

マイクロプラスチックって何だ？

レジ袋もらいますか？ペットボトルでビール飲みますか？
そんなことを続けていると、プラスチックの屑混じりの魚を食べることになります。

高田秀重



東京農工大学 農学部 環境資源科学科

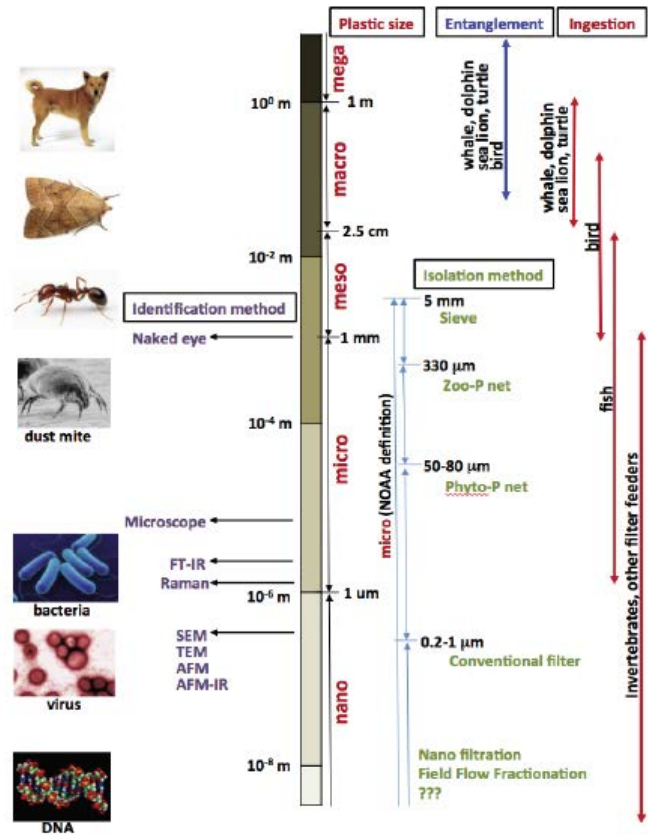
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日本列島から1000km離れた太平洋上で気象庁が採取したマイクロプラスチック。
これにも有害な化学物質が含まれています。

マイクロプラスチック: 5mm以下のプラスチック

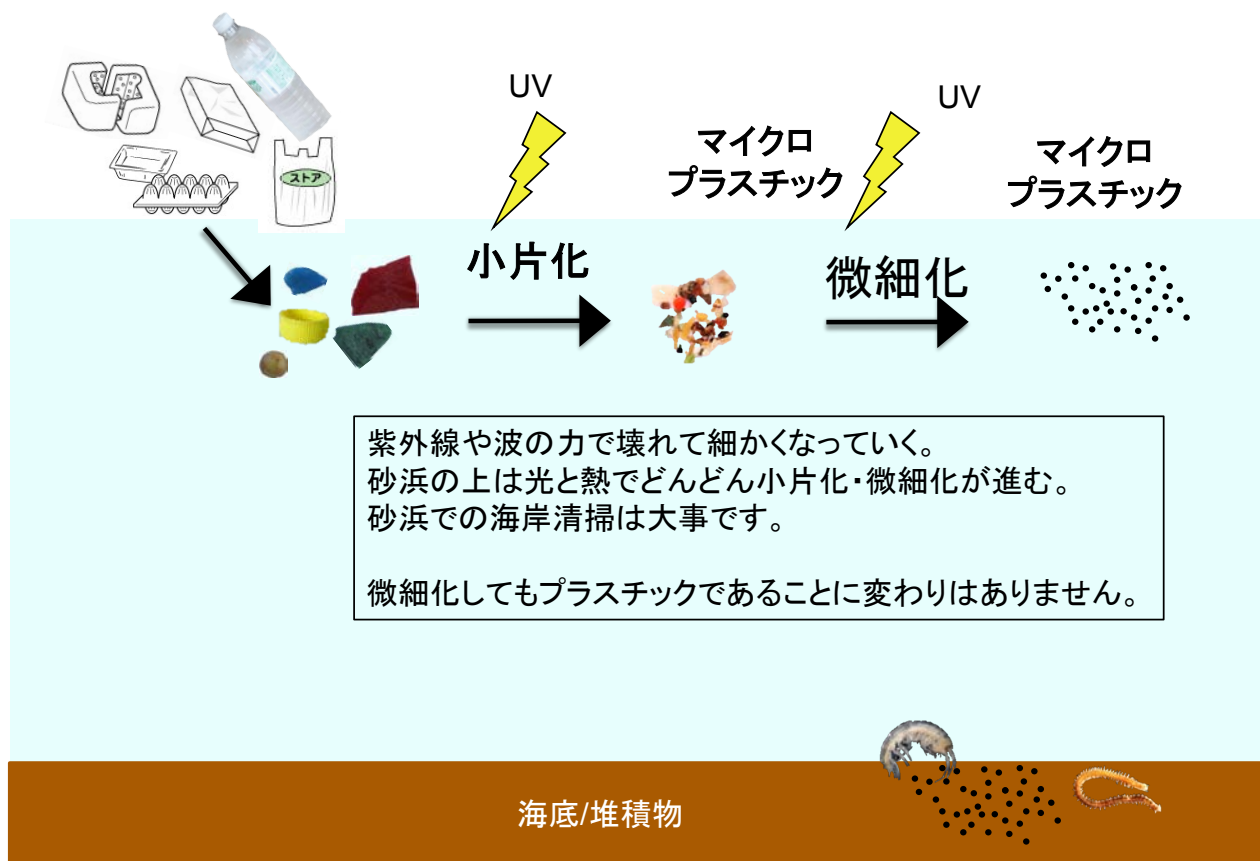
国連の海洋汚染の専門家
会議(GESAMP)の定義



FT-IR Fourier-transform infra-red spectroscopy, Ramon spectroscopy,
SEM scanning electron microscopy, TEM transmission electron microscopy,
AFM atomic force microscopy, AFM-IR infra-red spectroscopy



マイクロプラスチック:もともとは私たちが使っているプラスチック



増加するプラスチックの生産量

年間3億トンのプラスチックが生産されている。

石油産出量の8%がプラスチックに

4%: 原材料

4%: 製造・加工のエネルギー

そのうち半分は容器包装

一人年間に数十kg、のプラスチックを消費

ペットボトル: 100本程度

レジ袋: 300枚

食品のパッケージ、コンビニのお弁当箱、.....

1世帯で1日1kgのプラゴミを出す

毎年約800万トンのプラスチックが海へ流入している

Plastic waste inputs from land into the ocean

Jenna R. Jambeck,^{1*} Roland Geyer,² Chris Wilcox,³ Theodore R. Siegler,⁴ Miriam Perryman,⁵ Anthony Andrady,⁶ Ramani Narayan,⁶ Kara Lavender Law⁷

Plastic debris in the marine environment is widely documented, but the quantity of plastic entering the ocean from waste generated on land is unknown. By linking worldwide data on solid waste, population density, and economic status, we estimated the mass of land-based plastic waste entering the ocean. We calculate that 275 million metric tons (MT) of plastic waste was generated in 192 coastal countries in 2010, with 4.8 to 12.7 million MT entering the ocean. Population size and the quality of waste management systems largely determine which countries contribute the greatest mass of uncaptured waste available to become plastic marine debris. Without waste management infrastructure improvements, the cumulative quantity of plastic waste available to enter the ocean from land is predicted to increase by an order of magnitude by 2025.

Jamebeck et al. (2015), Science

ごみ収集されずに、路上や地面に落ちているプラスチックは雨で洗い流されます。ポリエチレンやポリプロピレンなど水より軽いプラスチックは浮いて川を流れて、海に運ばれます。海水浴の時などに捨てられてものではなく、街でポイ捨てされたものが、主な発生源です。風に飛ばされたレジ袋やペットボトルが落ちていることなどよくみかけますよね。

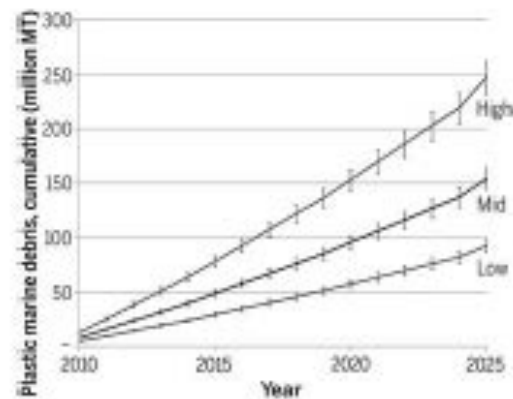
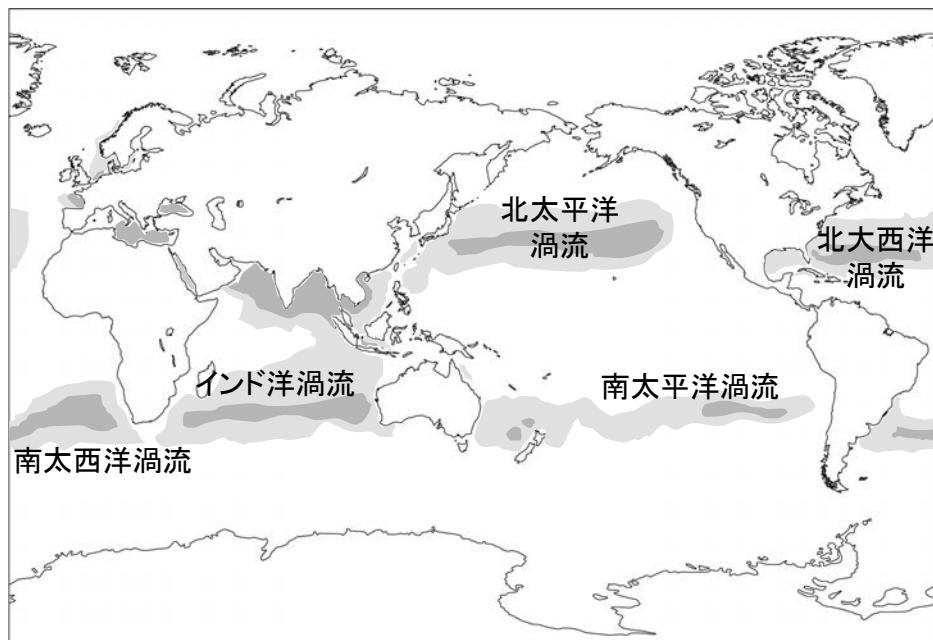


Fig. 2. Estimated mass of mismanaged plastic waste (millions of metric tons) input to the ocean by populations living within 50 km of a coast in 192 countries, plotted as a cumulative sum from 2010 to 2025. Estimates reflect assumed conversion rates of mismanaged plastic waste to marine debris (high, 40%; mid, 25%; low, 15%). Error bars were generated using mean and standard error from the predictive models for mismanaged waste fraction and percent plastic in the waste stream (12).

