2014　Research project undertaken by Ministry of the Environment, Japan

2014　Research report on marine debris floating on the ocean surface and settled on the sea bed in offshore areas around Japan

[Summary]

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I. Objective and research outline

Measures to control coastal debris have been promoted on the basis of "the Act on Promotion of Disposal of Articles Washed Ashore for Conservation of Good Coastal Views and Environment for Conserving Beautiful Rich Nature (Act No. 82 of 2009; Washed-Ashore Articles Disposal Promotion Act)" enacted in July 2009, and surveys of marine debris accumulated in coastal areas have been conducted for the purpose of designing effective measures to control this debris. To determine the occurrence, sources, and processes of washed-ashore marine debris, actual data on marine debris floating on the ocean surface and accumulated on the sea bed should be obtained in offshore areas around Japan as well as data on marine debris that has accumulated in coastal areas. As micro-plastics, which are produced by physical and chemical factors, are also of concern from the viewpoint of having adverse effects on marine eco-systems. Surveys are required to determine the distribution of micro-plastics floating at the sea surface in offshore seas as well as in the coastal seas around Japan.

This research survey was undertaken by the Japanese Ministry of the Environment. Two research and training (R/T) vessels, UMITAKA maru and SHINYO maru, which belong to the Tokyo University of Marine Science and Technology, were used to perform visual observations of marine debris floating on the ocean surface and settled on the sea bed and neuston net sampling to target micro- (and meso-) plastics floating on the ocean surface in offshore areas around Japan. In the four cruises of the two R/T vessels (Table 1), observations and samples were obtained at sites around Japan (Fig. 1).

Table 1 Overview of No. 42 and 43 cruises of R/T vessel UMITAKA maru and No. 93 and 94 cruises of R/T SHINYO maru

	UMITAKA maru		SHINYO maru	
Length overall	93 m		53 m	
Observer's eye height	14 m		7 m	
Gross tonnage	1886 t		649 t	
Cruise no.	42nd	43rd	93rd	94th
Departure date	Jyly 12 2014	Oct. 2 2014	July 11 2014	Aug. 16 2014
Return date	Aug. 10 2014	Oct. 16 2014	Aug. 8 2014	Sep. 12 2014
Arrival ports	Tateyama Kochi Hakata Kanazawa Hakodate	Kagoshima Shimizu	Osaka Hakata Wajima Hakodate Kesennuma Oarai	Miyazaki Nagasaki Shimoseki Nagoya
Cruise distance	2778.8 miles	2158.7 miles	2379.0 miles	2205.6 miles
Observation distance	849.7 miles	247.5 miles	846.3 miles	388.3 miles
Number of visual observations	81	21	78	39
Number of neuston net samplings.	27	2	25	11

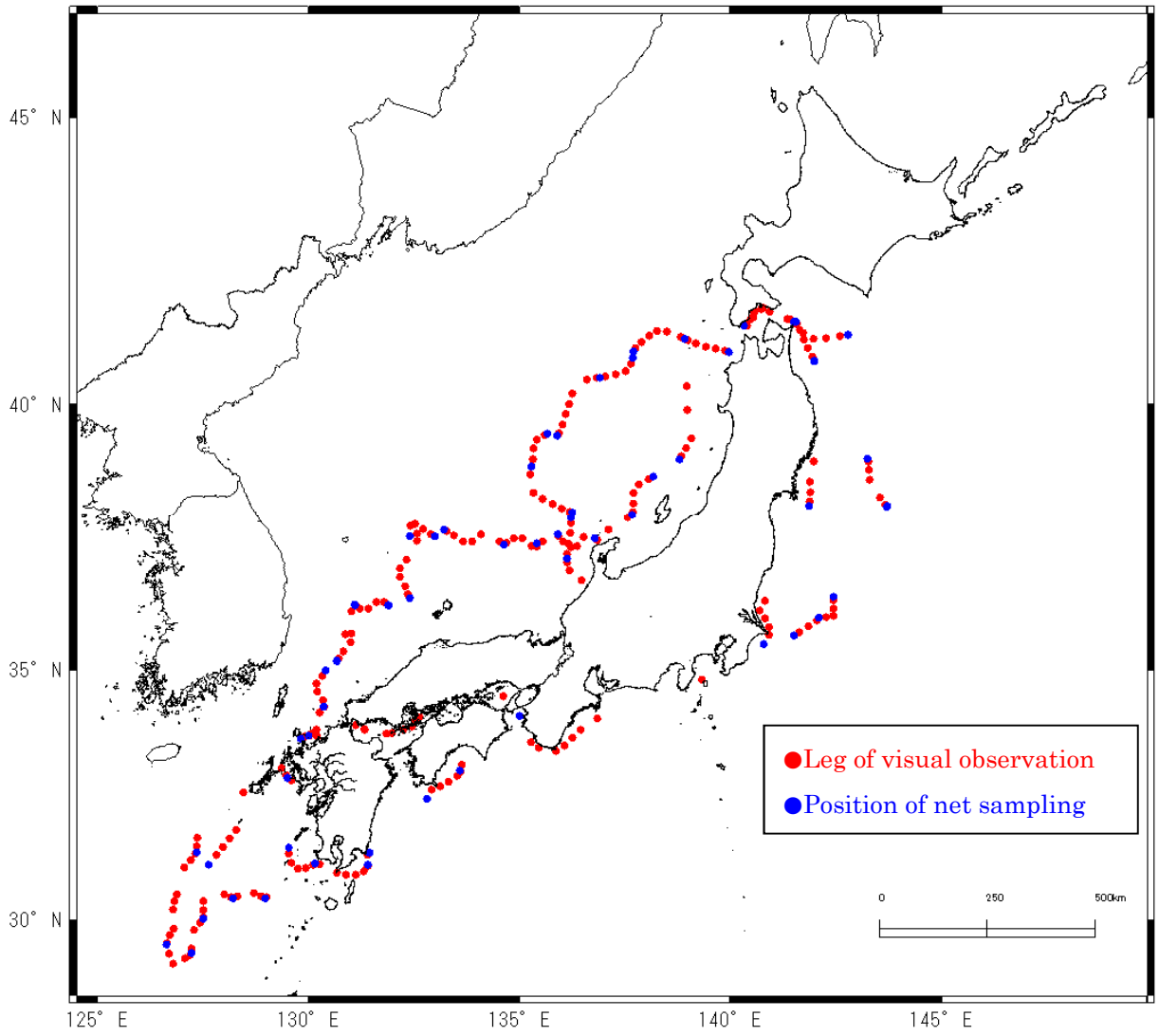


Fig. 1. Sites of visual observations of floating marine debris and locations of neuston net sampling for micro- (and meso-) plastics floating on the ocean surface in offshore areas around Japan.

