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Marine debris observed in the North Pacific during Oshoro-maru cruise in 2012

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Abstract

The distribution and abundance of marine debris were investigated by visual survey and a neuston net in the North Pacific and Bering Sea during the T/S *Oshoro Maru* cruise from June to August 2012. The observed debris included pieces of plastic, plastic and glass bottles, metallic objects, glass, and fishing gear. The concentrations of plastic sampled by a neuston net were higher in the Transition Zone than those in the Subarctic North Pacific and Bering Sea. The abundance and weight of these small plastic pieces collected by a neuston net did not significantly increase from 1980s. Long-term monitoring and information sharing are important in concert with related countries and organizations.

Key words : Marine debris, North Pacific, Visual survey, Neuston net

Introduction

Marine debris poses problems for marine animals. In the North Pacific, most of the observed objects are plastic debris (Dahlberg and Day, 1985). Packaging bands and fishing gear affect marine animals through entanglement (Shomura and Yoshida, 1985). Subsequently, this floating plastic debris breaks into small fragments from prolonged exposure to ultraviolet rays and seawater (Moore, 2008). These small pieces of plastic are ingested by various marine organisms, and their biological effects are of great concern (Derraik, 2002). Day et al. (1987) and Day et al. (1990) used a neuston net to determine the distribution and abundance of small plastic debris and reported that floating plastic was high in abundance the subtropical and transitional waters of the North Pacific Ocean (35-42°N). After the study by Day et al. (1990), no study has been conducted in the central North Pacific Transition Zone, despite its importance to a large number of migratory marine animals, such as loggerhead turtles and northern elephant seals (Polovina et al., 2006 ; Simmons et al., 2010).

This marine debris can threaten marine life ; therefore, it is important to track the debris field. Satellite imaging, covering a wide range of the ocean, is a useful method for tracking the debris field ; however, dispersed debris could not be tracked by satellite images. Visual surveys have also provided marine debris information, although it cannot cover a wide range of pelagic area like a satellite image. The visual survey can be easily conducted from a ship, and provide a useful and cost-effective way to monitor marine debris accumulation and distribution in sea (Titmus and Hyrenbach, 2011).

In the summer of 2012, we had the opportunity to survey a wide range of the North Pacific Ocean including the Transition Zone and Bering Sea in the T/S Oshoro-maru. During this cruise, large marine debris was observed during routine visual surveys for marine mammals and birds, and small marine debris was caught with a neuston net. This study provides information about the distribution of marine debris in the North Pacific Ocean and Bering Sea.

Methods

Observations were made from either the bridge or the

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upper bridge while the T/S Oshoro-maru (72.8 m length and 1,792 gross tonnage) was traveling between oceanographic sampling stations in the northern North Pacific and Bering Sea from June 8 to August 6, 2012. The length of the research cruise was 53 days.

Debris items were usually sighted while scanning abeam and ahead of the vessel. Either 7 × 50 binoculars (Fujinon) were used or photographs were captured with a digital single-lens reflex camera (Nikon D300 with 70-300 mm lens, Nikon D300S with 80-400 mm lens, Canon EOS 50D with 100-400 mm lens, Canon EOS 7D with 400 mm lens, Canon EOS Kiss X3 with 70-300 mm lens, and Olympus E-520 with 70-300 mm lens). Time and location [using a Geographic Positioning System (GPS)] were recorded, and the items were described for each encounter.

