令和5年度環境研究総合推進費公開シンポジウム

「微細なマイクロプラスチック濃度の計測」

2023年5月29日　13:20-13:40
Web講演

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自己紹介：東京海洋大学　海洋環境科学部門

- 専門：海洋環境学　（特に海中の光と濁度）

なぜ光と濁りなのか？

〇海の諸現象（物質やエネルギーの循環）は光によって駆動されている。
〇光の分布は濁りの分布に支配。
〇 濁りの分布は自然と人間活動

➡　マイクロプラスチックも粒子

本日の内容

(1)　微細なマイクロプラスチックの調べる理由

(2)　微細なマイクロプラスチックの分布
　　・・・最新のデータも交えて。

(3)　微細なマイクロプラスチックの連続計測

海洋プラスチックごみ問題とは？

海洋プラごみの問題点：

- 船舶航行への障害（海面の大きなプラごみ、ロープ）
- 漁業操業への影響（底引き網にプラごみ多数）
- 沿岸域居住環境への影響
- 観光資源への影響

Malalayang beach, Manado Bay, Nov. 2019. Photo: Prof. Roeroe

- 生態系への影響：生物に絡まる。

誤飲・誤食による摂食障害・成長阻害

生息場の環境悪化

どのくらいあるのか？

いままでの環境への総流出量5億トンのうち、2500万トン（5%）が海洋に蓄積している。(Isobe and Iwasaki, 2022)

浮いているプラスチックは、世界の海に、5兆個以上。27万トン。(Eriksen et al., 2014)⇒missing sink?

河川からのフラックスが過大評価。⇒missingはない。(Weiss et al., 2021)

⇒ 海洋プラスチックの分布や挙動の把握に至っていない。

(1)　微細なプラスチックの調べる理由

<u>捕え方</u>

- Macro-; 目視 (> 数cm)
- Meso-, Micro-;
  ネットサンプリング (> 数百μm)
- Small micro-, nano-; filter (< 数百μm)

<u>前処理</u>

- 酸化処理 (H_2O_2など)
- 密度分離 (NaI, NaClなど)

Micro-plastics

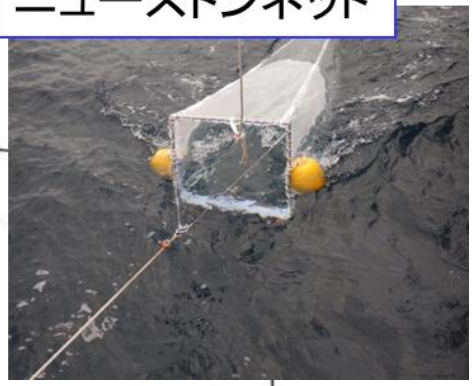
Sea area	Classification	Particle size (mm)	Concentration (pieces m^{-3})	Total particle count (pieces m^{-2})	Reference
East Asian Sea	meso	5 <	0.38	-	Isobe et al., 2015
East Asian Sea	micro	0.35 <<5	3.74	1.72	Isobe et al., 2015
Seto Island Sea	micro	0.35 <	0.4	0.4	Isobe et al., 2014
Canal in Tokyo Bay	micro	0.31 << 1	-	2.4 - 3.2	Matsuguma et al., 2017
Tokyo Bay (Summer)	micro	0.35 <<5	3.98	0.42	Nakano et al., 2021a
Tokyo Bay (Winter)	micro	0.35 <<5	0.55	0.03	Nakano et al., 2021a
Hiroshima Bay	micro	0.3 << 5	-	0.03-0.24	Sagawa et al., 2018
East China Sea	micro	0.35 <	1.26	-	Nakano et al., 2021b