II Visual observation of floating marine debris in offshore areas

1. Methods

Using the data obtained by visual observation of floating marine debris (FMD) from the research vessels, this report attempts to determine the overall amounts of FMD in offshore waters around Japan. In this study, a line-transect method that has usually been utilized for stock assessment of cetaceans was applied to obtain better estimations of the density and abundance of FMD on the sea surface.

In the onboard visual observation, the items, sizes, and colors of detected objects were recorded, and the perpendicular distance (PD, distance from the transect line to the detected object) was estimated. A detection function that expresses the probability of detecting an object at the PD was estimated from the data, and the effective search half-width (ESHW) derived from the detection function was utilized to determine the survey area. The parameters of the detection function that express perpendicular distance distributions were estimated using the maximum likelihood method. In this research, a half-normal function was applied to express PD distributions, which has the advantage of allowing easy calculation of the ESHW.

2. Results

2.1. Item composition of FMD and detectability-dependence of item characteristics

The ratio of the number of artificial objects to the number of natural objects was 2. The majority of artificial objects were plastics such as expanded polystyrene, plastic sheets (including plastic bags), and polyethylene terephthalate (PET) bottles. Fishing gear floats and abandoned nets that were also made of plastic were often counted. The other artificial objects were glass products (mostly glass bottles that had contained liquor), metal products (mostly beverage and paint cans), and lumber and timber.

From the results of the ESHW estimation using the visual data obtained in the SHINYO maru survey, the ESHWs of fishing gear float, expanded polystyrene, and PET bottles were over 50 m larger than those of plastic bags and seaweed (Table 2). This result suggests that fishing gear floats, expanded polystyrene, and PET bottles were easily detectable even at a little distance from the transect line. A possible explanation is that most of these items were floating above the sea surface and were thus easily detected (Fig. 2). In contrast, items sinking beneath the sea surface were difficult for the observer to detect from the deck of the vessel owing to the reflection of the sea surface.

In a further analysis, the density in a one-hour track line was calculated using the estimated value of ESHW for each item.

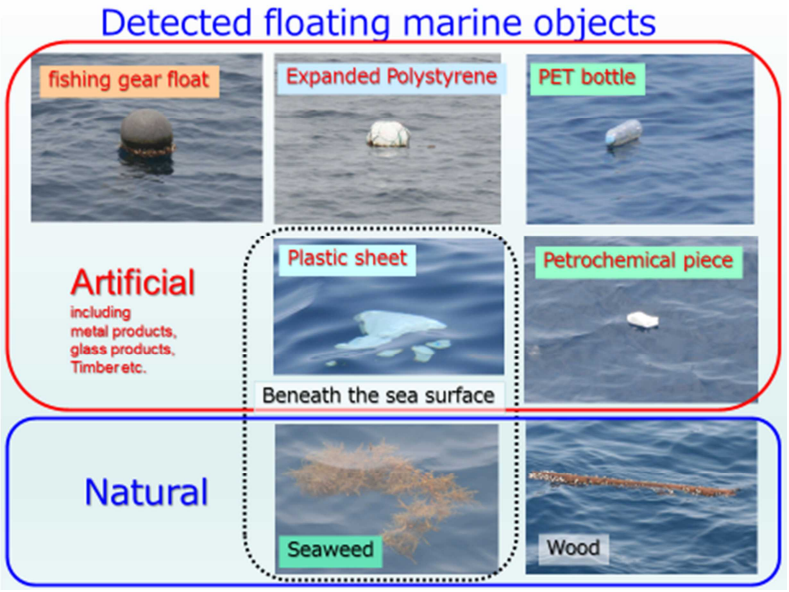


Fig. 2. Photographs of floating marine debris.

Table 2 Effective Search Half-width (ESHW) of each item in the visual survey from the SHINYO maru

Items of floating marine object	ESHW (m)
Fishing Gear (Net)	36.8
Fishing Gear (Float)	247.8
Fishing Gear (Other)	53.5
Expanded polystyrene	93.8
Plastic sheet (bags)	37.6
Plastic (PET) bottle	52.0
Petrochemical pieces	24.0
Glass goods	21.5
Metal products	24.0
Wood (natural)	33.4
Artificial products	72.2
Seaweed	17.9
Lumber & timber	36.0

2.2. Spatial distribution of density for each item type

Sites with a high density of expanded polystyrene occurred in the waters northeast of the Tsushima Strait, and the highest value of the density was 68 individuals per sq km (Fig. 3). A certain amount of floating expanded polystyrene was also observed in the East China Sea; therefore, it is possible that these pieces of expanded polystyrene were aggregated and then detected in the Tsushima Strait. Fish farming is very popular in the northern coastal area of Kyushu and in the southern coastal area of Korea, and this industry uses expanded polystyrene as floats for net cages. Another possibility is that the expanded polystyrene was abandoned and floated from fish farming in the northern coastal area of Kyushu and in the southern coastal area of Korea. However, a few pieces of expanded polystyrene were found in the middle part of the Japan Sea, probably because they were blown north by the south wind in the summer season, and partly because they were so finely comminuted as to be undetectable by visual observation.

