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The impact of debris on marine life

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ABSTRACT

Marine debris is listed among the major perceived threats to biodiversity, and is cause for particular concern due to its abundance, durability and persistence in the marine environment. An extensive literature search reviewed the current state of knowledge on the effects of marine debris on marine organisms. 340 original publications reported encounters between organisms and marine debris and 693 species. Plastic debris accounted for 92% of encounters between debris and individuals. Numerous direct and indirect consequences were recorded, with the potential for sublethal effects of ingestion an area of considerable uncertainty and concern. Comparison to the IUCN Red List highlighted that at least 17% of species affected by entanglement and ingestion were listed as threatened or near threatened. Hence where marine debris combines with other anthropogenic stressors it may affect populations, trophic interactions and assemblages.

1. Introduction

Marine habitats are spoiled with man-made debris, from the poles to the equator and from shorelines, estuaries and the sea surface to the depths of the ocean (Thompson et al., 2009). The incidence of marine debris is cause for concern for a number of reasons. It is known to be harmful to organisms and to human health (Coe and Rogers, 1997; Derraik, 2002; Gregory, 2009; Rochman et al., 2013), it has potential to increase the transport of organic and inorganic contaminants (Gaylor et al., 2012; Holmes et al., 2012; Mato et al., 2001; Rochman et al., 2012; Teuten et al., 2009), it presents a hazard to shipping, and it is aesthetically detrimental, thus generating negative socio-economic consequences (Mouat et al., 2010). The scale of the marine debris problem and its potential to negatively impact biodiversity has not been widely evaluated.

Marine debris is defined as any persistent manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment (Coe and Rogers, 1997; Galgani et al., 2010). It includes items made or lost by people, and those deliberately discarded into or unintentionally lost in the marine environment including, among others, items of plastic, wood, metal, glass, rubber, clothing and paper (Galgani et al., 2010; OSPAR, 2007). The material types most commonly found in marine debris are glass, metal, paper and plastic (OSPAR, 2007), and it is readily apparent from the published literature that on a global scale, plastic items are consistently among the most numerically abundant types of marine debris (OSPAR, 2007; Thompson et al., 2009; UNEP-CAR/RCU, 2008; UNEP, 2005, 2009). There are a number of transport pathways by which debris enters the marine environment, including rivers, drainage or sewerage systems, and wind, and once there, debris persists, with its durability making it resistant to degradation (Barnes et al., 2009).

Plastic debris is of particular concern due to its abundance, and its persistence in the environment, which makes it a ubiquitous category of marine debris. Global production of plastics has increased considerably over the last few decades from 5 million tonnes per year in the 1960s to 280 million tonnes per year in 2011 (PlasticsEurope, 2012). The absolute quantity of plastic debris that enters the marine environment is, however, unknown. Sampling is typically restricted to the sea surface in coastal waters and shorelines, and temporal trends have been found to vary between regions (Barnes et al., 2009; Derraik, 2002). It is evident, however, that despite efforts to remove debris from the marine environment, and restrictions on dumping at sea, quantities of plastic are increasing in some locations (Harper and Fowler, 1987; Thompson et al., 2004; Goldstein et al., 2012). In many areas quantities are highly variable but stable and for some debris types there is evidence of a decrease, but it seems inevitable that since most plastics will not biodegrade, quantities in the marine environment will increase over time (Andrady, 2011). It is likely that the lack of consistent trends in temporal data represent the movement of debris to compartments where monitoring is minimal such as deep sea sediments Woodall et al. (2014) and offshore

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areas, and also the fragmentation of plastic debris into pieces smaller than those routinely sampled.

The impact of marine debris on marine life is of particular concern, and effects can be wide reaching (Fig. 1), with the consequences of ingestion and entanglement considered to be harmful. Reports in the literature began in the 1960s (Brongersma, 1968; Caldwell et al., 1965; Holgersen, 1961) with fatalities being well documented for birds, turtles, fish and marine mammals (Laist, 1997; Secretariat of the Convention on Biological Diversity and the Scientific and Technical Advisory Panel – GEF, 2012). Debris has also been shown to provide an additional surface for the rafting of organisms (Aliani and Molcard, 2003; Barnes and Fraser, 2003; Barnes and Milner, 2005; Carpenter et al., 1972; Winston et al., 1997) which has implications for the transport of non-native species, and to provide new habitat for colonisation (Ayaz et al., 2006; Carr et al., 1985; Donohue et al., 2001; Goldstein et al., 2012; Good et al., 2010; Pace et al., 2007) which may be particularly important where it provides hard substrate in areas that are otherwise predominantly of soft sediment (Pace et al., 2007). It may also cause physical changes to habitats (Aloy et al., 2011; Carson et al., 2011), in particular coral reefs (Al-Jufaili et al., 1999; Chiappone et al., 2005; Chiappone et al., 2002; Donohue et al., 2001; Richards and Beger, 2011). Particular concern is associated with species listed on the IUCN Red List as these are at the greatest risk of extinction from a diverse range of impacts.

The incidence of marine debris and its potential to cause harm has resulted in it being recognised as a global problem (STAP, 2011; Sutherland et al., 2010) and its listing among the major percieved threats to marine biodiversity (Gray, 1997). The problem has been recognised in global and regional agreements such as the decisions of the 11th Conference of the Parties to the Convention on Biological Diversity (CBD COP 11 Decision XI/18), the 10th Conference of the Parties to the Convention on the Conservation of Migratory Species of Wild Animals (CMS Resolution 10.4), the International Convention for the Prevention of Pollution From Ships (MARPOL) Annex V, and the EU Marine Strategy Framework Directive (MSFD). Furthermore, the cumulative impacts of plastic resins on human health and the environment have led to proposals enacting legislation and policies classifying the most harmful types of plastic debris as hazardous waste (Rochman et al., 2013).

Fig. 1. (A) Debris discarded on the shore near a coral reef, Ta'u Island, American Samoa (Courtesy of Wolcott Henry/Marine Photobank). (B) Debris extracted from the carcass of a Laysan Albatross chick, Kure Atoll, Hawaii (Courtesy of Claire Fackler, NOAA Marine Sanctuaries/Marine Photobank). (C) Debris incorporated into the nests of a Northern Gannet (*Morus bassanus*) on Grasholm, UK (Courtesy of Dr. Stephen Votier, Plymouth University). (D). Marine debris and derelict fishing gear among albatross nesting habitat. Midway Atoll, Northwestern Hawaiian Islands (Courtesy of Steven Siegel/Marine Photobank). (E) Turtle entangled in plastic rope in Caribbean (photo: UNEP-CAR/RCU, 2008).

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