MARINE DEBRIS: HANGERS-ON AND HITCH-HIKING ALIENS

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Abstract

A great diversity of sessile and motile organisms have been reported from freely drifting and shore-cast marine debris. The communities described bear resemblances to those associated with *Sargassum* and other drifting seaweeds. They also include a number of fouling organisms, mostly bryozoans which have already achieved global distribution through attachment to natural substrates such as wood and turtles Furthermore it has been suggested that aggressive marine (and in some instances terrestrial) invasive species could be amongst the hangers-on and hitch-hikers. Dispersal of alien taxa rafted in this way could endanger environments both near and far from their natural habitats. The prospects for translocation are similar to those associated with ballast-waters.

Introduction

For centuries the earth's oceans have been viewed as a vast and unlimited sink into which humankind could indiscriminately cast all manner of waste. While populations were small and materials for disposal were mostly biodegradable the environmental consequences remained minimal. However, over the past four or five decades, there has been ever-growing awareness of the extent to which contamination of the marine realm by plastics and other persistent synthetic materials, including derelict fishing gear, was becoming an environmental threat with global implications. The ocean surface's often filthy state was dramatically revealed in observations made by Heyerdahl (1971) during the raft Ra II's 1970 westwards drift across the Atlantic Ocean. The situation has not improved over the past thirty years given comments made by participants in recent long distance rowing events between Tenerife and Barbados (Gregory, 1998). Moore (2003) has recently demonstrated that waters of the central North Pacific gyre have been similarly "trashed". Anecdotal evidence suggests that equatorial waters of the South Pacific Ocean north of Kiribati may be fouled in a comparable fashion. The sources, distribution, detrimental environmental and other undesirable impacts, together with possible solutions created by these discarded materials (known collectively as "marine debris") are comprehensively reviewed in Coe and Rogers (1996).

The widely and long-recognized detrimental impacts of these materials include:- death and/or debilitation of wildlife through entanglement and ingestion; impairment of behavioral responses, reduced quality of life and reproductive performance; potential hazards to commercial shipping and recreational boating; damage to subsistence and commercial fisheries; health implications; aesthetic values tourist perceptions and other emotive issues; blanketing effects endangering biotas of both soft and hard substrates and possibilities for locally induced anoxia or hypoxia. Theprobability, remote as it may seem at first glance, of aggressively invasive species being introduced to environmentally sensitive marine environments through hitching a ride on drifting marine debris (e.g.,

Gregory, 1990; 1991; Winston et al., 1996; Barnes, 2002a and b) is a further problem that requires serious investigation and needs to be added to this list.

Hangers-on and Hitch-hikers

Freely drifting (*i.e.* pelagic) plastic items are commonly colonized by a great diversity
of encrusting and fouling epibionts, as well as proving an attractive substrate for a varied motile biota. The pseudo-planktic community that develops is similar to that associated with *Sargassum* and other drifting seaweed although species richness and diversity are reduced (Stevens et al., 1995; Winston et al., 1996). Substantial aggregations of marine debris may also provide habitats suitable for the larval and juvenile stages of many marine organisms as well as be attractive to adults of larger species, and in many ways are attractants that resemble fish aggregating devices (FAD's). Substantially more than 100 species have been found on, or associated with beach-cast marine debris items. Most of these are hard-shelled or crustose organisms. This community is typically dominated by bryozoans, but also includes barnacles, tube worms, foraminifera, coralline algae, hydroids and bivalve mollusca. However, records based on beach-cast material are biased towards those taxa with resistant hard parts. Studies of freely drifting items in open waters as well as observations made in experiments with moored materials have emphasized the importance of soft fleshy biota including, brown and filamentous algae, hydroids, ascidians, sea anemones and sponges, as well as motile organisms including crabs, amphipods, isopods, errant polychaetes, gastropods, limpets, chitons, echinoids, sea slugs and cucumbers (e.g., Ye and Andrady, 1991; Winston et al., 1996; Stevens et al., in prep). Soft fleshy marine organisms suffer from rapid desiccation and quickly disintegrate once exposed to the atmosphere and harsh beach environments, and are rarely recorded in studies of beach cast marine debris. A latitudinal gradient has been recognized in the extent to which drifting plastics are colonized by epibionts. Surface area coverage, particularly by bryozoans, and also species richness and diversity appears to be greatest in tropical latitudes, decreasing through temperate mid- and least in high polar latitudes (see Gregory, 1990; Winston et al., 1996; Barnes and Sanderson, 2000; Barnes 2002a)