Similar to expanded polystyrene, a large number of PET bottles were detected in the Japanese exclusive economic zone (EEZ) of the East China Sea and in the northeast waters of the Tsushima Strait (Fig. 4). The highest density was 16 individuals per sq km at a site in the East China Sea. It was observed that many fishing boats conduct fishing in these waters; the PET bottles might have been discarded from these boats. Plastic sheets/bags were observed relatively more frequently off Fukuoka Port (138 individuals per sq km) and the northern site north of the Noto Peninsula (77 individuals per sq km) in Fig. 5, and may have floated into the sea from the urban area. A large number of petrochemical pieces were counted in the East China Sea (84 individuals per sq km) and at sites north-west of the Noto Peninsula (50 individuals per sq km) in Fig. 6.

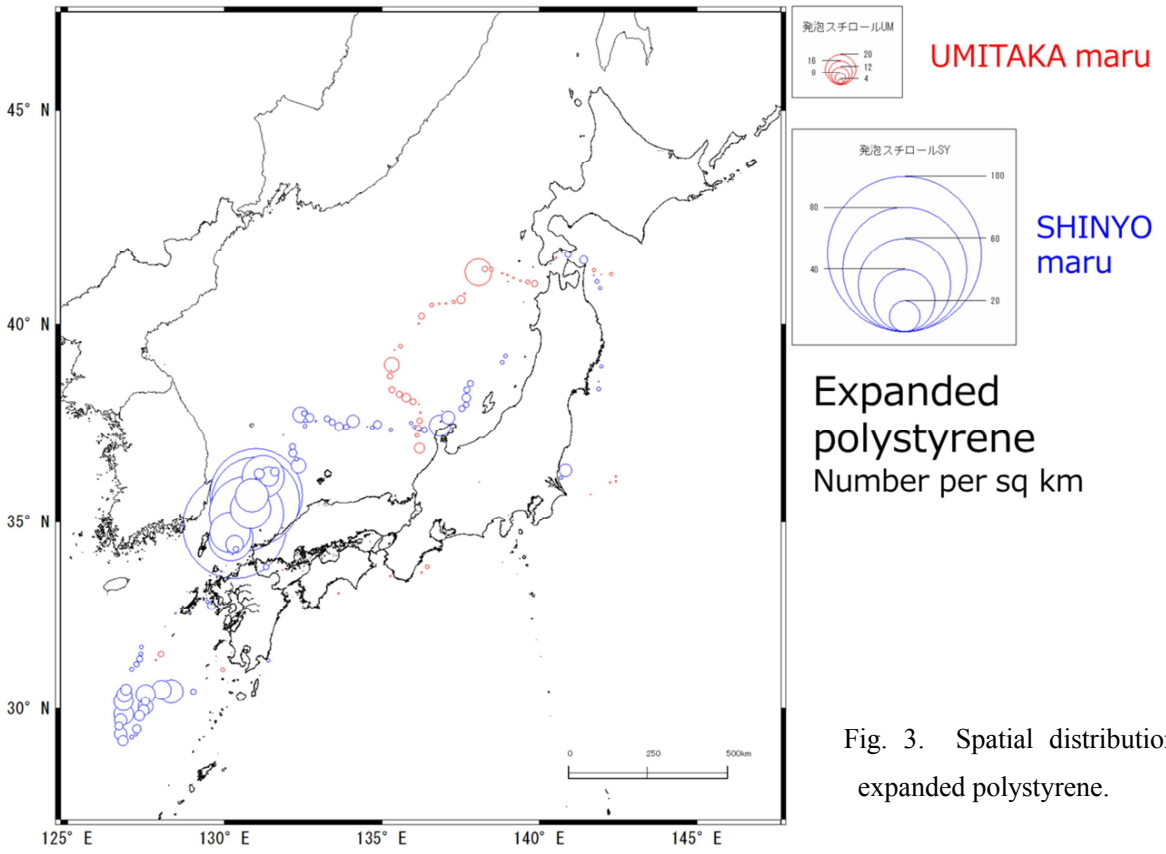


Fig. 3. Spatial distribution of expanded polystyrene.

