Plastic Marine Debris:
An in-depth look

Introduction

One of the main types of marine debris that you hear about today is plastic marine debris. In many places, it is the main type of debris that you will see as you walk along a beach, though perhaps not underwater. Below you will find detailed, science-based information on plastic marine debris.

A trained NOAA diver among floating marine debris, primarily plastics, near Hanauma Bay, HI. *Photo coutesy of NOAA PIFSC CRED.*

Quantification

Monitoring Large Debris

Currently, no one knows how much plastic marine debris enters the ocean each day. Some estimates exist, but none are confirmed. To better understand the impacts of marine debris, we need to know quantity and debris type. NOAA has begun a project to monitor beaches and surface waters for all debris types, including plastics. We hope to eventually expand this monitoring to include the seafloor, water column, and sediments.

Counting Microplastic Debris

What about the plastic debris pieces that are too small to count while at the beach? A laboratory method is needed to count small plastics <5mm in length, known as *microplastics*. Researchers at the University of Washington Tacoma have developed a reliable method to quantify microplastics (by weight) in a sand, sediment, or water sample. It has also been used to quantify plastics used in personal care products, such as facial cleansers and scrubs that use tiny plastics as abrasives. New research continues into a process to isolate microplastic particles and confirm their polymer composition (i.e., type of plastic) through infrared spectroscopy.

Plastic marine debris of all sizes, iincluding microplastics, found in sand.

Degradation

Eventually, plastics will *degrade* into small pieces. This process takes longer in the ocean than on land due to lower temperatures. The rate of degradation depends on chemical composition, molecular weight, additives, environmental conditions, and other factors (Singh and Sharma 2008). Full degradation into carbon dioxide, water, and inorganic molecules is called *mineralization* (Andrady 2003). Based on research to date, most commonly used plastics do not mineralize in the ocean and instead break down into smaller and smaller pieces.

Bio-Based Plastics

There are some bio-based (e.g., corn, wheat, tapioca, algae) plastics on the market and in development. Bio-based plastics use a renewable carbon source instead of traditional plastics that source carbon from fossil fuels. Bio-based plastics are the same in terms of polymer behavior and do not degrade any faster in the environment.

Biodegradable Plastics

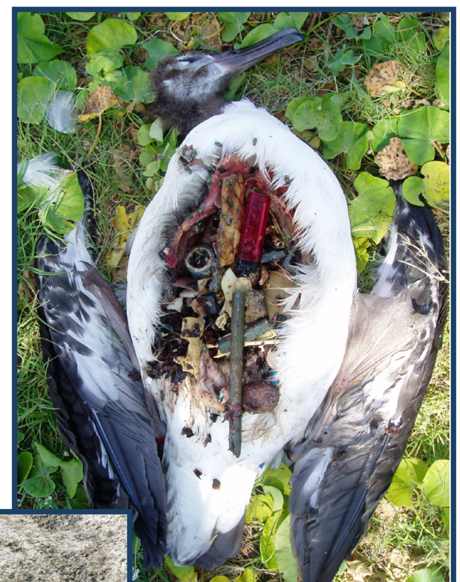
Biodegradable plastics are designed to break down in a compost pile or landfill where there are high temperatures and suitable microbes to assist degradation. However, these are generally **not** designed to degrade in the ocean at appreciable rates.

Impacts

Plastic debris has the potential to harm wildlife in two main ways: direct and indirect impacts. While localized impacts have been studied, there are still many questions to answer concerning the large-scale, population-level impacts of plastic debris on marine organisms.

Direct Impacts – Ingestion

Studies have shown that marine life, including sea birds, sea turtles, fish, marine mammals, and sharks,eat plastic (Auman et al. 2004; Barreiros and Barcelos 2001; Baird and Hooker 2000; Boerger et al. 2010; Cliff et al. 2002; Possatto et al. 2011); however, no study has yet described in detail the physical damage caused by ingestion (eating) of the plastic. Plastics could cause irritation or damage to the digestive system. The ingestion of inert, indigestible marine debris has been documented to result in obstruction of the digestive tract, mouth, and stomach lining of various species (Derraik 2002). Some obstructions can prevent organisms from taking in food, which can result in nutrient deficiency and eventual starvation (Pierce, Harris et al. 2004). If plastics are kept in the gut instead of passing through, the fish could feel full (of plastic not food) and this could lead to malnutrition or starvation. The accumulation of indigestible material has been shown to dilute nutrient uptake and energy gains in post-hatchling and juvenile loggerheads (McCauley and Bjorndal 1999).



Seabirds (above), such as the Laysan albatross, may ingest plastic debris, which can lead to death. *Photo courtesy of C. Fackler, NOAA ONMS.* Other marine animals like the endangered Hawaiian monk seal (left), may become entangled or studk in plastic marine debris. *Photo courtesy of NOAA PIFSC, permit # MMPA-ESA848-1365.*

Direct Impacts – Entanglement

Today, many fishing gear items are made of plastic, including nets, pots, and traps. Because of this, they last a long time when lost or discarded in the marine environment. Sitting at the bottom of the ocean or floating near the surface, these derelict fishing gear items pose an entanglement risk to marine species of all types (Laist, 1997). Entanglement can cause death due to drowning, starvation, physical damage and maiming; it presents issues of limited mobility, which can lead to laceration, infection, and potential mortality; and entangled animals can be seen as easy prey by predators, Designed to trap and catch marine life, derelict fishing gear debris continues to indiscriminately entangle and trap target and non-target organisms. This is known as *ghostfishing* and occurs with derelict nets (entanglement) and derelict fishing traps (entrapment). Ghostfishing removes target species from the population available to fishermen. In turn, this impacts both fisheries resources and economies.

Indirect Impacts – Pollutants

Plastic debris accumulates persistent organic pollutants (POPs)such as PCBs (polychlorinated biphenyls) up to 100,000 to 1,000,000 times the levels found in seawater (Mato et al. 2001). Oceanic fragments have also tested positive for other POPs, such as DDT, PAHs, and aliphatic hydrocarbons (Rios, Moore et al. 2007). Many of these pollutants, such as PCBs and DDTs, are known endocrine disruptors and developmental toxicants. Teuten et al. (2009) demonstrated that it is possible for PCBs to transfer from contaminated plastic into the tissue of chicks, where PCB concentrations in preen gland oil demonstrated a non-significant increase until full depuration after 42 days.

Small plastic debris collected during plankton sampling in the Pacific Ocean. *Photo courtesy NOAA Okeanos Explorer Program.*

All chemicals have many non-point sources to the marine environment. This makes it difficult to determine the contributions of plastic debris pollutants to concentrations in marine species. The potential transfer of chemicals throughout the food chain and the implications for the bioaccumulation with humans is a valid concern (vom Saal, Parmigiani et al. 2008), though the science is not clear on the added risk that plastic debris contributes to the availability and transfer of chemicals in the marine food web.

Participants of the 2008 international research workshop.

International Research Workshops

The NOAA Marine Debris Program and the University of Washington Tacoma (UWT) coordinated two meetings to stimulate scientific discourse about microplastic debris.

The first research workshop (September 9-10, 2008) had the goals of starting a global dialog, synthesizing what was then known about microplastics in the marine environment, and discussing possible research initiatives.

The second research workshop (November 5-6, 2010) focused on framing the microplastics debate in a risk assessment framework.

www.MarineDebris.noaa.gov

For more information visit

www.MarineDebris.noaa.gov/projects/microplastic.html
www.MarineDebris.noaa.gov/info/plastic.html

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