A number of animals and plant epibionts are reported from natural floating substrata such as seeds, logs and lumber, and pumice as well as pelagic sea turtles and sea snakes and may drift thousands of kilometers on these substrates (see Jokiel, 1989). Dispersal of marine organisms through attachment to kelp rafts has also been invoked to explain disjunct species relationships existing between the near-shore and shallow water benthos of the remote and widely separated sub-Antarctic islands that encircle the Southern Ocean (e.g. Knox, 1994; Helmuth, et al., 1994; Smith, 2002; Barnes and Fraser, 2003). It has been suggested that pelagic plastics may similarly act as a passive vector in effecting local, regional and trans-oceanic dispersal of some marine (and possibly terrestrial) taxa (e.g., Gregory, 1978; 1991; 1998; 1999a; Winston et al, 1996; Barnes, 2002a and b). Not only have colonizers managed to survive on their floating plastic island haven, some have reached sexual maturity and reproduced during lengthy voyaging. Examples include several species of bryozoa, crustose algae and possibly gastropods (see, Winston et al., 1996; Barnes and Fraser, 2003). Rafting in this way may have broad and important

biogeographic and environmental implications. It could facilitate introduction of, and subsequent colonization by invasive and aggressive alien taxa that imperil the ecology of receiving habitats – both marine and terrestrial. Examples, which in themselves are yet to be proven endangering, but which illustrate the possibilities include:-

i) first local records in the early 1970's of the bryozoan *Membranipora tuberculata* in northern waters of New Zealand were on plastic substrates. It was inferred there had been eastwards dispersal from Australia across the north Tasman Sea by way of eddies in the East Australian Current (Gregory, 1978; 1990);

ii) numerous specimens of a common tropical water, indo-pacific oyster (*Lopha cristagalli*) attached to a tangled mass of synthetic rope found on a remote beach of Fiordland, southwestern New Zealand (Winston et al., 1996);

iii) West's (1991) report of a plastic toy boat stranding on a small island lying *c.*4 km off-shore near Auckland, New Zealand, which carried a cargo of seeds with eight plant species represented, is instructive. Of these five were native and three exotic; one was of a species not known from the island and three were viable;

iv) a bryozoan resembling *Thalamoporella evelinae*, described from Brazil, arriving on Florida shores through attachment to pelagic plastic artifacts, and where it had not previously been recorded (Winston et al., 1996);

v) a fish crate with prominent Venezuela markings stranding on Bermuda in 1990 with several single attached valves of a mollusc (? *Pinctata sp*) suggests long distance transport from the Caribbean courtesy of the Gulf Stream (unpublished);

vi) discovery in November 2000 of numerous individuals of the invasive intertidal sea anenome (*Diadumene lineata*) on derelict trawl net in the lagoon at Pearl and Hermes Reef, Northwestern Hawaiian Islands. This cosmopolitan taxon is a native of Japan and had not been recorded previously from the Hawaiian Islands. Zabin et al. (in press) suggested the net with its cargo of hitch-hiking *D. lineata* could have arrived from afar - possibly Japan;

vii) the recent report by Barnes and Fraser (2003) of a plastic packaging band washing up on Adelaide Island, Antarctic Peninsula, to which were attached 10 species belonging to 5 phyla (Bryozoa, Porifera, Annelida, Cnidaria and Mollusca). From the size of a bryzoan colony it was estimated that this artifact had been afloat for at least one year.

It has also been suggested that matted rafts of marine debris could provide a substrate platform upon which some small aggressive, and habitat-endangering vertebrates, such as mice, rats and mustelids as well as some larger taxa (e.g. possums in the New Zealand context) could voyage, ark-like, and wreak havoc in island ecosystems once they disembark (Gregory, 1991, 1998).

While large masses of derelict fishing gear settling to the sea floor may have a blanketing effect similar to that of plastic sheeting which is known to induce hypoxia and anoxia in muddy and fine sandy sediments. They could also, if caught up by and entangled with rocky outcrops and reefs attract a varied sessile and motile biota. Ironic as

it may appear at first glance, this may be to the enrichment of local biotic diversity. These both will be short-term phenomena for in the longer term marine debris is doomed for permanent entombment in accumulating sediment.