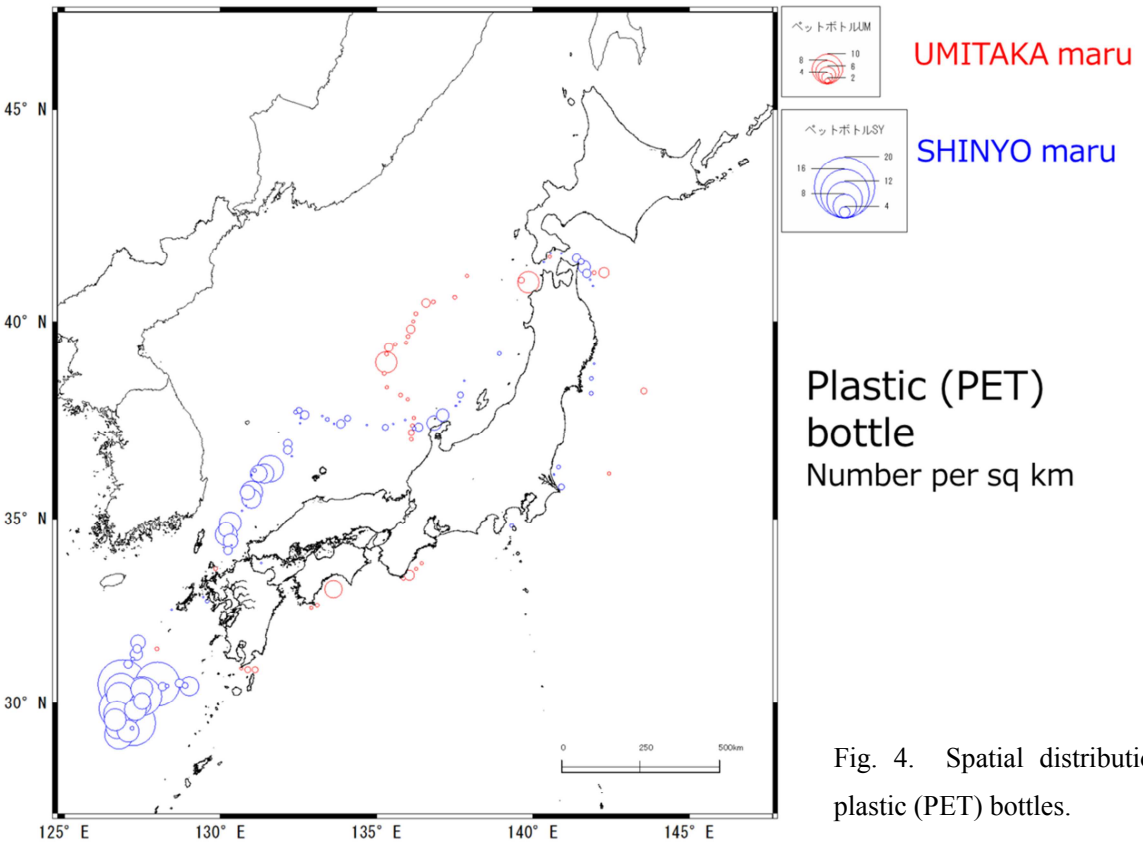


Fig. 4. Spatial distribution of plastic (PET) bottles.

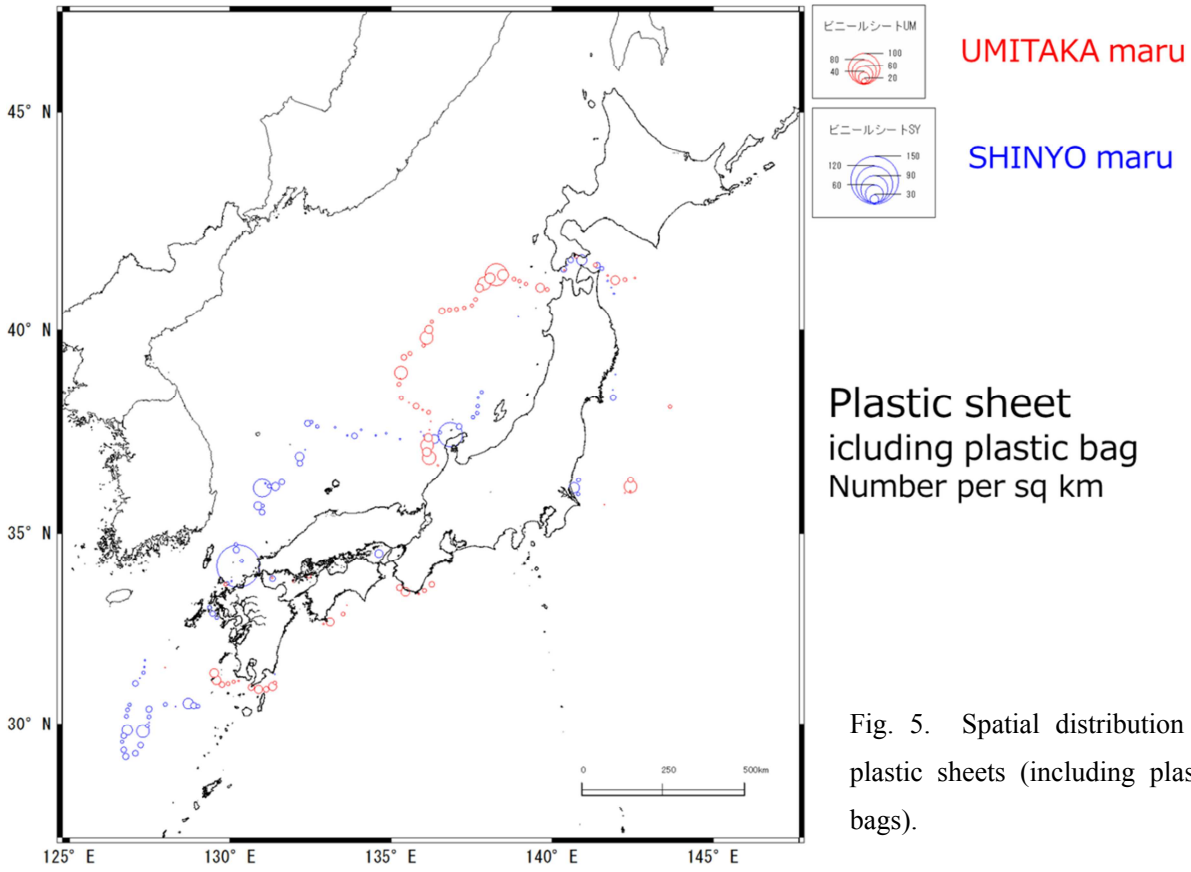


Fig. 5. Spatial distribution of plastic sheets (including plastic bags).