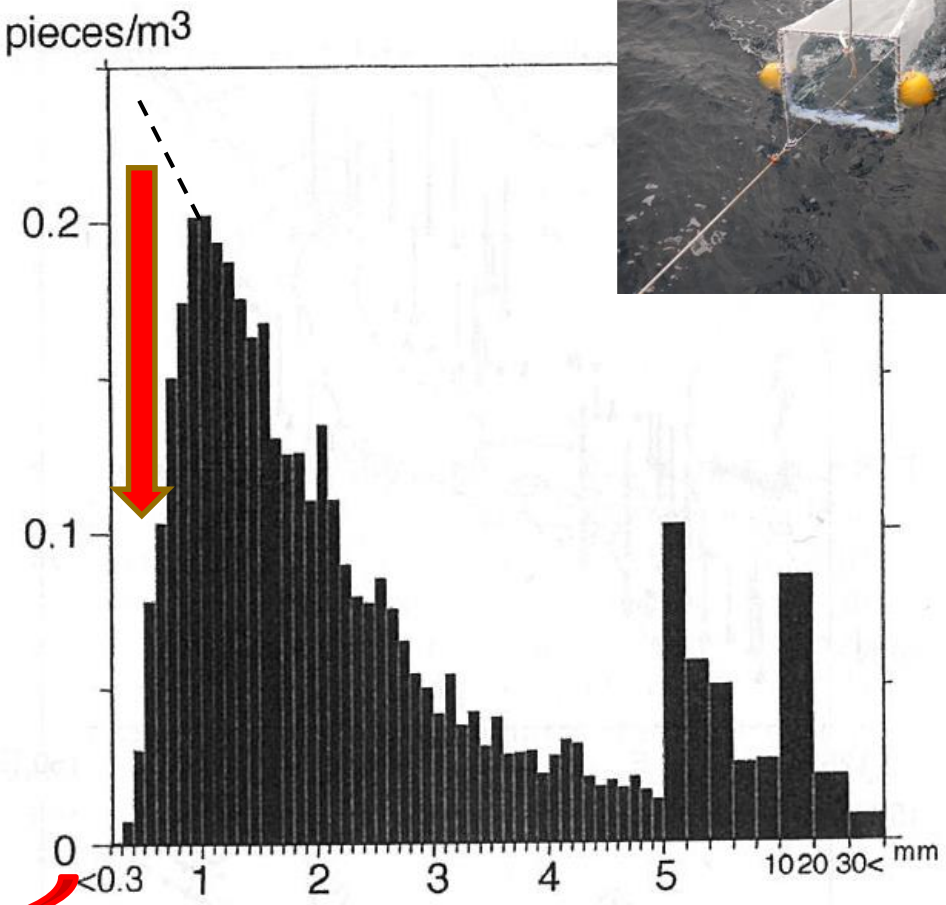
MPs shape	Concentration (pieces m^{-3})						
	2014	2015	2016	2017	2018	2019	Average
Plastic fragments	3.74	2.38	2.15	0.53	3.71	1.8	2.4
Expanded plastics	1.25	0.28	0.32	0.09	0.46	0.25	0.42
Fibers	0.13	0.06	0.09	0.01	0.05	0.05	0.07

（環境省報告書, 2020）

粒径分布

ニューストンネット





微細なマイクロプラスチック
(SMPs)

Fig. 2. Size distribution of small plastic fragments. The bars indicate the concentration in each size range on the abscissa. Note that the intervals of size ranges are 0.1 mm for microplastics, 1 mm for mesoplastics < 10 mm, and 10 mm for mesoplastics > 10 mm.

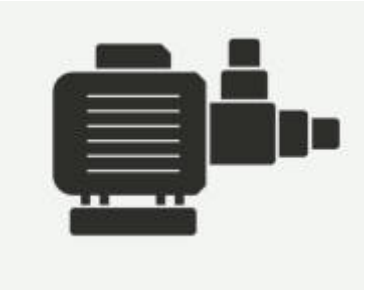
(Isobe et al., 2015)

SMPs(<350μm)のとらえ方

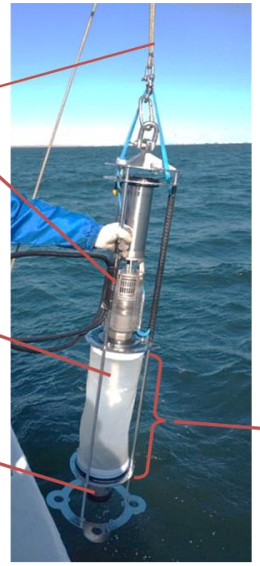
ネット

目開き；10-50 μmなど
濾過量；20 L-100 L

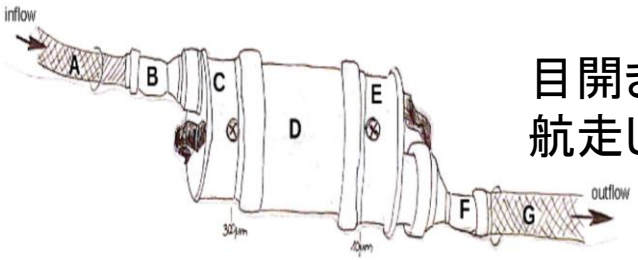
ポンプ+ネット



水中ポンプ



フィルター



目開き；10 μmなど
航走して連続的に

(Enders et al., 2015)