Small plastic samples were collected with a neuston net

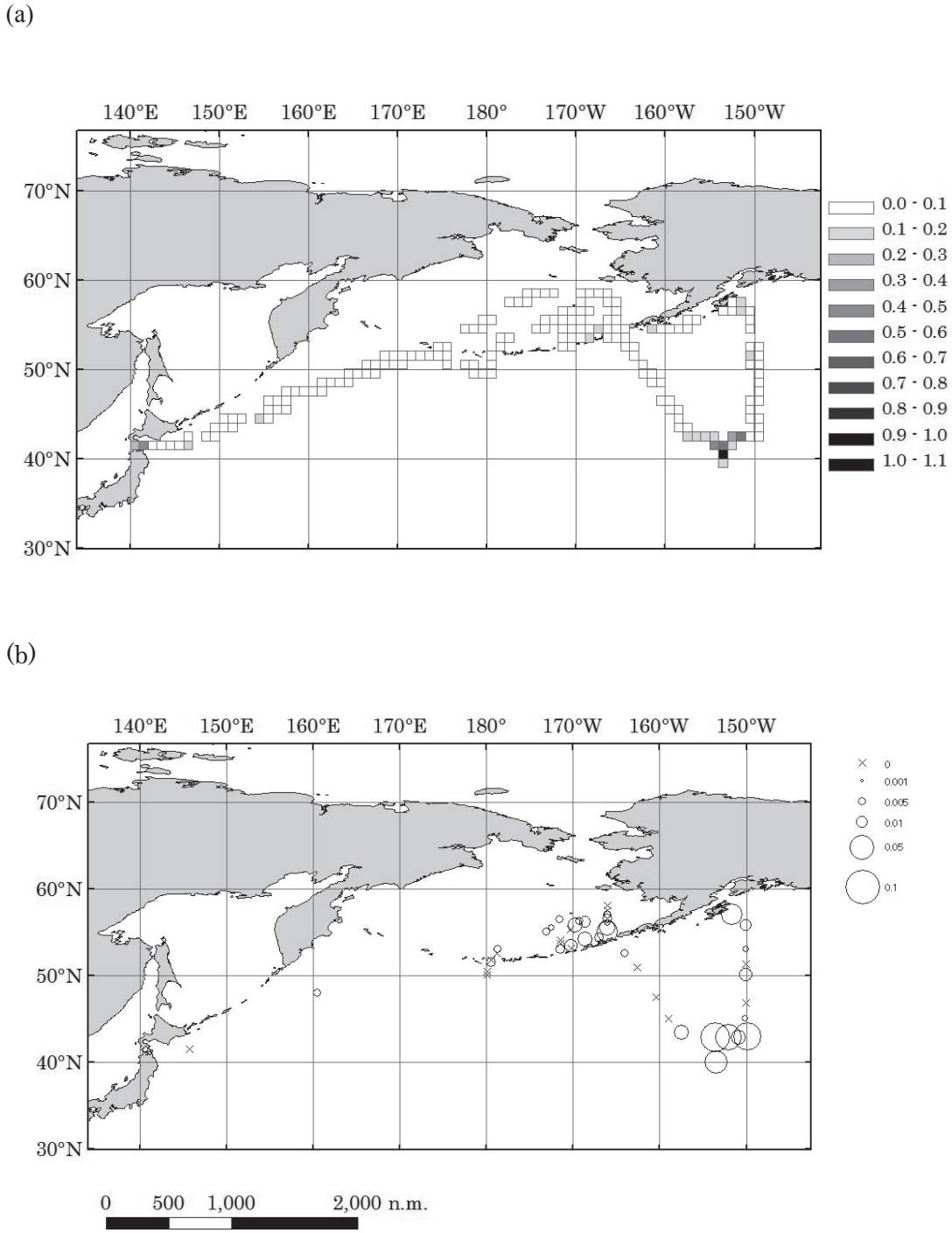

Fig. 1. Encounter rates for floating debris per 1 nautical mile within 1 degree grid during visual survey from the T/S Oshoro-maru (a) and densities of plastics collected by a neuston net (b). The size of circle indicates the number of plastics (piece/km^2). × denotes that no plastics were collected.

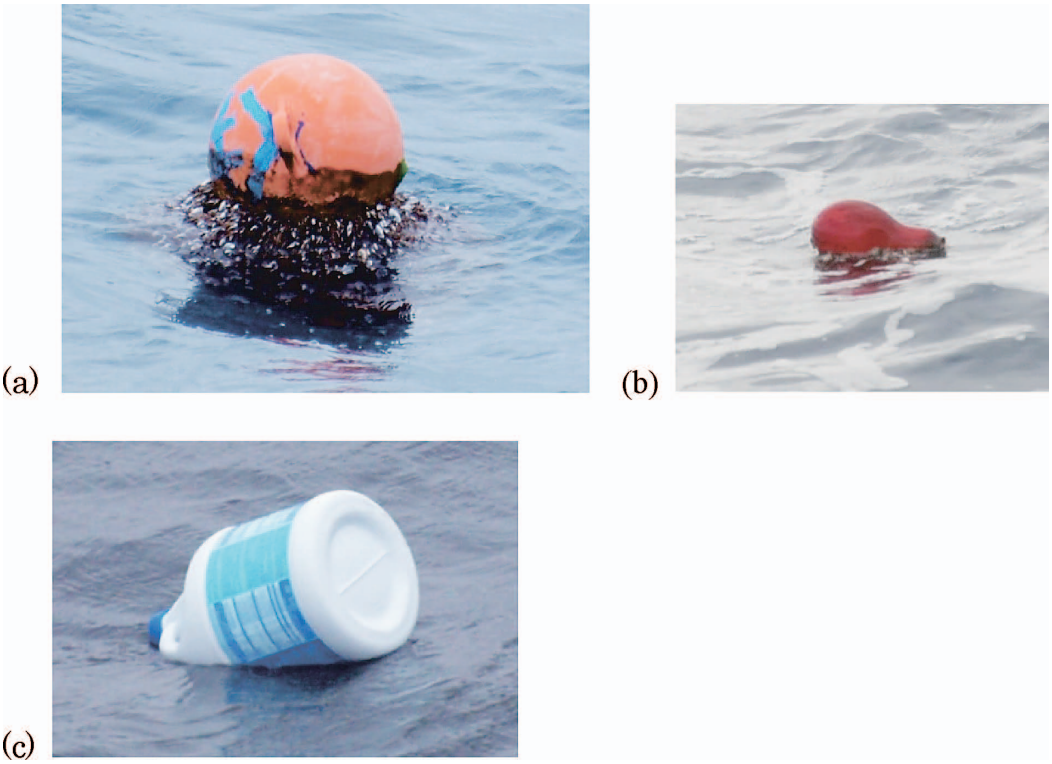

Fig. 2. Pictures of various floating debris. (a) A fishing float painted with a Japanese shop's name, (b) a red electric bulb, which is used for Pacific saury *Cololabis saira* fishing in Asian waters, and (c) plastic bottle with label in English. Goose barnacles were attached to many of the marine debris.

