

Microplastics and food security

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How microplastics enter the food chain

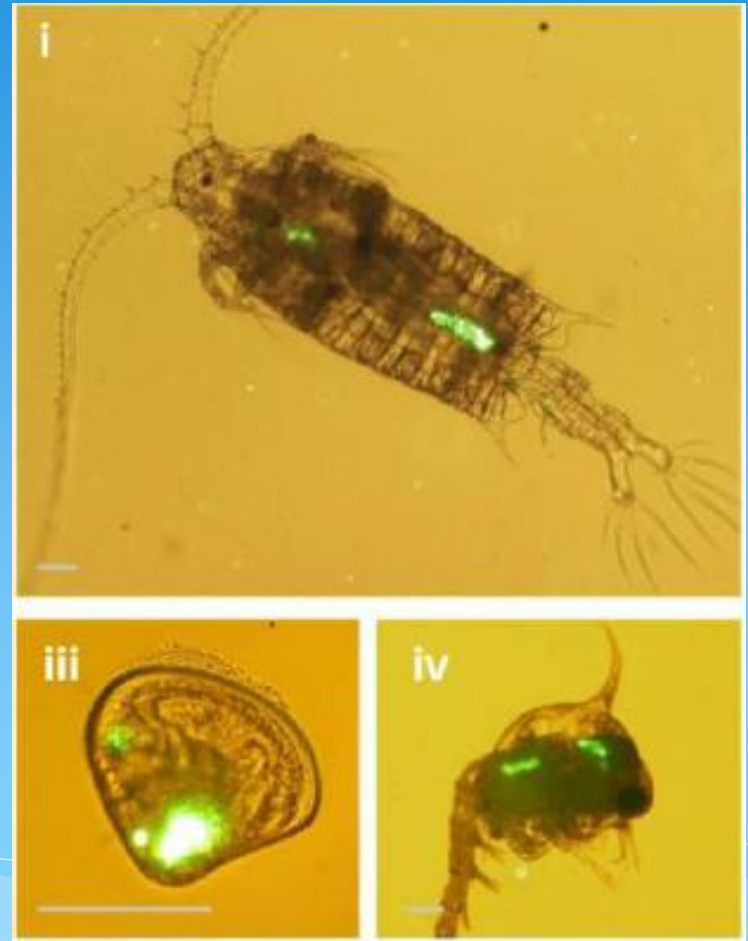
Microplastics are available to a wide range of organisms because of their small size and presence in both pelagic and benthic environments.

Low density particles in the water column are filtered out by suspension feeders. Higher density particles in sediment are available to deposit feeders.

Microplastics are easily ingested by marine invertebrates that feed indiscriminantly and cannot differentiate between plastic particles and food.

Uptake by suspension feeders

Laboratory studies (Cole et al, 2013; Setälä et al, 2014) have shown that zooplankton such as copepods, rotifers, ciliates, cladocerans and bivalve, decapod and polychaete larvae can ingest polystyrene microbeads up to a diameter of $31\mu\text{m}$.



The blue mussel *Mytilus edulis* can ingest microplastic particles from 2-10 μ m (Browne et al, 2008). Over 3 days the particles were shown to translocate from the gut to the circulatory system and were still present after 48 days.

Smaller fragments were more abundant than larger fragments suggesting that as the plastic disintegrates the potential for accumulation within the tissue of an organism increases.



