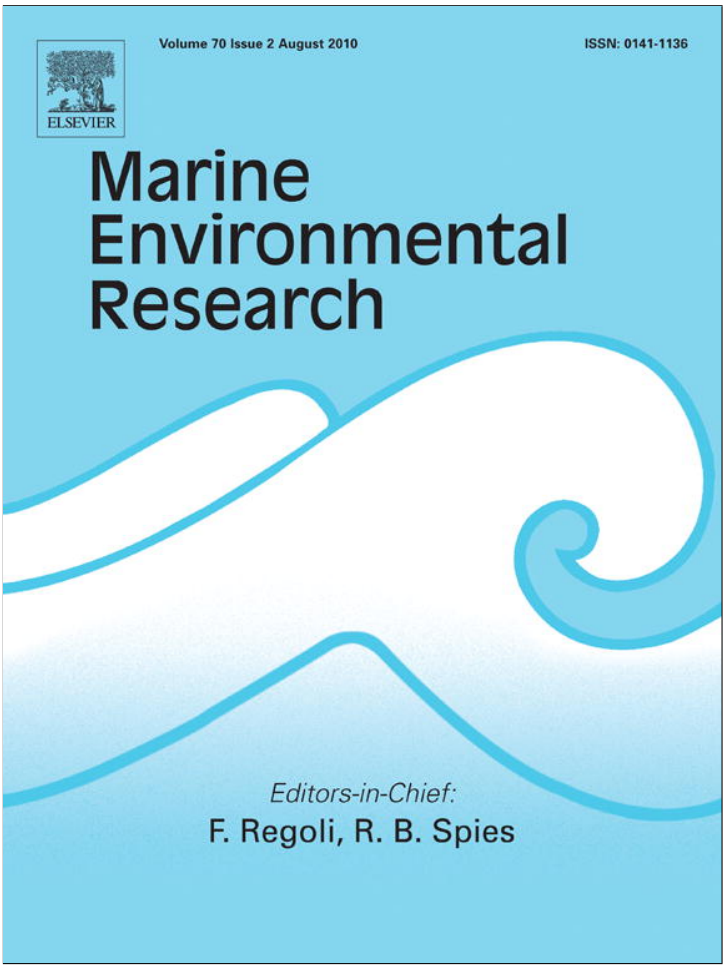

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Short communication

Macroplastics at sea around Antarctica

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ABSTRACT

More so than at any previous time, there is a heightened awareness of the amount of plastic in the environment, it's spread to even remote localities and the multiple influences of this on organisms. In the austral summer of 2007/08 Greenpeace and British Antarctic Survey ships (MV Esperanza and RRS James Clark Ross respectively) conducted the first co-ordinated joint marine debris survey of the planet's most remote seas around East and West Antarctica to reveal floating macroplastics. With observations also made from the ice patrol vessel HMS Endurance in the same season and seabed samples collected from the RRS James Clark Ross, this was the widest survey for plastics ever undertaken around Antarctica.
Main features: The 2008 visit of RRS James Clark Ross to the Amundsen Sea breached two last frontiers; the last and most remote sea from which biological samples and plastic debris have been reported. A plastic cup and two fishing buoys were seen in the Durmont D'Urville and Davis seas while two pieces of plastic packaging and a fishing buoy were observed in the Amundsen Sea. Agassiz trawls revealed rich biodiversity on the Amundsen (and south Bellingshausen) seabed but no sunken plastic pieces. We found no microplastics in five epibenthic sledge samples (300 μm mesh) from the Amundsen seabed. The seabeds immediately surrounding continental Antarctica are probably the last environments on the planet yet to be reached by plastics, but with pieces floating into the surface of the Amundsen Sea this seems likely to change soon. Our knowledge now touches every sea but so does our legacy of lost and discarded plastic.

1. Introduction

Plastics and other man-made litter at sea has grown drastically as a scientific, popular and financial issue across the last few decades from the first reports at sea (Carpenter et al., 1972). Gregory et al. (1984) showed that various plastics and oils were even accumulating in part of the Southern Ocean. Over the last few decades there have been surveys of stranding debris on many remote island shores and some repeat observations showed drastic increases over just a decade (Ryan and Moloney, 1993). This was not just a problem of the ocean surface and shorelines; considerable amounts were sinking onto the continental shelf seabed and even deeper (Galgani et al., 2000). Evidence emerged that plastics could not only choke and starve (through accumulation in stomachs) different types of wildlife, but also transport a wide variety of organisms around the planet, potentially transporting harmful and non-indigenous species (Barnes, 2002). Most early literature on the global spread of plastic into the environment concerned large fragments but more recently studies have examined degradation and the build up of billions of microplastic fragments in sediments worldwide (Thompson et al., 2004). The current study aimed to investigate the frequency of plastic pieces on the ocean surface (large) and seabed (large and small fragments) in the most remote areas of the Southern Ocean.