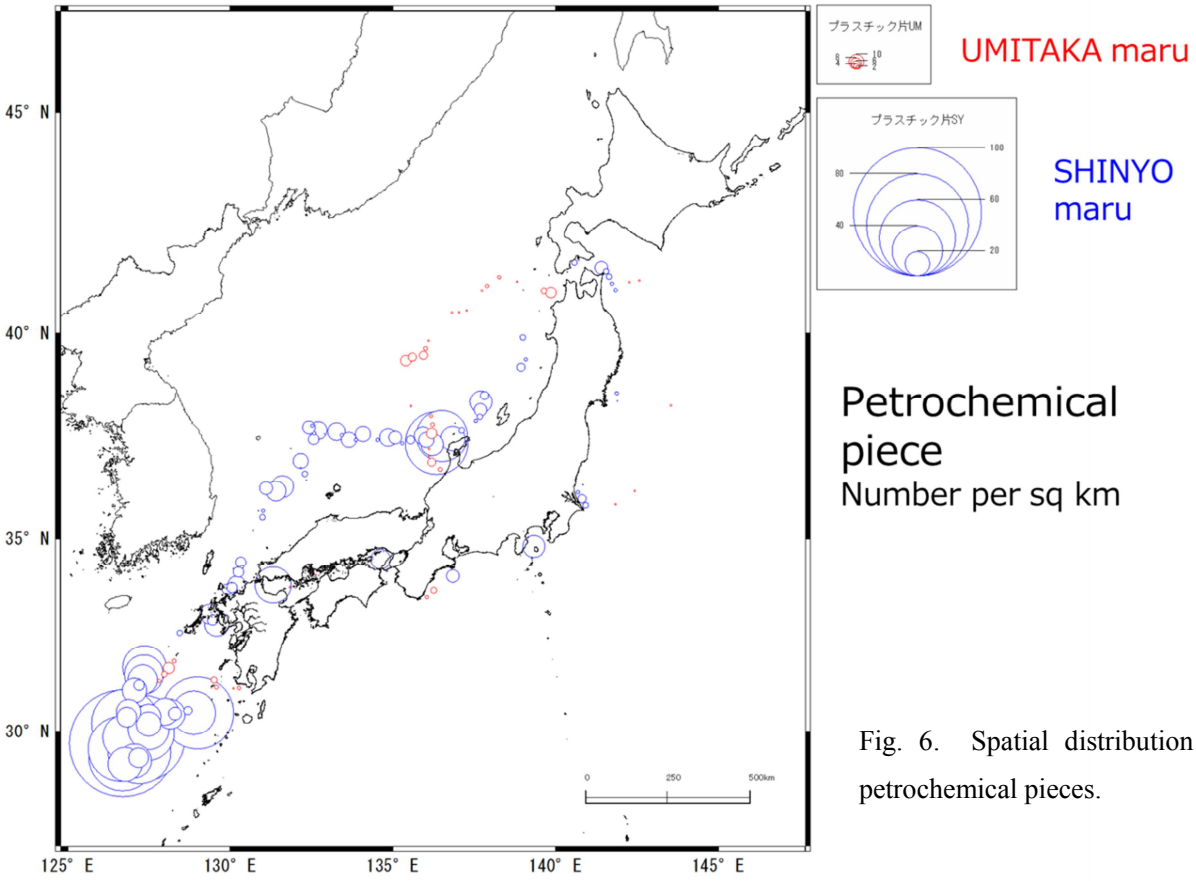


Fig. 6. Spatial distribution of petrochemical pieces.

III. Survey of micro-plastics floating on the ocean surface

1. Methods

Micro-plastics (pieces smaller than 5 mm) and meso-plastics (pieces larger than 5 mm) were sampled using a neuston net in the four cruises. The results were used to elucidate the effect of micro- and meso-plastics on the marine environment around Japan. In this survey, a neuston net (JMA No. 5552) with a net mouth 75 cm on each side (0.56 m^2), a net length of 300 cm, and a 350 μm mesh size was employed with a flow meter. The towing speed was 2–3 knots and the towing duration was 20 min.

2. Results

Micro-plastics (Fig. 7) had a slightly higher density than meso-plastics (Fig. 8). Their spatial distributions appeared to be non-uniform and large differences in density were observed between areas. The density values in the Pacific around Shikoku and Kyusyu and off the Noto Peninsula were more than 2 piece/m^3, higher than the values in other areas, while the density was low in the waters off San-in with less current rip surveyed by the SHINYO maru. Only three sites with a high density of meso-plastics were detected, and in general the density of meso-plastics was lower than that of micro-plastics.

Similarly, micro-sized pieces of expanded polystyrene were abundant (Fig. 9), compared with meso-sized pieces (Fig. 10). However, no relationship of micro-plastics with either micro- or meso-sized pieces of expanded polystyrene was detected. This finding indicates large difference in the sources and transport processes of micro-plastics and pieces of expanded polystyrene. As mentioned above, the majority of large-sized expanded polystyrene was detected in the Tsushima Strait. In contrast, micro-pieces of expanded polystyrene were detected in the downstream areas of the offshore branch of the Tsushima current, rather than in the Tsushima Strait. A possible reason for this is that the pieces were generated around the Tsushima strait and were subsequently moved by the Tsushima warm current.

One particular site south of Kyusyu contained a high density of both plastics and expanded polystyrene. At this site, a large amount of floating marine debris entered the neuston net, and subsequently many fine pieces attached to debris were detected. There was strong doubt as to whether these pieces that were not floating but instead were attached to other debris should be counted or not. The conclusion was that the pieces were present on the ocean surface, and therefore were counted in this study.

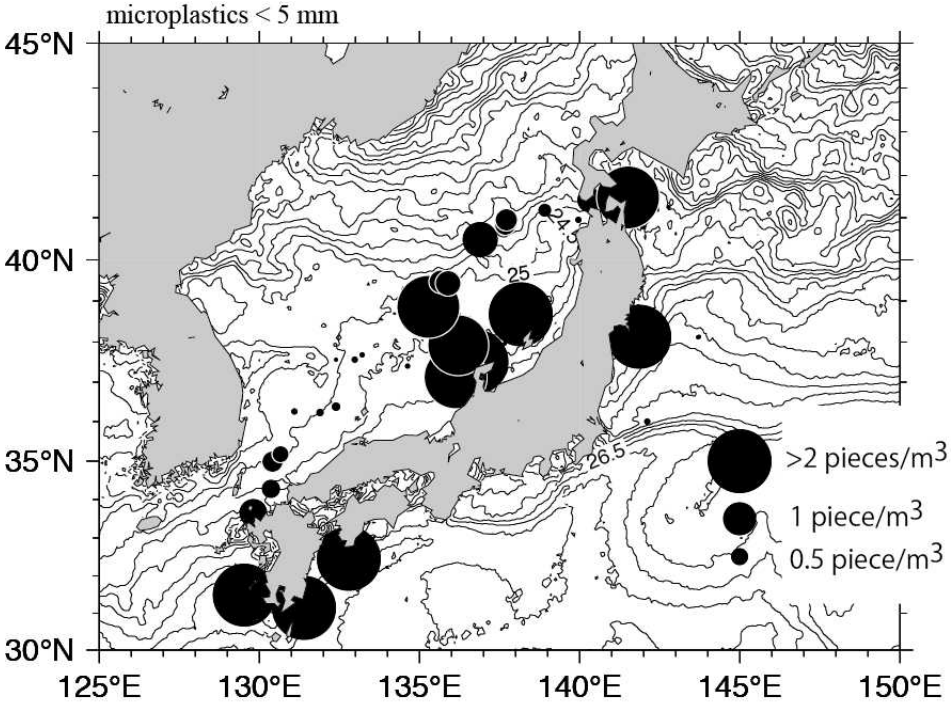


Fig. 7. Spatial distribution of floating micro-plastics around Japan.