Glass plate

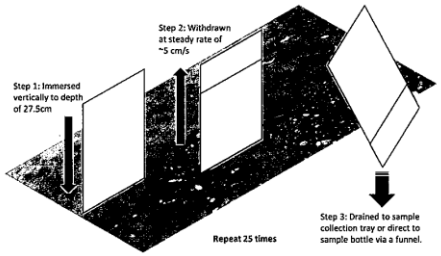
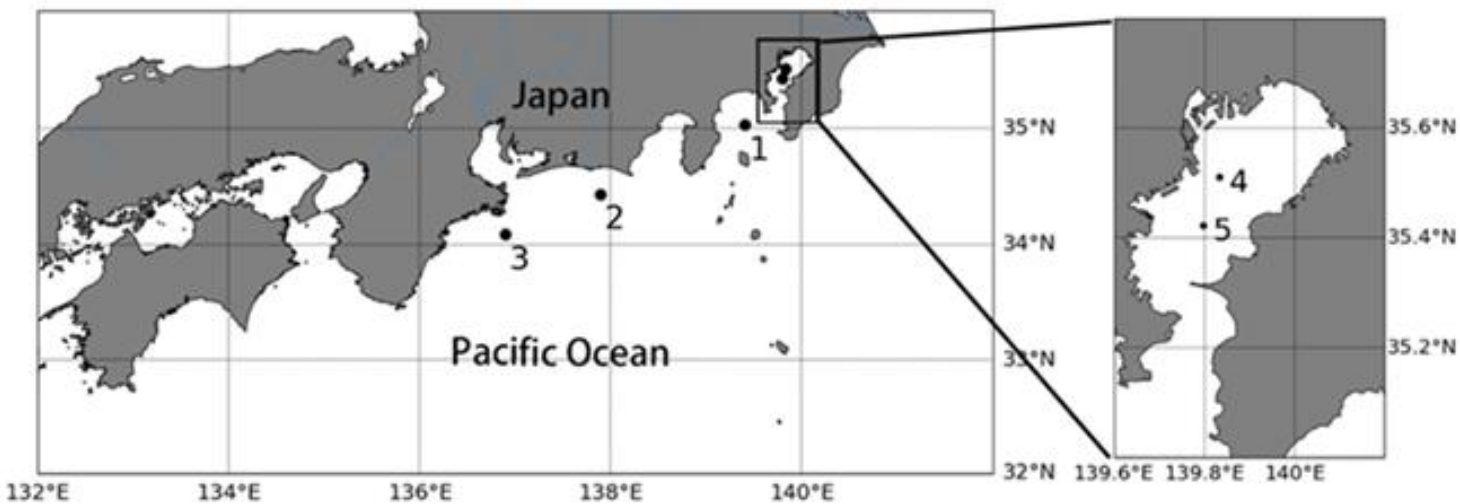


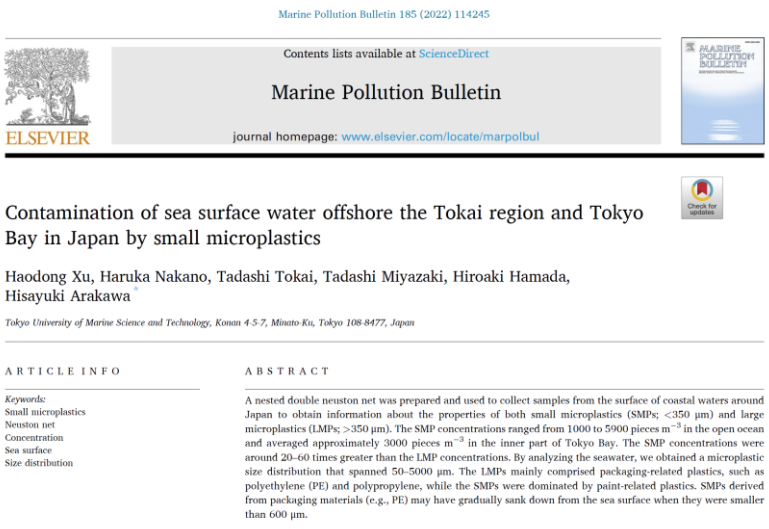
Figure 6. Schematic illustration of the glass plate sampling method used in the present study.

(Anderson et al., 2018)

ネットか、フィルターか➡粒径分布が不連続になる。

(2)SMPsの分布





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Contamination of sea surface water offshore the Tokai region and Tokyo Bay in Japan by small microplastics