At the start of 2008 the Greenpeace vessel MV Esperanza headed south into the Southern Ocean around East Antarctica to highlight, and if possible, stop a Japanese scientific whaling fleet from successful catches. A month later at 180° longitude the British Antarctic Survey vessel RRS James Clark Ross steamed into the Southern Ocean around West Antarctica to highlight, and if possible, catch the first biological samples ever from the continental shelf of the Amundsen Sea (see Kaiser et al., 2009; Ocean Biogeographic Information System website for global samples and SCARMarBIN website for detail of Southern Ocean records). However, both vessels had a purpose in common, which was the first co-ordinated ship-board survey of Southern Ocean marine debris, specifically to quantify macroplastics in the planet's most remote seas. Furthermore a scientist on board the ice patrol vessel HMS Endurance, which was supporting science projects along the West Antarctic Peninsula also recorded observations of plastics at

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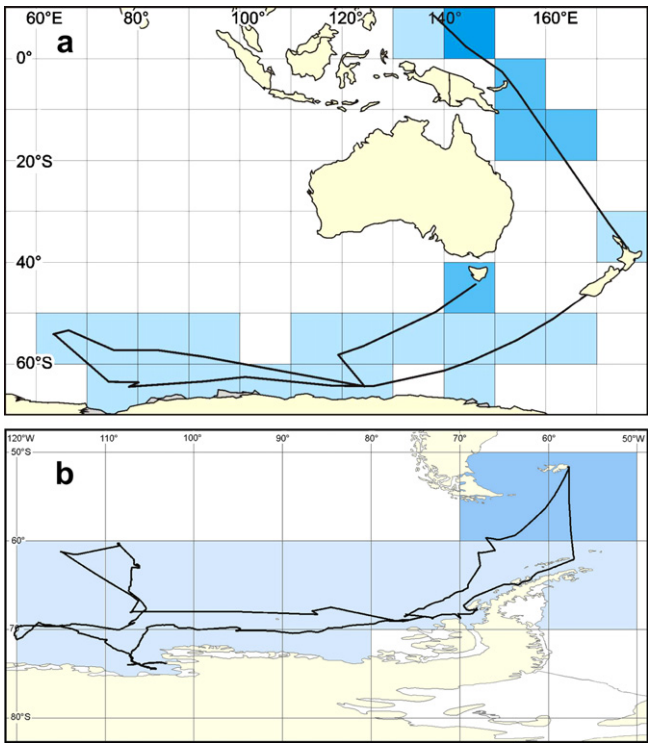

Fig. 1. Densities of marine debris at sea in and adjacent to the Southern Ocean by 10° latitude and longitude areas. Shades of light to dark blue code for densities 0–1, 2–10 and 11–100 items per km^2 respectively. The black lines are the cruise track of the MV Esperanza (1a) and RRS James Clark Ross (1b).

sea. This survey was not only the first at the sea surface and seabed in the Southern Ocean but also combined the most unusual team of vessels belonging to research, pressure group and military organisations to gain unprecedented spatial coverage.

2. Methods

Ship-board observers made the first surveys of the last seas to be surveyed for plastics at sea. Areas as far south as 74°S and from 60 to 170°E and 57 to 120°W were surveyed by observers on the MV Esoperanza and RRS James Clark Ross. The regions surveyed were parts of the Scotia, Bellingshausen, Amundsen, Durmot D'Urville, Davis and the edge of the Cosmonaut seas. They used high-powered binoculars for an hour each day to scan and identify floating items (other than ice). The details of these were recorded together with geographic position, environmental and ship information (such as speed and heading). Even with experienced observers, ideally marine debris surveys would be much more rigorous with dedicated towed collection apparatus, slower transit speeds (both vessels were travelling at 8–10 knots for many of the observations) and repeat sampling in areas of poor sea conditions. However pragmatic approaches are needed as justification of ship use for dedicated debris surveys of remote areas such as the Southern Ocean are unlikely given the long transits, large ship sizes, rising fuel costs and realisation of environmental impact (carbon footprint) involved.

