Estimate of the outflow area of marine debris using disposable lighters as an indicator item on the beach of northern Australia

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Abstract

Disposable lighters were collected from 13 beaches in the Northern Territory and a beach in the Western Australia, Australia in 2011. The lighter has characteristics that a production or consumption area can be distinguished by using punched marks on the tank bottom and by types of tank body. A consumption location can be distinguished by printed characters/letters on the tank surface. There were 565 lighters collected, and the outflow area of 30.6% of total was distinguished. Lighters identified as from Taiwan, Japan and China accounted for 14.7%, 9.4 % and 3.9%, respectively. The outflow locations of 6 lighters were identified as from coastal cities in Indonesia, Vietnam, Taiwan, China and Australia.

Key words: Arafura Sea, Australia, indicator item, lighter, marine litter

Introduction

The tropical Arafura and Timor Seas are partially enclosed by the Indonesian Archipelago and New Guinea to the north and the Australian continent to the south（Fig. 1）. The Northern Territory coastline is approximately 7,200 km in length （Hanly & Couriel 1992）. The recent meta-analysis of Halpern et al.,（2008）further identified these seas as having one of the lowest levels of human impact globally. However, marine debris has been also documented on the northern Australian beaches（Haynes 1997; Whiting 1998）and also around the Indonesia coast （Willoughby 1997）. On Northern Australian beaches, items were made up of plastics, rubber and glass whereas plastic items were easily the most numerous recorded as the most common debris on the beach of islands and cays along the Cape York Peninsula, Queensland（Haynes 1997）and on the beach of Fog Bay, Northern Territory（Whiting 1998）. The entire coastline of the Northern Territory lies within the monsoon tropics, and is subject to strong southeasterly winds during the dry season of May-October. In the wet season, during November-April, prevailing winds are from the northwest（Hanly & Couriel 1992）. Low frequency currents in the Gulf of Carpentaria of the Arafura Sea showed a pronounced seasonal signal in response to the cycle of stratification and wind（Condie 2011）. Therefore, marine debris that flowed out of other regions is gathered in this area, however the outflow region still remains unclear.

We have developed a method to monitor outflow areas, flow and extent of the effect of marine debris using disposable lighters as an indicator item on the coast of the East Asia（Fujieda 2003; Fujieda & Kojima 2006; Fujieda et al. 2006）. This method studies the consumption area （shop address） of lighters from printed information（e.g. shop address, shop name, telephone number）on the tank surface. The lighter is the only flotsam having the information of consumption area. For example, on the coasts of Japan Sea, lighters that flowed out of south areas were found on the north area of this sea, and the reverse was minimal（Fujieda & Kojima 2006; Fujieda et al. 2006）. This flow assents with the Tsushima Warm Current. It was suggested by using this method that it is possible to monitor the outflow area, distribution of influence area and annual change of marine litter from the coast of own and foreign countries. Fujieda et al.（2011）expanded the observation area further to the remote islands of North Pacific and began monitoring marine debris from Japan

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to North Pacific using this method since 2010.

The objective of this study was to clarify the outflow area of marine litter on the coast of northern Australia by using this method and to try to apply it as it has been done in the Northwest Pacific. It must also be noted that the study area of the Timor and Arafura Sea has extensive commercial fishing activities operating in Australian and International waters and as such, maritime traffic with international crews may also be a source of the lighters found in marine litter through accidental loss or waste disposal (Morrison, *pers. comm.* 2012).

Methods

In this method, disposable lighters are used as a indicator item because of following the characteristics. A disposable lighter is a popular item among smokers. It can drift a long time on the sea because of its robust, hollow construction. It can easily be found, picked up and carried because of its bright color and small size. An outflow (production or consumption) area and country can be distinguished by punched marks on the tank bottom and by types of tank body. A consumption region or location can be distinguished by printed characters/letters on the tank surface.

Samples were collected from 13 beaches of the Arnhem Land coast in the Northern Territory and a beach on the Maret Islands in Western Australia (Fig. 1). The collecting period was from May to September in 2011. All washed up lighters regardless of being gas filled, broken, and with or without printed characters/letters were picked up from the beach. Site name, position on the map, date (day/month/year) and estimated beach length was recorded at each site. If there was liquid in the tank, a hole was drilled by a power drill with 2.0 mm bit so as to remove the gas from the lighters before transport to the laboratory.

Fig.1 Locations of lighters collection (●) (total of sites) on the Northern Australia.

The production or consumption area and country that distinguished by a punched mark on the tank bottom, types of tank body and printed character and bar code was classified to Japan, China, Indonesia, Taiwan and other. This is referred to as "outflow area" and shown as a country or area.

The shop address of lighters was researched on the Internet following the shop address, shop name and telephone number printed on the tank surface of lighter. This is referred to as "outflow location" and shown as a city.

Results

A total of 565 lighters were collected from 14 beaches. Out of the total collection, the outflow areas of 173 lighters (30.6%) were distinguished. Of those, lighters were identified as from Taiwan, Japan and China and accounted for 14.7%, 9.4% and 3.9%, respectively. Other countries are Australia, Philippines and Vietnam (0.4%), Korea and Malaysia (0.2%).

Out of 173 lighters, the outflow locations of only 6 lighters were identified (Fig. 2). The outflow locations of 5 lighters that drifted ashore on the coasts of Northern Territory and Western Australia were identified as the coastal cities in Indonesia (Surabaya), Vietnam (SaiGon), Taiwan (Tainan) and China (Weihai, Shanghai). Additionally on Cape Arnhem, a lighter was found from Weipa, north Queensland, on the opposite shore of Gulf of Carpentaria.