(mouth opening : 0.5 m × 0.5 m ; mesh sizes 330 µm) towed horizontally. Sampling was conducted for 10 min at a ship speed of 2 knots. We collected 46 neuston samples in the southeastern Bering Sea, Gulf of Alaska, and North Pacific. The samples were washed from the net, fixed in 5% formalin, and sorted later in the laboratory. The number of individual pieces of plastics was counted during sorting. Data were compiled as total density (number per square kilometer) and total concentration (mass per square kilometer) of neuston plastic at each station.

Results

During the T/S Oshoro-maru survey, 4,947 nautical miles and 469.6 h of survey effort were completed. We sighted 348 floating objects, and 227 of them were photographed. Encounter rates for floating debris per 1 nautical mile within 1 degree grid were high around 40°N in the eastern central North Pacific (Fig. 1a), where small plastic pieces were also at higher concentrations (Fig. 1b). Additionally, quite a lot of plastics were sighted and collected near the Aleutian Islands coast. Although neuston sampling was not conducted in the Tsugaru Strait, many large floating objects were observed in that area (Fig. 1a).

Most of the large floating objects were either foam or structural plastics (n = 235, 67.5%) in the form of fishing floats, Styrofoam, plastic bags, sheets, bottles, PP bands, helmets, and fragments. Wooden materials (logs, lumber, and duckboards) were the second most frequent debris (n = 78, 22.4%), followed by paper (n = 7, 2.0%), metal (n = 4, 1.1%), rubber (n = 4, 1.1%), and glass (n = 2, 0.6%), except for unidentified objects (n = 18, 5.2%). Barnacles were attached to many of the marine debris (Fig. 2a, b). One fishing float had paint symbolizing the store name, "Yagou," which is used in Japan (Fig. 2a). In addition, glass floats observed at the Transition Zone of the North Pacific (40–41°N, 153°W) were red electric bulbs, which are used for Pacific saury *Cololabis saira* fishing in Asian waters (Fig. 2b). One of the plastic bottles observed near a coastal area on the Aleutian Islands had a label in English (Fig. 2c).

The abundance of small plastic debris collected by neuston net was significantly higher in the Transition Zone than that in the Subarctic North Pacificand the Bering Sea in this study (Table 1 ; Scheffe's test : abundance $p<0.01$, mass $p<0.01$).

Discussion

During our cruise in June–August 2012, the abundance of floating plastic was high in the Transition Zone, both by visual survey and a neuston net. Previous reports (Dahlberg and Day, 1985 ; Day and Shaw, 1987 ; Day et al., 1990) indicated that floating plastic was in high abundance in the North

Table 1. Densities and concentrations of neuston plastics.

Location	Year	Mean density (piece km^{-2})	Mean concentration (g km^{-2})	Reference
Transition zone				
	1985-1990	57,900	291.6	Day et al., 1990
	2012	45,608	154.0	This study
Subarctic North Pacific				
	1985	3,370	45.8	Day & Shaw, 1987
	1985-1989	12,800	61.4	Day et al., 1990
	2012	5,346	7.4	This study
Bering Sea				
	1974-1975	68		Shaw, 1977
	1985	80	3	Day & Shaw, 1987
	1985-1988	100	1	Day et al., 1990
Basin	2012	5,874	4.2	This study
Shelf	2012	9,316	4.5	This study

Pacific subtropical and transitional waters (35-42°N). Our results agreed with their results.

It is rather difficult to identify the origin of marine debris in the ocean because it may originate from Japan, Asia, North America, and from ships traveling through these areas (Kubota, 1994 ; Ebbesmeyer et al., 2012 ; van Sebille et al., 2012). Marine debris from the State of Oregon, USA, takes approximately 4 years to reach the northwestern Hawaiian Islands (Ebbesmeyer et al., 2012), whereas tsunami debris from Japan landed on the west coast of North America approximately a year later (NOAA, 2012). By photo, this survey confirms that some items were from Japan or not based on the type, markings, and the labels on them. If it is possible to photograph these objects and share the information in the nations concerned, it will give better chances to reveal the origins of the marine debris.

The abundance and weight of small plastic pieces in this study did not different with 1980s. Plastic is alien to the marine environment, and highly resistant to aging and degradation. The Japanese government estimates that 1.5 of 5 million tons of debris has washed into the Pacific Ocean from Japan by the tsunami in 2011 and predicted that this debris heading eastward would pass north of Hawaii and reach the west coast of North America in October 2012 (Ministry of the Environment, Government of Japan, 2012). It may take longer period for tsunami debris to be broken into small pieces. Therefore, long-term monitoring will be important.

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