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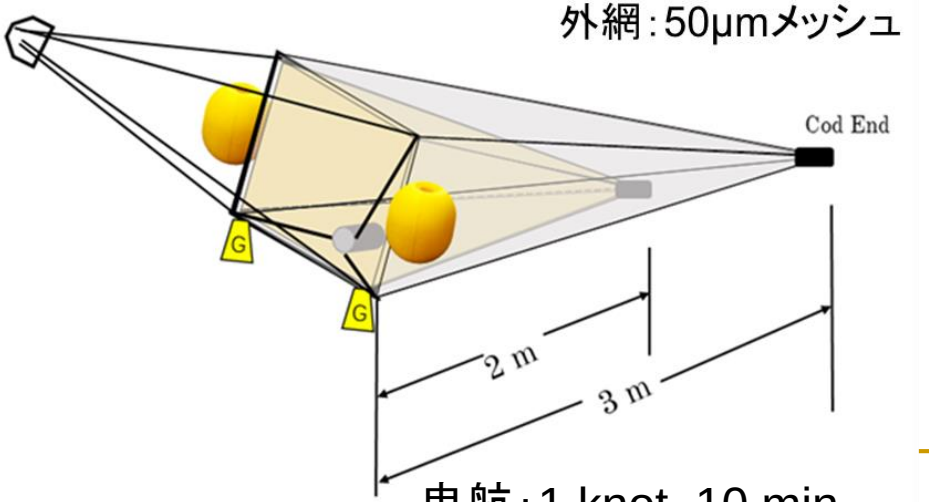
ARTICLE INFO

Keywords:
Small microplastics
Neuston net
Concentration
Sea surface
Size distribution

ABSTRACT

A nested double neuston net was prepared and used to collect samples from the surface of coastal waters around Japan to obtain information about the properties of both small microplastics (SMPs; <350 μm) and large microplastics (LMPs; >350 μm). The SMP concentrations ranged from 1000 to 5900 pieces m^{-3} in the open ocean and averaged approximately 3000 pieces m^{-3} in the inner part of Tokyo Bay. The SMP concentrations were around 20–60 times greater than the LMP concentrations. By analyzing the seawater, we obtained a microplastic size distribution that spanned 50–5000 μm. The LMPs mainly comprised packaging-related plastics, such as polyethylene (PE) and polypropylene, while the SMPs were dominated by paint-related plastics. SMPs derived from packaging materials (e.g., PE) may have gradually sank down from the sea surface when they were smaller than 600 μm.