海に流入したプラスチックの一部は海岸に漂着している



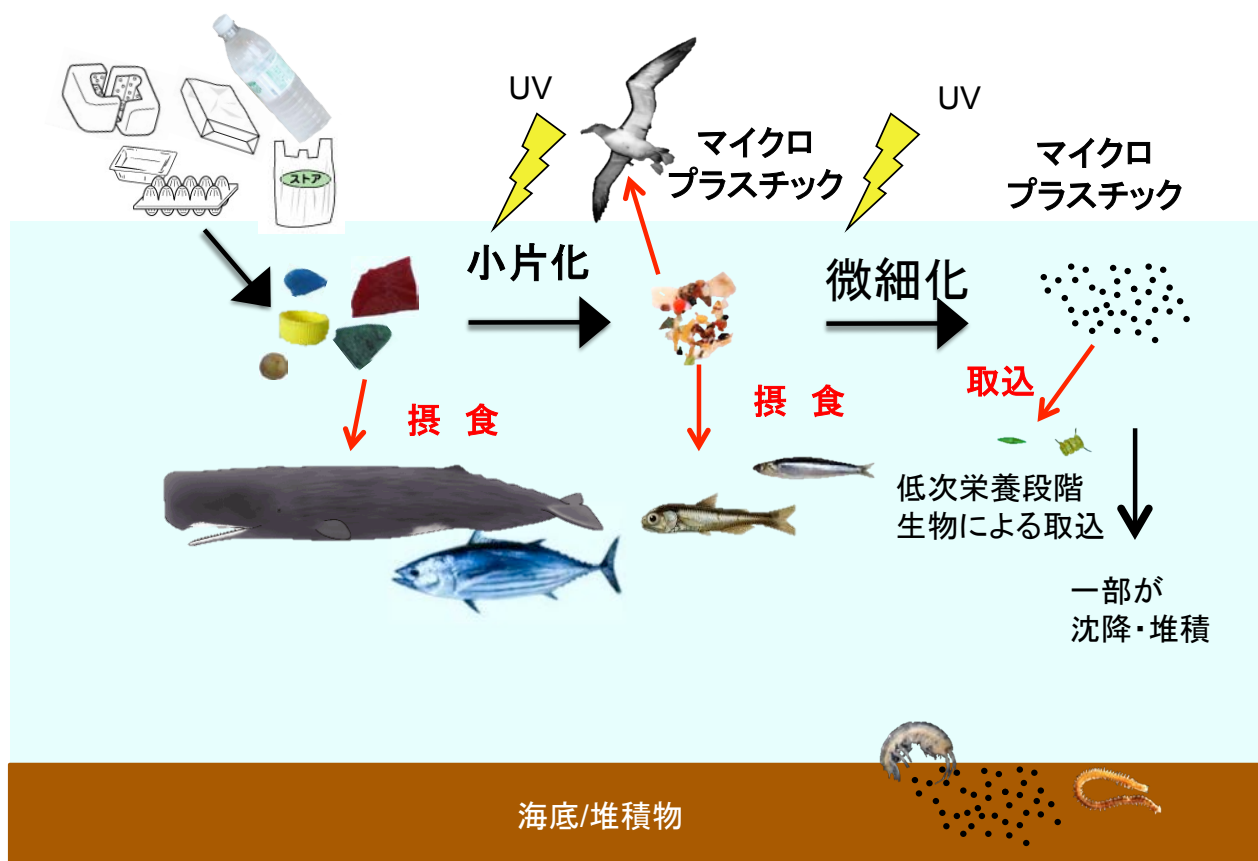
世界の海に浮遊しているマイクロプラスチック



人口密集地の沿岸(ユーラシア大陸南岸、地中海、黒海)にたくさん浮遊している。
外洋の真ん中にも海流や風の関係でたくさん浮いている場所があり、5Gyresとよばれている。

Dr. Marcus Eriksenの講演資料より作成

マイクロプラスチックは海洋生物が摂食している



200種以上の海洋生物(海鳥、魚、貝、ウミガメ、クジラ、など)がプラスチックを摂食している。

Laist (1997)によると177種と報告されているが、その後の報告を含めると現在では200種以上と考えられる。

物理的なダメージが報告されている。

(Wrightら、2013)

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ハシボソミズナギドリ(北海道大学の綿貫先生より提供)



砂嚢からたくさんプラスチックが検出される

調べた12羽全ての個体の消化管内からはプラスチックが検出された



最大1羽から0.6g →人間に換算すると60gのプラスチックが胃の中にある

微細プラスチックは実際に海に棲息する二枚貝の体内からも検出された

Microplastics in bivalves cultured for human consumption

Lisbeth Van Cauwenberghe*, Colin R. Janssen

Ghent University, Laboratory of Environmental Toxicology and Aquatic Ecology, Jozef Plateauststraat 22, 9000 Ghent, Belgium

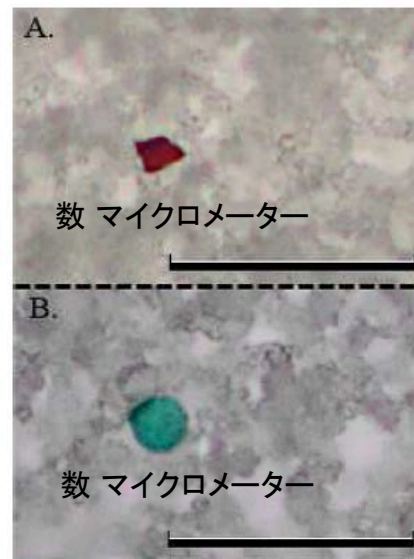


Fig. 1. Microplastics detected in the acid digested *Mytilus edulis* and *Crassostrea gigas*. A. Red particle recovered from *Mytilus edulis*; B. Green sphere detected in the soft tissue of *Crassostrea gigas*. (Scale bar: 50 μ m). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

東京湾で釣ったカタクチイワシ64尾中49尾からマイクロプラスチックを検出



Ingestion of Microplastics by Zooplankton in the Northeast Pacific Ocean

Jean-Pierre W. Desforges¹ · Moira Galbraith² · Peter S. Ross¹

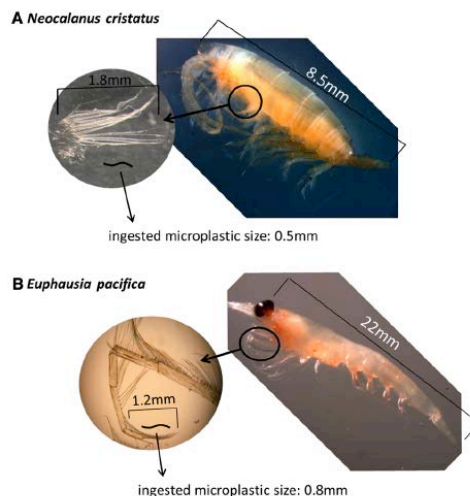
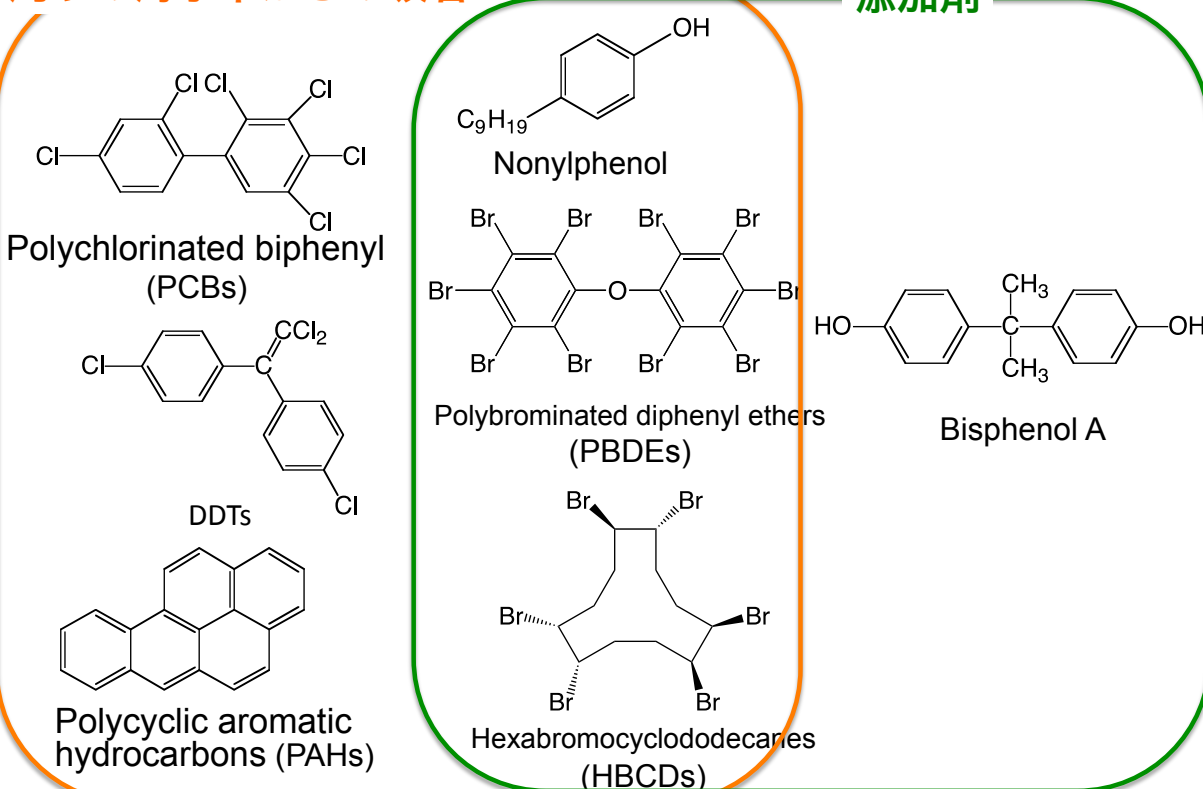


Fig. 2 The feeding appendage anatomy of a *N. cristatus* and b *E. pacifica* suggest that the sizes of ingested microplastic particles were within the physical limits of mouth gape and handling capacity of setae. The average microplastic particle size detected in this study is shown in relation to the size of setae for both zooplankton species

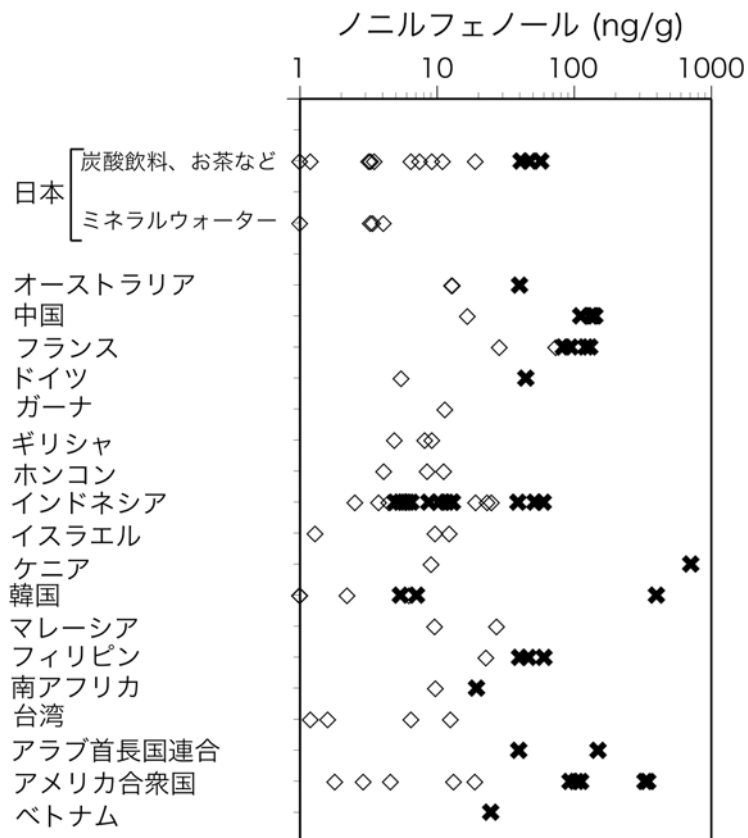
海洋プラスチックゴミは有害化学物質を生態系に運ぶ

周りの海水中からの吸着

添加剤

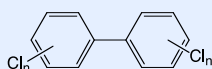


添加剤の例：ペットボトルの蓋中の環境ホルモン



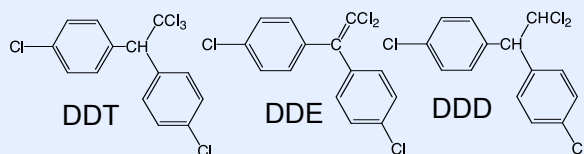
プラスチックは周辺海水中から汚染物質を吸着する =プラスチックの有害化

PCBs



- Industrial products for a variety of uses including dielectric fluid, heat medium, and lubricants.
- Endocrine disrupting chemicals

DDTs

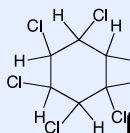


- DDT and its metabolites such as DDE and DDD.
- DDT was used as insecticides
- Endocrine disrupting chemicals