Discussion

While it is today widely accepted that much marine debris has near-by land-based sources, there is also recognition that derelict and/or discarded fishing gear, as well as domestic wastes relating to the industry, can be conspicuous components of marine debris stranding on shores adjacent to and down-drift from major fishing grounds. The wider distribution of marine debris, including that related to fishery activities, is dependent upon oceanic circulation and weather patterns. These may be subject to both short term seasonal and longer period (*e.g.*,Southern Oscillation) variations. In low to middle tropical and sub-tropical latitudes of the South Pacific Ocean, persistent southeasterly trade winds will tend to drive marine debris westwards onto east-facing shores (see Gregory, 1999a), This contrasts with higher temperate latitudes and into the Southern Ocean with their strong prevailing westerlies (the roaring 40's, furious 50's and screaming 60's) and a strong easterly drift ensures that marine debris is herded on to west- and southwest-facing sandy or pebbly beaches (*e.g.*, Macquarie and Stewart Islands) but where it is quickly battered to pieces against cliffed and hard rocky shores (e.g., Auckland Islands). Marine debris also tends to concentrate (as do some fisheries) along oceanic fronts and convergence zones. Subtle northwards and southwards latitudinal shifts of these may influence apparent seasonal changes in amounts of fisheries related marine debris on some shores (*e.g.*, the subtropical convergence and northern shore of Chatham Island, New Zealand; Gregory, 1999b, Fig. 1).

Marine debris is known to accumulate and concentrate at oceanic fronts (e.g., Gregory and Ryan, 1996) and is conspicuously trapped in regions of gyral circulation (Moore, 2003). While it has been appreciated for some time that fronts were obstructions difficult for marine debris to cross (e.g. Gregory and Ryan, 1996), it is also recognized that these are somewhat "leaky barriers" (see, Barnes and Fraser, 2003). In the Southern Ocean, initiation of the strong, easterly flowing Antarctic Circumpolar Current and Polar Front (Antarctic Convergence) some 30-20 million years ago, has effectively encircled and isolated the Antarctic Continent. Because of this isolation, the biota of shallow marine environments around the continent is highly endemic Knox (1994), and yet to be invaded by exotic taxa (Barnes and Fraser, 2003). Lewis et al. (2003) have demonstrated that there is a potential for alien marine introductions across the Southern Ocean in both northwards and southwards directions. The mechanisms identified included hull-fouling, ballast waters (e.g. Carlton, 1985; Carlton and Gellar, 1993), natural media, including kelp rafts, as well as anthropogenic marine debris. The possibilities of this north-south transfer are probably greatest through disturbances and eddying in the waters of Drake Passage as well as in the gyral circulation patterns that develop off the Weddell and Ross Seas. Barnes and Fraser's (2003) recent report of ten invertebrate species attached to plastic strapping stranded on Adelaide Island (68°S), west off the Antarctic Peninsula, demonstrate that exotic taxa could transfer into and out of the Southern Ocean in this way. Predicted climate changes and warming of surface waters of the Southern Ocean will only enhance the possibilities of this two-way latitudinal traffic.

Derelict fishing gear creates many problems of which hangers-on and hitch-hiking invasive and aggressive aliens is but one. While anecdotal evidence abounds, there is a dearth of quantitative information on amounts, types and locations of fishing gear that are accidentally lost or otherwise discarded in waters of the South Pacific Ocean. Data of this kind are being assembled by the Hobart-based secretariat of CCAMLR (Convention for the Conservation of Antarctic Marine Living Resources). There is need for appropriate authorities across the South Pacific community to adopt a comparable approach.

Conclusions

The environmental threats posed by marine debris, which may include large amounts of derelict fisheries related gear, are frequently viewed at an emotive level. Often this involves cosmetic and aesthetic factors together with emphasis on those arising from entanglement, ingestion and quality of life. Commercial and safety factors are also considered matters of importance. While it may well have less potential for environmental harm than those associated with ballast water discharges Lewis et al. (2003), the possibilities that matted masses of marine debris, harbouring hangers-on and hitch-hiking aliens, may introduce aggressive and invasive species and thus threaten receiving habitats warrants serious consideration and further research (e.g., Gregory, 1991; Winston et al., 1996; Barnes, 2002a and b; 2003). “There are matters here to be addressed by those having stewardship and management responsibilities for sensitive coastal estate – particularly for areas having heritage status, high conservation values or harbouring endangered species, whether marine or terrestrial” (Gregory, 1998, p.7).

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