内網：350μmメッシュ
外網：50μmメッシュ

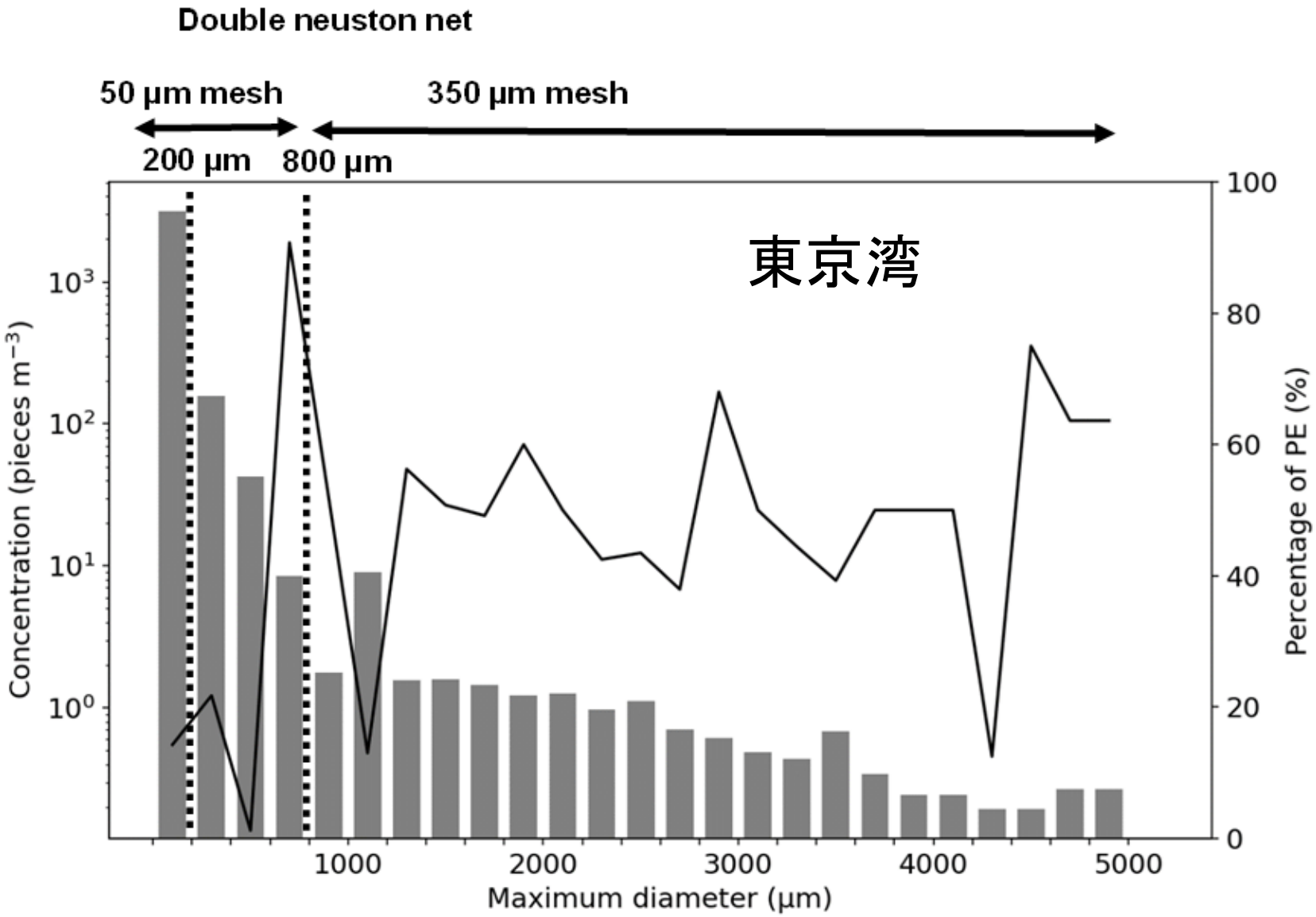


曳航：1 knot, 10 min

Small micro-plastics

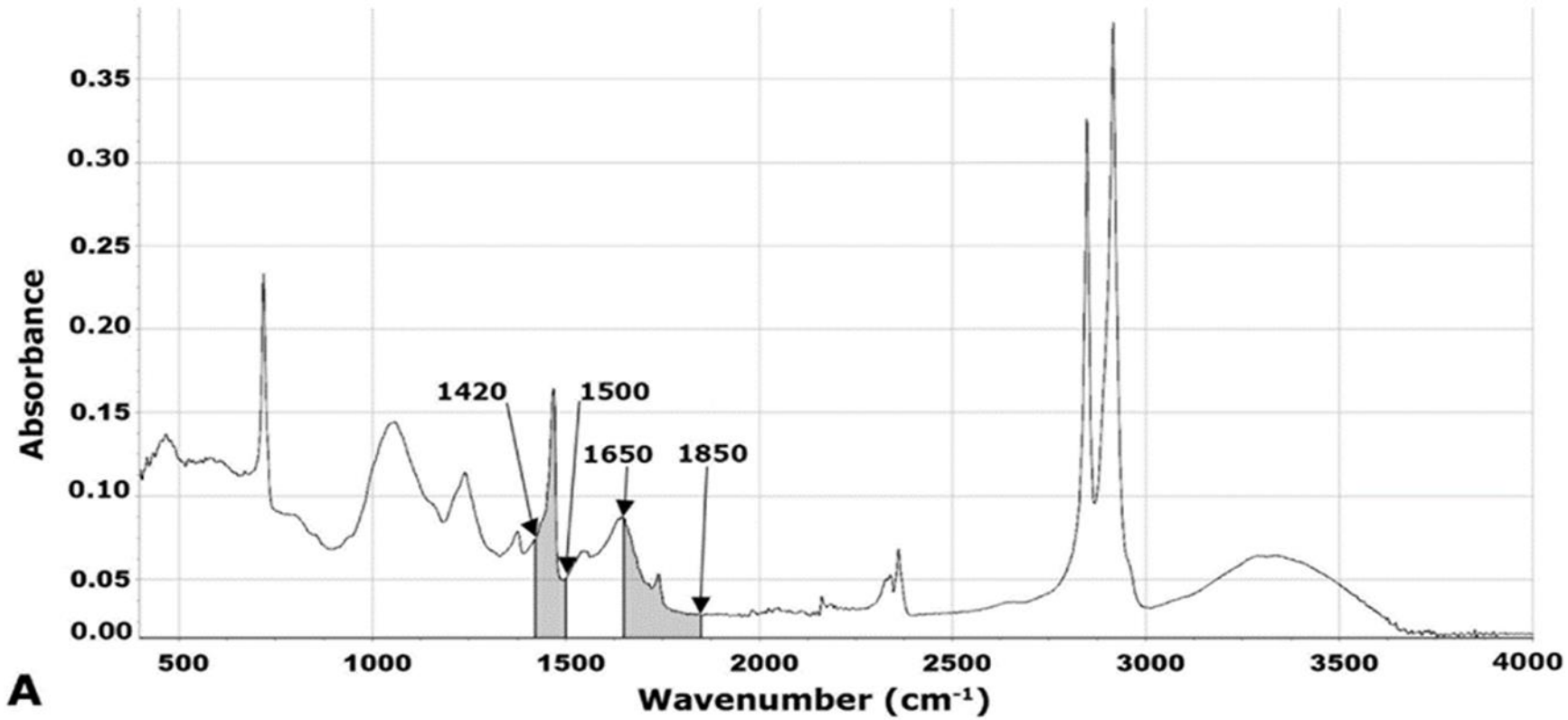
Station	Net type	Mesh opening (μm)	Sample number	Counts (pieces ± SD)	Filtered water amounts (m^3)	Water volume for analysis (m^3)	Concentration (pieces m^{-3})
Sta. 1	Conventional	350	1	28	292	292	0.1
	Double	350	1	22	269	269	0.08
		50	-	-	-	-	-
Sta. 2	Conventional	350	1	15	125	125	0.12
	Double	350	1	20	115	115	0.17
		50	3	54.3 ± 5.90		0.037	5900 ± 642
Sta. 3	Conventional	350	1	7	111	111	0.06
	Double	350	1	3	73	73	0.04
		50	3	45.3 ± 17.8		0.176	1030 ± 403
Sta. 4	Conventional	350	1	338	68	68	4.97
	Double	350	1	841	41	41	20.5
		50	3	16.7 ± 4.80		0.021	3220 ± 924
Sta. 5	Conventional	350	1	234	72	72	3.25
	Double	350	1	84	34	34	2.47
		50	3	60.3 ± 27.4		0.079	3060 ± 1390