周辺海水中から吸着

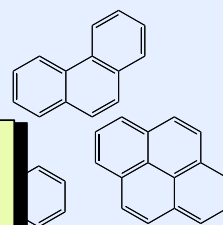
プラスチック

HCH



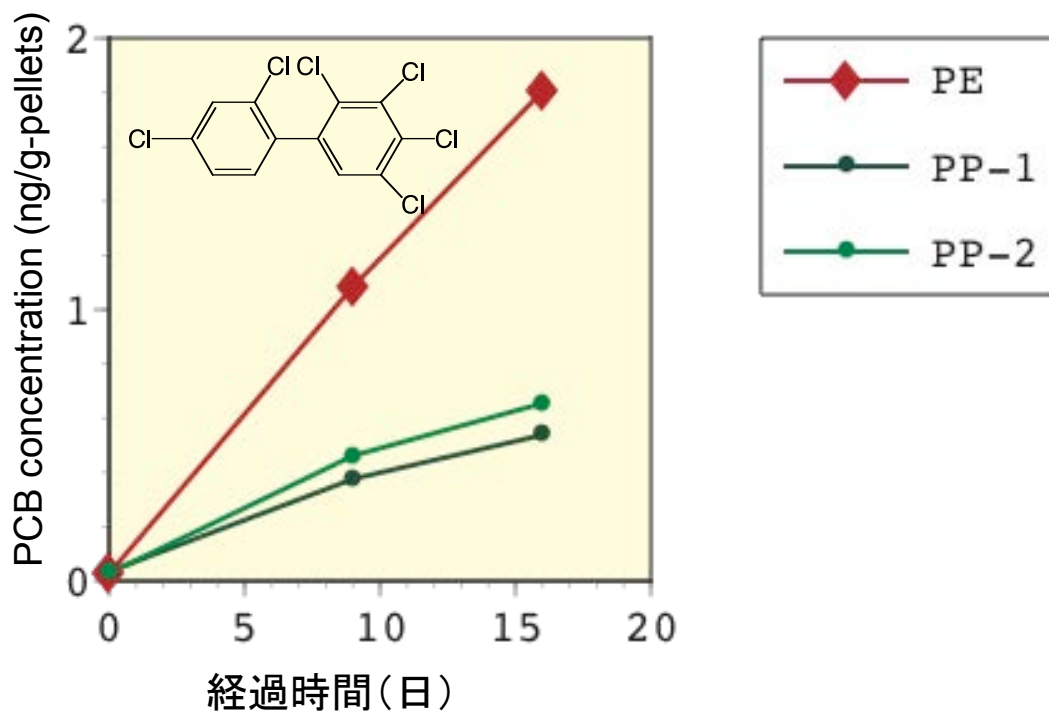
- Insecticide

PAHs



プラスチック中の汚染物質濃度は
周辺海水中の十万倍～百万倍

海に浮かぶプラスチックへの化学物質の吸着



インターナショナルペレットウォッチ: プラスチックの有害化を世界の市民といっしょに理解する

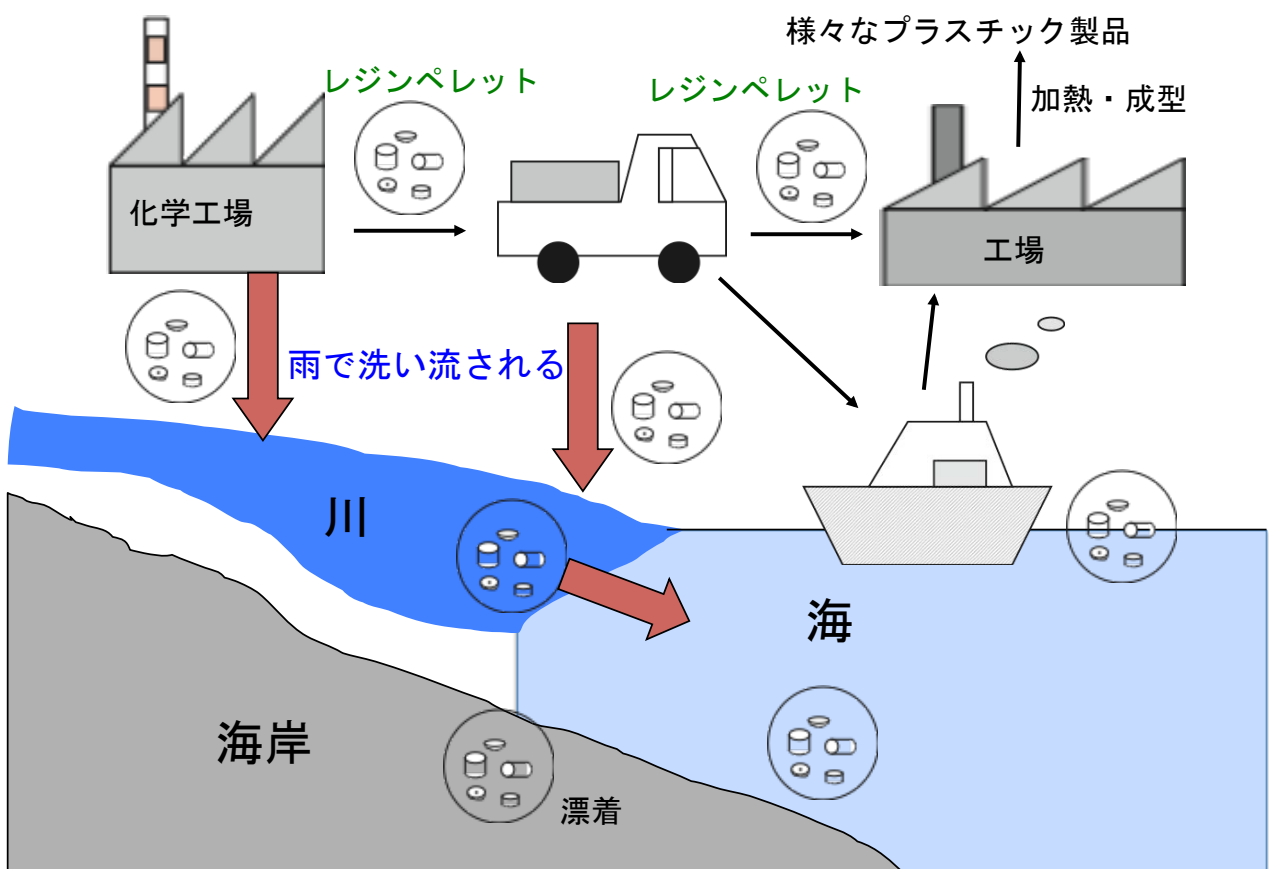


インターネットや雑誌で
世界の人にペレットの採
取と送付を呼びかける

プラスチックレジンペレット： プラスチック製品の間接材料



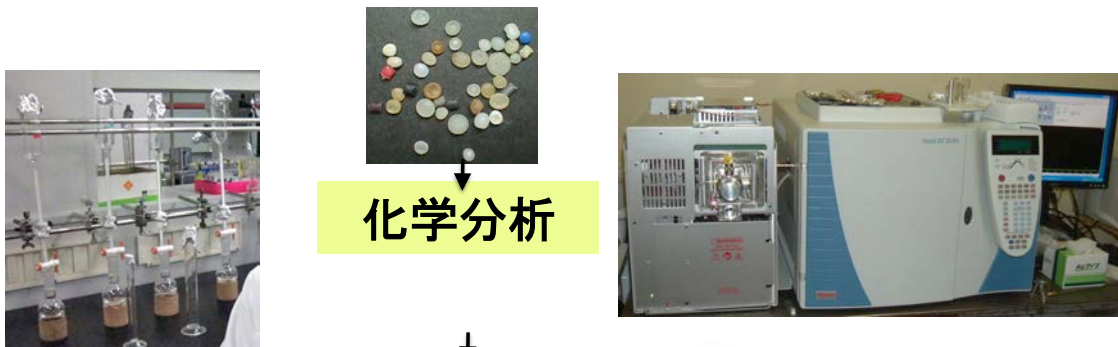
レジンペレットとは？何故海岸に漂着しているのか？



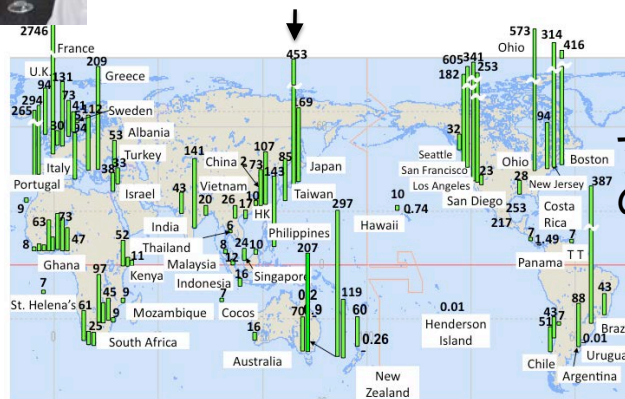
世界中からマイクロプラスチックが届く



マイクロプラスチック中の有害化学物質を分析する



海の汚染が
わかる

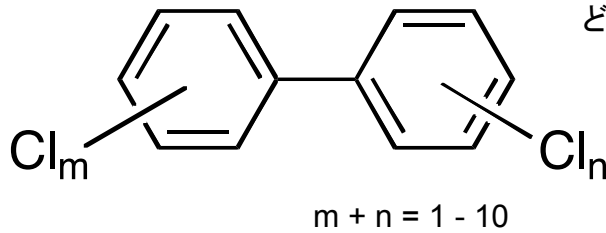


マイクロプラスチック
の危険性がわかる

- 結果は採取者にメールでお知らせする。
- 汚染マップはwebで公開する

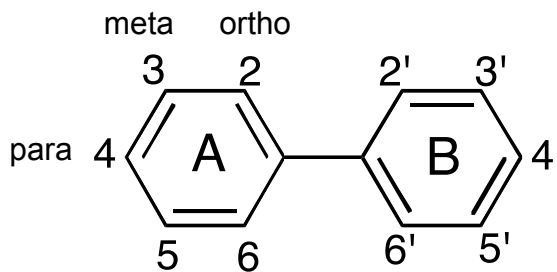
<http://www.pelletwatch.org/>

ポリ塩化ビフェニル(PCBs)



