energy, rural beaches; Fig. 1a, b); Ballywalter; Ballyhornan; Cloughey; Drains Bay; Tyrella. Drain's Bay (the most northerly of this group) is the only beach not composed of wide, flat sand. Ballyhornan is backed in part by a till escarpment up to 10 m high.
d) North Coast (higher energy, exposed rural beaches; (Fig. 1a, b); Rathlin; Runkerry; White Park Bay. Runkerry and Rathlin are both exposed sand beaches where bathing is prohibited due to strong currents, with Runkerry also having some 2–4 m depth of cobbles over the 100 m stretch (at the eastern end). Rathlin was a split area, with the 100 m section on sand within the bay next to the marina, whilst the remainder of the 1 km was on the exposed pavement and pebble beach on the other side of the seawall. White Sand Bay is owned by National Trust, with no surrounding development. The survey area was the beach centre - flat, fine-grained sand, backed by dunes located at the base of a high limestone cliff.

4. Methodology

Litter items were categorised according to OSPAR (2007a, 2007b) at 14 Northern Ireland beach sites, carried out on five survey occasions: Autumn 2012, Winter 2012–13, Spring, Summer, and Autumn 2013 (total 70 samples). These data form part of a UK data set, which is being used to compile a response for Descriptor 10 of the EU Marine Strategy Framework Directive. Other than three harbour beaches (Ardglass, Kilkeel, Portavogie), the areas surveyed were located at least 500 m from any frequently visited beach section and no beach cleaning was carried out, apart from removal of 300 bottles at Hazelbank in 2012. Even at Tyrella, it was unusual to see anyone other than kite surfers or dog walkers within the area hence fewer people discarded fewer recreational litter items directly on site.

4.1. Beach litter surveys

4.1.1. 100 m Beach transect

At each location, a detailed count of litter items from the highest strand line to the back of the beach (seawall, dunes etc.) down to the sea, were undertaken if possible within a 100 m wide strip located either side of the access point (Fig. 2; EA/NALG, 2000). A surveyor's wheel measured the distances and the points were marked with GPS. At some beaches, with a distant or poorly-defined access point, the 100 m section was located arbitrarily. All litter items within the transect area were recorded (107 OSPAR categories). There was little variation in the extent of study areas between sites. This methodology ensures that virtually all litter types present on a beach are recorded (Tudor and Williams, 2001).