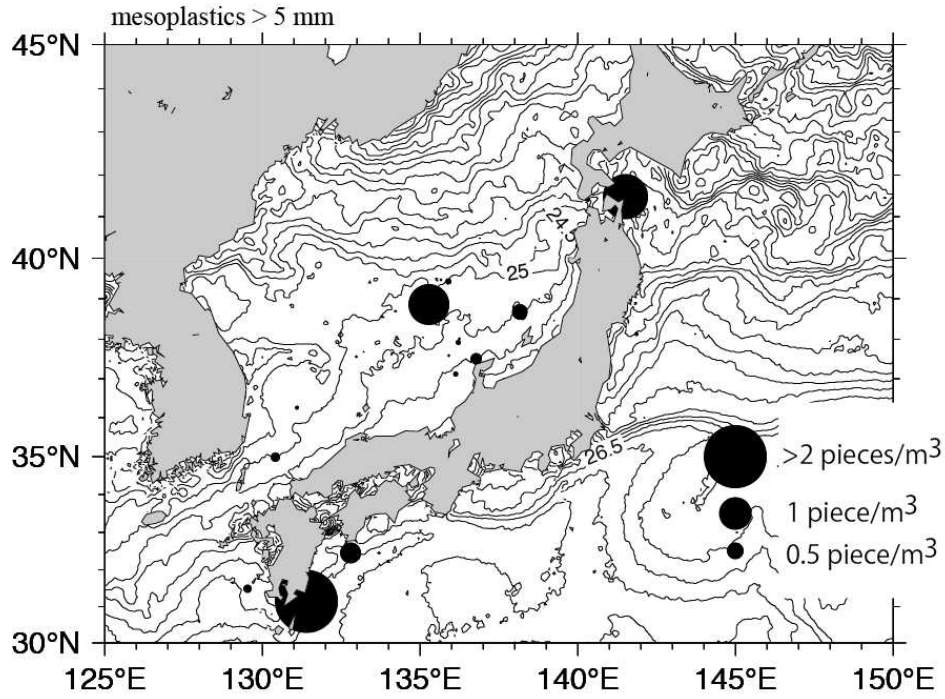


Fig. 8. Spatial distribution of floating meso-plastics around Japan.

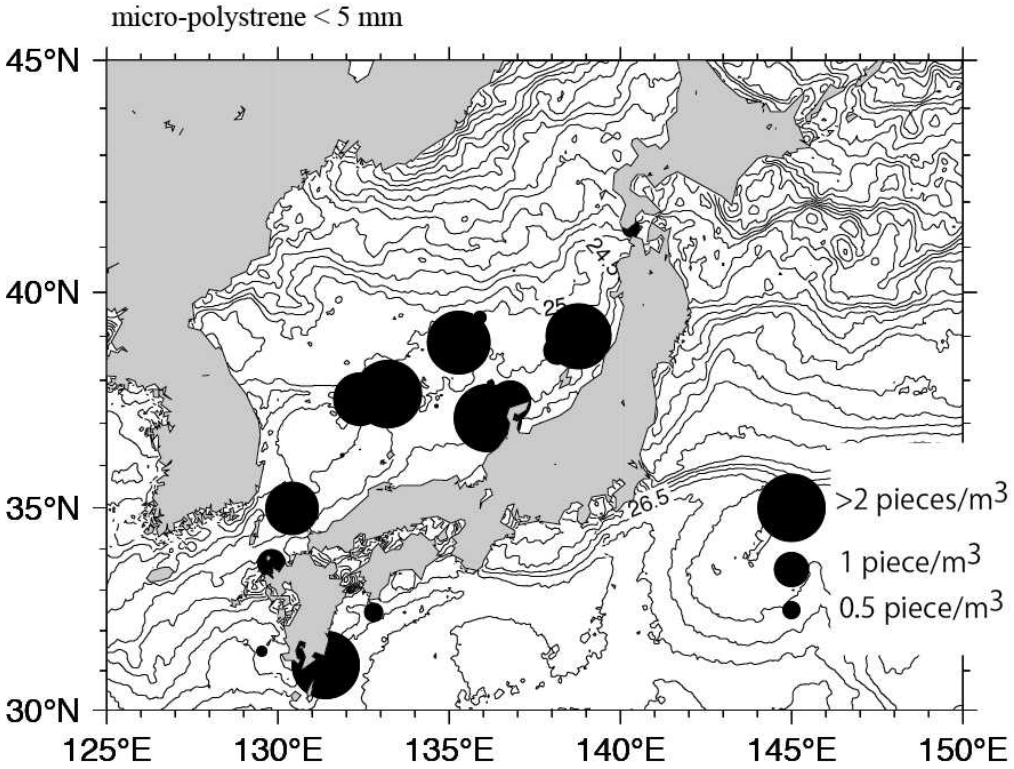


Fig. 9. Spatial distribution of micro-sized floating expanded polystyrene around Japan.