トランス、コンデンサー、熱媒体など様々な工業用途で使われた。

1960年代に使われ、
1970年代初頭に使用禁止



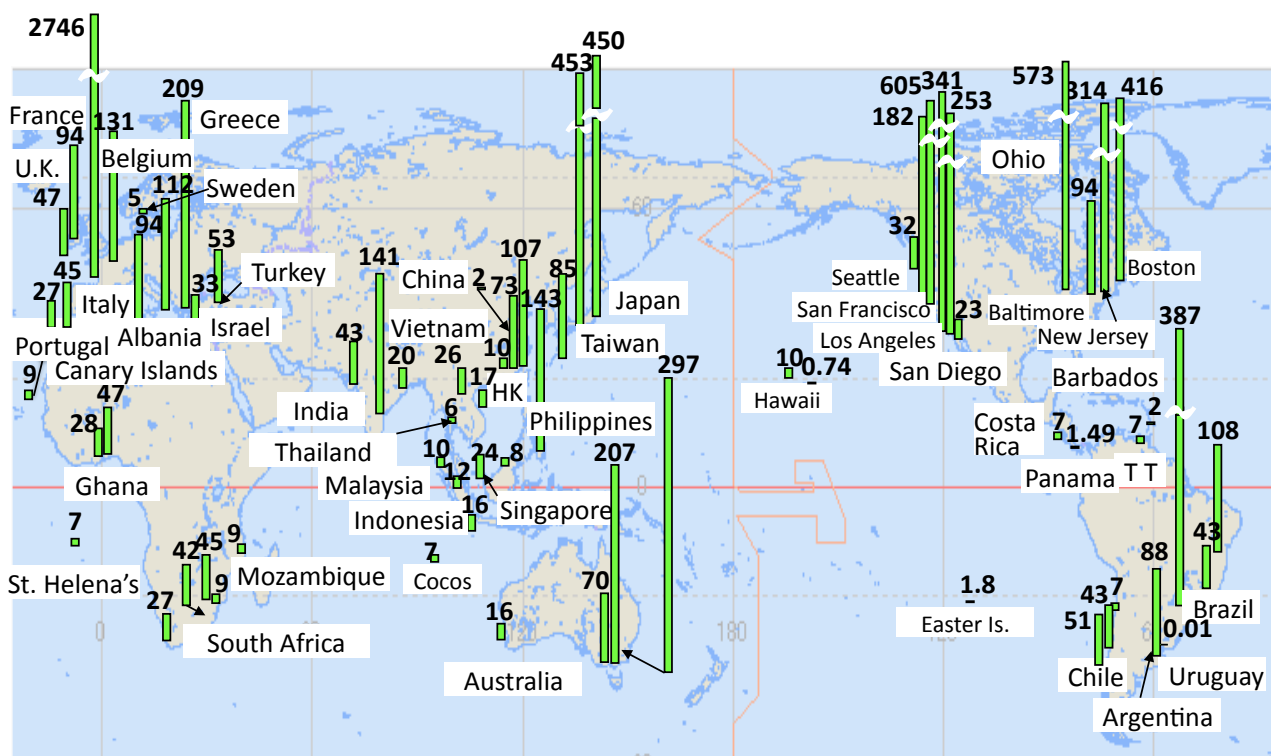
カネミ油症

奇形、発ガン

免疫力の低下

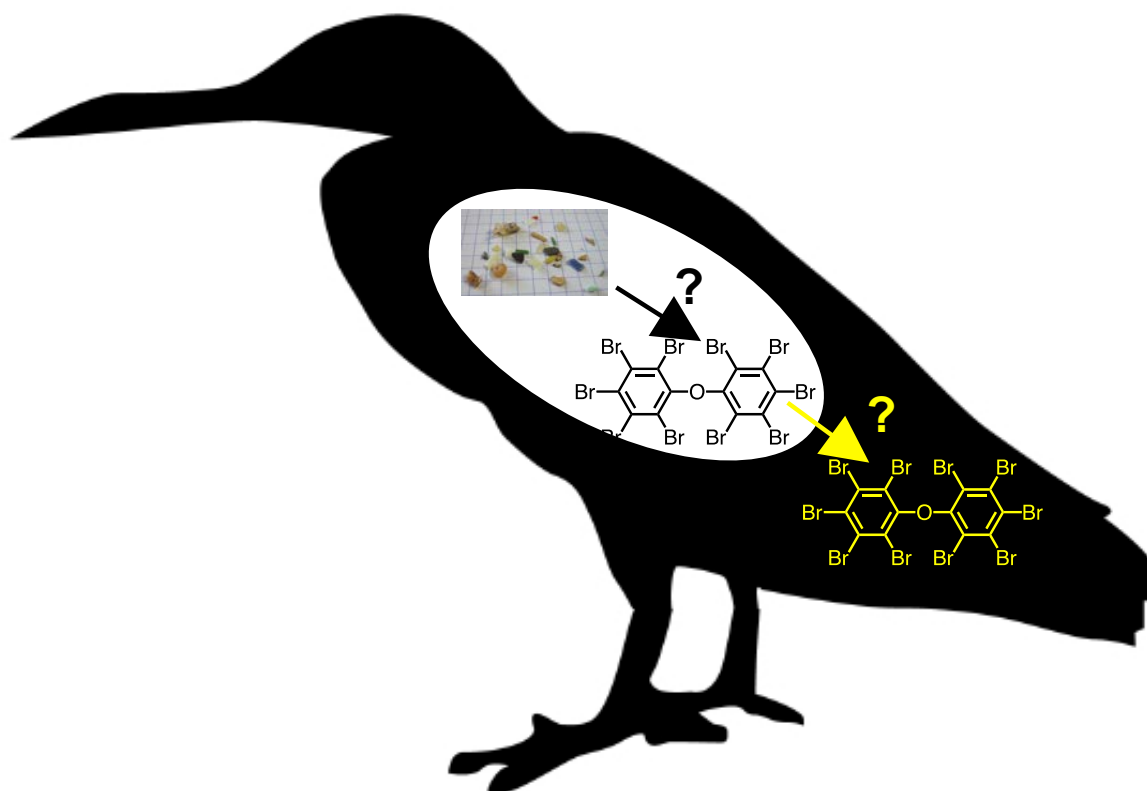
脳神経系に影響

プラスチックの有害化は世界中で起こっている



海岸漂着プラスチック中のPCBs濃度(ng/g)

生物に取り込んだプラスチックから化学物質は生物組織に移行するのか？



北太平洋の海鳥へのプラスチック摂食の影響



Contents lists available at SciVerse ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul



Baseline

Edited by Bruce J. Richardson

The objective of BASELINE is to publish short communications on different aspects of pollution of the marine environment. Only those papers which clearly identify the quality of the data will be considered for publication. Contributors to Baseline should refer to 'Baseline—The New Format and Content' (*Mar. Pollut. Bull.* **60**, 1–2).

Physical and chemical effects of ingested plastic debris on short-tailed shearwaters, *Puffinus tenuirostris*, in the North Pacific Ocean

Rei Yamashita^{a,c,*}, Hideshige Takada^a, Masa-aki Fukuwaka^b, Yutaka Watanuki^c

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^cGraduate School of Fisheries Sciences, Hokkaido University, 3-3-1 Minato, Hakodate 041-8611, Japan

ARTICLE INFO

Keywords:

Marine plastic debris
Polychlorinated biphenyls (PCBs)
North Pacific Ocean
Plastic ingestion
Plastic contaminants
Short-tailed shearwater

ABSTRACT

We investigated the plastics ingested by short-tailed shearwaters, *Puffinus tenuirostris*, that were accidentally caught during experimental fishing in the North Pacific Ocean in 2003 and 2005. The mean mass of plastics found in the stomach was 0.23 g per bird ($n = 99$). Plastic mass did not correlate with body weight. Total PCB (sum of 24 congeners) concentrations in the abdominal adipose tissue of 12 birds ranged from 45 to 529 ng/g-lipid. Although total PCBs or higher-chlorinated congeners, the mass of ingested plastic correlated positively with concentrations of lower-chlorinated congeners. The effects of toxic chemicals present in plastic debris on bird physiology should be investigated.

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胃内のプラスチック量が増えると脂肪中の有害化学物質濃度が上昇

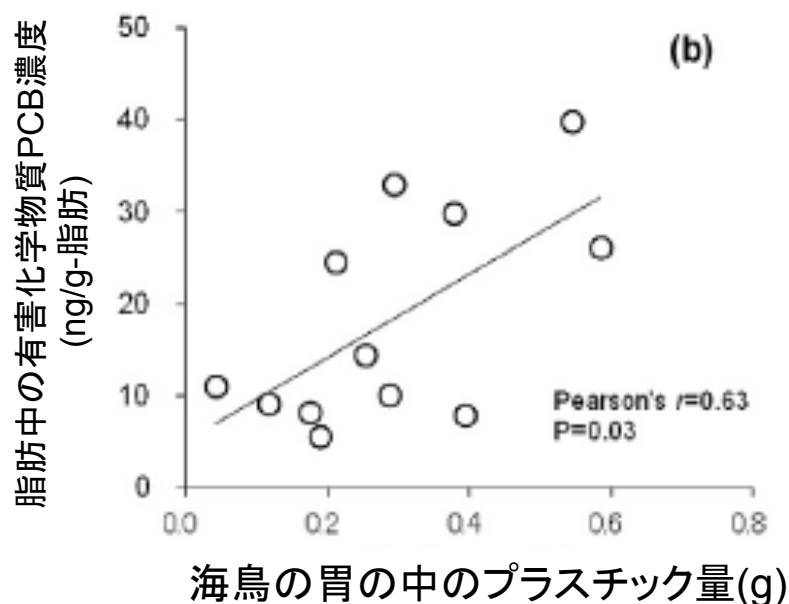


Fig. 4 Relationships between ingested plastic mass and concentrations of (a) total PCBs, (b) lower-chlorinated congeners (CI number 2–4, see Fig. 3), and (c) higher-chlorinated congeners (CI number 5–9, see Fig. 3) in abdominal adipose tissues of shearwaters that ingested plastics.

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プラスチックを摂食した海鳥の脂肪への臭素系難燃剤の蓄積

Marine Pollution Bulletin xxx (2013) xxx–xxx



Contents lists available at SciVerse ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul



Baseline

Accumulation of plastic-derived chemicals in tissues of seabirds ingesting marine plastics

Kosuke Tanaka^a, Hideshige Takada^{a,*}, Rei Yamashita^a, Kaoruko Mizukawa^a, Masa-aki Fukuwaka^b, Yutaka Watanuki^c

^a Laboratory of Organic Geochemistry (LOG), Tokyo University of Agriculture and Technology, Fuchu, Tokyo 183-8509, Japan

^b Hokkaido National Fisheries Research Institute, Fisheries Research Agency, Kushiro, Hokkaido 085-0802, Japan

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ARTICLE INFO

Keywords:

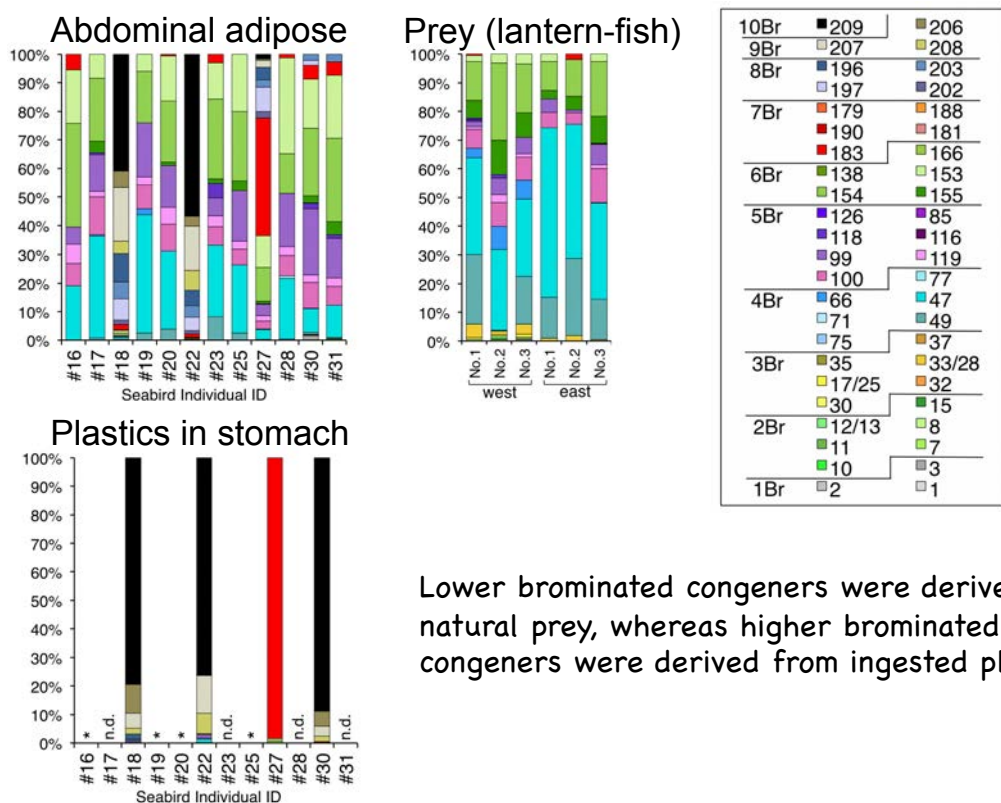
Polybrominated diphenyl ethers (PBDEs)
Plastic debris
Additives
North Pacific Ocean
Short-tailed shearwater
Bioaccumulation

ABSTRACT

We analyzed polybrominated diphenyl ethers (PBDEs) in abdominal adipose of oceanic seabirds (short-tailed shearwaters, *Puffinus tenuirostris*) collected in northern North Pacific Ocean. In 3 of 12 birds, we detected higher-brominated congeners (viz., BDE209 and BDE183), which are not present in the natural prey (pelagic fish) of the birds. The same compounds were present in plastic found in the stomachs of the 3 birds. These data suggested the transfer of plastic-derived chemicals from ingested plastics to the tissues of marine-based organisms.

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Lower brominated congeners were derived from natural prey, whereas higher brominated congeners were derived from ingested plastics.