MPsの粒径分布

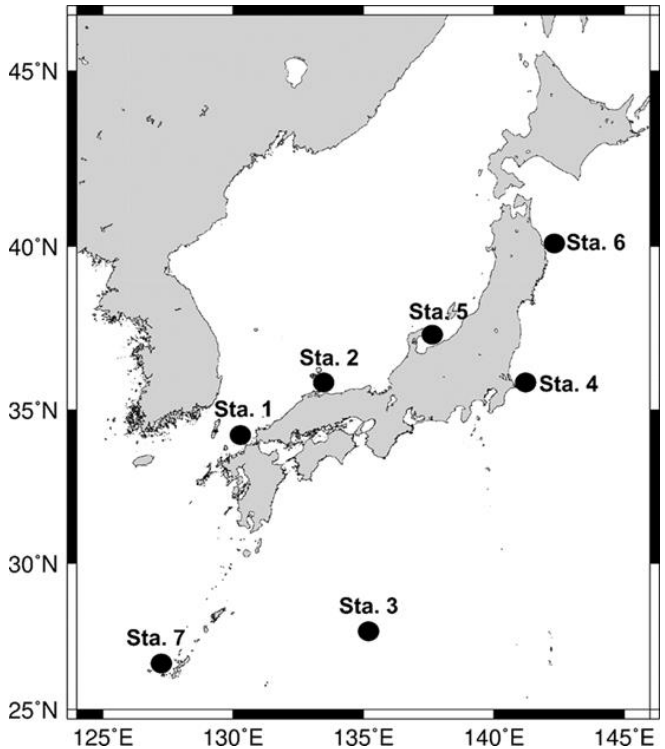

Double neuston net
50 µm mesh
350 µm mesh
200 µm
800 µm
東京湾
Concentration (pieces m^{-3})
10^3
10^2
10^1
10^0
Percentage of PE (%)
100
80
60
40
20
0
1000
2000
3000
4000
5000
Maximum diameter (µm)

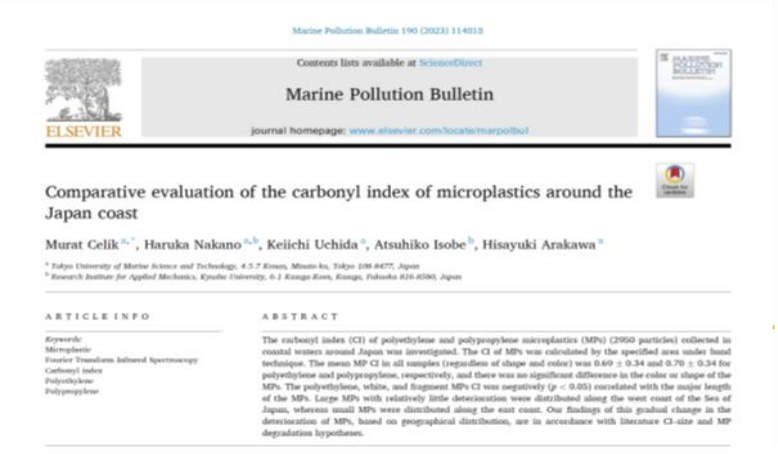
マイクロプラスチックの劣化

$$Carbonyl\ index = \frac{Area\ under\ band\ 1{,}850 - 1{,}650\ cm^{-1}}{Area\ under\ band\ 1{,}500 - 1{,}420\ cm^{-1}}$$