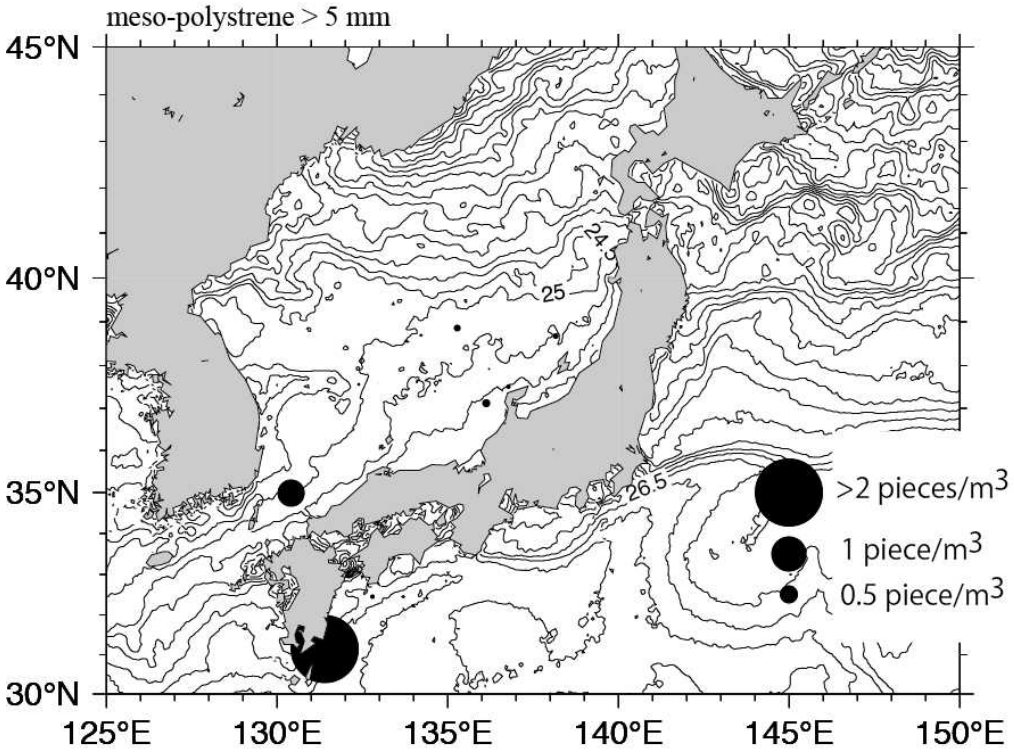


Fig. 10. Spatial distribution of meso-sized floating expanded polystyrene around Japan.

IV. Survey of marine debris on the seabed of offshore waters

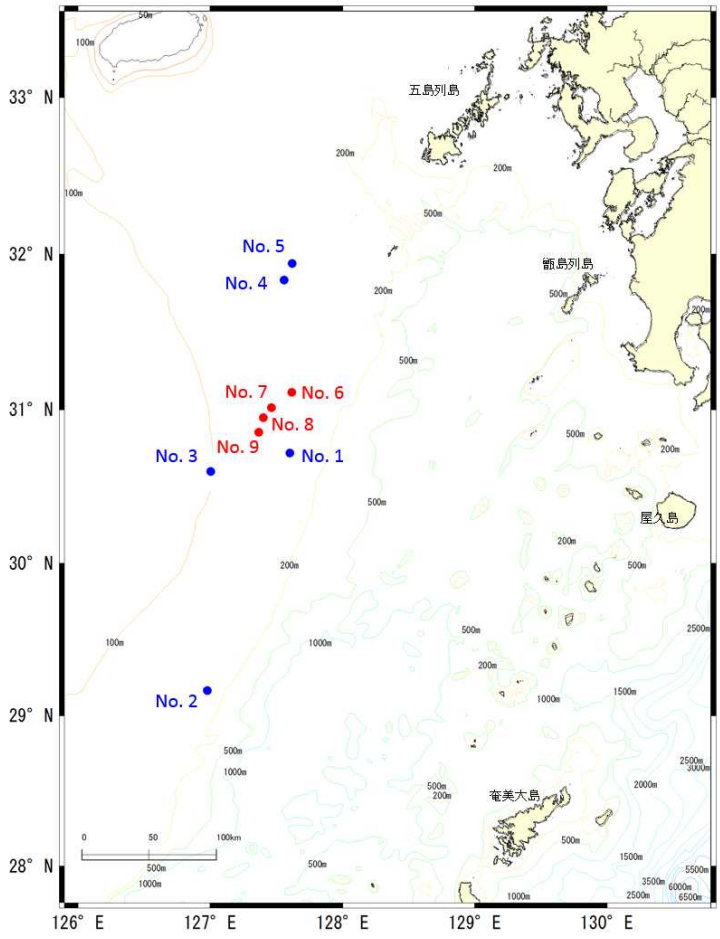


Fig. 11. Sites of trawl sampling for marine debris on the sea bed.

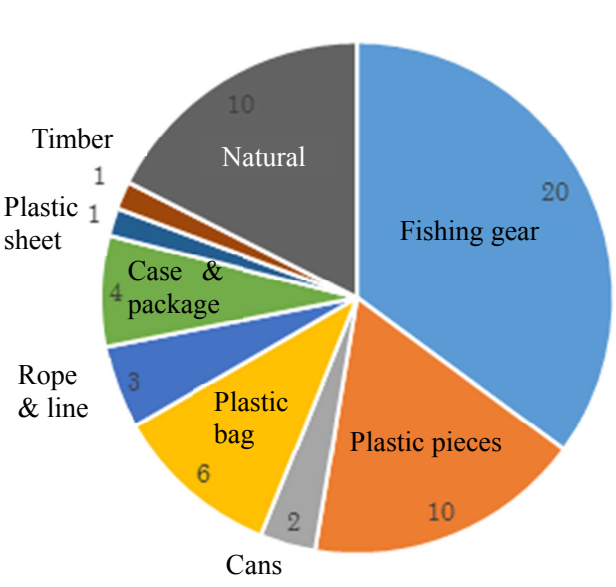


Fig. 12. Item composition of marine debris (total number 60).

1. Methods

Sampling of marine debris on the sea bed was conducted using an otter trawl. The trawl net was towed on the continental shelf of the East China Sea five times from August 16 to September 12 in the No. 94 cruise of the SHINYO maru and four times from October 2 to October 16 in the No. 43 cruise of the UMITAKA maru (Fig. 11). The depths of the sites varied from 100 to 151 m. The total towing distance was 21.5 nautical miles (32.82 km).