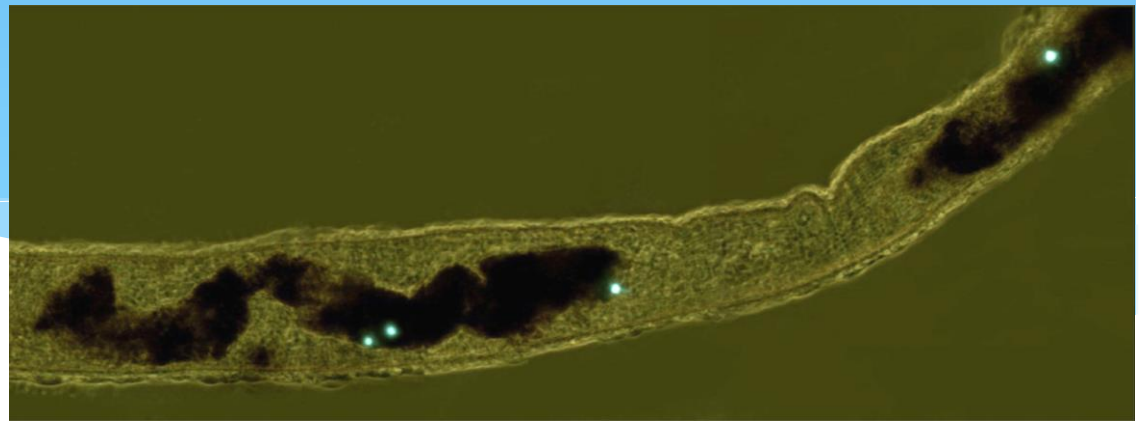
Uptake by deposit feeders

Detritivores such as deposit-feeding sea cucumbers that feed off the biofilm and organic matter that accumulate on the sea floor can ingest plastic particles present in the sediment (Graham & Thompson, 2009). Their research suggests that the sea cucumbers may even selectively ingest these particles.



Transfer through the food chain

Microplastics can be transferred between trophic levels in the food chain. In the study by Setälä et al (2014) copepods that had ingested plastic microbeads were subsequently eaten by mysid shrimps. This showed that microplastics could be transferred through the planktonic food web from a lower trophic level (mesozooplankton) to a higher trophic level (macrozooplankton).