MPsのCI





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ELSEVIER

Comparative evaluation of the carbonyl index of microplastics around the Japan coast

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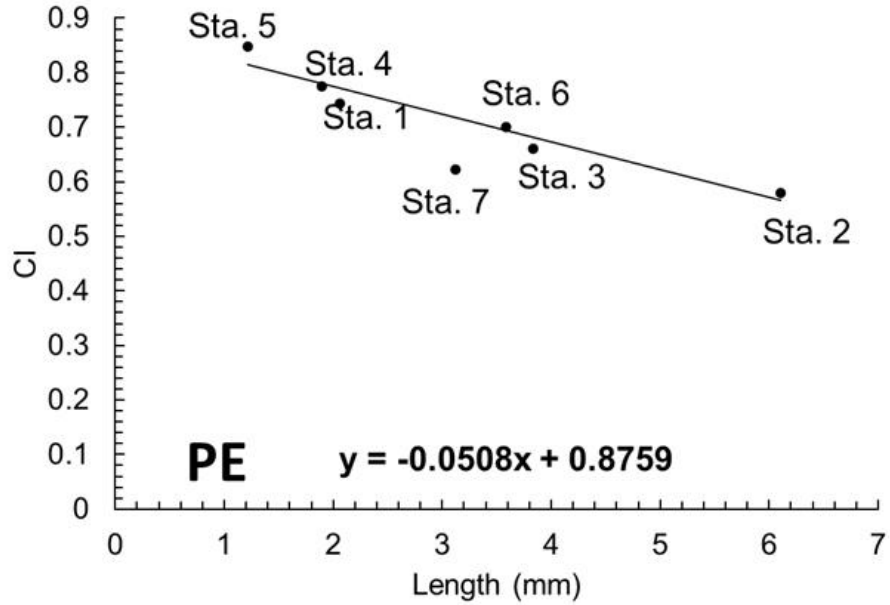
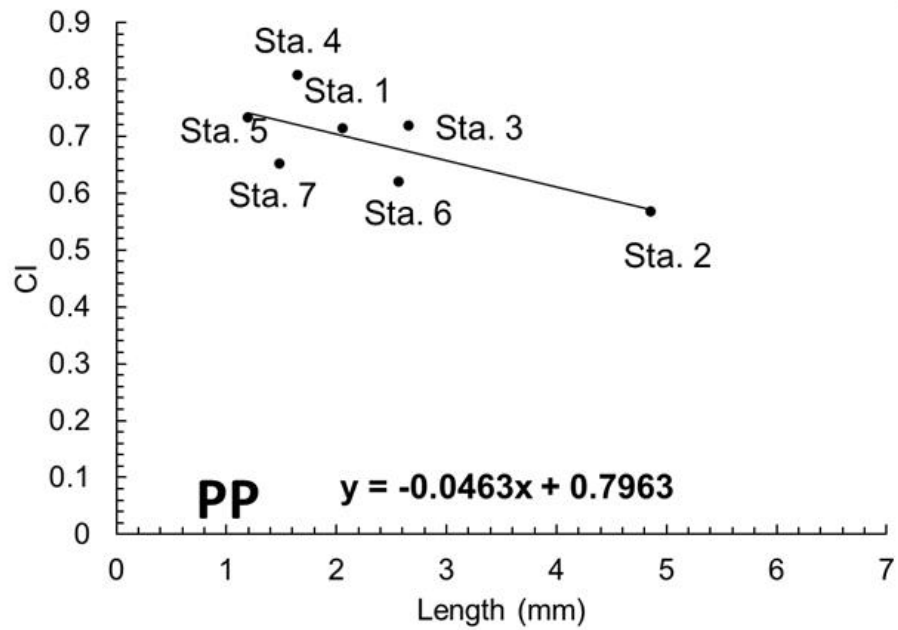
ARTICLE INFO

Keywords:
Microplastic
Fourier Transform Infrared Spectroscopy
Carbonyl index
Polyethylene
Polypropylene