Facilitated Leaching of Additive-Derived PBDEs from Plastic by Seabirds' Stomach Oil and Accumulation in Tissues

Kosuke Tanaka,[†] Hideshige Takada,^{*,†} Rei Yamashita,[†] Kaoruko Mizukawa,[†] Masa-aki Fukuwaka,[‡] and Yutaka Watanuki[§]

[†]Laboratory of Organic Geochemistry, Tokyo University of Agriculture and Technology, Fuchu, Tokyo 183-8509, Japan

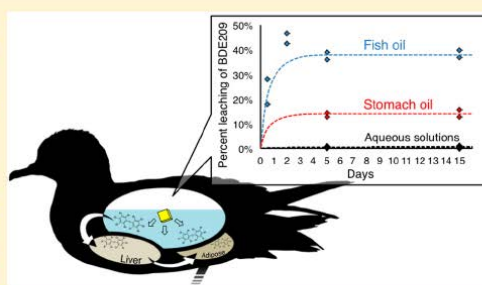
[‡]Hokkaido National Fisheries Research Institute, Fisheries Research Agency, Kushiro, Hokkaido 085-0802, Japan

[§]Faculty of Fisheries, Hokkaido University, Hakodate, Hokkaido 041-8611, Japan

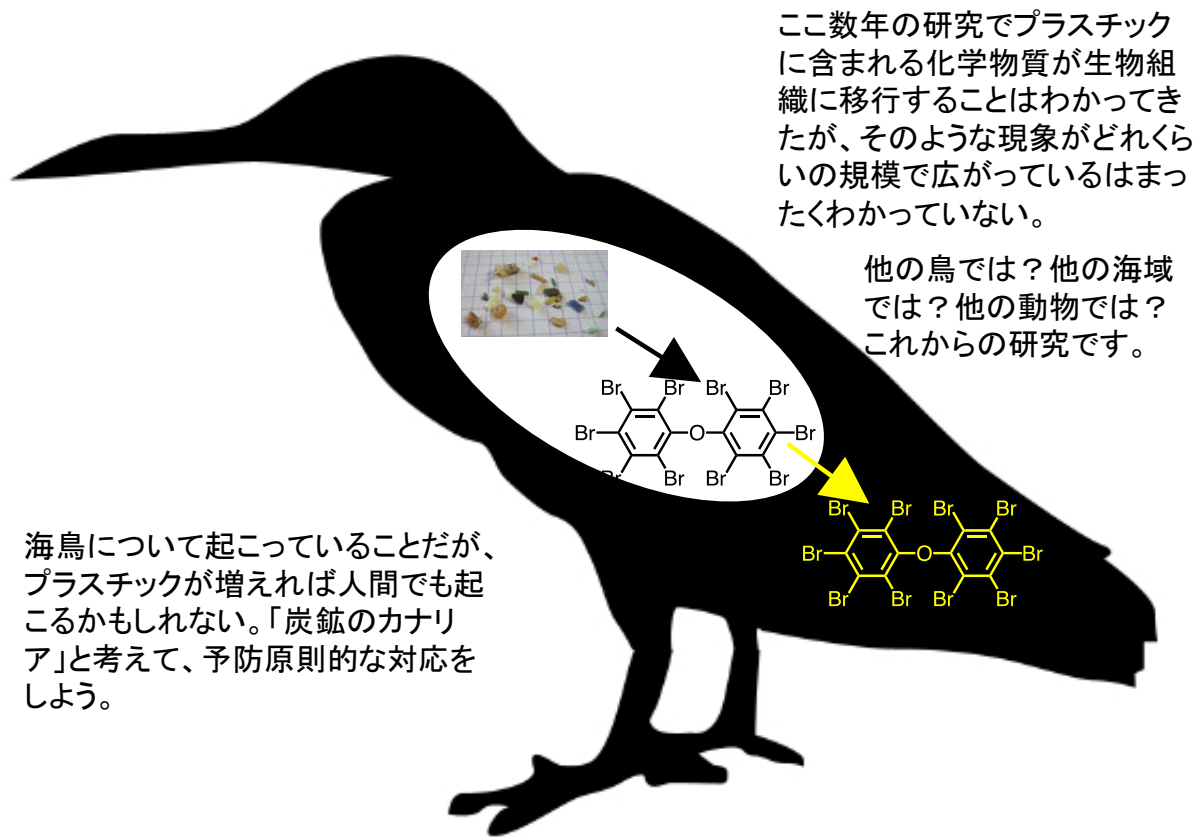
S Supporting Information

トロイの木馬

ABSTRACT: Our previous study suggested the transfer of polybrominated diphenyl ether (PBDE) flame retardants from ingested plastics to seabirds' tissues. To understand how the PBDEs are transferred, we studied leaching from plastics into digestive fluids. We hypothesized that stomach oil, which is present in the digestive tract of birds in the order Procellariiformes, acts as an organic solvent, facilitating the leaching of hydrophobic chemicals. Pieces of plastic compounded with deca-BDE were soaked in several leaching solutions. Trace amounts were leached into distilled water, seawater, and acidic pepsin solution. In contrast, over 20 times as much material was leached into stomach oil, and over 50 times as much into fish oil (a major component of stomach oil). Analysis of abdominal adipose, liver tissue, and ingested plastics from 18 wild seabirds collected from the North Pacific Ocean showed the occurrence of deca-BDE or hexa-BDEs in both the tissues and the ingested plastics in three of the birds, suggesting transfer from the plastic to the tissues. In birds with BDE209 in their tissues, the dominance of BDE207 over other nona-BDE isomers suggested biological debromination at the meta position. Model calculation of PBDE exposure to birds based on the results of the leaching experiments combined with field observations suggested the dominance of plastic-mediated internal exposure to BDE209 over exposure via prey.



生物に取り込んだプラスチックから化学物質は生物組織に移行する



プラスチックに含まれる化学物質による生物への影響

室内実験ではプラスチックに吸着した化学物質により、プラスチックを摂食した生物(メダカ、ゴカイ)の肝機能の障害が観測されている。

Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress

Chelsea M. Rochman¹, Eunha Hoh², Tomofumi Kurobe¹ & Swee J. Teh¹

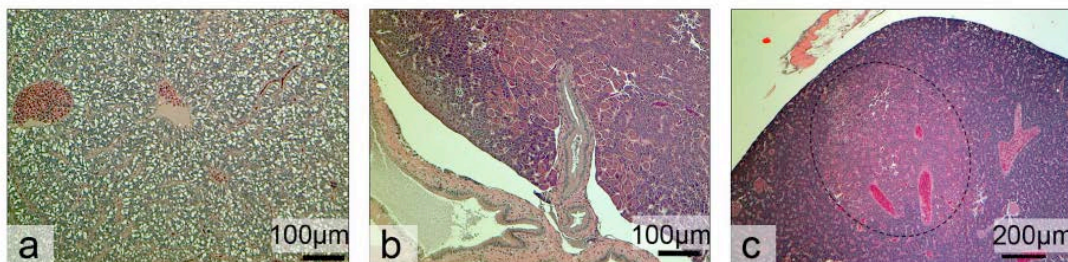


Figure 4 | Liver Histopathology in medaka sampled after 2 months. Micrographs show livers that are glycogen-rich from the control treatment (a) and glycogen-depleted from the virgin-plastic (b) and the marine-plastic treatment (c). An eosinophilic focus of cellular alteration, a precursor to a tumor, was observed in one fish from the virgin-plastic treatment (b). The circle highlights eosinophilic (pinkish coloration) hepatocytes, approximately twice as large as the basophilic (blue coloration) glycogen-depleted hepatocytes. The progression of neoplastic hepatocytes is evidence by the presence of a tumor, a hepatocellular adenoma, in one fish from the marine-plastic treatment (encircled in panel c).

プラスチック摂食がアカアシミズナギドリの 個体数減少と関連している可能性

ABSTRACT

To provide much needed quantitative data on the lethal and sublethal effects of plastic pollution on marine wildlife, we sampled breast feathers and stomach contents from Flesh-footed Shearwater (*Puffinus carneipes*) fledglings in eastern Australia. Birds with high levels of ingested plastic exhibited reduced body condition and increased contaminant load ($p < 0.05$). More than 60% of fledglings exceeded international targets for plastic ingestion by seabirds, with 16% of fledglings failing these targets after a single feeding (range: 0.13–3.21 g of plastic/feeding). As top predators, seabirds are considered sentinels of the marine environment. The amount of plastic ingested and corresponding damage to Flesh-footed Shearwater fledglings is the highest reported for any marine vertebrate, suggesting the condition of the Australian marine environment is poor. These findings help explain the ongoing decline of this species and are worrying in light of increasing levels of plastic pollution in our oceans.

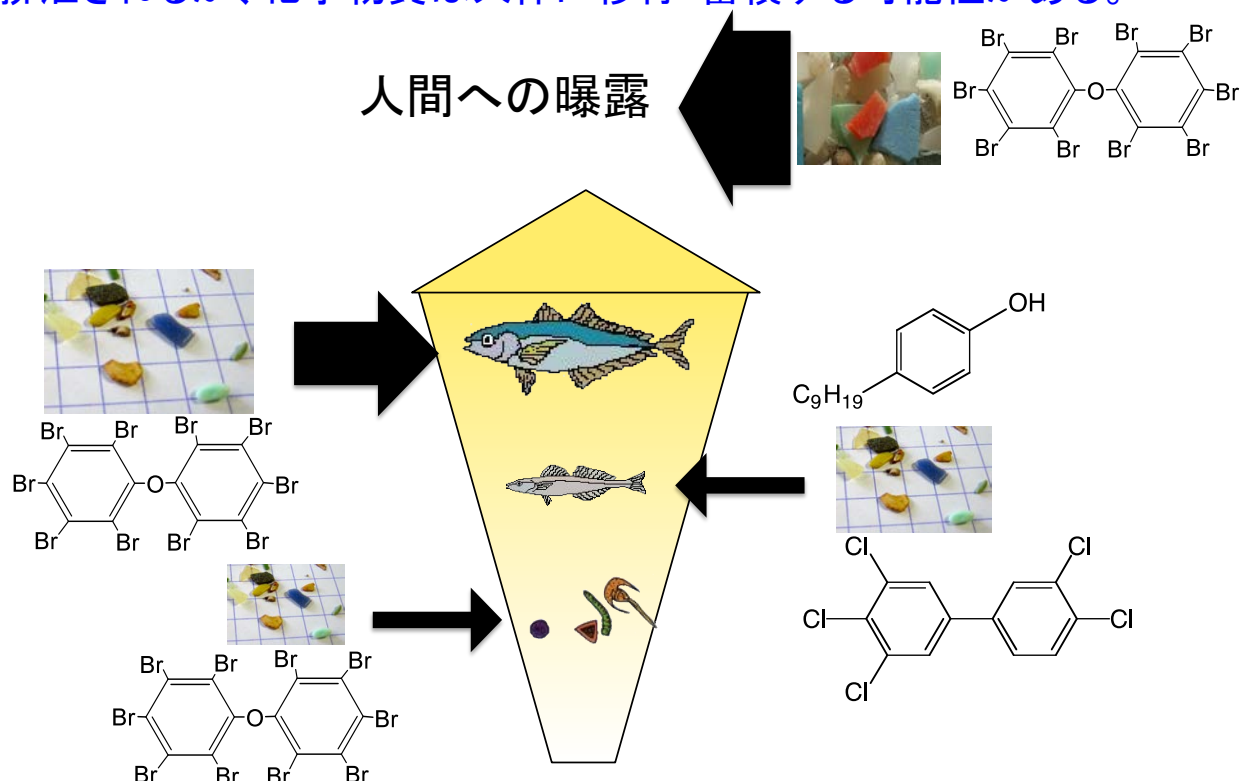
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海鳥についての話で、推定ですが、予防原則的に捉えましょう。

Lavers, J.L., Bond, A.L., and Hutton, I., 2014. Plastic ingestion by Flesh-footed Shearwaters (*Puffinus carneipes*): Implications for fledgling body condition and the accumulation of plastic-derived chemicals. *Environmental Pollution* 187, 124–129.