Marine debris sampled from the trawl catch was classified, and the item names and dimensions (length and weight) were recorded with pictures. The towing area of one trawl net towing was estimated as the towing distance times the width of the net mouth approximated from the net plan. The density of marine debris was calculated as the number of pieces of debris divided by the towing area.

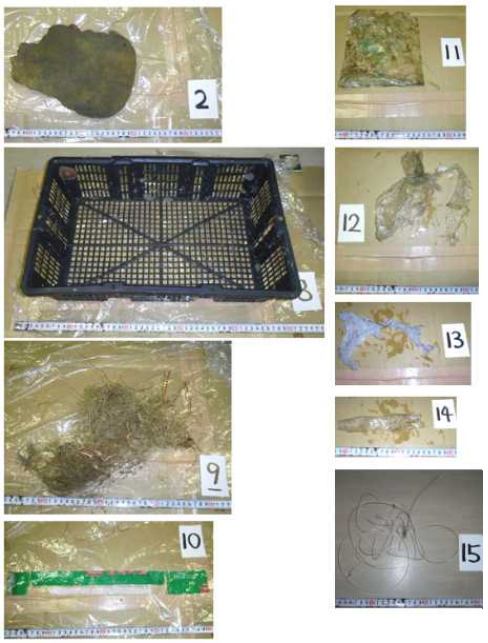


Fig. 13. Examples of artificial goods in marine debris caught during haul No. 2.

2. Results

2.1 Item composition of marine debris sampled by trawl net

The marine debris from the sea bed obtained by trawl towing consisted of 60 items with a total weight of 25.65 kg, of which artificial products were 50 items and 12.25 kg in weight and natural products were 10 items and 13.40 kg in weight.

The average density was estimated to be 31.39 kg/km^2, of which artificial goods comprised 14.99 kg/km^2 and natural materials comprised 16.40 kg/km^2. However, the number of items which were artificial goods was larger than the number of natural materials because the natural goods tended to be heavy, e.g., driftwood. Fishing gear and plastic pieces accounted for 50% of the total debris (Figs. 12, 13). Cans were known to have been produced in China because of the Chinese characters on the surface (Fig. 14).

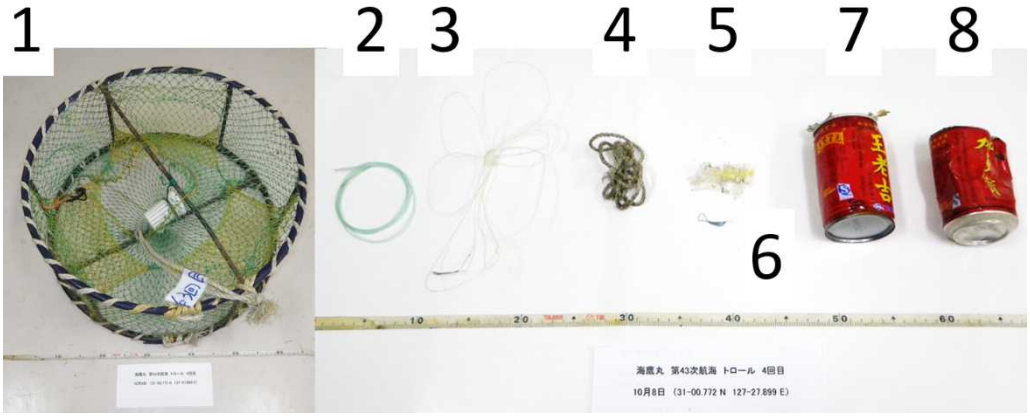
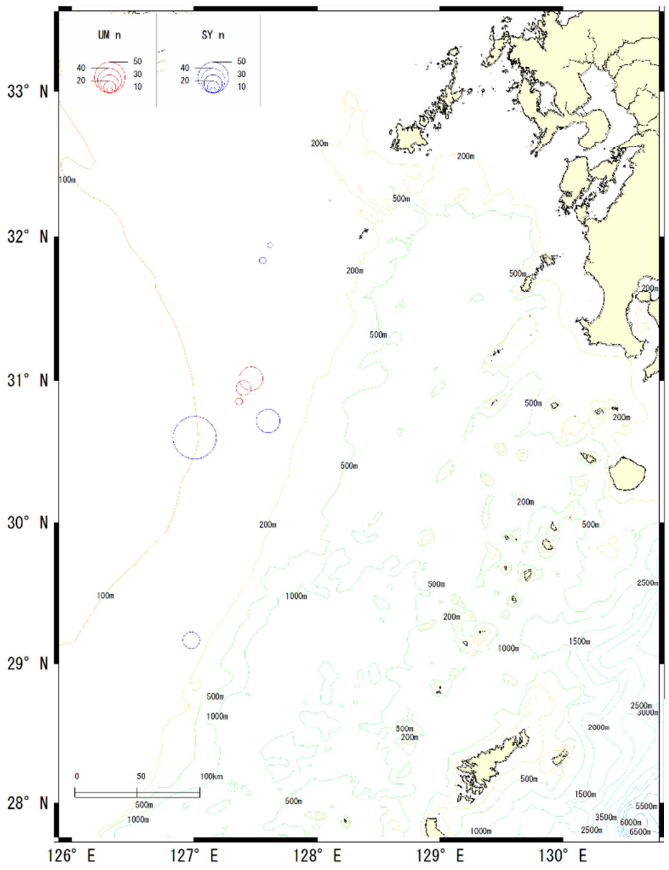


Fig. 14. Photographs of marine debris sampled at haul No. 9 in Fig. 11



2.2 Spatial distribution of marine debris on the sea bed

No large difference was observed in the density of artificial goods between sites in the waters. The abandoned fishing gear that was the most common item was distributed mainly in the western area of the waters (Fig. 15). This area is in the Japan–China Provisional Waters Zone, and during the survey period many Chinese fishing boats were observed around the area. These fishing boats are a possible source of marine debris, including abandoned fishing gear, cans, bottles, and plastic bags.

Fig. 15. Spatial distribution of abandoned fishing gear as marine debris (individuals/km^2) on the sea bed. SY: SHINYO maru; UM, UMITAKA maru