Discussion

We could distinguish the outflow area of 30.6% of total lighters collected (n=565). Lighters identified as Taiwan, Japan and China accounted for 14.7%, 9.4% and 3.9%, respectively. However these percentages are extremely lower compared to those from East Asia coasts (Fujieda 2003; Fujieda & Kojima 2006; Fujieda et al. 2006). This is because we would have little

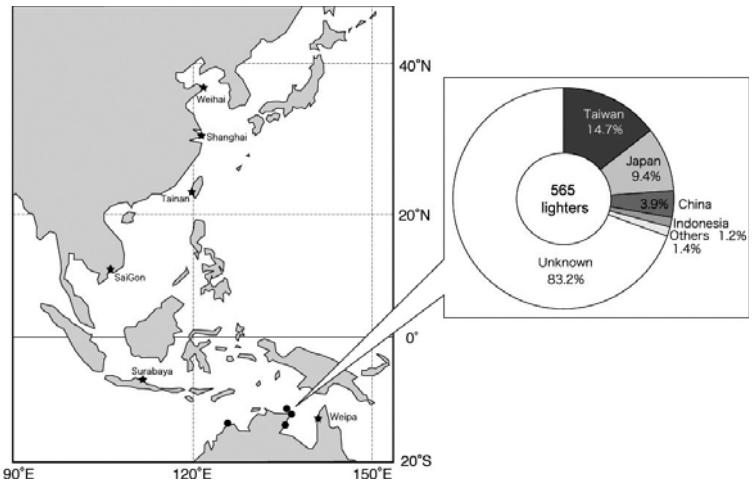

Fig.2 Relation between the outflow locations (★) of lighters and the sampling 14 sites (●) on the Northern Australia and percentage of outflow area for total collected lighters.

information (e.g. types of tank body, punched marks on the bottom) of consumed lighters in South East Asia (Malaysia, Indonesia etc.), hence the outflow area could not be distinguished. Additionally the discriminant percentage (3.5%) of outflow locations was also lower than collected lighters on the East Asia coasts (15.2%) (Fujieda & Kojima 2006). This is expected as the prevalence of printed lighters differs between countries.

This region is identified as having one of the lowest levels of human impact globally (Halpern 2008). However, Haynes (1997) reported that the most common debris observed on near shore of islands and cays along the Cape York Peninsula, between Lockhart River and Cape York, Queensland, Australia were artifacts made from plastics, rubber and glass whereas plastic items were easily the most numerous recorded on the two outer cays. Rubber, plastic and expanded polystyrene artifacts were common on exposed continental island beaches. The majority of plastic items found at all locations consisted of soft-drink bottles and kitchen and laundry detergent containers. Large plastic fishing floats were also common. Whiting (1998) also reported that in total, synthetic products (plastic, rubber, foam) accounted for 45% of total items collected while metal and glass accounted for 35% and 15.6%, respectively on the coast of Fog Bay, Northern Australia. Drink containers comprising metal cans, plastic drink bottles and glass bottles were the most common items found on the beaches. The outflow locations of 6 lighters drifted ashore on the coasts of Northern Territory and Western Australia were identified as from the coastal city in Indonesia, Vietnam, Taiwan, China and Weipa at the opposite shore of Gulf. (Fig. 2). All lighters came from the north area of collecting sites. Whiting (1998) showed that three percent of all items collected were identified as originating from foreign vessels or foreign shores by their label or other identifying marks on the beach of Fog Bay, Northern Australia. The countries are Indonesia, China, West Germany, Philippines, USA and Spain. The origin of the most collected item was Indonesia. In this area, during the summer monsoon, northwesterly winds flow into the northern Gulf of Carpentaria where a basin scale clockwise gyre was centered in the northern half of the Gulf. As the winds switched to southeasterly trades, most of the Arnhem Current continued west along the outer shelf. By April, eastward flow into the Gulf of Carpentaria had almost ceased and significant westward transport through Torres Strait was beginning to influence the circulation in the northeastern part of the Gulf. The pattern of gyres continued to evolve as the trade winds strengthened through July, with inflow through Torres Strait contributing to the development of an anti-clockwise gyre in the northeastern Gulf of Carpentaria (Condie 2011). The results of this and Whiting (1998) agree with the dominant winds and currents in this area. As such, on the coast of Northern Territory and Western Australia it would be

assumed that it was more affected by marine debris that flowed out of South East Asia to the north or foreign vessels rather than marine litter of local origin.

These results indicate the origin of all identified lighters, except one from Weipa, were north of the collecting sites. The result demonstrated that lighters that flow out of East Asia（Taiwan, Japan, China）can not only reach neighboring countries（Fujieda 2003; Fujieda & Kojima 2006; Fujieda et al. 2006）and the coast of North Pacific Islands（Fujieda et al. 2011）but can also be transported as far away as the Southern Hemisphere.

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使い捨てライターを指標とした北部オーストラリア海岸における海洋ごみの流出地の推定

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要　約

2011年，北部オーストラリアのノーザンテリトリー13海岸および西オーストラリア州1海岸，計14海岸において565個の使い捨てライターを採取し，その流出国および流出地を求めた。流出国の判別率は30.6%と東アジアでの調査に比べ低かった。また流出国の割合は，台湾14.7%，日本9.4%，中国3.9%となった。そのうち，流出地（都市）まで判別できたものは6個であり，インドネシア，ベトナム，台湾，中国，オーストラリアの沿岸都市であった。