プラスチックの大きさに応じて食物連鎖の様々な生物に摂食され、化学物質も曝露する

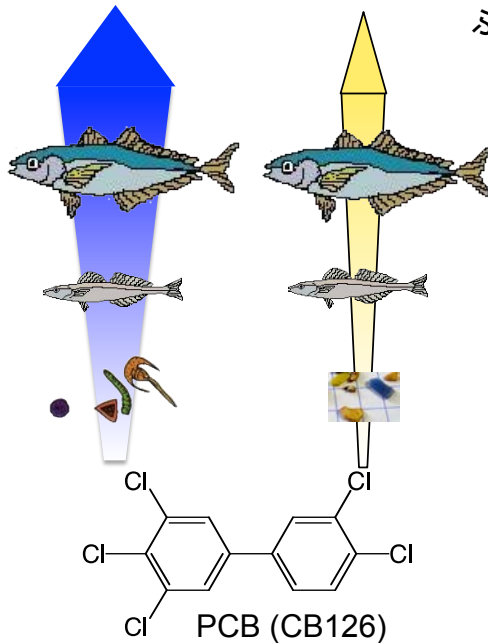
人間が魚貝類を通してプラスチックを食べても、プラスチック自体は排泄されるが、化学物質は人体に移行・蓄積する可能性がある。



しかし、魚貝類は餌からも汚染物質に曝露されている

ヒト

プラスチック微細片はプランクトンと同じように汚染物質を濃縮し、汚染物質を食物連鎖に運ぶ。



プラスチックに濃縮された汚染物質の量が少なければ、相対的には問題が少ない。

何も手を打たなければ、海に流入するプラスチックの量は20年後には10倍に増加する

Plastic waste inputs from land into the ocean

Jenna R. Jambeck,^{1*} Roland Geyer,² Chris Wilcox,³ Theodore R. Siegler,⁴ Miriam Perryman,¹ Anthony Andrady,⁵ Ramani Narayan,⁶ Kara Lavender Law⁷

Plastic debris in the marine environment is widely documented, but the quantity of plastic entering the ocean from waste generated on land is unknown. By linking worldwide data on solid waste, population density, and economic status, we estimated the mass of land-based plastic waste entering the ocean. We calculate that 275 million metric tons (MT) of plastic waste was generated in 192 coastal countries in 2010, with 4.8 to 12.7 million MT entering the ocean. Population size and the quality of waste management systems largely determine which countries contribute the greatest mass of uncaptured waste available to become plastic marine debris. Without waste management infrastructure improvements, the cumulative quantity of plastic waste available to enter the ocean from land is predicted to increase by an order of magnitude by 2025.

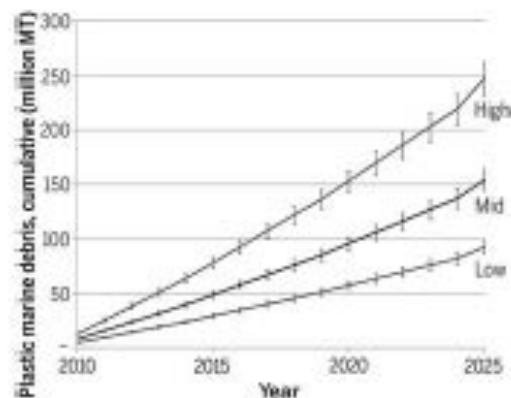
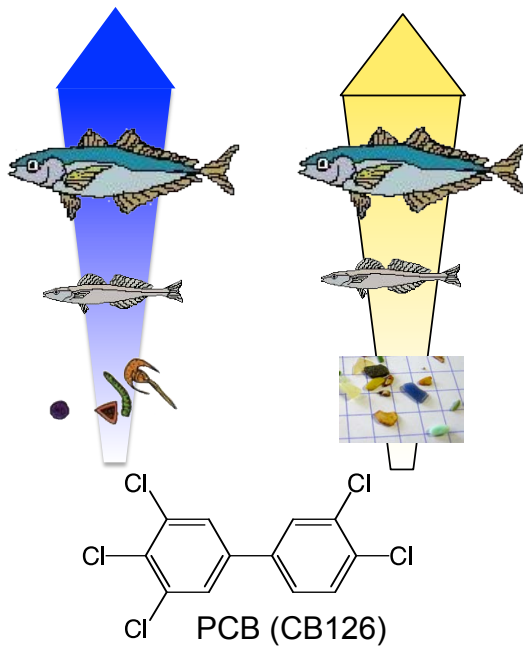


Fig. 2. Estimated mass of mismanaged plastic waste (millions of metric tons) input to the ocean by populations living within 50 km of a coast in 192 countries, plotted as a cumulative sum from 2010 to 2025. Estimates reflect assumed conversion rates of mismanaged plastic waste to marine debris (high, 40%; mid, 25%; low, 15%). Error bars were generated using mean and standard error from the predictive models for mismanaged waste fraction and percent plastic in the waste stream (12).

Jamebeck et al. (2015), Science

でも、このままの状態が続くと..
プラスチック微細片による暴露量>プランクトンによる暴露量になってしまう
可能性がある

ヒト



カタクチイワシから検出されたマイクロプラスチックの10%はマイクロビーズ



マイクロプラスチックはいろいろな起源から供給される

アジアではこれが一番多い(9割程度)

- プラスチック製品の破片
- 化学繊維
- レジンペレット
- マイクロビーズ(スクラブ)
- メラミンフォームスポンジ

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Accumulation of Microplastic on Shorelines Worldwide: Sources and Sinks

Mark Anthony Browne,^{*,†,‡,§} Phillip Crump,[¶] Stewart J. Niven,^{§,||} Emma Teuten,[§] Andrew Tonkin,[¶] Tamara Galloway,[⊥] and Richard Thompson[§]

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ABSTRACT: Plastic debris <1 mm (defined here as microplastic) is accumulating in marine habitats. Ingestion of microplastic provides a potential pathway for the transfer of pollutants, monomers, and plastic-additives to organisms with uncertain consequences for their health. Here, we show that microplastic contaminates the shorelines at 18 sites worldwide representing six continents from the poles to the equator, with more material in densely populated areas, but no clear relationship between the abundance of microplastics and the mean size-distribution of natural particulates. An important source of microplastic appears to be through sewage contaminated by fibers from washing clothes. Forensic evaluation of microplastic from sediments showed that the proportions of polyester and acrylic fibers used in clothing resembled those found in habitats that receive sewage-discharges and sewage-effluent itself. Experiments sampling wastewater from domestic washing machines demonstrated that a single garment can produce >1900 fibers per wash. This suggests that a large proportion of microplastic fibers found in the marine environment may be derived from sewage as a consequence of washing of clothes. As the human population grows and people use more synthetic textiles, contamination of habitats and animals by microplastic is likely to increase.



1回1着の洗濯で約2000本の細かな化学繊維(マイクロプラスチックの一種)が放出

洗顔剤や化粧品に配合されているマイクロビーズが下水道を通して、川、海、湖に入ってくる。

Microplastic pollution in the surface waters of the Laurentian Great Lakes



Marcus Eriksen^{a,*}, Sherri Mason^{b,1}, Stiv Wilson^{a,2}, Carolyn Box^{a,3}, Ann Zellers^{c,4}, William Edwards^{d,5}, Hannah Farley^{b,1}, Stephen Amato^a

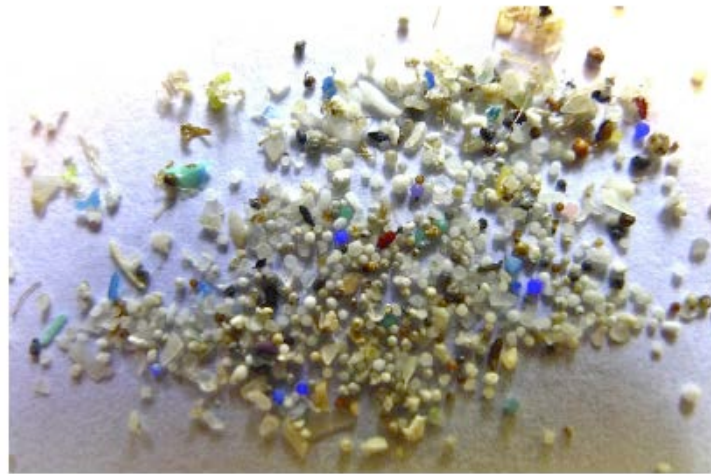


Fig. 3. Color variation among particles <1 mm from Sample 21.

アメリカではマイクロビーズの化粧品等への配合を禁止する法案が成立した。他の国でも同様に禁止の動き。日本でも規制すべきである。

Microplastic pollution in the surface waters of the Laurentian Great Lakes



Marcus Eriksen^{a,*}, Sherri Mason^{b,1}, Stiv Wilson^{a,2}, Carolyn Box^{a,3}, Ann Zellers^{c,4}, William Edwards^{d,5}, Hannah Farley^{b,1}, Stephen Amato^a

他人の顔の垢がついた
プラが自分の食べるもの
に入ってくることを許せますか？



Fig. 3. Color variation among particles <1 mm from Sample 21.

マイクロビーズは下水処理で分解されない

下水処理場では、95%～99%のマイクロビーズが沈殿除去される。放流水中に1Lあたり0～7個のマイクロビーズが検出された。

アメリカでは1日8兆個のマイクロビーズが河川や海へ放出されると推定。

Scientific Evidence Supports a Ban on Microbeads

Chelsea M. Rochman,^{*,†,‡} Sara M. Kross,^{†,§} Jonathan B. Armstrong,^{†,||,ⓧ} Michael T. Bogan,^{†,⊥,ⓧ}
Emily S. Darling,^{†,#,ⓧ} Stephanie J. Green,^{†,||,ⓧ} Ashley R. Smyth,^{†,▲,ⓧ} and Diogo Veríssimo^{†,▼,ⓧ}

しかし、雨天時には沈殿除去されず、もっと大量のマイクロビーズが河川や海へ放出される。

雨天時の下水の越流(マイクロビーズの供給)は東京湾岸では年間70日ほど起こっている(水川・高田, 2015)

マイクロプラスチックはいろいろな起源から供給される

- プラスチック製品の破片
- 化学繊維
- レジンペレット
- スクラブ(マイクロビーズ)
- メラミンフォームスポンジ

削れたスポンジくずも微生物分解されずに環境に残留する

砂浜はマイクロプラスチックの生成場所＝小さくなる前に取りのぞこう

海岸清掃は大事です

Generating microplastics

One 62 litre buoy



7,600,000
microplastics
(2.5 mm diameter)

7.6 x 10²¹
nanoplastics
(250 nm diameter)

Example of regional difference in source and fate: large-scale use of expanded polystyrene (EPS) buoys for aquaculture in Korea



EPS buoys © Korea National Marine Debris Monitoring program; EPS microplastics - © Peter Kershaw

マイクロプラスチックの表面には微生物が付着する

Life in the "Plastisphere": Microbial Communities on Plastic Marine Debris

Erik R. Zettler,^{†,||} Tracy J. Mincer,^{‡,*||} and Linda A. Amaral-Zettler^{§,*||}

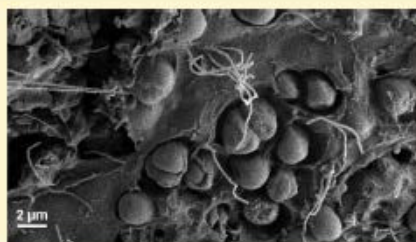
[†]Sea Education Association, P.O. Box 6, Woods Hole, Massachusetts 02543, United States

[‡]Marine Chemistry & Geochemistry, Woods Hole Oceanographic Institution, 266 Woods Hole Rd., MS# 51, Woods Hole, Massachusetts 02543, United States

[§]The Josephine Bay Paul Center for Comparative Molecular Biology and Evolution, Marine Biological Laboratory, 7 MBL Street, Woods Hole, Massachusetts 02543, United States

Supporting Information

ABSTRACT: Plastics are the most abundant form of marine debris, with global production rising and documented impacts in some marine environments, but the influence of plastic on open ocean ecosystems is poorly understood, particularly for microbial communities. Plastic marine debris (PMD) collected at multiple locations in the North Atlantic was analyzed with scanning electron microscopy (SEM) and next-generation sequencing to characterize the attached microbial communities. We unveiled a diverse microbial community of heterotrophs, autotrophs, predators, and symbionts, a community we refer to as the "Plastisphere". Pits visualized in the PMD surface conformed to bacterial shapes suggesting active hydrolysis of the hydrocarbon polymer. Small-subunit rRNA gene surveys identified several hydrocarbon-degrading bacteria, supporting the possibility that microbes play a role in degrading PMD. Some Plastisphere members may be opportunistic pathogens (the authors, unpublished data) such as specific members of the genus *Vibrio* that dominated one of our plastic samples. Plastisphere communities are distinct from surrounding surface water, implying that plastic serves as a novel ecological habitat in the open ocean. Plastic has a longer half-life than most natural floating marine substrates, and a hydrophobic surface that promotes microbial colonization and biofilm formation, differing from autochthonous substrates in the upper layers of the ocean.