ABSTRACT

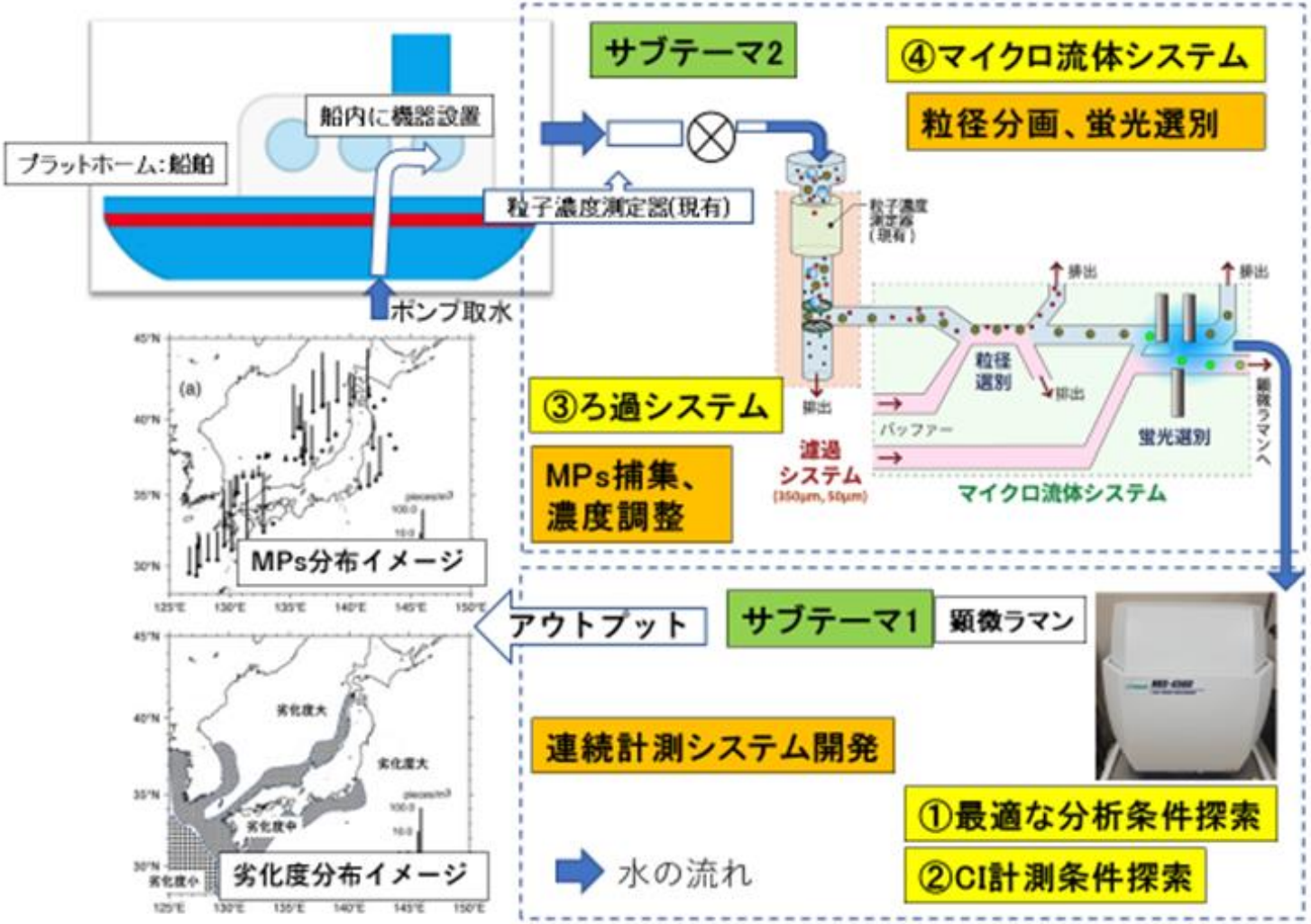
The carbonyl index (CI) of polyethylene and polypropylene microplastics (MPs) (2950 particles) collected in coastal waters around Japan was investigated. The CI of MPs was calculated by the specified area under band technique. The mean MP CI in all samples (regardless of shape and color) was 0.69 ± 0.34 and 0.70 ± 0.34 for polyethylene and polypropylene, respectively, and there was no significant difference in the color or shape of the MPs. The polyethylene, white, and fragment MPs CI was negatively ($p < 0.05$) correlated with the major length of the MPs. Large MPs with relatively little deterioration were distributed along the west coast of the Sea of Japan, whereas small MPs were distributed along the east coast. Our findings of this gradual change in the deterioration of MPs, based on geographical distribution, are in accordance with literature CI-size and MP degradation hypotheses.





微細なマイクロプラスチックの連続計測

開発システムの完成イメージと最終結果



いまだマイクロプラスチックの分布や挙動がはっきりしない。

- 表面には大きなMPsが多く分布する。
- 北上するほど粒子が小さくなり、SMPs濃度も増加する。
- MPsの粒径が小さいほどCIは高い。
- 連続的なSMPs濃度およびCIの変化を知る必要がある。連続計測システムが不可欠である。

謝辞：

- 本研究の多くの部分は、環境保全再生機構の推進費によって進められています。お礼申し上げます。