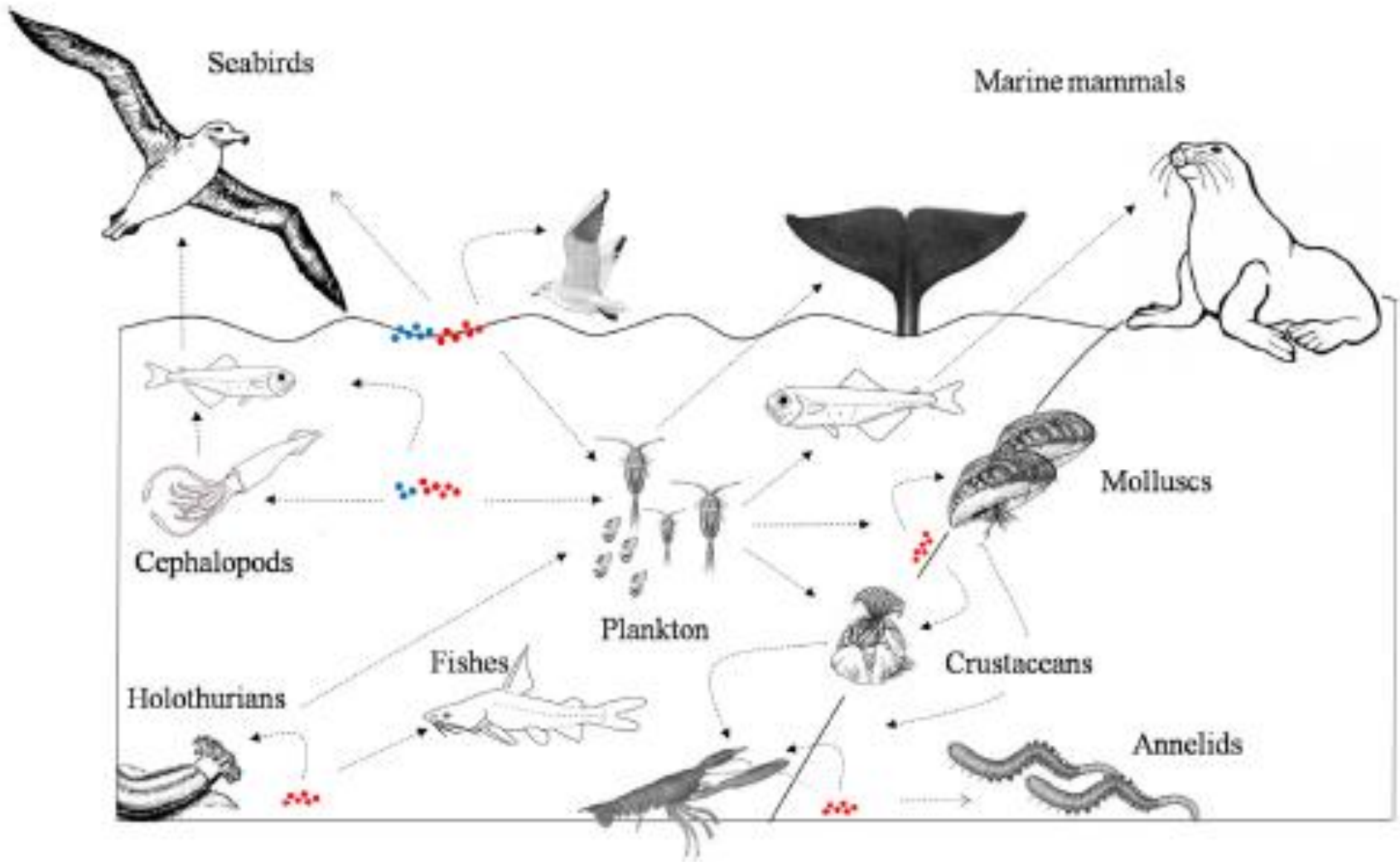


The blue mussel *Mytilus edulis* is a food source for many other organisms. One of its predators is the shore crab *Carcinus maenas*, which itself is predated by other species. Blue mussels exposed to polystyrene microspheres were fed to shore crabs and microspheres were subsequently discovered within the crab tissue, having translocated from the gut to other tissues.

Microplastics have also been found in the tissue of lobsters, many species of fish, and fur seals and this may have occurred through trophic transfer.

Several surveys have observed microplastics in the digestive tract of fish. Ingestion could have occurred directly or through trophic transfer.

- One-third of samples of pelagic and demersal fish taken from the English Channel contained microplastics ranging from 150 μ m to 5mm (Lusher et al, 2013)
- In the North & Baltic Seas, 5.5% of pelagic and demersal fish contained plastics, with 40% being in the microplastic size range (Rummel et al, 2016)



Uptake of microplastics and transfer through the food chain (red = higher density particles, blue = lower density particles)

Getting to the top of the food chain...

Surveys have shown that microplastics are present in fish and shellfish on sale for human consumption:

- A survey of fish on sale for human consumption in markets in the US and Indonesia found that 25% of the US fish sampled and 28% of the Indonesian fish were contaminated with microplastics (Rochman et al, 2015)
- Synthetic fibres ranging in size from 200µm to 1.5mm were discovered in the soft tissue of mussels for sale in 3 Belgium supermarkets (De Witte et al, 2014)
- 33% of oysters sampled from markets in California were found to contain microplastics (Rochman et al, 2015)

Toxic effects of microplastics

Microplastics are bio-inert as no enzymatic pathways exist within marine organisms to digest the synthetic polymers. However, microplastics have potential toxic effects because:

- Additives (called plasticisers) used in plastic manufacture may leach out and introduce toxic chemicals to the organism after ingestion. Additives such as bisphenol A are known to be endocrine-disrupters and can affect the synthesis and activity of endogenous hormones.

- Persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and organochlorine pesticides are present in sea water in low concentrations. Microplastics have a large surface area to volume ratio and these lipophilic chemicals adhere and concentrate on the hydrophobic surface of the plastic. Upon ingestion of the microplastic and its associated adsorbed contaminants, these contaminants can become bioavailable to organisms.

Effect of microplastics on human health

Where microplastics have been transferred up the food chain, bioaccumulation and biomagnification of toxic contaminants is likely to have occurred.

Whilst microplastics have been shown to be present in the digestive tract of fish on sale for human consumption, most fish are eaten cleaned and this part is discarded before consumption. Gutting fish therefore decreases exposure compared to eating whole fish. However, in shellfish or smaller fish the digestive tract is not removed before consumption.

The European Food Safety Authority (2016) has estimated that eating a 225g portion of mussels would lead to ingesting 7µg of plastics. This would result in a small increase in exposure to PCBs of 0.006%, to PAHs of 0.004% and to bisphenol A of 2% (assuming the contaminants are present at their highest observed levels and are released completely into the gastrointestinal tract).



Intestinal absorption of microplastics is low as the epithelium of the gut wall forms a barrier. It is possible for microplastics smaller than $150\mu\text{m}$ to translocate from the gut via lymphatic tissue. Microplastics larger than $150\mu\text{m}$ are unlikely to be absorbed and would only cause local effects such as inflammation of the gut. The smaller particles (under $150\mu\text{m}$) could cause systemic exposure but the data available suggests that only particles under $1.5\mu\text{m}$ could penetrate organs.

Gaps in the data

Data is limited and more research is needed on:

- the presence of microplastics in food in order to ascertain dietary exposure
- many of the chemical contaminants that are present as additives or adsorb to microplastics
- the fate of microplastics in the gastrointestinal tract, the potential for degradation into nanoplastics and subsequent translocation via lymphatic tissue
- the effect of contaminants that may be released by microplastics in the gastrointestinal tract