Benthic towed apparatus (Agassiz trawl [mesh size 1 × 1 cm] and Epibenthic sledge [mesh size 300 μm]) were deployed from the RRS James Clark Ross in the southern Bellingshausen and eastern Amundsen seas (see Supplementary materials for tow durations and positions). Trawled material was transferred to precooled 100% ethanol for fixation for 24 h. Fixed samples were then sorted and examined using stereomicroscopy.

3. Results and discussion

Our 2008 survey showed that large pieces of marine debris were not common or abundant in the seas studied, but that it is reaching even seas with virtually no human presence (in the Amundsen Sea there is no local source of anthropogenic debris as there are no scientific research stations or other bases and only very rare and brief scientific vessel visits). We report geographic variability of plastics at a coarse geographic scale as appropriate to the methods and for comparison with previous ocean wide surveys (Fig. 1). The combined survey of both ships showed that marine debris was more common and abundant in the South Pacific and South Atlantic oceans than in the Southern Ocean (see e.g. Barnes and Milner, 2005 and papers in Thompson et al., 2009). At the positions we examined in the Southern Ocean, marine debris was dominated by plastic (for breakdown of materials found by day, see supplementary material).

Overall and throughout each sea surveyed, man-made items dominated marine debris and only plastic was seen south of 63°S. Plastic comprised 43% of the 69 items seen from MV Esperanza and 41% of the 51 items recorded by RRS James Clark Ross. Plastic bags, which have recently been highlighted in a number of countries as a serious issue of environmental concern, only comprised two items in the South Atlantic, both close to the Falkland/Malvinas Islands. In the most remote areas off East and West Antarctica, these plastics were a cup and a fishing buoy in the Durmont D'Urville Sea, a fishing buoy in the Davis Sea and two pieces of plastic packaging and a fishing buoy in the Amundsen Sea. The most southerly debris item was one of the pieces of plastic packaging (a banding tape used to keep wooden crates together) was seen at 72.7°S (107.3°W) – above the continental shelf of the Amundsen Sea. However an observer in a third ship, HMS Endurance, operating in the Bellingshausen Sea at the same time, reported three items of marine debris even further south at 73°S, 76°W including two plastic fishing buoys and a metal oil drum (P. Convey pers. Com.). Past surveys of marine debris in the South Atlantic Ocean, Scotia Sea and remote Southern Ocean Islands (Barnes and Milner, 2005) do not suggest densities of large plastic pieces are still increasing significantly at highest southern latitudes (papers in Thompson et al., 2009). Monitoring, accumulation patterns, effects and potential solutions to plastics in the environment are highly complex, as illustrated in a special volume of the Philosophical Transactions of the Royal Society of London B (Thompson et al., 2009).

The fact that plastics are floating into the remotest of localities is a strong measure of human influence on the surface of the planet. However the presence of plastics deep within the Southern Ocean is much more significant than mere aesthetics or even the strangling of megafauna, such as fur seals where plastic banding often ends up (Fig. 2). Plastic is an ideal substratum not only for sorbing and concentrating persistent organic pollutants (POPs) but also for fouling organisms. Thus both POPs and organisms can be distributed widely to new localities across the planet over decades of travelling (Mato et al., 2001; Rios et al., 2007). This is of particular importance to Southern Ocean biodiversity as it is the last big area where non-indigenous animal species are not yet known to be established. However, recent warming of surface waters (Meredith and King, 2005) is enhancing their chance of survival and establishment if transported. Plastics, when they degrade into tiny fragments, can be ingested by, and carry toxins into organisms, such as, suspension feeders (Graham and Thompson, 2009). Again this of particular importance in the Southern Ocean for two reasons, firstly

Fig. 2. A common fate of plastic marine debris in the Southern Ocean. Fur seal (a) and elephant seal (b) entangled in drift plastic. Images copyright British Antarctic Survey.

suspension feeders often dominate Antarctic shelf biodiversity (Arntz et al., 1994). Secondly UV light levels, a major agent of plastic degradation, are raised due to seasonally thinned stratospheric ozone over Antarctica. Microplastic fragments have already been found in the sediments around the remote Southern Ocean island of South Georgia (Thompson et al., 2009). In contrast, we found no large plastic fragments in the 37 Agassiz trawls (see Appendix 1) carried out from 500 m to 3500 m in the Bellingshausen and Amundsen seas nor did we find any microplastics in any of the five epibenthic sledge samples from 500 m examined to date.

Appendix. Supplemental material

Supplementary data associated with this article can be found in the online version, at doi:10.1016/j.marenvres.2010.05.006.

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