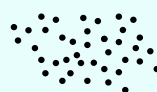


微細マイクロプラスチックは海底に沈む

マイクロ
プラスチック

マイクロ
プラスチック

微細化



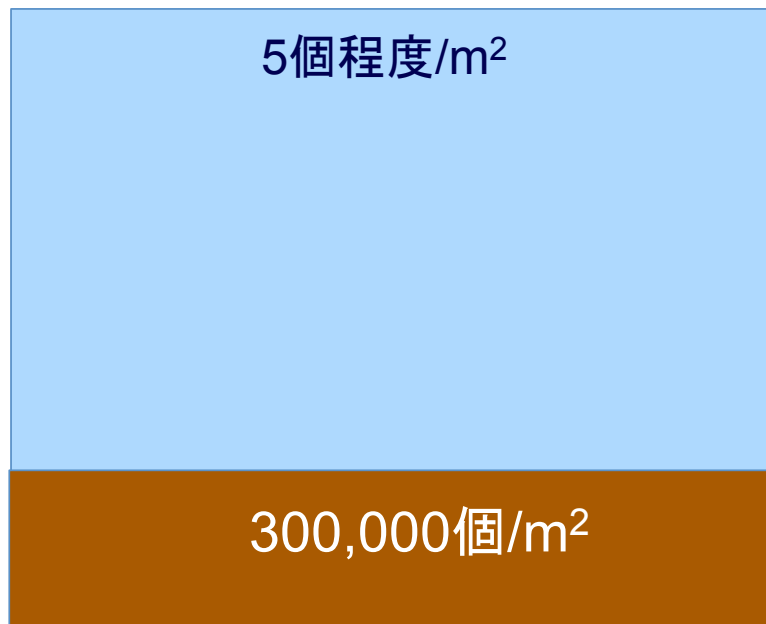
一部が
沈降・堆積

マイクロプラスチックの表面に微生物が付着することによって、重くなったマイクロプラスチックは海底に沈む。

海底/堆積物



海底の泥の中には海面に浮いているもの(5個/m²)に比べて、
大量のマイクロプラスチック(300,000個/m²)が堆積している
: 東京湾運河部の場合



皇居の桜田壕で採取した柱状堆積物を分析すると、江戸時代の層からはもちろんプラスチックは検出されないが、1950年代からプラスチックが検出されはじめ、2000年代には急増している。



2005-2013



残留性の高いプラスチックは地質学的なスケールでの人間活動の痕跡になっている

EARTH HISTORY

The Anthropocene is functionally and stratigraphically distinct from the Holocene

Colin N. Waters,^{1*} Jan Zalasiewicz,² Colin Summerhayes,³ Anthony D. Barnosky,⁴ Clément Poirier,⁵ Agnieszka Gałuszka,⁶ Alejandro Cearreta,⁷ Matt Edgeworth,⁸ Erle C. Ellis,⁹ Michael Ellis,¹ Catherine Jeandel,¹⁰ Reinhold Leinfelder,¹¹ J. R. McNeill,¹² Daniel deB. Richter,¹³ Will Steffen,¹⁴ James Syvitski,¹⁵ Davor Vidas,¹⁶ Michael Wagreich,¹⁷ Mark Williams,² An Zhisheng,¹⁸ Jacques Grinevald,¹⁹ Eric Odada,²⁰ Naomi Oreskes,²¹ Alexander P. Wolfe²²

チャールズモア船長が太平洋巨大渦流にプラスチックゴミだまりを発見(1997)



写真はCharles Mooreさんから市民講座等で使うことを条件にコピーさせていただいているものです。

プラスチックが海洋環境 中で有害化学物質の 運び屋になる

我々の2001年の論文

Environmental Science & Technology
2001, vol.35, 318-324



顕微鏡サイズのプラスチックが海洋環境中で発見される (2004年)

7 MAY 2004 VOL 304 SCIENCE www.sciencemag.org

Lost at Sea: Where Is All the Plastic?

Richard C. Thompson,^{1*} Ylva Olsen,¹ Richard P. Mitchell,¹
Anthony Davis,¹ Steven J. Rowland,¹ Anthony W. G. John,²
Daniel McGonigle,³ Andrea E. Russell³

2005年、ロングビーチで海洋プラスチックの
国際シンポジウムが開催された



インターナショナルペレットウォッチも2005年に開始



Available online at www.sciencedirect.com

ScienceDirect

Marine Pollution Bulletin 52 (2006) 1547–1548



Since 2005

Editorial

Call for pellets! International Pellet Watch Global Monitoring of POPs using beached plastic resin pellets

On our beaches, we see various quantities of many materials (e.g., seaweed, driftwood, trash, plastic fragments, cigarette ends) along the high-tide line. Among them, we can commonly find plastic resin pellets. Recently we have started a global monitoring programme of persistent organic pollutants (POPs) using these stranded plastic resin pellets (International Pellet Watch: <http://www.iuat.ac.jp/~gaia/ipw/index.html>).

Plastic resin pellets are small granules, generally with shape of a cylinder or a disk with a diameter of a few mm (Fig. 1). These plastic particles are the industrial raw material of plastics which are transported to manufacturing sites where "user plastics" are made by re-melting the pellets and molding them into the final products. Resin pellets can be unintentionally released to the environment, both during manufacturing and transport. The released resin pellets are carried by surface run-off, streams and river waters, eventually leading to the ocean. Because of their environmental persistence, they are distributed widely in

the ocean and are now found on beaches all over the world. In 2001, we revealed the existence of various organic micro-pollutants (i.e., polychlorinated biphenyls: PCBs, DDE, and nonylphenol) in these stranded plastic resin pellets collected on beaches (Mato et al., 2001).

Because of the hydrophobic nature of the plastic surfaces, hydrophobic pollutants such as PCBs and DDTs are adsorbed to the pellets from the surrounding seawater with concentration factors of up to 10^5 . We observed a weak correlation between PCB concentrations in plastic resin pellets collected on beaches with levels in traditional monitoring media (i.e., mussels), although large piece-to-piece variability of PCB concentrations was also observed (Endo et al., 2005). Because the resin pellets are distributed on beaches the world over, and because collection and shipping of the pellets are easy, we propose global monitoring of persistent organic pollutants (POPs) using these beached plastic resin pellets.

In the International Pellet Watch project, we ask people from all countries to collect plastic resin pellets on their nearby beaches and send them to our laboratory via air-mail. No cooling nor freezing is necessary during shipment. People just need to put the pellets into a paper envelope and post it to us. To get representative data, we need 100–200 pieces of pellets (preferably yellowed pellets) from each location. Organic micro-pollutants in the pellets will be analyzed in our laboratory. Based on the analytical results, global distributions of these organic micro-pollutants will be mapped. Results will be sent to the participants through e-mail and will be released on the web as well.

The purpose of International Pellet Watch is to understand the current status of global POPs pollution, and the advantage of Pellet Watch is its extremely low cost of sampling and shipping as compared with conventional monitoring using water, sediment and biological samples. Further, we can draw global POPs pollution maps for a very low cost. Already several NGOs who conduct beach clean-up projects are helping with sample collection.

So far, our spatial coverage is very limited and of course the strength of the programme will be related to the coverage



Fig. 1. Plastic resin pellets.

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doi:10.1016/j.marpolbul.2006.10.019

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サイエンスに「海洋プラスチック汚染の新しい展開」を掲載

New Directions in Plastic Debris

RICHARD THOMPSON,^{1*} CHARLES MOORE,²
ANTHONY ANDRADY,³ MURRAY GREGORY,⁴
HIDESHIGE TAKADA,⁵ STEPHEN WEISBERG⁶

Science, 2005

アメリカの行政機関も国際ワークショップを開催



2007, Tacoma, WA

TacomaのNOAAのワークショップで5mm以下のプラスチックをマイクロプラスチックと呼ぶことを定義した。この定義はその後のGESAMPの定義に引き継がれている。



ワークショップ後、Indian Pale AleをRichardといただく。
やはりビールはグラスで飲みたい。ペットボトルのビールには断固反対。

2010 June GESAMP Workshop Paris

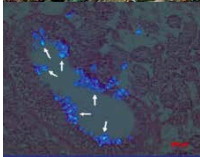
GESAMP：海洋環境保護
の科学的事項に関する専
門家合同グループ



GESAMP
Joint Group of Experts on the
Scientific Aspects of Marine
Environmental Protection

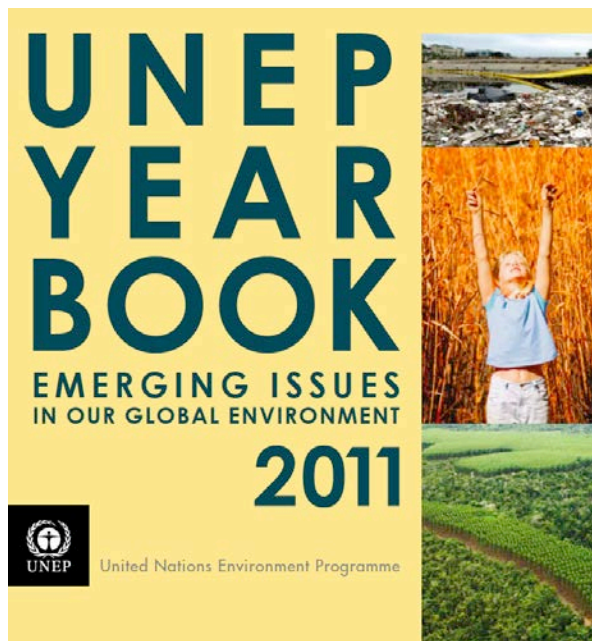
Proceedings of the GESAMP International Workshop on Microplastic particles as a vector in transporting persistent, bio- accumulating and toxic sub- stances in the ocean





国際機関も海洋プラスチック汚染に注目

国連環境計画の年鑑



Plastic Debris in the Ocean

Every year large amounts of plastic debris enter the ocean, where it slowly fragments and accumulates in convergence zones. Scientists are concerned about the possible impacts of small plastic fragments—microplastics—in the environment. The role of plastics as a vector for transporting chemicals and species in the ocean is as yet poorly understood, but it is a potential threat to ecosystems and human health. Improved waste management is the key to preventing plastic and other types of litter from entering the ocean.

Box 3: Plastic pellets

Plastic resin pellets are small granules, generally in the shape of a cylinder or disc, with a diameter of a few millimetres. These particles are an industrial raw material that is remelted and moulded into final products. They enter the ocean as a result of spills or accidental releases. Like other plastic particles, they have been shown to accumulate PBTs. In the case of thin plastic films, for example those 50 micrometres or less, it may take only a few days for this process of accumulation or release to occur (Adams et al. 2007). In the case of pellets, equilibrium between the concentration of a given compound in a pellet and in the surrounding water or sediment may take many weeks or months. Older pellets consequently tend to have higher concentrations of contaminants and have been used to map the distribution of pollution in coastal waters around the world (Ogata et al. 2009, International Pellet Watch 2011) (Figure 5). Their consistent size makes them a useful monitoring tool.

Transport by plastic particles does not represent a significant additional flux of PBTs on a global scale compared with atmospheric or water transport (Zarif and Matthies 2010). However, the concentration of contaminants by microplastic particles presents the possibility of increasing exposure to organisms through ingestion and entrance into the food chain—with the prospect of biomagnification in top-end predators in the food chain such as swordfish and seals. Ingestion of small particles by a wide variety of organisms has been well reported. However, the basic information needed on the biochemical and physiological response of organisms to ingested plastics contaminated with PBTs in order to quantify the scale of the problem is currently unavailable (Arthur et al. 2009, GESAMP 2010). It is conceivable that PBTs in plastic particles will be less bioavailable than those from the surrounding water or food sources (Soun et al. 2011).



Collected from beaches around the world, plastic pellets like these have been found to accumulate persistent, bio-accumulating and toxic substances. The pellets are used in the manufacture of plastic products and have been introduced into the ocean through accidental releases. They may also be released as a result of poor handling or waste management. While there is evidence that quantities entering the marine environment have been reduced as a result of improved industrial practices, pellets already released will persist for many years. Credit: International Pellet Watch

Figure 5: Concentration of PCBs in beached plastic resin pellets, in nanograms per gram of pellet. Samples of polystyrene pellets have been collected at 50 beaches in 29 countries and analyzed for concentrations of organochlorine compounds. PCB concentrations were highest in pellets collected in the United States, Western Europe and Japan. They were lowest in those collected in tropical Asia and Africa. This spatial pattern reflects regional differences in the use of PCBs. Source: Ogata et al. (2009) with additional data provided by International Pellet Watch in 2010



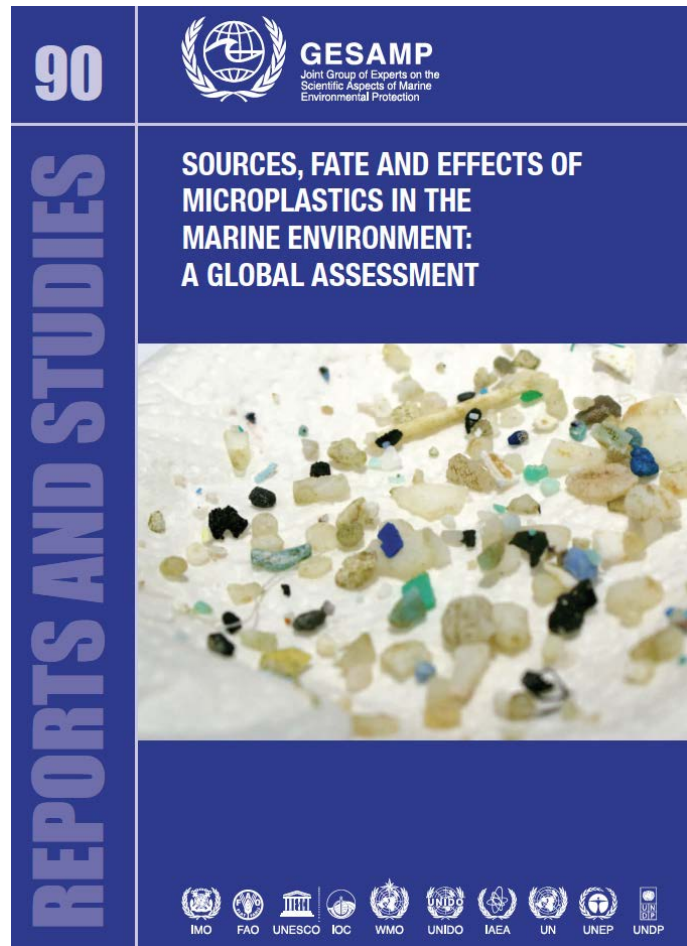
GESAMP

(Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection of IMO/FAO/UNESCO/WHO/IAEA/UN/UNEP)

海洋環境保護の科学的
事項に関する専門家合
同グループ

WG40 Microplastic

2012-2014



海産物への侵入も含めた国際的な懸念が高まっている

GESAMP
国連海洋汚染専門家会議

2015年4月21-23日





Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

East Asian seas: A hot spot of pelagic microplastics

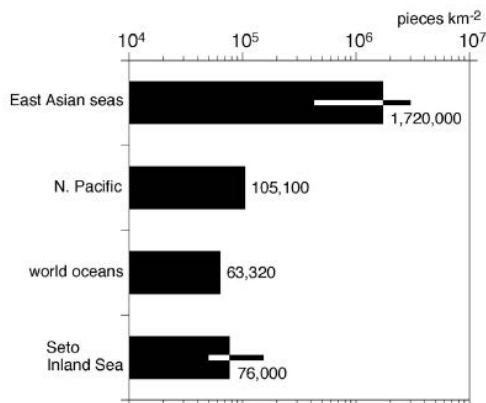
Atsuhiko Isobe ^{a,*}, Keiichi Uchida ^b, Tadashi Tokai ^b, Shinsuke Iwasaki ^a^a Research Institute for Applied Mechanics, Kyushu University, 6-1 Kasuga-koen, Kasuga, Fukuoka 81-8580, Japan^b Department of Ocean Sciences, Tokyo University of Marine Science and Technology, 4-5-7 Konan, Minato-ku, Tokyo 108-8477, Japan

Fig. 4. Comparison of total particle counts computed in four areas. The total particle counts are shown by digits as well as bar heights. Superimposed on the bars of the East Asian seas and the Seto Inland Sea is the margin of error evaluated by a t-test with a 95% confidence interval.

Plastic waste inputs from land into the ocean

Jenna R. Jambeck,^{1*} Roland Geyer,² Chris Wilcox,³ Theodore R. Siegler,⁴
 Miriam Perryman,¹ Anthony Andrady,⁵ Ramani Narayan,⁶ Kara Lavender Law⁷

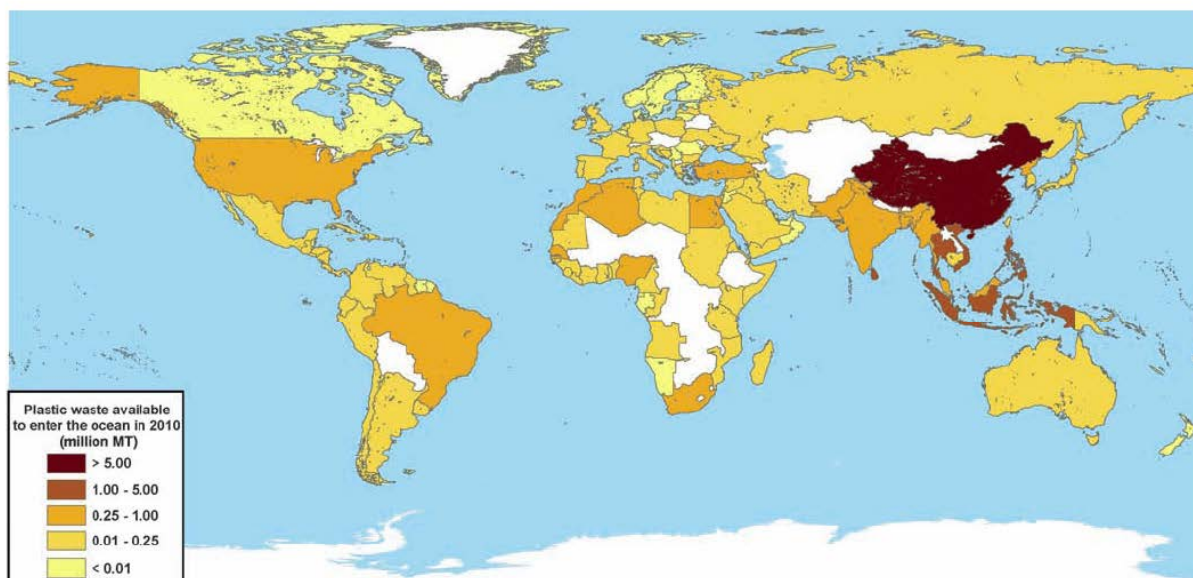


Fig. 1. Global map with each country shaded according to the estimated mass of mismanaged plastic waste [millions of metric tons (MT)] generated in 2010 by populations living within 50 km of the coast. We considered 192 countries. Countries not included in the study are shaded white.

COMMENT

ECODESIGN Olympic velodrome engineer builds with nature p.172



ECODESIGN Materials makers on how to do more with less p.174

THEATRE New York play explores why Isaac Newton stuck a needle in his eye p.175

METRICS Some altmetrics are too easy to game so lack credibility p.176

ILLUSTRATION



海へ流入するプラスチックを減らす必要がある。



Volunteer cleaners negotiate a Bulgarian reservoir jammed with plastics.

Policy : Classify plastic waste
as hazardous

海のプラスチックごみの大半は陸上で使われたプラスチック製品

ゴミ収集の徹底、リユース・リサイクルの技術革新と促進

プラスチックや有害化学物質が環境へ出ることのない最終
処分技術の開発、など廃棄物管理の仕組み作り・技術革新

プラスチックによる汚染低減のために

- ・3Rの3つのRにも優先順位がある

Reduce > Reuse > Recycle

削減 > 再利用 > リサイクル

- ・プラスチック、
特に使い捨てのものの使用を極力避ける。

レジ袋、ペットボトル飲料、コンビニ弁当等

No single-use plastic!

プラスチックによる汚染低減のために

2014年8月：米カリフォルニア州でレジ袋禁止の法案成立

2014年11月：EUが加盟国へレジ袋削減案策定を義務づけ

2025年までにレジ袋の消費を

1人1年40枚まで削減がEUの目標

日本では年間300億枚以上のレジ袋が使われている。

1人あたりでは年間300枚

日本でもレジ袋は禁止、せめて有料化が必要

リサイクルだけで海へのプラスチックの流入を防げるか？

リサイクル率も100%ではなく、多く使えば、それだけ、リサイクルを逃れ環境を汚染するプラスチックの量も多くなります。例えば、関東の荒川流域の河岸環境保全のNGOは2012年だけでも、約30,000本のペットボトルを河原から回収しています。1つの河川でこの数です。

リサイクルは持続的か？

年間3億トンのプラスチックが生産されている。

石油産出量の8%がプラスチックに

4%: 原材料

4%: 製造・加工のエネルギー

+ リサイクルするためのエネルギー

例えば、人口22万人の市でリサイクルのためにペットボトル、プラゴミを収集・運搬する費用として、それぞれ年間1億円、2億円かかる。

リサイクルは持続的な解決策ではない

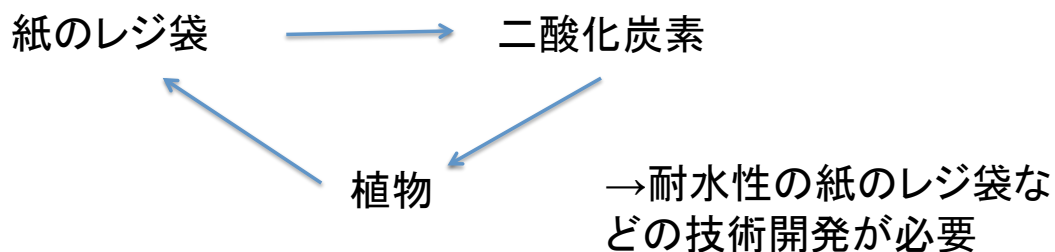
→プラスチック自体を減らす必要がある

もちろん燃やすことは危険で、持続的でない

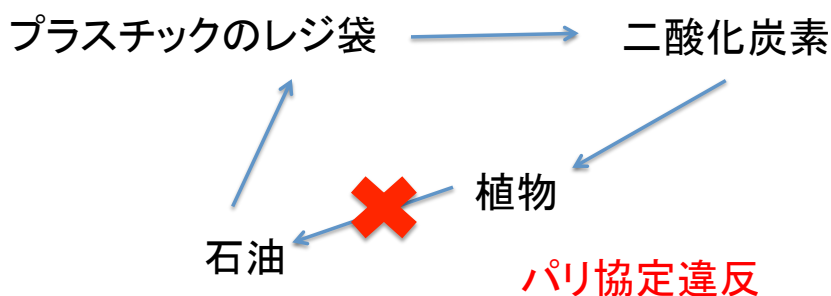
40万人の都市のゴミを焼却するためには、**焼却炉の建設に100億円**かかり、**運転には年間2億円以上**かかります。**焼却炉の寿命は30年程度**ですので、また30年後に100億円の建設費を用意しなければいけません。現在の技術力をもってすれば、有害物質を煙として排出しない焼却炉の建設は可能です。しかし、費用が膨大にかかります。海外では、バグフィルタの交換費が払えずに、停止しているゴミ焼却炉もあるということです。

さらに、古い焼却炉の解体も必要で、**高濃度のダイオキシンや重金属が含まれ廃焼却炉の解体にはさらに莫大な費用**がかかりますし、危険性も伴います。持続可能な方法でしょうか？莫大な借金と危険物を将来の人類に押しつけてよいのでしょうか？

循環型



一方通行、温暖化が進む



ほんの少しの利便性のために、将来の人類に汚染を残してよいのでしょうか？ ペットボトルの飲みものを買う前、コンビニで弁当を買う前、スーパーでレジ袋をもらってしまう前に、もう一度、それがほんとうに必要なのか？ 環境汚染・環境負荷の少ない代替物はないのか？ と考えていただきたいと思います。